INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA)

Proceedings of the International Conference on:

Promoting Community-driven Conservation and Sustainable Use of Dryland Agrobiodiversity

ICARDA, Aleppo, Syria
18-21 April 2005

Edited by
Ahmed Amri and Adi Damania
Proceedings of the International Conference on:

“Promoting Community-driven Conservation and Sustainable Use of Dryland Agrobiodiversity”

ICARDA, Aleppo, Syria
18-21 April 2005

Edited by
Ahmed Amri and Adi Damania
Acknowledgments

Edited by - Ahmed Amri and Adi Damania
The editors would like to express their gratitude to colleagues within ICARDA and amongst the wider scientific community who have contributed to this publication.

We would like especially to acknowledge the Global Environment Facility and the United Nations Development Programme for their financial support of the regional Project on "conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria", Bioversity International and ACSAD for their technical backstopping, and IDRC for their financial contribution to the organization of the conference.

Feedback
ICARDA welcomes comment and feedback on this publication.
Please visit www.icarda.org/ to share your views.

Key words: Dryland, agrobiodiversity, in situ, conservation, sustainable use, species richness, diversity, ICARDA, landraces, wild species, collection, crop wild habitats, community, sustainability.

International Center for Agricultural Research in the Dry Areas (ICARDA)
PO Box 114/5055, Beirut, Lebanon
E-mail: icarda@cgiar.org www.icarda.org

The views expressed are those of the authors, and not necessarily those of ICARDA. Where trade names are used, it does not necessarily imply endorsement of, or discrimination against, any product by the Center. Maps are used to illustrate research results, not to show political or administrative boundaries.

Copyright ©2013 ICARDA  (International Centre for Agricultural Research in the Dry Areas)

All rights reserved.

ICARDA encourages fair use, sharing and distribution of this information for non-commercial purposes, with proper attribution and citation.
FOREWORD

Central and West Asia and North Africa region encompasses the centers of origin and the primary and secondary centers of diversity and domestication of several crops of global importance, such as wheat, barley, lentil, forage legumes, and several horticultural crops such as olive, fig, pistachio, almond, pomegranate and plum. Landraces of these crops and their wild progenitors forms constitute valuable genetic resources. Landraces form the major component of the traditional farming systems still prevailing in the dry areas and highland ecosystems where they contribute to the livelihoods of indigenous communities living under harsh conditions. However, this valuable and potentially useful agro-biodiversity is increasingly being threatened by rapid loss that will consequentially degrade the environment and exacerbate social and cultural problems at the national, regional and international levels. In addition, this loss will deprive the world of valuable genetic resources needed to sustain agricultural development and food security along with other environmental benefits.

Conservation of the genetic diversity requires the use of both *in situ* and *ex situ* conservation approaches. Germplasm banks are important in preserving samples of landraces and primitive forms and of scattered and small wild populations of species. Large, evolving and varied populations and species with recalcitrant seeds, however, cannot be adequately stored in seed genebanks and their conservation *in situ* need to be developed. However, closed protected areas are not always adequate for species requiring active management to conserve their genetic diversity. *In situ/on-farm conservation and continuous use of such species can help conserve these resources. The *in situ* management and *ex situ* preservation of dryland agrobiodiversity are, therefore, vital to ensuring the availability of genetic diversity needed to circumvent the effects of desertification and global warming and provide sources of valuable traits to respond the needs of breeders and other users.

Rural people are the main custodians of this rich agrobiodiversity of crops and their wild relatives, many of which are neglected and under-utilized. Some of these crops are labeled as traditional or indigenous or ethnic in opposition to the handful of economically valuable crop and often exotic varieties that are relevant in agricultural trade and urban food habits. Farmers and farming communities have limited financial and land resources, but at the same time have rich agro-biological resources, a long history of performing agriculture, and a strong cultural heritage with accumulated indigenous knowledge.

ICARDA is playing a key role in collecting and conserving *ex situ* genetic resources of wheat, barley, lentil, chickpea, fababean and many feed legumes and forage species. It is collaborating with NARS and other advances institutions to ensure a continuous flow and availability of genetic resources for further crop improvement and rehabilitation of degraded natural habitats. ICARDA is also working towards sustaining natural resources including the promotion of *in situ/on-farm conservation of local agrobiodiversity. I am particularly pleased that ICARDA together with other national and international institutions have associated themselves to the development of concepts and approaches for promoting *in situ/on-farm conservation of dryland agrobiodiversity, a rapidly developing field of research.

The outcomes and impacts of the project on “Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestinian Authority and Syria” and the experiences of several other teams from the region and abroad were presented in the conference organized at ICARDA. We decided to publish the proceedings of the conference hoping that more research be reserved to on-farm/*in situ* conservation and sustainable use of agrobiodiversity to meet the growing demands for the reducing rural poverty and increasing food production.

Mahmoud Solh
Director General, ICARDA
PREFACE
The Global Environment Facility-the United Nations Development Programme (GEF/UNDP)-funded project on “Conservation and Sustainable Use of Dryland Agrobiodiversity” was implemented in Jordan, Lebanon, the Palestinian Authority, and Syria and coordinated by ICARDA in cooperation with the International Plant Genetic Resources Institute (IPGRI, now Bioversity International) and the Arab Center for Studies of the Arid Zones and Dry Areas (ACSAD). All the participating countries fall within the ‘Fertile Crescent’ which has not only been the cradle of civilizations but also where wheat, barley, lentil, forages, and numerous fruit trees were domesticated. To commemorate the completion of the project and to discuss the data gathered, lessons learned, and identify avenues for future work, an international conference on “Promoting Community-driven Conservation and Sustainable Use of Dryland Agro-biodiversity” was held at ICARDA Headquarters, Tel Hadya, Aleppo, Syria, 18-25 April, 2005. The conference attracted global participation and included keynote speakers, invited papers, and participants from the national programs of 19 countries in CWANA region, among others. These proceedings are based on the presentations and posters delivered by a multidisciplinary group of scientists and co-workers at the international conference. The conference also included country presentations from each of the national components of the GEF-funded/ICARDA-coordinated Project and papers based on the following nine themes: 1) Understanding the status and current trends of dryland agrobiodiversity conservation; 2) Documentation of local agro-biodiversity featuring in the livelihoods of local communities, their indigenous knowledge, major factors contributing towards degradation of the environment through the use of Geographical Information System/Remote Sensing tools; 3) Technological and management options of agro-biodiversity within natural and semi-natural habitats including rangelands, forests, and protected areas; 4) Technological and management options for managing agro-biodiversity in farmers’ fields; 5) Added-value products and alternative sources of income for improving the livelihoods of local custodians of agro-biodiversity; 6) Public awareness activities for promoting agro-biodiversity conservation through mass media and other related means; 7) Valuation of dryland agro-biodiversity including diverse uses of genetic resources; 8) Enabling policies and legislation on access to agro-biodiversity, including national strategies, and aspects related to benefit-sharing and Intellectual Property Rights; and 9) Impacts of global constraints and challenges on dryland agro-biodiversity conservation. Each of the above topics was the subject of sessions, which sometimes ran concurrently, and were introduced by an invited keynote speaker. The presentations were followed by discussions. The conclusions and recommendations are also given in this book. We would like to mention here that while every effort was made to produce these proceedings immediately after the conference, some authors had other professional commitments that did not allow them enough time to prepare a paper for submission on time.

We are very grateful to all the donors and the support staff at ICARDA. The financial support for the production of this book is also gratefully acknowledged. The editors would specifically also like to thank the Global Environment Facility (GEF); the United Nations Development Programme (UNDP) the International Development Research Center (IDRC), Canada; and the Syrian institutions for their support to the conference. The help of Ms. Natalya Rukhkyan, Mr. Gregory Sixt and Dr. Rami Khalil in formatting and editing of these proceedings is highly appreciated.

We hope these proceedings will be useful to all who are interested in the conservation and utilization of agro-biodiversity of the drylands.

Ahmed Amri          Adi Damania
SESSION ONE

UNDERSTAND THE STATUS AND CURRENT TRENDS OF ON-FARM/IN-SITU DRYLAND AGROBiodiversity for Designing Conservation and Sustainable USE STRATEGIES
The Current Status of On-farm and In situ Conservation of Dryland Agrobiodiversity and Strategies for their Future Conservation and Sustainable Use

E. Porceddu\(^1\), A. Damania\(^2\) and A. Amri\(^3\)

\(^1\) Department of Agrobiology and Agrochemistry (DABAC), University of Tuscia, Via S.C. de Lellis, 01100 Viterbo, Italy. Email: porceddu@unitus.it
\(^2\) Genetic Resources Conservation Program (GRCP), Agriculture and Natural Resources (ANR), University of California, Davis, CA 95616-8602, USA. Email: abdamania@ucdavis.edu
\(^3\) Genetic Resources Section, International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. Email: a.amri@cgiar.org

Keywords: Dryland agrobiodiversity, importance, in situ conservation, sustainable use

Abstract
Wild plant species were used for food at least 30,000 years before present (BP), whereas these were brought under cultivation through domestication only about 10,000 BP. During the last century, with crop improvement programs developing better and high yielding bred varieties, the local landraces have been disappearing. The natural habitats of the wild progenitors are now threatened due to urbanization, over grazing, and misuse of natural resources especially in the drylands of West Asia where cereal domestication first occurred 10,000 BP. There is, therefore, a great need to conserve in a sustainable way these wild progenitors in their natural habitat through on-farm/in situ conservation practices. To this end, several projects based on our founder crops have begun in West Asia and the countries bordering the Mediterranean sea. An experiment set up in 1992 at the main research station of the International Center for Agricultural Research in the Dry Areas (ICARDA) at Tel Hadya and two other stations in Sarghaya and Yahmoul in Syria simulating the reintroduction of wild relatives of crop species into their original habitats has had some interesting preliminary results. Some of these have been described and strategies for monitoring and implementing the same in Syria and neighboring region discussed.

Introduction
Agriculture is a relatively recent phenomenon in man's history having begun just over 10,000 years ago in the Fertile Crescent of the Near East and almost simultaneously in parts of the tropical world (China and South America), although the developments in the Near East may have had a longer prelude. The transition from hunting and gathering to agriculture and a pastoral way of life had revolutionary consequences for human society. It led to the stabilized human populations and emergence of human civilizations. For example, the archaeological excavations at Ebla (54 km south of Aleppo on the highway to Damascus) had a flourishing civilization about 4500 years before present. It also led to man’s large dependence on a relatively few domesticated plants and animals. Over 90% of man's food supply comes from crop and pasture plants (Harlan 1992).

Domesticated plants evolved near the wild relatives with whom they occasionally exchange genes. These evolutionary dynamics, which provided the foundation of peasant farming, have created and maintained a wide range of genetic diversity that characterizes wild species and domesticated plants in their centers of origin. For thousands of years, animal and plant species have dispersed and radiated away from these centers and gradually adapted themselves to highly diverse natural cropping environments. These adaptations have led to the release of an additional amount of genetic diversity in the forms of traditional farm animal breeds and crop landraces. These plants, animals, and associated microorganisms, are necessary to sustain key functions of...
the agrosystems, their structure, and their processes. They form the agricultural biodiversity that we see today or agrobiodiversity. This agrobiodiversity contains:

- Genetic resources for food and agriculture (harvested crop varieties, livestock breeds, and non-domesticated wild relatives, forests, rangelands and aquatic ecosystems);
- Components that provide ecological services including, pollinators, nutrient cycling species, natural enemies, as well as services important to agriculture such as water catchments (also known as water harvesting), maintaining water quality, carbon sequestration, and maintenance of local wildlife and habitats; and
- Biotic factors affecting the agricultural biodiversity and the socio-economic factors that are shaping it through human activities and management.

The Convention on Biological Diversity (CBD) recognizes the intrinsic value of these biological diversities and expresses concern over the extent and speed of its degradation, and the need to take collective actions to prevent losses. The Subsidiary Body, on the Scientific, Technical and Technological Advise (SBSTTA) of the CBD, recommended the Conference of Parties (COP) to establish a program of dryland biodiversity including grasslands, savannah, and the Mediterranean islands. In fact the drylands occupy over 6 billion hectares representing more than 40% of the global land area, with an average annual net primary production of 1200 to 1500 kg/ha. Over a billion people, one sixth of the world’s population, live in the drylands. Their biological diversity is a very significant and valuable asset because of its high species diversity and high endemism present in some biota. Resistance to harsh conditions, such as drought and heat makes this material a vital source of genes for breeding activities. Moreover, most of the major food crops and pasture plants originated in the drylands. The Mediterranean type ecosystems are exceptionally important in this regard. They contain four out of the 18 hotspots. One of the three nuclear centers of agriculture, the Near East region is the center of origin for wheat, barley, lentil, forage species (often called the “founder crops”), and many species of fruit trees (Hawkes, 1983). The plant species that originated from this area feed some 40% of the world’s population. Wheat alone accounts for about one third of the world’s food production. However, the ecosystems in the drylands are fragile due to degradation of habitats and the losses of related biodiversity are already leading to irreversible situations responsible for migration of considerable number of rural communities (see Damania and Amri this volume), desertification, and an increase in mass poverty. Due to these concerns, the conservation of dryland agrobiodiversity is receiving increasing attention equally from world bodies and concerned scientists.

Socioeconomic surveys conducted by the GEF/UNDP project executed by the International Center for Agricultural Research in the Dry Areas (ICARDA), found that almost all farmers in the drylands and mountainous areas in Syria, Jordan, Lebanon and Palestine are using landraces of barley, lentil, fig, and olive in their traditional farming systems and for generating their incomes. Most farmers still use durum wheat landraces. In the case of almond, apricot, and plum, more than half of the farmers still use landraces. The quality and adaptation advantages of using landraces are well known to farmers, even though improved varieties from outside the region are available. However, the area planted to these landraces is decreasing due to the rapid spread of other cash fruit crops such as apple, cherry, and olive. Mainly overgrazing, expansion of non-agricultural land, and expansion of quarrying activity adversely affect the agrobiodiversity in natural habitats where these landraces and their wild relatives thrive.

In the past, explorations and collecting missions have been mounted which have visited these areas since a long time and the material they collected is kept in storage at different genetic resources centers. However, it should be noted that many of these missions were aimed at finding material for evolutionary and taxonomic studies and accessions were represented by few seeds often from some selected plants belonging to some precise species. They often
included only wild species without much consideration for their domesticated and cultivated relatives. Other missions were interested in some specific traits, such as resistance to a pathogen and hence they collected only resistant material for field analysis and conservation. Harlan (1995) described this dilemma in his book the “Living Fields” when he talked about a decision he had to take when he observed some plants growing high above him on a hillside, as to whether he should abandon his route momentarily and climb the hillside in search of what could or could not be valuable germplasm? If he ignored the opportunity it is possible some highly valuable genes would remain uncollected.

Only during last few decades, missions started to have as an objective the collection of representative samples of the existing variation present in one or a few specific species in a particular targeted area. However, the representativeness of these samples is rather relative. The dimensions of samples were originally calculated taking into account the percentage or the presence of genes without much consideration about the gene complexes that are mainly responsible for the adaptation in landraces. During field collections, some genotypes may be left out just because the seeds were not yet mature enough for collection, or because the seeds were no longer on the plant (Porceddu and Damania 1991). Pilot studies carried out at ICARDA (Valkoun and Damania 1992) and elsewhere (Jana 1993) have demonstrated extensive genetic diversity in the original populations of the wild genepool in the natural habitat that is impossible to preserve by any standard ex situ procedures. In addition, material stored in ex situ facilities in the form of field genebanks, seed and other banks, do not have the advantage of long-range ecological processes and organic evolution that operate under natural conditions and constantly refine and update biodiversity through mutations, recombinations, and natural selections. In essence, biodiversity stored do not enjoy the advantages conferred by the exposure to processes of natural selection as when the material is conserved in situ.

In industrialized countries, the most frequent response to the growing threats to the survival of biological diversity has been the creation of the protected areas and national parks. Technical capacity to design protected areas systems has increased during last century and the network of protected areas has expanded to include more than 105,000 sites covering an area of more than 19.7 million km² (2,7). The problem with this strategy is that impacts on development are often negative, as protected areas cause the foreclosing of future land options, with potentially significant economic opportunity costs (9), mainly paid by local, poor people. The strategy of industrialized countries cannot be extended automatically to developing countries. Conservation has to be based on real world, taking into account the economic situation of rural people and the socio-economic structures of the concerned societies. We should be aware that biodiversity conservation has not been invented by modern society. It was inherent in the traditional use of resources, developed during centuries by different societies. Different plants are cultivated and farming is associated with livestock and use of natural pastures. The agricultural enterprise is labor intensive, even at the cost of some economic efficiency. Family business and communal effort dominate the economic structure. Harvest is sold in local and regional markets, with only a few highly valued products exported. The primary strategy of the concerned people is based more upon long-term stable use of resources than on maximizing production.

Such diversity continues to be an essential component of production for most of world's farmers. Approximately 60% of global agriculture still involves subsistence farming using traditional methods. This provides about 15-20% of the world's food, a figure that may well underestimate the nutritional contribution made by such farming, given the importance of traditional methods in vegetable and fruit productions, which often are considered in statistics. Removal of resources from their control has lead to rebellions and confrontations that seldom
ended easily and rapidly, and that never had a positive effect on biodiversity conservation. Social instability accentuated the worst predatory pressure. To be effective, conservation plans have to avoid any social unrest. This does not mean that protected areas should not be created. On the contrary, it means that prioritisation of the use of natural resources has to take into account, along with ecological values, also social values, the interests, customs and culture of local populations. Those who for centuries have developed and conserved the biodiversity have to be included in the decision making process and share the benefits of conserving biodiversity. Taking into account these points, the 7th CBD / COP called for an assessment of the economic and socio-cultural costs of protected areas and policies to ensure that local people are fully involved. The relation between economic development and biodiversity conservation has been approached in various ways and has represented an important element of debate about conservation policy during the last decades. The principle that local people should be systematically integrated into protected areas planning was agreed to at the third World Parks Congress in 1982; ten years later, in 1992 the President of the International Union for Conservation of Nature (IUCN) argued that local people have to support protected areas if these are to last, and the IUCN’s Director General suggested that protected areas should represent “islands of biodiversity in an ocean of sustainable human development”, with their benefits extending far beyond their boundaries. Actually the question of whether economic development can be combined with biodiversity conservation is part of the more general debate about environmental dimension of development. During most of last century, the dominant approach was to push for economic growth first on the assumption that environmental problems and social welfare could be sorted out later, as, with the growth of economies, societies would be keen to invest in clean technologies and less resources-depleting processes. Thus in the 1950s and 1960s development planners paid scant attention to environmental impacts, whether focusing on poverty alleviation, the creation of high-productivity agriculture, or physical infrastructures. Agriculture in a number of developing countries moved to high productivity and the result was the Green revolution, which freed many developing countries from going round with a begging bowl for food and many populations from acute hunger. It also saved many million hectares of forests and pastures, rich in biodiversity, from being put in cultivation. However not all populations have benefited from these yield increases, and increases were not entirely friendly, because they were accompanied by the replacement of a huge number of diverse landraces, with a relatively few uniform varieties and because of some pollution problems. Concerns gave rise to a different approach to development, in the concept of sustainable development, which underpinned the 1980 World Conservation Strategy document, the World Conference on Environment and Development in Rio de Janeiro in 1992 and the World Summit on Sustainable Development in Johannesburg in 2002. Among other things, sustainability in agriculture was considered to depend on the ability to combine high productivity with high diversity. Indirect evidence from studies carried out so far has indicated that in situ methods should be effective for the conservation of genetic diversity in populations of both cultivated and wild species. On-farm conservation of local varieties can be achieved with two-fold results. For example, there is an area in Egypt close to the northern border with Libya, which is very rich in genetic variations of the fig (Ficus carica L.). Nearly 40 different types of figs are grown in this area. These command a good price in the market because of their unique taste and cultural attributes. Their on-farm conservation and cultivation not only preserves the varieties, but also helps their custodians to generate a sizable side income. On-farm performance of landraces of cereals and food and feed legumes can be improved by following the proper procedures for cleaning and treatment of seeds against seed-borne diseases and judicious use of herbicides.
To promote rangeland rehabilitation, reseeding with native species, application of fertilizers, targeted grazing, water harvesting, plantation of shrubs, and production of feed blocks needs to be encouraged. Some of the merits and demerits of *in situ* conservation have been discussed by Jana (1993).

As an incentive to generating an alternative income source for local communities, who are the true custodians of agrobiodiversity, training and technical support could be provided for such activity as apiculture, diversification of dairy products, cultivation and marketing of medicinal herbs, and creation of community nurseries for the multiplication of useful seedlings. Research and extension efforts should contribute to the promotion of conservation and sustainable use of dryland agrobiodiversity. Further success can be achieved if the important role that local communities play is fully recognized, evidenced by their full participation, empowerment, and sharing in resulting benefits. For example, there are several cherry and peach varieties in Lebanon that have not yet been documented and the authentic names of the local varieties are unknown. Old varieties were named by the farmers who grow them on the basis of the name of the person who first introduced the germplasm or, if local, by the grower in relation to a precise trait and distinctive nature of the fruit. Other denominations seem to be an Arabic translation of the original name of the accession. Thanks to the GEF/UNDP West Asia Dryland Agobiodiversity project, the value of these genetic resources have been highlighted and the local communities made aware of the need for their conservation with an added benefit that can generate a subsidiary income, especially for the womenfolk.

From biological considerations, the relative merit of the *in situ* method for conserving biodiversity within a cultivated species may be best evaluated in comparison with its wild evolutionary progenitor. Although several comparative studies on diversity in wild and cultivated barley have been reported (Jana 1993), comparable investigations are rare in wheat. In a preliminary assessment of genetic variation in durum wheat (*Triticum turgidum* subsp. *durum*) and its wild progenitor (*Triticum turgidum* subsp. *dicoccoides*) populations from Turkey, the results showed that there was no difference in overall genetic diversity between the two.

An ongoing experiment spanning several years is being carried out at the Genetic Resources Unit (GRU) of ICARDA to establish well-defined populations of wild relatives of cereals and legumes conserved *in situ* and thereby determine the main factors which affect survival and competitive ability, and evaluate colonizing ability and regeneration capacity in populations of the target species, viz., *Triticum urartu*, *T. boeoticum*, *T. dicoccoides*, *Lens orientalis*, *L. odemensis* and two annual *Medicago* species and their mixtures. Sheep are allowed to lightly graze the experiments so as to simulate as far as possible the actual disturbance factors involved in this type of conservation effort. The main objectives of these experiments are to:

1) study the feasibility of restoring lost natural populations of wheat and other wild relatives using seeds from accessions collected from previous natural populations in those very same areas and conserved *ex situ* in the ICARDA genebank;

2) establish self-regenerating local populations of wild *Triticum* spp. and their mixtures with other cereal and legume species. The aim was to study the population dynamics under simulated conditions similar to actual *in situ* conservation sites;

3) have a reference populations for *in situ* site management studies in order to develop appropriate methodologies for conservation of cereal and other wild relatives;

4) restore semi-annual plant eco-systems similar to those that had existed in the region before the land was cultivated and grazed; and

5) train the national program staff in species identification and in monitoring natural populations of wild relatives of cereals and legumes for future *in situ* conservation projects in the region.
The above experiment that started with the 1992/1993 season at Tel Hadya, Aleppo, Syria and at two other stations in Sarghaya and Yahmoul in Syria continues to this day. One of the most interesting findings of this experiment is that, today several other species of plants have taken root in the experimental plot that were not originally present nor were they put there by anyone during these years. This indicates that once a certain species is re-introduced in to the wild other ‘companion’ species also establish themselves around it, and this further enriches the biodiversity in the in situ conserved area. These companion species could take root because of favorable environment brought about by the droppings from grazing sheep or other mechanisms or seed dispersal by the wind. This can result in re-establishment of the complete original ecosystem or an entirely new one based upon a fresh set of species.

Results at the Yahmoul site in Syria, after 6 years of simulated experimentation, show that the diploid wild Triticum spp. and their mixtures competed very successfully with the autochthonous vegetation (mostly weedy species of various families). The number of plants per m$^2$ increased in the diploid species T. boeoticum and T. urartu from approximately 25-30 in the first season to 130-170 at the end of 2001, and from 25 to 18 plants per m$^2$ in the case of tetraploid T. dicoccoides. It was also observed that the plant height and other morphological characters were similar to those of the natural populations of these species in the Aleppo province. The conclusions, therefore, were (ICARDA 2004): Firstly, the results so far show that self-re generating, semi-natural ecosystems based on annual wild cereal (Triticum, Hordeum and Avena spp.) and forage and pasture legumes species of the Near Eastern origin can be established on cultivated land using seeds from an ex situ genebank. Secondly, they indicate that controlled grazing can be compatible with, and even beneficial for in situ conservation of the target species. And, thirdly, it shows that other ‘companion’ species will establish themselves to the re-introduced species, further enriching the biodiversity. It was concluded that an in situ conservation plot of 1000m$^2$ would be sufficient to conserve a population of 6,000 to 15,000 individual plants. The scientists involved continue to monitor these sites and the results will be reported in forthcoming reports. These results and information acquired from the experiments in Syria provided valuable input in to the GEF/UNDP project on agrobiodiversity conservation in Jordan, Lebanon, the Palestinian Authority and Syria.

In wild cereals such as T. boeoticum, T. dicoccoides and Hordeum vulgare subsp. spontaneum, selection for a non-brittle rachis led to their domestication. Both wild diploid wheats and wild barley show great climatic tolerance in terms of their natural distribution. Their natural habitats range widely in latitude and altitude. Wild einkorn (T. boeoticum), for example, can be found growing from sea level in Macedonia to 2000 m asl in Iran and Iraq. The densest stand encountered so far has been in southeastern Turkey at altitudes between 900 and 1500 m (Willcox 1992). Wild emmer, T. dicoccoides, has been reported from 100 m below sea level in the Jordan valley and at 1500 m on the slopes of Mt. Hermon in Palestine (Zohary 1969). Several of these habitats could qualify for consideration as in situ conservation sites.

Genetic diversity through the study of seed storage protein (gliadin) polymorphism was carried out on populations of H. spontaneum, T. urartu, T. boeoticum and T. dicoccoides collected from the southern provinces of Sweida and Damascus, the Anti-Lebanon Mountains, and the northern province of Aleppo during 1991, 1992, and 1993. Relatively high genetic diversity was found in populations collected from the high plateau in the province of Sweida, while populations found in valleys of the Anti-Lebanon Mountains showed lower diversity (Valkoun and Damania 1992). The discovery of T. urartu growing in close proximity with T. dicoccoides and H. spontaneum in the middle of the Hauran plain forms a link between the T. urartu populations found on the slopes of Mt. Hermon and the Jebel Al Arab mountains of the Sweida province in southern Syria. This may also indicate that the Hauran plain used to be the natural habitat of the two wheat
ancestors and wild progenitor of cultivated barley before the area came under cultivation and was intensively grazed by sheep and other small ruminants. These wild progenitors could have been even more widespread than today during the Neolithic period and there may have been a considerable time lapse between their usage as a food source, i.e., beginnings of cultivation and their actual morphological domestication (Willcox 1996).

Long-term monitoring of biodiversity is essential to develop an understanding of its value for conservation and sustainable use. During 1993 a monitoring trip was conducted jointly with Syrian scientists with the objective of gathering information on these sites (land use, farming system and socio-economic background, botanical composition of the associated vegetation, etc.), and the target species populations (phenology, reproductive ability, vigor and health). It was observed that the populations of wild progenitors of cereals are relatively well protected from grazing during the vegetative phase when they grow on non-arable habitat among the basaltic rocks. They are inaccessible before the harvest of durum wheat by which time the spikes have matured and shattered on the ground avertting damage from grazing small ruminants. However, when the ownership of the land is not in private hands, flocks belonging to wandering Bedouin tribes graze continuously with deleterious effect on the plants. Only highly unpalatable spiny weeds survive this form of grazing and not a single plant of wild Triticum spp. is left standing (Damania 1994). During these missions T. urartu populations were also sampled from the Anti-Lebanon mountains growing on the borders of orchards, above the summer Syrian resort town of Bloudan, at an elevation of 1840 m asl, the highest collection site reported for this species so far (ICARDA 1995). Studies on heat and cold tolerance in wild and obsolete wheat forms by Damania and Tahir (1993) revealed that T. dicoccoides was most susceptible to heat as well as cold. Among the diploids T. urartu was significantly more cold tolerant than T. boeoticum, indicating perhaps the reason that the former can still be found at high altitudes in its center of diversity. Results of these studies are being used to identify the most suitable populations and sites and to develop a sustainable strategy, together with the appropriate land management system, for in situ conservation of the indigenous wild wheat progenitors in Syria and the neighboring countries and adjoining territories. With the initial support of the United States Department of Agriculture (USDA), a project for in situ conservation of T. dicoccoides populations has been underway in Eastern Galilee since almost a decade. Between the years 1984 and 1989, individual plants were monitored at closely spaced permanent sampling points along with four topographically diverse transects. Single spike collections were made annually from these plants and seed from progenies were sent for ex situ conservation. The one hectare site is located one km west of Kibbutz Ammiad, in a hilly tract that is the southern extension of the Mt. Kenaan ridge. The in situ conservation site so established would protect and maintain the entire genepool of the selected populations. The climate is typical Mediterranean type with an average rainfall of 580 mm that falls during the winter months. As in Syria, the survival of these populations of wild wheat progenitors is now increasingly threatened by human population pressures and intensified mechanical agricultural practices of the settlers (Anikster and Noy-Meir 1991). Some of the problems in areas of in situ conservation of wild species have been highlighted by results of the Ammiad experiments. One of the most difficult decisions of all in the establishment of such reserves is to determine the size of its area. The minimum viable population size will be greater than the minimum effective population size of individuals that can contribute to the next generation. During the last four years, the wild wheat study using the Ammiad methods of sampling and progeny testing has been extended to other populations particularly in two nature reserves in Yahudiya, an area in the Golan Heights and Har Meiron in Upper Galilee (Anikster et al. 1997).
In situ conservation of wild wheat relatives at the Erebuni Nature Reserve, northeast of Yerevan in Armenia, has been met with some success. Vavilov (1951) first recommended protection of this site because of its unique richness of the wider Triticum genepool. T. urartu was discovered there in 1935 by Tumanyan and later this species was fully described by the late Professor Gandilyan (Gandilyan, 1972). Other wild wheat species, such as T. boeoticum and T. araraticum, grow in the protected area together with Aegilops spp. Amblyopyrum muticum, a species considered to be taxonomically intermediate between Aegilops and Agropyron, was also found near this nature reserve. Hence, this site in Armenia is the only site outside Turkey where the uncommon species of the Anatolian highlands are found. The actual size of the reserve is about 100 ha but protection of a much wider area, about 400 ha, is needed in order to include rare populations of other species growing on the periphery of the protected area as well as to provide a buffer zone for the protection of the core area. It has been suggested that those islands in the Mediterranean and elsewhere, that are under military control and closed to the public for security reasons, could be made available for research to small teams of scientists who can monitor the in situ sites where no disturbance can occur as opposed to highly vulnerable sites close to the dense urbanized areas.

Many crop relatives are associated with recent historical events such as the demarcation of international borders. For example, the border zone between southern Turkey and northern Syria houses many wild cereals, legumes and other ancestors of crop plants. In situ conservation may also take place on state farms and experimental stations. The Ceylanpinar State Farm in southeastern Turkey is a recent well-known example where the World Bank is funding research on in situ conservation methods. Protected experiment stations may become more important as future in situ conservation sites because of the ease of controlling the system (Waines 1998). For example, one of the in situ conservation sites of either native or introduced species is on national agricultural experimental stations or state farms. The Ceylanpinar state farm in Urfa province, southeastern Turkey, is being developed as an in situ conservation area for wild cereals, legumes and other Near Eastern species by the Turkish Government and the World Bank. This large state farm is located in the northern apex of the Fertile Crescent. The advantage of using state farms is that the state already controls the system of agriculture practiced there (Waines 1998).

A final example of the usefulness of national agricultural experiment stations to study in situ conservation is found in Syria, where cooperation between the Syrian Agricultural Research Center and ICARDA has set up study sites in four different ecogeographic areas in the country. The site at Yahmoul Experiment Station near Azaz in Aleppo province has allowed for replicated experiments lasting several years, in which wild cereal and legume relatives can be studied in single species plots or as interactions in multiple species plots. Similar experiments have been set up at Tel Hadya, south of Aleppo, at Sarghaya station near the Lebanese border, and at Sweida one in the Jebel Al Arab. There is a need for sites similar to the long-term Rothamsted Park Grass Experimental Field to study in situ conservation over many seasons, including many different members of the relatives of Near Eastern crop plants. There is also the possibility to study controlled grazing or burning of these in situ sites to approximate more exactly conditions in natural habitats (Waines 1998).

The need to encourage in situ conservation of landraces in the communities in which they occur has been advocated by several authors (Altieri and Merrick 1987; Brush 1995; Peña-Chocarro 1996). Qualset et al. (1997) caution that, it is a challenge to undertake in situ conservation of indigenously developed germplasm without a return to or preservation of obsolete agricultural practices which may be unacceptable or impracticable under socio-political systems in areas where diversity abounds. Besides, in situ conservation of germplasm of economically important crops would most probably also result in the conservation of associated species occurring naturally in the same ecosystem. In situ conservation also permits natural evolution to continue, an extremely important aspect for the preservation of genes for abiotic and biotic stress
resistance as species coevolved with their pathogens and changing environment. *In situ* methods of conservation of landraces and wild progenitors are, understandably, looked upon skeptically by plant breeders. As long as genetic conservation and crop improvement are directly linked, any form of conservation will be judged by its short-term benefits to breeders, and *in situ* methods will attract considerable criticism (Brush 1991). On-site conservation is more plausible if these two goals are decoupled, making biodiversity conservation an end in its own right. In fact, Jana (1993) has said that we should get away from the notion that *in situ* conservation of biodiversity of wild progenitors and landraces is only for safeguarding breeding materials for the future. Conservation should be practiced for its own sake; it keeps the landscape green, enhances the quality of life and ensures the continuation of the ecosystem, and thereby the well-being of humankind.

Agriculture has to move towards diversity within crops and among crops. But in addition to technical aspects, there are political problems to be considered. Therefore, there is a need for clarity of vision regarding the relationship between diversity, productivity and technology. As a first point, the institutional structure that controls technology should not overshadow the institutions which deals with conservation of biodiversity and should not ignore the rights of those who possess the biodiversity. One of the problems is that biodiversity rich countries are poor in technology and, *vice versa*, the biodiversity poor countries are rich in technology. The situation is exacerbated by the fact that the extent and nature of flow of technology from North to South does not commensurate with the flow of biodiversity from South to North. This is an unequal exchange and will remain such until the countries of South become self-reliant in technology. But whereas at least some countries do have the capacity to develop technology, countries of the North cannot make it, because they do not have any worthwhile biodiversity growing naturally. They do not have the advantage of long-range ecological processes and evolution that operate under natural conditions and constantly refine and update biodiversity through mutation, recombination, and natural selection. Over thousands of generations plant populations experienced very fine recombination events, and they are replacing experimental populations in identifying genes and gene complexes, which endow them in adaptation to specific environmental conditions. Scientific advances also allow us to develop those technologies that allow taking full advantage of these findings for the benefit of mankind.

Realizing their richness in biodiversity and the need of it by industrialized countries, developing countries pushed for a comprehensive international agreement on genetic resources. The international undertaking includes, among its major elements, the concepts of plant genetic resources (PGR) heritage of mankind and that of farmers’ rights. The common heritage concept has been open to rather variable interpretation and the CBD laid much greater emphasis on the recognition of national sovereignty in respect of such resources. Specific attention is paid to the farmers’ rights, which are defined as the rights arising from past, present and future contributions of farmers in conserving, improving and making PGR available. This concept is of key importance in providing a framework to recognize the importance of conservation of the countries and communities that are rich in crop diversity. The increasingly developed political framework for the conservation of PGR makes new demands on the technical capabilities of those involved in carrying out conservation work. Scientific and technical challenges associated with conservation are wide ranging. Sound biosystematics and experimental evolutionary, genetic and breeding studies are needed to work out the details of distribution patterns of life forms, regenerative capacity, population genetics, evolutionary biology, breeding systems, size and extent of gene exchange within the gene pools, etc. Besides, expertise would be needed in several cognate fields such as meteorology, land and water management, landscape and restoration ecology, forestry, agriculture, economics, etc.
Conclusion
Several strategies can be applied towards conserving dryland agrobiodiversity in a sustainable way. Whatever they may be, they have some key points in common. They are: (1) assessment and monitoring of agrobiodiversity and generating knowledge about major factors contributing to its degradation; (2) demonstration of low cost technologies and ways to increase the productivity and marketability of products making use of agrobiodiversity; (3) drafting an appropriate policy and legislation reforms; (4) enhancing capacity building; (5) increasing public awareness; (6) investigation of alternative sources of income; and (7) impact assessment and contribution to the development of scientific basis for in situ conservation.

The entire Fertile Crescent area, that gave the world agriculture through the domestication of the founder crops, is a mega-center of agrobiodiversity. However, due to short-sighted policies of the past this agrobiodiversity has been neglected and degraded and several of its vital components are now in danger of irreversible loss and the region that gave the world agriculture itself stands in need of food imports. Unfortunately, the hostile situation created by the presence of the military forces and the building of concrete barriers through areas with rich agrobiodiversity does not help the situation. Looking at the success and tremendous impact that the GEF/ICARDA dryland agrobiodiversity project has had, it should be the recommendation of this Conference that projects such as the Conservation and Sustainable Use of Dryland Agrobiodiversity in West Asia be reproduced and extended to other regions where agrobiodiversity abounds and is threatened.

References


Status and Threats to Crop Wild Relatives in Selected Natural Habitats in West Asia Region

A. Amri¹, M. Monzer², A. Al-Oqla³, N. Atawneh⁴, A. Shehahdeh¹ and J. Konopka¹

¹ International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria, E-mail: a.amri@cgiar.org; j.konopka@cgiar.org; a.shehadeh@cgiar.org
² Manager of the Ago-biodiversity Conservation Project, National Center for Agricultural Research and Technology Transfer (NCARTT), Amman, Jordan,
³ Manager of the Ago-biodiversity Conservation Project, Lebanese Agricultural Research Institute, Tel Amara, Lebanon.
⁴ Ministry of Agriculture/UNDP –PAPP, Palestinian Authority. E-mail: nawwaf70@hotmail.com.

Keywords: Crop wild relatives, natural habitats, threats, in situ conservation, management plans, West Asia

Abstract
West Asia encompasses the center of diversity for many crops of global importance. The landraces and wild relatives of these crops are important genetic resources for the improvement of cereals, food and feed legumes and several species of fruit tress. But, their abundance and distribution are highly affected by various threats calling for more efforts for their effective in situ and ex situ conservation. The GEF-funded, ICARDA-coordinated project on “conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestinian Authority and Syria” conducted eco-geographic and botanic surveys in 75 monitoring areas during the period of 2000-2004 to better know the status and threats to wild relatives of field crops, forage legumes and fruit trees. The results showed that all of the major causes of habitat degradation are induced by human activities. Overgrazing was the most important factor responsible for biodiversity degradation, followed by agricultural expansion into natural habitats of wild species for plantation of fruit tress and for urbanization purposes. Wood cutting and fires are observed in the natural forests in Jordan, Lebanon and Syria. Quarries are prominent threats in parts of Hebron in Palestine and Aarsal in Lebanon. The political situation in the West Bank is affecting seriously the biodiversity. All of these factors along with the underlying factors of population pressure, poverty of local communities, limited enforcement of protection laws, are seriously threatening the remaining populations of wild relatives which are needed for sustaining agricultural development and for the rehabilitation of degraded ecosystems. These factors are meaningful and reliable indicators of the status and trend of biodiversity in much of the arid and semi-arid land in the Near East Fertile Crescent. Elements of management plans were recommended for safeguarding some natural habitats.

Introduction
Agricultural diversity (agrobiodiversity) occupies a unique place within biodiversity since it is directly linked to the provision of basic needs of humankind and is needed for future agricultural development and food security (CBD, 2000). The agrobiodiversity in the dryland areas is of particular importance because many of today’s major food crop species are domesticated in these regions (Harlan, 1992, Hawkes, 1983) The Mediterranean and West Asia regions encompasses Vavilovian Centers of diversity and origin of crops of global significance such as wheat, barley, lentil, and many forage legume and dryland fruit tree species. Increasing attention is devoted to the preservation of the agrobiodiversity of the drylands to sustain the livelihoods of its custodians and to continue to provide genetic resources needed in breeding programs to ensure further genetic gains in productivity,
quality and resistance and tolerance to biotic and abiotic stresses (Frankel, 1978; Cooper et al. 1992). Vavilov was among the first to recognize the importance of conserving both cultivated species and the wild species belonging to their respective gene pools (Vavilov, 1922) and the global importance of the plant biodiversity of West Asia mega-center of diversity (Vavilov, 1926).

The Convention on Biological Diversity stressed the need for substantial efforts to conserve in situ the biodiversity and mainly the biodiversity of the drylands and centers of diversity (CBD, 1993). Biodiversity is mainly affected by anthropogenic factors and poor management of natural resources and unsustainable grazing regimes have impacted negatively the fragile ecosystems (Maxted et al. 1997a). Fragmentation has affected seriously the forests (Harris and Silva-Lopez, 1992). It is necessary to clarify the differences and links between fundamental causes (population growth, poverty, economic growth, etc), the underlying causes (deficiencies in property rights, information exchange and institutional and political arrangements) and the threatening processes which include the factors of environment degradation and loss of biodiversity. Climate change could affect more this biodiversity.

Crop wild relatives are crucial for improving agricultural production and sustaining food security and for maintaining sustainable agroecosystems and healthy environments. Crop wild relative species have contributed significant genes to the improvement of the most grown crops, allowing them to adapt to abiotic stresses, to resist major diseases and insects and to improve the nutritive qualities (Cooper et al., 1992; Frankel et al., 1997). The direct progenitors of wheat, barley and lentil are found in West Asia region. ICARDA in collaboration with National Agricultural Research Systems (NARS) in the Central, West Asia and North Africa region (CWANA) have collected several accessions of these species which are actually conserved ex situ in national and ICARDA genebanks. Additional and complementary efforts are needed to ensure a dynamic in situ conservation of broader genetic diversity and species richness to cope with increasing virulences of pests and with the negative effects of climate change. The existing exclusionary protected areas did not target the conservation of wild relatives in the past and most often were not accepted by local communities. Several authors presented the elements for management of natural reserves for effective conservation of wild relatives of crops (Ingram and Williams 1984; Maxted et al., 1997a; Hawkes et al., 1997).

The knowledge of the status of local agrobiodiversity and of the major factors affecting its distribution and abundance is highly important in designing conservation strategies (Maxted et al. 1997c, 1997d; WCMC, 1992). The International Union for Conservation of Nature (IUCN, 1993) has developed a system that helps in classifying species into extinct, threatened, endangered, vulnerable and low risk species. The conservation efforts are mainly based on sampling of populations and the conservation of the collected accessions ex situ in the genebanks and on creation of exclusionary reserves which are often not targeting the crops wild relatives and are often not accepted by local communities. The designing of sound and community-driven management plans could promote the in situ conservation of local agrobiodiversity.

Eco-geographic surveys were first used by Vavilov (1926) to document and monitor the plant species distribution and to postulate the major Centers of plant diversity. Most of studies have assessed the changes in species richness and distribution of species but only few have assessed the losses in intra-specific genetic diversity (Guarino, 1995). Methodologies subjective or objective to assess and monitor the trends in agrobiodiversity and the use of molecular markers techniques and GIS/RS tools were very instrumental in assessing respectively genetic diversity and changes in landuses, respectively. Many statistical parameters are used to assess the species diversity and Shannon diversity index is actually the most widely used as it combines species richness and evenness of distribution (Jana, 2007).
Many sampling methods are used to assess species frequency, density and distribution and the transect-quadrate method is largely used for plants. This contribution aims at assessing and monitoring the status and threats of wild relatives and natural habitats in selected areas of West Asia region and at recommending elements for promoting their in situ conservation.

Materials and Methods

- Characteristics of monitoring areas

One of the main output of the GEF-UNDP funded, ICARDA coordinated regional project on “Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria” is aiming at better understanding of the status and trends of local agrobiodiversity mainly of target species. The target species are landraces and wild relatives belonging to *Triticum*, *Aegilops*, * Hordeum*, *Lens*, *Allium*, *Medicago*, *Lathyrus*, *Vicia*, *Trifolium*, *Amygdalus*, *Pyrus*, *Prunus*, *Pistacia*, *Ficus*, *Olea* and *Cerasus* genera. The assessment of the status of landraces was done through farming systems surveys conducted at the community level while the assessment of the status and trends of wild relatives, forage species and other species found under natural habitats was done through eco-geographic/botanic surveys conducted at the monitoring areas selected within the project sites.

For each country, two target areas were selected during the preparation phase of the project on the basis of the presence of target species and the complementary representativeness of the prevailing ecosystems (Muwaqqar and Ajloun in Jordan; Baalbek and Aarsal in Lebanon; Jenin and Hebron in Palestine; and Sweida and Al-Haffeh in Syria). These areas cover a wide range of ecosystems from desert to high elevation and high rainfall areas and contain most prevailing farming system in West Asia and North Africa region (WANA). The project sites and monitoring areas in target areas are selected by a multidisciplinary and multi-stakeholders team including farmers and governmental local authorities. Fourteen criteria were used in the selection with most weight given to the presence of target species, the threats to local agrobiodiversity, the willingness of local communities to collaborate in the conservation efforts and the representativeness of the most prevailing ecosystems. Some monitoring areas were eliminated due to the destruction of natural habitats through reclaiming the land for urbanization or agricultural uses. Other monitoring areas were added over years because of their richness in some rare targeted species. Some of the monitoring areas are located in natural habitats where harsh conditions and the sloppy nature have prevented so far the reclaiming of the encroachment of agriculture. Some monitoring areas were selected because they contained remaining populations of threatened wild *Triticum* species. Farmers were very helpful in spotting some areas where important populations of targeted species were found as in the case of Bishwet for fruit trees and wild wheat species and Talat Sawdeh in Lebanon where three wild *Triticum* species are found exceptionally at an altitude exceeding 1700 m asl. The total numbers of project sites and monitoring areas per country were respectively: 9 and 15 for Jordan, 3 and 22 for Lebanon, 6 and 7 for Palestine, and 10 and 29 for Syria. The number of monitoring areas selected per project target area varied from 1 to 10 depending on the diversity of ecosystems and on the surveys objectives for either herbaceous or wild fruit trees or both.

- Eco-geographic/botanic surveys

Due the presence of the slope gradient in most of the selected monitoring areas, the transect/quadrates survey method was used to assess and monitor local agrobiodiversity over years. The number of transects varied from 1 to 6. Each transect had 3 to 5 quadrates of 1 m², 25 m equidistant in case of surveys of herbaceous/shrubs species, and of 20*20 m², 50 m equidistant when surveying wild fruit tree species. Generally, the surveys of herbaceous
species were done on annual basis while wild fruit trees were surveyed in 2000 and 2003. Some monitoring areas were surveyed only for one or two years. A FoxPro facilitated database was developed by the Genetic Resources Unit at ICARDA to facilitate data management and to allow preliminary analysis of data. The survey forms for project and monitoring areas used the internationally agreed classification of environmental, socioeconomic, management and species vitality characteristics reported in ICARDA and IPGRI collection forms and the Corine levels 2 and 3 for land cover and land use. Species density or cover was recorded in each quadrat along with other characteristics such as % of rockiness, land use and soil characteristics. The vitality of wild fruit trees was recorded in terms of numbers of seedlings, juvenile and adult plants and in terms of healthy and non-healthy plants. The height and diameter of major branch of adult trees were also recorded.

- **Survey of major factors affecting local agrobiodiversity**

This assessment was done in 2000 and 2004 by national teams including farmers with the participation of the Regional Coordinator who tried to ensure homogeneity among the scores given by respective national teams. A scale of 0 (no sign of degradation due to the factor), 3 (few cases are observed), 5 (50% of area affected), and 7 (exceptionally high occurrence). This assessment was done at the project site level by driving in area of at least 10 km and at the monitoring area by looking the area and its immediate surrounding. The factors assessed are overgrazing, overuse, land reclamation for agricultural purposes, urbanization, cutting of trees and shrubs, fire, quarries and cultivation. Other factors such as the changes in land use were assessed with the help of farmers accompanying the teams.

- **Statistical analysis**

Species richness was determined for each monitoring areas and classified as target and non-target for herbaceous and tree/shrubs groups. The densities and frequencies were derived for each species and the trends over years were plotted. SPSS and the FoxPro database were used to calculate the above parameters.

**Results and Discussion**

- **Characterization of project sites and monitoring areas**

Most of the project sites are located in mountainous areas or in plateaus with 23% of project sites are in hilly areas, 19% in mountains, 23% in the valleys and 11.5% each in uplands, plateaus and plains. The altitude ranges from 250 to over 2000 m above see level. The average annual rainfall ranged from less than 200mm in the Muwaqqar region to more than 900mm at the high elevation sites in Al-Haffe region. The climate ranged from arid and semi-desert type in Muwaqqar to sub-humid in Al-Haffe region but predominantly of the Mediterranean type except in Wahadeneh where starts the influence of the Jordan rift valley tropical climate. These results showed that the remaining biodiversity rich areas are confined to harsh environments in the mountainous areas and in arid regions. The target species are found in forest areas or on field edges but are submitted to increasing degradation. Inaccessibility, hilly physiography and some government protection have retained so far the land reclamation process undertaken in the mountainous areas. Rangelands are predominant in Sweida, Hebron, Aarsal and Muwaqqar target areas. With the exception of forests in Al-Haffe, all other forest areas are fragmented leaving only small patches of forest where wild pistachio, almond, prune and pear with populations of *Creategus*, *Arbutus* and *Rhamnus* could be found. The predominant land tenure is privately or individually owned with the exception of open communal lands in two sites, Al-Ganoob in Hebron and East Theiba in Muwaqqar. Although there are shared forests and rangelands in some project sites, local communities and individuals claim ownership of these areas. The majority of the communities are sedentary except for Al-Ganoob community which is still practicing nomad life and some communities in Hebron, Sweida and Muwaqqar which are semi-sedentary.
Most of the herders’ communities are practicing transhumance between the plains and the plateau and the mountain areas. Within the project sites, protected areas are mainly found in Syria as natural and artificial forests in Lattakia region or as the remaining forests used mainly as military areas in Sweida. A protected area was created between Sale and Rashida in Sweida rich in *Triticum* species but the reforestation with pine species could affect the richness in native species. In Sweida, the grazing by small ruminants was forbidden since 1999 but local agrobiodiversity is still grazed by cows and equines and affected by the land reclamation for plantation of fruit trees. In Jordan, the University of Jordan farm is the only protected area in Muwaqqar. In Lebanon and Palestine, no protected areas are established with the exception of military and confiscated lands in the West Bank which could serve to create protected natural habitats in the future.

Seventy-three monitoring areas were selected in the target areas: 15 in Jordan, 22 in Lebanon, 7 in Palestine and 29 in Syria. The majority (81.4 %) of those were located in high elevation areas with 55.7% are either on hill tops or hill sides. The predominant landcovers and landuses are showing the dominance of rangelands and of areas with a mix of natural vegetation and agricultural farmed land. The land tenure is characterized by the dominance of privately or individually owned areas representing 85.5%, public land 7.2% and open communal lands 7.2%. The predominance of privately owned land will make difficult any process of designation for *in situ* conservation in the absence of incentives and farmers willingness to conserve and manage the selected biodiversity rich area.

The monitoring areas selected by the project are covering most of the ecosystems prevailing in West Asia region which will facilitate the out-scaling process of management plans developed to preserve local agrobiodiversity in similar ecosystems. Private ownership of some of these areas is questioned as these are located within forest areas and local people are confounding the rights of use with full ownership. The clarification of this issue should help in the implementation of future management plans to be developed for the conservation of the remaining biodiversity hot spots. Land reclamation of natural habitats is always guided by securing the ownership of communal or government lands rather than by profitability of conversion to agricultural production. Some of the monitoring areas are located in very harsh environments making any alternative use other than natural habitats, irrational. Most of the monitoring areas do not benefit from any protection except when they are planted to crops. The rangelands are openly accessed to all herds of the communities and outside communities except in Syria where grazing is prohibited since 1999 in parts of rangelands in Sweida region.

- **Results of botanic survey**

The difficulty in identification of species by national teams stresses the need to develop national expertise in plant taxonomy.

**In Jordan**, significant differences in species richness are observed between the sites in Muwaqqar and the sites in Ajloun (Table 1). The drier sites in Muwaqqar had a lot less number of species most of which were not within the targeted species. These drier sites have significant populations of *Poa bulboa*, *Hordeum murinum* and of unidentified *Allium* species and have few populations of *Hordeum spontaneum*, *Aegilops neglecta*, *A. biuncialis* and *Vicia monantha*. No target wild fruit tree species are found in these harsh and degraded ecosystems. Samta site in Ajloun, located in degraded forest area is rich in plant species compared to Wahadeneh site located in drier conditions. The number of target herbaceous species in Ajloun monitoring areas ranged from 20-29 species. The target wild fruit tree species were only recorded at Samta and Ba’oun and did not exceed four species (*Pyrus syriaca*, *Amygdalus orientalis*, *Pistacia atlantica* and *P. palestinea*). Populations of *Arbutus*, *Crataegus* and *Rhamnus* were found within the *Quercus calliprinos* and *Q. lentiscus*...
dominated forests in Ajloun. But most of the cultivated fruit tree species including olive, figs, prune, apple and grape were found in the farmed lands. In Muwaqqar, olive orchards were established with drip irrigation in few farms. The non target species were dominated by non- or less palatable range species with the predominance of spiny shrubs such as *Poterium spinosum*.

Table 1: Total target and non target species recorded in Jordan project sites during the period of 2000-2004

<table>
<thead>
<tr>
<th></th>
<th>Al-Wahadneh</th>
<th>Ba'oun</th>
<th>Samta</th>
<th>Wadi Rayan</th>
<th>Thheiba</th>
<th>Mghayer Hana</th>
<th>Nguera</th>
<th>Rojm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non target herbs</td>
<td>88</td>
<td>97</td>
<td>138</td>
<td>101</td>
<td>43</td>
<td>24</td>
<td>49</td>
<td>21</td>
</tr>
<tr>
<td>Target herbs</td>
<td>20</td>
<td>28</td>
<td>29</td>
<td>28</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Non target trees</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Target trees</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>108</td>
<td>131</td>
<td>173</td>
<td>129</td>
<td>49</td>
<td>30</td>
<td>52</td>
<td>22</td>
</tr>
</tbody>
</table>

For herbaceous species *Trifolium* and *Medicago* are the most predominant species in Ajloun sites. Two to four *Hordeum* wild species, predominantly *H. murinum* and *H. marinum* were found in the sites including in the driest areas. Wild *Triticum* species, predominately *T. dicoccoides* were found in very limited areas in Ajloun sites, mainly on field edges in Samta.

In Lebanon, Aarsal which is located in drier areas has less plant species that the other two project sites (Table 2). Nabha is exceptionally rich with forty-six species of target herbaceous species. Ham/Maaraboun site has fourteen target fruit tree species and the other two sites have 12 species. Up to four *Prunus*, three *Amygdalus*, two *Crataegus* and two *Pistacia* species were found in these project sites. Large population of *Pyrus syriaca* was found in Aarsal and large population of *Prunus ursina* was found in Nabha.

Table 2: Total target and non target species recorded in Lebanon project sites during the period of 2000-2004

<table>
<thead>
<tr>
<th></th>
<th>Aarsal</th>
<th>Ham</th>
<th>Nabha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non target herbs</td>
<td>63</td>
<td>79</td>
<td>94</td>
</tr>
<tr>
<td>Target herbs</td>
<td>14</td>
<td>28</td>
<td>46</td>
</tr>
<tr>
<td>Non target trees</td>
<td>6</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Target trees</td>
<td>12</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>95</td>
<td>123</td>
<td>163</td>
</tr>
</tbody>
</table>

For herbaceous species, large number of target species is found in Nabha monitoring areas including twelve *Trifolium*, nine *Aegilops*, seven *Vicia* and five *Hordeum* species. *Triticum dicoccoides*, *T. urartu* and *T. boeoticum* species are found in Ham at the altitude exceeding 1700 m asl but only *T. dicoccoides* is found in the other sites. Up to six *Aegilops* species are found in the three sites. One *Lens* wild species is found at Aarsal and Nabha monitoring areas but with very low density and frequency. Few *Lathyrus* species are found in Ham and Nabha but the 2-7 species of *Vicia* are recorded in the three sites. *Allium* species are rare.

In the West Bank, Dahriya, located in a dry area has the lowest number of species with 22 target herbaceous species and none of the target fruit trees. The other sites have similar numbers of species with herbaceous target species ranging from 33 to 44 and target fruit trees from 5 to 7 (Table 3).
Table 3: Total target and non target species recorded in the Palestinian project sites during the period of 2000-2004

<table>
<thead>
<tr>
<th>Species</th>
<th>Dahriya</th>
<th>Deir Abu Deif</th>
<th>Wadi Sair</th>
<th>Tayassir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non target herbs</td>
<td>47</td>
<td>64</td>
<td>68</td>
<td>64</td>
</tr>
<tr>
<td>Target herbs</td>
<td>22</td>
<td>44</td>
<td>33</td>
<td>35</td>
</tr>
<tr>
<td>Non target trees</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Target trees</td>
<td>0</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>69</td>
<td>116</td>
<td>109</td>
<td>109</td>
</tr>
</tbody>
</table>

Up to three *Amygdalus* species and one species of *Olea* are recorded in Deir Abu Deif, Sair and Tayassir sites. Two *Pistacia* species are found in Deir Abu Deif and Tayassir sites, but two *Prunus* and one *Ficus* species are only found in Sair.

For herbaceous species, *Trifolium* has the highest number of species in all project sites ranging from six in Dahriya to fifteen in Deir Abu Deif followed by *Medicago* species which number ranged from six to nine and *Aegilops* species ranging from two to six. Four *Vicia* species and three *Hordeum* species are found in all project sites. The number of *Lathyrus* species ranged from two to four. *Triticum dicoccoides* is found only in Jenin sites and only one *Lens* species is recorded in Sair. Two *Allium* species are found in Deir Abu Deif and one in Sair.

**In Syria.** The total number of recorded species ranged from 144 in Kanawat to 34 in Tishrine site. With the exception of Birin site, the number of species recorded in Al-Haffeh monitoring areas was less than the number of species recorded in Sweida sites (Table 4). This could be explained by the limited expertise in the identification of species of the team which conducted the survey in Al-Haffeh sites. Larger number of non target herb species is found in Sweida sites and larger number of non target tree species is found in Al-Haffeh sites. The same conclusion is found for target species. Kanawat site in Sweida region is the richest in both herbaceous and fruit tree species targeted by the project. Birin at Al-Haffeh is the richest for both targeted species groups. Rashida site has no target fruit trees but has the largest population of *Triticum dicoccoides* in all the sites surveyed in the four countries.

Table 4: Total target and non target species recorded in the Syrian project sites during the period of 2000-2004

<table>
<thead>
<tr>
<th></th>
<th>Al-Haffeh</th>
<th>Birin</th>
<th>Sharifa</th>
<th>Teshrine</th>
<th>Wadi Kars</th>
<th>Mushanaf</th>
<th>Kanawat</th>
<th>Rashida</th>
<th>Sahwat AlKhodr</th>
<th>Sahwat Blata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non target trees</td>
<td>16</td>
<td>15</td>
<td>12</td>
<td>13</td>
<td>15</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Target trees</td>
<td>16</td>
<td>19</td>
<td>14</td>
<td>12</td>
<td>13</td>
<td>6</td>
<td>17</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Non target herbs</td>
<td>20</td>
<td>38</td>
<td>11</td>
<td>4</td>
<td>34</td>
<td>65</td>
<td>74</td>
<td>40</td>
<td>52</td>
<td>48</td>
</tr>
<tr>
<td>Target herbs</td>
<td>7</td>
<td>35</td>
<td>12</td>
<td>5</td>
<td>22</td>
<td>26</td>
<td>47</td>
<td>17</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td>107</td>
<td>49</td>
<td>34</td>
<td>84</td>
<td>98</td>
<td>144</td>
<td>58</td>
<td>86</td>
<td>87</td>
</tr>
</tbody>
</table>

For fruit tree species at least 3 *Prunus*, 2 *Crataegus*, 2 *Amygdalus* and 2 *Pistacia* species were identified at the project sites. *Cerasus* species is recorded in Birin and it is the introduced cultivated cherry species. *Ficus carica* is found at most project sites as well as *Olea europaea* species.

For the herbaceous species, *Trifolium* species are predominant all over the sites with the total number of species ranging from 1 to 18. *Medicago*, *Vicia* and *Lathyrus* species are found in most sites and their number ranged from 1 to 10 species. *Lens* species are only recorded in Sahwat al Khodr and Sahwat Blata sites in Sweida and *Triticum dicoccoides* and *T. urartu* are found in Sweida sites mainly in Rsheida and Mushanaf monitoring areas. *Hordeum bulbosum*
and *H. spontaneum* are found in two sites in Al-Haffeh and in all the sites in Sweida. *Allium* species are found in 3 sites in Sweida.

- **Assessment of major factors of agrobiodiversity degradation**

This assessment was done at the project sites and monitoring areas levels using the scale of 1, 3, 5, and 7. This later is supplemented by the information collected from quadrates on species abundance, frequency and vitality, and destruction of habitats and by the interviews with local communities on land use changes over the years. This assessment is done in the year 2000 during the selection process of the sites and monitoring areas (Table 5, Graph 1). Grazing and over-exploitation of natural vegetation either for wood collection, harvesting of medicinal plants were common to all sites and the scores were generally high showing the pressure of overgrazing and the depletion of vegetation cover.

Table 5: Percent project sites of the four countries affected by different levels of factors of degradation assessed during year 2000

<table>
<thead>
<tr>
<th>Levels of degradation</th>
<th>None (1)</th>
<th>Low (3)</th>
<th>Medium (5)</th>
<th>High (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduced species</td>
<td>30.9</td>
<td>25.5</td>
<td>34.5</td>
<td>9.1</td>
</tr>
<tr>
<td>Overgrazing</td>
<td>1.8</td>
<td>14.5</td>
<td>40.0</td>
<td>43.6</td>
</tr>
<tr>
<td>Urbanization</td>
<td>78.2</td>
<td>14.5</td>
<td>5.5</td>
<td>1.8</td>
</tr>
<tr>
<td>Cut &amp; carry</td>
<td>52.7</td>
<td>18.2</td>
<td>25.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Fire</td>
<td>81.8</td>
<td>12.7</td>
<td>5.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Quarries</td>
<td>96.4</td>
<td>0.0</td>
<td>0.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Extended drought</td>
<td>18.2</td>
<td>23.6</td>
<td>38.2</td>
<td>20.0</td>
</tr>
</tbody>
</table>

Local communities attributed the loss of agrobiodiversity to the observed increased frequency of droughts in most sites. Fire is affecting native plant populations in the forest areas and on field edges where farmers are burning to eliminate weeds. The destruction of natural habitats is an important factor which affects local agrobiodiversity, causes its fragmentation and significant loss of wild relatives of crops of global significance. The conversion of natural habitats (newly land reclaimed) to agricultural farming is dominant in the mountainous areas mainly for the establishment of new plantations of fruit trees, apples in Sweida, cherries in Aarsal and Al-Haffeh and olive in all target areas (Graph 2), and in the rangelands mainly to grow barley or to establish olive orchards under irrigation. Urbanization is progressing into natural habitats and natural forests in the absence of good planning mainly in mountainous areas of Al-Haffeh in Syria and Ajloun in Jordan. The extension of industrial zones affects both farmed lands and natural rangelands in Muwaqqar sites. In Palestine, it is the farmed lands that are suffering most from the extension of towns and villages. Quarries are a serious threat to ecosystems in two sites, Sair in Palestine and Aarsal in Lebanon where large areas of natural habitats are continuously destroyed in the absence of organized and well planned exploitation. Small quarries are initiated at Teshrine and Sahwat Al-Khodr in Syria and they are affecting biodiversity rich areas.
Graph 1: Scoring of major factors of degradation of local agrobiodiversity in some monitoring areas in the four countries during year 2000

**Palestine:** DAH: Dahriya; DAD: Deir Abu Deif; GAN: Ganoub; WSA: Wadi Sair; TAY: Tayassir
**Lebanon:** ARS: Aarsal; HAM: Ham/Maaraboun; NAB: Nabha
**Syria:** TSR: Teshrine; BIR: Birin; KAN: Kanawat; SAB: Sahwat Blata; SAK: Sahwat Al-Khodr; SHR: Sherifa; HAF: Al-Haffeh; WKA: Wadi Al-Kars; RSD: Rsehida; MUS: Mushanaf
**Jordan:** BAON: Ba‘oun; THB: Thheiba; MHIN: Mghayar Al-Hana; NGR: Nguera; ROJ: Rojm; Sam: Samta; WAH: Hahadneh; WRY: Wadi Rayyan

Graph 2: Percent monitoring areas affected by introduced fruit trees

The degradation of natural habitats is worsened by the disintegration of traditional systems responsible for better management of shared resources including grazing. Additionally, the decrease in transhumance and nomadic herding styles have forced many herders communities to stay closer to water resources and the herding is done by hired labor who lack experience and knowledge about grazing routes and arrangements. The disappearance of “Hema” and “Natour” systems and the limited enforcement of laws along with the absence of land suitability maps and land use planning at local and national levels are important factors affecting local agrobiodiversity at both natural habitats and farmed lands. In some areas, no economic feasibility analysis was done prior to the conversion of natural habitats for new plantations, and many failure cases of alternative landuses were experienced by farmers in some regions but it appears that the land conversion was often done to secure ownership of natural habitats traditionally used by all members of the local communities. The introduction of apple plantations in Mushanaf is a good example of failure of alternative land use since most of the farmers are not getting the projected benefits form the land reclamation highly subsidized by the government. Actually, olive plantation are extending to many biodiversity...
rich sites in Jordan and Syria under irrigation, but some fields are already abandoned due to the depletion of underground water. In Palestine, local agrobiodiversity is affected by the prevailing political situation which reduced the grazing area causing serious overgrazing in limited accessed rangelands.

- **Elements of management plans for conservation of target species**
  All of the eco-geographic and botanical surveys are done to analyze the status and threats of local agrobiodiversity, mainly of the wild relatives of species of global significance. The concept of management plans was introduced by the project to develop technical, institutional and policy options to conserve and ensure the sustainable use of local agrobiodiversity. The management plans could be designed for the protection of one species, a group of species or for natural habitats in general. Examples of these management plans are presented in the Table 6. A management plan generally includes:
  - A general description of the ecosystems and species targeted. GIS/RS tools can be used to assess the extent of representativeness of the site;
  - Analysis of the results of botanical surveys on species distribution and abundance and of the major factors of its degradation;
  - The delimitation and characterization of the area(s) to be protected and managed;
  - Determination of the conservation objectives including the justification based on the global significance of the species and ecosystems and the extent and levels of threats;
  - The determination of technological options, socio-economic benefits, institutional arrangements and policy options to be discussed with key stakeholders especially with local communities;
  - The designation process including the development of contracts between the parties for effective protection of targeted agrobiodiversity and its sustainable management;
  - A monitoring system to assess the temporal changes in local agrobiodiversity.
  Management plans could range from exclusionary reserves in case of highly threatened or endangered species, to community-managed areas. Patches, alleys or corridors can also be created in case of fragmented natural habitats. *Ex situ* conservation could also be recommended for species with few populations restricted in their distribution but can also complement the *in situ* conservation through periodic sampling of the existing natural populations. Table 6 summarizes the options for the conservation of some key natural habitats, ecosystems and species. Some of the technological options were tested in some monitoring areas and management plans were implemented in few of them with the agreements established with individual farmers or local communities.

The project has also selected many additional sites for *in situ* conservation, 9 in Jordan, including the NCARTT experiment station at Sourra for the conservation of *Allium* species and forage species; 4 in Palestine and 5 in Syria. Other suggestions for protection of highly threatened species and ecosystems were proposed outside the project areas to protect many target species. In Syria, the project helped the Environment General Commission to characterize the biodiversity in Alajat area, where the Commission intends to create a protected area over 2500 ha (Established in 2008). There is a request for initiating the development of biosphere reserve in Sweida to include Alajat area and Danna forest reserve. It will be also rewarding to establish a trans-boundary reserve between Syria and Lebanon at the Masnaa border and between Syria and Turkey in the North. This will allow to protect many wild relatives of fruit trees and herbaceous species of global importance. The occupied territories in Syria and Palestine could also serve to establish well managed reserves for the conservation of the wild relatives and range species of the Fertile Crescent, when decolonized.
Table 6: Elements of management plans for *in situ* conservation and management of selected natural habitats and species in Jordan, Lebanon, Palestine and Syria

<table>
<thead>
<tr>
<th>Target area</th>
<th>Monitoring area</th>
<th>Major threats</th>
<th>Species targeted</th>
<th>Proposed technological, socio-economic, institutional and policy options</th>
</tr>
</thead>
</table>
| Ajloun               | Samta (privately owned land, actually fenced by the project) | Land reclamation for plantation of trees                  | *Triticum, Aegilops, Trifolium, Medicago, Lathyrus, Hordeum, Allium, Pistacia, Amygdalus* and medicinal plants | - Introduction of water harvesting techniques for plantation of fruit trees and medicinal plants and for good regeneration of wild fruit trees and natural vegetation;  
- Protection of neighboring fields and road edges for protection of the remaining populations of *T. dicoccoides*;  
- Benefits from medicinal plants by better packaging and establishment of links with markets, honey production.  
- To be fully managed by the farmer. |
| Al-Wahadneh          | Al-Wahadneh (area managed by Princess Basma Center) | Overgrazing and non regulated access by visitors          | *Aegilops, Medicago, Trifolium, Lathyrus and Vicia* species in addition to establishment of park for conservation of old olive trees of the region | - Introduction of water harvesting techniques for plantation of old olive trees and medicinal plants and for good regeneration of wild fruit trees and natural vegetation;  
- Benefits from medicinal plans and from honey production;  
- The management of the park by the center with access regulation to some parts where targeted species will be protected; |
| Muwaqqar             | University of Jordan experiment farm                 | Some grazing and cultivation with barley                   | *Aegilops, Vicia, Hordeum* and *Allium* species                                  | - Regulated grazing and water harvesting using contour lines to plant native shrubs;  
- To be used for academic purposes and for conducting research;  
- Managed by the University |
| Mahareb area         | Mahareb area (selected areas by the project)         | Overgrazing and cultivation                               | *Allium*, few feed legume species and native shrubs species such as *Salsola vermiculata* | - Improvement of rangelands through reseeding and re-plantation of native species using water harvesting techniques;  
- Avoid cultivation of areas with high slopes and with shallow soils;  
- Management of grazing with local communities;  
- Provide technical backstopping and training on dairy production and livestock management. Some incentives in the form of dairy unit, feed block unit and veterinary services should be provided to local communities at the initial stages; |
<table>
<thead>
<tr>
<th>Location</th>
<th>Ownership/Use</th>
<th>Problems/Activities</th>
<th>Solutions</th>
</tr>
</thead>
</table>
| Aarsal        | Wadi Saweid (privately owned by members of local community) | Land reclamation for plantation of fruit trees orchards and some grazing pressure and urbanization. The extension of quarries could affect the area. | • Management by local communities or individual farmers.  
• Avoid land reclamation of areas with high slopes and introduce the plantation of fruit trees without disturbance of the natural habitats using appropriate water harvesting technique;  
• Investigate the possible use of the produce of wild fruit trees in feed blocks or other uses;  
• Keep or transplant wild species on the edges of reclaimed fields;  
• Introduce apiculture and cultivation of medicinal plants in the region for additional sources of income.  
• The protection will require policy and legislation on regulating the quarries.  
• Increasing awareness of local communities on the importance of preserving the remaining natural patches in the region. |
| Nabha         | Bishwet (private ownership or common land with the right of use) or Abu Taha site (Privately owned) | Overgrazing and land reclamation for agricultural purposes and urbanization | • Establishment of protected area with possibilities for regulated grazing;  
• Possibilities for introducing many alternative sources of income (eco-tourism, honey production, cultivation of medicinal plants, etc);  
• Improve agricultural productivities of fruit trees and field crops in cultivated areas by transferring low-cost technologies;  
• Co-management of the area with local communities and mainly with the newly established women NGO;  
• Design mechanisms for conflicts resolution among and within the communities and over the ownership of the area. |
| Al Azraa area  | Al Azraa area (Quercus forest) | Cutting trees for charcoal, grazing | • Allow for the regeneration by rest grazing of the cut trees;  
• Regulation of grazing through improvement of rangelands and introduction of feed blocks using the produce of wild fruit trees;  
• Promote alternative sources of income such as honey production, cultivation of medicinal plants and dairy production;  
• Demonstrate appropriate packages for increasing productivity of landraces of fruit trees and field crops and introduction of figs and almonds in low altitude areas with |
<table>
<thead>
<tr>
<th>Location</th>
<th>Land Details</th>
<th>Economic Activities</th>
<th>Management Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ham Maaraboun</td>
<td>Talat Sawdah (privately owned by Ham Mokhtar)</td>
<td>Grazing and possibility of reclaiming for agricultural purpose</td>
<td>- Provide initial incentives such as feed blocks, food processing units, dairy production units and help in marketing local produce; - Co-management with local communities.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Patches very rich in target herbaceous species mainly the three wild <em>Triticum</em> species and many <em>Aegilops</em> and feed legume species.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jenin</td>
<td>Tayassir (Land owned by patriarchate and used by local communities)</td>
<td>Overgrazing and reclamation for agricultural purposes</td>
<td>- Regulate grazing and avoid natural habitat destruction; - It will be good to collect the species mainly of <em>Triticum</em> for ex-situ conservation; - Demonstrate appropriate packages for increasing productivity of landraces of fruit trees and field crops; - Promote alternative sources of income such as honey production, cultivation of medicinal plants and food processing; - Continue to link eco-tourism with the conservation of local agrobiodiversity; - Incentives could include the establishment of food processing units; - Increasing the awareness of local population on the importance of local agrobiodiversity; - Management by individual farmers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rangeland species including <em>Aegilops</em> and many feed legume species</td>
<td></td>
</tr>
<tr>
<td>Hebron</td>
<td>Wadi Sair (privately owned by farmers from different surrounding villages)</td>
<td>Rapid extension of quarries and overgrazing outside the farmed lands, land reclamation for agricultural and urbanization and for settlements purposes</td>
<td>- Rangeland improvement combined with grazing management and the search for alternative feed resources including the introduction of feed blocks technology; - Demonstrate appropriate packages for increasing productivity of landraces of fruit trees and field crops; - Land reclamation should be based on land suitability; - Co-management between the patriarchate and local users; - Introduce add-value technologies for local products and</td>
</tr>
<tr>
<td>Area</td>
<td>Description</td>
<td>Species</td>
<td>Recommended Actions</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Al-Haffeh</td>
<td>Salahdin Castle surrounding area (government forest area and farmers fields)</td>
<td>Crateagus, Olea, Ficus and Ceratonia species.</td>
<td>- Reforestation with native species;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Enforcement of law for land reclamation causing the destruction of natural habitats;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Stop the quarries;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Link agrobiodiversity conservation with the tourist activities;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Promote alternative sources of income such as food processing, dairy production and sustain the agrobiodiversity shop to help in marketing local produce;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Demonstrate appropriate technologies for increasing the productivities of land races of fruit trees and field crops.</td>
</tr>
<tr>
<td></td>
<td>Reclamation of forest land for urbanization, quarry and agricultural purposes</td>
<td>Many feed legume species including Lathyrus, Medicago, Trifolium and Vicia species and wild fruit trees species including Crateagus, Olea, Myrthus, Pistacia and Ceratonia species.</td>
<td></td>
</tr>
<tr>
<td>Sweida</td>
<td>Natural reserve between Sale and Rsheida (government forested area with pine trees)</td>
<td>Dense plantations of introduced species which will affect the native herbaceous species;</td>
<td>- Uproot the pine trees and reforest with Crateagus and Amygdalus species found in the surrounding areas;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Large number of herbaceous species but site rich in T. dicoccoides and some rare species.</td>
<td>- Extend the area to include larger population size of target species or grazing management of the surrounding areas;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Avoid more land reclamation.</td>
</tr>
<tr>
<td></td>
<td>Land reclamation for agricultural purposes, clearing all field edges and field from target species) and urbanization</td>
<td>Large populations of Aegilops, Trifolium, Vicia and Medicago species and good populations of Amygdalus, Pyrus, Pistacia and Rhus species</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overgrazing and natural habitats destruction for new plantations</td>
<td>Very degraded with few legume species and no Triticum species</td>
<td>- Keeping wild relatives of fruit trees in the field edges;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Avoid non economic land reclamation and land use alternatives;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Promote the benefits from wild fruit trees such as Rhus, Amygdalus, Pyrus and Pistacia species;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Demonstrate appropriate technologies for increasing the productivities of landraces of fruit trees and field crops;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Increase the awareness of local communities on the importance of conserving the ecosystems and the target species.</td>
</tr>
<tr>
<td>Mushanaf rangeland area</td>
<td>Overgrazing and natural habitats destruction for new plantations</td>
<td></td>
<td>- Rangeland improvement through reseeding of target herbaceous species, water harvesting and application of P2O5;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Introduction of native shrubs (Salsola vermiculata and Atriplex halimus);</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Introduction of field blocks;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Dairy production unit for local community.</td>
</tr>
</tbody>
</table>
References


Assessing the Impact of Agrobiodiversity Conservation on Rural Livelihoods in the Dry Areas

A. Mazid, K. Shideed and A. Amri

*International Center for Agricultural Research in the Dry Areas (ICARDA), P.O.Box 5466, Aleppo, Syria*

**Keywords:** On-farm conservation, landraces, agrobiodiversity, livelihoods, impacts, drylands.

**Abstract**

A GEF-funded and ICARDA-coordinated five-year regional project on “Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Palestinian Authority and Syria” was launched in 1999 to promote community-driven *in situ* conservation of landraces and wild relatives of crops of global importance originating from West Asia center of diversity in Jordan, Lebanon, the Palestinian Authority and Syria. A holistic approach based on the involvement of major stakeholders, including farmers and herders, and on the coverage of major ecosystems and farming systems and focusing on improvement of livelihoods of the main custodians of agrobiodiversity was developed. The project national teams assisted by ICARDA scientists have conducted farming surveys in 2000 and 2004 to assess the status and threats to local on-farm agrobiodiversity and the impacts of project activities on the livelihoods of local communities. The livelihood assets and the income sources were analyzed for project participants and non-participants groups and wealth indices were derived. Most farmers classified their livelihood level as moderately well-off except Ajloun farmers in Jordan, where 44% of responders classified themselves as well-off. Off-farm income was an important source in all target areas and ranged from 43% to 68%. Agriculture is mainly based on landraces for field crops, olive, fig and grapes and on local sheep and goat breeds. Livestock is the main source of on-farm income in Jordan, whereas plant production (crops and fruit trees) is the major source of on-farm income in Lebanon, Palestine, and Syria target areas. The analysis of income from agricultural indicated that average household income for households who participated in the project was higher than those households who did not participate.

**Introduction**

West Asia encompasses one of the three mega-centers of diversity of global importance where wheat, barley, lentil, many forage legume and fruit tree species were domesticated over the last 10,000 years (Hawkes, 1983; Harlan, 1992). Landraces and wild relatives of these crops continue to form the basis of the livelihoods of local communities and the farming systems in the dry areas and mountain regions. The *in situ/on-farm conservation of agrobiodiversity is recently stressed by the Convention on Biological Diversity as an essential strategy for making available genetic resources to sustain agricultural development and food security worldwide (UNCED, 1992). This conservation should be linked to enhancing the livelihoods of the custodians of local agrobiodiversity (Jarvis and Hodgkin, 1998). Livelihood strategies are diverse (Ellis 1998), influenced by linkages in and outside agriculture (Bebbington 1999; de Haan 2000; Reardon *et al.* 1992), and life cycle family characteristics such as age, education, and the number of family members (Kusterer 1989; Valdivia 2001). The degree of diversification of the household
portfolio is determined by these characteristics, and by the household’s and
individual’s objectives, such as risk management practices, and/or strategies available
to cope with shocks. In areas of greater risk, household strategies are expected to be
more diversified as a mean to minimize possible shocks from negative climate events,
especially when loss-management strategies are limited (Dunn et al., 1996). The
livelihoods of local communities were analyzed and the wealth index was derived. In
the wealth ranking, variables were identified by the key factors of Principal
Components Analysis as important in distinguishing households from each other in
each country. Cavendish (1999; 2002), in his household studies from Shindi Ward in
Chivi; and Compble et al. (2002) in a study on household livelihoods in semi-arid
regions used wealth quartiles to explore patterns of income distribution. We
undertook similar analysis and calculated wealth indices as the most important factor
to be used in characterizing household livelihoods. It was thus necessary to develop
some means of differentiating wealth levels among households, and to do this a
wealth index based on household assets was developed. The sources of income were
analyzed for farmers in different wealth categories.

The main objectives of this study were to: assess the impact of the project on
conserving the agrobiodiversity in targeted areas and the benefits of value-added,
income-generating activities introduced by the project on the livelihoods of rural
communities.

Materials and Methods
A five-year project entitled “Conservation and Sustainable Use of Dryland
Agrobiodiversity” was launched in 1999 to promote in situ conservation and
sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian
Authority and Syria. The project is funded by the Global Environment Facility (GEF)
through the United Nations Development Programme (UNDP), and is coordinated
regionally by ICARDA. The project focuses on conservation of landraces and wild
relatives of barley, wheat, lentil, *Allium*, feed legumes (*Lathyrus, Medicago, Trifolium*
and *Vicia*), and fruit trees (olive, fig, almond, pistachio, plum, peach, apricot, pear,
apple, cherry). A holistic approach based on the involvement of major stakeholders,
principally farmers and herders, and on the coverage of major ecosystems and
farming systems, investigation and demonstration of technological, adding-value,
income generating, institutional and policy options is developed.

The project was managed as five components. Each of the four participating countries
has its own nationally-executed component, with a national project manager, while
the regional component coordinating the national components is being executed by
the International Center for Agricultural Research in the Dry Areas (ICARDA). The
project activities are implemented at the national level by national research institutes:
National Center for Agricultural Research and Technology Transfer (NCARTT) in
Jordan, Lebanese Agricultural Research Institute (LARI) in Lebanon, and General
Commission for Scientific Agricultural Research (GCSAR) in Syria and the Ministry
of Agriculture and UNDP/PAPP (Programme of Assistance to the Palestinian People)
in the Palestinian Authority. The activities are implemented in two target areas per
country: Ajloun (mountain sub-humid) and Muwaqqar (semi-desert arid) in Jordan; Aarsal (mountain arid) and Baalbeck (mountain semi-arid) in Lebanon; Jenin (semi-
arid) and Hebron (mountain arid) in the Palestinian Authority; and Sweida (mountain
arid) and Al-Haffeh (mountain sub-humid) in Syria. These target areas cover ecosystems ranging from semi-desert to high rainfall high elevation areas and
different farming systems ranging for range-livestock dominated to fruit tree dominated systems.

A total of 26 communities were involved in the implementation of the project activities. A baseline socio-economic survey was conducted in 2000. In 2004, national teams in collaboration with ICARDA scientists carried out a formal survey of total 570 households; 145 from Jordan, 138 from Lebanon, 140 from Palestine and 147 from Syria. This survey covered all the target areas in the four participating countries. Farm characteristics including farming systems, and various assets were assessed. The surveyed farmers were grouped into those who participated in the project activities, those who heard about the project and those who did not participate. The participation included training workshops, demonstration trials, add-value (food processing, dairy production) and alternative sources of income (honey production, nursery establishment, eco-tourism).

**Results and Discussion**

1. **Household assets and socioeconomic characterization**

   Household characteristic is based on the main household assets, including natural capital, physical capital, financial capital, human capital, and social capital. Total holding area by household ranged from 9 dunum (1 dunum=0.1 hectare) at Al-Haffeh in Syria to 175 dunum at Muwaqqar in Jordan. Most farmers in the target areas owned their agricultural land except at Muwaqqar where some farmers either rented lands from other landlords or have shared-cropping arrangements. Common rangelands were available for the majority of households except in Jordan where this type of land was available for only 20% of households. Water resource was available for most households except in Sweida where only 7% of households reported that they had water resource. Percentage of irrigated area in the farm was low at all target areas.

   Average family size ranged from 7 to 13 persons per household, with labor opportunities outside the target area ranged from 6% at Hebron in Palestine to 45% at Al-Haffeh in Syria. Wage labors were available when needed in all target areas except at Muwaqqar. Although some household heads were illiterate, but others hold University degrees. Generally, the education level among households in the target areas was higher in Jordan and Palestine compared to Syria and Lebanon. Most farmers in the sample classified their livelihood level as moderately well-off except Ajloun farmers in Jordan, where 44% of responders classified themselves as well-off. Off-farm income was an important source in all target areas and ranged from 43% to 68% of total income. Average annual household income ranged from 2,200 to 9,000 US$ in the target areas, implying that daily per capita income ranges between < 1US$ to 5 US$. Income per person per day was around 2 US$ in Jordan, Lebanon, and Jenin (Palestine), while it was less than 2 US$ in Syria and Herbon (Palestine).

   Agricultural cooperatives were available in the target areas but most farmers in the sample were not members in these cooperatives except at Sweida in Syria and Aarsal in Lebanon where more than 60% of responders reported that they were members in the herders’ cooperatives. Most farmers in the target areas owned their houses, but few farmers owned a tractor, car, or pick-up. Many farmers in the sample had livestock, either sheep, goats, or cows, but flock size varied among the target areas. Flock size was larger in the dry areas compared to relatively wetter areas. Schools, public clinics, electricity, and telephones were available to most households in target areas. Most households had a separate kitchen in their house, and a satellite dish and T.V. Average number of rooms in the house was about five.
2. **Sources of household income**

Household farmers in the target areas have many activities to meet their livelihood needs. They have many income sources, and also there were variation in the amount and contribution of income sources among the four countries. Income from on-farm activities including returns from crops and fruit trees, livestock products, and live animals represented less than half of total household income in the four countries. Income from government employment was important in Jordan (48%) and Syria (20%), while income from off-farm (non-agriculture) was important in Lebanon (34%) and Palestine (26%). Livestock is the main source of on-farm income in Jordan, whereas plant production (crops and fruit trees) is the major source of on-farm income in Lebanon, Palestine, and Syria.

Contribution of alternative income sources to the total household income was diverse according to target area in each country. Table 1 presents percentage of household income sources by each item for each target area in the four countries. In Jordan, income from government employment was significant at Muwaqqar area followed by income from livestock, while at Ajloun income from crops and fruit trees was important. In Lebanon, household income from off-farm activities outside agriculture was the main source at Aarsal site and income from crops and fruit trees was the major income source at Nabha villages. However, there were many factors that influenced the contribution of alternative sources to total household income such as farm resources availability, farmers’ education, skills and experiences, opportunities of off-farm activities.

Table 1. Contribution of alternative sources to total household income by target area (%)

<table>
<thead>
<tr>
<th>Income source</th>
<th>Jordan Muwaqqar</th>
<th>Jordan Ajloun</th>
<th>Lebanon Aarsal</th>
<th>Lebanon Baalbek</th>
<th>Palestine Hebron</th>
<th>Palestine Jenin</th>
<th>Palestine Sweida</th>
<th>Syria Al-Haffeh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crops &amp; fruit trees</td>
<td>1</td>
<td>38</td>
<td>19</td>
<td>38</td>
<td>22</td>
<td>31</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Livestock products</td>
<td>20</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Live animals</td>
<td>17</td>
<td>4</td>
<td>8</td>
<td>5</td>
<td>12</td>
<td>20</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total on-farm income</strong></td>
<td><strong>38</strong></td>
<td><strong>49</strong></td>
<td><strong>32</strong></td>
<td><strong>50</strong></td>
<td><strong>38</strong></td>
<td><strong>58</strong></td>
<td><strong>43</strong></td>
<td><strong>43</strong></td>
</tr>
<tr>
<td>Off-farm (Agriculture)</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Off-farm (Non-agriculture)</td>
<td>3</td>
<td>6</td>
<td>45</td>
<td>22</td>
<td>39</td>
<td>12</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Government employment</td>
<td>54</td>
<td>39</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>17</td>
<td>12</td>
<td>39</td>
</tr>
<tr>
<td>Remittances (from outside)</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other sources</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>14</td>
<td>9</td>
<td>8</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total off-farm income</strong></td>
<td><strong>62</strong></td>
<td><strong>51</strong></td>
<td><strong>68</strong></td>
<td><strong>50</strong></td>
<td><strong>62</strong></td>
<td><strong>42</strong></td>
<td><strong>57</strong></td>
<td><strong>57</strong></td>
</tr>
</tbody>
</table>

3. **The Wealth Index**

In conducting the livelihood analyses in this study, the interest is to know how income sources differ between households in the four participating countries. Therefore, there is a need to use one indicator for comparison. This indicator is the wealth index, which is based on the status of the households' assets. The calculated wealth index will be used for ranking the households of a community.

Five main elements were hypothesized to represent the household well-being. These elements included human capital, natural capital, financial capital, physical capital, and social capital which were presented in the previous section. Several variables were selected and used to represent each element.

In order to use indices for assessing the poverty status, wealth index, which was calculated based on factor analysis, was sorted into wealth categories and classified.
the household in the sample into four welfare quartiles. The distribution of households among wealth quartiles were not the same at the target areas (Table 2). For example, most farmers in Sweida were located in the highest wealth quartile. Whereas, only 8% of farmers in Al-Haffeh were located in the highest wealth quartile, the rest were at lower wealth levels.

Table 2. Wealth quartiles by target area (% of households)

<table>
<thead>
<tr>
<th>Countries/target areas</th>
<th>Wealth quartiles</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lowest 25%</td>
<td>25 - 50%</td>
<td>50 - 75%</td>
<td>Highest 25%</td>
</tr>
<tr>
<td>Syria</td>
<td>Sweida</td>
<td>17.3%</td>
<td>25.3%</td>
<td>17.3%</td>
</tr>
<tr>
<td></td>
<td>Al-Haffeh</td>
<td>31.9%</td>
<td>26.4%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Palestine</td>
<td>Hebron</td>
<td>32.9%</td>
<td>10.0%</td>
<td>24.3%</td>
</tr>
<tr>
<td></td>
<td>Jenin</td>
<td>17.1%</td>
<td>38.6%</td>
<td>27.1%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>Aarsal</td>
<td>20.5%</td>
<td>32.9%</td>
<td>28.8%</td>
</tr>
<tr>
<td></td>
<td>Baalbek</td>
<td>29.2%</td>
<td>16.9%</td>
<td>20.0%</td>
</tr>
<tr>
<td>Jordan</td>
<td>Ajloun</td>
<td>41.3%</td>
<td>29.3%</td>
<td>16.0%</td>
</tr>
<tr>
<td></td>
<td>Muwaqqar</td>
<td>8.6%</td>
<td>20.0%</td>
<td>32.9%</td>
</tr>
</tbody>
</table>

4. **Livelihood strategies**

4.1 Sources of household income by wealth quartiles

Household income from all sources was calculated and summarized in Figures 1 to 4. The income from all sources increases as we move from lower to upper quartile. Percentage of income from crops production and off-farm labor wages from agriculture generally were higher in the lowest 25% compared to other groups.
Figures 1, 2, 3, 4. Income sources by wealth quartiles in the target areas of the four countries

4.2 Livelihood typologies

Overall, households in the study areas depend for their income on many sources as shown in the Table 3. The main sources of the households for the lowest 25% quartiles in the four countries were crop production followed by off-farm labor and government employment. The highest welfare quartile was those relatively more dependent on livestock products and live animals, in addition to crop production, off-farm labor and government employment. However, the lowest quartiles were relatively more dependent on livestock as compared with those in the highest quartiles.

Table 3. Main sources of household income in different countries and for wealth groups

<table>
<thead>
<tr>
<th>Wealth Group</th>
<th>Jordan</th>
<th>Lebanon</th>
<th>Palestine</th>
<th>Syria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest 25%</td>
<td>Government</td>
<td>Crops</td>
<td>Off-farm labor</td>
<td>Crops</td>
</tr>
<tr>
<td></td>
<td>Crops</td>
<td>Off-farm labor</td>
<td>Government</td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>Off-farm labor</td>
<td></td>
<td></td>
<td>Off-farm labor</td>
</tr>
<tr>
<td>25-50%</td>
<td>Government</td>
<td>Off-farm labor</td>
<td>Government</td>
<td>Crops</td>
</tr>
<tr>
<td></td>
<td>Crops</td>
<td></td>
<td></td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>Off-farm labor</td>
<td></td>
<td></td>
<td>Off-farm labor</td>
</tr>
<tr>
<td>50-75%</td>
<td>Government</td>
<td>Off-farm labor</td>
<td>Government</td>
<td>Crops</td>
</tr>
<tr>
<td></td>
<td>Crops</td>
<td></td>
<td></td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>Live animals</td>
<td></td>
<td></td>
<td>Off-farm labor</td>
</tr>
<tr>
<td></td>
<td>Livestock products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highest 25%</td>
<td>Government</td>
<td>Off-farm labor</td>
<td>Live animals</td>
<td>Crops</td>
</tr>
<tr>
<td></td>
<td>Livestock products</td>
<td></td>
<td>Off-farm labor</td>
<td>Government</td>
</tr>
<tr>
<td></td>
<td>Live animals</td>
<td></td>
<td>Others</td>
<td>Others</td>
</tr>
<tr>
<td></td>
<td>Crops</td>
<td></td>
<td>Live animals</td>
<td>Livestock products</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c3- Palestine
d4- Syria
5. **Impact on household income and livelihoods**

Previous assessments of the project indicated that the project impacts were very encouraging, and helped in the setting up of agrobiodiversity programs in research institutions in Jordan, Lebanon and Syria, and in the creation of agrobiodiversity units in the Ministry of Agriculture, Palestinian Authority, and in the Forestry Department in Jordan. There has been a shift towards the use of wild relatives of fruit trees in forestation efforts. In Syria, 500,000 seedlings of target fruit tree species were planted since 2003, compared to 130,000 in 1999. Awareness is increasing at all levels regarding the need to conserve agrobiodiversity. This has facilitated collaboration between agricultural research institutions/Ministries of Agriculture with Tourism and Education Ministries and with other projects and nongovernmental organizations. Sites rich in agrobiodiversity have been identified and their management plans were developed in consultation with local communities and government institutions. Many accessions of target species have been collected and placed in the genebanks. Protocols for ecogeographic-botanical survey database management were set and a policy framework was developed and shared.

However, the impact assessment explored also a wide variety of changes and trends introduced by the project in terms of their financial and livelihood impact, therefore, impact assessment had to differ from conventional project reviews in two ways: (1) it assessed impacts in terms of broad economic and livelihood changes, not in terms of pre-defined project objectives and plans. This is because it sought to identify overall contribution to development, not to assess only accomplishment of planned activities for internal management purposes. Changes in livelihoods were adopted as a key measure of impact; (2) assessment of commercial viability was an integral component, because these activities were enterprises oriented, so viability determined sustainability. The commercial assessment was a complement to, rather than a component of, the analysis of local economic and livelihood impacts.

Generation of cash income is the way in which development projects are expected to create incentives for conservation and sustainable use of natural resources. A focus on livelihoods was emphasized as a more appropriate measure of what the project means to local people, and therefore of its likely contribution to development and conservation. The rationale for this was grounded in greater understanding of poverty, such as the importance of assets, diversified portfolios of activities, and the variety of outcomes pursued by the poor.

The impact assessment in this study explored changes and trends caused by the project on the households in the target areas, and analyzed these in terms of their financial and livelihood impacts. Therefore, comparisons, in terms of income from agriculture, among households who participated in the project by type of participations and wealth quartiles with those who did not participate in the project were carried out. Households who participated in the project were classified into 3 groups: Those who participated in activities related to agrobiodiversity enhancement; those who participated in activities related to generated value added income; and those who participated in the field days or training activities.

Increasing agricultural income in the average not necessary lead to effect on poor farmers, therefore, other factors related to equity have to be taken into account. There are several ways to express the degree of income inequality in a society. The Gini coefficient is a measurement for inequality, and was used in this study.

The analysis of income from agriculture indicated that average household income for households who participated in the project was higher than of those who did not participate; the estimated Gini coefficients varied among participating and non-
participating households. If the comparison focused on the households participating in the agrobiodiversity enhancement and the non-participating households, Table 4 shows the differences in their annual income. The noticeable increase in the annual household income can be attributed to the household participation in the project, which reflects the impact of the project on rural livelihood. The annual increase, on average, is estimated at 1,616 US$ per household in the four countries.

Table 4. Comparison between average household income from agriculture by participation in agrobiodiversity enhancement activities. (US$/household)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrobiodiversity enhancement</td>
<td>Lowest 25%</td>
<td>1923</td>
<td></td>
<td>4527</td>
<td>0.591</td>
<td>2765</td>
<td>0.401</td>
<td>1056</td>
<td>0.477</td>
</tr>
<tr>
<td>Participants</td>
<td>25 - 50%</td>
<td>1274</td>
<td></td>
<td>3167</td>
<td>0.401</td>
<td>2765</td>
<td>0.463</td>
<td>2071</td>
<td>0.477</td>
</tr>
<tr>
<td></td>
<td>50 - 75%</td>
<td>5070</td>
<td></td>
<td>3973</td>
<td>0.463</td>
<td>3105</td>
<td>0.477</td>
<td>1207</td>
<td>0.477</td>
</tr>
<tr>
<td></td>
<td>Highest 25%</td>
<td>11186</td>
<td></td>
<td>6195</td>
<td>0.477</td>
<td>6266</td>
<td>0.463</td>
<td>4265</td>
<td>0.477</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>4280</td>
<td></td>
<td>4298</td>
<td>0.477</td>
<td>3897</td>
<td>0.477</td>
<td>2487</td>
<td>0.477</td>
</tr>
<tr>
<td>Non-participants</td>
<td>Lowest 25%</td>
<td>1473</td>
<td>0.438</td>
<td>2670</td>
<td>0.438</td>
<td>2125</td>
<td>0.438</td>
<td>1069</td>
<td>0.438</td>
</tr>
<tr>
<td></td>
<td>25 - 50%</td>
<td>2103</td>
<td>0.391</td>
<td>2179</td>
<td>0.391</td>
<td>5390</td>
<td>0.391</td>
<td>954</td>
<td>0.391</td>
</tr>
<tr>
<td></td>
<td>50 - 75%</td>
<td>2399</td>
<td></td>
<td>1460</td>
<td>0.391</td>
<td>3286</td>
<td>0.391</td>
<td>976</td>
<td>0.391</td>
</tr>
<tr>
<td></td>
<td>Highest 25%</td>
<td>3577</td>
<td></td>
<td>3268</td>
<td>0.391</td>
<td>15295</td>
<td>0.391</td>
<td>2663</td>
<td>0.391</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>2526</td>
<td></td>
<td>2384</td>
<td>0.391</td>
<td>5351</td>
<td>0.391</td>
<td>1339</td>
<td>0.391</td>
</tr>
</tbody>
</table>

References


Agrobiodiversity in Algeria: Status and Perspectives

H. Korichi¹ and R. Issolah²


Keywords: Agrobiodiversity, status, crops, animal, forest, Algeria

Abstract
Agrobiodiversity is of high importance due to the direct links to food security at global level and to the role in sustaining the livelihoods of local communities relying on them locally. Effective conservation and sustainable use of agrobiodiversity require better knowledge of local resources and related traditional knowledge. Algeria is a vast country with large diversity with different bioclimatic zones (humid, sub-humid, semi-arid and arid), with various ecosystems (marine and coastal, forest, steppe, and desert). Steppe and arid ecosystems constitute about 80% of total surface of Algeria. The country is also characterized by its richness in spontaneous species of high agronomic interest, and in crop landraces and livestock local breeds. Awareness on the importance of biodiversity has begun several years ago at different levels (university, research institutions and policy makers) and had led to different research and development projects. This contribution summarizes the status of local agrobiodiversity and future perspectives for its conservation.

Introduction
Algeria’s agrobiodiversity can easily be explained by its geographical position: north of Africa, southern part of Mediterranean basin, influenced by both continental and temperate climates. Ecosystems are, as a result of this combination, various and very contrasting (coastal and inside plains, mountains, steppes, desert (Erg and Reg), bioclimatic stages going from the sub humid to arid).
Algeria is known for its agricultural and cultural richness. Pliny the Ancient (Dubost, 1989) and Herodotus cited the green oasis with the sub-cultures of grapes, figs and olive trees, etc. These resources have allowed Algeria to be self sufficient but have explained the invasion and colonisation of neighboring empires during different historical eras (Ageron, 1968). In fact, during the famous hunger of 1880, numerous populations had nothing else to eat except for some spontaneous legumes such as white truffle, spontaneous beans, chard (Ageron, 1968) and wild and half venomous tubers and roots such as “talrouda, beqouqa, keroua” (Ageron, 1979). Minutia’s harvests of berries, acorns, cactus fruits and all kind of spontaneous herbs; palm buds were prized as sweets, stems and nervures of chard, and malva leaves were also used (Tchihatcheff, 1880 in Ageron, 1968).
This richness in spontaneous species with agronomic interest along with numerous landraces well adapted to harsh conditions (drought, frost, etc) has permitted local populations and farmers to develop an agriculture based on a solid knowledge of the environment, the specificities of local varieties and breeds and a strong know-how.
Plant genetic resources

Cereals
At present, the cereals are the Algerian agriculture predominant crops in the inner regions of the country (400/500 mm), covering about 70% of cultivated land. A good harvest is guaranteed only one year out of three, based on amount and distribution of rainfall (Rachedi, 2000). In 1929, fields sown to cereals crops covered more than three millions hectares. All main cereals except rice were represented in Algeria due to their adaptation to scarce water resources (Abdelguerfi and Laouar, 2000). Durum wheat, barley and, to some extent, bread wheat as well as sorghum (Bechna) stand still as essential crops in Algeria even after colonization (Ageron, 1968). Although durum wheat is very ancient in Algeria, introduction of bread wheat is relatively recent. A lot of landraces have also disappeared and replaced by newly released or introduced varieties (Abdelguerfi and Laouar, 2000). According to Ducellier (1930) cited by Abdelguerfi et Laouar (2000), wheat was represented by durum wheat (Triticum durum Desf.), bread wheat (Triticum aestivum Host.), wheat of Poland (T. polonicum L.). Mixtures of durum wheat and Poland wheat over about thousands hectares, as well as varieties of bread wheat of oasis (T. vulgare var. oasisicolum L.D. and T. spelta L. var. saharae L. D.) are used in limited areas. T. dicoccum Sch. mixed with red oats was also reported. This supports that North Africa region is considered as a secondary center of diversity of Triticum durum Desf. (Erroux, 1960).

Starting in 1967-68, a massive introduction of foreign cultivars of high genetic potential led to a strong regression of certain landraces (Abdelguerfi and Laouar, 2000). A great number of local varieties have practically disappeared and some of them have become rare. The only ones maintained are those which were largely spread before 1970’s or those well adapted like Mohamed Ben Bachir, Oued Zenati, Hedba and others. Even in oasis, local cultivars regression started to be felt. Certain cultivars used during seventies have totally disappeared (Abelguerfi and Laouar, 2000). In fact, following a mission carried out in Hoggar region by IBPGR and IDGC in 1977, another collecting mission focused on the Saharan wheat has been carried out in 1988 by IBPGR in cooperation with INRA-Algeria throughout the Hoggar mountains in the south of Algerian Sahara. The collecting mission resulted in 15 local wheat landraces called: Baida, Barudi, Boumellal, Bourba, Farh houia, Chati, Hamircha, Hamra, Iskandara, Labyad, Manga, Mekkaoui, Mshaara, Sudani, Touati. All collected accessions are bread wheat except Mekkaoui which is a durum wheat suggesting that farmers are very conservative in their choice of which landraces to grow and prefer local types to new varieties, probably because the former have a shorter growing cycle. The loss of local landraces in the area is, thus, likely to be slow, and more due to the abandonment of subsistence agriculture than the influx of modern varieties (Guarino et al., 1991).

Food legumes
Food legumes since a long time are an important component of the prevailing farming systems and contributes mostly to the diets of families with low incomes. The most practiced crops (average 1996-93) are by order of importance based on acreage: beans, spring planted chickpea, and peas especially used in fresh cloves. Those less practiced are: lentil,, haricot beans and vetch (Maatougui, 2002). Today, the Mediterranean region is considered the center of origin of faba bean (Vicia faba L.). It is one of the most ancient food legumes, cultivated and consumed since the remotest ages but after the introduction of potatoes and haricot beans, its importance started to decline (Kolev, 1976a). The beans crop in dry or fresh is more or less spread over all the regions of Algeria. It is a well appreciated legume and requested throughout the
year (Kolev, 1976a). Among the most cultivated and interesting varieties, Truet (1944) quoted Algerian beans “runner black butter” and the very ancient variety “dwarf runner bean” are highly appreciated for their excellent qualities.

**Market-garden vegetables**

In Algeria, market garden crops were omnipresent much of the time in Tell regions, coastal gardens and the oasis where they are part of under layer crops of the system. Among these crops, Battandier and Trabut (1998) indicated onions, pepper, beans, okra, coriander, madder and liquorice.

Onion (*Allium cepa* L.) is one of the most anciently cultivated vegetable. Classified rightly among the main and the best market-garden plants, onion is cultivated worldwide. In Algeria, it is one of the most appreciated and consumed vegetable around the year. Climate conditions throughout the country, including in the oasis in the south, are very suitable for a very good quality production. In comparison with the production in Europe, same varieties which are cultivated in Algeria produce bigger bulbs with softer flavor and are even sweeter (Kolev, 1979).

Garlic (*Allium sativum* L.) is a very ancient crop. In Algeria, garlic is a largely cultivated and consumed vegetable along the year (Kolev, 1979). Within the most cultivated and most interesting varieties Truet (1944) quoted red garlic. In the oasis, garlic is represented more often by very interesting local varieties. It is cultivated in different regions of the country in dry or irrigated, but in some regions like Saida, Sidi-Bel-Abbas, Kabylie, etc., garlic is one of the essential vegetables in food and medicine (Kolev, 1979).

Leek (*Allium porrum* L.) is very ancient vegetable, which cultivation and consumption go back to the remotest times. The primitive form seems to be *Allium ampeloprasum* L. (orient garlic, fake leek garlic, vineyards leek) a weed very spread and known species in Algeria (Kolev, 1976b). Collected in vineyards not yet ploughed, this wild vegetable is largely sold at markets and very appreciated. Mediterranean regions and western Asia are regarded as the centers of origin of this species (Kolev, 1976b).

Artichoke (*Cynara scolymus* L.) is native to the Mediterranean region where all species of *Cynara* tribe are found; but it’s not found in spontaneous state. Artichoke is largely cultivated and much appreciated as a delicate vegetable in the Mediterranean countries including Algeria, especially in coastal zones (Kolev, 1979). Among the most cultivated and most interesting varieties Truet (1944) quoted the thorny of Bouzareah and the artichoke of Sidi Okba with its good production and its good adaptation to oasis conditions.

Corn salad is spread in whole Europe, in North Africa, Asia Minor till the Caucasus. In Algeria, it is indigenous and can be observed during springs in vineyards, in the area around villages, etc., where it is collected and very often sold at markets (Kolev, 1976b).

The origin of cultivated carrots (*Daucus carota* L.) is uncertain. It is quite probable that its cultivation in the Arab countries was spread about XIII and XIV centuries (White, 1959 in Kolev, 1979). According to Kolev (1979), carrot was derived from wild carrot (*Daucus carota* L.) that can be found as a weed across whole Europe, North Africa, the regions of Caucasus, Asia Minor and China (Kolev, 1979). In Algeria, carrot is cultivated in all regions of the country (Kolev, 1979).

Asparagus (*Asparagus officinalis* L.) is native to Europe and Asia where it is cultivated for more than 2000 years. Wild form (*Asparagus officinalis* L.) from which the cultivated *Asparagus* was derived is spontaneous in Algeria (Kolev, 1979). It is
found almost everywhere in forests, at edges of ravines and gullies, etc. (Kolev, 1979). In Algeria, *Asparagus* is hardly cultivated except in hobby home gardens.

Parsley (*Petroselinum hortense* Noffm.) was known and used by ancient Greeks and Romans, based on historical data. Since long time, parsley is the main condiment plant, largely cultivated almost worldwide. Wild form of parsley is spread from Spain to Greece. According to de Candolle (1932 in Kolev, 1979), it has been found also in Tlemcen (region of Algeria) and in Lebanon. In Algeria, parsley is spread throughout the country. It is cultivated mainly for its leaves. Mild climate of the littoral is very suitable for intensive cultivation of parsley throughout the year (Kolev, 1979).

**Fruit trees**

**Olive**

The genetic diversity of olive tree is very important. Battandier and Trabut (1898) and Perruchot (1931) described a large number of local varieties including Chemlal population found mostly in the High Kabylie. It constitutes 40% of Algerian orchards (Loussert and Brousse, 1978) where different types exist (Tizi Ouzou, early of Tazmalt, the small hanging Chemlal, Oued Aïssa) and Azeradj or Adjeraz which origin is found mostly in the Soummam valley, in mixture with other varieties (Loussert and Brousse, 1978). These authors described many types praised earlier by Perruchot (1931) including Seddouk, Azeradj of Beni-Bou-Melek, and the big Azeradj of Ali Chérif. The Roussotte or Roussotte of Guelmia, the blanquette of Guelmia described by Perruchot (1931) are adapted respectively in hills and plains of Guelmia. Limli (imeli, limeli) in hillocks between Sidi Aïch and Bejaia, represents 8% of total olive tree orchards of Algeria. Bouchouk is also a variety presenting different types corresponding to different sites (Guergour, Sidi Aïch, Lafayette, Bougaa). The Sigoise or Tlemcen’s olive or Tell’s olive is principally cultivated in the western part of the country at Sig valley (Loussert and Brousse, 1978). Hamma was known as a table’s olives variety (Perruchot, 1931). Thomas (1928) described the Oualete of Beni bou Melek variety, more rustic than the Rougette, cultivated at up to 800m a.s.l in Béni-Melek douar village near Cherchell and which oil was famous for its finesse. Tefah variety, formerly widespread in Mouzaia and in the Chiffa, is more used for the fruits than for oil, but is less cultivated due to its low productivity.

**Vine grapes**

Grapes along with olive trees and cereals, have been always a part of Algerian predominant traditional farming systems. In fact, since the Carthaginian era, the famous Magon described, with precision, vine establishment conditions, plantation and dress techniques, vinification. The vine stocks had surely local and Asia Minor origin (MC, 1971). Different authors mentioned more than 30 local vine varieties such as the famous Farana, Kelabout el-Gat, Chaouch brought by the Ottomans, Lahmar bou Hemmar, Sbaa el-Ouldja, Kabouilla, Aneb Turki noir, Turc rouge, Taamalet, the Kermeya labiedh and the white Melouki (MC, 1971). In Tlemcen, Salomon (1860 in MC, 1971) cited local vines such as Courchi, Adari, Farana, the Anab Lakhal or black vine of Beni Snassen, Turkish vines such as the Chaouch, Lahmar Bou Hmar and Spanish varieties. In Kabylie, late maturing vines were cultivated such as Béni Abbès Lekhal, Bezoul el-Khadem, Galb el-Theîr, white vines as Ain Amokrane, Ain el-Kelb, Akkacha, Amelal, Bezoul el-Adra. Small Kabylie had the Grillah and Hasseroumb lekhal varieties. Cherchell region was well known for the white cherchali and the Bezoul el Zedem cherchali varieties. In the oasis, Ferani is cultivated as sub-culture under date palms; the same vine stock were also found in the Djbel Amour orchards. Numerous vines as Amokrane, Corchi, Farana were used for dry fruits (MC, 1971).
**Orange**

Battandier and Trabut (1898) mentioned the early and excellent “Algerian orange” known as the “orange of Blida”, very frequent at the end of the IX^th^ century, and the late orange trees of Toudja and the bloody orange (la sanguine).

**Apricot**

Vigorous apricots are found in mountainous massifs valleys, steppes and oasis. The most spread variety is *Mechmech* which grows in coastal plains, Aurès valley south of high plateaus (Ngaous, Hodna basin, M'sila, Barika) (Perruchot, 1931). The local variety *Messaad* or *Arbiaa* is highly appreciated in Messaad region (Djelfa).

**Figs**

Rebours (1955) described several common fig varieties, the white *Bakhor* and the violet *Bakhor*, and autumn fig varieties like, the Taranimt or Tizi Ouzou's fig which is more cultivated in humid parts of the Kabylie. Other varieties are Azendjar very common and reserved for local use, Abiarous and Alekake. Guillochon (1925) described more varieties than Rebours (1955). Some of them are Thaarint, Thaamriot, Thaabouchiabould, Tagamant, Abiarous, Arammi, Thacourt, Thabelout, Thahardoum, Thaiadelst for white figs; Azenhar, Aberkane, Tane karkor aberkane, Tabakone aberkane, Averane for violet or black figs. It seems that genetic erosion was already well advanced 50 years ago.

**Date palm**

Date palm (*Phoenix dactylifera* L.) is cultivated in dry and hot regions like the Sahara which Algeria possesses a surface of more than 2 millions km² (Belguedj, 2002). The number of date palms in Algeria is about 11 millions trees for a surface of more than 100,000 ha representing 21.4 % of fruit tree plantations (without vineyards), ranking after olive tree which occupies about 36 % (Belguedj, 2002). The inventory of the varieties carried out in over fifteen natural regions, showed that Algerian palm groves still preserve an important diversity. In fact, 940 cultivars were registered, among which 2/3 were sampled (Hannachi, 1978). In the regions of Oued-Souf, Oued-Righ, Ourgla and the M’Zab, *Deglet Nour* variety and other fine dates represent more than 50 % of date palm plants (36 % of national patrimony) and 50 % of country date production (Belguedj, 2002). Different selections were operated for centuries by farmers seeking genotypes which were able to meet different uses: human, animal food, transformation to sub-products: syrup, date dough and drinks (Belguedj, 2002). As a result, we have today a great number of cultivars all different from each another by taste, form, consistency, precocity, etc., and which each group of cultivars is adapted to one or several regions according to climatic conditions (Belguedj, 2002).

**Forage and range species**

Out of 978 known species of 18 types of fodder and/or pastoral Fabaceae, 336 species are endemic to the Mediterranean regions (ILDIS, 1999 in Hamilton et al., 2001 in Abdelguerfi et Abdelguerfi-Laouar, 2004). A survey carried out by INRA-Algeria (Institut National de la Recherche Agronomic) in 1998 in North East of Algeria reported a great number of species of spontaneous fodders, belonging to *Trifolium*, *Medicago*, *Astragalus*, *Phalaris*, *Scorpiurus*, *Avena*, *Hedysarum*, *Lolium*, *Picris*, *Carthamus*, *Sonchus*, *Dactylis*, *Festuca*, *Hordeum*, *Leontodon*, *Lepturus*, *Lotus*, *Onobrychis* genera (Issolah et al., 2001). In Algeria, endemism is quite important among Fabaceae and Poaceae (Abdelguerfi and Abdelguerfi-Laouar, 2004). The case of *Avena macrostachya* species which is a perennial oat, narrowly endemic to mountains of Northeastern Algeria, has been collected by a team of IBPGR and INRA.
of Algeria in July 1988. The species is apparently palatable. It may be an important forage resource in the Djurjura (Mokkadem, personnel communication).

**Medicinal plants**


**Forest species**

Among main species that constitute the Algerian forests, certain present themselves under massif form more or less important (cork-oak, Holm oak, Zeen and Afares oaks, Aleppo pine, Maritime pine, Atlas cedar, Berber thuya), others consisting of special formations (mainly white and black poplar tree, common ash tree, willow trees and in a way extremely localized in El Kala region, gluaulne tree) (Harfouche, 2001). In the Hoggar, six species of *Acacia* constitute to different degrees of importance the forest formation of a particular kind: steppe forests (or galleries forests), others constitute only relic or residue of forests, among those Tassili cypress, Numidia fir, black pine of Djurjura. Others native forest species exist even in scattered way or composing population very localized in certain regions of the country indeed even in certain massifs (cherry tree, maple, elm, poplar tree, argan, etc.) (Harfouche, 2001). Many other species introduced from other places and are acclimatized or naturalized in Algeria and used largely in afforestation efforts (Eucalyptus, certain ocean Acacias (mimosas), ever green cypress, umbrella pine, false Acacia locust, etc). Many other forest species are introduced but in limited areas compared to previous ones (Douglas fir, the Canaris pine, Corsican laricio pine and Radiata pine) (Harfouche, 2001).

**Animal genetic resources**

**Sheep**

The sheep represent "the tradition" and ensures the income of almost a third of the population (Chellig, 1992). It is indeed the only domestic animal being able to valorize 40 million hectares which constitute the steppe and the Saharan rangelands, respectively of 12 millions and 28 million ha. The size of this livestock is fluctuant and directly related to grazing charge and drought. It is composed of seven local breeds divided into three principal ones counting ten million heads and 4 secondary breeds composed of two million heads. The principal race is the white race “Ouled Djellal” known for its exceptional meat quality. It is composed of three different types: the Laghouat type, Hodna’s type and Ouled Djellal’s type; the Rumbi race of
the Saharan Atlas, which resembles the moufflon and the Hamra or Beni-Ighil race originating from the High Moroccan Atlas. The secondary races are the Berber race of the Tellian Atlas, Barbarine (Oriental Erg), the D’men known for its prolificacy (up to 5 lambs per range) and the Targui race. All are characterized by good adaptation to harsh environments. They are however threatened of disappearance (Chellig, 1992).

**Goat**

The local breeds are not well characterized. The Arab goat race or *Arabia* is the most widespread and very rustic (MADR, 2003).

**Cattle**

The local bovine belonging to only one group called "Brown of the Atlas" (MADR, 2003) is characterized by its tolerance to heat and cold, its aptitude to valorize the feed of poorest quality, its capacity to walk on hard grounds. Several types exist like Guelmoise, Cheurfa, Setifian and Chelifian. Battandier and Trabut (1898) characterized the guelmoise as alert and sharp, weighing from 150 to 250 kg, quickly fattened when transported to pastures in France.

**Camels**

The camel populations belong to two genetic groups, Chaâmbi and Targui or Mêhari which include many subtypes e.g. Reguibi, Sahraoui, camel of Aftouh, Adjer, Ait Kebbach, Ouled Sidi Echikh and the steppe camel. The dromedary is used for milk, meat, hair and skin productions, labors and tourism (MADR, 2003).

**Poultry farming**

Poultry species are of particular interest; they are present in all Algerian agro-systems including intensive peri-urban production systems but also found in dryland systems or agro-forest systems (GREDAAL, 2004). For chicken, few pockets of local strains of *Gallus gallus* remain in Algeria, mainly in the farmyards of Kabylie, Constantine zone and of the Oasis. They present a diversity of phenotypes, with rather low yields, an instinctive incubation tendency and a seasonal production. However, they are able to valorize the rests of food (GREDAAL, 2004). Since early 1980, government encouraged the importation of improved strains raised close to the great urban centers. This intensification led to the decrease in local breeds known for their rusticity. For the domestic guinea fowl (*Numida meleagris*) related to the African wild type it is adapted to Mediterranean climate and to rangeland. This species has not been targeted by the agriculture development policies but studies showed its capacity to adapt to conditions (GREDAAL, 2004). For turkey (*Meleagris gallopavo*), very few local breed stocks are still found in the eastern parts of Algeria at Oum El Bouaghi, Batna and Constantine. Local breeds are known for their rusticity, a fast growth and an appreciable food converting rate. Three types are distinguished (black, bronze and russet-red) (GREDAAL, 2004). It should be noted that 600,000 commercial turkeys exist in Algeria. the majority are improved hybrid strains introduced between 1985 and 1989 (GREDAAL, 2004). For the ruail (*Coturnix japonica*), it is mainly found in the Tellian farmyards or in the semi-intensive farming systems (GREDAAL, 2004). New European strains were introduced and developed since 2000 through the efforts of the National Fund of Regulation and Agricultural Development (FNRDA). Limited local ruail populations are preserved at the research stations of the Institute of the Small Animal Breeding (GREDAAL, 2004). For ducks and geese, the existing populations are confined in traditional farmyard systems in humid and sub humid areas. The duck populations consist of a mixture of phenotypes, resulting from crossing between Mallard and “Kaki Campbell" ducks which were introduced at the end of the 1970’s particularly in the Mitidja region by the Institute of Small Animal Breeding, (GREDAAL, 2004)
Domestic rabbits
The valorization of a low quality feed, the resistance to some diseases and the adaptation to heat characterize local populations of domestic rabbit (Oryctolagus cuniculus domestica). These populations present a significant phenotypic variability (GREDAAL, 2004).

Bees
The beekeeping is a secular activity in Algeria, where honey is used as a source of energy in the diets, as medicine and in facilitating pollination of fruit trees and native species. Two races of Algerian bee are recognized (GREDAAL, 2004): Apis mellifica intermissa, known as "tellian bee" or "Tell’s black bee" found in the Tellian Atlas, is the dominant type known for its productivity, resistance to diseases and aggressiveness. Several varieties have been described, including five types identified by the beekeepers: "Maazi", "Nalmi", "Begri", and two Kabyle wildtype "Thih Arzine" and "harezzine" adapted to the various biotopes. Apis mellifica sahariensis, called "Saharan bee" is found mainly in the South-western part of the country (Béchar, Ain Séfra) and is less aggressive.

Threats to agrobiodiversity
Since the beginning of the 20th century, not less than thirty animal species completely disappeared from the territory, and a greater number of species are currently threatened with extinction (MATE, 2005). More than 12 millions hectares are threatened with land degradation mainly due to water erosion. The forest shrunk was estimated to 1 million hectares between 1955 and 1997 and 8 millions hectares of the steppes became desert or subject to desertification (MATE, 2002). The reasons are multiple, often influenced or worsened by anthropologic activities (urban areas expansion, non-adapted ploughing techniques including slope-ploughing, overgrazing) and severe climatic conditions due to successive droughts experienced in recent years.

Actions to conserve agrobiodiversity
In Algeria, the interest in conserving biodiversity rises with time and several actions were launched. The Ministry of Land Planning and Environment developed the National Biodiversity Strategy and the National Action Plan for Environment and Sustainable Development (NAPE-SD) which promote the conservation and rehabilitation of ecosystems for improvement of the livelihoods of local communities (MATE, 2002). The need for developing organic farming has been strongly expressed, especially in certain rural zones.

The activities in the Agricultural and Rural Development National Plan covered actions to reverse the degradation processes of natural resources and to improve the incomes and the standard of living of farmers and rural communities (Bedrani, et al., 2001). The plan included the Steppe development program aimed at the rehabilitation of 30-35 million ha of rangelands through plantation of fodder plants and application of agreed grazing management arrangement; and the afforestation program aimed at protecting natural resources on 2.8 million ha in mountainous areas and 3 million ha in the steppe.

The National Research Program “Agriculture and Food” conducted a number of programs directly linked to agrobiodiversity conservation (MESRS, 1996) emphasizing the sustainable use of local agrobiodiversity through the preservation of high diversity ecosystems, particularly those in steppe and oasis. The program “Agriculture and Food” conducted with the Ministry of University Education and
Scientific Research (MESRS) in 1997, 1998 and 1999 activities on prospecting, characterization and valorization of local breeds of domestic animals. Collections of plant species were undertaken and the accessions are conserved in active collection and botanic gardens. Landraces are used in breeding efforts. Many other research and development projects were also based on the local agrobiodiversity conservation and sustainable use to contribute to poverty reduction.

References
Amrouche M. Terres et Hommes d’Algérie. Société algérienne de Publication, 316 pp

Indicators and Estimators of Agrobiodiversity: A Review

S. Jana

Department of Plant Sciences, University of Saskatchewan, Saskatoon, Canada S7N 5A8

Keywords: Agrobiodiversity, indicators, estimators, species richness, genetic diversity

Abstract

Brief accounts of the common indicators of biodiversity are presented. The literature is replete with over 50 indices that measure ecological diversity. The difficulty with these numerous indices is that many of them suffer from redundancy, and many others are affected by the relative frequency of various types (evenness). The simplest and widely used measures of ecological diversity are species richness and species abundance. These estimators are often used in the ecological literature, but are legitimate parameters for describing intra-species and intra-population diversity. A good estimator, according to Fisher, should be sufficient, efficient, consistent and unbiased. For our purposes, it may be convenient to add additional desirable properties, such as these should be easy to calculate, interpret and report. Although variance satisfies these properties well, its use is restricted to quantitative measurement characters. The most commonly used indicator of variation for quantitative characters in plant populations is the coefficient of variation (CV). Because the approximate standard error can be computed, two or more estimates of CV can be tested for statistical significance.

For discrete qualitative data, several estimators are used to measure diversity in plant populations. Of these, Nei’s genetic similarity (I_N), genetic difference (D_N) and heterozygosity (H) indices have been very popular, and are in use since the early 1970s. All of these three statistics are suitable for measuring genetic diversity at individual loci. When allelic frequencies are not known, one popular and useful measure of diversity is the phenotypic diversity index or polymorphic index. Although originally developed to measure interspecies or ecological diversity, two measures of diversity, Shannon’s information index and Simpson index are used to measure genetic diversity within species. These indices are attractive because they are easy to calculate, and interpret, and they allow approximate statistical tests of significance.

It is important to recognize that the total or overall diversity is a complex parameter, because it is comprised of among-species and within-species components. Similarly, total genetic diversity is a function of within-populations and among-populations diversity. Furthermore, as the natural and agricultural systems are often dynamic, estimates of the indices are expected to change over time. In order to formulate a reasonably comprehensive management strategy, we need to consider good estimators over time, just as we need good estimators over space. This introduces the important questions of sample size and sampling technique.

Introduction

Following Eugene P. Odum’s enthusiastic promotion since 1953, the term ‘ecosystem’, originally introduced by the British ecologist, Arthur C. Tansley over 70
years ago, has become a frequently used term in ecology and environmental biology. The most common use of the term is to denote interaction among species or the web of life (Wallach 2005, p291). Agroecosystem is a special application of the term, which refers to human-managed ecosystems resulting from agricultural activities for the production of food, fiber, feed and fuel. The activities include tillage, husbandry and harvest of plants, and sometimes involve the use of fertilizer, pesticide and irrigation. Because agricultural activities are influenced by social, cultural and economic needs of agrarian societies, agroecosystem is viewed as a bio-cultural and socio-economic system comprising domesticated plants and animals, and the people who husband them. Whereas traditional agroecosystems are still relatively species-rich, most modern agroecosystems with intensively practiced agriculture are species-poor, usually limited to a handful of domesticated species of animals and plants.

Biodiversity in an agroecosystem is expected to reflect the variation of “all species and varieties used by or useful to people, with a particular emphasis on crop plant, and animal combinations. It may include biota that are indirectly useful, and emphasizes the manner in which they are used to sustain or increase production, reduce risk, and enhance conservation” (Brookfield; Parsons and Brookfield 2003). Presently, agricultural biodiversity has been abbreviated to a shorter term, ‘agrobiodiversity’. For convenience, I use “biodiversity” in this review as the short form of the term agrobiodiversity of crop plants and their associated plant species, and of animals domesticated for agri-food production. Unless otherwise stated, I do not imply the broad-sense biodiversity, which includes biodiversity of natural as well as human-managed ecosystems.

It is well known that biodiversity is essential for agroecosystem health and fundamental to continued progress in agricultural production and global food security (Thrupp, 2004). The health of an ecosystem depends on its species composition, species richness, and genetic variation within the component species. Genetic variation in agricultural species has a special significance in agroecosystems, as adequate genetic variation ensures their health and long-term success in target environments. Without adequate genetic variation in component species, the health of any agroecosystem invariably deteriorates, and ultimately agricultural production declines.

Biodiversity is necessary for sustainable agriculture (Collins and Qualset, 1999). Many other authors have called for reversal of the negative trend in the status of biodiversity in agroecosystems (Swaminathan, 1996 a & b). Thrupp (2004) has rightly urged that biodiversity not only needs to be conserved, but enhanced. It must be emphasized that sustainable agriculture requires conservation on a much wider scale than that of food crops and livestock. Toward this end, an essential first step is to obtain a reliable assessment of biodiversity in agricultural landscapes.

**Agricultural practices as indicators of biodiversity**

An indicator of biodiversity is an observable characteristic that is closely associated with the status and level of biodiversity in an agroecosystem. Ideally, the characteristic should be measurable and the inherent cause of the association discernible. When measured over time, a meaningful indicator would indicate the change in the status and level of biodiversity. For this reason, indicators are valuable for developing sound policy framework and management practices for conserving or restoring biodiversity in agroecosytems.
Selection of an adequate set of indicators is often difficult, but important for the assessment of biodiversity in agricultural landscapes. OECD (2001) has listed four main criteria, which agri-environmental indicators need to meet. They should be policy relevant, analytically sound, measurable and easily interpretable. Quoting Bibby (1999), Heath and Rayment (2001) listed eight desirable properties of biodiversity indicators: (a) they should be formally measured, (b) simplify information, (c) user driven, (d) policy relevant, (e) scientifically credible, (f) easily understood, (g) realistic to collect in terms of manpower and cost efficiency, and (h) analyzable.

Factors affecting ecosystem degradation are many and varied. Fragmentation is known to be one of the most common causes of natural ecosystem degradation (Harris and Silva-Lopez 1992, Wilcox and Murphy 1985), which inevitably results in biodiversity loss. The causes of loss of species diversity (ecological diversity) and genetic diversity in natural populations are somewhat different from those usually encountered in agroecosystems. For example, genetic drift is rarely an important cause of loss of genetic variability in natural populations. On the other hand, drift due to human selection can be a major factor in agroecosystems. There is little evidence that inbreeding depression or inbreeding avoidance play a major role in natural populations. It is obvious that biodiversity loss in agroecosystems is caused largely by human activities.

A close relationship exists between agriculture practices and biodiversity (Srivastava et al. 1996). Some practices are biodiversity-friendly and are known to maintain high level of biodiversity, whereas some other practices appear to have negative impact on biodiversity. Hence, agricultural practices are expected to serve as approximate indicators of the level of biodiversity in agroecosystems. Srivastava et al. (1996) proposed six approaches under agricultural intensification, which they hoped would be biodiversity-friendly for both natural and agricultural ecosystems. These are:

1. Rational use of nutrients, space and energy in all land-use systems
2. Efficient recycling of nutrients
3. Utilization of biological resources to increase and maintain productivity
4. Effective measures to conserve soil and water resources
5. Deployment of environmental corridors in landscapes transformed by agriculture
6. Use of indigenous knowledge in conservation and utilization of biodiversity

Later, they listed 15 specific agricultural practices at the farm and community levels, which could be used to reduce natural resource degradation while increasing crop yields (Srivastava et al. 1999). These included relay cropping, crop rotation, mixed cropping, mixture of crop varieties, maintenance of traditional as well as modern breeds, buffer zones of natural habitats, release of biocontrol agents, fallow management, conservation tillage, crop-livestock integration, precision irrigation, precision fertilization, terracing, contour bonding, and control strips of grasses or perennial crops. Whereas, some of the above practices are directly related to the level of biodiversity in agroecosystems, others are only indirectly related. Hence, the former practices could serve as reliable indicators of biodiversity for monitoring purposes.

The type and intensity of tillage operation on farmlands is an indicator of biodiversity. Reviewing the effect of tillage on microbial biodiversity, Kennedy (1999) concluded that the type of tillage (e.g. no tillage, minimum tillage, etc.) determines the level of microbial biodiversity in agroecosystems. This in turn is likely to influence all the other levels of biodiversity in agroecosystems (Kennedy, 1999).
Use of some agrochemicals (e.g. pesticides) may have negative effects on soil biota, whereas others may not depress soil fauna directly through reduced biodiversity but indirectly through reduced vegetation. Similarly, excessive fertilizer use may affect cover crop and other vegetation on farmlands. Thus the type and level of pesticide and/or fertilizer use are possible indicators of agrobiodiversity in human-managed ecosystems.

The amount of biodiversity in an agroecosystem is likely to vary according to the size, location, land use system and cultural history of the area. Properly chosen indicators are valuable for identifying biodiversity-friendly best practices in a target region and taking appropriate management decisions.

### Biodiversity in agroecosystems

Biodiversity is depleted in certain agroecosystems, but preserved and even enhanced in others. For example, high input agricultural intensification leads to agroecosystems that are not only species poor, but also suffer from low genetic diversity within component species (genetic uniformity). On the other hand, agroforestry, an integrated land use system, maintain both species richness and high genetic diversity within component species (Leakey 1999). Other examples of biodiversity-friendly farming systems include intercropping, mixed cropping, crop rotation, use of cover crop, no or minimum tillage, home-garden (mixed farming), woodland and pastures etc. Small- or large-scale farming systems that use composting, green manuring, organic matter addition and windbreaks are known to be beneficial for biodiversity in agroecosystems. Lacher et al. (1999) and Kennedy (1999) have reviewed the effects of agroecosystems on biodiversity in detail.

As human needs are modulated by cultural, social and economic factors, so is the biodiversity in both natural and agricultural ecosystems. For maximum and sustainable benefits in conservation, it is necessary to identify and understand the historical, ecological, social and economic factors that create conditions conducive to conservation of animals, plants and microbes. A comprehensive approach towards maintaining biodiversity in agroecosystems should not only include agronomic and ecological factors, but also social and cultural aspects. It is important to consider social, cultural and economic indicators of biodiversity. Some of the characteristics that are known to have impact on biodiversity are: Urbanization of rural areas, agricultural expansion, monoculture, genetic uniformity, agricultural intensification, use of agrochemicals and pollutants, overgrazing, broadening the gene pool of cultivated species, biodiversity preservation as a national priority, preservation and promotion of cultural diversity, commitment of extension services to preserve biocultural diversity, strengthening seed production and distribution systems, encouraging informal breeding and selection, incentives for in situ and on-farm conservation, participation of local communities in biodiversity conservation, participatory plant and animal selection, participation of nongovernmental organizations in biodiversity conservation, ex situ conservation of plant and animal genetic resources, training in areas related to biodiversity conservation and strengthening and implementing legal instruments.

Amri et al. (2007) conducted a five-year survey research on the status and trends in biodiversity in West Asia. They used several indicators of biodiversity in 75 monitoring areas spread over four countries: Jordan, Lebanon, Syria and the West Bank region of the Palestinian Authority. The indicators included conversion of natural land to farming, overgrazing, overuse of biological resources (e.g. wild crafting of medicinal plants, firewood collection), recurrent drought, deforestation,
urbanization, quarry development, occasional fire, introduction of new and high yielding cultivars and alien species. They found that within a short period of five years (2000-2004), overall degradation of natural ecosystems and agroecosystems was substantial in the monitoring areas in Jordan, Syria, Lebanon and the Palestinian Territories. They recognized that all of the major causes of habitat degradation were anthropogenic. Overgrazing was the most important factor responsible for biodiversity loss, followed by agricultural expansion to natural habitats of wild species and introduction of alien species. These factors were considered to be meaningful and reliable indicators of the status and trend of biodiversity in much of the arid and semi-arid land in the Near East Fertile Crescent.

The purpose and use of agrobiodiversity indicators
The health of an agroecosystem is directly related to its state of biodiversity. Highly biodiverse systems are capable of responding well to biotic and physical stresses and are resilient to environmental perturbation. For this reason, the nature and quantity of biodiversity in agroecosystems is of considerable interest to both ecologists and agroecologists. According to the Organisation for Economic Co-operation and Development (OECD), an indicator is a ‘parameter, or a value derived from parameters, which points to, provide information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value’ (OECD 1994, quoted by Brouwer and Crabtree 1999). Tucker (1999) listed three basic functions of indicators; simplification, quantification and communication. Because the main purpose of using indicators is to highlight the main trends, it would be most efficient to use a limited number of relevant and well-defined indicators.

One of the most important agrobiodiversity indicators is the state of the genetic resources that are currently utilized in agricultural production systems, animals, plants and microorganisms. To this, OECD (2001) added habitat quantity, habitat quality and overall loss or gain of biodiversity.

Economic assessment of biodiversity provides a rationale for policy-makers to safeguarding biodiversity (OECD 2001). This consideration underscores the need to assign value to biodiversity for policy decisions, for determining priorities for conservation and management of biodiversity. Several authors have used indices to measures biodiversity to determine economic values of biodiversity (Benin et al. 2006, Gauchan et al. 2006). Reliable measures of biodiversity are useful for assessing economic values of local and regional biodiversity for making management and policy decisions.

For maximum and sustained benefits in conservation, it is necessary to identify and understand the historical, ecological, social and economic factors that create conditions conducive to conservation of animals, plants and microbes. A comprehensive approach toward maintaining biodiversity for and within agriculture should not only include ecological and economic factors, but also social and cultural aspects. We should, therefore, consider determinants of bio-cultural diversity as indicators of both short-term and long-term gains in biodiversity.

To be adequate, indicators should be relevant to biodiversity conservation programme and useful for formulating future policies and legal instruments (Mackey et al. 1994). They classified indicators into two broad categories, species-based and system-based. Because each indicator has its own advantages and limitations, Mackey et al. (1994) cautioned that unless used prudently, they might be subject to misinterpretation. According to them, ‘indicators are required to provide feedback to decision makers
and the wider community on the impact of land use and resource utilization’. Best indicators should be easy to implement, and data collected using these indicators should be easy to interpret.

Certain characteristic features of a community or region may have discernible relationship with the level of spatial biodiversity in the region. These characteristics are then used as indicators of the status of biodiversity. These indicators may be qualitative or quantitative. Information gathered from processing and analyzing the indicator variables can be used for scientific, as well as for policy and legislative purposes. In a recently published monograph on valuing crop diversity, several authors have used such characteristics as explanatory variables in socio-economic analyses of agrobiodiversity (Smale 2006).

Diverse agricultural management (agrobiodiversity) is usually an important determining factor of agrobiodiversity in a geographic region or country (Brookfield et al. 2003, Alteiri and Nicholls 2004). Thus agrobiodiversity could be an indicator of agrobiodiversity. This diversity may be spatial, temporal, or both.

Indices are often used to study spatial distribution and statistical trend. For this reason, they should be statistically robust and efficient. Managing biodiversity in an efficient manner requires the knowledge of its occurrence and amount, i.e. good management requires good assessment of agrobiodiversity. In order to manage biodiversity effectively and efficiently, one needs to know how much and where and why that diversity exists, and how much of it is vulnerable, endangered or threatened.

Measurement of biodiversity in agroecosystems

Various measures of biodiversity are available. These measures purport to describe biodiversity in numerical indices. The main purpose of these indices is to provide a tool to measure spatial biodiversity in an ecosystem. They provide a reference measure for biodiversity in different ecosystems across the region. Biodiversity indices, estimated at different periods in an ecosystem helps to assess temporal change in biodiversity, a gain or loss over time. This information is useful for assessing progress in biodiversity management and conservation programs. A good index should be simple to measure, but capture the complexity of biodiversity information. It should be consistent in repeated measurements, statistically robust and efficient. Furthermore a good index is a measure that resonates with the public and is easily understood by a non-technical audience.

A large number of biodiversity indices have been proposed, many of which suffer from redundancy (Magurran 1988, 2004). These indices generally have one or both of two components in common: (a) variety/richness in terms of entities such as alleles, genes, varieties, populations, species, genus, etc., and (b) relative abundance of the entities. Diversity measures have been defined by combining these two components in various ways. Ecological diversity is usually quantified as the number of species (species richness) and their respective relative frequencies (abundance) in a community or ecosystem. These measures of diversity may be combined in an index that gives a single numerical value to describe species richness and evenness of distribution of component species in a biological community (community diversity).

Several indices have been proposed for measuring species richness and abundance in natural ecosystems. These indices give numerical values to quantify the level of biodiversity in agroecosystems. The simplest and one of the most popular measures of ecological diversity is the count, i.e. the observed number of species in one or more samples from an ecosystem. Where S denotes the number of species or units of diversity, \( D_s = S \).
Some other commonly used indices of diversity in community ecology are given below:

**Maximum diversity**, $H_{\text{max}} = \ln S$, where $S$ is the total number of species in the community, and evenness is the ratio of observed diversity, $H_0$ and maximum diversity, $E = H_0 / H_{\text{max}}$.

Magurran (2004) has listed two simple indices that measure species richness. These are Margalef’s diversity index ($D_{\text{Mg}}$) (Clifford and Stephenson, 1975), and Menhinick’s index ($D_{\text{Mn}}$) (Whittaker 1977, respectively, $D_{\text{Mg}} = (S-1)/\ln N$, and $D_{\text{Mn}} = S/\sqrt{N}$, where, $S$ is the number of species (groups/clusters) recorded, and $N$ is the total number of individual (samples) summed over all the species (groups/clusters). In addition, Magurran (2004) has listed several other measures of species richness and has concluded that some nonparametric estimators, developed by Anne Chao and her colleagues (Chao 1984 and later) appear promising. She has described a number of parametric (e.g., $\log \alpha$) and nonparametric indices that are used to measure ecological diversity. Two of the most frequently used nonparametric indices are Simpson D (Simpson 1949) and Shannon $H'$ (Shannon, C. E. and W. Weaver 1949).

**Simpson index**, $D = \sum p_i^2$, where $p_i$ is the relative frequency of the $i^{\text{th}}$ species in a sample. Here $p_i$ is estimated as $n_i/N$, where $n_i$ is the species records (specimens, records from the flora, germplasm data) and $N$ is the total number of individual records of all species observed. This index indicates proportional abundance of species, and is heavily weighted toward the most abundant species. The Simpson index is simple to calculate and intuitively meaningful. Because diversity decreases as $D$ increases, the index is usually expressed as its reciprocal, $D^{-1}$, or its complement, $D_p = 1 - D$ (Magurran 1988, 2004). Lande (1996) recommended the use of $D_p$, rather than $D^{-1}$ for measuring average diversity of a set of communities.

**Shannon diversity index**, $H' = -\sum p_i \log p_i$ indicates evenness, equitability and proportional abundance of species. $H'$ is also denoted as $H_s$ or $D_s$. Sometimes $H'$ is calculated using $\log_2$ or $\log_{10}$ instead of the natural log, $\log_e$ or ln. Magurran (2004) recommends the use of a standardized base, preferably $e$, for simplicity and convenience of comparison among communities. It is noteworthy that the maximum value of $H'$ is obtained when all species in a community are equally frequent. Consider, for example two equally frequent species ($p_1 = p_2 = 0.5$) in Community A, which gives the maximum $H'$ for A = 0.693. Let Community B contains five species, with one dominant species: $p_1 = 0.88$; $p_2 = p_3 = 0.05$, and $p_4 = p_5 = 0.01$. The estimate of $H'$ for B = 0.504, which is 27.3 percent less than that of Community A, despite the fact that Community B is 2.5 times more species rich than Community A. In general, if the component species in Community A are more evenly distributed (i.e. more equally abundant,) than that of Community B, then the former is considered more diverse, even when both contain equal number of species.

The Shannon index has been corrected for bias (Hutcheson 1970, Bowman et al. 1971) as given below:

$$H' = - \sum p_i \ln p_i - (S-1)/N + (1- \sum p_i^{-1})(12N^2) + \sum (p_i^{-1} - p_i^{-2})(12N^3),$$

with the variance,

$$\text{Var}_{H'} = \sum (p_i \ln p_i)^2 / N - (S-1)/2N^2.$$ 

Magurran (2004, p108) discussed the difficulties regarding interpretation of $H'$ values. Both Simpson index and Shannon index have been extensively used to measure and compare species diversity and genetic diversity. On the two most
popular indices used to measure diversity, Magurran (2004) concluded that ‘the Shannon index has the properties that can impede the interpretation of results. On the other hand, the Simpson index performs well, both as a general purpose diversity statistics and when recast as an evenness measure’.

Berger and Parker (1970) referred to Simpson index and Shannon index as ‘compound diversity’ as the indices depend on the whole spectrum of species proportions. They also introduced a simple measure of proportional dominance of the most dominant species in a community, \( D_{BP} = 1/P_{\text{max}} \), where \( P_{\text{max}} \) is the maximum proportion of any one species in a sample.

Magurran (2004) provided useful practical hints on how to select a diversity index. Because all measures of diversity must emphasize either species richness or evenness, she has concluded that ‘no perfectly unified diversity index is possible’. Sample size is an important determinant factor of the values of diversity indices. Magurran (1988) has discussed the sensitivity of various diversity indices to sample size.

A study of plant diversity may shed light on species diversity, describing the abundance of species, estimating the number of species in a given region, comparing diversities across regions, association between species and geographical region, spatial modeling of abundance of species, etc. Indices that include elements of richness (number of taxa) and evenness (relative abundances) can be applied at scales ranging from alleles and species to regions and landscapes. However, diversity indices do not reveal the taxonomic composition of the community. For example, a community composed entirely of exotic species could have the same index value as a community composed entirely of endemic species. Therefore, a diversity index, by itself may not predict ecosystem health and productivity.

Often importance is given to the number of species in different class sizes, such as shrubs and trees in a terrestrial ecosystem (Krishnamurthy 2003, p. 54). If an ecosystem has higher hierarchical taxonomic groups with fewer species, it is considered more diverse than an ecosystem containing fewer taxonomic groups with more numerous species. Several authors have suggested weighting of ecological measures of species diversity on the basis of their genetic distance (May 1990, Humphries et al. 1995). In general, the result is to give greater weight on more distant taxa.

**Types of agrobiodiversity indicators**

Two types of indicators have been identified: simple and complex. Perhaps the latter are nearer to the situation and more realistic, but less comprehensible. A good indicator should be measurable, reportable and comprehensible to non-specialists (Mackey et al. 1994, OECD 2001). Indicators may be direct or indirect measurements of biodiversity, but they must be of interest to the intended audience and relevant to their purpose.

Biodiversity indicators are expected to provide useful information on the status of biodiversity in agroecosystems, and preferably at all three levels of biodiversity: genetic, species and community. Some indicators are species-based, for example, species richness, dominance, and evenness of frequency etc. Some other factors, such as the extent of soil and wind erosion, drought and biotic pressure are system-based indicators.

Agrobiodiversity is essentially a product of change in response to biotic and abiotic pressures in agroecosystems. The pressures could be constantly changing and evolving. The extent and effectiveness of remedial measures taken by farmers to
biotic and abiotic pressures on farmlands is a valid and useful indicator of biodiversity.  

*In situ* conservation of wild crop relatives and rehabilitation of degraded rangelands and natural habitats has been encouraged in recent years. Some plant breeders have promoted participatory plant breeding i.e., involving producers in breeding. This process is widely assumed to be conducive to the selection of crop varieties for specific farming conditions. Focusing on niche-specific adaptation, participatory plant breeding is expected to increase biodiversity in agroecosystems.

Socio-economic indicators are often complex and subject to change with time. For example, although small farms are known to be biodiversity friendly, farm sizes are likely to change in responses to changing environmental, social and economic conditions. Socio-economic indicators should include the extent of societal involvement in biodiversity conservation and willingness of farming communities to share biodiversity.

A useful socio-cultural indicator is the level of awareness of rural people of the value of biodiversity and participation in conservation program. The involvement of educational institutions in teaching and curriculum development with emphasis on biodiversity conservation has a long-term positive effect on biodiversity conservation. These activities, combined with the development of effective legal instruments constitute important positive indicators of biodiversity conservation and its enrichment. The involvement of community leaders, community based organizations, local and national agricultural extension services, environment and natural resource management services (e.g. ministries of planning, tourism, environment, forestry, wildlife, etc.), women and other private sector groups, and international and non-governmental organizations (NGOs) are useful indicators. An important but often overlooked indicator is the community effort on adequate documentation and utilization of indigenous knowledge on ecological and genetic diversity.

Prior knowledge of the distribution of species and amount of variation is also important for exploration and collection of plants and animals for *ex situ* conservation. The optimal sampling method for a target species is dependent upon the amount of phenotypic variation, allelic richness, genetic diversity, heterozygosity, disequilibrium coefficients and other population genetic parameters.

**Estimators of genetic diversity**

A good estimator, according to Fisher, should be sufficient, efficient, consistent and unbiased. Although variance satisfies these properties well, its use is restricted to quantitative measurement characters. The most commonly used estimator of variation for quantitative characters in plant populations is the coefficient of variation (CV). Because the approximate standard error can be computed, two or more estimates of CV can be tested for statistical significance. Van Valen (2005) gives the variance of estimate of univariate CV, which can be used to construct approximate confidence interval on true CV² and also for comparing CV estimates from different samples. Quoting from his earlier work (van Valen 1974) gives a multivariate generalization of CV (CVₚ).

For discrete qualitative data, several estimators are used to measure diversity in plant populations. Of these, Nei’s genetic identity index (Iₜ), genetic difference (Dₜ) and heterozygosity (Hₑ) indices have been widely used since the early 1970s (Brown and Weir 1983, Jana and Pietrzak 1988, Templeton 1995, Kremer *et al.* 1998 and Smale and Bellon 1999). All of the three Nei’s statistics are suitable for measuring genetic diversity at individual loci. Nei’s genetic identity index is a measure of the sharing of
alleles and similarity of alleles. Numerous workers have used Nei’s indices to report genetic diversity estimates from genetic survey data. When allelic frequencies are not known, a common measure of diversity is the phenotypic diversity index or polymorphic index, given by \( P_j = \sum p_i (1-p_i) \) or \( 1 - \sum p_i^2 \), where \( p_i \) is the frequency of the \( i^{th} \) phenotype of individual characters observed (Hedrick 1971, 1983). Note that \( P_j \) is equivalent to Nei’s heterozygosity index, \( H_{e.j} = \sum p_{ij}(1-p_{ij}) \) or \( 1 - \sum p_{ij}^2 \), where \( p_{ij} \) is the frequency of the \( i^{th} \) allele at the \( j^{th} \) locus.

The average per locus heterozygosity over \( k \) loci is calculated as the average of \( H_e \) over \( k \) loci:

\[
\overline{H_e} = \frac{\sum H_{e,j}}{k}
\]

Zhang and Allard (1986) derived an unbiased estimate of variance of average per locus heterozygosity:

\[
V(\overline{H_e}) = \frac{1}{k(k-1)} \sum \left( H_{e,j} - \overline{H_e} \right)^2.
\]

**Genetic richness:**

Genetic richness associated with groups of populations of a species has been expressed as (Collwell and Coddington 1995):

\[
S = S_{obs} + \sum (1 - p_{k})^n
\]

Where \( S_{obs} \) is the number of observed associations in populations, \( p_{k} \) is the relative frequency of individuals with the \( k^{th} \) association and \( n \) is the number of individuals analyzed (Piergiovanni and Taranto 2006).

Often in practice, for a single population, allelic richness is measured as the average number of alleles for a large number of markers. In case of sampling from several populations, the sampling strategy depends on the extent of genetic divergence among populations (e.g. in terms of number of alleles that attain appreciable frequencies in individual populations) and variation in the level of genetic variation (e.g. in the distribution of number of alleles per locus).

Molecular tools are being used increasingly to assess genetic diversity within and among populations. Kremer et al. (1998) have discussed parameters measuring genetic diversity within and genetic differentiation among populations. Some of the indices, such as Simpson index and Shannon index are described earlier as the measurements of ecological diversity. As indicated earlier, these methods are based on the richness of molecular variants, their respective relative frequencies and their evenness. These indices, \( H \) (equivalent to Simpson’s \( D \)) and \( H' \) (equivalent to Shannon’s \( D_s \)), have been very successful in comparative genetic analysis and evolutionary studies (Kremer et al. 1998).

Multivariate methods, especially the principal components analysis, have been extensively used to assess genetic diversity in crop germplasm collections. See, for example, some recent applications in Meghata et al. (2005), and Devakmar et al.
These authors have used the principal components method for analyzing molecular markers in ex situ preserved accessions of fruit crops.

**Selection of suitable traits for estimating genetic diversity**

The choice of appropriate characters for estimating and interpreting genetic diversity in plants and animals is not easy. It is desirable to choose characters that are highly heritable with little or no environmental effects, and collectively, they should represent a random sample of the genome. These are likely to include characters from the three following groups: (a) adaptive traits, (b) non-adaptive traits, and (c) pseudo-adaptive, i.e. traits which have no adaptive properties per se, but are correlated with the adaptive traits. Most likely the characters chosen for biodiversity estimates would combine desirable character-states of a number of adaptive traits. The characters must be measurable with little or no environmental effects (i.e. highly heritable) and their respective character-states unequivocally recognizable. Ideally one needs the frequencies of discrete character-states of each of the characters chosen for estimating biodiversity within species. If such frequencies are not available, say in the case of quantitative characters, sometimes a discrete conversion of the not-discrete measurement data is made (Yang et al. 1996).

**Conclusion**

Agroecosystems are human-managed ecosystems, created by human interventions of natural ecosystems. The impacts of agriculture on natural and agricultural biodiversity are widely assumed to be negative. Reliable quantification of biodiversity in a wide range of agroecosystems would help to establish specific and general relationships and thereby allow development of effective management plan and policy framework. This task may be achieved through a set of good indicators. Selection of a set of good indicators is helpful for assessing biodiversity in agricultural landscapes. They should be useful and relevant tools for surveying and monitoring biodiversity.

The health of an ecosystem depends upon its quantity and quality of biodiversity. A healthy agroecosystem is usually an indicator of high biodiversity. Whereas agriculture is generally believed to have negative impacts on biodiversity, some farming systems are known to be beneficial for protection and preservation of biodiversity. Furthermore, the level of biodiversity in an agroecosystem is also determined by social, economic and cultural factors in farming communities. Because it is a dynamic and interactive process, a set of good indicator of biodiversity today is likely to change with changing conditions.

The total or overall diversity is a complex parameter consisting of diversity within and among species. Similarly, total genetic diversity is a function of within-populations and among-populations diversity. Agrobiodiversity is not only a function of the total number of cultivars, but also the pattern of their distribution. For example evenness (cultivars occupying nearly equal areas) gives higher biodiversity than highly dissimilar acreages.

A wide variety of indices have been developed to quantify ecological and genetic diversity. There is no universally satisfactory index of biodiversity. As indicated by Smale (2006) in the context of crop diversity measurement, more than one index may be appropriate in a particular situation. The simplest and most widely used measures of ecological diversity are species richness and species abundance. Although originally developed to measure interspecies or ecological diversity, two measures of diversity, Simpson index and Shannon’s information index are widely used to quantify inter- and intra-population genetic diversity. These indices are attractive...
because they are easy to calculate, interpret and allow approximate statistical tests of significance. However, they are affected by the relative frequency of component species or phenotypes (i.e. evenness) in target areas or populations. One of the major functions of the estimators of biodiversity is to describe spatial and temporal variation or to serve as descriptors. Unequivocally measured descriptors can be used for scientific investigations into the nature and causes of variation. Furthermore, information gathered from processing and analyzing these descriptors should be useful for making management and policy decisions. For this reason, descriptors should be simple to measure and interpret.

Acknowledgements
I thank Professor Bruce E. Coulman of the Department of Plant Sciences, University of Saskatchewan, for a critical and careful review of this review article.

References


Plant Diversity and Systematic Evaluation of the Genus *Ornithogalum* L. (Liliaceae) in Jordan

M. A. Odah and S. A. Oran

Dept. of Biological Sciences, Faculty of Science, Univ. of Jordan/ Amman-Jordan, E-mail: oransaw@ju.edu.jo

Keywords: Diversity, systematic, *Ornithogalum*, identification, Jordan

Abstract
The diversity and systematics of the genus *Ornithogalum* L. (Star of Bethlehem) in Jordan has been studied. Biosystematic evidences such as comparative morphology, leaf anatomy, cytology, palynology and seed morphology were used for the identification and characterization of *Ornithogalum* taxa. Chromosome counts were carried out using root tip squash technique, to study the dividing merestimstic cell during the mitotic division. Chromosome counts for the studied taxa ranged between 2n=12, 14, 16, 18, 22, 27, 28, 32 & 34. Several counts were recorded for the same species as in *O. umbellatum* (2n= 16, 18 & 27), *O. neurostegium* subsp. eigii (2n= 16, 18, 22, 28, 32 & 34), *O. tenuifolium* (2n= 12& 14) and *O. narbonense* subsp. brachystachys (2n= 16& 18), while other species exhibited fixed chromosome counts among members of the same population, such as in *O. neurostegium* subsp. neurostegium (2n= 18) and *O. lanceolatum* (2n= 16), *O. trichophyllum* (2n= 18), or among different populations as in *O. montanum* (2n= 16). New counts were detected for *O. neurostegium* subsp. eigii (2n= 22, 28, 32, 34 & 16), *O. narbonense* subsp. brachystachys (2n= 16), and *O. umbellatum* (2n= 16). Leaf anatomy, was studied. Variations in studied sections were recorded. Pollen grains morphology was also studied using electron microscopy (SEM) and found to be prolate-perprolate, isopolar, bilateral symmetry, with one sulcate (monocuplate). The size of pollen grains ranged between 32-46/22-37µm in *O. trichophyllum*, and 57-69/26-42 µm in *O. neurostegium* subsp. eigii. The surface of the exine was regulate-foveulate to perforate, psilate or per-reticulate. Seed morphology was also examined using (SEM) and the seed primary sculpture was found to be of two types, granulate and reticulate. The shape of the outer epidermal cells as well as the sculpture of the secondary wall of the seeds varied between taxa. Upon using the previous biosystematic studies, eight *Ornithogalum* species and three subspecies, were identified, and these are *O. lanceolatum*, *O. trichophyllum*, *O. neurostegium* subsp. eigii, *O. neurostegium* subsp. neurostegium, *O. umbellatum* and *O. narbonense* subsp. brachystachys. *O. lanceolatum* is described for the first time in Jordan, and considered as a new record to the flora of Jordan. In this paper the systematics of *Ornithogalum* in Jordan is assessed on the basis of the morphological evidence. The other biosystematic studies such as, chromosome counts, palynology, leaf anatomy, and seed morphology will be dealt with in a separate article.

Introduction
*Ornithogalum* L. is an old-world genus. The botanical name of *Ornithogalum* originates from the Greek word ὄρνις or Ornithos, which means the bird and gala for the milk. This name was applied for that genus, due to the pure white color of its flowers (Richett, 1968, Stearn, 1975, Mathew, 1985). The genus *Ornithogalum* (Star of Bethlehem) comprises hundreds of species, mostly characterized by bulbous plants
with a star like white flowers (Stearn, 1975). This genus belongs to the family (Hyacinthaceae), and includes about 150 species found in the temperate regions of Africa, Asia and Europe (Littlejohn and Blomerus, 1997). The natural habitats of this genus range from dry semi-desert areas, with high temperature extremes, to mostly wetland and river banks, up to high level of mountain altitudes. It is easily grown, required a full sun and well drained soil (Littlejohn and Blomerus, 1997). The common name of the genus Ornithogalum is Star of Bethlehem, it was described for the cut flower O. thyrsoides, native to the United States of America, and for O. umbellatum in Europe and O. arabicum which is native to the Mediterranean Basin (Littlejohn and Blomerus, 1997). Small bulbs of O. narbonense are edible, while other species are known to produce poisonous bulbs such as O. umbellatum (Johns and Luchsinger, 1979; Hepper, 1981). However, many considered the Ornithogalum as an ornamental of horticulture important species suitable for the border, rock garden and for cutting (Witham-Fogg, 1974; Johns and Luchsinger, 1979).

Ornithogalum is a taxonomically difficult genus to work with, because of the important characters that can be used to distinguish the differences like: trichomes, bulblets and the foliage color band of the leaves, that are lost in the dried specimens (Mathew, 1985). This genus is described as a herbaceous, perennial, monocotyledon plant, adapted to overcome dry dormant period in the form of under ground bulb. The bulb is covered with a tunic of free scale, usually brownish to grey with silver-glossy dots on the surface of scale. The leaves are basal, ensheath the scape at the base, linear-slender, flat or filiform, entire or ciliate, with parallel-veined. A leafless, smooth flowering stem (scape) is carrying a stalk of long, cylindrical raceme or flat, top-corymbose inflorescence. Flower is actinomorphic, bisexual, white, perianth segment 6, divided free spreading into two wholed, with a longitudinal green stripe on the outside of each segment. Perianth segment is spreading in star-like form when it opens, and shows a bell-like shape upon closing. Bract is solitary, membranous, lanceolate, acuminate, with many or three vein, its length varies, as long, shorter or longer than pedicle, depending on the type of species. Pedicle is erect-patent to ascending. Stamens six, are adnated to base of inner perianth segment, with white, flat-linear, lanceolate acuminate, entire filament; another dorisfixed, versatile. Ovary is superior with 3 united carpels (compound pistil), 3-locules, multiovule, axile placentation; style filiform, white, arises in form of a depression at the top of the ovary; stigma is capitate. Fruit capsule is loculicidal with 3 valves, non-winged.

Al-Eisawi (1982), in the list of Jordan Vascular Plants, recorded 6 species of the genus Ornithogalum: O. tenuifolium, O. trichophyllum, O. montanum, O. narbonense, O. neurostegium and O. umbellatum. This contribution conducted a proper systematic revision of the genus Ornithogalum in Jordan and presented a key for different taxa.

Materials and Methods
The material, which was used to study the morphology of the genus Ornithogalum, was based on fresh specimens collected from all parts of Jordan, as well as on examining herbarium specimens deposited at Amman Herbarium (AMM)/Department of Biological Sciences/University of Jordan. Measurements were taken for the different parts of each studied specimen: the measurements were made at least for 20 specimens on average for each taxon, when enough material was available. This study was also supported by other studies of pollen grains, scanning electron microscopy of the seeds, and anatomy of leaf, petiole and seeds.

Morphological parts used in the morphological description are bulbs, bulblets, scales, leaf, leaf with trichomes, bract, pedicle, flower, outer and inner perianth segment and
fruit (capsule) (Figure 1). Key and synopsis of taxa are prepared. Map for the geographical distribution of all taxa also provided (Map 1).

Results, conclusions and recommendations
Eight species of *Ornithogalum* and three subspecies were identified and these are *O. lanceolatum*, *O. trichophyllum*, *O. neurostegium* subsp. *eigii*, *O. neurostegium* subsp. *neurostegium*, *O. umbellatum*, and *O. narbonense* subsp. *brachystachys*. *O. lanceolatum* is described for the first time in Jordan and considered as a new record to the flora of Jordan.

In conclusion, comparative morphological study among taxa of *Ornithogalum* revealed differences between species, especially with closely morphological characters as in *O. montanum* and *O. neurostegium* subsp. *eigii* and also between the closely related *O. neurostegium* subsp. *eigii* and *O. neurostegium* subsp. *neurostegium*. The plants of *Ornithogalum* are bulbous and can be used economically as ornamentals or for their chemical potential in the pharmaceutical industry. *In situ* and *ex situ* conservation methods are worthwhile adopting to protect and propagate these species found in Jordan. The taxonomic identification of species requires capacity building in the region and this study presents descriptors for discriminating among species.

Fig 1. Schematic diagram of morphological parts of *Ornithogalum* and their terminology:

- 1. Bulb
- 2. Scales
- 3. Bulblets
- 4. Scape
- 5. Leaf
- 6. Leaf with trichomes
- 7. Bract
- 8. Pedicle
- 9. Flower
- 10. Outer perianth segment
- 11. Inner perianth segment
- 12. Ovary
- 13. Style
- 14. Stigma
- 15. Filament
- 16. Anther
- 17. In-dehiscent capsule
- 18. Dehiscent capsule.
SYNOPSIS OF TAXA

Family: Liliaceae
Syn: Hyacinthaceae
Subfamily: Scilloideae
Tribus: Scillaceae Von Vest.
Genus: Ornithogalum L.
Subgenus: Heliocarmonos Baker.
Species: O. umbellatum L.
O. montanum Gyr.
O. neurostegium Bioss. & Bl.
subsp. neurostegium
subsp. eigii (Feinbr.) Feinbr.
O. trichophyllum Bioss. & Helder.
O. tenuifolium Guss.
O. lanceolatum Labill.

Subgenus: Beryllis (Salisb.) Baker.
Species: O. narbonense L.
Subsp. brachystachys (C. koch) Feinbr.

Key to taxa
1. Inflorescence raceme, narrow cylindrical; leaves shorter than scape; bracts lanceolate, long acuminate, with 3 veins near the base
   O. narbonense subsp. brachystachys

1. Inflorescence corymbose, wide ovate; leaves longer than scape; bracts ovate, lanceolate, subulate, with many green veins near the base or in the upper part.
  2. Leaves filiform (0.1-0.2 cm wide); bulb simple, without bulblets.
  3. Long scape (10.7-22 cm long); leaves with deep narrow furrow, without white band on the upper surface
     O. trichophyllum
  3. Short scape (4-11 cm long); leaves slender, with middle white band on upper surface
     O. tenuifolium

2. Leaves flat linear (0.3-3 cm wide); bulb with or without bulblets.
  4. Leaves ciliate at the margin.
  5. Long scape with inflorescence (13-22.5 cm long); leaves linear, ciliate at the margin glabrous on lower surface
     O. neurostegium subsp. eigii
  5. Short scape with inflorescence (8-14.5 cm long); leaves undulate, ciliate at the margin, pilose on lower surface
     O. neurostegium
     subsp. neurostegium

4. Leaves entire at the margin.
  6. Leaves narrow canaliculate, with white band on the upper surface; bulb with numerous bulblets
     O. umbellatum
  6. Leaves broad linear, without white band on upper surface; bulb simple.
  7. Leaves oblong lanceolate, mucronate (1.5-2.7 cm wide), appressed to the ground form rosette-like shape; pedicles ascending
     O. lanceolatum
  7. Leaves linear lanceolate, acute (0.5-1 cm wide), erect then fall down; pedicle erectopatent
     O. montanum
Map 1. Geographical distribution of different *Ornithogalum* species in Jordan.

**References**


The Fodder Legumes in Algeria: Distribution, Endemism and Utilization

R. Issolah1 R. and A. Beloued2

1 INRAA, Laboratoire des Ressources Phytogénétiques. Station Mehdi Boualem. BP 37. Baraki, Alger. Algérie. E-mail: issolah2001@yahoo.fr.

Keywords: Forage legumes, distribution, endemism, uses, conservation, Algeria

Abstract
Located in North Africa, Algeria contains 3139 plant species distributed over 2.4 million km². Biogeographical studies showed that fodder legumes include almost 33 genera, which are represented by about 293 species. These species can be classified in the following genera: Astragalus, Trifolium, Ononis, Vicia, Medicago and Lathyrus. Five genera (Acacia L., Alhagi Gagnebin, Crotalaria L., Indigofera L., Tephrosia Pers.) exist exclusively in the Sahara. One genus Argyrolobium Eckl. & Zeyh. seems to exist in the Hodna, the Saharan Atlas and the Sahara areas. The genera Biserrula L. and Pisum L. are distributed in the north throughout the Tell. Species belonging to other genera are found throughout different biogeographical areas in the north and the south of the country. There are 17 endemic species in Algeria, belonging to Ononis L., Astragalus L., Hedysarum L., Coronilla L., Crotalaria L., Lotus L., Trigonella L. and Vicia L. genera. Some species are not grazed, others species appear to be palatable and also are occasionally consumed by local people, particularly in the remote and marginal areas. In situ conservation of these species should be undertaken to avoid further genetic erosion.

Introduction
Algeria, a north African country, stretches over 2.4 million km² running from east to west along the Mediterranean sea over 1200 km, pushing from the north to the south over more than 2000 km at the heart of the great desert of the Sahara (DGF, 1998). This area of about 29.3 million inhabitants where 90% of the population lives in the north band of the country presents a geographical configuration characterized by a series of great physical sets. A set of ecosystems coexisting throughout the Algerian territory: marine, coastal and fresh waters ecosystems from one hand and forest, mountainous, semi-arid and arid ecosystems on another hand, with the last representing about 80% of the whole surface (DGF, 1998). Three great mountain chains depict the landscape: the Tell Atlas chain with its steep slopes and very compartmentalized relief, reaching its highest point at 2300 m a.s.l at the massif of Djurjura; the Saharan Atlas chain with its massive morphology reaching 2328 m a.s.l at its highest point at the massif of Aures and the great volcanic massif of Hoggar in the central Sahara reaching 3000 m at its highest point (DGF, 1998). The physical configuration is expressed by a latitudinal zone characterized by the existence of climate on which the Mediterranean influence decreases when moving way from the sea: Humid (900-1800 mm/year), sub-humid (800-900 mm/year), semi-arid (300-600 mm/year), arid (100-300 mm/year) and Saharan (less than 100 mm/year). The rainfall gradient is observed from west to east, the oriental band is distinctly the wettest (DGF, 1998).
Throughout this territory, the Algerian flora contains 3139 higher plant species (Quezel and Santa, 1962). The fodder leguminous species constitute important feed resources for livestock and wild fauna in addition to their capacity for fixation of nitrogen in the soils (Lapeyronie, 1982). The present synthesis consists in stressing out the diversity of fodder leguminous in Algeria and their importance for local communities livelihoods, especially in the most deprived regions throughout the country.

The analysis was fulfilled on the basis of the Algerian flora of the southern desert regions conducted by Quezel and Santa (1962). It comes to back up the contributions made in the extent of the valuation and valorization of fodder resources in Algeria (Issolah, 1991; Issolah, 1997; Issolah et Abdelguerfi, 1995; 1998; 1999a; 1999b; 2000; 2001; 2002; 2003; 2004; Issolah et al., 1993; 2000; 2001a; 2001b, etc.)

**Distribution**


**Endemism**

Regarding its strategic geographical position, Algeria is rich in endemic species like the other countries of North Africa and Mediterranean regions, including some species of fodder legumes. The number of endemic species per genus in different region are reported Quezel et Santa (1962) as follows:

1. **Africa** (2)*: *Acacia* (5/2)**, *Argyrolobium* (3/1)**.
2. **North Africa** (6)*: *Astragalus* (40/1)**, *Ebenus* (1/1)**, *Hippocrepis* (6/1)**, *Onobrychis* (6/1)**, *Ononis* (34/41)**, *Melilotus* (1)**.
3. **North eastern Africa** (2)*: *Trifolium* (37/1)**, *Astragalus* (40/1)**.
4. **North western Africa** (2)*: *Astragalus* (40/1)**, *Melilotus* (8/1)**.
5. **Mediterranean** (4)*: *Astragalus* (40/1)**, *Lupinus* (5/1)**, *Medicago* (22/1)**, *Trigonella* (9/1)**.
6. Mediterranean - Sahara (1)*: *Alhagi* (1/1)**.
7. Sahara (1)*: *Astragalus* (40/2)**.
8. North Sahara (2)*: *Argyrolobium* (3/1)**, *Astragalus* (40/1)**.
9. West Sahara (1)*: *Crotalaria* (2/1)**.
10. Algeria-Tunisia (2)*: *Hedysarum* (9/2)**; *Lathyrus* (22/1).
11. Algeria-Morocco (1)*: *Ononis* (34/1)**.
12. Algeria (7)*: *Ononis* (34/6)**, *Astragalus* (40/3)**, *Hedysarum* (9/3)**, *Crotalaria* (2/1)**, *Lotus* (15/1)**, *Trigonella* (9/1)** and *Vicia* (26/1)**.

* The figures between brackets point out the number of genera containing endemic species.
** The figures between brackets indicate the number of endemic species with respect to the total number of spontaneous species existing in Algeria.

Nineteen (19) fodder genera are endemic in these regions with the most frequent ones are: *Astragalus* (7 times), followed by *Ononis* (3 times). *Argyrolobium* (twice), *Hedysarum* (twice), *Melilotus* (twice) and *Trigonella* (twice). Algeria contains 17 endemic species of fodder legumes belonging to eight genera (Table 2). The genera *Ononis*, *Astragalus* and *Hedysarum* are distinguished by the large number of species they contain. Among the endemic fodder legumes existing in Algeria 23.5% are located exclusively in the Sahara, whereas the remaining exist elsewhere in the Sahel, Saharan Atlas, High Plateaus, Tell and coastal areas.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Species</th>
<th>Localization</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Astragalus</em> L.</td>
<td><em>A. genitorum</em> Maire</td>
<td>Northern Sahara</td>
</tr>
<tr>
<td></td>
<td><em>A. faurei</em> Maire</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>A. feinii</em> Reinii Batt</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Littoral Sahels: area of Nemours (Moroccan borders).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ouarsenis to Ain Lelout.</td>
</tr>
<tr>
<td><em>Coronilla</em> L.</td>
<td><em>C. atlantica</em> Boiss. &amp; Reuter</td>
<td>Kabylie, Numidie, littoral (secteur algérois), Tellian atlas.</td>
</tr>
<tr>
<td><em>Crotalaria</em> L.</td>
<td><em>C. vialattee</em> Batt.</td>
<td>Occidental Sahara</td>
</tr>
<tr>
<td><em>Hedysarum</em> L.</td>
<td><em>H. naudinianum</em> Coss. &amp; Durieu</td>
<td>Tell constantinois (Bibans, Guergours), littoral and algérois tellian atlas</td>
</tr>
<tr>
<td></td>
<td><em>H. perralderianum</em> Coss. &amp; Durieu</td>
<td>(Zaccars, Ouarsenis, Boggars).</td>
</tr>
<tr>
<td></td>
<td><em>H. aculeolatum</em> Boiss.</td>
<td>Aurès, Bellezma, Bou Thaleb.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Littoral (West of Algeria), littoral Sahels and littoral plains of oranese sector.</td>
</tr>
<tr>
<td><em>Lotus</em> L.</td>
<td><em>L. roudairei</em> Bonnet</td>
<td>Northern Sahara and occidental Sahara</td>
</tr>
<tr>
<td><em>Ononis</em> L.</td>
<td><em>O. antennata</em> Pomel</td>
<td>Oranese littoral, littoral and algérois tellian atlas,</td>
</tr>
<tr>
<td></td>
<td><em>O. incisa</em> Batt.</td>
<td>littoral sahels and littoral plains of oranese sector.</td>
</tr>
<tr>
<td></td>
<td><em>O. crinita</em> Pomel</td>
<td>Algérois, oranese and constantinois high plateaus.</td>
</tr>
<tr>
<td></td>
<td><em>O. avellana</em> Pomel</td>
<td>Dahra: cassaigne, M’ sila.</td>
</tr>
<tr>
<td></td>
<td><em>O. megalostachys</em> Munby</td>
<td>Dahra between Ténès and Mostaganem.</td>
</tr>
<tr>
<td></td>
<td><em>O. rosea</em> Durieu</td>
<td>Saint Denis of Sig, Bou tieles, Tell algérois.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tell algérois.</td>
</tr>
<tr>
<td><em>Trigonella</em> L.</td>
<td><em>T. balachowskyi</em> Leredde</td>
<td>Tassili n’Ajjjer</td>
</tr>
<tr>
<td><em>Vicia</em> L.</td>
<td><em>V. fulgens</em> Batt.</td>
<td>Tell constantinois, littoral algérois, maison carre.</td>
</tr>
</tbody>
</table>

Utilization
In most range areas, fodder production is seasonal and influenced by weather conditions (IEMVT-CIRAD, 1992). The efficiency of fodder production transformation as animal products depends on the quality and quantity of consumed fodder (Ben Tamallah, 1987). In Algeria, the production of fodder is of extensive type. Around 82% of the total fodder production is provided by fallowed land, cereal stubbles, grazing and range lands, and only 8% is provided by forage crops (Houmani, 1999).


Concerning the Sahara flora, Ozenda (1977) noted that a lot of plants with mol and fleshy foliage, especially those of Cruciferaceae, Leguminoseae and some Chenopodiaceae are grazed by all animals; grazing is also extending to *Acacia* species and most annual plants (*Plantains*, *Tribulus*, and small cruciferous species), and to certain species regarded as tough like *Aristida pungens*. Camels are less demanding and can graze on hard grasses, thorny species of Chenopodiaceae family and small shrubs like the *Calligonum*. Sheep, goat and the equines are more demanding. The toxicity of various Saharan plant species was proven by several observations and by experiences (Foley et collab., Boué In Ozenda, 1977). The best known case is that of *Perralderia coronopifolia* which grows plentifully on rocky soils throughout the Oranese and Algerian Sahara, and far into the south till the Hoggar. Some species would not be apparently palatable like *Astragalus lusitanicus*, *Lotus jolyi*, *Lupinus angustifolius*, *Ononis spinosa*, *O. hispida*, *O. pubescens*, *O. viscosa*, *Lathyrus ochrus* and *L. tingitanus*. Abundant in western and central Sahara, Ozenda (1977) considered *Lotus jolyi* as a dangerous plant for flocks. Its noxiousness is due to cyanogenetic heterosides. According to Maire (1933) the plant is very poisonous and feared by Touaregs, who move away carefully their camels from places where this species grows. For *Retama raetam* Webb, Maire (1933) noted that the branches are toxic and these are avoided by herbivores that consume mostly flowers. The same author remarked that *Trigonella anguina* Del., and *Medicago laciniata* Mill. are good feed for all herbivores along with *Astragalus vogelii* (Webb) Bornm, *A. corrugatus* Bertol. var. *tenuirugis* (Boiss.) Coss. et Kral., *A. eremophilus* Boiss., and *Psoralea plicata* Del. *Astragalus pseudotrigonus* Batt. & Trabut is very appreciated by donkeys, less by camels, sheep and goat (Maire, 1933). *Alhagi maurorum* Medik. is considered as a good feed for herbivores. Tube-like roots are consumed by local community (Maire, 1933). *Tephrosia leptostachya* DC. is a useful plant grazed by camels and other herbivores and when dried is mixed with green tea and used by the Touaregs (Maire, 1933).

Conclusion
Algeria is a very large country, rich with spontaneous fodder species. The share of leguminous species is noticeable and has a particular interest. More studies are needed to update the Algerian flora released by Quezel and Santa in 1962, to assess the trends in species richness and abundance and to characterize the genetic resources and their uses. Their uses. This could lead to identification of areas for in situ conservation and
management of remaining populations of valuable species in close collaboration with local communities

References


DPFF. / Med wet/ LIFE-CE. pp 46.


On-farm Conservation of Barley Genetic Resources in Morocco

S. Saidi\textsuperscript{1}, A. Amri\textsuperscript{2}, and D. Jarvis\textsuperscript{3}

\textsuperscript{1} Institut National de la Recherche Agronomique BP 415, Rabat, Morocco.
\textsuperscript{2} International Center for Agricultural Research in the Dry Areas, P.O. Box 950764 Amman, Jordan
\textsuperscript{3} International Plant Genetic Resources Institute, Via dei Tre Denari, 472/a, 00057 Maccarese, Rome Italy

Keywords: On farm conservation, landraces, barley, Morocco

Abstract
Barley is grown in all parts of Morocco, with an annual acreage of 2.5 million hectares. Up to 80\% of the acreage is in the arid and semi arid zones. Landraces are still widely used and occupy more than 75\% of the barley sown areas. Farmers produce their own seeds, which are then kept and modeled from season to the next under natural and farmers selection pressures. Diversity generated by local production techniques and environment fulfills the needs of the farmers and matches the prevailing environment conditions. Preserving the genetic diversity present in the local populations is essential for the conservation of local agrobiodiversity and the traditional farming systems, and for sustaining of livelihoods of local communities under harsh environments. In situ conservation on-farm was proposed as a strategy for preserving these populations and research should be undertaken to support farmers and local communities in carrying on-farm conservation process. A number of questions are to be answered: What is the extent and distribution of genetic diversity in the farm? Who is in charge of maintaining this diversity? What are the factors affecting farmer decision to maintain local populations? It is understood that some questions were answered and constitute a basis to implement a strategy for in situ conservation, others are under study. Depending on the area, any given farmer exploiting between 5 and 11 hectares ensures seed stock whatever the production level is in a given season. A small number of farmers store enough seed for a minimum of six years. These farmers are considered the retainers of diversity. A given barley population, grown under the same cultural practices (selection, storage) and in the same plot, for decades, is considered to be specific to the farmer and constitutes a Farmer Unit of Diversity (FUD). The in situ conservation of barley is conceivable by improvement of production techniques. Seed quality and availability, good storage conditions, low-cost production packages and improvement of local populations through participatory plant breeding could contribute also production increases and conservation of landraces. Implementation of production processing units would be beneficial to production stability in terms of quantity and quality. A local seed production system and laws, local products trade, quality norms should facilitate and accompany all the actions to be taken to ensure the durability and integration of in situ conservation for the country’s agriculture development.

Introduction
In situ conservation of crop diversity deals with the preservation of available diversity in populations cultivated by farmers. The objectives are not simply to preserve alleles or genotypes but to allow for the evolution of these populations to their environment changes and to farmers manipulation (Altieri and Merrick, 1987; Oldfield and Alcorn,
The prerequisite for such evolution and adaptation is the existence of genetic variation (Land and Barrowcough, 1990; Hamrick and Godt, 1997). Continuous use of local varieties by farmers is part of the conservation strategy, but the knowledge of the amount and levels of genetic variation is necessary for the evaluation of conservation approach and effectiveness.

On farm conservation studies focused, at a certain time, on the link between local varieties preserved by farmers and environmental and socio-economic factors. In many cases genetic diversity of local varieties had been measured by abundance of alleles in a population (Zimmer and Douches, 1991).

Investigation of circumstances in which local varieties are considered as a part of the production system has not yet been initiated. This new approach will requires the development of a database and the establishment of scientific bases for in situ conservation of cultivated plants diversity needed to better understand the processes and mechanisms affecting genetic diversity under farmers’ practices.

Farmers do affect genetic diversity of their crop by the processes of planting, cultural practices, harvest and production management. They modify the genetic structure of the population by selecting plants on the basis of preferred agro-morphological traits. Thus they contribute changing in the genetic composition of local populations. Amount of harvest used by the farmer, quantities sold, exchanged or kept as seed for the next season greatly affect the genetic structure of the next generation. These decisions are related to environment conditions, social and economic environment in which the farmers live.

Local varieties are used in subsistence farming systems. This type of production system is practiced under harsh environments, where the average yields do not exceed 1.2 ton/ha in Azilal and 2.4 ton/ha in Taounate. Constraints to barley production are various: sloppy landscape, poor soils, low and erratic distribution of rainfall, low winter temperatures, hot summer winds and the low or no-inputs use. Production is essential for local use. Local varieties are still well appreciated by farmers of their good adaptation to the prevailing harsh conditions. The loss of this valuable germplasm will deprive breeding programs from valuable genes for adaptation to changes in environment and farmers communities from valuable food and feed resources.

This study aims at assessing the genetic diversity of landraces of barley and the factors which are affecting them and at presenting the technological, socio-economic and legal options for promoting their on-farm conservation and sustainable use.

**Materials and Methods**

Two diverse areas were chosen based on the predominance of using local varieties of barley: Azilal located in the Middle Atlas mountain at 120 km south-east of Beni Mellal and Taounate in the Pre-Rif region in Morocco. Farmers in these regions were surveyed on the importance of their landraces, their uses, and the preferred landraces attributes. Samples of landraces were collected to conduct trials on agro-morphological and to demonstrate to farmers technological options for increasing their productivity.

**Results and Discussion**

*Extent and distribution of genetic diversity maintained by farmers in space and time*

- Naming system of local varieties
A local variety designates an entity associated with concepts and practices of farmers. It is defined as a unit of large diversity selected on the basis of criteria that maintain its identity. It is designated by a name or a description that corresponds to an identifiable plant type. This is true for durum wheat but not always for barley. In fact, for the latter, the generic naming relates to the area or territory of use or generally called only Beldi meaning landrace.

The first step in genetic diversity analysis was to list local varieties used as farmer’s units of diversity for a given area: village, community, region. In case of barley, farmers know that each region has its own local populations. Regional distribution of these populations is done through farmers known as the providers of seeds.

Each farmer uses his own seeds and the barley population cropped under the same conditions for several generations becomes specific to that farmer, thus assimilated to a Farmers Diversity Units (FDU). This specific adaptation is used by farmers to separate different areas and to name populations based on the area of origin. This constitutes justification to buy seeds at the market place.

- **Description of local varieties**

  Agro-morphological traits of local varieties were noted for each site (Table 1). Exclusively, six row type local varieties are used, characterized by long awns, large kernels (>3.5mm), protein content ranging between 11 and 15% and germination at harvest is less than 90%. Plant height is between 1.0-1.5 meters.

  The adaptation peak corresponds to the association of appropriate traits to frequent environment factors. This was determined for each site of study. Optimal level for each trait under investigation (height, cycle length, reaction to diseases, head and leaf type) was defined. However, selective value of optimal levels in the association has to be measured. Characterization of collections permitted the identification, in some areas of lines different from the usual landraces. Informal pathways of seed acquired from other regions led to redefining local variety genetics. Male sterility was detected at flowering with an estimate of 1% average. Height was not randomly distributed between lines and the selection against short stature was significant.

  
  Table 1: Main characteristics of local varieties and their environment
  
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Taounate</th>
<th>Azilal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield potential</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Minimal acreage of diversity holder</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>Total units (richness)</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Allogamy rate</td>
<td>0.2-0.5%</td>
<td>&lt;0.1%</td>
</tr>
<tr>
<td>Within and between population diversity (%)</td>
<td>47-53</td>
<td>42-58</td>
</tr>
<tr>
<td>Average number of units/farm</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Reaction to diseases**

  Continuous cereal cropping is very common. This permits most fungi to complete their cycle and build up inoculums. To overcome this situation farmers tend to increase the seed rate in order to compensate for loss due to diseases such as bunts, smuts and Fusarium. Using new seed stocks can reduce the effects of these seed borne diseases but not soil borne ones. Thus, seed treatment is the best and most efficient mean of controlling of seed transmitted diseases.
The collected material was evaluated for reaction to diseases in the field. A very low proportion of lines were found to be resistant (2%). Partial resistance was detected in 5% of the tested accessions. Among susceptible populations, some produced a larger number of heads than others, showing that tolerance constitutes the basic mechanism for local populations to reduce the losses from diseases.

**Storage of the production**

Storage facilities and conditions were precarious. Survey data showed that most of the barley grain was stored in bags (85%) and in granaries (*Matmora* in local language) for a small portion. Since storage in all cases was done inside the houses, pesticides were not used for safety reasons.

**Genetic diversity preservation within farmer community**

**Typology of farmers**

Small scale subsistence farming is predominant in the study areas. Farmers rely on other sources of income with 35% of them having revenue outside farming activity. Three types of farmers were identified based on the availability of seeds, both of barley and durum wheat. The first group would continuously keep seeds from their own production. The second group uses their own seeds, except in successive dry years. Finally, the third group uses seeds produced by the former two groups, except in good years where they use their own seeds. Seed movement depends on the production level in a given year and type of farmer. In good years, all farmers use their own seeds and therefore no seed movement is taking place. In average year, 40% of farmers buy seeds from their neighbors or at the market place and 35% of farmers prefer this option. In low production year, small and medium farm size holders are obliged to get seeds from other sources when their own stocks are fully used. In the other hand, depreciation of seeds (diseases, weed seed) is one reason to acquire seeds from other sources in 75% of the cases (Saidi, 2003; Saidi, 2004).

**Factors affecting farmers’ decision to maintain local varieties**

**Adaptation to environment**

Comparison of improved and local varieties was carried out under farm conditions. Techniques applied for the trials were those practiced by the farmers. Plots of the experiment were sown to barley for the previous six years. Planting was done in rows, by hand. Soil was plowed once, no fertilizer was applied before planting and some was broadcasted afterwards.

Performance of improved varieties was greatly affected. A yield reduction of 40 to 75% was observed. Local varieties were not affected to the same extent. Adequate inputs were necessary for improved varieties to exhibit their potential: soil preparation, fertilizers application, etc. Local populations showed adaptation to low soil fertility levels and had some tolerance regarding pests in general. The advantage of local varieties over improved cultivars could also be attributed to the large genetic base of landraces which can explain their better stability over time. Therefore, for most farmers considering barley as low risk aversion crop, landraces are preferred over improved uniform varieties. Genetic structure of local populations offers advantages for evolutionary and adaptation to harsh and adverse environmental conditions (Schultze, 1988). For millennia of cropping, natural selection and farmers’ selection did not end up with an individual genotype with survival
and high performance traits. Combined effects of both selection types led to genotypes with different combinations of traits leading to population buffering. Such population structure is probably the best answer for adaptation to unpredictable and adverse environment conditions (Ceccarelli et al., 1987).

- **End-use of the production**
  Barley is used in various ways. Grain is mainly used as feed (80%) and for human consumption (20%). Straw contributes largely to feed animals during periods where grazing is providing the needs of flocks. This explains the tendency of farmers to prefer tall varieties. They would not even test improved short stature varieties with a high harvest index. Straw yield comes as second criteria after grain yield in farmer’s selection criteria.

- **Subsistence farming system**
  Various selection criteria are used by farmers but yield is a major one. In a subsistence system, self sufficiency is the main goal of farmers. As a consequence, deciding on which seed to use is very important and the farmer relies on information he gets from his social group. Human ecologists define social group culture as a mechanism organizing the flow of information that is essential to survival. Local knowledge is generally well developed for genetic resources due to their high priority in community survival and in subsistence farming systems. Language and local culture differences are the main channel to transmit this knowledge. Acting this way, spreading information would not cost as much as if one would test a new technology.

- **Landscape effect**
  Mountains and hills inter-crosse d by diverse physical-geographical units such as plains, plateaux, valleys and waterfalls are the main landscape in the area of Azilal and Taounate. These variations in physical structure create an environmental heterogeneity that might influence the adaptation and the genetic diversity of the barley populations. In the Azilal area, cropped land is located in lowlands and on the south side slopes. Because of low rainfall, plot situation greatly influences the yields. North side exposed plots are relatively more humid than south side plots. Differences in days to maturity may vary from 20 days in rainy years to 30 days in dry years. Yields may be doubled as well, but in rainy years yield differences are reduced and the situation may be reversed when rainfall is excessive.

Effect of land exposure on the barley production, therefore on seed availability, was investigated using correlation coefficients between production in rainy, average and dry years and land exposure (Table 2).

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Dry</th>
<th>Medium</th>
<th>Rainy</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>0.78</td>
<td>0.78</td>
<td>0.66</td>
</tr>
<tr>
<td>South</td>
<td>0.49</td>
<td>0.63</td>
<td>0.78</td>
</tr>
<tr>
<td>Low land</td>
<td>0.71</td>
<td>0.49</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Production is highly correlated to north side exposure both in dry and medium years. Low lands contribute largely to the production mostly in dry years. In south exposed land the
production increases as rainfall increases. Regardless of the amount of rain in a given year there is a compensation in terms of production, thus seed is generally available at the village level. This advantage affects land cost either for sale or rent and prices are higher for north side exposed land than south side exposed lands or lowlands.

Processes in genetic diversity conservation at the farm level
Seed production and availability, regardless of climatic and socio-economic constraints, is a prerequisite to maintaining cropping systems. Seed is kept from one season’s harvest for the next planting. Local varieties, made of a large number of lines, are maintained and modeled through mechanisms and farming practices that correspond to the needs and preferences of farmers and to the adaptation to environmental conditions. Long-term storage of seed by large farm holders, qualified as genetic diversity holders, to avoid natural disasters consequences (severe successive drought, flooding), is of major importance to crop diversity conservation. Seed treatment and storage facilities improvement led to reduction of losses and constitutes a guaranty for availability, mainly during dry years.

In situ conservation options
- Improvement of production techniques

Seed treatment
Availability of quality seeds is the basis of in situ conservation. In the area of study, continuous cropping of cereals is very common. The practice enhances inoculums build up of pathogens such as Fusarium, smuts and bunts, resulting in a reduction of about 37% in grain yield. To reduce the effects of diseases, farmers proceed by renewing seed lots. The objectives of the operation are to control the seed and soil borne pathogenic organisms by applying fungicides (seed treatment mainly). Three actions were undertaken: organization of field days to inform farmers on the importance of seed treatment; technical assistance during treatment operations and providing local farmers associations and farmers cooperatives with necessary equipment. Information days on problems caused by diseases and their control did encourage farmers to request seed treatment before planting. Effects of these treatments were noted on the uniformity of emergence and crop stand. Plots with treated seed were disease free and the success of this operation was made possible by the availability of the small equipment for seed cleaning and treatment and the technique is being integrated within the agricultural practices in the areas of study.

Reduction of losses during storage
Storage techniques used by farmers are precarious and losses are very high. Loss of the total production is not unusual. Storage facilities, mainly located within the homes are not adequate and do not permit any kind of pest control using pesticides because of safety reasons. Information sessions on this issue were organized and actions on improving storage techniques were demonstrated including reducing grain humidity by further drying in the sun, insecticide application to storage bags with appropriate products, cleaning the storage area and sealing of the granaries. The manual in local language was edited and distributed.
Weed control
Weeding is mainly done by hand at a late stage of the weeds in order to be collected to feed animals. At this stage, the damage is already done to the crop. In order to investigate the weed problem in the area, a trial was conducted under farmer conditions. Chemicals were applied at tillering stage followed by hand weeding two weeks later at stem elongation. Data showed that although chemical control of weeds is beneficial in all cases their application costs can not often be supported by subsistence farmers. We thus suggested that weeding be done by hand but at early growth stages.

- Improvement of local varieties by participatory approach
Early studies on the participatory barley breeding were carried out using pure lines from exotic origin (PPB, Barley, 1998). Farmers were very interested, but they focused mainly on biomass production rather than grain yield. Very few lines were adopted. This work introduced some modifications and improvement regarding the genetic material and the methodology used by previous study. Use of local populations was combined to direct selection in the target environments and under farmer conditions. The objectives were to improve local populations by rearranging their composition. Four selection criteria were used by farmers: grain yield (60% of farmers), kernel size, straw yield (estimated by plant height and by number of tillers by others), head size as an index of fertility used by 30% of the farmers. Farmer selection ended up with at least one population per site. Seed of these populations was increased in large quantities and distributed to farmers in their respective localities. This procedure will allow, to improve yield at the farm level and to maintain the level of population diversity. This strategy is being integrated in the national barley breeding program of Morocco.

- Development of the production processing
Implantation of local processing units will contribute to add-value to barley production. Installation of a mill for barley in the Azilal area along with better packaging and libeling are to be considered to increase the marketability of barley grain for human food.

- Legal options
Local seed legislation setting (organization, norms, and repartition) and trade of local products, including quality norms, must accompany the realization of the above mentioned actions. This will permit integration of in situ conservation in the agricultural development process in the country. Management of genetic resources is a complex issue. Significant progress has been achieved in terms of quantifying and analyzing distribution of diversity. This was done through IPGRI’s “Strengthening the scientific basis of in situ conservation of agriculture biodiversity on-farm” project. Effects of official policies and laws of agricultural development on the management of genetic diversity should be more investigated. Biodiversity conservation should be fully integrated in the whole system of agricultural development policies. Implementation of legislation in managing biodiversity conservation in economic and agricultural development planning is essential. Efficiency of legislation will depend on physical, socio-economical and cultural conditions in the target area. Data generated by analysis of these conditions will help setting an approach that takes into account local management of agrobiodiversity and factors affecting it. Such information is lacking in most cases and, if available, it is not integrated at the national level. Difficulties of integrating this information during the formulation of legislation are allowing for continued erosion of genetic diversity, which is determined by various time dependent factors. Multifactor nature of conservation and the use of
agrobiodiversity are challenging to agricultural development policies and to support and sustain on-farm diversity conservation. During the project’s Phase I, some factors relevant to maintaining diversity were identified. Seed production system is one example of how legislation can affect the process. Various factors do affect the seed production process such as the relative importance of formal and informal processes, environment, etc. Consequences on genetic diversity conservation and poverty reduction are to be handled together and any legislation option evaluated accordingly.

References
SESSION TWO

DOCUMENTATION AND CHARACTERIZATION OF AGROBIODIVERSITY USING NEW TOOLS
Managing Wheat Genetic Resources for Today, Tomorrow, and Forever

B. S. Gill

Wheat Genetic and Genomic Resources Center, Department of Plant Pathology, Throckmorton Hall, Manhattan, KS 66506-5502, USA.

Keywords: Wheat genetic resources, wild species, collection, maintenance, utilization.

Abstract
Wild relatives comprise a relatively rich, yet difficult to exploit, source of genetic variation for crop improvement. Many crossability, hybrid dysgenic, and recombination related barriers have impeded the large-scale use of non-progenitor species for wheat improvement. There also are many management and other issues related to successful utilization of wild relatives that need to be considered. These issues relating to the wheat genetic resources, their current status and future prospects will be reviewed as follows.
1. Collection, conservation, maintenance, and evaluation of wild species and cytogenetic stocks: The current status of wild Triticeae collections with focus on the annual Triticum/Aegilops complex and wheat cytogenetic stocks will be discussed. The goal here should be to identify centers of genetic diversity for these species at the molecular level as well as for useful traits and their conservation in situ and ex situ.
2. Cytogenomic resources and analysis: We must apply state-of-the-art techniques to the cytogenomic analysis of cultivated wheat and wild relatives for efficient transfer of genetic variation, its documentation, and exploitation in crop improvement.
3. Germplasm enhancement strategies: We must devise efficient strategies for germplasm development from progenitor and non-progenitor species and the evaluation of germplasm at the international level.
4. Germplasm availability: How will the germplasm be distributed and made freely available needs discussion.
5. International coordination of germplasm research: This is another area that needs discussion.

It is hoped that this presentation will lead to concrete steps for an internationally coordinated effort in the conservation and use of wild germplasm in wheat crop improvement.

Introduction
It is now an established fact that bread wheat (Triticum aestivum L. 2n=6x=42, genomic constitution: AABBDD) originated under cultivation following chance hybridization of perhaps one genotype of tetraploid wheat (T. turgidum, 2n=4x=28, genome constitution: AABB) and two genotypes of Aegilops tauschii (2n=2x=14, genomic constitution: DD) in a farmer's field in Caspian Iran, ca. 8000 years ago (reviewed in Li and Gill 2006). Following this bottleneck, the AB genomes of the first essentially monomorphic hexaploids were enriched through spontaneous hybridization with tetraploid wheats
native to the Middle East and the surrounding regions. The ensuing pentaploid hybrids (AABBD) are fertile and readily produce tetraploid and hexaploid progeny upon selfing or backcrossing to either parent. Later (beginning about 100 years ago), breeders began making 6x/4x crosses experimentally. The most celebrated example was McFadden’s transfer, in the mid 1930’s, of the Sr2 gene from the tetraploid genotype "Yaroslav emmer" to the 6x line "Hope". The Sr2 gene source in Hope has provided durable resistance to stem rust to numerous cultivars around the world for the last 60 years. However, the D-genome of our bread wheat was essentially monomorphic until recent times. McFadden and Sears produced the first synthetic wheat in 1944 from a cross of 4x wheat with *Ae. tauschii*. The 6x wheat by synthetic wheat hybrids was fully fertile and a genetic pathway was in place for accessing the tremendous genetic diversity of *Ae. tauschii*. Kihara and his colleagues at Kyoto University began collecting *Ae. tauschii* in the 1950’s, documented its tremendous genetic diversity, and also produced a large number of synthetic wheats. In the 1960’s, Kerber in Canada transferred several rust resistance genes from *Ae. tauschii* through synthetic wheat crosses. In the 1970’s, the genetic variability of *Ae. tauschii* was accessed through direct 6x/2x crosses. In the 1980’s, CIMMYT began a large-scale production of synthetic wheats. Sixty years following the report of first synthetic wheat, the synthetic derivatives are now poised to make a big impact in wheat improvement.

Durum and dicoccum tetraploid wheats were domesticated from wild emmer wheat perhaps ca. 10,000 years ago in northern Syria. Wild emmer arose 300,000 years ago from hybridization of a species related to present day *Ae. speltoides* (2n=2x=SS, genome: SS) and *T. urartu* (2n=2x=14, genome: AA). Diploid wheat, ‘*T. monococcum*’, was domesticated from the wild *T. monococcum* subsp. *aegilopoides* (2n=2x=14, genome: AA) ca. 13,000 years ago in southern Turkey. In general, variation from wild emmer is readily accessible but has been little used because many undesirable wild traits are also introduced at the same time. The genetic variation from A-genome diploids also can be accessed (except chromosome 4A of polyploid wheat can no longer pair with 4A of diploid wheat) albeit with difficulty because of crossability barriers and high male and female sterility of hybrid derivatives. Surprisingly, some distant relatives of wheat such as rye can cross more readily with wheat. The famous 1B/1R wheat-rye translocation arose in the progeny of a spontaneous wheat-rye hybrid more than 100 years ago. Similarly, wheat has been crossed with perennial grasses such as *Agropyron* for many decades. Research on cytogenetic transfers from non-progenitor species was reviewed recently (Qi *et al.*, 2007).

This brief historical overview of wheat germplasm origins indicates that our cultivated wheats (95% of cultivated wheat is 6x), because of their recent polyploid origin, have a very narrow genetic base. As we have uncovered the evolutionary history of the polyploid wheat, it has furnished us the means to exploit the tremendous genetic diversity of its diploid progenitor species. Therefore, the management and utilization of wild relatives for wheat germplasm enhancement is a critical present and future need. The Wheat Genetics Resource Center (now known as Wheat Genetics and Genomics Resource Center) was founded in the 1980’s, as the very name suggests, as a center without walls serving the wheat research community to ensure the free availability of germplasm, genetic and genomic resources, and knowledge for sustainable and profitable wheat crop production (http://www.ksu.edu/wgrc). We have recently reviewed research
and service contributions of WGGRC and the collaborating scientists during the last 25 years (Gill et al., 2006). To begin with, WGGRC research is focused on wild relatives of wheat, their collection, conservation, and utilization through classical, cytogenetic, and genomic manipulations. We have done surveys of wild species collections to identify the gaps in the collections and how to fill those gaps. We have evaluated the collections for pest resistance and other traits. We have identified centers of genetic diversity for pest resistance and molecular markers. To expedite genetic transfers from wild species, we have developed standard karyotypes and are isolating single chromosome addition, substitution, and translocation lines. The genetic materials including wild species and genetic stocks and improved germplasm have been widely distributed.

In this contribution, I would like to focus on some issues that need our immediate attention and action.

Management issues in wheat genetic resources research

Plant genetic resources, their management, and utilization will be critical in any scheme of sustainable and profitable agriculture. I have been fortunate to work with two giant plant geneticists, Charley Rick and Ernie Sears. Rick single handedly rescued tomato wild species from extinction, established the Tomato Genetics Resource Center, and extensively used wild species to improve productivity and sustainability of tomato crop. Ernie Sears, the father of wheat genetics, from whom I learned to fashion genetic tools (we call them cytogenetic stocks) for use in genome mapping and extracting genes from wild germplasm. With large collections of primitive and wild germplasm in our genebanks for most crop plants, most barely used, I began work with the view that we have plenty of germplasm collections for the present and the future needs. Over the years and especially as the genomic information about gene sequences and evolution became available, I have come to the realization that while our genebank collections may be sufficient for the near future, they are essentially seed morgues for the future generations. So what are the management issues in wheat genetic resources research? First of all, let us try to see what are we trying to manage? For guidance on this issue we go to Vavilov and the centers of origin and diversity of crop plants. Then we go to the work of Kihara and Sax for their pioneering work in interspecific hybridization and description of genomic constitution of crop plant relatives. Then comes Sears, chromosome engineer par excellence, and many others who have developed countless cytogenetic stocks for extracting and describing and deploying of the new genetic traits. Then we need to consider the genomics and bioinformatics revolution and their role in managing our biodiversity.

So managing of wheat genetic resources spans the whole gamut from wild species population structure; conservation in situ and ex situ; development, maintenance and distribution of cytogenetic stocks; molecular resources development and distribution; wheat genomics and gene identification; bioinformatics; gene mining; and gene deployment. Conservation of wheat biodiversity is perhaps the most pressing issue. Essentially, we need to manage the Vavilovian center of wheat genetic diversity so that it is available to breeders at 10, 100, 1000, 10000, or 100000 years from now! There has been a tremendous erosion of wild wheat and related species populations and habitat from Vavilov centers in the Middle East. Many of the population collection sites recorded in WGGRC genebank data, no longer exist in their native habitat. We have now a fair
picture on the regions of greatest genetic diversity for each of the wild wheat species. It is critical that we survey these regions and make suitable arrangements for conserving such regions. Why do we need to conserve these species populations and habitats in situ, even though we may have ex situ collections from these regions in our genebanks? Wild crop relatives must be conserved in their native habitats so that natural evolutionary processes can go on in response to environmental (global warming?!) and biological pest stresses, to provide useful relevant genetic variation for future crop breeding programs. Recently, we have shown that new gene evolution is a dynamic and rapid process. Weedy and wild relatives in close proximity of crop plants are spawning new disease specificities in response to the inoculum load due to crop monoculture (Gill et al. 2008). We have to understand that biodiversity is our lifeline, and the Vavilov centers of crop diversity must be protected as future harvest centers. If that is not possible we should consider repopulating and recreating these oases of diversity elsewhere.

Of course, we must actively use biodiversity in crop breeding programs. Among the four wild progenitors of bread wheat (AB wild emmer, A diploids, D diploids, and B (S) diploids), we have made the greatest effort using the D-genome diploid because of its excellent disease resistance. We could easily produce synthetics based on A-genome diploids such as AAAABB that are highly vigorous as bridging crosses with AABBDD wheat. We have outlined the management strategies of genetic variation in species carrying different genomes (Gill et al., 2006). Regardless, how to manage the biodiversity in crop improvement programs is an issue that needs lot of attention from wheat geneticists and breeders.

The major reason that limits the use of wild species in crop improvement programs is the difficulty of evaluation and transfer of target traits to a crop plant. Now, let us imagine that we can sequence the wheat genome and identify all the genes in the wheat plant (a monumental task but something that is feasible). The cloned genes can then be very efficiently used to mine novel genes from wild and non adapted germplasm. The novel genes can then be transferred to a crop plant by sexual hybridization or transformation. The new technologies also allow us to look at and explore gene deployment issues as well. Bioinformatics is a great tool that brings this huge data within the reach of everyone anywhere in the world. Bioinformatics needs in relation to management of wheat genetic resources also need to be addressed. Admittedly, above is a gross simplification but a continuum that threads wild species habitats to genetic resources to genome sequencing to bioinformatics is wherein lies the future of wheat breeding.

**Scientific issues in wheat genetic resources research**

Any management strategy must be based on solid science. Although we have done considerable work, much remains to be done in addressing many issues relating to biodiversity analysis, documenting centers of greatest genetic diversity for all wild wheat and Triticeae species, what is the best way to evaluate genetic diversity, how to efficiently utilize it and what kind of tools are needed to accomplish these goals? The scientific approach has to be multidisciplinary and all-inclusive. Along with genetic diversity data, we need data on soils, environment, ecology, and anthropology to mention a few.
**Political issues in wheat genetic resources research**
How to work effectively in an uncertain political environment that is the present day Middle East? Some of the hotspot regions of wild wheat diversity in Iran, northern Iraq, Syria, and Transcaucasia are not accessible for scientific exchanges and exploration. How do we gather political support for such an undertaking? For one, the international centers like ICARDA have to take a leading role. But then how do centers like ICARDA reconcile their role of developing improved cultivars and modern agricultural practices to the imperative of biodiversity conservation? I think both goals can be accomplished provided we have the political will and scientific consensus. I think the approach has to be from bottom up and the resident scientists in biodiversity hotspot regions have to be on the frontline.

**Socioeconomic issues in wheat genetic resources research**
What are the socioeconomic benefits of biodiversity conservation to the local farmers, villages, cities, and states in the region? This is a key issue. This is an issue that can be best addressed by social scientists and economists but there is now a precedent for this from other biodiversity conservation projects. Those lessons need to be applied for crop genetic resources conservation as well. Could there be a shrine at a place in Caspian Iran where bread wheat originated? Is there anything left there to build on? Will visitors come? I would think so but it is difficult to predict until some spadework is done about the current situation and the conditions in the target region.

**IPR issues in wheat genetic resources research**
This is an issue to which I have not given too much attention. Under the WTO treaty, genetic resources belong to the country where they are native. How to reconcile this right with the need for free sharing of germplasm? I would think there has to be some transparent system to identity, preserve and share of benefits downstream to its place of collection. If such a system can be put in place then there could be tangible benefits for those who will tend to biodiversity for humanity.

**Common platform for action**
Based on the above discussion, I propose the following plan of action. This plan is applicable to all crop plants.

- Recognize that *in situ* conservation is critical for sustainable agriculture and future food security.
- Appoint multidisciplinary team of experts with a charge to identify hotspots of genetic diversity for our major crop plants.
- Follow up with a more intensive survey of specific areas for designation as world centers of crop biodiversity.
- Recognize the host countries as the custodians of designated crop bioreserves.
- Provide adequate compensation for those directly affected by such designation.
- Consider creation of *in situ* conservation areas using *ex situ* collections.
- Actively engage current Future Harvest Center Scientists in *in situ* conservation. Crop Biodiversity Reserves will be the true future harvest centers.
The intent here is to get this issue on the table and hopefully we can engage a large number of scientists in such deliberations and move forward to ensure the future of wheat and other crops as staples of humankind.

**Acknowledgements**
I thank John Raupp with the preparation of this manuscript and many of my colleagues at the WGGRC whose research and lessons from that research form the basis of this manuscript. Our genetic resources research has been supported by a special USDA-CSRESS grant to Wheat Genetics Resource Center, the Kansas Agricultural Experiment Station, and the Kansas Wheat Commission.

**References**
Applying Geographical Information Systems (GIS), Remote Sensing, and Agro-Ecological Characterization in Agro-Biodiversity Assessments

E. De Pauw

Natural Resource Management Program (NRMP), ICARDA, P.O. Box 5466, Aleppo, Syria. Email: e.de-pauw@cgiar.org

Keywords: GIS, agro-ecological characterization, environment similarity analysis, biodiversity index.

Abstract
The richness in agrobiodiversity in ICARDA’s mandate region can be linked to the diversity of agroecologies and land use systems in the region. One of the key challenges in agrobiodiversity assessment is to make the linkage between agrobiodiversity at levels where it is actually gained or lost (household or community level), to policy-making levels (landscape, national or regional). Cheap geo-referencing tools, such as the GPS, appropriate sampling procedures at each level, secondary resource data including satellite-derived information, appropriate out-scaling tools, and integration in a geographical information system (GIS), make the seamless linkage between different levels of agrobiodiversity gain and loss increasingly plausible. An additional need is for an appropriate spatial framework for capturing and bridging the ecological and human dimensions of agrobiodiversity at different scales.

A first challenge in agrobiodiversity assessments is to harness the technological revolution brought by the GPS. The enormous simplification and increased accuracy it brought to determining locations, made possible new stationary and roving observation procedures, which essentially allow expanding the number of samples, and brings geographical positioning within the reach of virtually anyone. There is therefore much potential in devising participatory sampling procedures that allow optimal use of local knowledge in the assessment of agrobiodiversity at household or community level.

A second challenge is to ensure that disparate observations at household or community level do not stay site-specific and that they add to a spatial database where they can be linked to Agroecological data at landscape or regional levels, and to various socioeconomic levels. GIS has now become sufficiently mainstream, to allow a wide range of users to master entry-level capabilities of geo-referencing point data, thematic overlaying, projection and scale matching. However, the necessary analytical and modeling tools for the integration of multi-scale and multi-thematic information sources are still being developed. Some of the tools and datasets developed by ICARDA, under the umbrella term ‘Agroecological characterization’, are presented in this paper. The growing importance of remote sensing in agricultural applications is another silent revolution, from which agrobiodiversity assessments could benefit tremendously. The increasing availability and affordability of satellite-derived products at different scales and the ‘democratization’ of image analysis offer enormous potential for seamless zooming from the level of the site to an entire region. In addition, a global record of
spatially contiguous data of land use changes, available from various satellite and airborne sensors for the last 40 years, is an at present undervalued and underutilized public good that will prove increasingly its value in quantifying, validating and monitoring the drivers of agrobiodiversity changes.

**Introduction**

The dryland areas of the world are characterized by a very high diversity in agro-ecologies and agricultural systems. Climate is the first determinant of agro-ecological diversity in drylands. Already by the simple combination of major aridity and temperature regimes, 44 different agro-climatic zones can be differentiated world-wide (De Pauw, 2004). Rainfall distribution in relation to the inter-annual temperature pattern is also a major determinant. Within this heterogeneous climatic setting, the drylands of the world exhibit a tremendous diversity in landscapes, soils, geological substrata, surface water and groundwater resources. Topography plays a major role in modifying the moisture supply, by trapping or releasing precipitation, attracting occult precipitation, or by lowering the rate of evaporation at higher altitude. Different landforms, lithologies, sparsity or density of vegetation, and regional tectonics combined with the differential resistance of the parent rock to stress and shear, create wide differences in the properties of land to generate runoff and to accept and store groundwater (De Pauw et al., 2000).

Agro-ecological niches constitute another source of dryland diversity. These are areas where natural conditions and production systems show abrupt differences with their surroundings. Such areas can occur at different scales and be either man-made or natural. Irrigation development is the single most important factor in creating artificial agro-ecological niches in the drylands at all scales. Examples of natural agro-ecological niches are the large river floodplains of North and West Africa (Nile, Niger) and the semi-arid mountain ranges of the Sahara and the Arabian Peninsula (Hoggar, Tibesti, Yemen and Asir Highlands). At meso- and micro-scales oases are typical examples of highly productive areas owing to a reliable but highly site-specific water supply from springs.

Dryland agro-biodiversity is closely interrelated with the diversity of the dryland agro-ecosystems. This diversity of environments has agro-ecological and socioeconomic components, and expresses itself at different spatial and temporal scales. A thorough understanding of the sources of variability and scale factors within the natural and human elements of the dryland agro-ecosystems is therefore essential for assessing and conserving dryland agrobiodiversity in an effective and economical way. Such understanding of the linkages between agro-biodiversity and environment is unfortunately often sorely missing. Agro-biodiversity assessments are often afflicted by failure to ‘see the forest through the trees’. With too much emphasis on site-specific sampling and inadequate attention to the characterization of broader environments, they frequently are unable to generalize the observations at the sampling sites to broader environments.

A key challenge in agrobiodiversity assessment is thus to make the linkage between agro-biodiversity at levels where it is actually gained or lost (household or community level), to policy-making levels (landscape, national or regional). New tools, such as the GPS and GIS, methods of agro-ecological characterization, and international public
datasets are now available for facilitating this ‘outsding’. Outscaling also requires a framework for linking spatial variability at different scales to different levels of decision-making.

In this paper these tools, methods, datasets and scaled spatial frameworks will be described in brief. Some illustrating examples from ICARDA work related to agro-biodiversity assessment and environmental characterization will be provided, as well as a suggested approach for outscaling agro-biodiversity from the local level to higher levels of generalization.

**Agro-biodiversity and the scaled nature of agro-ecosystem diversity**

The site is the spatial unit of agro-biodiversity. Any particular combination of plant species is by nature site-specific. The site-specificity of agro-biodiversity is a major challenge for outscaling since no two pieces of land are exactly the same. The uniqueness of land can be the outcome of interactions of microclimatic, soil, terrain and land use conditions, but also from site history, or differences in human influence. Solving this complex issue starts with an understanding of the multi-scale nature of agro-ecosystems. At a global level the ‘drylands’ can be visualized as a single broad ecosystem (Fig. 1a). However, as we zoom into smaller areas, new levels of diversity unfold (Fig. 1b-d). The extrapolation domain for agro-biodiversity at a particular scale is determined by the similarity in agro-ecological and socioeconomic conditions with the next level. Once we understand that agro-biodiversity and agro-ecosystem diversity can be portrayed at different scales, the next step is to define agro-ecological entities that best capture the variations in environmental conditions at different scales.

**Agro-ecoregion**

Agro-ecoregions cover large parts of the globe, such as the semi-arid and arid drylands (Fig. 1a), the humid tropics, the mountains, the coastal zones etc. The agro-ecoregion concept is a suitable spatial concept for stating broad agricultural management and environmental issues and is useful for research planning. The Consultative Group on International Agricultural Research (CGIAR) includes a number of international research centers with an ecoregional focus, such as CIAT, ICARDA, ICRISAT, IITA. However, the agro-ecoregion concept is unable to capture the considerable variations in land and water resources within. In order to address specific problems in parts of an agro-ecoregion, it is necessary to define agro-ecological conditions more precisely.

**Agro-ecological zone**

The ‘agro-ecological zone’ concept allows capturing macro-scale variations of land attributes, which occur over large areas. Climate is a typical example of a land attribute that shows major variations at macro-scale, hence agro-ecological zones are often primarily defined by climatic characteristics (Fig.1b). A few agro-ecological zones would typically cover small countries, primary or secondary subdivisions of countries, such as provinces, regions and districts. The variations of the land attributes can be analyzed and mapped at mapping scales in the order 1:500,000 to 1:250,000. However, smaller scales (e.g. 1: 1,000,000) may be acceptable in areas with low variability, but larger scales (e.g. 1:100,000) may be needed in areas of high spatial variability. Macro-scale variations of terrain features can already be observed with low-resolution remote
sensing platforms, such as AVHRR or MODIS. More will be said about the possibilities offered by remote sensing later in this paper.

**Agro-ecological unit**
The ‘agro-ecological unit’ concept allows capturing *meso-scale* variations in the attributes of the land that occur over smaller but sizeable areas, such as watersheds or development project areas. Agro-ecological units would typically cover lower-level administrative subdivisions within countries, such as (groups of) villages. The variations of the land attributes can be analyzed and mapped at medium mapping scales, which are typically of the order 1:50,000 to 1:25,000. Smaller resolutions e.g. 1:100,000 may be acceptable in areas of low spatial variability. Meso-scale terrain variations can be observed by either high-resolution remote sensing, such as Landsat or SPOT, but also through visual observations. Landforms typically show variations at meso-scale.

**Agro-ecological niche**
The ‘agro-ecological niche’ concept allows capturing *micro-scale* variations in the attributes of land that occur over small distances, such as slopes, farms, fields. The variations of the land attributes can be analyzed and mapped at typical scales of 10,000 to 1:5,000. Smaller resolutions (e.g. 1:25,000) are acceptable in areas with low spatial variability. Micro-scale terrain variations can usually only be recognized through visual observations or closely spaced sampling and analysis. Soils and vegetation species often show variations at micro-scale. Very-high-resolution remote sensing platforms, such as IKONOS, can assist with the detection and characterization of agro-ecological niches. A specific example can best illustrate the meaning of and linkages between these spatial entities. Fig. 2 shows an agro-ecological niche within the Jebel Sheikh Barakat agro-ecological unit (Fig. 3). The latter is a largely unvegetated limestone hill, sticking out as the highest hill in the Massif of Belus, a barren limestone hill system in northwest Syria at 400-500 m elevation (Fig. 4), which itself is one of the many agro-ecological zones in the dryland agro-ecoregion. Agro-ecological entities at all scales are determined by the interactions between the land attributes that are most relevant at each scale. At smaller scales, climatic factors are probably the most important to differentiate agro-ecological entities, at larger scales landforms and soils become more important. This, however, is a simplification. In mountainous terrain, for example, major variations in climatic conditions are common over short distances. For agro-biodiversity assessments it is important to note that most observation and collection sites will be located at the level of agro-ecological niches, and that several of those may be adequate to assess the variability within a single agro-ecological unit. Difficulties usually arise in making the connection between agro-ecological units and agro-ecological zones, particularly when environmental information about broader levels of generalization beyond the agro-biodiversity sampling sites is not available. In addition, it is not always the case that different observation sites are different aspects of the same agro-ecological unit or belong to different ones. In the following section we look at international public domain datasets that allow linking the site to the wider dryland environments.
Fig. 1. Scaled representation of agro-ecosystem diversity
Fig. 2. A typical agro-ecological niche in the Jebel Sheikh Barakat agro-ecological unit: a small plot between limestone rocks with a few fruit or olive trees and barley in donkey-ploughed furrows.

Fig. 3. The Jebel Sheikh Barakat agro-ecological unit is a hill of 870 m elevation, part of the low-elevation limestone hill complex of the Belus Massif in northwest Syria.
‘Global information with local relevance’: new sources of spatial data

The universal availability of the Internet and its search engines have improved, in a spectacular way, knowledge about and access to various public sources of spatially referenced environmental information. In many cases the information is free of charge or can be obtained for a small fee; in other cases, e.g. for satellite imagery, there may be a (very) substantial cost involved. These global databases continue to develop into an impressive (and underutilized) public good. Caution is required in their use. The quality, accuracy and observation density is often variable, and specialist skills may be needed to transform, use and integrate these databases for agro-biodiversity assessments. ICARDA has applied and adapted several of them, and generated some of its own, for use from sub-national to regional scale. Without going into extensive descriptions of individual datasets, the following sections will provide a brief overview on some of the public domain datasets that may be particularly useful in agro-biodiversity assessments. They relate to the most relevant environmental factors: climate, soils, topography, land use/land cover. In addition, some mention will be made of the new tools of direct earth observation, satellite imagery and remote sensing.

Climate

Climatic information is available for specific stations globally from national or international sources. In many countries national meteorological services have an open-public-access policy with nominal charges, and in such cases they are the best source of
climatic data. In other parts of the world, particularly the CWANA region, access to climatic information is restricted to the public at large by high acquisition costs, red tape and lack of quality control (De Pauw, 2000). In addition, the station network may be less dense and not necessarily cover all climatic conditions in the region (Fig.5).

Fig. 5. Climatic stations in the FAOCLIM2 database. Note the lower density in the CWANA region (marked in gray).

In order to overcome these problems, several international organizations have developed international quality-controlled climatic datasets, which are available to the public at large. The Food and Agriculture Organization of the United Nations (FAO) has released several databases which have proven highly successful in filling the data gaps in certain parts of the world. The FAOCLIM2 database\(^1\) (FAO, 2001) contains world-wide climatic averages and time series for selected stations on monthly basis. A follow-up version NewLocClim\(^2\) contains a much expanded data archive with possibility to derive site-specific estimates for various climatic parameters using different interpolation options. The International Research Institute for Climate and Society (IRI) acts as a data portal to the National Climate Data Center (NCDC)\(^3\) for the provision of global station data at daily basis. The archive is constantly updated with new information from stations under the World Meteorological Organization (WMO) Global Telecommunications Systems (GTS) agreement. The NCDC also maintains a web site with many climatic variables worldwide, of which the most useful for areas outside the USA is probably the Global Daily Climatology Network (GDCN)\(^4\). The International Water Management Institute (IWMI) has recently revamped its Web data portal\(^5\) for allowing users to obtain estimates of various climatic parameters, including both normals and time series, for any land site on the globe. These estimates are based on gridded data with 0.5 degree resolution

\(^1\) http://www.fao.org/sd/2001/EN1102_en.htm
\(^2\) ftp://ext-ftp.fao.org/SD/SDR/Agromet/
\(^3\) http://ingrid.ldeo.columbia.edu/SOURCES/.NOAA/.NCDC/.DAILY/.STATION.cuf/
\(^4\) http://www.ncdc.noaa.gov/oa/climate/research/gdcn/gdcn.html
\(^5\) http://dw.iwmi.org/dataplatform/ClickandPlot.aspx
(approximately 50x50 km cell size), obtained from the Climate Research Unit (CRU) of the University of Reading. Although the time series are valuable in their own right, the coarse resolution of the gridded data makes them less suitable for integration with fine-scale agro-biodiversity observations. In accessing these public climatic databases it is worth noting that they all have export facilities, some more user-friendly than others, and require transformation by the users into the specific formats they are interested in. Moreover, with the exception of the NewLocClim, which contains interpolation facilities, and the IWMI gridded data, the data all refer to stations and are therefore not necessarily relevant for a particular site where agro-biodiversity observations take place.

**Soils**
The FAO Digital Soil Map of the World (SMW)\(^6\) provides global coverage of soil information at 1:5,000,000 scale. The units are soil associations, described in terms of type and relative abundance of component soil units, classified according to the FAO soil classification system (FAO, 1974), and are therefore in general not homogeneous. In some parts of the world so-called SOTER (Soil-Terrain) maps are available. These are national soil coverages for selected countries\(^7\), with mapping units structured according to a soil-physiographic framework. The mapping units are well-described landforms, or terrain units, in which, as in the FAO SMW, the soils information is available in the form of an association. Unlike the SMW, the mapping units are validated by linkage to well-described soil profiles in a relational database structure. In addition to the polygon-based SMW and SOTER maps, which are therefore interpretations of raw data, a global archive exists with point-specific soil observation data. The WISE database\(^8\) is a global soil profile database (Batjes et al., 2002) which contains more than 4,000 soil profile and 15,000 horizon data linked to the FAO soil units. Soil maps in specialized national mapping services will in many cases provide more detail, but they may be either non-existent at the right scale for the area of interest or not available to the general public. Therefore, while the low resolution of the mapped soil units and their internal lack of homogeneity make them less suitable for correlating local-level agro-biodiversity observations with larger-scale soil patterns, the above public domain data sources are certainly helpful in those instances where no more detailed soil information is available.

**Terrain**
It is probably in availability of terrain data that the most critical advances have been made over the last decade. Previously terrain data only existed in the form of topographical maps at different scales, with availability set by national policies of public access. Nowadays terrain data is available globally at different resolutions in the form of digital elevation models (DEM), which are simply raster files containing only elevation data. In many cases these DEMs have resolutions approaching the detail of topographical maps at 1:50,000 scale and can therefore be useful replacements for the latter, at least for the terrain component, in cases where such maps are not available or their use is restricted.

\(^{6}\) http://www.fao.org/AG/agl/agll/dsmw.htm
\(^{7}\) http://www.isric.org/UK/About+ISRIC/Projects/Track+Record/SOTER+data.htm; http://www.fao.org/ag/aGL/agll/soter.stm
\(^{8}\) http://www.isric.org/UK/About+ISRIC/Projects/Track+Record/WISE.htm
The most important DEMs at global level are GTOPO30 and SRTM. GTOPO30\(^9\) was released in 1990 with 30 arc-second (approximately 1 km) resolution. A successor version of GTOPO30 called SRTM30\(^{10}\) came out recently, with many corrections based on the high-resolution SRTM\(^{11}\) (Shuttle Radar Topographic Mission) which was released in 2000. Resolution of this global dataset is 3 arc-seconds (90 m), and 1 arc-second for the continental USA. For some other parts of the world a DEM at 30 m resolution, derived from ASTER\(^{12}\) imagery can be obtained. The importance of resolution is illustrated in Fig. 6. For agro-biodiversity assessments the 30-m resolution is optimal, although the 90-m resolution already offers a very good approximation of natural terrain features.

![Fig.6. Effect of pixel size on landscape pattern visibility.](image)

Topographic features commonly derived from a DEM include single topographic parameters, such as elevation, slopes or aspect, but also combined parameters, such as landforms (e.g. based on elevation and slopes) or measures of curvature.

**Satellite imagery**

Remote sensing platforms exist now that can link the agro-ecoregion to the agro-ecological niche. Fig. 7 gives a non-exhaustive list of platforms with their potential use in different agro-ecological entities. Costs for satellite products tend to drop and are generally proportional to the resolution of the imagery, ranging from being virtually free (AVHRR, MODIS and SPOT Vegetation) to very expensive (IKONOS). In view of the fact that most platforms tend to cross scales, remote sensing has major potential for transferring research results from one site to another. The processing methods currently available in image processing, such as supervised classification methods and hierarchical decision trees, are very powerful tools for assessing similarity within the scale ranges of each platform, a principle applied e.g. for land use/land cover classification (see further). In addition, there is a high potential for outscaling across platforms, based on the similarity in spectral signatures.

---


\(^{10}\) http://www.dgadv.com/srtm30/

\(^{11}\) http://srtm.cgiar.org/SRTM_FAQ.asp

\(^{12}\) http://edcimswww.cr.usgs.gov/pub/imswelcome/
Land use/land cover

Land cover and land use are related but different mapping themes. The objective of mapping land cover is to describe and locate natural or man-made resources, whereas land use mapping aims to identify the goals, products and benefits from these resources. In practice, it is not always easy to dissociate them, hence they are often mapped together. Land cover/land use is one of the most useful environmental themes in agro-biodiversity assessments, allowing to link individual plants and plant communities, identified from field surveys, to physiognomic types, which themselves are more easy to upscale through remote sensing. The first digital raster-based global land cover map was produced from AVHRR data by the International Geosphere-Biosphere Program (IGBP) in 1991 with an approximate scale of 1:5-2,000,000. It was followed in 2000 by the Global Land Cover 2000 raster-based map produced under coordination of the Joint Research Centers (JRC) of the European Union. This product, at 1 km resolution, is based on data from the Vegetation sensor aboard the SPOT4 satellite. The GLC 2000 map itself is scheduled to be overtaken in 2006 by a new global mosaic with 300 m full resolution, to be produced in the Globcover Project from the MERIS sensor on the ENVISAT satellite of the European Space Agency. In addition to these existing or scheduled global raster products with resolutions ranging from minimum 8 km to maximum 300 m, many countries in Africa have fairly detailed land cover maps, generated through FAO’s AfriCover mapping project. These vector maps, most of which are public domain, can be downloaded from a dedicated FAO web site. They have scales ranging from 1:250,000

13 AVHRR: http://www.class.noaa.gov/nsaa/products/welcome
14 Aster and MODIS: http://edcswww.cr.usgs.gov/pub/imswelcome/
15 Landsat: http://edcsns17.cr.usgs.gov/EarthExplorer/
16 SPOT: http://sirius.spotimage.fr/anglais/welcome.htm
16 Documentation: http://edcsns17.cr.usgs.gov/glcc/globdoc2_0.html; Download:
http://islscp2.sesda.com/ISLSCP2_1/html_pages/groups/veg/edc_landcover_xdeg.html
15 http://www-gvm.jrc.it/glcc2000/
16 http://www.africover.org/system/africover_data.php
to 1:100,000 and use legends based on FAO’s own Land Cover Classification System (LCCS).

‘Putting it all together’: the power of Geographical Information Systems

The datasets described in earlier sections may be useful in their own right, but maximum efficiencies will be obtained only when combined with each other in a GIS.

A GIS is multi-dimensional: it has elements of a database, a general-purpose tool and an organizational set-up (Burrough and McDonnell, 1998). At the heart of the spatial information system is a database in which most of the data are spatially referenced. The database is linked to a suite of programs offering tools for collection, storage, retrieval, transformation and display of spatially referenced data. In most organizations GIS will occupy a special organizational niche and operate as a centralized entity, with its own specific technology, professional staff and specialized production line (spatial information). GIS is a major paradigm shift in the way we handle geographical information. In the not too far past the map was the information system (Fig.8).

Fig.8. The pre-GIS approach to mapping

GIS transformed the way we handle spatial information from a map-based paradigm to one centered around a database system, containing location and topological information (spatial objects) linked to attribute tables (Fig.9). The resulting system is capable of producing different kinds of maps, depending on the database queries and built-in transformation rules. In such system the map is no longer the database but a view inside the database (Fig.10).
Fig. 9. Soil map of Syria: linking the map to a database

Fig. 10. GIS as a database paradigm: each map is a window into the spatial information system
GIS has very powerful capabilities that allow generating new maps from existing ones or from georeferenced objects. The main GIS principle is the ‘overlay’, in which a new layer is created by the superposition of different thematic layers. The overlay approach includes map calculations and other transformation functions on grid data layers. Examples of how these capabilities can be used for agro-biodiversity assessments will be presented later in this paper.

**Knowing where we are’: satellite-based positioning with the GPS receiver**

The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. The GPS system uses these geostationary satellites as reference points to calculate positions accurate to a few meters. A GPS receiver measures distance from the satellites using the travel time of radio signals and can then calculate by triangulation the exact position on the earth surface. Being cheap (US$100+), the GPS receiver is a ‘cool tool’, requiring about the same skill level as a mobile phone. It avoids use of difficult-to-obtain, outdated or inaccurate maps, the data are easily exported and can be integrated with others in a GIS. The GPS brings geographical positioning within the reach of anyone and can thus be considered a genuine leap in technology leading to a virtually ‘free’ product (position location). As for all kinds of field surveys, the GPS is a godsend for agro-biodiversity assessments, allowing greater mobility and, by integration within a GIS, accurate linkage with secondary data sets.

**Approaches for outscaling agro-biodiversity observations: building on ICARDA experiences**

The multi-scale agro-ecological framework discussed earlier can be used to extrapolate agro-biodiversity observations from one specific site to another. The first step is to identify the agro-ecological characteristics of each observation site. The second step is to assess similarity in environmental conditions of locations in a ‘target’ area with that particular observation site. In the following sections some methodologies and approaches to outscaling with applicability in agro-biodiversity assessments, developed by ICARDA’s Agro-ecological Characterization Project, will be outlined.

**Agro-ecological characterization of agro-biodiversity sites**

In the context of the UNDP/GEF Project “Regional Conservation and Sustainable Use of Dryland Agro-Biodiversity of the Near East” all pilot areas in the participating countries (Jordan, Lebanon, Palestinian Authority and Syria) required an agro-ecological characterization. In view of their value as biodiversity sanctuaries, Haffeh and Sweida were selected as target areas in Syria for the Agro-Biodiversity Project. To understand the biophysical environment within these target areas, a comprehensive inventory was undertaken of the land resources, including climate, landscapes, soils and land use. ASTER satellite imagery was the basis for developing a DEM of each area. From the DEM elevation and slopes were extracted, which allowed the definition of landforms and terrain characteristics. Representative soil profiles were dug at the monitoring sites and in some other areas of interest, and their morphological, physical and chemical characteristics were determined. The information of the soil profiles was combined with already existing local soil map information to create new soil maps at approximate scales of 1:65,000 for Haffeh and 1:175,000 for Sweida. To predict where similar terrain and
soil conditions occur as in the monitoring sites, a similarity map was prepared for both target areas. A general analysis of the land cover/land use was conducted through supervised classification of Landsat images using the CORINE II classification. A more detailed study, based on Landsat imagery in combination with intensive fieldwork, was undertaken to prepare a land cover/land use map using the CORINE Level 3 classification. The CORINE III land cover map is linked with a spatial database that contains information on land cover/use, the occurrence of small landscape elements and a biodiversity rating which depends on the quantity and the kind of natural vegetation present.

The Syrian experience with agro-ecological characterization of agro-biodiversity target areas shows that this investment in understanding the local environment at the level of agro-ecological units pays off. Unfortunately the botanical surveys, undertaken at agro-ecological niche level, were scheduled simultaneously and could therefore not make use of this information. As shown later by similarity analysis, they were not always undertaken in the most representative sites. It is to be noted that the selection of monitoring areas was done on the basis of the presence of targeted wild species. A second conclusion was that there is a need for comprehensive guidelines for agro-ecological characterization to be applied across all agro-biodiversity sites.

**Biodiversity rating at landscape level**

One of the pay-offs from the agro-ecological characterization of the agro-biodiversity target areas in Syria was that the GIS database could be used to derive a landscape-level system of biodiversity ratings. Biodiversity rating is a tool used to evaluate the importance of biological diversity within particular landscape elements. As the spatial database contained, for every mapping unit, information on land cover/use (with a maximum combination of three kinds of land cover/use for every mapping unit), their coverage (in percent), the occurrence of small landscape elements (e.g. hedges, terraces, wadis, large trees, and land reclamation), it could be converted into a biodiversity rating scale, which depends on the amount and type of natural vegetation present (Table 1). This rating system uses physiognomic classes, based on easily observable features, and can be adapted to different land-use/land-cover classification systems. It is therefore particularly suitable for rapid visual assessment and mapping at the level of agro-ecological units. Obviously it is not intended to replace detailed botanical surveys at sampling sites. But, because of its focus on meso-scale variability, it can be used to target these surveys more precisely and to ensure that sampling is representative. Because the rating system is linked to a detailed land-use/land-cover classification, the rating is objective and reproducible. At the same time, the fact that the rating scale relies on visual observations provides a reality check and makes optimal use of expensive and time-consuming field work. The rating scale can also be developed in a participatory manner to ensure that local values are incorporated, and can be adapted to different land-use/land-cover classification systems. The combination of visual observations and remote sensing therefore makes accurate mapping possible. The Biodiversity Rating Map for the Sweida area is shown in Fig. 11.
Table 1. Relationship between land-cover/land-use types (CORINE Level 3) and biodiversity ratings.

<table>
<thead>
<tr>
<th>Land cover/use (CORINE Level 3)</th>
<th>Biodiversity rating†</th>
<th>Land cover/use (CORINE Level 3)</th>
<th>Biodiversity rating†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous urban fabric</td>
<td>1</td>
<td>Agro-forestry areas</td>
<td>4</td>
</tr>
<tr>
<td>Discontinuous urban fabric</td>
<td>1</td>
<td>Broad-leaved forest</td>
<td>6</td>
</tr>
<tr>
<td>Industrial or commercial units</td>
<td>1</td>
<td>Coniferous forest</td>
<td>4</td>
</tr>
<tr>
<td>Road and rail networks and associated land</td>
<td>1</td>
<td>Mixed forest</td>
<td>6</td>
</tr>
<tr>
<td>Airports</td>
<td>1</td>
<td>Natural grasslands</td>
<td>6</td>
</tr>
<tr>
<td>Mineral extraction sites</td>
<td>1</td>
<td>Maquis (tall shrubs)</td>
<td>6</td>
</tr>
<tr>
<td>Construction sites</td>
<td>1</td>
<td>Garrigue (short shrubs)</td>
<td>6</td>
</tr>
<tr>
<td>Green urban areas</td>
<td>2</td>
<td>Transitional woodland scrub</td>
<td>5</td>
</tr>
<tr>
<td>Sport and leisure facilities</td>
<td>1</td>
<td>Bare rock</td>
<td>2</td>
</tr>
<tr>
<td>Non-irrigated arable land</td>
<td>1</td>
<td>Sparserly vegetated areas</td>
<td>2</td>
</tr>
<tr>
<td>Permanently irrigated land</td>
<td>1</td>
<td>Burnt areas</td>
<td>1</td>
</tr>
<tr>
<td>Vineyards</td>
<td>1</td>
<td>Inland marshes</td>
<td>6</td>
</tr>
<tr>
<td>Fruit trees and berry plantations</td>
<td>1</td>
<td>Salt marshes</td>
<td>6</td>
</tr>
<tr>
<td>Olive groves</td>
<td>1</td>
<td>Saline depression</td>
<td>3</td>
</tr>
<tr>
<td>Pastures</td>
<td>1</td>
<td>Water courses</td>
<td>1</td>
</tr>
<tr>
<td>Annual crops associated with permanent crops</td>
<td>2</td>
<td>Water bodies</td>
<td>1</td>
</tr>
<tr>
<td>Complex cultivation pattern</td>
<td>1</td>
<td>Mixtures of fruit trees + vines in equal quantities</td>
<td>1</td>
</tr>
<tr>
<td>Land principally occupied by agriculture with significant areas of natural vegetation</td>
<td>4</td>
<td>Mixtures of fruit trees + olive trees in equal quantities</td>
<td>1</td>
</tr>
</tbody>
</table>

† Biodiversity rating: 1 = none, 2 = very low, 3 = low, 4 = medium, 5 = high, 6 = very high biological diversity.

Fig.11. Landscape–level biodiversity rating of Sweida
**Environmental similarity mapping**

A key principle in outscaling eco-geographical surveys is that the more similarity in the environments between the sampling site (‘match location’) and the compared sites (‘target locations), the more likely that similar species or varieties will be found or could be introduced successfully. At ICARDA several approaches for quantifying similarity have been developed.

**Similarity index mapping**

A first approach is to quantify similarity on a continuous scale using a similarity index derived from a distance function describing the difference between environmental variables in the match location and in the target area. To test this concept, a GIS study was undertaken to define the extrapolation domain for Khanasser, Syria, currently the most important benchmark site for ICARDA’s research into integrated natural resource management. The approach used two different spatial frameworks for representing similarity in either biophysical or socioeconomic conditions. To map biophysical similarity, only climatic parameters (temperature and precipitation) were considered. Climatic similarity was assessed by constructing a similarity index, based on simple distance functions, and comparing the monthly temperature and precipitation averages at the ‘match’ location (Khanasser) with those in the target region (CWANA region and the northern Mediterranean). Similarity indices were first calculated for precipitation and temperature separately, and afterwards in combination. To map similarity in production systems, a regional Land Use/Land Cover map previously developed by ICARDA was used. Only those land-use classes associated with the main production systems of Khanasser (rainfed crop production and natural rangeland management) were retained. By combining the areas identified using the climatic similarity indices with the relevant land-use/land-cover classes in one map, areas with climates and socioeconomic conditions (patterns of land use/land cover) highly similar to Khanasser were identified (Fig. 12). Table 2 summarizes the areas with different levels of similarity. This confirms earlier findings that only a small part of the CWANA area is similar to Khanasser.

Table 2. Land areas with high similarity to Khanasser (Syria), derived from mapping of climatic and land-use/land-cover characteristics.

<table>
<thead>
<tr>
<th>Similarity index†</th>
<th>Approximate land area in CWANA and N. Mediterranean (sq. km)</th>
<th>Percentage of land area in CWANA and the N. Mediterranean</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.4</td>
<td>22,960,072</td>
<td>93.11</td>
</tr>
<tr>
<td>0.4 - 0.5</td>
<td>1,201,864</td>
<td>4.87</td>
</tr>
<tr>
<td>0.5 - 0.6</td>
<td>406,495</td>
<td>1.65</td>
</tr>
<tr>
<td>0.6 - 0.7</td>
<td>65,338</td>
<td>0.65</td>
</tr>
<tr>
<td>0.7 - 0.8</td>
<td>16,491</td>
<td>0.07</td>
</tr>
<tr>
<td>0.8 - 0.9</td>
<td>8,177</td>
<td>0.03</td>
</tr>
<tr>
<td>0.9 - 1.0</td>
<td>1,639</td>
<td>0.01</td>
</tr>
</tbody>
</table>

†Higher values reflect greater similarity.

The similarity index mapping approach has advantages and disadvantages for agrobiodiversity assessments. The main advantage is that an entire agro-ecoregion can be

---

17 ICARDA Annual Report 2000, pp.49-52
compared in a quantitative manner with a site. A disadvantage is that only continuous variables, such as climatic data, lend themselves well to a quantitative comparison on a continuous scale. Combining these continuous indices with discrete variables based on classification, such as land use/land cover, either results in zero similarity or does not affect the index at all.

Fig. 12. Parts of CWANA and the northern Mediterranean countries with climates and land use/land cover patterns highly similar to Khanassir

**Mapping agro-ecological zones**

A second approach for mapping similarity is by combining discrete classes based on the combination of different environmental themes. Agro-ecological zones (AEZ) are integrated spatial units based on the combination of water resources, climate, terrain, soil patterns and land use systems. Agro-ecological zones were mapped for the entire CWANA and northern Mediterranean region at 1 km resolution by overlaying of single raster themes related to climate, terrain, soils and land use. The themes used for overlaying are *simplifications* of more complex thematic classifications. Simplification was necessary in order to avoid (i) a replication of the single-theme maps, and (ii) unnecessary complexity for the purpose of the AEZ map. Simplified agroclimatic zones (ACZ) were established by aggregating the agroclimatic zones of the UNESCO classification system (1979). The ICARDA land use/land cover map of CWANA and the Northern Mediterranean (Celis and De Pauw, 2003) was simplified from 12 to 3 classes and the landform map from 7 to 3 classes. Soils proved more difficult to simplify. Together with topography, they are the main factor of spatial variability in the region. Within CWANA and the northern Mediterranean 1047 soil associations occur, characterized by varying combinations of 112 basic FAO soil types. The reduction of this vast variability by regrouping was necessary in order to establish ecosystems that were not over-fragmented or differentiated on the basis of small variations. Simplification of
soil attributes was done in two steps. First the 112 FAO soil types were converted into 9 broader groupings that are relevant to their broad management properties (‘soil management groups’):

- Agricultural soils
- Soils of wetlands, poorly drained areas and floodplains
- Sandy soils
- Sodic and saline soils
- Rock outcrops and shallow soils
- Semi-desert soils
- Desert soils
- Non-agricultural soils
- Soils with high acidity and/or low nutrient status

Using these new soil groupings the Soil Map of the World was converted by reclassifying each of the 1047 FAO soil associations into a ‘Soil Management Domain’. A soil management domain is a combination of the main soil management groups inside an FAO soil association. After cleanup procedures in GIS to remove spurious or inconsistent mapping units, created by the overlaying process, a total of 677 agro-ecological zones were identified in the CWANA and northern Mediterranean region. A sample from this huge region is shown in Fig.13.

Fig.13. Extract from Agro-ecological Zones Map (southern part of Central Asia)

The AEZ approach to similarity assessment is holistic: it integrates the most relevant aspects of the natural environment (climate, land use/land cover, landforms and soils).
The units established through the overlaying process are substantially different from each other, because the number of possible combinations has been reduced dramatically. A disadvantage is that similarity can only be expressed in a binary mode (‘similar/not similar’) and not on a continuous scale. Moreover, the geographical distribution and extent of the AEZ classes will depend on the particular class thresholds used. Despite such disadvantages, an AEZ spatial framework, given its holistic nature, is extremely useful for outscaling of eco-geographical survey results from the level of the agro-ecological niche to the agro-ecological zone.

**Using GIS and remote sensing for rangeland rehabilitation strategies**

Rangelands are the main land cover type in the CWANA region and many of those are degraded. In the framework of a project, funded by the Swiss Development Corporation, to develop sustainable rangeland management strategies, a case study was undertaken in the Aleppo and Hama ‘steppe’ areas in NW Syria, covering an area of about 5000 km² to use GIS and remote sensing for the rapid identification of areas where vegetation degradation is most pronounced, and where prospects for rangeland rehabilitation are more or less favorable. The climate of the area is arid, with an average annual precipitation below 200 mm and the terrain is mostly lowland with elevations ranging between 200 and 800 m. The rangeland vegetation cover consists of various steppe species, mainly *Noaea mucronata*, *Artemisia herba-alba*, *Haloxylon articulatum* and *Salsola vermiculata*. There are also numerous Government plantations with *Atriplex* species. A GIS database was established for the area, containing georeferenced observations of soils and vegetation at 116 sites as well as the socioeconomic characteristics of 58 settlements and villages. These survey data were linked to secondary data such as roads, streams, and village locations, obtained from 1:50,000 topographical maps, as well as areas protected from uncontrolled grazing, lakes and *sabkhas* (saline seasonally inundated depressions), obtained from Landsat imagery, and the so-called ‘steppe line’, an administrative boundary corresponding roughly with the 200 mm annual precipitation isohyet. Altitude, slopes and landform (slope-elevation combinations) were derived from the SRTM DEM. Landsat imagery was part of the database, as it provided a convenient background for visualization and analyzing land use/land cover change between a recent year (2003), and a year (1987) just after cultivation was banned by the Syrian Government in the areas within the ‘steppe line’ (Jaubert *et al*., 1999).

Unsupervised classification was performed on the NDVI\(^{18}\) values of the two Landsat image sets (for 1987 and 2003), using the ISODATA algorithm, and resulted in the mapping for 1987 and 2003 of the land use/land cover classes ‘cultivated – rainfed’, ‘cultivated – irrigated’, ‘native rangelands’ (different vegetation cover ranges); and ‘barely vegetated’. From the comparison between the two years areas with the following land use/land cover change classes were identified: ‘cultivation stopped’, ‘continuous cultivation’, ‘new cultivation’, and ‘native rangelands’. Based on this classification five major domains were identified with different priorities for rangeland restoration (Fig. 14):

- High priority, high success, low vegetation cover
- High priority, high success, moderate vegetation cover
- Restoration probably not needed, high vegetation cover

\(^{18}\) NDVI: Normalized Difference Vegetation Index, an indicator of vegetation biomass density and vigor derived from reflectance in different spectral bands.
- Restoration probably needed, low vegetation cover
- Not needed, medium – high vegetation cover

**A vision for linking agrobiodiversity observation sites to regional levels**

The above study provides a good example of a ‘cheap and cheerful’ approach for using GIS and remote sensing to set priorities for rangeland management. At the same time it shows the limitations of an assessment of agrobiodiversity and degradation in rangelands that is not based on an appropriate sampling frame. Whereas a substantial sample set has been collected on plant species distribution and density, complemented with soil observations and even a socioeconomic characterization of the managers of the rangelands, there is no good linkage with the diverse spatial data from secondary sources. The basic reason for this failure is that the vegetation sampling strategy used for the characterization of the Aleppo and Hama steppes was based on the perception that they belong to a uniform agro-ecological and socioeconomic unit (the Syrian ‘Badia’). Given the practical difficulties of mounting surveys by multi-disciplinary teams, it appeared therefore justified to study vegetation, soils and socioeconomic conditions at random and dissociated from each other. This assumption was not justified and a more detailed zoning of these areas was called for to serve as a representative sampling frame. This leads to the formulation of a vision for outscaling agrobiodiversity observations at site level to broader dryland areas. It is based on the following elements:

- Definition of zones ‘homogeneous’ in ecological and socioeconomic characteristics;
- Stratified sampling based on the homogeneous management units;
- Outscaling through statistical correlations between species and environments.
Fig.14. Priority areas for restoration, Aleppo and Hama Steppes, Syria
**Definition of homogeneous zones**

At any particular scale the key factors that determine species distribution and productivity form the basis for defining homogeneous zones. The case study on agro-ecological zoning, reported earlier in this paper, offers a good start, pointing to climate, land use/land cover, terrain and soils as essential themes in the definition of homogeneous management units. However, depending on the objective of the agrobiodiversity survey (collection, protection, land use planning, restoration, etc.), the stratification into homogeneous zones may require the use of more detailed indicators. For example, appropriate climatic themes might be the average temperature throughout the year, the minimum temperature of the coldest month, the annual precipitation or the precipitation during the warm period etc. Land use/land cover themes may need to include indicators that describe rural-urban interactions, as well as spatially explicit indicators of farming and production systems. Terrain variables such as elevation, slopes and aspect will always be useful and are nowadays easy to obtain from DEMs. Information on soils is, with few exceptions, usually insufficient in detail, although it is one of the key themes determining species distribution. It points to a serious gap in secondary data that needs to be addressed within the surveys themselves. The same can be said about geological information, which can be critical in areas strongly influenced by the underlying lithology, but unfortunately is nearly always available at coarse resolutions only and in the form of lithological associations.

Once appropriate thematic indicators are identified, they can be integrated in GIS using an overlay approach similar to the one used for the definition of agro-ecological zones. Satellite imagery can be very useful at this stage by providing a visual check on the units defined through GIS.

**Stratified sampling**

Once an appropriate spatial framework has been defined, an observation/sampling plan can be developed that addresses the need to be representative of the main homogeneous units, considers the internal variability within these units - since absolute homogeneity is obviously an ideal - and balances these needs for sufficient information with survey cost considerations.

To reduce survey time and costs, more consideration should be given, particularly in rangeland surveys, to GPS-georeferenced observations, linking roving observations of plant physiognomic types to simple and rapid measurements of species and biomass, e.g. by line intercept, and to fewer but more comprehensive observations, such as quadrat measurements. The positioning of these sampling sites can be guided by satellite imagery, or by key informants in local communities with an intimate knowledge of the relationships between species distribution and environments.

**Outscaling**

As mentioned earlier, inference from sampling sites to other areas is based on the principle of similarity. To forecast where particular species can be found or introduced, where the same problems will emerge and the same solutions will be plausible, we look at similarity in the ecologies and socioeconomic environments. Using a well characterized spatial framework of agro-ecological zones and units, combined with a spatial framework of relevant socioeconomic factors is in theory the most obvious way to
outscaling. The reflectance patterns derived from satellite imagery allow establishing statistical relationships with species distribution and density that allow a much finer detail than is possible by simply transferring field observations to similar agroecologies. Whereas we now have sufficiently detailed databases to characterize agro-ecologies, our knowledge of the socioeconomic environments in the drylands is, generally speaking, inadequate to classify them into typologies that can be given a spatial dimension. Mapping of socioeconomic environments therefore remains a priority topic for GIS research. Also here remote sensing has a major role to play, given its capabilities to detect land use, the most spatially explicit dimension of production and livelihood systems.

To summarize all of the above, it can be said that the richness in agro-biodiversity in ICARDA’s mandate region can be linked to the diversity of agro-ecologies and land use systems in the region. One of the key challenges in agro-biodiversity assessment is to make the linkage between agro-biodiversity at levels where it is actually gained or lost (household or community level), to policy-making levels (landscape, national or regional). Cheap geo-referencing tools, such as the GPS, appropriate sampling procedures at each level, secondary resource data including satellite-derived information, appropriate out-scaling methods, and integration in a geographical information system (GIS), make the seamless linkage between different levels of agro-biodiversity gain and loss increasingly plausible. An additional need is for an appropriate spatial framework for capturing and bridging the ecological and human dimensions of agro-biodiversity at different scales.

A first necessity in agro-biodiversity assessments is to harness the technological revolution brought by the GPS. The enormous simplification and increased accuracy it brought to determining locations, permit new stationary and roving observation procedures, which essentially allow expanding the number of samples, and bring geographical positioning within the reach of virtually anyone. There is therefore much potential in devising participatory sampling procedures that allow optimal use of local knowledge in the assessment of agro-biodiversity at household or community level. A second challenge is to ensure that disparate observations at household or community level do not stay site-specific and that they add to a spatial database where they can be linked to agro-ecological data at landscape or regional levels, and to various socioeconomic levels. GIS has now become sufficiently mainstream, to allow a wide range of users to master entry-level capabilities of geo-referencing point data, thematic overlaying, projection and scale matching. However, the necessary analytical and modeling tools for the integration of multi-scale and multi-thematic information sources are still being developed. Some of the tools and datasets developed by ICARDA, under the umbrella term ‘Agro-ecological characterization’, are presented in this paper. The growing importance of remote sensing in agricultural applications is another silent revolution, from which agro-biodiversity assessments could benefit tremendously. The increasing availability and affordability of satellite-derived products at different scales and the ‘democratization’ of image analysis offer enormous potential for seamless zooming from the level of the site to an entire region. In addition, a global record of spatially contiguous data of land use changes, available from various satellite and airborne sensors for the last 40 years, is an at present undervalued and underutilized public good that will prove increasingly its value in quantifying, validating and monitoring the drivers of agro-biodiversity changes.
Conclusion

Given the multi-scale nature of agro-ecosystem diversity, the main challenge in agrobiodiversity assessment remains to make the bridge between local and regional levels of agrobiodiversity. The necessary analytical and modeling tools for the integration of multi-scale and multi-thematic information sources are still being developed in numerous case studies. Although progress has been made, more work is needed in developing appropriate outscaling procedures and guidelines, using GIS and RS. Ecogeographical surveys can benefit tremendously by harnessing the full power of the GPS. Issues of interest are the geo-referencing of local knowledge, less emphasis on the fairly stationary kind of observations, such as quadrat measurements, and more ‘roving’ observations of the ‘hit-and-run’ kind. A process that is already well underway is the linkage of ecogeographical surveys to multi-thematic spatial information systems. There is further scope for improving our understanding of linkages between land degradation and erosion of agrobiodiversity and of the interactions between urban and rural environments, particularly the impact of sub-urbanization and habitat fragmentation. Finally, it may be worthwhile to attempt upscaling of socioeconomic information, collected through participatory agro-biodiversity surveys, using a farming systems mapping approach.

References


Using GIS Model to Identify the Predictive Potential Suitable Sites of Wild Wheat Relatives in the Palestinian Authority

S. Allahham¹ and H. Hasasneh²

¹ Rangeland specialist, Conservation and sustainable use of dryland agrobiodiversity project, Palestinian Authority, Email: al_lahham salah@hotmail.com
² Crop breeder, Conservation and sustainable use of dryland agrobiodiversity project, Palestinian Authority, Email: hhasasneh@yahoo.com

Keywords: GIS, wild wheat, distribution, Palestine

Abstract
The high rate of loss of wheat wild relative species has brought a call to the scientific community to make comprehensive assessment of status, causes and trends of biodiversity to recommend appropriate conservation and management strategies. In this study the Diva-GIS software using the BIOCLIM model (Bio-climatic analysis and prediction system) was used to generate a predictive map showing the potential geographical distribution range of wheat wild relatives, based on climatic features of the sampled data in the Palestinian Authority areas. Geographical Information System (GIS) modeling was used to identify suitable sites for the conservation of these species. Annual mean temperature, maximum temperature of the warmest month, minimum temperature of the coldest month, annual precipitation, precipitation of the wettest month, digital elevation model (DEM), species names and spatial location (latitude and longitude of a set of localities) are the parameters used in the analysis. The Diva-GIS software predictive map showed distinct regions where the targeted species are predicted to occur at very high, high, medium and low levels. The best predicted suitable areas for Triticum turgidum subsp. dicoccoides (Körn. ex Asch. & Graebn.) Thell occur in the northern part of the West Bank in Jenin and eastern part of Nablus districts. Moreover, the highest species richness was in Jerusalem district. Aegilops geniculata and Aegilops peregrina prediction maps suggested the northern part as the most suitable areas while the model suggests the southern part of Hebron district as the adaptation area for Aegilops kotschyi. Based on the above results primary sites for conservation of wheat wild relatives were proposed.

Introduction
Wheat is the world's major crop in terms of food production and contribution to human diet (Harlan, 1995). Wheat is the most important cereal traded on international markets. The total world trade in wheat and wheat flour (in grain equivalent) is close to 95 million tones, with the developing countries accounting for almost 80 % of imports. Wheat is the major commodity provided as food aid. In 1992/93, for example, wheat accounted for just over half of the 15,200 tones of the cereal shipped as food aid to developing countries.

At the local level about 190,000 dunums (10 dunums=1 ha) are planted with wheat crop mainly concentrated in Hebron and Jenin districts in the West Bank. Twenty-three percent of the total area is in Jenin district, where the ecological conditions in term of
soil, topography and climate are suitable for wheat production. In Jenin district, the productivity of wheat in good years can reach 3500 kg/ha while in Hebron district where the climate is arid, the productivity does not exceed 1500 kg/ha. In Jenin, most grown varieties are improved ones while in Hebron landraces are still widely grown.

The first cultivation and domestication of wheat goes back more than 10,000 years. Archaeologists and historians agree that the rise of agriculture, along with the domestication of animals for food and labor, produced the most important transformation in human culture since the last ice age. Perhaps since the control of fire, farming and herding have led to the growth of large human settlement and increased competition for productive lands. Excavations at more than 50 sites over the last half-century have established the Fertile Crescent of the Middle East as the homeland of the first farmers. This arc of land, broadly defined, extends from Palestine through Lebanon and Syria, then through the plains and hills of Iraq and southern Turkey all the way to the head of the Persian Gulf. Among its "founder crops" were wheat, barley, various legumes, grapes, melon, dates, pistachio and almond. The region also hosted the first domesticated sheep, goats, pigs and cattle. New genetic studies suggested the Karacadag Mountains, in southeast Turkey at the upper fringes of the Fertile Crescent, as the site where einkorn wheat was first domesticated from a wild species around 11,000 years ago.

Genetic resources are fundamental to sustain global wheat production now and in the future. They embody a wide range of genetic diversity that is critical to enhance and to maintain the yield potential of wheat by providing new sources of resistance and tolerance to biotic and abiotic stresses. Modern high-yielding wheat cultivars are an assembly of genes or gene combinations pyramided by breeders using, in most cases, well-adapted cultivars from their regions. International agriculture research has enormously expanded the availability of widely adapted germplasm that is genetically diverse. However, introgression of additional variation found in genetic resources is necessary to increase yield stability and further improve wheat. For example, the genus Aegilops is closely related to Triticum (Kerby and Kuspira, 1988). Interest was directed in recent years in exploiting Aegilops spp. as important genetic resources for wheat improvement (Comeau et al., 1993; Mujeeb-Kazi, 1993; Farooq et al., 1996). Aegilops geniculata Roth (= Ae. ovata L.) is an annual, selfing (Hammer, 1980) allo-tetraploid species (2n = 4x = 28) with MU genome (van Slageren, 1994). This species is particularly interesting among the 22 species of the genus Aegilops as a source of disease and pest resistance (Valkoun et al., 1985; Dimov et al., 1993). Some information is also available concerning its response to drought (Rekika et al., 1998b) and salinity (Farooq et al., 1996), suggesting that this species could represent a valuable reservoir of genes for resistance to these stresses.

In Palestine, there are 13 species of wild relatives of wheat and eight species are found in the Palestinian Authority (PA) areas: Aegilops biuncialis, Ae. geniculata, Ae. kotschyi, Ae. longissima, Ae. triuncialis, Ae. searsii, Ae. peregrina, and Triticum turgidum subsp. dicoccoides.

Wheat wild relatives are essential components of natural and semi-natural habitats as well as agricultural systems and are critical for maintaining ecosystem health. Their conservation and sustainable use are essential for improving agricultural production, increasing food security and maintaining the environmental benefits. The germplasm conserved in genebanks is especially rich in wild relatives of crops, traditional farmer
cultivars and old cultivars, which represent an immense reserve of genetic diversity, but still more collections are needed to fill the gaps mainly by targeting areas and populations not sampled especially those with evolving under harsh conditions or threatened by rapid loss. Severe overgrazing by huge flocks of sheep and goats in the Near East and Central Asia can, in few years, wiped out the wild species populations found in the rangelands. The West Bank of Palestine relishes a tremendous diversity of climates and biomes, providing suitable habitats for more than 2,500 species of superior plants, 550 species of birds and 117 species of mammals. This unique rich diversity of Palestinian biota has long captured the interest of ecologists and scientists. In Palestine, the Mediterranean biome occurs roughly between 31:53 and 32:58 latitude on the western coastal plain and western slopes of the West Bank. The climate is unique in that the wet season coincides with the low sun or winter period. Summers are dry. Total annual precipitation ranges between 350 and 720 mm per year. Temperatures are those of the subtropics moderated by maritime influence and fog associated with the cold ocean currents. The result is a very limited but predictable growing season.

Severe overgrazing, urbanization, land clearing, over-exploration of species and lack of land use planning led to continued land degradation in many areas of the West Bank leading to loss of genetic diversity of important wild relatives of crops. Food demands and market forces have encouraged the replacement of the locally adapted varieties (landraces and local varieties) of both fruit trees, vegetables and field crops with higher yielding cultivars, hence hampering the gene pools of crops. Due to rapid genetic erosion and to high risks of more anthropogenic impacts (urbanization, overgrazing, desertification), it is critical to map the distribution of the wild relatives of wheat to advise on proper management plans for their conservation. Our objective was to use 1349 geo-referenced observations on wild relatives of wheat (eight species) to predict the potential distribution areas based on climatic variables in the West Bank areas using grid cells. This type of study can provide the baseline data for further GIS analysis for exploration, conservation and use of germplasm of wild crop relatives as well as for determining factors that explain the geographic distribution of these species.

**Material and Methods**

This section cover the spatial and non spatial data, softwares, and methodologies used to generate the species richness maps and predicative suitable sites for the species targeted.

**Data set used**

Spatial and non-spatial data and pervious technical reports were used in this study. The following is a brief description of the data used:

- Climatic data \(^{1}\): the data are extracted from a global interpolated climate database. The global climate layers (grids) at 1-km\(^2\) resolution. The data layers were generated through interpolation of average monthly climate data from weather stations on a 30 arc-second resolution grid (often referred to as "1 km\(^2\) resolution). Variables included are monthly total precipitation, and monthly mean, minimum and maximum temperatures;

---

\(^{1}\): the data sources of climate data from www.diva-gis.org site
- Altitude: one 1-km² resolution;
- Geographical distribution of eight species of wheat wild relatives;
- West Bank and district boundaries;
- Five bioclimatic parameters: annual mean temperature, maximum temperature of the warmest month, minimum temperature of the coldest month, annual precipitation and precipitation of the wettest month.

The softwares used are Arc View 3.2a for vector spatial analysis, and DIVA-GIS for analysis of biodiversity dataform CIP.

**Description of data set**

The data presented in this paper were derived from the Agro-biodiversity project botanical surveys and the Hebrew University of Jerusalem dataset (BioGIS Project available at http://www.biogis.huji.ac.il site). The data are a compilation of 1349 unique observations of wheat wild relatives accessions and herbarium specimens. Basic statistic of the distribution of these point observations were calculated to determine the number of *Aegilops* species and *Triticum dicoccoides* and the geographical distribution of these species in the West Bank and in the historical Palestine to assess surveyed area and determine the areas which were not well covered by previous surveys.

The number of observations and species richness were mapped using grid cells. Species richness is used because it is a simple, widely used, well-understood, and useful measure of taxonomic diversity (Gaston, 1996).

This paper used DIVA-GIS program (www.diva-gis.org) to predict the potential suitable areas of distribution of wild wheat species in the study area based on bioclimatic variables. Diva-GIS software was developed for predicting the distribution of organisms in the wild when little or nothing is known about the physiology of species involved. It is assumed that the climate at the point of observation of a species is representative of environmental range of the organism.

**Modeling capabilities**

Diva-GIS uses the BIOCLIM model (Bio-climatic analysis and prediction system) to generate a predictive map showing the potential spatial distribution range of wheat wild relatives based on five bioclimatic variables of the sampled data. The main idea of BIOCLIM modeling is to find a single rule that identifies all areas with similar climate to the various geographic regions for the species of interest. Such analysis is done by finding the climatic range of the points for each climatic variable. The Diva-GIS program was run with option BIOCLIM classic option (six groups) for identifying the excellent, very high, high, medium and low suitable and not suitable areas.

**Methodology**

Two stages are involved to generate the predictive model. The first stage was to extract the “climatic envelop\(^{20}\)” of the species from the data and the second stage was to project the climatic envelop from the multidimensional climatic space into two-dimensional geographic space. The bioclimatic variables used in modeling the predictive map are:

\[^{20}\text{Climatic envelop is the range of the species distribution within a multidimensional space determined by a set of climatic variables.}\]
1. Set of climatic variables: annual mean temperature, maximum temperature of the warmest month, minimum temperature of the coldest month, annual precipitation and precipitation of the wettest month;
2. Digital Elevation Model (DEM) (cell size = 1 km²);

The modeling process included the following:
1. The points (longitude and latitude) of each selected species in the West Bank, taken as points of occurrence of the species;
2. The climatic variable values of the sites where the species was recorded are ranked in numerical order;
3. Additionally, the minimum and the maximum percentile values of each climatic variable are determined in which these values define the climatic envelop of the species;
4. Cell falling within the climatic envelop of the species for all variables are marked by comparing the climatic characteristics of each grid cell on the grid map of the West Bank and the climatic envelop determined for the species.

Results and Discussion

Species distribution
In this study 1349 geo-referenced observations were used for eight species of wheat wild relatives distributed in Palestine. Basic statistics on the distribution of observations in the study area indicated a strong bias in collecting along the roads (Map 1). Around 70-80% of the observations are located near roads. The northern part of the West Bank, with higher species richness, was less covered by surveys than the southern parts.
Map 1: The relationship between wheat wild relative species distribution, species richness per district and distance to main roads.

Table 2 reveals that the highest number of observations was for *Aegilops peregrina* (38.5% from the total number of observations) while the lowest number of observations was for *Aegilops searsii* (0.5% of the total number of observations).
Table 2: Number and percent of occurrence of different species of wild wheat relatives in the study area in the West Bank

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of observations</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aegilops biuncialis</em></td>
<td>24</td>
<td>1.8</td>
</tr>
<tr>
<td><em>Aegilops geniculata</em></td>
<td>310</td>
<td>23.0</td>
</tr>
<tr>
<td><em>Aegilops kotschyi</em></td>
<td>226</td>
<td>16.8</td>
</tr>
<tr>
<td><em>Aegilops longissima</em></td>
<td>154</td>
<td>11.4</td>
</tr>
<tr>
<td><em>Aegilops triuncialis</em></td>
<td>18</td>
<td>1.3</td>
</tr>
<tr>
<td><em>Aegilops searsii</em></td>
<td>7</td>
<td>0.5</td>
</tr>
<tr>
<td><em>Aegilops peregrina</em></td>
<td>540</td>
<td>40</td>
</tr>
<tr>
<td><em>Triticum dicoccoides</em></td>
<td>70</td>
<td>5.2</td>
</tr>
<tr>
<td><strong>Number of observations</strong></td>
<td><strong>1349</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Simple analysis was used to calculate the number of species observed by district and to estimate the Shannon diversity index. The results showed that Jerusalem district has the highest species richness that could be explained, first by the high number of studies and surveys conducted in this district and second by the fact that the populations are better managed in this area. The lowest number of species were found in Jericho and Tubas districts which could be attributed to the climatic conditions which ranges from arid to hyper-arid and to overgrazing caused by large livestock flocks (Table 3).

Table 3: Biodiversity indices and number of target species per district

<table>
<thead>
<tr>
<th>District</th>
<th>Area (km²)</th>
<th>Number of species</th>
<th>NOB/ NOS</th>
<th>% from total</th>
<th>Menhinick index</th>
<th>Shannon index</th>
<th>Simpson index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jenin</td>
<td>573</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2.00</td>
<td>1.39</td>
<td>1.00</td>
</tr>
<tr>
<td>Tulkarm</td>
<td>245</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1.23</td>
<td>1.10</td>
<td>0.80</td>
</tr>
<tr>
<td>Tubas</td>
<td>366</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>0.50</td>
<td>0.56</td>
<td>0.40</td>
</tr>
<tr>
<td>Nablus</td>
<td>614</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>1.29</td>
<td>1.23</td>
<td>0.68</td>
</tr>
<tr>
<td>Qalqilya</td>
<td>174</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1.50</td>
<td>1.04</td>
<td>0.83</td>
</tr>
<tr>
<td>Jericho</td>
<td>609</td>
<td>3</td>
<td>34</td>
<td>34</td>
<td>0.30</td>
<td>0.62</td>
<td>0.36</td>
</tr>
<tr>
<td>Salfit</td>
<td>202</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>0.87</td>
<td>0.96</td>
<td>0.62</td>
</tr>
<tr>
<td>Ramallah</td>
<td>849</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>1.25</td>
<td>1.04</td>
<td>0.53</td>
</tr>
<tr>
<td>Jerusalem</td>
<td>354</td>
<td>8</td>
<td>9</td>
<td>23</td>
<td>0.96</td>
<td>1.27</td>
<td>0.63</td>
</tr>
<tr>
<td>Bethlehem</td>
<td>608</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>1.07</td>
<td>1.25</td>
<td>0.75</td>
</tr>
<tr>
<td>Hebron</td>
<td>1068</td>
<td>5</td>
<td>8</td>
<td>14</td>
<td>0.77</td>
<td>1.20</td>
<td>0.65</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5661</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOB/NOS: number of observations / number of species

*Species richness grid based distribution*

Species richness in the study area was calculated using the circular neighborhood method of the grid analysis functions of DIVA-GIS software. The species richness of wild wheats ranged from one to seven species per grid, the majority of grid values was 1-3 and there was one grid cell with the highest value of seven species. The area of the highest grid is located in Jerusalem district at the border area. It is worth mentioning that this area is protected from the anthropogenic activities.
**Bioclimatic analysis and predication system**

Based on the number of observations and genetic importance, four species were selected to use in the bioclimatic analysis and predication system model: *Aegilops geniculata*, *Ae. kotschyi*, *Ae. peregrina*, and *Triticum dicoccoides*. These species have more than 200 observations except for *Triticum dicoccoides* which is the direct progenitor of cultivated wheat. The other species have less observations which makes it difficult to run the model and predict the suitable sites for distribution. The results of the simulating model have suggested excellent suitable sites for *T. dicoccoides* in the northern part of the West Bank in Jenin district and eastern part of Nablus (Map 2). These areas represent the potential areas for the distribution of *T. dicoccoides*, but do not consider the factors of degradation that could have affected the populations. These areas are the main wheat growing areas in Palestine. More than 60% of the West Bank area is not suitable for *T. dicoccoides*. GIS analysis suggested that Hebron and Bethlahem, Jericho, and Tubas districts are not likely to contain this species. All observed species sites annual rainfall ranged from 413 to 784 mm (Fig. 1 and Fig. 2).

![Cumulative Frequency (%) vs. Annual Precipitation](image)

**Fig. 1:** Annual precipitation range for the *Triticum dicoccoides* observations sites

---

124 | P a g e
Map 2: Predicted suitable sites for *Triticum dicoccoides* species in the West Bank
Fig. 2: Bioclimatic envelope for *Triticum dicoccoides* species

Fig. 2 shows the points that fall within the envelopes for all the climatic variables and are colored in green. The points that fall outside of one or more envelopes are colored in red. The graph shows that 75% of the all observations of *Triticum dicoccoides* species are inside the envelope.

The bioclimatic model was run for three species of *Aegilops* genus: *Aegilops geniculata, Ae. kotschyi, Ae. peregrina*. The predication map suggested that the majority of the West Bank areas except the Jordan valley (Jericho district) are suitable for *Aegilops geniculata*, and the areas of optimum distribution are located in the northern region of the West Bank west of Jenin, Nablus and Ramallah districts (Map 3). This species can be used to improve drought and high temperature tolerance of wheat as stated by van Slagreen (1994).
Map 3: Predicated suitable sites for *Aegilops geniculata* in the West bank

The predication map suggested that the southern part of Hebron district is considered suitable for *Aegilops kotschyi* (Map 4). The chart 3 showed that *Aegilops kotschyi* is found in areas with rainfall ranging from 141 to 550 mm, and can be used a source of drought resistance (Fig. 3) as also reported by Blum (1988).
Map 4: Predicated suitable sites for *Aegilops kotschyi* in the West bank
The predication map shows that *Aegilops peregrina* is distributed in the majority of the West Bank but the most suitable areas are located in the middle areas (Eastern part of Ramallah and in the northern part of the West Bank and in Jenin district and eastern parts of Salfit and Nablus). The predication area for *Aegilops peregrina* is similar or overlapping with *Aegilops geniculata*. *Aegilops peregrina* is the most dominant species of wild wheat relatives present in 40% of the sites. It can be found in 207-784 mm rainfall range.

**Conclusion**

In Palestine some *Aegilops* species are still found in the central highlands. The predicted primary suitable sites for wheat wild relatives distribution did not take into consideration the interspecies competition as well as some physical environmental factors including soil type, soil depth, soil texture and erosion risk which require more field surveys and studies. However, this work highlighted the usefulness of GIS tools for spatial analysis of potential areas for distribution of species. Along with the eco-geographical surveys, areas for *in situ* conservation of wheat wild relatives can be determined. These could also guide the rehabilitation and restoration efforts through reseeding with natives species collected either from sites with similar characteristics or to be acquired from samples conserved in genebanks previously collected from the same regions. Urgent actions are needed to conserve the remaining populations of *T. dicoccoides*.

**References**

Diva manual. www.diva-gis.org

GARP and DIVA-GIS, Predicting the potential geographical distribution of sugarcane wooly aphid, current science, VOL.85, NO.11, 10 December 2003


Locating and Designing Biodiversity Conservation Sites: A Conceptual Framework

A. Bari\textsuperscript{1}, G. Ayad\textsuperscript{1}, S. Padulosi\textsuperscript{1}, T. Hodgkin\textsuperscript{1}, A. Martin\textsuperscript{2}, J.L. Gonzalez-Andujar\textsuperscript{2} B. Boulouha\textsuperscript{3} and L. Sikaoui\textsuperscript{3}

\textsuperscript{1}International Plant Genetic Resources Institute (IPGRI), c/o ICARDA, PO Box 5466, Aleppo, Syria. 
\textsuperscript{2}Instituto de Agricultura Sostenible (IAS-CSIC), Apdo 4084, 14080 Córdoba, Spain. 
\textsuperscript{3}Institut National de la Recherche Agronomique (INRA), BP 533, Marrakech, Morocco.

Keywords: Diversity analysis, geographic patterns, fractal geometry, \textit{In situ} conservation

Abstract

Geographic patterns have been historically used to trace the origin and evolution of plant species. However, not all the species have the same pattern. Different species exhibit different geographic patterns in response to a number of factors, including both biotic and physical environmental factors. While diversity patterns at a coarse scale are in response to climatic conditions and migration, at a finer scale they are under the influence of physical conditions, dispersal, and reproduction mechanisms including gene flow. The very great heterogeneity of physical environmental conditions found in dryland regions in particular may contribute to higher diversity. Intriguingly, diversity has also been found to scale with the area; as the area expands the diversity increases. This scaling behavior, known also by fractal behavior, where the diversity increases at a decreasing rate, has been recognized in the design of conservation site. Both fractal geometry and regionalized variable theory provide a conceptual framework for locating potential areas and investigating diversity-area relationship and other mechanisms that can assist in the conservation and management of biodiversity.

In the present paper we have reviewed the different techniques of both regionalized variable theory and fractal geometry to locate and design potential areas for \textit{in situ} conservation of biodiversity. Their usefulness was tested using both hypothetically constructed data and real data.

Introduction

Geographic patterns of variation have been historically used to trace the origin and evolution of cultivated plants. However, different species may exhibit different geographic patterns within the boundaries set up by ecological and evolutionary processes (Harlan, 1975; Maurer, 1994). These boundaries are delimited by a number of environmental factors, whether they are biotic factors (competition, predation), abiotic factors (temperature, precipitation) or topographic factors (mountains, rivers). While diversity patterns at a coarse scale are in response to climatic conditions and migration, at a finer scale they are under the influence of physical conditions, dispersal and reproductive mechanisms including mating systems and gene flow. The great heterogeneity of physical environmental conditions found in dryland regions in particular may contribute to higher diversity (Ritchie and Olff, 1999).
Given that these patterns are spatial in nature, the theory of the general regionalized variable model (GRVM) can be used to describe their features (Maurer, 1994). Under this theory the distance between the locations and their variation in diversity is measured by the spatial correlation. The spatial correlation has been extensively used to study spatial patterns of genetic variation (Epperson and Li, 1997; Bjørnstad and Falck 2001). The function which represents this correlation or dependence, under the theory of the general regionalized variable model (GRVM), is as follows (Cressie, 1993; Maurer, 1994):

\[ Z(i) = \mu(i) + \varepsilon(i) \]

where \( \mu(i) \) is a deterministic trend over space, \( \varepsilon(i) \) is a spatially dependent residual around the trend, with a mean of zero, variance \( \sigma^2 \), a spatial covariance \( \rho \) and \( i \) is the location.

GRVMT can be used to determine the geographic range, which is the area where diversity is maintained, including historically isolated lineages and geographic variation in the genome. Intriguingly diversity exhibits a scaling behavior in relation to the geographic range or area, which is known as fractal behavior. As the area increases the diversity increases in a non linear pattern at a decreasing rate. This pattern has been recognized also earlier by MacArthur and Wilson in 1967, who developed the bio-geographical island theory, which stipulates also that the species richness is a function of the size of the area and proximity to sources areas (Emerson and Kolm, 2005). In practical terms the extent of a geographical range or area, under both fractal geometry and bio-geographical island theory, including its shape and orientation, can be measured if the information on diversity is known.

In this context the relationship between the diversity and the area is a power-function relationship, of which the log values of diversity in terms of richness (\( S \)) and area (\( A \)) produces straight lines in a plot. The mathematical description of this relationship was first proposed by Olof Arrhenius in 1920 (Green, 2002) and later simplified to be as follows:

\[ S = cA^D, \text{ where } c \text{ is constant and } D \text{ is the slope with real values.} \]

The conceptual framework for locating and designing potential conserved areas in this study is based upon the notion that methods developed in one discipline may by analogy be used to advantage in another discipline (Mekjian, 1991). Similarities have been found in the mathematical structure for solving problems between the biological sciences and the physical sciences (West, 2002). Genetic diversity for instance has a correspondence with the size distribution of clusters in physics. The logarithmic series for species abundance developed by Fisher and others correspond to scale-invariant hyperbolic functions in mathematics (Mekjian, 1991). The entropy method, which is commonly used to measure diversity based on Shannon’s index (\( H \)) was originally developed within information theory (Battail, 1997).

The emergent patterns of diversity have been found to embody the presence of fundamental law-like processes, which include among many others, conservation of mass and energy, laws of biological inheritance, and evolution by natural selection (West,
2002; Brown et al., 2002). All of these mechanisms must play a role in regulating biodiversity and hence provide a framework to describe mathematically the patterns of diversity (Brown et al., 2002).

In the present paper we over-view some different mathematical methods to locate and design potential areas for in situ conservation of biodiversity. Both fractal geometry and regionalized variable theory provide a conceptual framework for locating potential conservation sites and investigating diversity-area relationships to assist in the conservation of biodiversity. Chaos theory was also found relevant to understanding diversity fluctuation over time under different environmental conditions. Thus, the theory may also be important to conservation planning and monitoring. The usefulness of these methods was tested using both hypothetically constructed data and real data.

2. Conceptual tools and frameworks for biodiversity conservation

2.1. The general regionalized variable model (GRVM)

The peculiarity property of a regionalized variable is that it varies continuously from one location to the next, but locations that are near each other show partial correlation whereas those that are widely separated are statistically independent. The estimation of the degree of this correlation is based on the variance between points. This variance is known by the variogram, a fundamental mathematical concept that was developed by Prof. George Matheron within the theoretical frameworks of mathematical morphology in the sixties and in particular the general regionalized variable model (GRVM) (Cressie, 1993; Maurer, 1994; Chilès and Delfiner, 1999). Matheron suggested to use the variogram instead of spatial covariance or correlation coefficients when the variance of $Z = f(z)$ is infinitely large (Agterberg, 2003).

Under the general regionalized variable model (GRVM) the “distance” between the locations and their variation in terms of diversity is measured by the variogram. Such information is generated from sets of neighboring locations that are correlated together or dependent on each other. The function mentioned below:

$$Z(i) = \mu(i) + \varepsilon(i)$$

includes the spatial correlation among sites in the modeling of spatial patterns where the spatial correlation in turn is statistically the product of the expected value between locations:

$$\text{cov}[Z(i), Z(j)] = E[(Z(i) - E[Z(i)])(Z(j) - E[Z(j)])]$$

The application of spatial statistics rests however on the assumptions of stationarity, whereby the data have a normal distribution, with the same mean and the same variance and that they also exhibits isotropy, which is the property that the characteristics of the pattern are the same in any direction (Fortin, 1999; Dale 2002).

If the locations are correlated in space, the difference between two random variables $Z(i)$ and $Z(i+d)$, which are here diversity values ($H$), can be expressed as a function of distance $d$ between the two sites. The covariance between these two sites is equal to the expected value of their product, which is here equal to the spatial covariance of the spatially dependent residual $\varepsilon(i)$ (Cressie, 1993).
The variogram expressed as the expected value of the squared difference between two \( Z \) values, separated by a distance \( d \), is (Cressie, 1993): \( 2\gamma(d) = E[(Z(i) - Z(i+d))^2] \) where \( d \) is called the lag, which is the distance between any two locations \( s_i(x_i, y_i) \) and \( s_j(x_j, y_j) \), \( d \) is calculated as follows: \[ |d_{ij}| = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \] where \( x \) is the longitude and \( y \) the latitude.

A typical variogram represents the spatial behavior that can be detected from:
- the constant \( (c_0) \), called the nugget variance; it represents location to variability between adjacent locations;
- the range or distance \( (a) \), beyond which the locations (based on their diversity values) are independent; it gives information on spatial dependence between the locations;
- the sill \( (c) \), which is the maximum value reached at the distance \( (a) \); it gives information on the total amount of variability.

The variogram provides information on the process that leads to a particular pattern, whether this pattern is the result of a completely random process (flat variogram) or it has a constrained random origin such as fractional Brownian motion (power variogram) (Cressie, 1993; Maurer, 1994; Bari et al., 2002). Cressie and Maurer listed several types of theoretical variograms to which an observed variogram might be fitted. The basic models are the linear, spherical, exponential, and power model.
2.2 Fractal geometry

Objects in nature are irregular in shape with segmented rugged edges. However, when seen at microscopic or telescopic level, they show a pattern where the object constituents are repeated in a similar manner. Fractal geometry was originally developed by Mandelbrot in 1982 to address the problem of irregular geometric shapes which has not been previously addressed by Euclidean geometry (Withers and Meentemeyer, 1999). Two important features characterize fractals, one of which is the fractional dimension to which they owe their name. The other feature is self-similarity, which is the manner in which variation is repeated (Fig. 2).

For example the length of the boundaries could be measured by using the unit $d$, which varies in length depending on the ruggedness of the line. As the number of segments becomes smaller, the unit of measurement becomes smaller. When the number of segments is squared the unit length decreases by one-third of its previous length. As $d$ tends towards 0, the dimension becomes:

$$D = - \lim_{h \to 0} \frac{\log L(d)}{\log (d)}$$

where $L(d)$ is the number of segments of length $d$ needed to cover the boundary. Thus the fractal dimension of the boundary is the limit of the sequence:

$$\frac{\log 1}{\log 1} \cdot \frac{\log 4}{\log 3} \cdot \frac{\log 16}{\log 9} \cdot \frac{\log 64}{\log 27} \cdots = \frac{n \log 4}{n \log 3} = 1.26185$$

The value 1.26185 is a dimension, but it is not the topological dimension of a line with $D = 1$ or a surface with $D = 2$. It is a dimension between the two Euclidean objects; it is a fraction of a dimension since the boundary exceeds its topological dimension by 0.26185. This type of boundary is known as the Koch coastline between a line and a surface.

The box-counting method can also be applied to two-dimensional point patterns to estimate diversity, which is similar to the areography technique (Nabhan, 1990; Bari et al., 1997). Diversity can also be measured using hexagons or circles instead of boxes.
The technique is based on counting the number of points or locations within each grid unit of size $\delta$.

Various values of $\delta$ define a power law relationship between the number $n$ of boxes (grids) and relative dispersion ($R$). For each size ($\delta$), the relative dispersion of the number of points per unit is calculated as the standard deviation ($SD$) over the mean ($\mu$):

$$R_\delta = \frac{SD_\delta}{\mu_{1,\delta}} \quad \text{(Dale et al. 2002)}$$

The fractal dimension is estimated from the slope $\theta$ of the log-log plot:

$$D = 1 + \theta.$$

In the context of the relationship between the diversity and the area is also a power-function relationship, of which the log values of diversity ($H$) and area ($A$) produce straight lines in a plot:

$$H = cA^d,$$

where $c$ is constant and $d$ is the slope with non-integer values.

The area can be derived on the basis of relative diversity scaled by a value $d$:

$$d = \frac{\log(H)}{\log(A)} \quad \text{(Brumitt and Lughadha, 2003)}.$$  

This is a nonlinear relationship, and leads to an emphasis on small area, in contrast to linear approaches. This relationship is also known as the species-area relationship (SAR), which is one of the commonly used models to study spatial patterns of species diversity. The slope of SAR has been found to have a direct relationship with the patterns of geographic ranges of species (Arita and Rodríguez, 2002).

### 2.3 Size and shape of conservation sites

The size and shape of a geographical range reflect the range of both environmental tolerances and resource distribution that a species uses (Maurer, 1994). Prior to defining size and shape of a geographical range we consider that the range be modeled as a fractal
geometrical “object”. We also assume that the distribution of the species across a geographical range is an optimal response surface. The sampled locations can be used to predict this probability surface from which descriptive statistics such as the size, shape and compactness of a geographical range can be derived (Maurer, 1994). The centroid of the probability surface and the variances in diversity contain information on the extent (size) of the distribution and the correlation between latitude and longitude provides information on the shape and orientation (Maurer, 1994).

In this context moments have been used to describe the shape. The moments $\mu_{20}$ and $\mu_{02}$ are the variances of $x$ (geographic longitude) and $y$ (geographic latitude) respectively and the moment $\mu_{11}$ as the covariance between $x$ and $y$ (Maurer 1994, Awcock and Thomas, 1996).

The centroid of the distribution can be expressed in terms of moments as follows:

$$x_c = \frac{m_{00}}{m_{00}} \quad \text{and} \quad y_c = \frac{m_{01}}{m_{00}}$$

where $(x_c, y_c)$ are the coordinates of the centroid. The moments in turn are calculated from the equation below:

$$m_{\alpha\beta} = \sum_x \sum_y x^\alpha y^\beta z_{xy}$$

where the order of the moment is $\alpha + \beta$,

$x$ and $y$ are the geographic coordinates,

$z_{xy}$ represents the diversity (number of entities found in the $i^{th}$ vector ($i^{th}$ square)

$$\mu_{\alpha\beta} = \sum_x \sum_y (x - x_c)^\alpha (y - y_c)^\beta z_{xy}$$

The estimates of the transformed latitudinal and longitudinal variances and covariances between them are:

$$S_{\alpha\beta} = \frac{\mu_{\alpha\beta}}{\mu_{00}}$$

where $\alpha + \beta \geq 2$ second central moment is the variance and covariance (for $\alpha + \beta = 2$).

The eigenvalues calculated to measure the shape are:

$$\lambda_1 = \frac{S_{20}^2 + S_{02}^2 + \sqrt{\phi}}{2} \quad \lambda_2 = \frac{S_{20}^2 + S_{02}^2 - \sqrt{\phi}}{2}$$

$$\phi = \left( S_{20}^2 - S_{02}^2 \right)^2 + 4S_{11}^2$$

where $a = 2\sqrt{\lambda_1}$ is the length of the major axis ($2*R_{\text{max}}$) of the ellipse and

$b = 2\sqrt{\lambda_2}$ is the length of the minor axis ($2*R_{\text{min}}$) of the ellipse
Sites may have complicated, irregular boundaries with large compactness value measured by the parameter:

\[ \text{compactness} = \frac{P^2}{4\pi \cdot A} \], where \( P \) is the perimeter and \( A \) the area.

\[ H = \sum p_i \log(p_i) \]

\( p_i \) is estimated as \( n_i/N \),
where \( n_i \) is the wild cowpea subspecies and \( N \) is the total number of individual samples of all the wild cowpea per grid.

Diversity was then analyzed by plotting the variogram of diversity \( H \) at increasing distance using the UTM coordinates. GIS Arc info and SYSTAT software were used to calculate the variogram. The dependent variable in this case was the diversity \( H \) (Shannon’ index). The semi-variogram in figure 4 increases linearly for small lags and becomes logarithmically for longer lags. Essays were made to fit the result to the theoretical function models. The most fitted one is the power model followed by the spherical model.

The parameters of the fitted variogram model are:
- Nugget \( (c_0) \): 0.100000
- Sill \( (c) \): 0.500000
- Range \( (a) \): 35.000000

![Variogram of the distribution of cowpea diversity across Africa](image)

**Fig 5: Variogram of the distribution of cowpea diversity across Africa**
Fig 6: Pattern of diversity of wild cowpea across Africa. The highest diversity site is shown in the south-east of the continent.

The distributions of all the encountered subspecies (13 subspecies) of cowpea were mapped and the highest diversity of cowpea is found to be located at the South East of Africa. The area harbors the highest degree of variation based on Shannon’s index and this could be considered a centre of diversity of cowpea wild forms. This confirms the early work of Padulosi (1993) that suggested strongly that *V. unguiculata* is an old polymorphic species whose speciation process has likely to have taken place within the Southern African region. Interestingly the site is located within a designated biodiversity hotspot, which extends over three countries and harbors three sites of high endemism and high diversity: 1) Maputaland (Tongaland) in the north, 2) Pondoland in the south, and 3) Albany in the southwest (Biodiversity International21 2005). This region is considered as one of the most diverse and complex floral areas in Africa and the region is extremely topographically heterogeneous with sand dunes, plains with rugged terraces, deep valleys, and a number of mountain ranges (WWF22, 2001).

3.2 Design of conservation site

Once the potential area for conservation has been located we performed the calculation of the different descriptors of the area such as its size, shape and compactness. As the area changes depending on the resolution (grid size) as shown in Figure 7, the descriptors were measured for different grid sizes as per the table 1. For illustration the different measurements were taken for the area with the highest diversity shown in Figure 6 based on GRVM.

Table 1: Size, shape and orientation of cowpea geographical range

<table>
<thead>
<tr>
<th>Grid size (scale)</th>
<th>(Major axis) $R_{max}$</th>
<th>(Minor axis) $R_{min}$</th>
<th>Perimeter</th>
<th>Area</th>
<th>Compactness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>2.187</td>
<td>1.123</td>
<td>7.710</td>
<td>10.917</td>
<td>0.434</td>
</tr>
<tr>
<td>0.500</td>
<td>2.147</td>
<td>1.376</td>
<td>9.272</td>
<td>11.322</td>
<td>0.605</td>
</tr>
<tr>
<td>0.250</td>
<td>4.032</td>
<td>1.548</td>
<td>19.597</td>
<td>19.180</td>
<td>1.594</td>
</tr>
</tbody>
</table>

The larger the compactness the irregular is the shape of the area (Table 1). As the grid size becomes smaller the irregularity of the shape increases as shown in figure 7. The large size of the area is impressive and yet to be defined in light of more data. However, although high genetic distances were found among the subspecies that forms the cowpea, the strong geneflow and introgression is high among the taxa, which make this gene-pool unusually large in its size (Stefano, 1993; Pasquet, 1999).

3.3 Design based on hypothetical data

To see how the species diversity will evolve over time we applied the population fluctuation model (May 1989). Given that such data is not available yet we constructed

21 http://www.biodiversityhotspots.org/xp/Hotspots
new data based on the equation $Z_{t+1} = k \cdot Z_t \cdot (1 - Z_t)$ with $k = 3.9$. Prior to the generation of constructed data the $z$ values were modified to vary between 0 and 1 and the results are shown in the graphs below. In generation 1 the diversity increased but decreased in generation 2 and then hops back to approximately its original level in generation 3. The size of the potential site for conservation changes with the scale but it could also change from generation to generation. Based on population or species’ fluctuation model the area may change in size as it may shrink but only to a limit that can allow the species to expand again.

Figure 6: The maps show the changes in space (a, b and c) of the potential site for conservation (further sampling) located in southern part of Africa (red squares)

b) Grid size = 0.25

Fig. 7: The maps show the changes in time of the potential sites located in southern part of Africa (red/dashed squares) based on hypothetical data of population growth.

High diversity

4. Discussion and future work
The analyses of geographical pattern of wild cowpea’s diversity showed that both fractal geometry and regionalized variable theory provide a conceptual framework for locating potential conservation sites and investigating diversity-area relationships to assist in the conservation of biodiversity. The general regionalized variable model (GRVM), in particular has been extensively used in mining and the variogram has been found useful for assessing and describing spatial patterns (De Jong and Burrough, 1995). The fractal geometry on the other hand has also been found useful to describe and rank conservation areas (Ovadia 2002). Chaos theory may also be important to conservation monitoring and planning since genetic diversity was also found to be a putative chaotic feature of ecological systems (Creanga and Creanga, 1997). The current study represents the areas that have been sampled and that is likely to be biased by accessibility to explorers. The analyses are based solely on data where plants have been recorded. Other locations can be added in the analysis to fine-tune the approach further. In subsequent studies we will be predicting potential locations where taxa could be found based on climate (Jones and Gladkov, 1999). Other similar methods (Dale et al., 2002) will be used to define areas that are likely to contain cowpea taxa and are yet un-sampled through explorations. Diversity is found to be dependent on scale and requires further study to optimize the methods so that the best site or network of sites that capture the best combinations of ecotypes or genotypes (genes/traits) that will eventually allow the species to evolve within the perspective of the concepts of the evolutionary significant unit (Moritz 1994) and the concept of "Operational Conservation Units" (OCUs) which include the interaction between biological and socio-economic factors (Dodson et al., 1998). Most importantly also is to use molecular data to model space-time variation based on space-time probabilities of identity by descent and coalescence probabilities since the observed diversity or genes found in present populations reflect the genes that are descended from ancient genes in the same population or nearby populations vs. geographically distant populations (Epperson, 1999). The envisaged work will further confirm the geographic of origin of wild cowpea and eventually determine the extent of the potential conservation site or network of sites.

Acknowledgements
We would like to thank Maria Garruccio for providing pertinent references for this paper. Our thanks to Jan Engels for his support and suggestions on the preparation process of this work. Our special thanks also to the *in situ* conservation workshop participants and organizers of the Triticaceae Conference of 2001 in Cordoba, Spain, namely: Pilar Hernandez, Luis Marin, Ahmed Amri, Jan Valkoun, Mary Barkworth, Roland von Bothmer, Devra Jarvis, Seddik Saidi and all others from IAS-CSIC, University of Cordoba, Centro de Investigación y Formación Pesquera y Acuícola (CIFA), Junta de Andalucía and ICARDA.

References


Using a Geographic Information System and Remote Sensing to Delineate Agro-Ecological Zones in the West Bank

J. Hilal and S. Saad

Geographic Information System and Remote Sensing Research Unit, Applied Research Institute - Jerusalem (ARIJ), P.O. Box 860, Bethlehem, Palestine. Email: jane@arij.org and sophia@arij.org

Keywords: GIS, agro-ecological zones, characterization, West Bank

Abstract
Agro-Ecological Zoning (AEZ) is an important tool for land-use planning, economic development, natural resource management, and as an indicator of social factors. This study used the integration of the Geographic Information System (GIS) and Remote Sensing (RS) techniques to develop AEZ for the West Bank and Gaza in Palestine. This paper addresses the creation of a computerized inventory of land resources and determination of agrological zones based on biophysical and climatic parameters to generate data that are appropriate to, and usable within the agro-ecological assessment. The concept involves the representation of land in layers of spatial information to define the zones using geographic information system. Satellite imagery was processed and classified in order to determine the current land cover. The results of remote sensing were analyzed in combination with existing geo-referenced datasets such as, land use/land cover characteristics, soil, landform, topography and climate to analyze the land for various kinds of agro-ecological zones assessment. Based on the input information layers, land suitability was assessed in terms of potential production and environmental impact. Overlay analysis was applied to produce a spatial database, which is the basic unit for land evaluation and data processing in an AEZ study. Each agro-ecological cell consisted of parcels of land which were identified having a particular soil and climatic characteristics. Finally, a map of agro-ecological zone for the West Bank and Gaza was compiled showing unique combination or specified range of sets of characteristics, relating to climate and soil within the same mapping unit.

Introduction
The West Bank is located on the coast of the Mediterranean Sea between 31° 10 00 to 32° 40 00 North latitude and between 34° 50 00 to 35°30 00 East longitude. Though relatively small in area, the West Bank has diverse topography, soil structure, climate conditions which are reflected in its rich biodiversity (ARIJ 1994). West Bank covers 5,661 square kilometers. The climate of the Palestinian territories is mainly of Mediterranean type with long, hot and dry summers and short, cool and rainy winters. The West Bank is relatively arid; about 50% of the land has a rainfall less than 500 mm/year, including hyper-arid area with a rainfall of less that 100 mm/year. However, the remaining land has a rainfall range of 500-800 mm/year. In general, climatic variations occur in different topographical regions of the West Bank. From north to south, the annual amount of rainfall decreases, while the temperature increases. Similar trends are observed from west to east. Also, there is a gradual decrease in the annual, monthly, and diurnal averages of relative humidity from north to south and from west to east.
throughout the whole area. West Bank is part of the West Asia mega-center for plant biodiversity where wild progenitors of cereals, food and feed legumes and many fruit trees still exist (Harlan, 1992).

Agro-ecological zones are separate areas with similar sets of potentials and constraints for assessment of land resources for better planning and management. Since climate and soil are the most important natural factors which determine the agricultural ability of land to produce crops, agro-ecological zoning consist of the delineation of land into zones that are homogenous with respect to climate and soil (http://www.fao.org/ag/agl/agll/aez.stm).

Applied Research Institute-Jerusalem (ARIJ) had conducted a research to classify the land system in the West Bank and Gaza according to a hierarchal nomenclature system, the CORINE land cover system with few modifications to adopt the European-wide classification system for environmental applications to the West Bank. Land cover classification system was as well adopted to include land use features such as urban areas. The result shows that 49.8% and 60% respectively of the total area of the West Bank and Gaza is agricultural land (most of which are arable land and permanent crops), 40.2% and 10.6 % are forest and semi-natural area (most of which are open space and shrub/ herbaceous vegetation association), whereas the urban fabric (Palestinian and Israeli settlements) make up a total of 10 % and 28.9 % of the total area of the West Bank and Gaza, respectively. The remaining land use/land cover classes include the water bodies (less that 1 % of the total area of the West Bank) (ARIJ, 2002).

**Research Methodology**

A methodology is introduced to define agro-ecological zones for the West Bank that could support the assessment and implementation of agricultural development. The integration of the Geographic Information System (GIS) and Remote Sensing (RS) was used to derive the agro-ecological zones. Information layers needed for this analysis were imported from GIS database for the West Bank of ARIJ. The zoning analysis considered the climatic parameters: 1- mean annual rainfall, 2- mean annual temperature, 3- mean annual relative humidity, soil and topographic characteristics, as well as the land cover and land use of the West Bank derived from recent satellite images. General description of the study area and climatic and the physical characteristics were recorded.

**Preparation of GIS layers**

The soil resources inventory for the West Bank was compiled from the soil map of Israeli and the occupied Palestinian Territories with a scale of 1:250 000. The various steps followed in the generation of the database were: identification of the soil mapping characteristics, computer storage of soil data, field verification of soil data and linkage of soil data to the land system database. The different climatic parameters including mean annual of relative humidity, mean annual temperature and mean annual rainfall used in this study were created using Israeli climatic maps covering the period from year 1961 through year 1990 and saved in three GIS layers in raster format (GRID). The land use/land cover database was generated by manual on screen digitization of the visible features in IKONOS satellite images captured between the year 2000 and 2002 of four meters resolution covering the West Bank. Additionally, the DEM grid is extracted from stereo panchromatic spot images with 10 meters resolution.
The agro-ecological approach is the start point to provide information on crop management. This includes the selection of cultivars, cropping pattern and time of planting, as well as soil management. Climate, soil and terrain play an important role in the agricultural production. The climatic information indicates the type of the crop that can be found within the region while the terrain information is the main factor in determining agricultural production. In addition, the soil information is a criteria that can limit the agriculture. For example, the selection of suitable crops for specific locations is based on slope and soil, as well as on moisture and temperature regimes. As part of this understanding, the availability of a resource inventory covering both soil and climate is important to analyze the expected outputs such as production system and selection crop.

An area can be classified into agro-ecological zones according to a variety of criteria. In this study, the classification of Palestinian agro-ecological regions or zones is based on mean annual rainfall, mean annual temperature, annual relative humidity, topography (Digital Elevation Model), and local soil type and their classification and distribution within the landscape of the West Bank. The map of agro-ecological zones will be appropriate as a basis for the natural resource management planning and agricultural research planning and management within the West Bank areas.

Processing the data sample groups (Map calculator)

Considering the limited quality and quantity of existing data, this approximation of the agro-ecological zones of West Bank will be refined and improved as more data become available. The methodology developed for mapping the agro-ecological zoning for the West Bank calls for integration of various environmental and natural resources information into a GIS. The climate, terrain and soil information was transformed and entered into a GIS format, and overlaid with the base maps of the West Bank area in order to produce a geo-referenced agro-ecological map. The study also focused on how GIS and RS techniques can support various models for natural resources and agricultural planning.

The GIS model comprises the GIS data that is linked to the GIS data inputting, data processing and data outputting components. The GIS software, ArcGIS 9 Spatial Analyst tool was used to perform the spatial analyses of the selected and transferred data sample groups. Spatial analysis techniques allow the identification of the relationships among geographic features (multiple map layers). These analyses serve as a guide for mapping the agro-ecological zones of the West Bank derived from weighted and combined map layers based on established criteria. The four general steps for developing agro-ecological model and producing agro-ecological map:

1. Determine which data sets are needed for the analysis;
2. Derive new data from existing data sets;
3. Classify data sets to create a common scale;
4. Determine the relative importance of each data set, weight them accordingly, and then combine the data sets to produce agro-ecological zoning map.

Because each map layer contains different data in different units, data transformations were performed to adapt the data sets to a common scale by ranking the spatial influence of each layer in the model. These ranking schemes were determined on an individual map
layer basis depending on the desired influence of each layer on the model. The spatial analysis map calculator was used to weight and combine individual map layers in order to produce agro-ecological model.

**Results and Discussion**

*Agro-ecological zones*

The zoning is a division of an area of land into smaller units, which have a unique combination of similar characteristics related to land suitability and potential production. Four different agro-ecological zones were delineated in the West Bank based on altitude, rainfall, temperature, humidity and soil. The spatial distribution and the characteristics of the agro-ecological zones in the West Bank are shown in Table 1 and Map 1.

Table 1: Characteristics of the main agro-ecological zones in the West Bank

<table>
<thead>
<tr>
<th>Agro-ecological zone</th>
<th>Climatic characteristics</th>
<th>Total area (km²)</th>
<th>Dominated soil</th>
<th>Dominated agricultural Land cover</th>
<th>Major factors affecting local agrobiodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone I</td>
<td>Hot dry summer</td>
<td>1115.4</td>
<td>Bare Rocks and desert Lithosols, and brown Lithosols and Loessial Serozems, and Regosols</td>
<td>Irrigated agriculture (open field cultivation and plastic houses)</td>
<td>Salinity, overgrazing</td>
</tr>
<tr>
<td>Zone II</td>
<td>Hot dry summer</td>
<td>1260.06</td>
<td>Brown Randzinas and pale Rendzinas, and brown Lithosols and loessial arid brown soils</td>
<td>Field crops and vegetables (mix of irrigated and rain-fed agriculture)</td>
<td>Overgrazing and urbanization</td>
</tr>
<tr>
<td>Zone III</td>
<td>Warm summer</td>
<td>1256.12</td>
<td>Terra Rossas, and brown Randzinas and pale Rendzinas</td>
<td>Field crops and vegetables (limited to the rain-fed)</td>
<td>Overgrazing and urbanization</td>
</tr>
<tr>
<td>Zone IV</td>
<td>Warm summer</td>
<td>2029.4</td>
<td>Terra Rossas brown Rendzinas</td>
<td>Permanents crops</td>
<td>Overgrazing and urbanization</td>
</tr>
</tbody>
</table>
Herein, the characteristics of the agro-ecological zones derived for the West Bank using map algebra analysis function are described below:

**Zone I:**
This zone lies along the Jordan valley to the west of the Dead Sea with an area of 1115.40 km². The elevation ranges from 400 m below the sea level near the Dead Sea to 635 m above sea level. The annual mean rainfall measured for this zone is low (50-144 mm). The mean annual average relative humidity is about 51%, while the mean annual temperature is 22°C. Hot summers and warm winters characterize the climate of this region. The soil in this region consists of brown Lithosols and Loessial arid brown, Bare Rocks and desert Lithosols, alluvial, solonchaks. It is worth to mention that the main soil problem in this region is salinity. The zone is located above the Eastern Basin of the West Bank Mountain aquifer system. Estimates of the annual ground water recharge of the
The limited amount of rainfall makes it an almost hyper-arid to arid zone. Consequently, this zone contains most of the irrigated area in the West Bank and has potential, but has large grazing areas. Approximately 8.3 % of the total area of this zone is an agricultural area, of which 5.75% is irrigated (open field cultivation and plastic houses), 2.6% are fruit trees and heterogeneous agricultural areas, whereas grazing area make up a total of 51% of the total zone area. Zone I is identified as irrigated zone with appropriate conditions for date palm plantation. Overgrazing is the major factor of degradation of plant biodiversity. The introduction of forage within the farming systems could decrease the pressure on rangelands. Salinity is a problem for irrigated lands.

**Zone II:**
The total area of this zone is approximately 1260.06 km$^2$. It forms the transitional zone between the arid and semi-arid regions. This zone has annual mean temperature around 19°C, and has an average annual rainfall of about 290 mm. The zone is rising up to 900 m above the sea level and drops to about 200 m below the sea level. As zone I, zone II is located above the Eastern Basin of the West Bank Mountain aquifer system. However, the Eastern Basin lies above three aquifers, namely the Upper Cenomanian aquifer, Lower Cenomanian aquifer, and Alluvial (Pleistocene) aquifer. Additional supplies of groundwater resources are found in this zone, (i.e. approximately, 73 wells and 30 springs). Much of the soils are brown Randzinas and pale Rendzinas, brown Lithosols and loessial arid brown soils. The availability of springs, wells and groundwater makes the area suitable for tree plantation. The agricultural areas in this zone make up 42.5% of the total zone area, in which 19.6% is field crops and vegetables, 7.4% is for fruit trees, and 14 % is classified as pasture areas. The remaining land cover classes consist of 50% of the total zone. The urban fabric in this zone covers 7.4% of the total area. In this zone, a mix of irrigated and rainfed agriculture is present where the irrigated agriculture mainly occupies the northern part of the zone.

**Zone III:**
This zone has an area of 1256.12 km$^2$, with an altitude of 1014 m above the sea level. It has annual mean temperature of 17°C and has a mean annual rainfall of 423 mm. According to the aridity index of the West Bank, this zone is located in the semiarid region; also it lies within the West Bank Central Highlands climatic and topographic region sharing the same climatic properties. Much of the soils are Terra Rosa, brown Rendzinas and pale Rendzinas, and Grumusols. The climatic characteristic and soil type of this zone make it limited to rain-fed cereals such as wheat and barley (26.96 % of the total zone area), the perennials tree (16 % of the total zone area), and the heterogeneous agricultural area (3.4%).

**Zone IV:**
This zone occupies 2029.40 km$^2$ of the total area of the West Bank and positioned in the semiarid and sub-humid region according to the aridity index of the West Bank. The
mean annual temperature measured for this zone is 17°C assigning 19°C as a maximum mean and 15°C as a minimum mean. This region is mostly mountainous with some areas exceeding an elevation of 1000 m above sea level. The zone’s region is characterized by rainy and cool winter with mean annual rainfall of 584 mm and mean annual relative humidity of 61%. The main soil type that found in this region is the Terra Rossas brown Rendzinas soils distributed all over the region. In addition, to the Terra Rossa soils, brown Randzinas and pale Rendzinas soils are also present in some part of this region. In this region (zone), agricultural lands cover about 51% (31.5% of permanent crops, 15% of field crops and the remaining 4.5% is heterogeneous agricultural area), mainly rainfed with limited area receiving supplemental irrigation. The groundwater resources in this zone include approximately 209 wells and 103 springs. Additionally, zone IV is located above the Upper Cenomanian, Lower Cenomanian and Eocene aquifers. In zone IV, a combination of irrigated crops (citrus plantations) and non–irrigated permanents crops are available.

**Conclusion**

A Geographic Information System (GIS) based model for agro-ecological zoning was developed using the main GIS layers (i.e. soil resources, temperature, humidity, rainfall, land cover) as input layers for geo processing. By the properly weighted combination of these composite layers, database of agro-ecological zones was developed; and agro-ecological zone map was produced. These results could be used to map the distribution of local agrobiodiversity including the landraces and wild relatives of major crops of global importance and to design strategies and management plans for the conservation of this biodiversity. Land suitability can be derived to better plan the reclamiation of natural habitats for urbanization and agricultural purposes. The same data can be used to develop plans for better management of watersheds and to introduce water harvesting techniques. The political situation prevailing in the West Bank has increased the pressure on natural resources including the degradation of soils, the depletion of water resources and the loss of biodiversity. The destruction of natural habitats is a common practice.

**References**


Comparative Analysis of Date Palm Cultivars Identification Using Isozymes and Molecular Methods

M. Trifi¹, S. Zehdi-Azouzi¹, A. Ould Mohamed Salem², S. Rhouma⁴¹, H. Sakka⁵, A. Rhouma³, and M. Marrakchi⁷

¹ Laboratoire de Génétique Moléculaire, Immunologie & Biotechnologie, Faculté des Sciences de Tunis, Campus Universitaire 2092 El Manar Tunis, Tunisie. Email: trifimokhtar@yahoo.fr
² Faculté des Sciences et Techniques, Université de Nouakchott, B.P. 5026, Mauritanie. Email: boukhary@univ-nkc.mr
³ IPGRI, Centre de Recherches Phoénicicoles, 2260 Degache, Tunisie. Email: a.rhouma@cgiar.org

Keywords: Date palm, genetic diversity, identification, DNA molecular techniques, isozymes, Tunisia.

Abstract
In the subtropical countries, oases are characterised by a large agrobiodiversity based mainly on the date palm cultivation. This important fruit crop constitutes the major factor of the agricultural system in these arid areas. The Tunisian date palm germplasm is one of the most diversified with a relatively high number of cultivars identified. These are selected and preserved by farmers mainly for the fruit qualities, using offshoots. Thus, identification of date palm cultivars is a considerable task in order to establish a sustainable management of the germplasm. Many efforts have been performed targeting the development of powerful methods to reduce the use of a combination of complementary approaches. This study portrays the achievements on date palm cultivars identification by summarizing the principles, advantages and limitations of different DNA molecular techniques.

Introduction
The date palm (*Phoenix dactylifera* L.) with 2n = 36 chromosomes, a dioecious long-lived monocotyledon is one of the most important fruit crop growing in arid and semi-arid areas of the North African and the Middle East countries. It constitutes the main factor of oases’ environmental and economic stability. Date palm is cultivated either for food or for many other commercial purposes. It serves as the higher strata for fruit trees, vegetables, field crops and forages which all-together form the basis of the livelihoods of the local communities in oasis ecosystems. Originated from the Fertile Crescent in Mesopotamia, its domestication has been established with many adapted ecotypes mainly locally called cultivars and selected for their fruit quality (Wrigley, 1995; Ben Khalifa, 1996). Therefore, a large genetic diversity characterises each local germplasm. For instance, in Tunisia more 250 cultivars have been identified (Rhouma, 1994; Rhouma, 2005) but the actual plantations are characterized by the prevalence of the elite variety called “Deglet Nour”. This trend have contributed significantly to the genetic erosion in this important phylogenetic patrimony and accelerated its vulnerability to biotic and abiotic stresses. In addition, for several decades many attempts aiming at the renovation of traditional oases have been undertaken. This was made possible by the clonal propagation mode through offshoots, a relatively slow method according to the very limited number of offshoots produced by individual trees. Also large scales of generated
plantlets using in vitro culture methods have shown efficient alternatives to improve new date palm plantations (Fky et al., 2001). Note that morphological traits, traditionally used to distinguish cultivars, must be improved by more information related to the plant material naturally produced or micropropagated as required by date palm farmers particularly in the case of elite cultivars at an early stage of life. Hence, it is imperative to elaborate a reliable method to discriminate genotypic variants of this crop. For this purpose, many reports have described the use of morphological and biochemical parameters to identify the Tunisian date palm varieties (Reynes et al., 1994; Rhouma, 1994). It should be stressed that despite their usefulness, the generation of these traits is time consuming, their number is limited and their expression is either highly influenced by the environmental conditions or often restricted to a short period. To overcome this inconvenience, we have designed the development of other methods to generate discrete markers suitable in the molecular characterization of Tunisian date palm ecotypes. The efforts focused on the use of isozymes and molecular methods namely cleaved amplified polymorphic sequence (CAPS) and simple sequence repeats (SSR), in order to establish a sustainable varietal identification in this crop. Among the molecular methods describing the genomic diversity, the CAPS and SSR are widely used either in higher plants or in animals (Baumbusch et al., 2001; Garcia de Leon et al., 1997; Reddy et al., 1999; Stepansky et al., 1999; Alvarez et al., 2001).

The present study reports the achievements on date palm cultivars identification. A summary of the principles, advantages and limitations of the investigated procedures is discussed in relation with the improvement of date palm cultivation.

Material and methods

Plant material

A set of Tunisian date palm cultivars including male ecotypes are included in this study. These were chosen either for their predominance in the main plantations or for their fruit quality. The plant material consists of young leaves sampled from adult trees randomly selected in the fields. Leaves were then frozen in nitrogen liquid until their use.

Isozyme analysis

Seven isozyme systems were analysed using either starch gel or polyacrilamid gel electrophoresis according to the method of Ould Mohamed Salem et al. (2001). These are identified as: esterases (EC. 3.1.1), peroxidases (EC. 1.11.1.7), glutamate oxaloacetate transaminase (EC. 2.6.1.1), shikimate deshdrenase (EC. 1.1.1.25), phosphoglucose isomerase (EC. 5.3.1.9), phosphoglucomutase (EC. 5.4.2.2) and malate deshydrogenase (EC. 1.1.1.37).

CAPS analysis

Starting from total cellular DNA as template, a set of consensus primers were used to amplify fifteen plastid DNA regions by the polymerase chain reaction (PCR). The resultant DNA fragments, corresponding to the most conserved coding regions in higher plants, were restricted by appropriate enzymes and analysed on polyacrylamid gel electrophoresis. Thirty PCR-fragment × enzyme combinations were tested in the study. Primers, PCR assays as well as the restriction fragment length polymorphism were
performed according to Sakka et al. (2004). The polymorphic banding profiles are called haplotypes and were used to determine the identification of each ecotype.

**SSR analysis**
Sixteen date palm specific primer pairs developed by Billotte et al. (2004) were used in this study. SSR assays and genotyping were performed according to Zehdi et al. (2004).

**Results**
**Date palm identification using isozymes**
Among the tested isozyme systems, only the following ones have generated polymorphic banding patterns: glutamate oxaloacetatetransamena se, shikimate deshydrenase, phosphoglucose isomerase and phosphoglucomutase. Based on controlled crosses, five loci were identified as Got-1, Got-2, Sdh, Pgi-2 and Pgm, which have exhibited a total of 12 alleles: three alleles each for Sdh or Pgm loci and two alleles for the remaining loci. In addition, the identified loci have permitted to cluster the ecotypes studied into 19 genotypes. Therefore, taking in account the multilocus genotypes provided, we have established an ecotypes’ identification key of the studied cultivars (Table 1). It should be stressed that only Boufagous and Fhal Ksebba cultivars have exhibited similar patterns. All the remaining are characterised by a single genotype corresponding to its fingerprint. Consequently, we assume that 27 out of 29 ecotypes are unambiguously discriminated allowing a resolving power of 93%.

Table 1: Multilocus genotypes identified in a sub-set of Tunisian date palm ecotypes based on 12 isozyme alleles. Males are labeled with an asterisk.

<table>
<thead>
<tr>
<th>Ecotype</th>
<th>Locus</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sdh</td>
<td>Pgm</td>
<td>Pgi-2</td>
<td>Got-1</td>
<td>Got-2</td>
</tr>
<tr>
<td>Lems</td>
<td>Aa</td>
<td>aa</td>
<td>aa</td>
<td>ab</td>
<td>ab</td>
</tr>
<tr>
<td>Rouchdi</td>
<td>aa</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
<td>aa</td>
</tr>
<tr>
<td>Kenta</td>
<td>ab</td>
<td>ac</td>
<td>ab</td>
<td>aa</td>
<td>aa</td>
</tr>
<tr>
<td>Bouhattam</td>
<td>ab</td>
<td>aa</td>
<td>aa</td>
<td>ab</td>
<td>ab</td>
</tr>
<tr>
<td>Smiti</td>
<td>ac</td>
<td>ac</td>
<td>aa</td>
<td>aa</td>
<td>aa</td>
</tr>
<tr>
<td>Aguiwa</td>
<td>ac</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
<td>aa</td>
</tr>
<tr>
<td>Grin ghzal</td>
<td>ac</td>
<td>ab</td>
<td>bb</td>
<td>ab</td>
<td>ab</td>
</tr>
<tr>
<td>Denga</td>
<td>ab</td>
<td>ac</td>
<td>aa</td>
<td>ab</td>
<td>aa</td>
</tr>
<tr>
<td>Fermla</td>
<td>ab</td>
<td>aa</td>
<td>ab</td>
<td>ab</td>
<td>aa</td>
</tr>
<tr>
<td>Horra</td>
<td>aa</td>
<td>bc</td>
<td>ab</td>
<td>aa</td>
<td>ab</td>
</tr>
<tr>
<td>Deglat nour</td>
<td>aa</td>
<td>ab</td>
<td>ab</td>
<td>aa</td>
<td>ab</td>
</tr>
<tr>
<td>Fhal kseba</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
</tr>
<tr>
<td>Rakli</td>
<td>aa</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
</tr>
<tr>
<td>Sfiri</td>
<td>aa</td>
<td>bb</td>
<td>ab</td>
<td>ab</td>
<td>aa</td>
</tr>
<tr>
<td>Tofli</td>
<td>ab</td>
<td>ab</td>
<td>aa</td>
<td>aa</td>
<td>aa</td>
</tr>
<tr>
<td>Kechehou ahamar</td>
<td>ab</td>
<td>aa</td>
<td>ab</td>
<td>ab</td>
<td>ab</td>
</tr>
<tr>
<td>Ammari</td>
<td>ab</td>
<td>ac</td>
<td>bb</td>
<td>aa</td>
<td>aa</td>
</tr>
</tbody>
</table>
Date palm identification using ctDNA CAPS markers

Among the 30 PCR-fragment×enzyme combinations tested, nine have revealed polymorphic banding patterns. Thus, a total of 21 out of 144 fragments were unambiguously reproducible and polymorphic. These have permitted to identify 28 banding profiles in the ecotypes analysed. The greatest number of six haplotypes was scored using the OA×\textit{Hinf}\textsubscript{I} combination. However, the smallest number of two haplotypes was registered for B2B3×\textit{Hinf}\textsubscript{I}, TF×\textit{Hinf}\textsubscript{I}, TC×\textit{Hinf}\textsubscript{I}, FV×\textit{Hinf}\textsubscript{I} and TC×\textit{Taq}\textsubscript{I}. Discrimination between the ecotypes was performed on the basis of the evidenced haplotypes. These were arbitrarily labeled A to I and followed by 1 to 6 according to the number of haplotypes. A precise genotyping of the ecotypes was then established and permitted to unambiguously identify 27 out of 38 ecotypes analysed (Table 2). Thus, we assume that the designed procedure based on the CAPS in the date palm, cpDNA constitutes an attractive approach to discriminate ecotypes in this crop. Nevertheless, as described in this study, this identification key is characterised by a resolving power of 71%.

Table 2: Genotypes of 38 Tunisian date palm ecotypes based on the identified ctDNA haplotypes. Haplotypes’ significance of OA×\textit{Hinf}\textsubscript{I} (A1-A6); VL×\textit{Hinf}\textsubscript{I} (B1-B5); FV×\textit{Taq}\textsubscript{I} (C1-C4); K1K2×\textit{Hinf}\textsubscript{I} (D1-D3); B2B3×\textit{Hinf}\textsubscript{I}(E1-E2); TF×\textit{Hinf}\textsubscript{I}(F1-F2); TC×\textit{Taq}\textsubscript{I} (G1-G2); TC×\textit{Hinf}\textsubscript{I} (H1-H2) and FV×\textit{Hinf}\textsubscript{I} (I1-I2). Males are labeled with an asterisk.
Date palm identification using SSR markers

Among the 16 primer pairs tested for their ability to generate microsatellites in Tunisian date palm, 14 have successfully provided DNA bands corresponding to the targeted microsatellites. The remaining ones identified as mPdCIR44 and mPdCIR48 were discarded in the study since they have generated weak and non reproducible bands. The other 14 primers’ pairs led to identify a total of 100 alleles. A maximum of 10 alleles was obtained for the mPdCIR78 locus while the mPdCIR16 is characterized by a minimum of 4 alleles. In addition, all the evidenced loci have clustered the date palm ecotypes studied in 201 genotypes. The number of genotypes varied from 16 for the mPdCIR16 and mPdCIR35 loci to 22 ones for the mPdCIR78 locus. Based on these primers, multilocus genotypes have been determined and permitted to establish an ecotypes’ identification key (Table 3). It is worth noting that according to this key, all the studied ecotypes are characterised by a single multilocus genotype suggesting that the designed procedure is strongly efficient for the survey of the DNA fingerprints in date palm. This is strongly supported since the established identification key is characterised by a resolving power of 100%.

<table>
<thead>
<tr>
<th>Name</th>
<th>Alleles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goundi</td>
<td>9=AIII+BIV+CII</td>
</tr>
<tr>
<td>OM Laghlez</td>
<td>10=AIII+BI+CIV</td>
</tr>
<tr>
<td>Zehdi</td>
<td>12=AV+BI</td>
</tr>
<tr>
<td>Hlawi</td>
<td>13=AV+BI</td>
</tr>
<tr>
<td>T156*</td>
<td>15=AIII+BIV+CIII</td>
</tr>
<tr>
<td>T159*</td>
<td>16=AIV+BIV+CIII</td>
</tr>
<tr>
<td>T160*</td>
<td>17=AIV+BIV+CII</td>
</tr>
<tr>
<td>T168*</td>
<td>18=AVI+BIV+CI+DI+EI</td>
</tr>
<tr>
<td>T203*</td>
<td>19=AIV+BIV+CI+DI+EI+FI+GI</td>
</tr>
<tr>
<td>Mahmoudia</td>
<td>20=AIII+BIV+CI+DIII</td>
</tr>
<tr>
<td>Fezzani</td>
<td>21=AIII+BI+CI+DI+EI</td>
</tr>
<tr>
<td>Aguiwa</td>
<td>22=AIII+BI+CI+DI+EII</td>
</tr>
<tr>
<td>Cheddakh</td>
<td>23=AIII+BI+CI+DI+EI+FI+GI</td>
</tr>
<tr>
<td>Dengh</td>
<td>24=AIII+BIV+CI+DI+EII+FI</td>
</tr>
<tr>
<td>Bezzoul Naaja</td>
<td>25=AIV+BV</td>
</tr>
<tr>
<td>Rhaimya</td>
<td>26=AIII+BIV+CI+DI+EII+FI+GI+HII</td>
</tr>
<tr>
<td>Smitti</td>
<td>27= AV+BI</td>
</tr>
<tr>
<td>Tantabecht</td>
<td>28=AIII+BIV+CI+DI+EII+FI+GI+HI</td>
</tr>
<tr>
<td>Bou Hattam</td>
<td>29=AVI+BIV+CI+DI+EII</td>
</tr>
<tr>
<td>Ftimi</td>
<td>11=AIII+BIV+CI+DI+EI</td>
</tr>
<tr>
<td>Hamra</td>
<td></td>
</tr>
<tr>
<td>Gasbi</td>
<td></td>
</tr>
<tr>
<td>Bidh Hamam</td>
<td></td>
</tr>
<tr>
<td>Angou</td>
<td></td>
</tr>
<tr>
<td>Bejjou</td>
<td></td>
</tr>
<tr>
<td>Ammari</td>
<td>14=AIV+BIV+CI+DI+EI+FI+GII</td>
</tr>
<tr>
<td>OM Essayed</td>
<td></td>
</tr>
<tr>
<td>Kharroubi</td>
<td></td>
</tr>
<tr>
<td>OM Lel</td>
<td></td>
</tr>
<tr>
<td>Lemsi</td>
<td></td>
</tr>
</tbody>
</table>

156 | Page
Table 3: Multilocus genotypes of 49 Tunisian date-palm ecotypes based on three microsatellite loci. Males are labelled with an asterisk.

<table>
<thead>
<tr>
<th>Ecotype</th>
<th>mPdCIR78</th>
<th>mPdCIR85</th>
<th>mPdCIR25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deglet Nour</td>
<td>a3/a9</td>
<td>b6/b8</td>
<td>c2/c5</td>
</tr>
<tr>
<td>Boufagous</td>
<td>a1/a5</td>
<td>b1/b1</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Ftiimi</td>
<td>a1/a8</td>
<td>b4/b8</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Kenta</td>
<td>a1/a1</td>
<td>b1/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Kintichi</td>
<td>a8/a8</td>
<td>b5/b6</td>
<td>c2/c7</td>
</tr>
<tr>
<td>Deglet Bey</td>
<td>a1/a8</td>
<td>b1/b8</td>
<td>c6/c7</td>
</tr>
<tr>
<td>Ghars Mttig</td>
<td>a1/a2</td>
<td>b1/b7</td>
<td>c1/c2</td>
</tr>
<tr>
<td>Zehdi</td>
<td>a3/a8</td>
<td>b5/b8</td>
<td>c2/c5</td>
</tr>
<tr>
<td>Arichti</td>
<td>a1/a9</td>
<td>b7/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Khouftimi</td>
<td>a1/a8</td>
<td>b4/b4</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Horra</td>
<td>a3/a9</td>
<td>b5/b6</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Okhet Degla</td>
<td>a1/a3</td>
<td>b6/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Hamra</td>
<td>a1/a7</td>
<td>b3/b6</td>
<td>c4/c5</td>
</tr>
<tr>
<td>Kharroubi</td>
<td>a1/a8</td>
<td>b5/b5</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Angou</td>
<td>a1/a4</td>
<td>b5/b8</td>
<td>c6/c7</td>
</tr>
<tr>
<td>Beijou</td>
<td>a1/a8</td>
<td>b7/b8</td>
<td>c2/c5</td>
</tr>
<tr>
<td>Goundi</td>
<td>a1/a1</td>
<td>b4/b8</td>
<td>c2/c5</td>
</tr>
<tr>
<td>Halwaya</td>
<td>a6/a9</td>
<td>b7/b7</td>
<td>c2/c3</td>
</tr>
<tr>
<td>Tezerzit Safra</td>
<td>a6/a8</td>
<td>b1/b1</td>
<td>c2/c7</td>
</tr>
<tr>
<td>Tezerzit Soda</td>
<td>a6/a6</td>
<td>b5/b7</td>
<td>c2/c3</td>
</tr>
<tr>
<td>Ammari</td>
<td>a1/a1</td>
<td>b5/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Besser Hlou</td>
<td>a7/a9</td>
<td>b5/b5</td>
<td>c6/c7</td>
</tr>
<tr>
<td>Mahmoudia</td>
<td>a1/a1</td>
<td>b5/b8</td>
<td>c2/c7</td>
</tr>
<tr>
<td>Chodak</td>
<td>a1/a8</td>
<td>b4/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Rhaimya</td>
<td>a5/a6</td>
<td>b7/b8</td>
<td>c3/c7</td>
</tr>
<tr>
<td>Om Lal</td>
<td>a1/a1</td>
<td>b3/b7</td>
<td>c1/c5</td>
</tr>
<tr>
<td>Om Esseyed</td>
<td>a1/a7</td>
<td>b3/b3</td>
<td>c4/c5</td>
</tr>
<tr>
<td>Bidh Hmam</td>
<td>a8/a8</td>
<td>b4/b5</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Gasbi</td>
<td>a1/a3</td>
<td>b1/b1</td>
<td>c5/c7</td>
</tr>
<tr>
<td>T124*</td>
<td>a3/a8</td>
<td>b5/b8</td>
<td>c2/c2</td>
</tr>
<tr>
<td>T138*</td>
<td>a3/a3</td>
<td>b5/b8</td>
<td>c5/c5</td>
</tr>
<tr>
<td>T158*</td>
<td>a5/a8</td>
<td>b3/b3</td>
<td>c7/c7</td>
</tr>
<tr>
<td>T169*</td>
<td>a7/a7</td>
<td>b5/b5</td>
<td>c6/c7</td>
</tr>
<tr>
<td>DF1*</td>
<td>a3/a3</td>
<td>b5/b8</td>
<td>c2/c2</td>
</tr>
<tr>
<td>DG9*</td>
<td>a5/a10</td>
<td>b4/b4</td>
<td>c2/c2</td>
</tr>
<tr>
<td>T159*</td>
<td>a1/a5</td>
<td>b1/b4</td>
<td>c6/c6</td>
</tr>
<tr>
<td>Rochdi</td>
<td>a1/a9</td>
<td>b7/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Lemsi</td>
<td>a1/a7</td>
<td>b4/b5</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Bouhattam</td>
<td>a1/a10</td>
<td>b1/b8</td>
<td>c1/c5</td>
</tr>
<tr>
<td>Smiti</td>
<td>a1/a8</td>
<td>b6/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Denga</td>
<td>a1/a9</td>
<td>b1/b6</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Aguiwa</td>
<td>a8/a9</td>
<td>b6/b8</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Deglet Nour K</td>
<td>a3/a9</td>
<td>b6/b8</td>
<td>c2/c5</td>
</tr>
<tr>
<td>Kchdou ahmar</td>
<td>a1/a9</td>
<td>b1/b1</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Fhal Ksebba</td>
<td>a1/a8</td>
<td>b1/b3</td>
<td>c4/c7</td>
</tr>
<tr>
<td>Rakhi</td>
<td>a1/a1</td>
<td>b3/b5</td>
<td>c5/c7</td>
</tr>
<tr>
<td>Fermla</td>
<td>a1/a7</td>
<td>b2/b8</td>
<td>c7/c7</td>
</tr>
<tr>
<td>Tamri</td>
<td>a1/a1</td>
<td>b5/b6</td>
<td>c2/c7</td>
</tr>
</tbody>
</table>

Alleles significance (size in pb):
- a1: 138
- a2: 142
- a3: 144
- a4: 148
- a5: 153
- a6: 157
- a7: 159
- a8: 165
- a9: 171
- a10: 173
- b1: 175
- b2: 181
- b3: 183
- b4: 185
- b5: 187
- b6: 189
- b7: 195
- b8: 197
- c1: 219
- c2: 231
- c3: 233
- c4: 236
- c5: 246
- c6: 248
- c7: 250
Discussion

The identification of date palm cultivars is a considerable task to improve their differentiation and then to contribute in their mislabeling (homonymy and synonymy) since a large number of ecotypes has been reported in the date-palms’ growing countries. For this purpose and as a part of our work, we have performed three methods based on isozymes, organelle and nuclear DNA analyses. Our data proved that the designed procedures are reliable for the discrimination of date palm ecotypes and presented different resolving power. For instance, resolving power values of 93%, 71% and 100% were scored using isozymes, CAPS ctDNA and nuclear SSR markers respectively. Relatively lower values have been reported in this crop using isozyme markers (Bennaceur et al., 1991; Booij et al., 1995). In addition, since they permitted to establish a precise date palm fingerprints, we assume that the molecular methods constitute attractive and reliable approaches for date palms’ differentiation. Surprisingly, isozyme markers have provided a relatively higher percentage of differentiation than the CAPS ones. Hypothesis of the great stability that characterises the plastid genome in higher plants could be forwarded to explain this result (Birky, 1988). In fact, a maximum of 420 genotypes would be theoretically identified using evidenced isozyme markers. However, 11,520 date palm haplotypes would be discriminated on the basis of the CAPS markers evidenced in the ctDNA. Moreover, the three microsatellites loci described above would permit to unambiguously differentiate a total of 71,280 genotypes. Thus, we assume that the designed methods are of a great interest to label at a large scale offshoots or any other plant material at early stage and in vitro plantlets. Moreover, their transfer to other laboratories over the world would either provide a precise fingerprinting of unlimited number of these closely related ecotypes or improve cultivars’ differentiation and then contribute in their mislabeling (homonymy and synonymy) in regards of the large number of ecotypes reported in the date palms’ growing countries (Mohamed et al. 1983; Rizvi and Davis, 1983; Sedra, 1996). Moreover, since offshoots’ exchanges are currently occurring in these countries, the evidenced markers are greatly recommended to be used as descriptors in the certification and the control of origin labels of date palm material originated from these countries. Nevertheless, as summarized in the Table 4, it is worth noting that the knowledge of advantages and limitations of the developed procedures is a prerequisite for their application taking in account the laboratories conditions.

Table 4: Summary of the principles, advantages and limitations of the markers designed in the present study.

<table>
<thead>
<tr>
<th>Marker Polymorphism</th>
<th>Isozyme</th>
<th>CAPS</th>
<th>SSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature</td>
<td>Substitutions</td>
<td>Insertion/deletion/substitution</td>
<td>Changes in the repeats’ number</td>
</tr>
<tr>
<td>Level</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Locus specificity</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Neutrality</td>
<td>Yes/No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Number</td>
<td>Limited</td>
<td>Nearly unlimited</td>
<td>Nearly unlimited</td>
</tr>
<tr>
<td>Dominance/Inheritance</td>
<td>Co-dominant/Mendelian</td>
<td>Co-dominant/Mendelian</td>
<td>Co-dominant/Mendelian</td>
</tr>
<tr>
<td>Technical</td>
<td>Low/Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>
Acknowledgements
This work was partially supported by grants from the Tunisian Ministère de la Recherche Scientifique, de la Technologie et du Développement des Compétences and from IPGRI (Project FEM-PNUD-IPGRI, RAB 98 G31).

References
Conservation of Tunisian Fig (*Ficus carica* L.) Germplasm Mediated by Molecular Genetic Diversity Studies

K. Chatti¹, A. Salhi-Hannachi¹, O. Saddoud¹, M. Mars², A. Rhouma³, M. Marrakchi¹ and M. Trifi¹

¹ Laboratoire de Génétique Moléculaire, Immunologie & Biotecnologie, Faculté des Sciences de Tunis, Campus Universitaire, 2092 El Manar Tunis, Tunisie. E-mail: ckhaled2000@yahoo.fr
² Ecole Supérieure d’Horticulture et d’Elevage, 4042 Chott Mariam, Tunisie. E-mail: messaoud.mars@laposte.net
³ IPGRI, Centre de Recherches Phoéniciques, 2260 Degache, Tunisie. E-mail: a.rhouma@cgiar.org

Keywords: Fig, *Ficus carica*, diversity, ecotypes, DNA molecular techniques, RAPD, ISSR

Abstract

The common fig (*Ficus carica* L.), a gynodioecious species, is growing throughout diverse environmental areas of the Mediterranean basin countries. Many ecotypes are selected by farmers mainly for their fruit quality and propagated through cuttings. In Tunisia, the fig germplasm is characterized by a great biodiversity since more than 100 ecotypes have been collected and maintained in several field collections. However, a severe genetic erosion, due particularly to a rapid urbanization and other biotic stresses, is currently threatening this fruit crop. Moreover, due to problems of appellation, synonymy and homonymy, the exact number of cultivars is actually unknown. Thus, it is imperative to elaborate strategies aiming at the enhancement and the rational management of the Tunisian fig patrimony conservation. This will be made possible by research actions (prospecting, collecting and evaluation of the local germplasm). The present study used molecular methods, the random amplified polymorphic DNA “RAPD”, the inter simple sequence repeats “ISSR”, the random amplified microsatellite polymorphism “RAMPO” and the simple sequence repeats “SSR”, to characterize the Tunisian fig diversity. Forty-two cultivars housed in four collections established in the centre and the south of the country, were analyzed. The results proved that these DNA molecular methods provide important tools for surveying the genetic diversity of figs. On the whole, cultivars’ clustering is made independently from the geographic origin and the sex of trees. In addition, the SSR method has permitted to fingerprint the studied cultivars. The contribution of the evidenced markers is discussed in relation to the solution of problems of cultivars’ appellation and to manage the conservation of the local fig germplasm in order to promote its cultivation in Tunisia.

Introduction

*Ficus carica* L. (*Moraceae*, 2n = 26) (Falistoce and Antonielli, 2002), is a gynodioecious crop with two sexual types: female fig and caprifig. Sexual reproduction is characterized by a mutualism between caprifig, blastophaghe and female fig tree (Kjellberg et al., 1987). This species, well adapted to the Mediterranean climate, is ubiquitous in Tunisia where large number of local varieties is cultivated (Mars et al., 1998; Rhouma, 1996). However, its cultivation has remained traditional and the fruit
production is mainly used for local consumption. Figs are either consumed fresh or dried or used for several industrial purposes (jam and spirit beverage production). In addition, this crop is vulnerable to biotic (mosaic fig disease) and abiotic stresses (drought). Thus, a research program has been initiated to preserve local fig germplasm and the collection missions have allowed to establish field genebanks for *ex situ* conservation (Mars *et al.*, 1998; Rhouma, 1996). Four main figs field genebanks are established at the Institut des Régions Arides of Medenine, the Centre de Recherches Phoénicoles of Degache, the Commissariat Régional du Développement Agricole of Gafsa and the Ecole Supérieure d’Horticulture et d’Élevage of Chott Mariems. Several genetic evaluation studies based on morphological parameters were accomplished for genotypes’ description (Mars *et al.*, 1998; Hedfi *et al.*, 2003; Hannachi *et al.*, 2003; Chatti *et al.*, 2004(a)). Therefore, it has been assumed that several traits mainly related to leaves and fruit characteristics are suitable for the discrimination of the figs ecotypes. However, despite their effectiveness, these characters are either sensitive to the environmental conditions or limited to the fruit production period. In addition, isozyme polymorphisms in common figs have proved their sustainability to characterize fig varieties (Hedfi *et al.*, 2003). Nevertheless, the success of varietal identification depends on the number of isozyme systems and alleles studied. Unfortunately, this number is often limited and the resultant polymorphism seems to be insufficient to distinguish among the closely related genotypes. To overcome these limitations, molecular genetic diversity analysis have been recently reported in Tunisian figs using the random amplified polymorphic DNA (RAPD) markers and inter simple sequence repeats (ISSR) (Chatti *et al.*, 2004(b); Hannachi *et al.*, 2004). These studies have allowed discrete markers and recommendations for reliable conservation of this important phytogenetic resource. However, the precise phylogenetic relationships and the genotypes fingerprints have not been studied in details. This contribution reports on the usefulness of molecular techniques for the characterization of genetic diversity and in fingerprinting of fig germplasm for rational management and conservation of local varieties.

**Materials and Methods**

*Plant material and DNA extraction*

A set of fig ecotypes maintained in four collections and originated from the South and the Sahel of Tunisia was used in this study (Table 1). Plant material consisted of young leaves randomly sampled from adult trees. These consisted either of common figs or caprifigs. DNA was extracted from frozen leaves according to Dellaporta *et al.* (1983) and its concentration was estimated by analytic agarose gel electrophoresis after staining with ethidium bromide (Sambrook *et al.*, 1989).
### Table 1. Tunisian *Ficus carica* L. ecotypes studied with their localities of origin

<table>
<thead>
<tr>
<th>Collection site</th>
<th>Accession name</th>
<th>Label</th>
<th>Botanical variety</th>
<th>Locality origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESHE Chott Mariem</strong>*</td>
<td>Soltani 01*</td>
<td>Common type</td>
<td>Ouardanine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soltani 02*</td>
<td>“”</td>
<td>“”</td>
<td>Kalaa Kebira</td>
</tr>
<tr>
<td></td>
<td>Khahli 03*</td>
<td>“”</td>
<td>“”</td>
<td>Kalaa Kebira</td>
</tr>
<tr>
<td></td>
<td>Khahli 04*</td>
<td>“”</td>
<td>“”</td>
<td>Enfidha</td>
</tr>
<tr>
<td></td>
<td>Hemri 05*</td>
<td>“”</td>
<td>“”</td>
<td>Enfidha</td>
</tr>
<tr>
<td></td>
<td>Hemri 06*</td>
<td>“”</td>
<td>“”</td>
<td>Ghadhabna</td>
</tr>
<tr>
<td></td>
<td>Bither Abiadh 07*</td>
<td>“”</td>
<td>“”</td>
<td>Mesjed Aissa</td>
</tr>
<tr>
<td></td>
<td>Bither Abiadh 08*</td>
<td>“”</td>
<td>“”</td>
<td>Chott Mariem</td>
</tr>
<tr>
<td></td>
<td>Bither Abiadh 09*</td>
<td>“”</td>
<td>“”</td>
<td>Khamara</td>
</tr>
<tr>
<td></td>
<td>Bidhi 10*</td>
<td>“”</td>
<td>“”</td>
<td>Kalaa Kebira</td>
</tr>
<tr>
<td></td>
<td>Bidhi 11*</td>
<td>“”</td>
<td>“”</td>
<td>Khamara</td>
</tr>
<tr>
<td></td>
<td>Baghali 12*</td>
<td>“”</td>
<td>“”</td>
<td>Mesjed Aissa</td>
</tr>
<tr>
<td></td>
<td>Zidi 13*</td>
<td>“”</td>
<td>“”</td>
<td>Mesjed Aissa</td>
</tr>
<tr>
<td></td>
<td>Besbassi 14*</td>
<td>“”</td>
<td>“”</td>
<td>Mesjed Aissa</td>
</tr>
<tr>
<td></td>
<td>Gouiti 15*</td>
<td>“”</td>
<td>“”</td>
<td>Chott Mariem</td>
</tr>
<tr>
<td></td>
<td>Jrani 16*</td>
<td>Caprifig</td>
<td>Ghadhabna</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assafri 17*</td>
<td>Caprifig</td>
<td>Ghadhabna</td>
<td></td>
</tr>
<tr>
<td><strong>IRA Médenine</strong></td>
<td>Bither Abiadh 18**</td>
<td>Common type</td>
<td>Tataouine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dechiche Assal 19**</td>
<td>“”</td>
<td>“”</td>
<td>Ghadhabna</td>
</tr>
<tr>
<td></td>
<td>Dhokkar Zarzis 20**</td>
<td>Caprifig</td>
<td>Zarzis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hammouri 21**</td>
<td>Common type</td>
<td>Beni Khedache</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kahl 22**</td>
<td>“”</td>
<td>“”</td>
<td>Enfidha</td>
</tr>
<tr>
<td></td>
<td>Makhtech 23**</td>
<td>“”</td>
<td>“”</td>
<td>Zarzis</td>
</tr>
<tr>
<td></td>
<td>Rogaby 24**</td>
<td>“”</td>
<td>“”</td>
<td>Beni Khedache</td>
</tr>
<tr>
<td></td>
<td>Sawoudi 25**</td>
<td>“”</td>
<td>“”</td>
<td>Beni Khedache</td>
</tr>
<tr>
<td></td>
<td>Tayouri Asfar 26**</td>
<td>“”</td>
<td>“”</td>
<td>Douiret</td>
</tr>
<tr>
<td></td>
<td>Widiani 27**</td>
<td>“”</td>
<td>“”</td>
<td>Beni Khedache</td>
</tr>
<tr>
<td></td>
<td>Zaghoubi 28**</td>
<td>“”</td>
<td>“”</td>
<td>Beni Khedache</td>
</tr>
<tr>
<td></td>
<td>Zidi 29**</td>
<td>“”</td>
<td>“”</td>
<td>Ghadhabna</td>
</tr>
<tr>
<td><strong>CRPh Degache</strong>*</td>
<td>Dhokkar 30***</td>
<td>Caprifig</td>
<td>Tozeur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grichy 31***</td>
<td>Common type</td>
<td>Tozeur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hamri 32***</td>
<td>“”</td>
<td>“”</td>
<td>Tozeur</td>
</tr>
<tr>
<td></td>
<td>Khalt 33***</td>
<td>“”</td>
<td>“”</td>
<td>Tozeur</td>
</tr>
<tr>
<td></td>
<td>Khzami 34***</td>
<td>“”</td>
<td>“”</td>
<td>Tozeur</td>
</tr>
<tr>
<td></td>
<td>Tounsi 35***</td>
<td>“”</td>
<td>“”</td>
<td>Tozeur</td>
</tr>
<tr>
<td><strong>CRDA Gafsa</strong>**</td>
<td>Dhokkar 36****</td>
<td>Caprifig</td>
<td>Gafsa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assal boudchiche 37****</td>
<td>Common type</td>
<td>Gafsa</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bither Abiadh 38****</td>
<td>“”</td>
<td>“”</td>
<td>Gafsa</td>
</tr>
<tr>
<td></td>
<td>Sawoudi 39****</td>
<td>“”</td>
<td>“”</td>
<td>Gafsa</td>
</tr>
<tr>
<td></td>
<td>Mlouki 40****</td>
<td>“”</td>
<td>“”</td>
<td>Gafsa</td>
</tr>
<tr>
<td></td>
<td>Gaa Zir 41****</td>
<td>“”</td>
<td>“”</td>
<td>Gafsa</td>
</tr>
<tr>
<td></td>
<td>Kadhouri 42****</td>
<td>“”</td>
<td>“”</td>
<td>Gafsa</td>
</tr>
</tbody>
</table>

**Primers and PCR assays**

Universal decamer oligonucleotides purchased from Operon technologies inc. (Alameda, USA) were used to generate RAPD banding patterns according to Chatti *et al.* (2004)(b). Different arbitrary oligonucleotides that are complementary to microsatellites were tested for their ability to amplify ISSR bands according to Zehdi *et al.* (2002). The primers mentioned above were tested in combination to investigate the genetic diversity analysis.
on the basis of the random amplified microsatellite polymorphism (RAMPO) markers. Three microsatellite primers that showed previously clear polymorphisms in Ficus carica L. (Khadari et al., 2001) were used in this study. SSR assays were performed according to the protocol of Saddoud et al. (2005).

Data analyses
DNA banding profiles generated by RAPD, ISSR and RAMPO procedures were manually screened and only the unambiguously reproducible bands were taken in account for the analysis of the genetic diversity. Data were transformed into binary matrix, computed with appropriate programs (Genedist and Neighbour) of the PHYLIP software to estimate genetic distances and to construct dendrograms illustrating the phylogenetic relationships among the ecotypes studied. In addition, allele frequencies, the number of alleles per loci, the observed and the expected heterozygosis were estimated taking in account the revealed SSR banding profiles.

Results
Genetic diversity as revealed by RAPD
Among the tested primers, only six have generated reproducible and polymorphic bands that are consistently and unambiguously revealed. These primers, identified as OPA-01, OPA-02, OPA-05, OPA-11, OPA-16 and OPA-18, were used to assess the genetic relationships. A total of 35 out of 54 bands has been evidenced and scored as RAPD markers in the ecotypes studied. A genetic distance matrix among cultivars shows an average distance ranging from 0.00 to 0.78 with a mean value of 0.41. Thus, it may be assumed that the ecotypes tested in this study are highly divergent at the DNA level. The smallest distance value of 0 was observed between Soltani 2* and Kahli 1* cultivars which appear to be the most similar and can be closely regrouped. The maximum distance value (0.78), indicating a great dissimilarity, is observed between either Hemri 1* and Bidhi 1* or Assafri * accessions. All the remaining ones displayed different intermediate levels of similarity.

The resultant UPGMA phenogram illustrates the divergence between the used varieties and suggests their tree branching (Figure 1). Three main clusters could be identified: the first one, a monophyletic group labelled (1), is composed of Hemri 1* cultivar which is significantly divergent from all the other accessions. The second group labelled (2) is composed of the two caprifigs Jrani* and Assafri*. All the remaining cultivars are clustered in the third group which exhibits secondary ramifications labelled (3-1), (3-2) and (3-3) respectively. Surprisingly, this dendrogram exhibits cultivars with similar appellation that diverged significantly in the observed clusters. This is well exemplified in the case of Hemri 1 [5] and Hemri 2 cultivars that belong to clusters (1) and (3) respectively. In addition, the strong association between Soltani 2 and Kahli 1 cultivars suggests that these cultivars are characterized by large similarities at the DNA level and could correspond to the same genotype.
**Genetic diversity revealed by ISSR**

The detection of cultivar polymorphism has been performed using a total of 13 arbitrary primers. The resulting genetic matrix exhibits genetic distances ranging from 0.16 to 0.95 with a mean of 0.54. These distances express high genetic diversity within local fig germplasm. The smallest genetic distance of 0.16 is observed between Grichy (GR) and Rogaby (RB) cultivars, suggesting that these varieties are characterized by maximum similarity. However, Kalt (KL) appears to be the most dissimilar from Tayouri Asfar (TA) and Mkhabech (MK) accessions, since they presented the highest genetic distance of 0.95. All the remaining ones present intermediate genetic distances. Figure 2 shows the derived UPGMA phenogram that exhibits two main clustering groups. The first one is composed of six cultivars of the Medenine collection, but originated from different regions. The second cluster is composed of two sub-clusters and includes all the remaining varieties that are originated either from the Medenine or Degache field genebanks. In addition, the caprifig cultivars are unlikely clustered with the common fig varieties. On the other hand, this phenogram typology presents similarities to those obtained on the basis of morphometric and/or analytic parameters, particularly those related to the fruit characteristics.
Fig. 2: Dendrogram of a subset of 18 Tunisian fig accessions elaborated from Nei and Li’s genetic distance matrix estimated from ISSR data and clustered with the UPGMA.

**Genetic diversity as revealed by RAMPO**

Among the 18 primer combinations, 16 have generated reproducible and polymorphic bands that are consistently and unambiguously revealed. The primers combinations have generated a total of 63 polymorphic out of 119 bands that are scored as RAMPO markers and used to assess the genetic relationships. The resulting genetic distance matrix exhibits genetic distance values ranging from 0.0 between Soltani 2 and Kahli 1 varieties to 0.74 between Bidhi 2 and Zidi with an average value of 0.35. Therefore, we assume that the ecotypes studied are characterised by a large diversity. The derived UPGMA dendrogram discriminated the ecotypes into two main clusters. The first one is composed by three ecotypes namely Besbessi, Bither Abiadh 2 and Bither Abiadh 3. The second one is subdivided in two subgroups b1 and b2, including the remaining genotypes. It should be stressed that this tree branching is made independently of either the sex or of the geographic origin geographic of cultivars (Figure 3).
Genetic diversity revealed by microsatellites

Three microsatellite loci were targeted using appropriate primers and starting from total cellular DNAs as templates. These, identified as MFC2, MFC5 and MFC8 microsatellites have exhibited alleles ranging from 118 to 228 pb. As reported in table 2, a total of 15 alleles were evidenced in the 8 ecotypes studied suggesting the existence of an important genetic variability among these cultivars. This is strongly supported by the scored allele frequencies that varied from 0.062 for MFC2 locus to 0.437 for MFC8. Moreover, the observed heterozygosity was relatively high and varied from 0.5 to 0.875 (Table 2). In addition, an excess of heterozygosity was detected for the MFC2 locus suggesting that the genetic diversity is mainly explained at the inter-cultivars level. Furthermore, based on the multilocus genotypes, a precise fingerprint of the ecotypes studied has been established. Thus we assume that SSR analysis constitutes the most efficient procedure to discriminate the fig ecotypes.
Table 2: Number of alleles, observed heterozygoty and Fis parameter calculated in Gafsa population.

<table>
<thead>
<tr>
<th>Loci</th>
<th>Number of alleles</th>
<th>Observed Heterozygoty</th>
<th>Fis parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>MFC2</td>
<td>6</td>
<td>0.875</td>
<td>-0.054</td>
</tr>
<tr>
<td>MFC5</td>
<td>4</td>
<td>0.625</td>
<td>0.213</td>
</tr>
<tr>
<td>MFC8</td>
<td>5</td>
<td>0.5</td>
<td>0.349</td>
</tr>
</tbody>
</table>

Discussion
The outcome of the present study was to provide molecular markers suitable in the exploration of the genetic diversity of the Tunisian fig germplasm and to molecularly characterise the local ecotypes. The results proved that the designed procedures constitute attractive approaches to provide precise information about the distribution of the variability in this crop. In fact, a typically continuous genetic diversity has been evidenced using all the designed methods as observed in the PCR analyses (data not shown). This result could be explained by unstructured genetic diversity that characterizes Tunisian fig genotypes: each variety maintains its independent status since an important gene flow has occurred in the natural populations from which cultivars are originated (Salhi Hannachi et al., 2004). It is obviously necessary to enlarge the number of SSR primers and/or ecotypes in order to establish cultivars’ identification key. This would be of great interest in the resolution of ecotypes mislabeling and then to rationally manage the conservation of this crop. Work is currently in progress to have a deeper insight of the genetic diversity in this crop and to enhance its ex situ and in situ preservation.

Acknowledgements
This work was partially supported by grants from the Tunisian Ministère de la Recherche Scientifique, de la Technologie et du Développement des Compétences.

References


Study of Genetic Diversity of Local and Wild Syrian Wheat Using Molecular Markers Techniques

Y. Wajahani

General Commission for Scientific Agricultural Research,(GCSAR), Douma, Syria.

Keywords: Wheat, landraces, genetic diversity, DNA molecular techniques, Syria

Abstract
RAPD, AFLP and SSR molecular markers techniques were used to study the genetic diversity among 14 Triticum accessions, including six Triticum durum, two T. aestivum, two T. urartu and four T. dicoccoides. Thirty nine 10-mer random primers for RAPDs, 11 AFLPs primer combinations and 11 SSR primer pairs were used to detect genetic polymorphism among the studied accessions. All marker systems were able to uniquely fingerprint each of the genotypes. The three molecular systems differed in the ratio of polymorphism detected; the lowest was the AFLP technique (90.4%), while it was 92.3% in RAPD and 100% in SSRs. The genetic similarity calculated according to Dice coefficient, ranged from 55.6% to 96.3% for RAPD, from 50.9% to 90.8% for AFLP, while SSR revealed genetic similarity ranges from 21.4% to 100%.

Cluster analysis performed with the three systems of markers clearly discriminated between the genotypes. The information content measured by the heterozygosity was higher for RAPD (0.41), while AFLP was characterized by a very high Marker Index (195.3) and very high Effective multiplex ratio (594). The correlation coefficient using similarity matrices between the three marker systems was significant. These results have confirmed that all three systems of markers can detect polymorphism among the Triticum accessions and are capable of generating fingerprints for discriminating and characterizing these accessions.

Introduction
During the past few decades, classical strategies of evaluating genetic variability such as comparative anatomy, morphology, embryology and physiology have been increasingly complemented by molecular approaches, particularly molecular markers. In recent years, attention has increasingly focused on the DNA molecular as a source of informative polymorphism. At the species level, molecular markers can provide information that can define the distinctiveness of species and their ranking according to close relatives and their phylogenetic position. Furthermore, wild relatives bear valuable genes for the genetic improvement of cultivated crops, the transfer of which can be enhanced through marker-assisted selection with backcrossing.

Wheat is one of the three major cereal crops in the world. It has economical and strategically importance as a food. Wheat belongs to the genus Triticum, family Poaceae (Gramineae). The genus Triticum includes different species with different ploidy levels (i.e., diploid, tetraploid and hexaploid). In this study four species were used:
Bread wheat (*Triticum aestivum* L.) or hexaploid wheat (2n=6x=42) contains three genomes A, B, and D with the formula BBAADD.

Durum wheat (*Triticum turgidum* subsp. *durum* (Desf.) Husn.) is a tetraploid species (2n=4x= 28) with genomic formula BBAA. Widely cultivated in many countries, durum wheat ranks eighth among all cereals. Small amount of durum is used in manufacturing couscous, local flat bread, bourghol, and pasta in some Mediterranean countries.

Wild emmer (*Triticum turgidum* subsp. *durum* (Desf.) Husn) is also a tetraploid species (2n=4x=28) with A and B genomes and considered as the direct progenitor of cultivated wheats.

*Triticum urartu* Thumanian ex Gandilyan is a wild diploid wheat (2n=2x=14) with AA genome. It is first described in 1938 as a rare endemic species of Transcaucasia (Jakubizner, 1959). Several *T. urartu* accessions were found in Turkey, Lebanon, Iraq and Iran by Johnson (1975).

**Materials and Methods**

Fourteen accessions representing four wheat species i.e., *T. durum*, *T. aestivum*, *T. dicoccoides*, and *T. urartu* were selected for this study. Among the fourteen accessions, eight represent local varieties cultivated in Syria: six varieties of durum wheat and two varieties of bread wheat. As shown in Table 1. all accessions of wild wheat and some of cultivated were collected from different locations in Sweida province in Syria. These locations are within the target areas of the GEF-funded project on “conservation and sustainable use of dryland agrobiodiversity”. The other cultivated accessions were collected from different locations as shown in Table 1.

Table 1. List of the *Triticum* accessions used in the study and the species to which they belong

<table>
<thead>
<tr>
<th>Acce. #</th>
<th>Common name and Abbr.</th>
<th>Species</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Biadi (Bi)</td>
<td><em>T. durum</em></td>
<td>Outside Damascus</td>
</tr>
<tr>
<td>2</td>
<td>Hamari (Ha)</td>
<td><em>T. durum</em></td>
<td>Hama</td>
</tr>
<tr>
<td>3</td>
<td>Hourani (Ho)</td>
<td><em>T. durum</em></td>
<td>Daraa</td>
</tr>
<tr>
<td>4</td>
<td>Aiubieh (Ai)</td>
<td><em>T. durum</em></td>
<td>Sweida</td>
</tr>
<tr>
<td>5</td>
<td>Bosiedi (Bo)</td>
<td><em>T. durum</em></td>
<td>Sweida</td>
</tr>
<tr>
<td>6</td>
<td>Senaljamal(Se)</td>
<td><em>T. durum</em></td>
<td>Alrakka</td>
</tr>
<tr>
<td>7</td>
<td>Salamoni(Sa)</td>
<td><em>T. aestivum</em></td>
<td>Damascus</td>
</tr>
<tr>
<td>8</td>
<td>Hredanieh(Hr)</td>
<td><em>T. aestivum</em></td>
<td>Latakia</td>
</tr>
<tr>
<td>9</td>
<td>D1</td>
<td><em>T. dicoccoides</em></td>
<td>Sahwet alkhoder (Sweida)</td>
</tr>
<tr>
<td>10</td>
<td>D2</td>
<td><em>T. dicoccoides</em></td>
<td>Moushnaf (Sweida)</td>
</tr>
<tr>
<td>11</td>
<td>D3</td>
<td><em>T. dicoccoides</em></td>
<td>Kanawat (Sweida)</td>
</tr>
<tr>
<td>12</td>
<td>D4</td>
<td><em>T. dicoccoides</em></td>
<td>Rasheda (Sweida)</td>
</tr>
<tr>
<td>13</td>
<td>U1</td>
<td><em>T. urartu</em></td>
<td>Rasheda (Sweida)</td>
</tr>
<tr>
<td>14</td>
<td>U2</td>
<td><em>T. urartu</em></td>
<td>Moushnaf (Sweida)</td>
</tr>
</tbody>
</table>
**1- Extraction and purification of genomic DNA:**
A modified CTAB (hexadecyl trimethyl ammonium bromide) procedure based on the protocol of Porebski et al. (1997) was the method of choice for obtaining good quality total DNA.

AFLP is based on the selective amplification of restriction fragments from total genomic DNA with different primer pairs (Vos et al., 1995). AFLP was performed using the Gibco BRL system I (Cat.No.10544), according to the manufacturer's protocol with minor modifications.

**2- AFLP Reaction**
- **Restriction digestion of genomic DNA**
  A 250 ng of wheat genomic DNA was digested with 2 ul of EcoRI/MseI (1.25 u/ul each). The reaction was carried out in the presence of 5X reaction buffer at 37°C for 3 hours, then the enzymes were inactivated at 70°C for 15 min.

- **Adapter ligation reaction**
  *EcoRI and MseI* adapters (Table 2) were ligated to the digested DNA fragments as follows: Twenty-four µl adapter/ligation solution and 1 ul of T4 DNA ligase were added to the digested DNA samples then incubated at 20°C for 2 hours. The ligation mixture was diluted 1:10 in TE buffer and used as template DNA for preamplification reactions.

Table 2. List of AFLP primers and adapters sequence

<table>
<thead>
<tr>
<th>Name</th>
<th>Sequence (5' – 3')</th>
</tr>
</thead>
<tbody>
<tr>
<td>MseI forward adapter</td>
<td>GACGATGAGTCTCTGAG</td>
</tr>
<tr>
<td>MseI reverse adapter</td>
<td>TACTCAAGACTCAT</td>
</tr>
<tr>
<td>EcoRI forward adapter</td>
<td>CTCGTAGACTGCGTACC</td>
</tr>
<tr>
<td>EcoRI reverse adapter</td>
<td>AATTGGTACGCAGTCTAC</td>
</tr>
<tr>
<td>MseI primer core region (M)</td>
<td>GATGAGTCTCTGAGTAA</td>
</tr>
<tr>
<td>MseI pre-selective primer (M+1)</td>
<td>M + C</td>
</tr>
<tr>
<td>MseI selective primer (M + 3)</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>M + CTA</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>M + CAG</td>
<td>GATGAGTCTCTGAGTAACAA</td>
</tr>
<tr>
<td>M + CAA</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>M + CTG</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>M + CTC</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>M + CAC</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>M + CTT</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>M + CAG</td>
<td>GATGAGTCTCTGAGTAACAG</td>
</tr>
<tr>
<td>EcoRI primer core region(E)</td>
<td>GACTGCGTACCAATTC</td>
</tr>
<tr>
<td>EcoRI pre-selective primer (E+1)</td>
<td>E + A</td>
</tr>
<tr>
<td>EcoRI selective primer (E+3)</td>
<td>EACG</td>
</tr>
<tr>
<td>E + ACG</td>
<td>GACTGCGTACCAATTCACG</td>
</tr>
<tr>
<td>E + AGC</td>
<td>GACTGCGTACCAATTCAGC</td>
</tr>
<tr>
<td>E + AAG</td>
<td>GACTGCGTACCAATTCAG</td>
</tr>
<tr>
<td>E + ACA</td>
<td>GACTGCGTACCAATTCACC</td>
</tr>
<tr>
<td>E + ACC</td>
<td>GACTGCGTACCAATTCACC</td>
</tr>
</tbody>
</table>
- (C) Pre- selective PCR amplification reactions

*EcoRI* primer plus one extension base at the 3’position and *MseI* primer plus one extension complementary sequence. The PCR amplification was carried out in 0.2 ml thin – walled PCR tube containing the following components:

<table>
<thead>
<tr>
<th>Components</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluted template (from the previous step B)</td>
<td>5 µl</td>
</tr>
<tr>
<td>Pre-amp primer mix</td>
<td>40 µl</td>
</tr>
<tr>
<td>10 X PCR buffer plus Mg++</td>
<td>5 µl</td>
</tr>
<tr>
<td><em>Taq</em> DNA polymerase (5µ/µl)</td>
<td>1µl</td>
</tr>
<tr>
<td>Total volume</td>
<td>51 µl</td>
</tr>
</tbody>
</table>

Twenty PCR cycles were performed at 94°C for 30 second, 56°C for 60 sec, and 72°C for 60 sec, soak temperature was 4°C. The pre-amp reaction was diluted 1:50 in TE buffer.

- Selective amplification PCR reactions

Eleven primer combinations between *EcoRI* primer plus three 3’extension bases and *MseI* primer plus three 3’ extension bases (Table 2) were used to selectively amplify the DNA fragments that matches the primer-extension sequence. The selective amplification was performed as follows: for each primer pair, the following components were added into a 0.2 ml thin wall PCR tube:

<table>
<thead>
<tr>
<th>Component</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>EcoRI</em> selective primer (27.8 ng/ ul)</td>
<td>0.5 µl</td>
</tr>
<tr>
<td><em>MseI</em> selective primer (6.7 ng/ul, dNTP’s)</td>
<td>4.5 µl</td>
</tr>
<tr>
<td>10X PCR buffer plus Mg--</td>
<td>2.0 µl</td>
</tr>
<tr>
<td><em>Taq</em> DNA polymerase (5U/ul)</td>
<td>0.2 µl</td>
</tr>
<tr>
<td>Diluted pre-amp products (1:50)</td>
<td>5 µl</td>
</tr>
<tr>
<td>Distilled water</td>
<td>7.8 µl</td>
</tr>
<tr>
<td>Total volume</td>
<td>20 µl</td>
</tr>
</tbody>
</table>

The thermocyclying profile was consisting of one cycle at 94°C for 30 sec, 65°C for 30 sec, followed by a decrease in the annealing temperature each cycle 0.7°C during 12 cycles that gave a touch dow n phase of 13 cycles. Then, twenty-three cycles were performed at 94°C for 30 sec, 56°C for 30 sec, and 72°C for 60 sec.

3- Detection of AFLP products

Polyacrylamide denaturing sequencing gel preparation and electrophoresis

The BIO-RAD Sequencing gel system was used. The gel was pre-run at 60 w to achieve a gel surface temperature of approximately 55°C, then 9 µl of each denatured samples, were loaded into the respective well. At completion of loading, running of the gel was performed using the same conditions of the pre-run step. Then, the gel was processed into the silver staining steps.

4- Data analysis
The banding patterns generated by RAPD-PCR, microsatellites or AFLP markers analyses were compared to determine the genetic relatedness of the 14 wheat accessions. The amplified fragments were scored either as present (1) or absent (0). Bands of the same mobility were scored as identical. The genetic similarity coefficient (GS) between two accessions was estimated according to Dice coefficient (Sneath and Sokal, 1973).

**Dice formula:** \( GS(ij)=\frac{2a}{2a+b+c} \)

Where \( GS \) (ij) is the measure of genetic similarity between individuals i and j, (a) is the number of bands shared by i and j, (b) is the number of bands present in (i) and (c) is the number of bands absent in i and present in j.

The similarity matrix was used in the cluster analysis. The cluster analysis was used to organize the observed data into meaningful structures, that is, to develop taxonomies. At the first step, when each accession represents its own cluster, the distances between these accessions are defined by the chosen distance measure (Dice Coefficient). However, once several accessions have been linked together, the distance between two clusters is calculated as the average distance between all pairs of accessions in the two different clusters. This method is called Unweighted Pair Group Method using Arithmetic Average (UPGMA) (Sneath and Sokal, 1973).

**Results and Discussion**

The AFLP technique is a powerful DNA marker technique. AFLP is based on the detection of DNA restriction fragments by PCR amplification (Vos et al., 1995 and Zabeau and Vos, 1993). Amplification of restriction fragments is accomplished by the ligation of double stranded (ds) adapter sequences to the ends of restriction sites, which can, subsequently, serve as "universal" binding sites for primer annealing in PCR. Fig.1 illustrates the AFLP profiles of the 14 wheat accessions.

- **Polymorphism**

The fourteen *Triticum* accessions were assayed for AFLP using 11 selective primer combinations, which generated a total of 657 bands (Table 3). The mean number of bands amplified per assay was 59.7. From the 657 amplified fragments, 594 were polymorphic, representing 90.4% polymorphism and an average number of polymorphic bands of 54 per AFLP primer combination. The size of AFLP fragments generated by the different primer combinations ranged from 36 to 1198 bp and the number of amplicons produced by the different primer combinations ranged from 48 (Eacg× Mcac) to 80 (Eaag× Mctg). Combination (Eacg × Mcta ) exhibited the highest percentage of polymorphism (94.8%). Therefore, this combination was the most informative. While combination (Eaag × Mctg) showed the lowest percentage of polymorphism (86.3 %). In this respect, Russel et al. (1997) used AFLPs to determine the genetic relationships among 18 cultivated barley. They scored 279 bands of which 54% were monomorphic. Similar results were also reported by Fossati et al. (2001) who used 4 AFLP primer combinations to study ten grapevine cultivars belonging to varietal groups, and yielded 276 bands of which 128 (46%) were polymorphic. Moreover, Lefebvre et al. (2001) employed ten AFLP primer combinations for estimating the genetic distances among 47 pepper inbred lines and yielded 863 amplified DNA fragments of which 378 were polymorphic markers (43.8%). Similarly, Warburton et al. (2002) fingerprinted one hundred Bobwhite sister lines using
4 AFLP primer combinations, and found a total of 273 bands of which only 40 were polymorphic (14.7%).
Fig. 1. AFLP profiles with primer combination Eagc × Mcag. Lanes from 1-14 represent 1 (Bi), 2 (Ha), 3 (Ho), 4 (Ai), 5 (Bo), 6 (Hr), 7 (Sa), 8 (Sc), 9 (D1), 10 (D2), 11 (D3), 12 (D4), 13 (U1) and 14 (U2). M: pGEM DNA molecular weight marker.
Table 3. Total number of amplicons, monomorphic and polymorphic amplicons and the percentage of polymorphism as revealed by AFLPs markers among the 14 wheat accessions.

<table>
<thead>
<tr>
<th>Primer combination</th>
<th>Total no. of amplicons</th>
<th>Monomorphic amplicons</th>
<th>Polymorphic amplicons</th>
<th>% Polymorphism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eagc × Mcag</td>
<td>75</td>
<td>7</td>
<td>68</td>
<td>90.7</td>
</tr>
<tr>
<td>Eacc × Mctc</td>
<td>60</td>
<td>5</td>
<td>55</td>
<td>91.7</td>
</tr>
<tr>
<td>Eaca × Mctt</td>
<td>49</td>
<td>4</td>
<td>45</td>
<td>91.8</td>
</tr>
<tr>
<td>Eacg × Mcag</td>
<td>68</td>
<td>7</td>
<td>61</td>
<td>89.7</td>
</tr>
<tr>
<td>Eaag × Mctg</td>
<td>80</td>
<td>11</td>
<td>69</td>
<td>86.3</td>
</tr>
<tr>
<td>Eacc × Mctg</td>
<td>56</td>
<td>6</td>
<td>50</td>
<td>89.3</td>
</tr>
<tr>
<td>Eaag × Mcac</td>
<td>48</td>
<td>4</td>
<td>44</td>
<td>91.7</td>
</tr>
<tr>
<td>Eaag × Mcta</td>
<td>56</td>
<td>6</td>
<td>50</td>
<td>89.3</td>
</tr>
<tr>
<td>Eaca × Mcta</td>
<td>58</td>
<td>5</td>
<td>53</td>
<td>91.4</td>
</tr>
<tr>
<td>Eacg × Mcac</td>
<td>49</td>
<td>5</td>
<td>44</td>
<td>89.8</td>
</tr>
<tr>
<td>Eacg × Mcta</td>
<td>58</td>
<td>3</td>
<td>55</td>
<td>94.8</td>
</tr>
<tr>
<td>Total</td>
<td>657</td>
<td>63</td>
<td>594</td>
<td>90.4</td>
</tr>
<tr>
<td>Average</td>
<td>59.7</td>
<td>5.7</td>
<td>54</td>
<td></td>
</tr>
</tbody>
</table>

- Genotype identification by unique markers

As shown in Table 4, a total of 98 unique AFLP markers were identified in the fourteen *Triticum* accessions of which 52 were unique positive markers and 46 were unique negative markers. The total number of unique markers per accession ranged from 1 to 17. The highest number (17) of unique markers was exhibited by *T. dicoccoides* 1 from Sahwet alkhoder, while the lowest number (1) of unique markers was revealed by *T. durum* varieties (Biadi, Hamari, Aiubieh and Bosidi). All 14 accessions were characterized by unique positive markers except Biadi, Hamari and Hourani, which were characterized by 1, 1 and 2 unique negative markers (190 bp, 210 bp, 261 bp and 286 bp) with the primer combinations Eacg× Mcag, Eacg× Mcta and Eagc× Mcaa, respectively. Primer combination Eaca× Mcta revealed the highest number of unique markers (13) followed by combination Eaag Mcta (12). The combination Eaca× Mctt introduced the lowest number of unique markers (4) and combination Eacg× Mcac and Eacc× Mctg exhibited an intermediate number of unique markers (8 and 10, respectively).

Table 4. Wheat accessions characterized by unique positive and/or negative AFLPs markers, marker size and total number of markers identifying each accession (for local cultivated accessions).

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Unique positive markers</th>
<th>Unique negative markers</th>
<th>Gr. tot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primer combination</td>
<td>Molecular size</td>
<td>Total</td>
</tr>
<tr>
<td>Biadi</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hamari</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hourani</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Aiubieh</td>
<td>Eacg× Mcta</td>
<td>373</td>
<td>1</td>
</tr>
<tr>
<td>Bosiedi</td>
<td>Eacg× Mcag</td>
<td>269</td>
<td>1</td>
</tr>
<tr>
<td>Senaljamal</td>
<td>Eacc× Mctc</td>
<td>161</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Eacg× Mcac</td>
<td>217-410</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eacg× Mcta</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eacg× Mcta</td>
<td>116-192</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table (4): continued (for wild wheat accessions)

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Unique positive markers</th>
<th>Unique negative markers</th>
<th>Gr. tot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primer combination</td>
<td>Molecular size</td>
<td>Total</td>
</tr>
<tr>
<td>D 1</td>
<td>Eacc× Mctc</td>
<td>123-556</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Eaca× Mcta</td>
<td>95-100-350</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eacg× Mcac</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaat× Meta</td>
<td>115-413</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaat× Mta</td>
<td>114-292-347-676</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaat× Mcta</td>
<td>179</td>
<td></td>
</tr>
<tr>
<td>D 2</td>
<td>Eacg× Mcag</td>
<td>171</td>
<td>3</td>
</tr>
<tr>
<td>D 3</td>
<td>Eacc× Mctc</td>
<td>126-220</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Eaca× Mctg</td>
<td>110-159</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eacg× Mctg</td>
<td>96-290</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaag× Mcta</td>
<td>114-292-347-676</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaag× Mcac</td>
<td>179</td>
<td></td>
</tr>
<tr>
<td>D 4</td>
<td>Eaag× Mctg</td>
<td>287</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Eacc× Mctc</td>
<td>147-205-227</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaca× Mcta</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaca× Mcta</td>
<td>280-828-444-567</td>
<td></td>
</tr>
<tr>
<td>U 1</td>
<td>Eacc× Mcag</td>
<td>210-396</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Eaca× Mcac</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaat× Meta</td>
<td>166-206-232</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaat× Mta</td>
<td>91-214</td>
<td></td>
</tr>
<tr>
<td>U 2</td>
<td>Eacg× Mcac</td>
<td>417</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Eacc× Mctg</td>
<td>386</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eaca× Mcta</td>
<td>368-532</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td></td>
<td>52</td>
<td></td>
</tr>
</tbody>
</table>

The combinations Eacg×Mcta, Eacg×Mcag, Eacc×Mctc and Eaca×Mcta distinguished 6 out of the 14 tested *Triticum* accessions representing the highest number of identified accessions (Table 5), while the combination Eaca×Mctt identified the lowest number of accessions (2). In this respect, El-Khishin et al. (2003) studied the AFLP fingerprinting of some Egyptian date palm (*Phoenix dactylifera* L.) cultivars and the analysis permitted the
distinction of unique markers among the five studied cultivars. A total of 78 positive and 48 negative markers were identified by the six AFLP primer combinations. The total number of unique markers per genotype ranged from 13 to 51.

Table 5. The AFLP primer combinations revealing unique positive and/or negative markers in the tested Triticum genotypes and total number of identified genotypes.

<table>
<thead>
<tr>
<th>Primer</th>
<th>Genotypes showing unique Positive markers</th>
<th>Genotypes showing unique Negative markers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eacg×Mcta</td>
<td>Ai,Hr,Sa,Se,d1</td>
<td>Ha</td>
<td>6</td>
</tr>
<tr>
<td>Eacg×Mcag</td>
<td>Bo,D1,D2</td>
<td>Bi,Hr,U1</td>
<td>6</td>
</tr>
<tr>
<td>Eacg×Mcaa</td>
<td>D1,U1</td>
<td>Ho,Se</td>
<td>4</td>
</tr>
<tr>
<td>Eaag×Mctg</td>
<td>Hr,D3,D4</td>
<td>Se,D3,D4,U1</td>
<td>5</td>
</tr>
<tr>
<td>Eaca×Meta</td>
<td>Hr,Sa,Se,D1,U1</td>
<td>Hr,Se,D3</td>
<td>6</td>
</tr>
<tr>
<td>Eace×Mtc</td>
<td>Sa,Se,D1,D3</td>
<td>Se,D3,U1,U2</td>
<td>6</td>
</tr>
<tr>
<td>Eacg×Mcac</td>
<td>Se,D1,U1,U2</td>
<td>D3</td>
<td>5</td>
</tr>
<tr>
<td>Eaca×Mcta</td>
<td>D1</td>
<td>Se,D1</td>
<td>2</td>
</tr>
<tr>
<td>Eacc×Mctg</td>
<td>D2,D4,U1</td>
<td>D3,D4,U2</td>
<td>5</td>
</tr>
<tr>
<td>Eaag×Meta</td>
<td>D3,D4</td>
<td>Se,D3,D4,u2</td>
<td>4</td>
</tr>
<tr>
<td>Eacg×Mcag</td>
<td>-</td>
<td>D1,D3,D4,U1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>10</td>
<td>53</td>
</tr>
</tbody>
</table>

- **Species-specific markers**

As shown in Table 6, a total of 13 species-specific markers were identified in two out of the four studied species. *T. aestivum* was identified by 3 positive species-specific markers, revealed by the primer combinations Eacg×Mcag, Eacg×Mcag and Eacg×Mcta. In addition *T. aestivum* was identified by 1 negative species-specific marker revealed by the primer combination Eacg×Mcta. On the other hand, the species *T. urartu* was identified by 2 positive species-specific markers revealed by the combinations Eacg×Mcag and Eacg×Mcac, in addition to 6 negative species-specific markers revealed by the combinations Eaca×Mcta, Eacg×Mcaa and Eacc×Mcta.

Table 6. The AFLP marker combinations revealed positive and / or negative species-specific markers in the tested 4 species of Triticum including 14 accessions and total number of identified genotype.

<table>
<thead>
<tr>
<th>Species</th>
<th>Genotype</th>
<th>Positive markers</th>
<th>Negative markers</th>
<th>Grand total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Primer</td>
<td>To.</td>
<td>Size</td>
</tr>
<tr>
<td>T. urartu</td>
<td>U1-U2</td>
<td>240</td>
<td>Eacg</td>
<td>Mcag</td>
</tr>
<tr>
<td>T. aestivum</td>
<td>Sa-Hr</td>
<td>175</td>
<td>Eacg</td>
<td>Mcag</td>
</tr>
<tr>
<td>T. aestivum</td>
<td>Sa-Hr</td>
<td>160</td>
<td>Eacg</td>
<td>Mcag</td>
</tr>
<tr>
<td>T. urartu</td>
<td>U1-U2</td>
<td>390</td>
<td>Eacg</td>
<td>Mcag</td>
</tr>
<tr>
<td>T. urartu</td>
<td>U1-U2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>T. urartu</td>
<td>U1-U2</td>
<td>200</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>T. aestivum</td>
<td>Sa-Hr</td>
<td>270 and 320</td>
<td>Eacg</td>
<td>Mcag</td>
</tr>
<tr>
<td>T. urartu</td>
<td>U1-U2</td>
<td>-</td>
<td>-</td>
<td>100 and 165</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Genetic relationships**

The AFLP assay allows the screening of a large number of loci with few primer combinations, thus, facilitating the rapid detection of genetic relatedness with high certainty. The genetic similarity among the fourteen wheat accessions was determined
using the scoring data obtained from 11 primer combinations. The similarity level among the 14 wheat accessions ranged from 90.8 to 50.9%. The highest genetic similarity, (90.8%) was between Bosiedi (Bo) and Aiubieh (Ai) followed by (88.2%) between Hourani (Ho) and Hamari (Ha), and (87.5%) between Aiubieh (Ai) and Hamari (Ha). On the other hand the lowest genetic similarity (50.9%) was between Senaljamal (Se) (*T. durum*) and U1 (*T. urartu*). Moreover, on average the intra-specific genetic similarity was in *T. aestivum* (86.2%), followed by *T. durum* (76.5%), then *T. urartu* (70.9%), while the lowest similarity (67.2%) was revealed by *T. dicoccoides* (Table 7). The AFLP results revealed a lower level of similarity compared with that resulting from RAPD. This might be attributed to the higher level of polymorphism revealed by AFLP. This is in good agreement with the results of Hussein et al. (2002) in cotton and Hussein et al. (2004) in citrus. Pakniyat et al. (1997) found that the similarity values between the 39 wild barley genotypes ranged from 71 to 91%. Ajmone et al. (1998) surveyed genetic divergence among 13 inbred lines of maize with 6 primer combinations and revealed 63.7% as a highest genetic similarity while the lowest was 19.5% with an average of 45.9%. Bohn et al. (1999) estimated the genetic similarity among 11 wheat lines and found that the genetic similarity ranged from 0.40 for cross Harrach/Berthold to 0.83 for crosses Admater/Rabe and Jubilar/Schernaver with an average of 0.61. Segovia-Lerma et al. (2003) estimated the genetic distances among 9 alfalfa using 34 primer combinations as ranged from 0.52 to 1.46.

Table 7. Genetic similarity (GS) matrices computed according to Dice coefficient from AFLPs for the 14 wheat accessions.

| T. urartu | 2 | 100.0 |
| T. dicoccoides | 2 | 74.1 | 100.0 |
| T. urartu | 1 | 70.9 | 68.1 | 100.0 |
| T. durum | 2 | 70.1 | 63.9 | 100.0 |
| T. dicoccoides | 3 | 69.1 | 76.9 | 64.6 | 100.0 |
| T. dicoccoides | 4 | 65.5 | 70.5 | 67.4 | 65.4 | 100.0 |
| T. urartu | 1 | 64.0 | 69.0 | 58.6 | 81.1 | 63.0 | 59.9 | 100.0 |
| T. durum | 3 | 63.7 | 67.6 | 57.8 | 76.3 | 62.4 | 57.7 | 87.5 | 100.0 |
| T. durum | 4 | 63.0 | 68.0 | 57.9 | 75.3 | 62.6 | 59.2 | 86.3 | 90.8 | 100.0 |
| T. dicoccoides | 1 | 62.6 | 68.6 | 55.9 | 68.0 | 65.4 | 55.2 | 75.2 | 74.8 | 76.3 | 100.0 |
| T. durum | 3 | 61.2 | 65.8 | 56.0 | 75.7 | 57.4 | 60.4 | 88.2 | 83.7 | 81.9 | 69.4 | 100.0 |
| T. aestivum | 1 | 59.7 | 64.8 | 55.6 | 70.7 | 61.5 | 56.8 | 78.5 | 76.5 | 78.7 | 73.5 | 73.0 | 100.0 |
| T. aestivum | 2 | 59.0 | 66.2 | 55.6 | 69.4 | 60.6 | 59.0 | 76.0 | 75.0 | 79.3 | 70.0 | 73.4 | 86.2 | 100.0 |
| T. durum | 1 | 57.7 | 64.1 | 50.9 | 66.8 | 59.4 | 54.5 | 71.3 | 69.9 | 69.6 | 72.8 | 67.3 | 72.2 | 68.6 | 100.0 |

- Cluster analysis

As shown in Fig. 2, the genetic similarity among the 14 accessions of wheat resulted in a dendrogram comprised of two clusters. One cluster was divided into two subclusters. The first subcluster included only one accession (*T. urartu* 1 from Rasheda), while the other subcluster was divided into two groups; the first group included only one accession (*T. dicoccoides* 4 from Rasheda), while the second group included two subgroups; the first subgroup included only one accession (*T. urartu* 2 from Moshanaf), while the other subgroup included two accessions (*T. dicoccoides* 2 from Moshanaf ) and (*T. dicoccoides* 3 from Kanawat).
Fig. 2. Dendrogram for the 14 wheat accessions constructed from AFLPs data using Unweighted Pair-Group Arithmetic Average (UPGMA) and similarity matrices computed according to Dice coefficient.

The second cluster was divided into the subclusters; the first subcluster included two accessions Senaljamal (Se) (*T. durum*) and (*T. dicoccoides* 1 from Sahwet alkhoder), while the other subcluster was divided into two groups; the first group included two accessions Salamouni (Sa) and Hredanieh (Hr), both belonging to *T. aestivum*, while the other group is divided into two subgroups; the first subgroup included only one accession Biadi (Bi), while the other subgroup included four accessions Hamari (Ha), Hourani (Ho), Bosiedi (Bo) and Aiubieh (Ai) all belonging to *T. durum*. Therefore, this dendrogram clustered all wild accessions in one cluster except D1 that is grouped with Senaljamal in one subcluster, probably due to gene flow and that is also the reason for separating U1 from U2 but both still in one cluster. Ajmone et al. (1998) clustered 13 inbred lines of maize to survey genetic divergence using 6 AFLP primer combinations. They indicated a high co-phenetic coefficient (0.90) and assigned the 13 inbred lines to three major groups. In this respect, Warburton et al. (2002) demonstrated that among Bob White lines of bread wheat using four AFLP primer combinations; the cluster analysis gives two main very distinct clusters, lines clustered together, for the most part with other sister lines are sharing a common selection history.

**References**


Variation in Quantitative Attributes of *Aegilops* Species under Water Stress

R. Baalbaki, N. Hajj-Hassan and R. Zurayk

*Faculty of Agricultural and Food Sciences, American University of Beirut, P.O. Box 11-02361, Beirut, Lebanon, e-mail: riadbaal@aub.edu.lb*

**Keywords:** *Aegilops*, RAPD Quantitative attributes, drought tolerance, genetic resources, Lebanon

**Abstract**

*Aegilops* species in semi-arid areas constitute important sources for genes for improving resistance to abiotic stresses in wheat. Twenty-one populations belonging to six species, *Ae. biuncialis*, *Ae. cylindrica*, *Ae. geniculata*, *Ae. markgrafii*, *Ae. triuncialis*, and *Ae. vavilovii* were collected from the drylands of Lebanon. The genetic diversity of these accessions were analyzed using RAPD technique and their vegetative and reproductive attributes (dry weight, plant height, tillers per plant, days to maturity, productive tillering, spike length, kernels per spike, seed number, seed weight and yield) were evaluated at three levels of moisture stress. The results showed that the average within species similarity was relatively high, with Jaccard’s similarity index ranging from 61.6 to 75.5%. Cluster analysis grouped populations according to species, but location effects did not affect the population grouping. Based on changes in quantitative attributes, *Ae. geniculata* and *Ae. markgrafii* were found to be more drought tolerant. Attributes accounting for most of the variation under different levels of water stress are classified in two groups, the “seed yield” group and the “tiller” group, although the extent of attribute variation in each group depended on water stress level. Under severe water stress, the ability of plants to produce fertile tillers with few large seeds became a distinguishing characteristic that should be considered in evaluating plants for drought tolerance.

**Introduction**

The species of *Aegilops* (Poaceae) belong to gene pools readily available for wheat breeding (Hedge *et al.*, 2002; Valkoun, 2001; Zaharieva *et al.*, 2001a). *Aegilops* is characterized as a Mediterranean-Western Asiatic element (Blumler, 1994; Hedge *et al.*, 2002; Valkoun, 2001, van Slageren, 1994), and its center of diversity, including regions of Lebanon and Syria, comprises the semi-arid areas known for frequent and inherent droughts. Consequently, *Aegilops* species in this area are expected to contain high levels of genetic diversity (Sasanuma *et al.*, 2002), and are potential sources of genes for abiotic stress resistance (Farooq *et al.*, 1996; Valkoun, 2001; Zaharieva, 2001). Many *Aegilops* species, such as *Ae. cylindrica* and *Ae. triuncialis* are noxious weeds, especially outside their area of origin (Donald and Ogg, 1991). Therefore, studying the genetic structure, adaptation and patterns of growth of *Aegilops* species may lead to more efficient ways of their control as weeds.
Diversity of *Aegilops* germplasm, as is the case with other wild species, has until recently been mainly determined based on morphological approaches not necessarily reflecting their genetic diversity, leading to frequent failures of their exploitation in breeding programs (Hegde et al., 2000). Populations with morphological differences may be genetically quite similar, while genetic diversity might exist despite morphological uniformity, explaining the frequently observed lack of correlation between the two (Garcia et al., 2002; Ontivero et al., 2000). The imprecise nature of qualitative morphological characters as indicators of genetic potential has justifiably led many researchers to concentrate on biochemical and molecular approaches in evaluating wild populations (Dvorak et al., 1998a and 1998b; Hegde et al., 2000; Pestsova et al., 2000; Sasanuma et al., 2002). The same applies to quantitative traits, largely avoided as measures of genetic diversity because of their high susceptibility to environmental influences. However, even though quantitative traits should not be used as primary indicators of diversity, their evaluation can provide the background against which genetic as well as qualitative phenotypic variation is compared. Valuable insight into the processes determining the phenotypic appearance, similar adaptation patterns, presence of useful genes, as well as evolutionary and taxonomic significance can be gained by studying the sources and extent of quantitative variation under different environmental conditions (Ortiz et al., 1998; Pfenninger and Magnin, 2001).

When investigating the quantitative variation of a number of related species, Keddy (1992) recommended the pragmatic approach of measuring many traits on a large number of species. Alternatively, a functional approach can be followed by selecting groups of traits of potential functional significance, each group reflecting a different emphasis on plant processes of interest, such as vegetative and reproductive growth under varying moisture stress. The latter approach is more interesting since it combines large and complex data sets into smaller and more easily interpreted sets of attributes, including traits of known or potential adaptive value (Willby et al., 2000).

The objective of this investigation was to study the structure and extent of variation in quantitative attributes of *Aegilops* species subjected to varying degrees of water stress. This was accomplished by first broadly evaluating levels of genetic diversity within and between several species collected from semi-arid areas of Lebanon, followed by analyzing the variation in vegetative and reproductive attributes of those species under different levels of soil water availability.

**Materials and Methods**

**Plant Materials**

Twenty-one populations of six *Aegilops* species (*Ae. biuncialis* Vis. (=*Ae. lorentii* Hochst.), *Ae. cylindrica* Host, *Ae. geniculata* Roth, *Ae. markgrafii* (Greuter) K. Hammer (=*Ae. caudata* Auct), *Ae. triuncialis* L., and *Ae. vavilovii* (Zhuk.) Chennav.) were collected during spring and summer of year 2000 from 14 locations representing typical variations within the semi-arid Beqa’a region of Lebanon (Table 1). Depending on occurrence, one or more species were collected from each location, and the total collection area did not exceed 100 km². One spike was collected from each of 20 randomly selected plants, at least 1-m apart, of a single population. For the purposes of this study, to obtain a broad estimate of diversity within and among species and
populations, seeds from the 20 spikes of each population were bulked producing one sample per population.

Table 1. Number and geographic origin of populations belonging to different *Aegilops* species collected the semi-arid region of Beqa’a in Lebanon

<table>
<thead>
<tr>
<th>Location</th>
<th>Species</th>
<th>Population</th>
<th>Longitude (East)</th>
<th>Latitude (North)</th>
<th>Altitude (m a.s.l.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Ae. triuncialis</em></td>
<td>AT1</td>
<td>36°13′96″</td>
<td>34°12′73″</td>
<td>1400</td>
</tr>
<tr>
<td></td>
<td><em>Ae. markgrafii</em></td>
<td>AM1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Ae. biuncialis</em></td>
<td>AB1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td><em>Ae. triuncialis</em></td>
<td>AT2</td>
<td>36°08′74″</td>
<td>34°09′65″</td>
<td>1450</td>
</tr>
<tr>
<td></td>
<td><em>Ae. markgrafii</em></td>
<td>AM2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td><em>Ae. triuncialis</em></td>
<td>AT3</td>
<td>36°11′95″</td>
<td>33°51′83″</td>
<td>1525</td>
</tr>
<tr>
<td>4</td>
<td><em>Ae. geniculata</em></td>
<td>AG1</td>
<td>36°13′25″</td>
<td>33°51′49″</td>
<td>1800</td>
</tr>
<tr>
<td></td>
<td><em>Ae. triuncialis</em></td>
<td>AT4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td><em>Ae. geniculata</em></td>
<td>AG2</td>
<td>36°11′00″</td>
<td>33°51′93″</td>
<td>1700</td>
</tr>
<tr>
<td></td>
<td><em>Ae. biuncialis</em></td>
<td>AB2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><em>Ae. triuncialis</em></td>
<td>AT5</td>
<td>36°13′10″</td>
<td>33°51′33″</td>
<td>1700</td>
</tr>
<tr>
<td></td>
<td><em>Ae. biuncialis</em></td>
<td>AB3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><em>Ae. biuncialis</em></td>
<td>AB4</td>
<td>36°23′81″</td>
<td>34°10′33″</td>
<td>1450</td>
</tr>
<tr>
<td>8</td>
<td><em>Ae. biuncialis</em></td>
<td>AB5</td>
<td>36°22′77″</td>
<td>34°09′75″</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td><em>Ae. vavilovii</em></td>
<td>AV1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><em>Ae. geniculata</em></td>
<td>AG3</td>
<td>36°21′20″</td>
<td>34°07′60″</td>
<td>1625</td>
</tr>
<tr>
<td>10</td>
<td><em>Ae. vavilovii</em></td>
<td>AV2</td>
<td>36°26′04″</td>
<td>34°08′74″</td>
<td>1800</td>
</tr>
<tr>
<td>11</td>
<td><em>Ae. vavilovii</em></td>
<td>AV3</td>
<td>36°23′97″</td>
<td>34°08′34″</td>
<td>1900</td>
</tr>
<tr>
<td>12</td>
<td><em>Ae. geniculata</em></td>
<td>AG4</td>
<td>36°26′99″</td>
<td>34°09′37″</td>
<td>1750</td>
</tr>
<tr>
<td>13</td>
<td><em>Ae. biuncialis</em></td>
<td>AB6</td>
<td>36°23′29″</td>
<td>34°12′04″</td>
<td>1475</td>
</tr>
<tr>
<td>14</td>
<td><em>Ae. cylindrica</em></td>
<td>AC1</td>
<td>36°11′62″</td>
<td>34°12′40″</td>
<td>1650</td>
</tr>
</tbody>
</table>

**DNA analyses**

Total DNA was extracted from fresh young leaves, randomly selected from 5 field-grown plants of each population, using the CTAB method (Murray and Thompson 1980). DNA was quantified spectrophotometrically and adjusted to a final uniform concentration of 1.5 ng μl⁻¹. Thirty-six random decamer primers (Operon Technologies, Inc., Alameda, CA) were screened for polymorphism and reproducible banding patterns, and 10 of these primers belonging to Operon series A and B were retained (Table 2). PCR reaction mixtures of 15 μl contained 7.5 ng of template DNA, one unit of Taq polymerase (Thermoprime Plus DNA Polymerase; ABgene, Surrey, UK), 75 mM Tris-HCl (pH 8.8), 20 mM (NH₄)₂SO₄, 0.01% (v/v) Tween 20®, 0.2 mM of each DNTP, 7 ng of each primer (0.15 μM), 2.5 mM MgCl₂ and bovine serum albumin (0.8 μg μl⁻¹). Amplification products were electrophoresed on 1.2% agarose gels, stained with ethidium bromide and visualized using a UV transilluminator. Sizes of RAPD bands were determined by comparison to a 100-bp DNA ladder.

Gels were scored for the presence (1) or absence (0) of RAPD bands, omitting weak, unstable or smearing bands. Each band was regarded as a single locus (Lynch and Milligan 1994), assuming bands with the same molecular weight to be identical. RAPD polymorphism was measured as the proportion of polymorphic loci to the total number of loci scored in all populations of the same species. Jaccard’s similarity index \((J)\) was calculated as
\[ J = \frac{a}{n - d} \]

where \( a \) is the number of positive matches (bands present in both loci), \( n \) is the total number of loci, and \( d \) is the number of negative matches (bands absent in both loci). Jaccard’s similarity indices were used to construct a dendogram by the unweighted pair-groups method average (UPGMA).

**Evaluation of quantitative attributes under varying moisture stress**

Quantitative attributes were evaluated in the greenhouse at three levels of moisture stress. Each experimental unit consisted of a 4-liter pot filled with a soil mix (1 to 1 to 2 parts of peat, loam and sand, respectively), into which five seeds of a single population were sown, randomly distributed within three blocks in the greenhouse. Unless otherwise noted, measured attributes were averaged over the number of surviving plants per pot. Immediately after seed sowing, all pots were irrigated with tap water until seedlings emerged and were established, then irrigated to drainage with half strength Hoagland’s solution till the two first leaves were completely developed, unfolded and green. Three moisture stress treatments were then applied by maintaining the soil at a field capacity (FC) of 75 to 100% (control or no moisture stress treatment), 50 to 75% (moderate stress) or 25 to 50% (severe stress). To maintain desired FC ranges, pots were weighed daily and change of weight from an initial, predetermined dry soil weight was used to calculate irrigation volume, assuming water loss to be due to evaporation and plant weight to be insignificant relative to total weight. Frequency of irrigation depended on daily plant water use and environmental conditions, and was continued till the completion of anthesis.

Days to maturity (DTM) were the number of days from germination to physiological maturity, when 50% of plants had yellow uppermost internodes. Plant height (PLH) of the main stem was measured as the distance from the soil level to spike tip, excluding awns, and plant dry weight (PDW) was the total above ground dried biomass. Productive tillering capacity (PTC) was the total number of fertile tillers per plant at maturity, and the total number of tillers per plant (TNT) was the sum of fertile and non-fertile tillers. Spike length (SLE) was the average of five randomly selected spikes per plant, from the base to the tip of the highest spikelet, excluding awns, and the number of kernels per spike (KPS) was the average seed number based on the same spikes. Seed number per plant (SNP) was the total number of seeds from all spikes from a single plant, and seed weight per spike (SWS) was the total yield per plant (YLD) averaged over the total number of fertile tillers per plant (PTC).

Analysis of variance was performed separately for each species as a factorial experiment in a complete randomized block design, with populations and moisture levels as factors. Since analysis of variance for all species indicated that population effects were not significant, even at \( p \leq 0.1 \), reported means are the averages of blocks and populations. Differences between the three water level treatment means within each species were determined for each attribute using Bonferroni’s test (\( p \leq 0.05 \)). Unless otherwise noted, Pearson’s simple linear correlation coefficients were calculated for pairs of attributes. Principal component analysis (PCA) was carried out on all species separated according to water stress treatments. Calculations of eigenvectors were made using correlation matrices with Kaiser’s Varimax rotation of axes. All analyses were done using SPSS 11.5 (SPSS, 2002).
Results

The 10 primers used to screen the 21 different populations amplified 86 DNA fragments, ranging in size from 598 to 2067 bp (Table 2), though the highest number of markers per species did not exceed 73. The percentage of polymorphic bands varied greatly between species (Table 3). *Ae. markgrafii* had the lowest level of RAPD polymorphism (25.5%), while *Ae. triuncialis* had the highest (65.8%), with generally low overall intraspecific polymorphism. Within species similarity was relatively high with Jaccard’s similarity index ranging from 61.6 to 75.5% (Table 3), and these results were significantly associated with percentage polymorphism values ($r = 0.89$, $p \leq 0.05$). Only one marker was species specific, band OPB9-613 for *Ae. vavilovii*. However, the specificity of this band, and its use for positive identification should be further verified comparing other species and testing a larger number of populations per species.

Table 2. Primers used in RAPD analysis, their sequence, number of bands produced and size range.

<table>
<thead>
<tr>
<th>Primer</th>
<th>Sequence (5’→3’)</th>
<th>Maximum No. of scorable bands</th>
<th>Size range of bands (bp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPA5</td>
<td>AGGGGTCTTG</td>
<td>5</td>
<td>598-1004</td>
</tr>
<tr>
<td>OPA12</td>
<td>TCGGCGATAG</td>
<td>9</td>
<td>422-2094</td>
</tr>
<tr>
<td>OPA15</td>
<td>TTCCGAACCC</td>
<td>9</td>
<td>361-2023</td>
</tr>
<tr>
<td>OPA16</td>
<td>AGCCACGCAA</td>
<td>12</td>
<td>449-2403</td>
</tr>
<tr>
<td>OPA17</td>
<td>GACCGCTTGT</td>
<td>11</td>
<td>374-2263</td>
</tr>
<tr>
<td>OPA19</td>
<td>CAAACGTCGG</td>
<td>11</td>
<td>290-1941</td>
</tr>
<tr>
<td>OPA20</td>
<td>GTTGGCATCC</td>
<td>6</td>
<td>759-1644</td>
</tr>
<tr>
<td>OPB7</td>
<td>GTTGACGCAG</td>
<td>7</td>
<td>446-1124</td>
</tr>
<tr>
<td>OPB8</td>
<td>GTCCACACGG</td>
<td>8</td>
<td>295-1832</td>
</tr>
<tr>
<td>OPB9</td>
<td>TGGGGGACTC</td>
<td>8</td>
<td>613-2067</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>86</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 3. RAPD polymorphism and average Jaccard similarity index within species of *Ae. biuncialis*, *Ae. markgrafii*, *Ae. geniculata*, *Ae. vavilovii* and *Ae. triuncialis*.

<table>
<thead>
<tr>
<th>Species*</th>
<th>No. of populations</th>
<th>No. of RAPD markers</th>
<th>% polymorphism</th>
<th>Jaccard similarity index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Polymorphic</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ae. biuncialis</em></td>
<td>6</td>
<td>73</td>
<td>44</td>
<td>60.0</td>
</tr>
<tr>
<td><em>Ae. markgrafii</em></td>
<td>2</td>
<td>51</td>
<td>13</td>
<td>25.5</td>
</tr>
<tr>
<td><em>Ae. geniculata</em></td>
<td>4</td>
<td>66</td>
<td>36</td>
<td>54.6</td>
</tr>
<tr>
<td><em>Ae. vavilovii</em></td>
<td>3</td>
<td>52</td>
<td>18</td>
<td>34.6</td>
</tr>
<tr>
<td><em>Ae. triuncialis</em></td>
<td>5</td>
<td>73</td>
<td>48</td>
<td>65.8</td>
</tr>
</tbody>
</table>

*No results for *Ae. cylindrica* are reported since only one population was found.

Populations within each species, although relatively similar, were nevertheless distinct. Cluster analysis confirmed the differences between species, and with only one exception, populations belonging to the same species were grouped together. Location effects, in terms of distance and altitude, did not affect population grouping. For example, population AG2 of *Ae. geniculata* was more similar to population AG4 than AG1, although it was collected from a close location to that of AG1. Likewise, population AT2
of *Ae. triuncialis* was more similar to AT5 than AT1, although it was collected from a comparable location, in terms of both distance and elevation, to population AT1.

Analysis of variance (data not shown) revealed that population effects for all species had no significant effect on any of the quantitative attributes, while water stress effects did. To facilitate the interpretation of results, quantitative attributes were divided into two groups. The first is vegetative growth attributes, to which DTM, PLH, TNT and PDW belong. The second is reproductive attributes, to which PTC, KPS, SNP, SLE, SWS and YLD belong. PDW of all species was reduced with increased moisture stress (Table 4). However, with one exception, reductions were only significant under severe moisture stress compared to the control. Species did not exhibit a uniform response to water stress in terms of PLH, and the heights of *Ae. markgrafii*, *Ae. geniculata* and *Ae. triuncialis* did not significantly vary with varying water stress. PLH of *Ae. biuncialis*, *Ae. cylindrica* and *Ae. vavilovii* was significantly reduced under severe moisture stress, but *Ae. cylindrica* was also the only species to show an appreciable height increase under moderate water stress compared to the control. Soil moisture level had no effect on TNT of *Ae. markgrafii*, *Ae. cylindrica* or *Ae. triuncialis*, while TNT of *Ae. biuncialis* and *Ae. vavilovii* decreased when moisture stress increased. Under moderate water stress, *Ae. geniculata* tillers increased compared to the control, and then significantly decreased under severe stress. Although DTM tended to increase with increasing stress, such increases were statistically significant for only two species, *Ae. biuncialis* and *Ae. markgrafii*. Of all the vegetative attributes, only PLH and PDW were significantly correlated (Table 5).

Table 4. Effect of water stress levels on plant dry weight (PDW), plant height (PLH), days to maturity (DTM), total number of tillers (TNT), productive tillering capacity (PTC), spike length (SLE), seed number per plant (SNP), number of kernels per spike (KPS), seed weight per spike (SWS) and yield per plant (YLD) of six *Aegilops* species grown in the greenhouse.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Water Stress Level</th>
<th>Species</th>
<th>Species</th>
<th>Species</th>
<th>Species</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>Ae. biuncialis</em></td>
<td><em>Ae. markgrafii</em></td>
<td><em>Ae. cylindrica</em></td>
<td><em>Ae. geniculata</em></td>
<td><em>Ae. triuncialis</em></td>
</tr>
<tr>
<td>PDW (g)</td>
<td>1</td>
<td>15.79a</td>
<td>13.13a</td>
<td>11.55a</td>
<td>10.61a</td>
<td>16.22a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>13.27a</td>
<td>10.02ab</td>
<td>13.74a</td>
<td>08.78ab</td>
<td>12.45b</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>08.20b</td>
<td>06.34b</td>
<td>06.75b</td>
<td>07.78b</td>
<td>09.66b</td>
</tr>
<tr>
<td>PLH (cm)</td>
<td>1</td>
<td>46.75a</td>
<td>43.17a</td>
<td>47.83b</td>
<td>38.73a</td>
<td>47.97a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>47.77a</td>
<td>40.33a</td>
<td>60.75a</td>
<td>35.97a</td>
<td>50.69a</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>37.79b</td>
<td>44.58a</td>
<td>37.50c</td>
<td>37.08a</td>
<td>43.53b</td>
</tr>
<tr>
<td>TNT</td>
<td>1</td>
<td>32.6a</td>
<td>30.2a</td>
<td>27.0a</td>
<td>29.6ab</td>
<td>25.1a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>22.5a</td>
<td>27.8a</td>
<td>20.3a</td>
<td>35.4a</td>
<td>26.1a</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>21.2b</td>
<td>26.3a</td>
<td>23.0a</td>
<td>28.3b</td>
<td>21.1b</td>
</tr>
<tr>
<td>DTM</td>
<td>1</td>
<td>175.5b</td>
<td>143.8b</td>
<td>137.7a</td>
<td>164.5a</td>
<td>167.1b</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>185.5ab</td>
<td>165.3a</td>
<td>137.0a</td>
<td>172.7a</td>
<td>165.6b</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>200.1a</td>
<td>162.5a</td>
<td>143.2a</td>
<td>178.8a</td>
<td>183.7a</td>
</tr>
<tr>
<td>PTC</td>
<td>1</td>
<td>25.3a</td>
<td>24.0a</td>
<td>24.3a</td>
<td>21.9b</td>
<td>18.5a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>15.3b</td>
<td>21.8a</td>
<td>18.7ab</td>
<td>30.8a</td>
<td>17.1a</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>17.7b</td>
<td>20.6a</td>
<td>14.8b</td>
<td>24.6ab</td>
<td>19.4a</td>
</tr>
<tr>
<td>SLE (cm)</td>
<td>1</td>
<td>2.91b</td>
<td>8.13a</td>
<td>7.33a</td>
<td>2.11b</td>
<td>4.87a</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.98b</td>
<td>6.53a</td>
<td>6.82ab</td>
<td>2.24ab</td>
<td>5.29a</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3.87a</td>
<td>7.39a</td>
<td>6.07b</td>
<td>2.37a</td>
<td>4.73a</td>
</tr>
<tr>
<td>SNP</td>
<td>1</td>
<td>132.8a</td>
<td>189.2a</td>
<td>152.7ab</td>
<td>233.3a</td>
<td>107.0b</td>
</tr>
</tbody>
</table>
Table 5. Correlation coefficients among quantitative attributes over all *Aegilops* species.

<table>
<thead>
<tr>
<th></th>
<th>PTC†</th>
<th>SLE</th>
<th>SNP</th>
<th>KPS</th>
<th>SWS</th>
<th>PDW</th>
<th>PLH</th>
<th>TNT</th>
<th>DTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>YLD</td>
<td>0.75**</td>
<td>-0.02</td>
<td>0.63**</td>
<td>0.13</td>
<td>0.92**</td>
<td>0.21</td>
<td>0.16</td>
<td>0.61*</td>
<td>-0.25</td>
</tr>
<tr>
<td>PTC</td>
<td>-0.23</td>
<td>0.51*</td>
<td>-0.14</td>
<td>0.51*</td>
<td>0.13</td>
<td>-0.13</td>
<td>0.89**</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>SLE</td>
<td>0.07</td>
<td>0.84**</td>
<td>0.13</td>
<td>0.02</td>
<td>0.42</td>
<td>-0.32</td>
<td>-0.73**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNP</td>
<td>0.16</td>
<td>0.71**</td>
<td>0.18</td>
<td>0.30</td>
<td>0.45</td>
<td>-0.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KPS</td>
<td>0.29</td>
<td>0.13</td>
<td>0.57*</td>
<td>-0.35</td>
<td>-0.75**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWS</td>
<td>0.13</td>
<td>0.30</td>
<td>0.35</td>
<td>-0.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PDW</td>
<td>0.68**</td>
<td>0.16</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLH</td>
<td>-0.25</td>
<td>-0.39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TNT</td>
<td>0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

†YLD: seed yield; PTC: productive tillering capacity; SLE: spike length; SNP: seed number per plant; KPS: number of kernels per spike; SWS: seed weight per spike; PDW: plant dry weight; PLH: plant height; TNT: total number of tillers; DTM: days to maturity. *, **Significant at the 5% and 1% probability levels, respectively.

PTC was highly and positively correlated to TNT (Table 5), and similar to TNT results, PTC of *Ae. biuncialis* and *Ae. vavilovii* were the most sensitive species to water stress (Table 4). Very little within species variation in SLE was detected, and no consistent trend of change with changes in water stress could be observed (Table 4). Species varied considerably in SNP, a potentially important character, in the presence or absence of stress. SNP was significantly reduced when *Ae. biuncialis*, *Ae. geniculata* and *Ae. vavilovii* plants were moderately stressed, but the other three species did not exhibit similar variation. Correlation between SNP and KPS was low and non-significant (Table 5). Very little within species variation was observed for KPS, and only *Ae. vavilovii* exhibited an incremental decline in kernel number with increasing moisture stress. SWS of *Ae. biuncialis*, *Ae. cylindrica*, *Ae. geniculata* and *Ae. vavilovii* was significantly reduced when moisture stress was imposed, while that of *Ae. markgrafii* and *Ae. triuncialis* was not affected to a significant degree.
Table 6. Principal component loadings of quantitative attributes of six Aegilops species measured at three levels of water stress.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Water stress level**</th>
<th>C1*</th>
<th>C2</th>
<th>C3</th>
<th>Water stress level**</th>
<th>C1*</th>
<th>C2</th>
<th>C3</th>
<th>Water stress level**</th>
<th>C1*</th>
<th>C2</th>
<th>C3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDW**</td>
<td>1</td>
<td>-0.03</td>
<td>0.10</td>
<td>0.96</td>
<td>2</td>
<td>-0.13</td>
<td>0.03</td>
<td>0.08</td>
<td>3</td>
<td>-0.03</td>
<td>-0.04</td>
<td>0.99</td>
</tr>
<tr>
<td>TNT</td>
<td>1</td>
<td>0.27</td>
<td>0.90</td>
<td>0.07</td>
<td>2</td>
<td>0.89</td>
<td>0.22</td>
<td>0.18</td>
<td>3</td>
<td>0.31</td>
<td>0.26</td>
<td>0.07</td>
</tr>
<tr>
<td>PLH</td>
<td>1</td>
<td>0.03</td>
<td>0.04</td>
<td>0.20</td>
<td>2</td>
<td>0.13</td>
<td>0.15</td>
<td>0.95</td>
<td>3</td>
<td>0.12</td>
<td>0.18</td>
<td>0.07</td>
</tr>
<tr>
<td>DTM</td>
<td>1</td>
<td>0.16</td>
<td>0.30</td>
<td>0.06</td>
<td>2</td>
<td>0.20</td>
<td>0.05</td>
<td>0.15</td>
<td>3</td>
<td>0.20</td>
<td>0.10</td>
<td>-0.06</td>
</tr>
<tr>
<td>PTC</td>
<td>1</td>
<td>0.46</td>
<td>0.82</td>
<td>0.12</td>
<td>2</td>
<td>0.92</td>
<td>0.10</td>
<td>0.02</td>
<td>3</td>
<td>0.80</td>
<td>0.40</td>
<td>-0.19</td>
</tr>
<tr>
<td>SLE</td>
<td>1</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.07</td>
<td>2</td>
<td>0.01</td>
<td>-0.10</td>
<td>0.03</td>
<td>3</td>
<td>-0.02</td>
<td>0.39</td>
<td>-0.04</td>
</tr>
<tr>
<td>KPS</td>
<td>1</td>
<td>-0.05</td>
<td>-0.14</td>
<td>0.13</td>
<td>2</td>
<td>-0.04</td>
<td>-0.03</td>
<td>0.18</td>
<td>3</td>
<td>-0.06</td>
<td>0.13</td>
<td>0.07</td>
</tr>
<tr>
<td>SNP</td>
<td>1</td>
<td>0.85</td>
<td>0.34</td>
<td>0.05</td>
<td>2</td>
<td>0.34</td>
<td>0.95</td>
<td>0.12</td>
<td>3</td>
<td>0.36</td>
<td>0.19</td>
<td>0.10</td>
</tr>
<tr>
<td>SWS</td>
<td>1</td>
<td>0.94</td>
<td>0.26</td>
<td>-0.09</td>
<td>2</td>
<td>0.38</td>
<td>0.77</td>
<td>0.12</td>
<td>3</td>
<td>0.30</td>
<td>0.93</td>
<td>-0.09</td>
</tr>
<tr>
<td>Cumulative variance</td>
<td></td>
<td>39.2</td>
<td>58.7</td>
<td>71.6</td>
<td>39.2</td>
<td>58.7</td>
<td>71.6</td>
<td>39.2</td>
<td>58.7</td>
<td>71.6</td>
<td>41.4</td>
<td>63.4</td>
</tr>
</tbody>
</table>

1: control (75 -100% field capacity); 2: moderate stress (50-75% field capacity); 3: severe stress (25-50% field capacity). *Component number. **PDW: plant dry weight; TNT: total number of tillers; PLH: plant height; DTM: days to maturity; PTC: productive tillering capacity; SLE: spike length; KPS: number of kernels per spike; SNP: seed number per plant; SWS: seed weight per spike.

To gain a better understanding of the sources of variation across species, and the change in attribute variation with changing water stress, PCA analysis was carried out (Table 6). Three principal components were enough to describe the main features of the data and reduce its dimensionality at all stress levels, with little loss of information. In the absence of stress, the main explanatory variables were SNP and SWS (PC1), TNT and PTC (PC2) and PDW (PC3). Subjecting plants to moderate stress reversed the main explanatory variables, with TNT and PTC accounting for most of the observed variation (PC1), and SNP and SWS showing high loadings in PC2. Only three attributes varied across species under severe water stress, PTC (PC1), SWS (PC2) and PDW (PC3). A plot of PC1 and PC2 based on the no stress treatment did not result in well defined groupings of species or populations within species. In contrast, under moderate moisture stress, two groups were clearly distinguishable along PC1, one with negative coordinates that included Ae. biuncialis, Ae. markgrafii and Ae. vavilovii, and a second with positive coordinates that included populations of Ae. cylindrica, Ae. geniculata and Ae. triuncialis, with one exception. PC2 further separated the second group into two sub-groups, with Ae. cylindrica and Ae. triuncialis in one and Ae. geniculata in the other. Under severe moisture stress Ae. geniculata and Ae. triuncialis populations mostly varied with respect to PC1, with no distinct grouping, while most of Ae. biuncialis populations formed one group, along with Ae. cylindrica, with negative coordinates, and Ae. vavilovii and Ae. markgrafii populations clustered around the center.

Discussion

Ae. markgrafii is a Mediterranean species, occurring mainly in the Aegaeis and western Turkey (van Slageren 1994), so its sporadic occurrence in the collection area was not surprising. On the other hand, the collection area was within Ae. cylindrica’s center of diversity and distribution and more than one population was expected. Hegde et al. (2002) also collected one Ae. cylindrica population from approximately the same
location, but it was unclear if that was the only population they found. Except for naturally protected pockets, almost all the collection area was heavily grazed by goat and sheep, and the disappearance of *Ae. cylindrica* could be a result of preferential grazing. Populations could have also been reduced due to severe droughts that occurred in the area for at least three consecutive growing seasons, and our results show that, compared to the respective control treatments, *Ae. cylindrica*'s seed number under severe water stress experienced the largest percentage reduction of any species (Table 4).

Population diversity, based on percentage polymorphism and Jaccard's similarity index, was rather low (Table 3). Intraspecific variation was related to the number of tested populations per species, suggesting that diversity estimates might increase if more populations were evaluated. However, other workers have also reported on the low population diversity of *Aegilops* species collected from the same or different areas (Zaharieva et al. 2001b). Hegde et al. (2002) reported that many *Aegilops* species, including five used in this study, were genetically less diverse than other annual grasses. The small collection area and absence of wide environmental gradients are probably the main causes of the observed genetic uniformity, in agreement with conclusions reached by Hegde et al. (2000). Medlinger and Zohary (1995) found that most of the variation in *Aegilops* of the *Sitopsis* group was within populations and species, rather than among populations, and cluster analysis results support a similar conclusion for the tested species. Our results also support the recommendation of Hegde et al. (2000) to sample many populations over wide geographic and environmental gradients in order to maximize genetic diversity. Although evaluating within population diversity was not an objective of this study, such information is also needed for a complete assessment of diversity in the target area.

Based on the magnitude of reduction in quantitative attributes of each species under water stress compared to its respective control, *Ae. geniculata* and *Ae. markgrafii* appeared to be more drought tolerant, but their tolerance was due to different reasons. Villegas et al. (2001) concluded that both biomass and seed yield should be considered when evaluating wild accessions. This is certainly true for wild accessions under semi-arid conditions, where dry matter accumulation under drought is an important characteristic. Based on changes in vegetative attributes of each species with increasing water stress, *Ae. geniculata* appeared to be more tolerant than other species. Compared to the control treatment, its vegetative attributes, especially PDW, were the least affected by severe water stress (Table 4), in agreement with the conclusions by Rekika et al. (1998). Zaharieva et al. (2001a, 2003) also observed that *Ae. geniculata* achieved high biomass under drought and was more tolerant than *Ae. cylindrica*. Vegetative growth of all species was largely unaffected by moderate water stress, with no reduction in PDW for any of the species except *Ae. triuncialis* (Table 4), reflecting the species' adaptation to semi-arid environments with limited water availability. However, PDW of all species significantly declined under severe stress. While Guzy et al. (1989) found that biomass variation of wild wheats under a range of conditions was due to differences in tillering, our results indicated that biomass decrease under stress was due to a decrease in plant height rather than tiller number (Table 5). Gupta et al. (2001) also reported that plant height rather than tiller number of differentially drought tolerant wheat cultivars decreased with imposed water stress. The lack of correlation of PDW with TNT and the former's high correlation with PLH is probably due to the growth habit of the studied species, with tillers initiated...
throughout their life span regardless of water stress that reduces height by affecting cell growth and elongation, explaining results of Zaharieva et al. (2003) who also determined that plant height of Aegilops species varied greatly with environmental conditions. Our results therefore demonstrate that plant height is a better indicator than tiller number for drought tolerance of Aegilops species, and the same might also apply to other wild grasses. A high and positive correlation between TNT and PTC was observed (Table 5), but the former only indirectly affected yield through its association with PTC, as revealed by a non-significant partial correlation ($r=0.04$) between TNT and YLD. The plasticity and adaptive significance of reduction in days to heading under water stress (Zaharieva et al., 2001a and 2001b) are sometimes assumed to indicate a quicker overall development rate under water stress, which is mostly not the case. Our results agree with conclusions by Blum (1996) that drought more often does not delay overall plant development by inhibiting growth, and also show that DTM is not a good indicator of overall plant development since it was not associated with either PDW or YLD.

Yield of Ae. markgrafii and Ae. triuncialis was not affected by water stress (Table 4). While none of the reproductive attributes of Ae. markgrafii significantly varied with stress level compared to the control, yield stability for Ae. triuncialis was due to component compensation. Ae. markgrafii was also found to be heat tolerant in terms of biomass, yield and seed weight (Khanna-Chopra and Viswanathan, 1999). In contrast, all reproductive attributes of Ae. cylindrica were significantly reduced with increased moisture stress, indicating its low tolerance to drought. The importance of yield stability of wild species under varying water stress should not be overstated, and should be evaluated in conjunction with yield potential. In this study, species with relatively high yield under no stress were the ones that suffered significant yield reductions (Table 4). Ae. geniculata's yield was significantly reduced, but was still higher under severe stress than Ae. markgrafii's, making it a more useful source of genes for wheat improvement, since it was also the most tolerant in terms of vegetative attributes. Other studies have also shown yield stability of wheat wild relatives to be associated with poor yield potential (Basnal and Sinha, 1991; Khanna-Chopra and Viswanathan, 1999). The positive correlation between PTC and YLD (Table 5) contradicts results by Guzy et al. (1989), who determined that total tiller number of wild wheats remained high under dry conditions, but fertile tillers decreased. Spike attributes SLE and KPS were less subject to change under varying water availability, and were not correlated to YLD or its components, suggesting their inadequacy as indicators of drought tolerance. In contrast to cultivated wheat, exhibiting a positive correlation between biomass and yield, even under contrasting soil moisture levels (Khanna-Chopra and Viswanathan, 1999; Villegas et al. 2001), we found no correlation between PDW and YLD. This was probably due to the fact that biomass was mainly dependent on PLH, an attribute unrelated to either yield or its components. The positive correlation between SNP and SWS reflected the growth conditions of this study, particularly the availability of nutrients at all growth stages. Whether the same relationship will hold true under field conditions, or, as expected, component compensation will alter this relationship, should be further investigated. Variation in traits is usually attributed to a combination of phenotypic plasticity, ecological sorting, and adaptation by natural selection (Ackerly, 2003). Variation in quantitative attributes in this study was mainly due to phenotypic plasticity since RAPD
results and variance of attributes between populations showed considerable uniformity among populations, and the restricted area of selection makes ecological sorting unlikely. Populations were clustered according to quantitative attributes (data not shown), and compared to clustering based on RAPD analysis. Congruence of the two diversity estimates was then determined by calculating Spearman's cophenetic correlation coefficient of the two matrices. Correlation between the two diversity estimates was not significant ($r=0.012$), indicating a lack of relationship between quantitative and genetic (RAPD) diversity results, in agreement with similar conclusions by other researchers (Garcia et al. 2002; Ontivero et al. 2000).

PCA analysis reduced the nine original variables to three new explanatory variables or components. In the absence of stress, the main explanatory attributes belonged to two groups, a “seed yield” group (SNP and SWS), which accounted for most of the variation, and a “tiller” group (TNT and PTC), which was second in importance. Subjecting plants to moderate stress reversed the main explanatory attributes, with the “tiller” factor accounting for most of the variation, and the “seed yield” factor becoming a less important source of variation. The ability to develop productive tillers rather than high tillering capacity was the most important factor contributing to variation under severe stress, with the first component accounting for 41.4% of the total variation, followed by the plants’ ability to produce large or heavy seeds (Table 6). Under all stress levels, biomass, expressed either as PDW or PLH, was a minor source of variation across species. All other attributes had insignificant contributions to overall variation across species. These results illustrate the change in attribute variation and shift in adaptive strategy as water becomes less available, and support conclusions by Zaherieva et al. (2003) that part of the observed morphological variation in three Aegilops species was due to adaptation to environmental constraints. When soil water does not limit vegetative growth, seed number and weight are the most important characters contributing to plant differences. As water availability decreases, the main differentiating feature becomes tillering capacity, and as stress becomes severe and survival is at stake, total tillers and seed number is reduced across species, with the ability to produce fertile tillers with few large seeds becoming a distinguishing feature, as also suggested by Blum (1996). Our results also indicate that use of quantitative attributes as indicators of variation is only appropriate if the extent of variation under specific conditions is known, and the relationships among attributes and their environmental dependency is clarified.

Acknowledgments

This work was gratefully supported by the “Conservation and sustainable use of dryland agrobiodiversity, GEF/UNDP, ICARDA and the Lebanese Agricultural Research Institute.

References


SPSS (2002) SPSS for Windows, release 11.5. SPSS Inc. Chicago, IL. 


Phenotypic Diversity of Peach (*Prunus persica* L.) Clones Cultivated in Lebanon

A. Chehade¹, L. Chalak¹, A. Elbitar¹, P. Cosson², A. Zanetto² and E. Dirlewanger²

¹ Lebanese Agricultural Research Institute, P.O. Box 287 Zahle, Lebanon. Email: lchalak@lari.gov.lb
² Institut National de la Recherche Agronomique, UREFV, B.P. 81, F-33883 Villenave d’Ornon, France. Email: dirlewan@bordeaux.inra.fr

Keywords: Genetic diversity, peach, *Prunus persica*, Microsatellites DNA, clones, Lebanon

Abstract

A preliminary characterization was conducted on 27 clones of cultivated peach distributed in different zones of Lebanon (Bekaa, North and Mount Lebanon) at an altitude between 400 and 1500 m. Each clone was described using 15 traits related to flowering dates, maturity dates and morphological characteristics of leaves and fruits. Principal component analysis revealed that fruit diameter, leaf width and maturity dates had a higher contribution to the total variation. Distances between clones were calculated according to the studied traits, leading to cluster them into four main groups.

Introduction

Peach (*Prunus persica* L.) is one of the most important components of cultivated fruit trees in Lebanon. Peach clones were introduced in Lebanon at different periods. They have not been yet inventoried and the authentic names are unknown. Old clones were nominated directly by the nurseries in reference to the name of the introducer or by the farmer in relation to a precise trait of the fruit. Other denominations seem to be an Arabic translation of the original name of the clone. The original name was held only for the clones recently introduced (as Dixired and Redhaven). This study reports for the first time an inventory of different clones of cultivated peach in Lebanon. Morphological, physiological and molecular characterizations were performed in order to evaluate the distance between clones.

Materials and Methods

Twenty seven clones of peach distributed in different regions in Lebanon were characterized. Six qualitative and nine quantitative traits were studied according to peach descriptors previously developed by IPGRI (Bellini *et al.*, 1984)). Principal Component Analysis was performed on the nine quantitative traits. DNA extraction was performed using young leaves as described by William *et al.* (1990). Sixteen primer pairs of microsatellites were used based on their high discrimination power on peach and cherry (Dirlewanger *et al.*, 2002).

The relationships among clones were analyzed with the SimGend procedure of NTSYS P.C. 2.0 package which computes similarity coefficient for both genetic and monogenic qualitative data. Distances were calculated according to Rogers (1972) modified by Wright (1978). Trees were produced by clustering the data with the unweighted pair-group method (UPGMA).
Results and Discussion

Morphological characterization

Ten clones were considered early in flowering (from March 10 to 15), eleven clones intermediate (from March 15 to 20) and six clones late (from March 20). The maturity date is early for the clones of Ayari, Nectarine Juin, Springtime Orange and Starken 1; intermediate for Dixired, Nectarine Juillet, Redhaven, Soukari Chikhani, Starken 2, Ukrani, Beccoque Zahra and Beccoque Abdellakis; and late for 13 clones such as Elberta and Beccoque. The 2 clones Aswad and Halberta were classified extremely late (data not shown). All the clones presented a lanceolate leaf shape with a crenate margin. Fruit shapes varied between flat and round. The 27 collected clones consisted of 18 peaches with a downy skin and freestone including eleven clones with yellow flesh (alberge) and seven clones with white flesh (ordinary peach). Six clones were considered as pavie with a downy skin and clingstone. Three clones were noted as nectarine with a smooth skin and freestone (data not shown).

Principal Component Analysis (PCA) based on the quantitative traits revealed that 72.8% of the total variation was explained by the first 3 components. The first component accounting 35.9% of the variation was mainly due to the fruit diameter and leaf width. The second component, contributing to 25.8% of the variation, included petiole length and leaf length. The third component, explaining 11.1% of the variation was due to the fruit skin color. The fruit diameter and the leaf length were mainly responsible of the total variation between clones (Table 1).

Table 1. Principal Component Analysis of 27 peach clones with nine quantitative morphological traits.

<table>
<thead>
<tr>
<th>Traits</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit diameter</td>
<td>-0.763</td>
<td>-0.272</td>
<td>0.153</td>
</tr>
<tr>
<td>Width leaf</td>
<td>-0.762</td>
<td>0.450</td>
<td>0.063</td>
</tr>
<tr>
<td>Flowering date</td>
<td>-0.682</td>
<td>-0.282</td>
<td>-0.487</td>
</tr>
<tr>
<td>Leaf length</td>
<td>-0.661</td>
<td>0.680</td>
<td>0.082</td>
</tr>
<tr>
<td>Stone size</td>
<td>-0.608</td>
<td>-0.396</td>
<td>-0.201</td>
</tr>
<tr>
<td>Maturity date</td>
<td>-0.559</td>
<td>-0.582</td>
<td>-0.251</td>
</tr>
<tr>
<td>Peduncle length</td>
<td>-0.538</td>
<td>0.531</td>
<td>0.156</td>
</tr>
<tr>
<td>Fruit skin color</td>
<td>0.433</td>
<td>0.334</td>
<td>-0.705</td>
</tr>
<tr>
<td>Petiole length</td>
<td>-0.043</td>
<td>0.785</td>
<td>-0.323</td>
</tr>
<tr>
<td>Percentage of total variation</td>
<td>35.9</td>
<td>25.8</td>
<td>11.1</td>
</tr>
</tbody>
</table>

Genetic analysis

Molecular study was conducted only on 20 clones, since the others had a bad DNA quality. All the 16 primers tested gave polymorphism and revealed 72 alleles with an average of 4.5 alleles per primer. The most frequent alleles were found in Redhaven, because it is a parent of most peach cultivars (Dirlewanger et al., 2002). The expected heterozygosity ranged from 0.4 to 0.79 (mean 0.58). The observed heterozygosity was lower than the expected one with an average of 0.39. Eight microsatellites had a discrimination power higher than 0.7 (UDP 96015, UDP 98407, UDP 98022, BPPCT 007, BPPCT 038, BPPCT 015, BPPCT 017 and CPPT 005). In general, these results confirm the efficiency of these primers previously reported in peach cultivars in Italy.
(Testolin et al., 2000), in Spain (Aranzana et al., 2002) and in France (Dirlewanger et al., 2002).

The dendogram based on microsatellites and qualitative data showed 5 groups at 0.57 Rogers distance modified by Wright (Fig. 1). The early to intermediate flowering date clones (Abi, Elberta, Moukhmali, Dixired, Starken 1, Oubaidi, Redhaven, Gannoumi, Mawardi and Nectarine Juillet) were distinguished from the others and presented 7 alleles in common with the primers CPPCT 017, BPPCT 001, BPPCT 007, BPPCT 017, UDP 98022, UDP 98025 and UDP 96015. The second group included 3 clones (Ayari, Beccoque and Ukrani) presenting a similar petiole gland shape (reniform) and fruit shape (round). Beccoque Awsaf clone grouped with the Nectarine clones due to fruit shape (round), petiole gland shape (circular) and having the seven alleles in common with the primers BPPCT 006, BPPCT 007, BPPCT 017, BPPCT 038, UDP 98408, CPPT 002 and CPPT 017. Pavie clones with intermediate maturity date were classified alone and presented 14 alleles in common for the majority of primers studied. Oubaidi and Redhaven clones were not distinguished although they are different by nectar foliar shape and the flesh color.

Fig. 1. Dendogram constructed from single-locus SSR and qualitative data, with 20 peach clones cultivated in Lebanon, using SimGen program, Rogers distance modified by Wright and UPGMA clustering.

Acknowledgments
The authors are grateful to the CEDRE French-Lebanese program for their financial support. They also thank the GEF-UNDP West Asia Dryland Agrobiodiversity project for their contribution in collecting the material.
References
In Situ Conservation and Sustainable Use of Lathyrus Plant Genetic Resources

A. Shehadeh¹, N. Maxted², A. Amri³, and L. Guarriño⁴

¹ International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria.
² School of Biological Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, U.K.
³ International Center for Agricultural Research in the Dry Areas (ICARDA), West Asia Regional Project, Amman, Jordan.
⁴ Plant Genetic Resources Adviser, Secretariat of the Pacific Community, Private Mail Bag, Suva, Fiji.

Keywords: Agrobiodiversity, conservation, ex situ, in situ, Lathyrus

Abstract
The genetic diversity of the genus Lathyrus (Grasspea) is important, particularly for its potential use within the rainfed cropping systems and as a genetic resource for the improvement of grasspea used for both feed and food in resource poor regions of the world. Several other species are cultivated for human consumption, animal feed, and fodder, as well as for ornamental purposes but there is potential for further exploitation of the Lathyrus gene pool also for the same purposes. Therefore, the collection, conservation, characterization, study of genetic diversity and utilization of the genus Lathyrus deserves attention. There is an urgent need to conserve the genetic diversity of the genus using both ex situ (gene bank) and in situ (natural habitat) conservation methods. This will permit a critical assessment of the genetic diversity and the genetic erosion of the genus, along with enhancing its exploitation. This paper proposes a strategy for promoting in situ conservation of Lathyrus species in West Asia region in general with emphasis on Syria.

Introduction
One of the critical challenges facing the world today is the conservation of biological diversity and the use of its components for the benefit of humanity. Answering this challenge is a core activity for contemporary biologists whose role is to catalogue existing biological diversity, to halt, or at least to reduce the loss of species and ecosystem diversity and to conserve what remains for the future benefit of mankind. Plant diversity plays a pivotal role in the functioning of all natural ecosystems, as well as providing direct benefits in terms of food and medicine for humans and foodstuffs for wild and domesticated animals. The consequences that are likely to arise from careless loss of diversity or unsustainable exploitation combined with rapid population growth will have a devastating and direct effect on humanity as a whole.

The genetic diversity of the genus Lathyrus (grasspea and chicklings)
The genetic diversity of the genus Lathyrus (Grasspea and chicklings) is of great importance, particularly for potential use in rain-fed cropping systems of many countries (Campbell et al., 1994) and as a source of genes for the crop improvement of L. sativus L. Several species are cultivated for human consumption, animal feed, and fodder, as well as
for ornamental purposes (Sarker et al., 1997), but there is potential for further exploitation of the *Lathyrus* gene pool. Therefore, the collection, conservation, characterization, study of genetic diversity and utilization of the genus *Lathyrus* deserves ample attention as a priority research area. There is urgency to conserve the genetic diversity of the genus using both *ex situ* (e.g. gene banks) and *in situ* (e.g. within natural habitats) conservation techniques. This will permit a critical assessment and monitoring of the genetic diversity, evolution and genetic erosion of the genus, as well as enhancing its exploitation (Sabancı, 1996).

*Lathyrus* is relatively a large genus containing around 170 species (ILDIS, 2004), mainly located in Europe, Asia and North America, and extending to temperate South America and tropical East Africa, but the genus has its center of diversity primarily in the Mediterranean and Irano-Turanian regions (Kupicha, 1981). It is adapted to temperate regions but can also be found at high altitudes in tropical Africa. Endemic species are present in all continents, except Australia and Antarctica (Kupicha, 1981).

*L. sativus* L., *L. cicera* L. and *L. ochrus* (L.) DC, provide important human food, animal feed and fodder sources. *L. sativus* is widely cultivated for human consumption, as well as for fodder and green manure. Its primary centers of cultivation are in Southern Asia, particularly in Bangladesh, China, India, Nepal, and Pakistan, and in Ethiopia (Asthana, 1996), with more limited production in southern Europe and West Asia. *L. cicera* is cultivated in Greece, Cyprus, Iran, Iraq, Jordan, Spain and Syria and *L. ochrus* in Cyprus, Greece, Syria and Turkey (Saxena et al., 1993). Some other species are used as minor forage or fodder crops: *L. hirsutus* L. is cultivated in southern United States as a fodder species and *L. clymenum* L. is cultivated on Kos, Greece (Sarker et al., 2001). It is an important low risk aversion crop because it has relatively good tolerance to water-loggin (in the case of flooding), good ability to grow on residual moisture after the end of the rains or in case of drought, and because it requires low production costs (Tadesse, 1997).

**Center of diversity of genus Lathyrus**

Europe, the Mediterranean, and West and Southern Asia are the most important centers of diversity for *Lathyrus*. Secondary centers of diversity exist in South America, North America and Ethiopia, extending into East Africa (Kupicha, 1983). *L. ochrus* and *L. sativus* are mostly distributed in coastal, lowland sites, while *L. cicera* is the most common species in highland and cold temperate sites (Sarker et al., 2001). The natural distribution of *L. sativus* has been completely obscured by cultivation, even in southwest and central Asia (Townsend and Guest, 1974). It is quit difficult to clarify the centre of origin of the genus. It can be argued that relative species concentrations can be used to indicate the centre of origin, which would therefore suggest a South Eastern Europe and North Western Asian origin. More than half of the *Lathyrus* taxa are endemic to this area (Sarker et al., 2001). However, due to floristic migration caused by the recent ice ages, Kupicha (1974) concludes that *Lathyrus* evolved in the early tertiary and the centre of origin is likely to have been much further north than is indicated by contemporary concentrations of taxa. (Sarker et al., 2001).

*Lathyrus* species can be in many different habitats: open, disturbed-open habitats such as field margins and roadsides; and in closed habitats such as woodlands and steeps (Sarker et al., 2001). The species considered more advanced are generally those found in the more disturbed, open communities. The cultivated species have mostly evolved from
disturbed habitats; they were originally the wild and weedy floras of agricultural fields (Vavilov, 1926). Farming systems have therefore had a great influence on the recent evolution of the genus. Their weedy nature would explain the widespread distribution of many species. Although there have been several investigations of genetic diversity within and between related genera in *Vicia*, *Lens* and *Pisum*, there have been no comprehensive studies of genetic diversity in *Lathyrus*.

The genus contains many restricted endemics, for which only very few sites have been documented or which are bound by specific soil types and climatic regimes (Maxted and Goyder, 1988; Ehrman and Maxted, 1990; Maxted et al., 1990; Maxted, 1993; Maxted et al., 1990; Bennett et al., 1998, 1999; Shackle et al., 2001). The ecogeographic distribution of all but a few *Lathyrus* species is poorly understood, particularly those in section Notolathyrus that are endemic to South America. A detailed ecogeographic study of the whole genus is needed if it is to be effectively and efficiently conserved and utilized (Sarker et al., 2001).

Clarification of the centre of origin of the genus is however more problematic. It can be argued that relative species concentrations can be used to indicate the centre of origin, which would therefore suggest a South Eastern Europe and North Western Asian origin. However, due to floristic migration caused by the recent ice ages, Kupicha (1974) concludes that *Lathyrus* evolved in the early tertiary and the centre of origin is likely to have been much further north than is indicated by contemporary concentrations of taxa. The earliest archaeological remains of *Lathyrus* appear in the Neolithic age in the Balkans and Near East of Bulgaria, Cyprus, Iraq, Iran, and Turkey (Erskine et al., 1994). A single *Lathyrus* seed, presumed to be a field weed, was found in Cayono in Turkey and dated at around 7200 B.C., where bitter vetch was the prevalent pulse (van Zeist, 1972). Compared with the early-domesticated species, lentil, pea and bitter vetch, *Lathyrus* is only found in small quantities in Turkey, Cyprus, Iraq, Iran and Bulgaria, dating from 6750 to 4770 B.C. However, a different picture appears from late Neolithic finds at Dimini in Greece (c. 4000-3500 B. C.), where grasspea is as frequent as pea and lentil (Kroll, 1979). This increased frequency of grasspea is suggestive of domestication. *Lathyrus* was the chief crop component mixed with lentil (c. 2100-1800 B.C.), providing stronger evidence of domestication by the Middle Bronze Age (Helback, 1965). It was also found mixed in substantial quantities with other leguminous crops in later finds. *L. clymenum* was cultivated in the Bronze Age in Thera, Crete and Melos in Greece (Sarpaki and Jones, 1990) and *L. ochrus* was possibly cultivated on Knossos, Greece at the same time (Jones, 1992). *L. cicera* is believed to have been domesticated in southwestern Europe by 4000 - 3000 B.C. (Kislev, 1989). Written records provide very little knowledge about the origin of grasspea. *Lathyrus* is an ancient Greek plant name probably used for a pulse and possibly for *L. sativus* (Westphal, 1974). The Romans also do not mention *Lathyrus*, which reflects little importance or lack of knowledge of the crop. Thus, the archaeological evidence suggests that domestication of *Lathyrus* possibly occurred during the late Neolithic and surely by the Bronze Age. Prior to that time, it was probably a tolerated weed of other pulses (Erskine et al., 1994).

**Genetic diversity and ecogeographic distribution of genus *Lathyrus***

Genetic diversity studies of the genus have been carried out by few, Yunus (1990) and Kearney (1993); their attempts were focused on the agricultural importance of grasspea.
and its close relatives in the section *Lathyrus*. These have been found to be predominantly self-pollinating, with anther dehiscence usually occurring before the flower has fully opened. Inter-specific hybridization has been successful between *L. sativus* and two other *Lathyrus* species, though the production of successful hybrids remains low. The first successful inter-specific cross was with *L. cicera* (Saw Lwin, 1956; Davies, 1957; 1958). Yunus (1990) crossed 11 species in section *Lathyrus* with *L. sativus*, and found that *L. cicera* and *L. amphicarpos* gave viable seeds. Other species formed pods but these did not form fully developed viable seeds. *L. cicera* is thought morphologically to be the closest relative of *L. sativus* (Yunus & Jackson, 1984). Plitmann *et al.* (1986) arrived at the same conclusion, based on studies of pollen morphology, karyotype and flavonoid aglycones.

It is possible to apply Harlan and De Wet’s gene pool concept to this crossability information for *L. sativus* to elucidate its gene pools (Harlan and De Wet, 1971). The cultivated and wild races of *L. sativus* are included in the primary gene pool. Townsend and Guest (1974) suggested that the primary gene pool is poorly differentiated in terms of morphological characters, as there are no clear-cut discontinuities between the cultivated and wild forms. Although Smartt (1984) concluded that the white flowered, white seeded varieties are the most highly selected and Jackson and Yunus (1984) suggested that the blue flowered; small speckled seeded forms are primitive. Therefore, it could tentatively place the white flowered, white seeded varieties in GP1A and the blue flowered, small speckled seeded forms in GP1B. The secondary gene pool includes the other biological species that will cross with some difficulty with the crop species. Therefore in GP2 include: *L. chrysanthus*, *L. gorgoni*, *L. marmoratus* and *L. pseudocicera*, with which *L. sativus* can cross and produce ovules, and possibly more remotely *L. amphicarpos*, *L. blepharicarpus*, *L. chloranthus*, *L. cicera*, *L. hierosolymitanus* and *L. hirsutus*, with which *L. sativus* can cross and with which pods are formed. The tertiary gene pool includes species that can cross with the crop species only with use of specialized techniques such as embryo rescue and culture or the use of bridging species. The remaining species of the genus can be considered members of the tertiary gene pool (GP3) (Sarker *et al.*, 2001).

Cytogenetic studies in section *Lathyrus* show that the vast majority of species have the chromosome compliment 2n=2x=14. There is some variation in karyotype, but the majority of chromosomes are sub-metacentric. In *L. sativus*, all seven pairs are sub-metacentric while two cross-compatible species (*L. cicera* and *L. amphicarpos*) have one pair metacentric and six pairs sub-metacentric. This indicates that some chromosome structural differentiation has occurred between genomes of different species. From meiotic studies of interspecific hybrids, it would seem that *L. amphicarpos* is structurally more differentiated from *L. sativus* than is *L. cicera*. In F1 hybrids of *L. cicera* x *L. sativus* the configurations observed were 6II + 2I and 7II. In the hybrid of *L. amphicarpos* x *L. sativus*, multivalent were frequently observed, suggesting that translocation changes had occurred (Yunus, 1990; Yunus and Jackson, 1991), (Sarker *et al.*, 2001).

Proper evaluation, characterization and documentation are an important part of utilizing genetic resources of *Lathyrus*. However, in-depth evaluation for phenological, morphological, agronomical and quality characters of available germplasm has yet to be carried out adequately at the national and global level. The Germplasm Resources, Crop
Improvement and Agronomy Committee of the International Network for the Improvement of *Lathyrus sativus* and the Eradication of Lathyism (INILSEL) proposed a list of 16 descriptors to characterize *Lathyrus* genetic resources (Campbell, 1994).

**Conservation status**

Turkey has the richest diversity of *Lathyrus* species genetic diversity. Davis (1970) reported the presence of 58 species in Turkey, some of them endemic at local or regional level and many of these are held in the genebank of the national program. Prior to 1987, Turkish collection missions targeted forage grasses and legume genetic resources but *Lathyrus* species were not a high priority. Expeditions were launched specifically to collect forage legumes in 1987, 1988, 1995, 1996 and 1997 from nine different agricultural regions (Sabanci, 1996) and collected material was stored at the Aegean Agricultural Research Institute in Menemen. Majority of accessions are duplicated at the International Center for Agricultural Research in the Dry Areas (ICARDA). The number of species collected is over half of those found by Davis, including a new species *L. belinensis* Maxted and Goyder, which is closely related to *L. odoratus*, first discovered during the 1987 mission. These expeditions focused on collecting material from areas of Turkey with a Mediterranean climate (Aegean and Southern Turkey) and they did not attempt to systematically collect representative collections from throughout the country. They also concentrated at the lower altitudes favored by annual species. Therefore, some endemic species, particularly perennial species, were not encountered and are not currently conserved. Undoubtedly, the environment in Turkey is being changed rapidly by human intervention building dams, constructing recreational areas along the coast and overgrazing (Tan, 1998). The flora is obviously suffering genetic erosion as a result and priority should be given to the collection of *Lathyrus* germplasm from throughout the country, particularly in the under-collected areas of the North, central and South East.

ICARDA has the most extensive collection of germplasm for the Mediterranean region (Table 1). At present ICARDA is concerned with collection and conservation for *Lathyrus* species in the Mediterranean region and other *Lathyrus*-growing areas of the world. ICARDA holds “in-trust” 3219 accessions of *Lathyrus* germplasm from 50 countries under the auspices of the Food and Agriculture Organization (FAO) of the United Nations. While the emphasis at ICARDA for genetic resources and improvement of *Lathyrus* is for three species (*L. sativus, L. cicera* and *L. ochrus*), a sizeable collection of 50 other species is being maintained. The majority of accessions of all species of *Lathyrus* held in the ICARDA gene bank, except *L. sativus*, are from the West Asia and North African region. The collections have been collected from cultivated or from naturally occurring populations, found mostly in disturbed habitats such as roadsides, crop fields and orchards. The *L. sativus* accessions in the ICARDA collection are from Ethiopia and the Indian sub-continent and are local landraces. Besides, expeditions within the Mediterranean, expeditions from ICARDA have been made to Bangladesh, Ethiopia, India, Nepal and Pakistan, primarily to collect genetic resources of *L. sativus*. The majority of accessions of all species of *Lathyrus* held in the ICARDA gene bank, except *L. sativus*, are from the West Asian and North African as well as Central Asian Regions.
ICARDA paid attention to improve three species of *Lathyrus* (*L. sativus*, *L. cicera* and *L. ochrus*); in addition to these species, ICARDA has a collection of 50 other species (Table 1)

Table 1 ICARDA’s holdings of *Lathyrus* species

<table>
<thead>
<tr>
<th>Taxa name</th>
<th>No of Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Lathyrus amphicarpos</em></td>
<td>4</td>
</tr>
<tr>
<td><em>Lathyrus angulatus</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus annuus</em></td>
<td>70</td>
</tr>
<tr>
<td><em>Lathyrus aphaca</em></td>
<td>285</td>
</tr>
<tr>
<td><em>Lathyrus articulatus</em></td>
<td>105</td>
</tr>
<tr>
<td><em>Lathyrus aureus</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus basalticus</em></td>
<td>4</td>
</tr>
<tr>
<td><em>Lathyrus belinensis</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus blepharicarpus</em></td>
<td>40</td>
</tr>
<tr>
<td><em>Lathyrus cassius</em></td>
<td>8</td>
</tr>
<tr>
<td><em>Lathyrus chloranthus</em></td>
<td>3</td>
</tr>
<tr>
<td><em>Lathyrus chrysanthus</em></td>
<td>6</td>
</tr>
<tr>
<td><em>Lathyrus cicera</em></td>
<td>200</td>
</tr>
<tr>
<td><em>Lathyrus cilicicus</em></td>
<td>9</td>
</tr>
<tr>
<td><em>Lathyrus ciliolatus</em></td>
<td>4</td>
</tr>
<tr>
<td><em>Lathyrus clymenum</em></td>
<td>10</td>
</tr>
<tr>
<td><em>Lathyrus cyaneus</em></td>
<td>3</td>
</tr>
<tr>
<td><em>Lathyrus digitatus</em></td>
<td>2</td>
</tr>
<tr>
<td><em>Lathyrus gloeospermus</em></td>
<td>2</td>
</tr>
<tr>
<td><em>Lathyrus gorgoni</em></td>
<td>61</td>
</tr>
<tr>
<td><em>Lathyrus hirticarpus</em></td>
<td>2</td>
</tr>
<tr>
<td><em>Lathyrus hierosolymitanus</em></td>
<td>116</td>
</tr>
<tr>
<td><em>Lathyrus hirsutus</em></td>
<td>29</td>
</tr>
<tr>
<td><em>Lathyrus inconspicuus</em></td>
<td>171</td>
</tr>
<tr>
<td><em>Lathyrus incurvus</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus latifolius</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus laxiflorus</em></td>
<td>4</td>
</tr>
<tr>
<td><em>Lathyrus laxiflorus</em> subsp. laxiflorus</td>
<td>2</td>
</tr>
<tr>
<td><em>Lathyrus marmoratus</em></td>
<td>33</td>
</tr>
<tr>
<td><em>Lathyrus mulkak</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus nissolia</em></td>
<td>9</td>
</tr>
<tr>
<td><em>Lathyrus occidentalis</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus ochrus</em></td>
<td>137</td>
</tr>
<tr>
<td><em>Lathyrus odoratus</em></td>
<td>3</td>
</tr>
<tr>
<td><em>Lathyrus pallescens</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Lathyrus pratensis</em></td>
<td>5</td>
</tr>
<tr>
<td><em>Lathyrus pseudocicera</em></td>
<td>74</td>
</tr>
<tr>
<td><em>Lathyrus rotundifolius</em> subsp. miniatus</td>
<td>5</td>
</tr>
<tr>
<td><em>Lathyrus sativus</em></td>
<td>1654</td>
</tr>
<tr>
<td>Lathyrus saxatilis</td>
<td>2</td>
</tr>
<tr>
<td>-------------------</td>
<td>---</td>
</tr>
<tr>
<td>Lathyrus setifolius</td>
<td>7</td>
</tr>
<tr>
<td>Lathyrus sp.</td>
<td>85</td>
</tr>
<tr>
<td>Lathyrus sphaericus</td>
<td>24</td>
</tr>
<tr>
<td>Lathyrus stenophyllus</td>
<td>2</td>
</tr>
<tr>
<td>Lathyrus sylvestris</td>
<td>1</td>
</tr>
<tr>
<td>Lathyrus tingitanus</td>
<td>18</td>
</tr>
<tr>
<td>Lathyrus tuberosus</td>
<td>8</td>
</tr>
<tr>
<td>Lathyrus vinealis</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3219</strong></td>
</tr>
</tbody>
</table>

A standard collecting form for passport data developed by the Genetic Resources Section (GRS), ICARDA, based on the International Plant Genetic Resources Institute (IPGRI) standards was used for all collection, which means passport data is available for all accessions that provide information on use such technology (such as Geographic Information System) to draw a clear maps of Lathyrus geographical distribution as shown in Figure 1. The extensive Lathyrus collections at ICARDA and the existence of new molecular techniques now offer the opportunity to carry out a more thorough investigation of the genetic diversity within Lathyrus.

Fig.1. Geographical distribution of Lathyrus germplasm held by ICARDA.

There are also ex-situ collections of Lathyrus germplasm conserved in Bangladesh, Chile, China, Canada, Ethiopia, Ecuador, France, Germany, India, Nepal, Pakistan, Russia, Syria, USA and UK. However, several of these are relatively small collections and do not represent a true sample of the breadth of taxonomic and genetic variability that is found in the genus.

In situ conservation, whether in a genetic reserves or on-farm, has so far not been used for Lathyrus species, except for initial attempts in Turkey (Firat and Tan, 1997) at Kaz Dag (Aegean Anatolia), Amanos, (Southern Turkey) and Ceylan Pinner (in Southeast Turkey. Maxted (1995) proposed the establishment of reserves for Vicieae species in Syria and Turkey, but those have not yet been initiated. There is an urgent need to make
positive steps to establish both reserves for the wild species of *Lathyrus* and on-farm projects to conserve the ancient landraces of cultivated *Lathyrus* species (Sarker et al., 2001)

**Genetic reserve for conservation of *Lathyrus* diversity**

Several authors working independently have specifically proposed or illustrated methodologies for genetic reserve conservation, most notably Jain (1975), Gadgil et al. (1996), Safriel et al. (1997), Safriel, (1997), Maxted et al. (1997b) and Maxted et al. (1998). It is important to stress before discussing this methodology, however, that no model, methodology or schema should be followed slavishly; in this case the methodology proposed is meant to act as a guide to some of the important issues that require discussion. This general methodology will almost invariably require adaptation for each particular taxon and each situation where it is to be applied.

The objective of genetic reserve conservation is to ensure that the maximum possible range of genetic diversity is represented within the minimum number and size of *in situ* genetic reserves (Maxted et al., 1997b). Part of the process of selecting target taxa will involve a review of existing conserved *Lathyrus* material and therefore we must now briefly review what is currently conserved. There has been no attempt to systematically conserve *Lathyrus* diversity *in situ* using either genetic reserves or on-farm techniques. However, undoubtedly existing genetic reserves (e.g. Kaz Dag, Aegean Region, Ceylanpinar of South-east Turkey, and Amanos, Mersin in Turkey) and other protected areas throughout the range of the genus contain *Lathyrus* species. In these areas conservation is passive (*Lathyrus* species and genetic diversity is not monitored and managed) and therefore it is susceptible to further unobserved genetic erosion.

Relatively large *ex situ* collections of cultivated and wild *Lathyrus* species exist (Sarker et al., 2001) (Table 2). The earliest collections are the accessions collected by Vavilov and co-workers in the 1920s (Vavilov 1926). Although the number of accessions collected in recent years is considerable, gaps still exist, particularly for the South American species, perennial species and those species of less immediate utilization potential, which have not been systematically conserved *ex situ*. It is undoubtedly true that there is currently serious genetic erosion of *Lathyrus* diversity, particularly in the Mediterranean Basin (IBPGR, 1985), mainly as a result of intensification of agriculture, overgrazing, decline of permanent pastures and disappearance of sclerophyll evergreen trees, as well as maquis and garrigue shrubs vegetation in the Mediterranean Basin. Many weedy *Lathyrus* species are associated with traditional farming systems which are also disappearing rapidly throughout the region. Further attention needs be focused on systematic conservation of *Lathyrus* diversity using both *in situ* and *ex situ* techniques; because their habitats are threatened by anthropogenic changes and the potential that the genus has for novel exploitation (Sarker et al., 2001).
Table 2. *Lathyrus* accessions conserved *ex situ* in major collections (Sarker *et al.*, 2001).

<table>
<thead>
<tr>
<th>Species</th>
<th>AARI</th>
<th>ATFC</th>
<th>ICARDA</th>
<th>IPK</th>
<th>IBEAS</th>
<th>W-6</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. annuus</em></td>
<td>44</td>
<td>6</td>
<td>68</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><em>L. chrysanthus</em></td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>L. cicera</em></td>
<td>90</td>
<td>141</td>
<td>182</td>
<td>63</td>
<td>785</td>
<td>31</td>
</tr>
<tr>
<td><em>L. clymenum</em></td>
<td>1</td>
<td>10</td>
<td>2</td>
<td>25</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td><em>L. gorgoni</em></td>
<td>27</td>
<td>6</td>
<td>60</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>L. hierosolymitanus</em></td>
<td>22</td>
<td>13</td>
<td>104</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><em>L. hirsutus</em></td>
<td>2</td>
<td>1</td>
<td>17</td>
<td>8</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td><em>L. latifolius</em></td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>13</td>
<td>326</td>
<td>10</td>
</tr>
<tr>
<td><em>L. marmoratus</em></td>
<td>4</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>L. ochrus</em></td>
<td>1</td>
<td>85</td>
<td>136</td>
<td>46</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td><em>L. odoratus</em></td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td><em>L. pseudocicera</em></td>
<td>8</td>
<td>1</td>
<td>65</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>L. sativus</em></td>
<td>17</td>
<td>572</td>
<td>1627</td>
<td>170</td>
<td>2382</td>
<td>222</td>
</tr>
<tr>
<td>Other <em>Lathyrus</em> sp.</td>
<td>300</td>
<td>172</td>
<td>698</td>
<td>108</td>
<td>984</td>
<td>111</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>519</td>
<td>1020 (42)</td>
<td>3001 (44)</td>
<td>445</td>
<td>4477 (6)</td>
<td>464 (23)</td>
</tr>
</tbody>
</table>

* Numbers in brackets indicate the number of other *Lathyrus* species conserved. AARI = Aegean Agricultural Research Institute, Menemen, Turkey; ATFC = Australian Temperate Field Crop Collection, Horsham, Australia; IBEAS = IBEAS, Université de Pau et des Pays de l’ Adour, Pau, France; W-6 = Regional Plant Introduction Station, Washington, USA; ICARD = International Centre for Agricultural Research in the Dry Areas, Syria; IPK = Institut für Pflanzengenetik und Kulturpflanzenforschung, Gatersleben, Germany.

There have been no published ecogeographic surveys for *Lathyrus* species, though Baggott (1997) undertook an initial survey of *Lathyrus* section Lathyrus and Shehadeh and Maxed are currently preparing an ecogeographic study of *Lathyrus* species in the Mediterranean Basin. The objectives of these ecogeographic studies are to determine the geographical and ecological distribution of *Lathyrus* species, assess their conservation status using IUCN categories of threats (IUCN, 1994) and provide clear guidance on the most appropriate conservation strategy. 21 species and 3 subspecies out of 170 species of *Lathyrus* are listed by the 1997 IUCN Red List of Threatened Plants (Walters and Gillett, 1998) in the following categories:

<table>
<thead>
<tr>
<th>Red List Category</th>
<th>Number of Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinct</td>
<td>4</td>
</tr>
<tr>
<td>Vulnerable</td>
<td>5</td>
</tr>
<tr>
<td>Rare</td>
<td>11</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>5</td>
</tr>
</tbody>
</table>

The listed species listed are mostly narrow endemics, with the highest concentration of threatened taxa being indicated in Turkey and the United States. The species listing simply reflects the areas studied in most detail and does not indicate a complete picture of threat. It can be assumed that the current list reflects the taxa that have been well studied by nationally based monographers rather than an accurate description of levels of threat for the taxa of the genus internationally. There is therefore a need for a thorough review of the threat status of the *Lathyrus* as a whole.

Maxed (1995) concluded that the most seriously threatened taxa are those restricted to Syria, Lebanon, Turkey and Israel, and the highest concentrations of potentially
threatened taxa are located in Southern Syria. The application of gap analysis concepts (Margules and Nicholls, 1988) to the *Lathyrus* gene pool has allowed the identification of key populations of *Lathyrus* in the region. Maxted therefore recommended the establishment of five genetic reserves for *Vicia* and *Lathyrus* diversity in Syria: Ain Diwar, Al Hasakah (37 15 N, 42 20 E), Kessab, Kessab (35 54 N, 35 56 E), Qal'at Al Hosn, Homs (34 46 N, 36 18 E) and Mimas, Djebel Druze (32 36 N, 36 43 E), as well as in the Olimpos Beydaglari National Park, Cavus, Turkey (36 21N, 30 25E). Each site has extensive populations of rare and diverse *Lathyrus* species found in a range of habitat from climax maquis vegetation through garrigue to deciduous and pine forest, and steppe grassland, as well as pine plantation and cropped land. In these sites there is also a wealth of other forage legume diversity, along with numerous other Mediterranean species. The potential sites are in both private and state ownership, but the populations are currently threatened by over-grazing, unsustainable cultivation and forestry plantation, making the population vulnerable unless they are appropriately managed. The Turkish sites recommended for establishment of a genetic reserve is already located within a protected area and the Mimas site in Southern Syria has subsequently been designated as a genetic reserve by the Syrian Scientific Agricultural Research Commission, as part of their Global Environment Facility (GEF) funded “Conservation and Sustainable Use of Dryland Agrobiodiversity in West Asia” project.

As regards the *Lathyrus* case study, some of the sites, chosen for the establishment of genetic reserves, are located on private lands or on areas managed for activities other than conservation, establishment of a reserve would be expensive as the land must be purchased and management regime is likely to require amendment. Thus the establishment of reserves on land already where there is an existing conservation interest, such as local National Parks or Protected Areas is desirable, where the site already has legal or voluntary protection from abrupt management changes or development (e.g. building dams or agricultural intensification). The relative cost of reserve establishment will also affect selection of alternative sites, which means that for practical reasons reserves are often sited in forestry areas where the establishment costs are relatively low. It may be advisable to undertake some form of cost-benefit analysis prior to final reserve site selection. If the ecogeographic data suggest locating the reserve in a particular area, it may be that this area or a closely adjacent one contain an existing protected area, whose management plan could be adapted to permit genetic conservation in a portion of the wider reserve, therefore saving some of the costs of genetic reserve establishment and maintenance. For instance, one of the high diversity sites for the *Lathyrus* is located in the Olimpos Beydaglari National Park at Cavus in Antalya, Turkey and the cost of establishing a genetic reserve would be low as the land is already protected. However, in this particular site the local management plan would need revision as it has recently been planted with *Pinus nigra* L., which are unlikely to provide a suitable habitat for *Lathyrus* species. Therefore, if a genetic reserve would have been established at this site there would need to be carefully monitored and managed or the large population of *Lathyrus belinensis* Maxted and Goyder (which is endemic to this one site) to ensure it remained extant.

The current usage of the site at Mimas in Southern Syria was heavily grazed by herds of local Bedouin shepherds and the level of grazing has been significantly reduced in the last two years resulting in the return of relatively lush vegetation. However, attempts to
persuade Bedouin shepherds and land-owners to reduce the size of flocks resulted in serious local unrest and therefore required agile management. The changes were necessary as the former unrestricted management policy for the Djebel Druze has undoubtedly led to a rapid loss of biological diversity, which is particularly alarming considering the high number of endemic legume and grass taxa found on this relatively small basaltic enclave.

Trained specialists with appropriate skills required to adequately conserve and manage the genetic materials *in situ*, are needed. Experience gained from GEF funded “Conservation and Sustainable Use of Dryland Agrobiodiversity” project in the Middle East has shown that the limited expertise in taxonomic identification of species and monitoring of populations. This shortage of trained staff is not limited to the Middle East, as taxonomy and traditional botany courses are being replaced by more biotechnological and molecular orientated courses, the lack of potential staff able to identify and conserve biodiversity is becoming more apparent worldwide.

Sustainability is fundamental to *in situ* conservation. Adequate long-term political and economic commitment to the reserve is necessary to ensure its long-term management. Appropriate development plans for the region should be checked to see if there is, for example, any building, industrialization or hydro-electric projects planned in the region that might adversely affect the conservation objectives of the reserve.

The establishment and management of the reserve is not an end in itself. There is an explicit link between genetic conservation and utilization, therefore conservation in the genetic reserve must facilitate sustainable utilization, either now or in the future. The utilization of the material conserved in the reserve may be divided among traditional, general and professional users.

Reserves are very rarely established in an anthropogenic vacuum. There are likely to be local farmers, land-owners and other members of the local population who may wish to utilize the proposed reserve site and who are likely to remain as neighboring communities. The traditional use made by local people may be disrupted by the establishment of the reserve. These local people may have historically harvested or collected from, hunted over or may simply have enjoyed visiting the site on which the reserve has been established. It is unlikely that any *in situ* conservation project can succeed without support of local communities. The effort is likely to fail if the local population opposes the establishment of the reserve and constant and effective monitoring will be in jeopardy. Therefore where traditional utilization is compatible with conservation objectives, sustainable exploitation of the buffer or transition zones by local, traditional user communities should be encouraged. However, to avoid negation of the conservation objectives their access and any harvesting, hunting, etc. may need to be regulated.

Finally, it is important to stress that *ex situ* technologies should always be used to act as a backup for *in situ* conserved taxa. The two strategies are complementary and just as a good genebank manager will duplicate the collection in other genebanks to ensure safety, the reserve manager should also duplicate the collection in *ex situ* collections. For *Lathyrus*, a series of complementary conservation strategies involving both *in situ* and *ex situ* conservation are currently being enacted (Sarker *et al.*, 2001). Traditionally, *Lathyrus* species have been conserved *ex situ* as seed accessions in the genebanks and it is
important that this method continues to act as a back up for any in situ genetic reserve conservation.

**Conclusion**
There has been a growing interest among genetic conservationists in the in situ conservation of plant genetic resources, because of the urgent need to protect natural and agri-ecosystems threatened with imminent change. The contemporary conservationist when formulating an overall conservation strategy should think in terms of applying a combination of different techniques, including both in situ as well as ex situ, where the different methodologies complement each other. With the majority of research in the past having been focused on developing techniques for the ex situ conservation of plant genetic resources, there is now a need to redress the balance and it is hoped that this paper, building on the experience of other biological disciplines, begins to provide a firm scientific base for in situ genetic reserve conservation.

The models for in situ genetic conservation discussed in the case of Lathyrus attempts to provide a generalised methodological framework which can be applied by researchers to establish and implement genetic reserve that will form part of an overall conservation strategy for conservation of a crop gene pool. However, it is stressed that the methodologies outlined are not meant to be prescriptive or to imply that any single methodology would be appropriate for all situations; they are presented as a reference point from which to explore the application of in situ conservation techniques. Another key point that requires reiteration is that whenever possible an in situ conservation project will require a true partnership of equals between conservationists and local communities in order to succeed.

**References**


Genetic Diversity Studies of Wheat Landraces in Palestine Using RAPD Markers and Phenotypic Evaluation

K. Sawalha¹, H. Eideh¹, S. Laham¹, H. Hasasneh ² and B. Mezeid²

¹ Biodiversity & Biotechnology Group. Life Sciences Department, Faculty of Science & Technology/ Al-Quds University. Abu Dies - Jerusalem. Palestine.  
² Ministry of Agriculture, Palestine.

Keywords: Wheat, landraces, genetic diversity, morphological characterization, RAPD markers

Abstract

Description of landraces is essential in order to protect farmers’ rights. Information on genetic diversity is also valued for the management of germplasm and for designing conservation strategies and molecular markers are the valuable tools for this purpose. RAPD molecular technique was used to characterize wheat cultivated in Palestine. Eight durum wheat landraces, two durum checks from ICARDA, one bread wheat variety and one accession of wild Triticum were used.

Most of the varieties can be differentiated on the basis of morphological characteristics of spikes and grain. Wild wheat and Arael bread wheat are easily distinguished for the durum varieties. Of the five primers used we found that P4 primer was the most useful giving the maximum discrimination index. An average of six bands where scored. Using P4 primer, about 65% (10 of the 14 wheat cultivars) showed polymorphic bands. Cluster analysis revealed three main clusters, one including Arael variety, the second cluster included both the accession of Triticum dicoccoides and one of the durum landraces (Debiya Bida), and the third cluster contained the remaining durum wheat varieties and could be subdivided into four sub-clusters.

RAPD and morphological characters can be used to differentiate the populations of wheat grown in Palestine and could help in the registration of landraces and wild relatives as germplasm for the recognition of farmers’ rights.

Introduction

The project “Conservation and Sustainable use of Dryland Agrobiodiversity in West Asia” involving the Palestinian Authority aimed at promoting the community-driven in situ/on-farm conservation of landraces and wild relatives of crops originating from the West Asian center of diversity. On-farm conservation is one of the strategies of in situ conservation which deals with conserving and maintaining landraces of crops at the farmers’ fields. To reach such goal, the project encouraged the participatory selection, the informal seed production and the demonstration of low-cost technological packages for improving the productivity of landraces.

Wheat is considered among the first crops domesticated by humans and it is now the first and the most important food crop grown in the world. This global importance stresses the need for conservation of genetic resources to ensure sustainable agricultural development and food security. These genetic resources, landraces or wild relatives are needed to transfer genes for adaptation to biotic and abiotic stresses, and to improve quality in new
varieties. The desirable characters can be assessed by field and laboratory evaluations, but could also be done by using newly developing DNA markers techniques. Information on genetic diversity is valuable for the management of germplasm and for designing conservation strategies. Many studies were using agro-morphological data to characterize the phenotypic diversity. DNA markers have proven to be the best tools for studying genetic diversity and for determining genetic relatedness. Many types of marker systems have been used to study plant diversity. These include restriction fragment length polymorphism (RFLP), simple sequence repeats (SSR), amplified fragment length polymorphism (AFLP) (Vos et al., 1995) and random amplification of polymorphic DNA (RAPD) (Williams et al., 1990; Karp et al., 1997). These techniques are different in their principles and dependant on the amount of data generated. However, most of these techniques are labor intensive, time consuming, expensive and prior information about genome is necessary. On the other hand, despite the problems associated with RAPD reproducibility (Devos and Gale 1992; Staub et al., 1996), this technique gained importance due to its simplicity and efficiency (Karp et al., 1997). RAPDs do not require DNA probes sequence information for the design of specific primers and the procedure involves no blotting or hybridization steps. Except the phenotypic characterization, no information is available on the extent of genetic variation present in the Palestinian wheat landraces. This study and for the first time in Palestine has attempted to use DNA based techniques such as RAPD to examine the relatedness of twelve cultivars of wheat collected from different locations.

Material and Methods

Plant material

Seeds of wheat landraces were collected from farmers’ fields in Jenin and Hebron of Palestine and planted at two agricultural research stations Al-Aroub (Hebron) and Biet Qad (Jenin). Farmers visited to the stations to evaluate the accesses and participate in the selection within landraces. Fourteen accessions were used in this study including one wild Triticum species (T. dicoccoides), one bread wheat variety (Arael), and twelve durum wheat varieties including nine Palestinian landraces and cultivars and three lines obtained from the International Center for Agricultural Research in the Dry Areas (ICARDA) (Sham 1, Sham 3, and Sham 5). The national project team, over three years of evaluation, recorded the morphological, agronomic and productivity information and helped the farmers in recording their visual assessment of landraces and selected populations. The leaves of the wheat varieties were collected at the seedling stage for DNA analysis.

DNA isolation

DNA was isolated from dried leaves following CTAB method (Doyle and Doyle 1990). Briefly 0.1-0.5g of dry wheat leaves were surface sterilized with 20% detergent (chlorox) solution and were placed in a liquid nitrogen and then grinded using pestle and mortar. 1 ml of extraction buffer was added to the powder, then incubated at 65°C for 30min, centrifuged at 1000xg (rpm), Potassium acetate was added so that the final concentration is 1M, incubated at 0°C for 40min, then centrifuged at 12000rpm for 15min. An equal volume of phenol/chloroform was added, mixed well by inverting slowly then centrifuged at 3000xg (rpm) for 10min. The supernatant was transferred to new tube and
phenol/chloroform step was repeated twice. Pure DNA sample in the upper aqueous phase was decanted (about 100 μl).
For DNA precipitation, 1ml of isopropanol was added and incubated for 10 min at –80°C, then centrifuged at 12000rpm for 20min. The pellet was re-suspended twice in 70% cold ethanol and centrifuged at 10000rpm for washing. Finally the pellet was dried for 30min at room temperature then resuspended in 50μl 10Mm TE buffer.

**Selection of the appropriate primers**
Five different primers - P1, P2, P3, P4 and P5 were tested on all wheat cultivars using the PCR reaction condition below with the only change in the annealing temperature, which was different for each primer.

P1- GACAGACAGACAGACA
P2- GAGCAAGATTCAGCCTGG
P3- TAATACGACTCACTATAGGG
P4- TCAGGACGCTAC
P5- AGCCTGATGCG

**PCR reaction and RAPD analysis**
The PCR reaction was performed in a final volume of 25ml containing 1X Taq polymerase buffer (Gibco, BRL), 1.0units of Taq polymerase (Gibco, BRL), 100mM of each dNTPs (Promega), 50pg of random primer (Operon technologies), 2.5mM MgCl₂ and about 50ng of total genomic DNA. The reaction mixture was overlaid with 25 ml of mineral oil and PCR was performed using the following cycling parameters: 1cycle of 2 min at 94°C, annealing temperature were calculated according to the primer used based on the total number of AT₈ and GC₅, 40 cycles of 30 sec at 94°C, 15 s at 37°C, 1 min at 72°C; and at 72°C for 10 min. The PCR products were resolved on 2% agarose gels and visualized under UV light after ethidium bromide staining.

**Agarose gel electrophoresis**
After amplification, the PCR products were separated on a 2% agarose gel. After electrophoresis, the gels were stained with ethidium bromide (2mg/liter) and visualized using the Nighthawk (pdi), dark room system incorporating UV transilluminator and CCD camera.

**Data analysis**
Bands were scored as 1 for their presence or 0 for their absence across the cultivars to generate a matrix. A genetic similarity (GS) was computed based on Jaccard’s coefficient of similarity (Jaccard 1908).

The data was subsequently used to construct a dendrogram using the un-weighted pair group method of arithmetical averages (UPGMA) algorithm. All the computations were carried out using the computerized software.

**Results and Discussion**
1- Morphological and agronomic characterization
Clear differences were found among the durum varieties for the spike and grain characteristics (Table 1). Arael spike type was different. The wild wheat is completely different because of the shattering and other phenotypic characteristics of the plant as a whole and the spike particularly. Using the morphological traits, the durum varieties can be grouped into black and white awned, redish-brown and white grains, oval-round-elongated grains. Further differentiation could be done on the basis of plant height and spike length. With the exception of Sham 3 and Sham 5, all the other varieties could be distinguished from each other on the basis of the morphological characteristics. Even Sham 3 and Sham 5 can be differentiated on the basis of 1000 kernel weight. The agromorphological characterization has been and still used for the registration of varieties and could be supplemented by other measurements and assessment such as resistance to diseases and insects and quality attributes. But, because of the heterogeneity inherent to the landraces, some varieties will have a mixture of types with a whole range of phenotypes making the differentiation hard, which supports the use of DNA molecular technique to assess the genetic diversity within and between populations.
Table 1: Morphological and agronomic characteristics of wheat varieties

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Plant height (cm)</th>
<th>Seeds/ spike</th>
<th>1000KW (gm)</th>
<th>Grain characteristics</th>
<th>Awn</th>
<th>Spike length (cm)</th>
<th>Productivity (kg/1000m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shape</td>
<td>Size</td>
<td>Color</td>
<td>Color</td>
</tr>
<tr>
<td>Kahatat</td>
<td>80-90</td>
<td>40-45</td>
<td>35-40</td>
<td>Round</td>
<td>Med</td>
<td>Reddish</td>
<td>Yellow</td>
</tr>
<tr>
<td>Nab Al-jamal</td>
<td>80-85</td>
<td>40-45</td>
<td>60</td>
<td>Elongated</td>
<td>Med.</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Debiya soda</td>
<td>80-90</td>
<td>30-40</td>
<td>35</td>
<td>Oval</td>
<td>Med.</td>
<td>Reddish</td>
<td>Black</td>
</tr>
<tr>
<td>Hetti safra</td>
<td>85-90</td>
<td>32-37</td>
<td>42</td>
<td>Oval</td>
<td>Small-med.</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Arael</td>
<td>75-80</td>
<td>40-50</td>
<td>30-35</td>
<td>Oval</td>
<td>Small-med.</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Nemra 8</td>
<td>90-100</td>
<td>40-45</td>
<td>40</td>
<td>Oval</td>
<td>Med.-big</td>
<td>Brown</td>
<td>Yellow</td>
</tr>
<tr>
<td>Wheat 870</td>
<td>70-75</td>
<td>45-50</td>
<td>43</td>
<td>Oval</td>
<td>Med.-big</td>
<td>Yellow</td>
<td>Yellow</td>
</tr>
<tr>
<td>Anbar</td>
<td>90-100</td>
<td>40-50</td>
<td>40-45</td>
<td>Oval</td>
<td>Med.-big</td>
<td>Brown</td>
<td>Black</td>
</tr>
<tr>
<td>Sham 1</td>
<td>90</td>
<td>38-40</td>
<td>45</td>
<td>Elongated</td>
<td>Med.</td>
<td>Brown</td>
<td>Black</td>
</tr>
<tr>
<td>Sham 3</td>
<td>80</td>
<td>40</td>
<td>33.5</td>
<td>Elongated</td>
<td>Med.</td>
<td>Brown</td>
<td>Yellow</td>
</tr>
<tr>
<td>Sham 5</td>
<td>90</td>
<td>45</td>
<td>50</td>
<td>Elongated</td>
<td>Med.</td>
<td>Brown</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
2- RAPD results

RAPD detected 65% polymorphism for only one primer P4 which was used to differentiate the accessions used in this study. Ten accessions out of 14 showed polymorphism 5 % (Fig. 1). An average of 6 bands was generated and a double band was prominent in most of the patterns approximately at the range of 600 bp. The pairs of varieties (Haiti Safra and Sham 3) and (Anbar and Debiya Soda) showed similar banding patterns.

The clustering analysis allowed to differentiate three main groups (Fig. 2): one cluster including the bread wheat variety Arael; the second cluster including both the wild *Triticum* accession (*T. dicoccoides*) and one of the landrace (Debiya Bida); and the third cluster which contains the remaining durum wheat varieties. This later cluster can be subdivided into four sub-clusters: the identical pair (Haiti Safra and Sham 3) in one sub-cluster; Sham 1 forming isolated sub-cluster, the sub-cluster formed by Menka and Sham5 and the last sub-cluster with the identical pair formed of Anbar and Debiya Soda varieties. P4 primer was not able to differentiate among Haiti Safra and Sham 3 which are different by pedigree and origin.

These results showed the need to use more polymorphic primers to differentiate among all accessions.

![Fig. 1. RAPD banding patterns (profiles) of wheat crops using P4 primer. Lanes L, shows the molecular weight marker. Lanes 2 - 13, shows different samples of wheat.](image-url)
Fig. 2. Dendrogram showing the clustering of wheat populations using the banding patterns obtained from RAPD technique using PA primer.

References
Systematic Study of the Genus *Allium* in Jordan

G. Omar and D. Al-Eisawi

*Department of Biological Sciences, University of Jordan, Amman 11942, JORDAN, E-mail: ghador_omar@yahoo.com; e-mail: aleisawi@ju.edu.jo*

**Keywords:** *Allium*, Palynology, PCR – ISSR Markers

**Abstract**

The genus *Allium* is a good representative of the Mediterranean plants. This genus is one of the largest in the world flora with about seven hundred *Allium* species found in the Northern Hemisphere, from Europe and Asia to the shores of Pacific Ocean in North Western America. It is characterized by several speciation centers, of which the most important ones are located in the Middle East and Central Asia. *Allium* the wild garlic, the wild onion, the chive, the shallot and the leek are mostly bulbous, sometimes rhizoidal herbs with linear (or hollow centric) stem and cymose umbels of flowers. Many have collateral buds in the axils. In many species the flowers are replaced by bulbils serving for vegetative reproduction. In some species, honey is secreted by the septal glands of the ovary; flowers are protandrous. *Allium* species are considered to be particularly difficult to define and classify. This is due to the minor morphological differences among *Allium* species and to the presence of different sections. Previous studies have supported splitting the species based on morphological and phenological patterns of variation. However, overlapping circumscriptions of the split taxa complicates plant identification. Therefore, *Allium* genus needs more emphasis on its classification in many regions. There are many wild species which need to be more studied, classified and described.

**Key to the *Allium* species**

2. Outer tunics reticulate or fibrous
3. All filaments simple
4. Umbel up to 8 cm in diameter; perianth pink-dark purple; filaments purple; anthers dark purple .................................................1. *A. sindijarenses*
4. Umbel smaller than 8 cm in diameter; perianth not pink-dark purple; filaments white; anthers whitish-pale yellow or yellow
5. Leaves usually up to 3, 1-3 mm broad, sub-triquetrous; umbel many flowered, more than 9 flowers; perianth urceolate, white-pinkish; pedicels not bracteolate at base; anthers whitish-pale yellow .................................................2. *A. desertorum*
5. Leaves usually up to 4; 0.5-0.75 mm broad, filiform; umbel few flowered, 4-9 flowered; perianth campanulate, white-greenish-pinkish; pedicels bracteolate at base; anthers yellow.........................................................3. *A. callidictyon*
3. Inner filaments 3-cuspidate
6. Perianth blue or blue-violet; stamens included ................4. *A. hierochuntinum*
6. Perianth dull green, yellowish-green or white; stamens distinctly exerted or sub-exerted
7. Tall plants; stem 70-150 cm tall; outer tunics prolonged into a long neck around shape; umbel up to 5 cm in diameter; perianth bright green-yellow green, white marbled, obtuse and rounded at apex; inner segments notched and emarginated; stamens long distinctly exerted; anthers yellow .........................................................5. *A. dictyoprasum* 7. Short plants; stem 6-30 cm tall; outer tunics not forming a neck around the scape; umbel smaller than 5 cm in diameter; perianth white with purplish or reddish or greenish midvein; segments not white
margined, sub-acute or sub-obtuse apex; inner segments not emarginated; stamens sub-exerted included; anthers purplish
8. Stem 15-30 cm tall, flexuose; leaves 1-2 mm broad, semi-terete-striate; umbel dense, many flowered, fastigiated; perianth segments 3-5 mm, sub-acute; style exerted

..................................................6. *A. artemisietorum*

8. Stem 6-10 cm tall, stout; leaves 2.2-2.5 mm broad, terete; umbel few-many flowered, hemispherical-globose; perianth segments 6-7 mm, sub-obtuse; style included

..................................................7. *A. sinaicum*

2. Outer tunics membranous
9. All filaments simple; spathe persistent, 2-valved, valves unequal, each valve ending in a slender appendage, valves as long as or longer than umbel
10. Filaments and anthers are distinctly exerted
11. Stem 40-60 cm tall, straight; perianth segments connivent, light green to brownish-green; outer segments broadest at apex, apiculate or notched ..........8. *A. albotunicatum*
11. Stem 10-35 cm tall, flexuose; perianth segments not connivent, purplish-pink; outer segments rounded, entire at apex ..........9. *A. stamineum*
10. Filaments and anthers included or anthers slightly exerted
12. Spathe valves mostly ovate at base, not exceeding umbel; perianth milky-white; segments often with a purplish or greenish mid-vein; flowering pedicels more or less equal; anthers partly exerted ............10. *A. pallens*
12. Spathe valves narrowly lanceolate at base, one or both valves distinctly exceeding umbel; perianth white-greenish; segments often with whitish mid-vein; flowering pedicels very unequal; anthers included ..........11. *A. paniculatum*
9. Filaments 3-cuspidate. Spathe persistent, 1-valved, valve split into several lobes, not ending in a slender appendages, whole spathe shorter than umbel, reflexed
13. Stem 80-100 cm tall; leaves terete; filaments slightly exerted; median cusp of inner filaments shorter and thicker than the longer and finer lateral cusps; cusps of inner filaments as long as their ciliolate basal lamina ..............12. *A. phanerantherum*
13. Stem 10-35 cm tall; leaves semi-terete; filaments distinctly exerted; median cusp of inner filaments thicker and longer than lateral cusps; cusps of inner filaments shorter than basal lamina .................................................................13. *A. curtum*

1. Leaves flat
14. Spathe caduceus; filaments 3-cuspidate
15. Anthers included; perianth outer and inner segments not of same color (inner segment more whitish); bulbllets few, sessile (attached to the mother bulb), dark purple-black color

..................................................14. *A. scorodoprasum*

15. Anthers exerted; perianth outer and inner segments of same color; bulbllets either few, borne on stolons, whitish or numerous, sessile, yellowish
16. Perianth cylindrical, campanulate, dark purple; inner segments truncate and minutely denticulate at tip, somewhat longer than the outer, segments overlapping or laterally touching one another during anthesis; bulbllets borne on stolons several cm long, whitish, few......................................................................................................15. *A. truncatum*
16. Perianth cup-shaped or broadly campanulate, white, purple, lilac or green; inner segments not truncate, not longer than the outer; segments remote from one another laterally; bulbllets sessile, yellowish, numerous ................................16. *A. ampeloprasum*
14. Spathe persistent; all filaments simple
17. Umbel 10-40 cm in diameter; polygamous with hermaphrodite, staminate or neuter flowers; pedicels very unequal, the longest generally not bearing fruit 17. *A. schubertii*
17. Umbel not exceeding 10 cm in diameter; all flowers hermaphrodite
18. Leaf sheaths reaching above ground level and sheathing at least 1/4 of stem; perianth segments erect after flowering and enveloping capsule
19. Perianth stellate
20. Stem 3-quetrous, rarely terete; umbel nodding in bud; anthers pale green; leaves glabrous, often scabridulous at margins ...............................18. A. neapolitanum
20. Stem terete; umbel erect in bud; leaves hairy or long-ciliate at margins, rarely glabrous; anthers yellow. ..............................19. A. trifoliatum
19. Perianth campanulate
21. Stem 80-130 cm tall; perianth pink-purple or cream colored; filaments exerted ..................................................................20. A. carmeli
21. Stem 10-60 cm tall; perianth not pink or purple colored; filaments included or slightly exerted
22. Leaves and sheath glabrous; bulb bearing several bulbllets; perianth segments obtuse, pink with a darker mid-vein .............................................................21. A. roseum
22. Leaves and sheath hairy; bulbs not bearing bulbllets; perianth segments not obtuse, not pink
23. Stem 40-60 (70) cm tall, striate; leaves densely and minutely velutinous on sheath and both faces of blade; style long exerted ...........................................22. A. qasyynenese
23. Stem 10-40 cm tall, terete; leaves not densely and minutely velutinous on sheath and both faces of blade; style not long exerted
24. Stem thin, one-two; umbel larger than 3 cm in diameter; anthers included or sub-exerted
25. Leaves pilose on both surfaces; umbel 4-5 cm in diameter; perianth straw colored; segments oblong-Inceolate, sub-acute-acute; anthers exerted, yellow ..... 23. A. erdelli
25. Leaves hairy velutinous along veins on lower face and on sheath; umbel 7-10 cm in diameter; perianth milky-white, greenish at base; segments oblong, acute-obtuse; anthers included, yellow-green .................................................. 24. A. negevense
24. Stem thickish, two; umbel 2-3 cm in diameter; anthers included ......25. A. papillare
18. Leaf sheaths all subterranean, or just reaching ground level; perianth segment withered after flowering, usually reflexed and not enveloping capsule
26. Perianth segments deep purple; anthers purple; filaments deep purple; ovary purple
27. Plants of rocky places; stem 6-20 cm tall; leaves 2-3 broad; umbel 4-5 cm in diameter; filaments white .................................................. 26. A. rothii
27. Plants of steppe and desert districts; stem 30-80 cm tall; leaves 2-4 cm broad; umbel 4-8 cm in diameter; filaments all deep purple .......... 27. A. aschersonianum
26. Perianth segments white or greenish-white; anthers pale yellow; filaments white or purple; ovary not purple
28. Stem 60-100cm tall; leaves 2.5-8 cm broad; perianth stellate; segments white, pale lilac or mavvish dark purple in their lower part ......................28. A. nigrum
28. Stem 15-40 cm tall; leaves 1-2 cm broad; perianth not stellate; segments more or less erect, greenish-white; ovary green; filaments white ................. 29. A. orientale

Palynology
Pollen morphological characteristics of Allium species were studied using scanning electron microscopy (SEM). Data about symmetry, polarity, shape, size, apertures and surface sculpturing are recorded. Results obtained so far indicate variations between studied taxa. All Allium species have typical monocots pollen grains, of elliptic to oblong shape and monocolpi aperture with variable degree of perforation ranging from perforate rugate to rugate or striate perforate sculpturing surface.
Leaf surface

Leaf surface study of *Allium* species by scanning electron microscope of both fresh and herbarium specimens are carried out to reveal the surface ultra structures which can not be observed by classical means. Results obtained so far showed the presence of variations between studied taxa, which may provide extra information that can be used to distinguish between studied taxa.
PCR – ISSR Markers
Wild species provide diverse genetic pools where it would be possible to transfer important genes like those responsible for resistance to pests, viruses and fungal diseases to the cultivated species. Therefore, it is important to evaluate the genetic diversity and levels of relatedness between and within the wild species. Molecular techniques in general and ISSR markers in particular are highly useful for such application. In addition to all previous taxonomic tools, molecular taxonomy using ISSR molecular markers using different UBC primers set # 9 is conducted to establish phylogenetic relationships among studied species using RAPD-PCR. With primers composed of microsatellite sequences and using higher annealing temperature, ISSR markers give good reproducibility. This particular investigation is expected to reveal clear cut between studied *Allium* species in Jordan.

Results obtained so far using some of the primes that will be screened indicated different banding pattern among the studied taxa as shown in the following diagram. So we expect that the present study will demonstrate that ISSR can provide a clear portrayal of relationships among closely related *Allium* species.

![Image](image_url)

Discussion
From the studies conducted on Allium and to enhance the expertise in the region, the following conclusions are made:

1. The species of the genus *Allium* need taxonomic study using different evidences to be able to reach the best taxonomic decision.
2. The morphological characters of *Allium* are highly variable specially, through the stages of the morphological growth of the plant specially, the color of the perianth, exertion of stamens and ovary and capsule color.
3. The accurate identification of any *Allium* species usually needs the presence of the whole plant parts.
4. Notes should be taken in the field on the spot about different morphological characters specially, those changing with the dryness of the plants such as the color and shape of perianth.
5. So far it is clear that different taxonomic tools other than the morphology play an important role in the definition of the species of the genus *Allium*.

References
SESSION THREE

USE OF GENETIC RESOURCES IN CROP IMPROVEMENT
Plant Genetic Resources in Crop Improvement: Case of Cereals

S. Rajaram, M. Nachit and O. Abdalla

*International Center for Agricultural Research in the Dry Areas (ICARDA) Integrated Gene Management (MP2), Aleppo, Syria.*

**Keywords:** Genetic resources, conservation, utilization, cereals, wheat

**Abstract**

The wise use of genetic resources is the backbone of advances made in plant breeding over 100 years since rediscovery of Mendelian Genetics. The case of Green Revolution based on wheat and rice was very much dependent on dwarfing gene resources from wheat cv. ‘Norin 10’ and Dee-gee-woo-gene, respectively. The modern biotechnological gene revolution is based on Bt and Ht genes derived from bacterial sources. The CGIAR Centers hold over 0.5 million wheat accessions as genetic stocks, landraces, varieties and wild progenitors on behalf of entire humanity. The CWANA represents maximum diversity of types in wheat and barley. The Mesopotamia region is also credited with first domestication of einkorn and emmer wheats approximately 10,000 years ago. This contribution will highlights the importance of conserving these valuable genetic resources for sustaining the genetic gains by breeding programs over the world.

**Introduction**

Modern plant breeding began almost 100 years ago in the beginning of 20th century with the discovery of Mendelian genetics. By 1906, the concept of heredity got fully established through study involving yellow rust resistance by Biffen in England. Since Mendelian genetics fully recognized, there have been many advances of methodological, technical and biometrical nature, which have permitted stepwise improvement in plant adaptation. Application of biometry has permitted efficient analysis of data. The statistical methodology and field plot technique have revolutionized the identification of variances due to genetics and non genetics. Knowledge of concept of heterosis revolutionized the plant breeding for cross-pollinated crops such as maize. Efforts to date for self-pollinated crop such as wheat have had limitation. The genetical basis of hybrid vigor is perhaps less understood; nonetheless it has not hindered progress for yield, quality or fiber. Eventually, breeding of all crops would be based on exploitation of heterosis. In the 4th quarter of 20th century, the chromosomal engineering had become the most fashionable tool of breeding. It provided opportunity to transfer a piece of chromosome from one species to related genera and species. The genus *Triticum* was intensely studied by many scientists. It resulted into many useful stocks such as 1B/1R translocation. Modern plant breeding is a blend of so called conventional methods and biotechnology. In the last 10 years, molecular markers based selection has become an important tool along with conventional technique.

Cereal wheat breeding progress depends, irrespective of methodology on clearly defined genetic stocks utilization. The genebanks harbor such genetic stocks. There are more than 160,000 accessions of wheat genotypes in CGIAR genebanks available to any breeder around the world. Introductions of genetic stocks and varieties have played a great role into crop improvement. According to Donald Rasmusson, University of Minnesota, at least 50% of genetical advances have occurred due to plain introduced germplasm. In this presentation, using wheat as example, we would like to establish significant advances in genetic improvement and its association with germplasm utilization.
Origin of Wheat Genetic Resources
Wheat originated in the Fertile Crescent between the rivers Euphrates and Tigris, most probably the region bordering between today’s Syria, Turkey, Iraq and Iran. The region is highly variable in climatic conditions for rainfall, temperature extremes and topography. The wild relatives of wheat *Aegilops tauschii*, *Triticum dicoccum*, *T. dicoccoides* and *T. urartu* are still found in this region. Many landraces are commonly grown within the traditional farming systems. International centers such as the International Center for Agricultural Research in the Dry Areas (ICARDA) has taken advantage of this variability in collection, preservation and utilization in breeding. However, the untold numbers of landraces and wild relatives are presumed lost due to modern agriculture. It is necessary to create biodiversity parks where we can maintain the future evolution in these species.

Green Revolution and (NORIN10)
The utilization of height reducing genes Rht1 and Rht2 from Japanese variety Norin10 is a classical example of introduced genetic resource in mid 1950’s. The dwarf wheats revolutionized the wheat production when these were used under proper agronomic practices and when nutrients and water were not limiting. The story of Norin10 is illustrated in Figure 1. It is derivative of landrace Daruma that may have originated in Korea. Few seeds of these varieties were given to Dr Orville Vogel at Washington State University, who generously gave few seeds of a cross Norin10 x Brevor to Dr N.E. Borlaug in Mexico. Norman E. Borlaug used these stocks in his own breeding program and produced a series of dwarf varieties, which were very high yielding under optimum conditions of agronomic management. The modern wheat breeding is based on these dwarving genes and Almost 90% of all bread wheats and durum wheats have either Rht1, or Rht2 or both. Some have Rht8. The rice story is very similar to wheat because the rice revolution was also based on a dwarfin gene derived from Dec-Gee-Woo-Gen and 95% of all Rice improved varieties and germplasm have the dwarfin gene of Dee-Gee-Woo-Gen (Figure 2).

Daruma (Japan)  
Shiro (white)-Daruma x Glassy Fultz (1917)  
Fultz Daruma x Turkey Red (1925)  
Norin 10 (1935) x Brevor (1949)  
N10 x Brevor (Rht1 + Rht2)  
x Mexican tall wheats  
Semidwarf wheats (1962)  

Fig. 1. Green Revolution and Norin 10 (Rht1 + Rht2)  

Peta x Dee-Gee-Woo-Gen  
(Indonesia landrace) (Taiwan dwarf)  
IR8  

Fig.2. Sources of dwarfin gene of rice
McFadden’s Hope
Until the late 1950’s stem rust was justifiably the most feared of the three wheat rusts on a global scale. The epidemics of this rust have been recorded in all major wheat growing areas of the world in last century. The resistance to this disease bred by Mr McFadden at Brookings, South Dakota resulted into a landmark variety Hope. The resistance to stem rust in Hope is perhaps derived from Yaraslav Emmer, a tetraploid wheat which was crossed to improved variety Thatcher/Marquis (Fig. 3). The resistance complex of stem rust was transferred into Mexican semi-dwarf germplasm by Dr N.E. Borlaug. The source variety Hope, has remained resistant for the last 60 years. Similarly a Brazilian variety Frontana has contributed durable leaf rust resistance gene Lr34 in many modern wheat varieties.

YARASLAV EMMER x BREAD WHEATS
(Tetraploid wheat) (Thatcher-Marquis)
Donor: SR2 complex durable resistance

BRAZILIAN FRONTANA
Donor of durable Leaf Rust resistance LR34 complex

Fig. 3: Origin of durable resistance to leaf rust and stem rust in bread

Six years ago, a virulent stem rust race was identified in the highland of Uganda, called Ug99. This race has spread out in entire East African highlands and most varieties grown there are susceptible. This race attacks Sr31, a gene derived from 1B/1R translocation from rye. In a test made at Kenya’s Njoro station in 2005, there were 6000 genotypes evaluated from CIMMYT, USA, Australia and India. In general, most genotypes were highly susceptible (scores > 70S). There were very few survivors. Amongst, the susceptible ones, not all carried Sr31, but most carried Sr2, a gene associated for durability of stem rust resistance and derived from Hope. This discovery (senior author’s personal observation) needs reexamination on our previously stated hypothesis on Sr2’s role as an interactive gene involved into durability. A well-known variety Seri 82 with both Sr31 + Sr2 was more than 70S into field conditions. Similarly, many other varieties with known Sr2 gene were highly susceptible. It is our opinion that Sr2 in itself has very little role as interactive gene in East African highlands. However, there were many other sources of resistance genes effective in East African conditions. These are: Sr24 linked to Lr24; Sr26 present in variety Kite; Sr25 linked to Lr19; Tam 200/Tui; Pavon 76 and Tinamou.

Story of Veery
In every agro-ecosystem, the varietal performance is variable due to various prevailing climatic conditions. The breeders generally employ the existing methodology to implement a dynamic breeding program. It is every breeder’s desire to produce varieties, which are superior to previously existing varieties and cultivars. However, the superior progenies do not come out easily due to several factors. Some of these are listed below:

1. Environmental variation is larger than genotypic variance in the experiment and it is highly unlikely that the stable progenies would be selected. This is very common in most breeding programs and especially in rainfed conditions.
2. Even though the right kinds of parents have been used in the crosses, the progeny size is too small to detect the variation and make right decision. F2 population size is very limiting in most breeding programs.

3. Not always, a proper set of conditions has been created to detect the gene constellation. For example, lack of rust epidemic with proper race spectrum is lacking when the cross is executed for rust resistance breeding.

4. Combining ability of the parents in the crosses are poor consequently, the progenies are very poor. This knowledge of combining ability is critical to a breeders’ progress. Many times, thousands of crosses are done and the progenies are tested on hectares but without much success.

The hallmark germplasm are those, which have high general combining ability and seem to produce fixable high heterotic response in the progenies. The crosses involving with hallmark germplasm are necessary in prebreeding because these functions as bridge cross as well. The example of such hallmark germplasm is variety Veery. Veery is a generic name and many outstanding varieties were released out of this complex top cross. Its combining ability has been outstanding. Its recent progeny is variety Attila now grown on 10 million hectares worldwide. The performance of Veery is graphically shown in Figure 4.

![Figure 4: Performance of Veery ‘S’ germplasm in 73 global environments (ISWYN 15)](image)

**Broadening Genetic Diversity in Bread Wheat**

*Triticum aestivum* (bread wheat) is a natural hybrid made by nature involving 3 genomes ABD. The D genome donor *Aegilops tauschii* also called goat grass contributed many important characters such as bread making quality.
A large number of *Ae. tauschii* accessions have been collected and these are available in many gene banks. These accessions can be used to synthesize bread wheat with added variability to such traits as: drought tolerance, Septoria resistance, fusarium tolerance, yellow rust and leaf rust resistance, high temperature tolerance, frost tolerance, and Hessian fly resistance. The goat grass accessions are gold mine for allele mining and most probably, these would be the biggest reservoir of genes easily transferable in bread wheat (Fig. 5) for synthetic bread wheat production.

*Fig. 5. Production of synthetic bread wheat using *Ae. tauschii**

Populations of this species are still found in many countries in West Asia and efforts for their preservation under natural habitats will allow continuous supply of valuable germplasm for wheat improvement around the world.

**Future of Yield Potential Improvement**

In Figure 6, are represented the classic gain of 38 years in yield potential of wheat varieties since 1962 to 2000. There has been utilization of many genes, which permitted this continuum. The height reducing genes Rht\(_1\) or Rht\(_2\) contributed significantly to yield gains in first semi dwarfs such as Pitic 62 and Siete Cerros. The rye segment 1B/1R contributed to yield in the latter varieties such as Seri 82 and Bacanore 88. The gene Lr19 has been demonstrated to show at least further gain in yield by 10% over Seri 82 and represented by Super Seri. Fifteen years ago, the senior author has pursued the concept of super wheat based on the long spike, higher spike fertility, robust stem, and broad leaf and dwarf types. The model is not based on unicum. The genotypes which could contribute to super wheat are *Agropyron*, *Tetrastichon*, *T. polonicum*, the variety Morocco, , and normal high yielding bread wheat (Fig. 6).
In conclusion, the future of germplasm improvement depends on easy and cheap access to all germplasm. CGIAR Centers are critical to such availability especially to NARS of developing countries which can not maintain their own genebanks. Biodiversity reserves without intervention of modern agriculture in center of origin are required to allow conservation and continuous evolution of species. Hallmark germplasm identification and utilization are necessary to realize further genetic gains.
Salient Results of Wild Relatives Use in Wheat Breeding Program in Morocco

N. Nsarellah¹, J. El Haddoury¹, A. Amri², M. Nachit², S. Lhaloui¹, and M. El Bouhssini²

¹ Institut National de la Recherche Agronomique (INRA), Centre Regional, Settat, Morocco
² International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

Keywords: Durum wheat, breeding, wide relatives, interspecific crosses, Morocco

Abstract

Bread wheat and durum wheat are respectively grown annually on average of 1.5 and 1.3 million hectares in Morocco. These crops are also important in the entire CWANA region. Sources of genetic resistance or tolerance to biotic stresses such as Hessian fly, root rot and leaf rust are difficult to find in common germplasm. In the 1980s and 1990s evaluation and use of wild Triticum species in wheat breeding were undertaken by the joint collaborative work between INRA and ICARDA wheat improvement programs. Hessian fly resistance was found in Triticum araraticum species and was introgressed into durum wheat. The varieties INRA 1804, 1805, 1807, 1809, and ICAMOR series are either released or on the release pipeline. Also new Hessian fly resistance was found in an Aegilops species and is being introgressed to bread wheat. Leaf rust resistance was found in Triticum monococcum and was introgressed into durum wheat. Root rot tolerance is still being evaluated in wild relatives while some improved tolerance has been obtained in durum wheat from interspecific crosses.

Introduction

Intra-specific genetic variability is essential to plant genetic improvement. However, considering the wide range of biotic stresses prevailing in the temperate dryland areas, and in order to prevent the breakdown of existing genetic resistance, intra-specific genetic variability may not be sufficient. Genetic pests resistance existing in wild relatives may be the answer to narrow genetic base observed for resistance to specific biotic stresses. In wheat breeding for West Asia and North Africa region, Hessian fly resistance, root rot tolerance and leaf rust resistance were difficult to find and incorporate in breeding material. Wild relative parents were chosen as possible sources.

Work on Hessian fly resistance

Hessian fly, Mayetiola destructor (Say) is a major insect pest in most of the bread and durum wheat producing areas of the USA, Canada, South-western European and North African regions. The erratic pattern of rainfall in regions with Mediterranean climate usually causes delayed planting which in its turn makes the emergence of the second generation of the fly coincide with the early stages of wheat plant development causing high levels of incidence and damage. These conditions may lead to total crop failure.

Resistance genes actually incorporated in bread wheat were named ‘H1’ to ‘H29’ in the light of screening activities in the USA. The H1, H2, H3, h4, H5, H7, and H8 were identified in bread wheat. The genes H6, H9, H10, H11, H14, H15, H16, H17, H18, H19, H20, H28 and H29 were identified in durum wheat but are not effective in the WANA region. The genes H21 and H25 were translocated from Rye. The H5, H7/H8, H11, H13, H14/H15, H21, H22, H25, and H26 are effective against the fly biotypes in North Africa countries and the South Europe region and were available only on bread wheat cultivars. Durum wheat was the source of many resistance genes
that were transferred to bread wheat but did not allow identification of genes effective for the Mediterranean fly biotypes. Many of durum landraces from Morocco and Tunisia are resistant to the biotypes in USA. Bread wheat has the ability to receive the resistance genes from the wild relatives with the D genome. The introgression of resistance from wild *Triticum* species have resulted in the release of two lines with resistance derived from *Triticum araraticum* (Nsarellah, Nachit and Amri, 1999). Genes derived from rye and *T. tauchii* were also transferred to durum background (Friebe *et al*., 1999).

Since 1990, new sources of resistance to Hessian fly have been identified in wild relatives of wheat (Tables 1 and 2). Most of these sources are mostly useful in bread wheat breeding. Most of these new resistance genes are to be studied and utilized.

Table 1: Reaction of an ICARDA collection of wild wheat (*Aegilops* and *Triticum*) species for resistance to Hessian fly in Morocco

<table>
<thead>
<tr>
<th>Species</th>
<th>Number</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ae. biuncialis</em> (UM)</td>
<td>2</td>
<td>2(H)</td>
</tr>
<tr>
<td><em>Ae. cylindrica</em> (CD)</td>
<td>2</td>
<td>2(R)</td>
</tr>
<tr>
<td><em>Ae. caudata</em> (C)</td>
<td>2</td>
<td>1(R)</td>
</tr>
<tr>
<td><em>Ae. ventricosa</em> (DUn)</td>
<td>6</td>
<td>5(R)</td>
</tr>
<tr>
<td><em>Ae. ovata</em> (UM)</td>
<td>47</td>
<td>32(14R,18H)</td>
</tr>
<tr>
<td><em>Ae. triaristata</em> (UM)</td>
<td>2</td>
<td>2(H)</td>
</tr>
<tr>
<td><em>Ae. speltoides</em> (S)</td>
<td>4</td>
<td>1(H)</td>
</tr>
<tr>
<td><em>Ae. umbellulata</em> (U)</td>
<td>2</td>
<td>1(R)</td>
</tr>
<tr>
<td><em>Ae. uniaristata</em> (Mu)</td>
<td>1</td>
<td>1(H)</td>
</tr>
<tr>
<td><em>Ae. geniculata</em> (MU)</td>
<td>2</td>
<td>1(R)</td>
</tr>
</tbody>
</table>

H: Heterogeneous for resistance, R: Homogeneous for Resistance

Table 2: Reaction of a wild wheat collection from the wheat genetic resources of Kansas State University, Manhattan, Kansas, USA, for resistance to Hessian fly in Morocco.

<table>
<thead>
<tr>
<th>Species</th>
<th>Number</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>T. monococcum</em> subsp. boeoticum* (A)</td>
<td>2</td>
<td>1(H)</td>
</tr>
<tr>
<td><em>T. dichasians</em> (C)</td>
<td>1</td>
<td>1(H)</td>
</tr>
<tr>
<td><em>T. tauschii</em> (D)</td>
<td>2</td>
<td>1(R)</td>
</tr>
<tr>
<td><em>T. longissima</em> (S)</td>
<td>1</td>
<td>1(H)</td>
</tr>
<tr>
<td><em>T. timopheevii</em> subsp. araraticum (AG)</td>
<td>2</td>
<td>1(H)</td>
</tr>
<tr>
<td><em>T. cylindricum</em> (CD)</td>
<td>2</td>
<td>2(R)</td>
</tr>
<tr>
<td><em>T. ventricosum</em> (DM)</td>
<td>1</td>
<td>1(R)</td>
</tr>
</tbody>
</table>

H: Heterogeneous for resistance, R: Homogeneous for Resistance

Useful to durum wheat breeding, *Triticum araraticum* and *Triticum carthlicum* were good sources of Hessian fly resistance. These resistance genes are also more effective than the H series genes coming from the A and B genome on bread wheat since most of their effectiveness is not affected by high temperatures. Resistance from *T. araraticum* is currently introgressed in several varieties registered since 2003.
Table 3: Species crossed to durum wheat and bread wheat and followed by embryo rescue in order to transfer Hessian fly resistance.

<table>
<thead>
<tr>
<th>Species</th>
<th>Genome</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Triticum monococcum</em></td>
<td>AA</td>
<td>TA 240</td>
</tr>
<tr>
<td><em>Triticum beoeticum</em></td>
<td>AA</td>
<td>TA 242; TA 230</td>
</tr>
<tr>
<td><em>Triticum araraticum</em></td>
<td>AAGG</td>
<td>TA 28; TA 36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TA 927; TA 9236</td>
</tr>
<tr>
<td><em>Aegilops tauschii</em></td>
<td>DD</td>
<td>TA 1664; TA 1670; TA 1671; TA 1677</td>
</tr>
</tbody>
</table>

Table 4: *Triticum araraticum* and *T. carthlicum* accessions used as Hessian fly resistance donors.

<table>
<thead>
<tr>
<th>Accession</th>
<th>Species</th>
<th>Origin</th>
<th>Donor</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA9, TA11, TA13, TA14,</td>
<td><em>T. araraticum</em></td>
<td>Iraq</td>
<td>University of California, Riverside. USA</td>
</tr>
<tr>
<td>TA16, TA17, TA86, TA863</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TA974</td>
<td><em>T. araraticum</em></td>
<td></td>
<td>University of California, Riverside. USA</td>
</tr>
<tr>
<td>TA2838, TA2879, TA2880,</td>
<td><em>T. carthlicum</em></td>
<td>Turkey</td>
<td>University of California, Riverside. USA</td>
</tr>
<tr>
<td>TA2882</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Leaf rust resistance

Leaf rust, caused by *Puccinia recondita* is one of the most wide spread rust disease on wheat in WANA region. In Morocco, mid-season droughts are frequent and late rains usually trigger leaf rust epidemic on an already weakened crop. Losses are important both in terms of quantity and grain quality. Bread wheat has many genes for resistance that are effective in Morocco but durum wheat does not have so many genes. The efforts of the researchers are concentrated on identifying genetic resistance in durum wheat. As some *Triticum monococcum* accessions were found to have some field resistance, crosses were performed in order to transfer this resistance.

Root rot tolerance

Dryland root rot is a major disease under dry conditions. This disease is caused by *Fusarium culmorum* and *Helminthosporium sativum* pathogen complex. Studies have shown that durum wheat suffers from dryland root rot more than bread wheat. Chemical treatments are not fully effective and sources of genetic resistance are not yet available. Root rot was also found under wet conditions and the isolated pathogenic agents were similar to those of dryland root rot. Since the mid 1990s crosses with suspected root rot tolerant wild relatives *T. monococcum* and *T. dicoccum* were performed and are currently in their evaluation stage. Crosses between *T. araraticum* and durum wheat have yielded advanced lines that have better root rot tolerance.

Conclusion

Most of the work was concerned with Hessian fly resistance in both bread and durum wheat. There is far more genetic resistance available to bread wheat than to durum wheat. And even though the constraint in durum wheat is no longer acute, other sources of resistance have to be identified for the future. Work on Root rot tolerance and leaf rust resistance is starting to produce germplasm with good prospects for durum wheat production. Derived from crosses with *Triticum araraticum*, durum wheat varieties with resistance to Hessian fly, leaf rust and good levels of root rot tolerance: INRA 1804, INRA 1805, INRA 1807, INRA 1809, ICAMOR 1, ICAMOR 6, ICAMOR 11 were released for farmers use in Morocco.
References
Amri A. 19989. Inheritance of Hessian fly resistance in wheat. PhD Thesis, Kansas State University, Manhattan, Kansas, USA
Morphological Evidence of Natural Introgression between Jordanian Wild Emmer wheat (*Triticum dicoccoides*) and Durum Wheat

M. Syouf 1*, B.E. Abu-Irmaileh 2 and J. Valkoun 3

1 National Center for Agricultural Research & Technology Transfer (NCARTT), Ministry of agriculture, Jordan; P.O. Box639 Baqa'(19381) Jordan. Fax: 009626-4726099; e-mail: syoufmaha@yahoo.com;
2 Department of Plant Protection, Faculty of Agriculture, University of Jordan;
3 Plant Genetic Resources Unit, ICARDA, Aleppo, Syria. Email j.valkoun@cgiar.org

**Keywords:** Durum wheat, landraces, *Triticum dicoccoides*, gene flow, drought resistance

**Abstract**

Morphological characterization of wild emmer wheat (*Triticum turgidum* subsp. *dicoccoides*) populations which were collected from different sites in Jordan was conducted to assess the occurrence of natural introgression. Sixteen morphological, developmental and productive parameters were measured.

The presence of natural introgression from durum wheat landraces into wild emmer wheat populations was ascertained by significant morphological similarities of certain characters such as days to emergency, days to heading, early growth vigor, number of fertile tillers, absence of pigmentation of first leaf and awns, peduncle and awn length, and number of spikelet per spike. The highest level of introgression appeared in *T. dicoccoides* populations from Sakhra (554), Zatari (553) and Naimeh (558). These populations were similar to durum wheat landraces for more than 8 morphological characters. The lowest level of introgression was in *T. dicoccoides* population from Ibbin (560), as this population was similar to durum wheat landraces for four to six morphological characters. The remaining populations were similar to durum landraces for five or more characters.

**Introduction**

Wild relatives of wheat harbor a high level of genetic diversity for almost all-important economic traits used in breeding programs (Jaradat and Humeid, 1990; Jaradat et al., 1988). *Triticum turgidum* subsp. *dicoccoides* (Korn. ex Asch. & Graebn.) Thell.) (*Td*), the progenitor of the cultivated emmer (*T. dicoccon*), all durum wheat (*DWh*) landraces in addition to bread wheat are largely self-pollinated annuals. *T. dicoccoides* is endemic in six countries, namely: Jordan, Palestine, Lebanon, Syria, Iraq and Turkey (Anikster and Noy-Meir, 1991). Crosses of *T. dicoccoides* with tetraploid wheat resulted in fertile F1 hybrids, whereas crosses with hexaploid wheat resulted in partially-fertile hybrids (Feldman and Millet, 1991). Thus, continuous gene exchange between the wild progenitor and cultivated wheat are possible (Blumler, 1998). Gene introgression from wild diploid progenitors: *Triticum urartu*, *T. boeoticum*, *Aegilops speltoides* and *Ae. tauschii* and from the tetraploid progenitor, *T. dicoccoides*, can be achieved through conventional breeding methods (Valkoun, 2001). In the centers of origin, plants of *T. dicoccoides* grow near and within the fields of durum wheat landraces and consequently crosses occur occasionally (Harlan, 1992). Transfer of genes from cultivated crops to the wild relatives may exhibit greater fitness in wild populations or even in the new hybrids (Darmency and Vigouroux, 2000). However, plants of *Td* populations are common in fields and come in contact with cultivated wheat sufficiently to cross occasionally (Harlan, 1992). Gene flow was estimated by indirect methods in *Td* populations to occur within 5-7m distances. Crosses in open grassland...
of the Fertile Crescent can result in substantial increases in variation. Variation in local and
temporal plant density, species composition, plant size, environmental stress, and genetic
composition may seriously influence out crossing and gene flow of a population (Golenberg,
1987). Gene flow in Td populations in Jordan was not investigated. In this research detection of
introgression in Td populations merits testing due to their direct breeding potential. Within this
context, gene flow renders an important option for new Td population diversity. The need to
detect and evaluate the ongoing natural introgression in the gene pool of crop diversity is needed
to provide new genotypes in the agro-ecosystem.

Materials and Methods
This research was conducted at the University of Jordan (longitude 35.52.502°E and latitude of
32.00,594°N; 958.3 m above sea level). Bulk seed collections of sixteen populations of T.
dicocoides (Td) from various sites in Jordan were obtained from the Genetic Resources Unit at
the National Center for Agricultural Research and Technology Transfer (NCARTT). The most
cultivated three DWh landraces were also included as reference checks. All Td populations and
durum DWh landraces with their code numbers are listed in Table 1. The seeds of all populations
were planted on 27 February 2001 (Table1). Each population was represented by five replicates
(1 pot per replicate). Urea fertilizer (45 N %) at a rate of 20g/20 liters was added for all pots.
Plants were irrigated twice a week. As morphological similarities in certain characters between
Td and DWh landraces are believed to be a result of gene flow from durum into T. dicocoides,
i.e. introgression (Blumler, 1998), the following characters were measured and recorded for each
plant during the growing season up to maturity according to the ICARDA’s Durum Germplasm
Catalogue (Damania, 1991):
A. Vegetative characters
- Days to emergency were calculated from planting day until 50 % emergence;
- Days to heading were calculated as number of days from emergency to the appearance
  of the first spike from the sheath;
- Early growth vigor on a scale 1-9 where as healthy (9), intermediate (5) and weak (1);
- Plant height was measured just before maturity on the standing plant from the base to
  the tip of the longest tiller, including spike but excluding awns;
- Number of tillers, were calculated as number of lateral shoots at the base of the plant;
- Presence of pigmentation on first leaf used the scale of 1= pigment was not present,
  and 2= pigment was present;
- Growth habit was measured on a scale of 1 to 3; where 1=erect, 2= early growth
  prostrate then semi erect and 3=prostrate.

B. Inflorescence characters
- Peduncle length from base of the spike up to the flag leaf node;
- Spike length measured from the spike node to the tip of the spike excluding awns;
- Number of spikelets per spikes;
- Awn length measured from the tip of the spike to the tips of the awns;
- Awn’s color on scale: white to yellow=1, and black=2.

C. Seed characters
- Thousand seed weight;
- Seed length and seed width.

Seeds were labeled and stored at NCARTT genebank at +4°C temperature. All measured
characters for Td populations and cultivated DWh landraces were used to detect introgression,
based on approaches identified by Blumler (1998) and Harlan (1992). Morphological
characterization data were analyzed using computer software SPSS (version 10 for windows, SPSS Inc., Chicago, Illinois, USA).


<table>
<thead>
<tr>
<th>Collection number</th>
<th>Collection date</th>
<th>Triticum species</th>
<th>Collection site</th>
<th>Elevation (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>347</td>
<td>05/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Tafila/E of cement factory</td>
<td>1400</td>
</tr>
<tr>
<td>553</td>
<td>17/06/92</td>
<td><em>T. dicoccoides</em></td>
<td>Salt/Zatari</td>
<td>1060</td>
</tr>
<tr>
<td>554</td>
<td>18/06/92</td>
<td><em>T. dicoccoides</em></td>
<td>Irbid/Sakhra</td>
<td>1180</td>
</tr>
<tr>
<td>555</td>
<td>18/06/92</td>
<td><em>T. dicoccoides</em></td>
<td>Irbid/Afana</td>
<td>1150</td>
</tr>
<tr>
<td>557</td>
<td>20/06/92</td>
<td><em>T. dicoccoides</em></td>
<td>Irbid/Natifia</td>
<td>620</td>
</tr>
<tr>
<td>558</td>
<td>21/06/92</td>
<td><em>T. dicoccoides</em></td>
<td>Irbid/Naimeh</td>
<td>1030</td>
</tr>
<tr>
<td>559</td>
<td>22/06/92</td>
<td><em>T. dicoccoides</em></td>
<td>Jeresh/Balila</td>
<td>760</td>
</tr>
<tr>
<td>560</td>
<td>22/06/92</td>
<td><em>T. dicoccoides</em></td>
<td>Irbid/Ibbin</td>
<td>1100</td>
</tr>
<tr>
<td>562</td>
<td>19/07/92</td>
<td><em>T. dicoccoides</em></td>
<td>Salt/Um-Al-Amad</td>
<td>800</td>
</tr>
<tr>
<td>567</td>
<td>01/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Irbid/Samta</td>
<td>1030</td>
</tr>
<tr>
<td>568</td>
<td>01/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Irbid/Ibbin</td>
<td>1020</td>
</tr>
<tr>
<td>569</td>
<td>02/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Irid/Sakhra</td>
<td>1020</td>
</tr>
<tr>
<td>570</td>
<td>03/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Salt/Al-Zaatari</td>
<td>900</td>
</tr>
<tr>
<td>572</td>
<td>05/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Tafila/Qadesieh</td>
<td>1480</td>
</tr>
<tr>
<td>576</td>
<td>05/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Tafila/E of cement factory</td>
<td>1400</td>
</tr>
<tr>
<td>578</td>
<td>06/06/95</td>
<td><em>T. dicoccoides</em></td>
<td>Tafila/Ain Al-tareek</td>
<td>1310</td>
</tr>
<tr>
<td>289</td>
<td>31/05/95</td>
<td><em>T. durum</em></td>
<td>Mafraq/Khatal</td>
<td>665</td>
</tr>
<tr>
<td>505</td>
<td>21/05/91</td>
<td><em>T. durum</em></td>
<td>Amman/Rajam Al-Shouk</td>
<td>940</td>
</tr>
<tr>
<td>522</td>
<td>23/05/91</td>
<td><em>T. durum</em></td>
<td>Mafraq/Hian Al-Rwaid</td>
<td>670</td>
</tr>
</tbody>
</table>

Results

Vegetative characters

**Days to emergence, days to heading and early growth vigor**

Populations of *T. dicoccoides* showed variations in days to emergence, days to heading and early growth vigor among sites. The emergence of Natifa *Td* population (557) was the earliest (Table 2). There were no significant differences in earliness of emergence between Natifa (557) population and the two *DWh* landraces (289) and (522) collected from Mafraq. The latest emerging population was Ibbin *Td* (560). There were wide variations in emergence among *Td* populations. The emergence of Natifa population (557) was not significantly different from *Td* populations from Naimeh (558), Balila (559), UmAl Amad (562), Ibbin (568) & Ain Al-Tareek (578).

In general, heading was earlier in *DWh* landraces compared to *Td* populations, however, *Td* populations of Zatari (553) and Sakhra (554) were not significantly different from *DWh* populations. A-Zaatari *Td* population (570) was the latest to reach the heading stage (Table2). Confidence intervals (CI 95%) showed wide variations within each population in days to heading (Fig. 1).
All *Td* populations showed wide variations in early growth vigor, within the population per site and among sites (Fig. 2). Samta *Td* population (567) was the most heterogeneous population in early growth vigor (range 0.4-8.5) followed by Tafeila/East of cement factory (347) population, with a range of 2-6.9 (Fig. 2). *Td* populations from Tafeila/East of cement factory (347), Afana (555), Natifa (557), Samta (567) had significantly weaker vigor than *DWh* land races. (Table 2).

**Plant height, flag leaf length-width, number of fertile tiller and growth habit**

Plants of Zaatari (570) and Afana (555) *Td* populations were the tallest among all *Td* populations, but were not significantly different from *DWh* landraces. Ibbin *Td* population (568) was the shortest (Table2). Even though wide variations were detected in the values of number of fertile tillers among all *Td* populations, the values were not statistically different from those of *DWh* landraces. Comparing the growth habit, *DWh* landraces were erect throughout the growing season While all *Td* populations were prostrate until the start of heading, then became semi-erect, except for Afana *Td* population (555) which stayed more prostrate during heading (Table 2).

**Leaf pigmentation**

Leaf pigmentation of the first leaf was evident in most *Td* populations except for populations of *Td* collected from Balila (559), Qadesieh (572), Sakhra (554, 569) and Samta (567) lacked pigmentation of the first leaf. This pigmentation was rarely observed for *DWh* landraces.
Table 2. Vegetative characteristics of wild emmer wheat populations and durum wheat landraces*

<table>
<thead>
<tr>
<th>Collection number</th>
<th>Days to emergence</th>
<th>Days to heading</th>
<th>Early growth vigor</th>
<th>Plant height</th>
<th>Fertile tiller number</th>
<th>Leaf pigmentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>289</td>
<td>15.60ab</td>
<td>64.20a</td>
<td>9.00c</td>
<td>64.80cdef</td>
<td>3.2abc</td>
<td>2.0d</td>
</tr>
<tr>
<td>347</td>
<td>20.40 bcd</td>
<td>90.00ab</td>
<td>4.80abc</td>
<td>45.64ab</td>
<td>9.20d</td>
<td>2.0d</td>
</tr>
<tr>
<td>505</td>
<td>20.60 bcd</td>
<td>61.40a</td>
<td>9.00c</td>
<td>72.20f</td>
<td>4.0abcd</td>
<td>1.4abc</td>
</tr>
<tr>
<td>522</td>
<td>16.40 abc</td>
<td>64.60a</td>
<td>9.00c</td>
<td>66.00def</td>
<td>6.0abcde</td>
<td>2.0d</td>
</tr>
<tr>
<td>553</td>
<td>18.80 bcd</td>
<td>72.80ab</td>
<td>6.00abcd</td>
<td>51.54abcde</td>
<td>8.0bcd</td>
<td>1.6bcd</td>
</tr>
<tr>
<td>554</td>
<td>20.00 bcd</td>
<td>73.60ab</td>
<td>5.20abc</td>
<td>56.86abcdef</td>
<td>4.4abcd</td>
<td>2.0d</td>
</tr>
<tr>
<td>555</td>
<td>20.80 cd</td>
<td>92.00de</td>
<td>7.20d</td>
<td>68.20ef</td>
<td>4.2abcd</td>
<td>1.2ab</td>
</tr>
<tr>
<td>557</td>
<td>13.80 a</td>
<td>87.40cde</td>
<td>7.20d</td>
<td>48.00abc</td>
<td>2.6ab</td>
<td>1.6bcd</td>
</tr>
<tr>
<td>558</td>
<td>17.20 abcd</td>
<td>80.80bcd</td>
<td>5.80abcd</td>
<td>48.02abc</td>
<td>4.60abcd</td>
<td>1.8cd</td>
</tr>
<tr>
<td>559</td>
<td>17.40 abcd</td>
<td>80.00bcd</td>
<td>5.60abcd</td>
<td>58.40abcd</td>
<td>4.8abcd</td>
<td>2.0d</td>
</tr>
<tr>
<td>560</td>
<td>21.80 d</td>
<td>77.80bc</td>
<td>7.00cd</td>
<td>50.84abcd</td>
<td>4.6abcd</td>
<td>1.0a</td>
</tr>
<tr>
<td>562</td>
<td>20.60 bcd</td>
<td>90.80cde</td>
<td>6.80ecd</td>
<td>56.80abcdef</td>
<td>4.6abcd</td>
<td>1.8cd</td>
</tr>
<tr>
<td>567</td>
<td>19.80 bcd</td>
<td>84.40bcd</td>
<td>4.40a</td>
<td>60.90abcdef</td>
<td>5.4abcd</td>
<td>2.0d</td>
</tr>
<tr>
<td>568</td>
<td>17.40 abcd</td>
<td>87.20cde</td>
<td>7.00cd</td>
<td>42.00a</td>
<td>2.0a</td>
<td>1.8cd</td>
</tr>
<tr>
<td>569</td>
<td>20.60 bcd</td>
<td>89.60e</td>
<td>6.20abcd</td>
<td>59.80abcdef</td>
<td>2.6ab</td>
<td>2.0d</td>
</tr>
<tr>
<td>570</td>
<td>20.00 bcd</td>
<td>94.00de</td>
<td>6.60bcd</td>
<td>66.80def</td>
<td>4.6abcd</td>
<td>1.4abc</td>
</tr>
<tr>
<td>572</td>
<td>19.60 bcd</td>
<td>89.80cde</td>
<td>5.80abcd</td>
<td>50.20abcd</td>
<td>7.6bcd</td>
<td>1.8cd</td>
</tr>
<tr>
<td>576</td>
<td>19.60 bcd</td>
<td>82.80bcd</td>
<td>6.00abcd</td>
<td>55.20abcd</td>
<td>8.6cd</td>
<td>2.0d</td>
</tr>
<tr>
<td>578</td>
<td>17.80 abcd</td>
<td>90.20cde</td>
<td>6.00abcd</td>
<td>58.62abcd</td>
<td>3.6abc</td>
<td>2.0d</td>
</tr>
<tr>
<td>Total</td>
<td>18.85</td>
<td>82.18</td>
<td>6.56</td>
<td>56.89</td>
<td>4.96</td>
<td>1.821</td>
</tr>
</tbody>
</table>

*Means for groups in homogeneous subset are displayed using Duncan, subset for alpha=0.05

Inflorescence characters

Peduncle length, spike length, number of spikelets per spike, awn length, and awn pigmentation

The longest peduncles were recorded in Td populations of Balila (559) and Tafeila/East of cement factory (576). The peduncle length of Td populations of Zatari (553), Sakhra (554), Afana (555), Um Alamad (562), and Samta (567) were not significantly different from DWh landraces. Sakhra Td populations (569) had shortest peduncles (Table 3).

Spikes of DWh landraces were shorter than spikes of any Td population. However, wide ranges of spike length were recorded for all Td populations. Spikes of Td populations: Afana (555), Natifa (557), Balila (559), Ibbin (560 and 568), UmAlAmad (562), Samta (567), Sakhra (569), Zaatari (570) and Tafeila Ain Al-tareek (578) were significantly longer than DWh landraces. Spike length in Tafeila/East of Cement factory (347), Sakhra (554) and Qadesieh (572) Td populations were not significantly different from that of DWh landraces (Table 3).

Number of spikelets per spike in DWh landraces was higher than all Td populations, except for Tafeila/East of Cement factory (347) and Qadesieh (572) Td populations (Table 3).

Awns of DWh landraces, in addition to some Td populations Neimeh (558), Samta (567) and Natifa (557) were characterized by being the shortest. Mean awn length in some other Td populations including Tafeila/East of Cement factory (347); Ibbin (560); UmAlAmad (562); and Sakhra (569) was not significantly different from that of DWh landraces. The rest of Td populations had significantly longer awns (Table 3). However, awn length varied within each population widely (Figure 3).
DWh landraces in addition to most Td populations had white awns. Only five Td populations: Tafeila/East of cement factory (347), Ibbin (560), Samta (567), Qadesieh (572), and Tafeila/Ain Tareek (578) had black awns (Table 3).

Table 3. Inflorescence characters of wild emmer wheat populations and durum wheat landraces*

<table>
<thead>
<tr>
<th>Collection number</th>
<th>Peduncle length</th>
<th>Spike length</th>
<th>No of spikes</th>
<th>Awn length</th>
<th>Awn color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>289</td>
<td>10.24cdef</td>
<td>3.84ab</td>
<td>20.00c</td>
<td>7.42a</td>
<td>1.00a</td>
</tr>
<tr>
<td>347</td>
<td>8.68ab</td>
<td>4.94abcde</td>
<td>10.00ab</td>
<td>10.46bcdef</td>
<td>2.00b</td>
</tr>
<tr>
<td>505</td>
<td>10.14cdef</td>
<td>3.80a</td>
<td>24.00f</td>
<td>7.34a</td>
<td>1.00a</td>
</tr>
<tr>
<td>522</td>
<td>10.26cdef</td>
<td>4.20abc</td>
<td>17.60de</td>
<td>8.10ab</td>
<td>1.40a</td>
</tr>
<tr>
<td>553</td>
<td>9.62bcd</td>
<td>5.96efgh</td>
<td>10.20ab</td>
<td>10.86cdef</td>
<td>1.00a</td>
</tr>
<tr>
<td>554</td>
<td>9.92bcde</td>
<td>4.60abcd</td>
<td>9.00a</td>
<td>12.48def</td>
<td>1.20a</td>
</tr>
<tr>
<td>555</td>
<td>9.5bcd</td>
<td>6.00efghi</td>
<td>9.40ab</td>
<td>12.92ef</td>
<td>1.00a</td>
</tr>
<tr>
<td>557</td>
<td>11.08ef</td>
<td>5.90defgh</td>
<td>10.80ab</td>
<td>11.42cdef</td>
<td>1.00a</td>
</tr>
<tr>
<td>558</td>
<td>11.3ef</td>
<td>5.40cdefg</td>
<td>10.20ab</td>
<td>9.14abc</td>
<td>1.00a</td>
</tr>
<tr>
<td>559</td>
<td>12.4gh</td>
<td>5.74defgh</td>
<td>10.00ab</td>
<td>11.18cdef</td>
<td>1.20a</td>
</tr>
<tr>
<td>560</td>
<td>5.66bcd</td>
<td>6.66def</td>
<td>8.20a</td>
<td>10.12bcd</td>
<td>2.00b</td>
</tr>
<tr>
<td>562</td>
<td>10.42def</td>
<td>5.74defg</td>
<td>9.20a</td>
<td>10.58bcdef</td>
<td>1.00a</td>
</tr>
<tr>
<td>567</td>
<td>6.30abc</td>
<td>6.60fghi</td>
<td>11.20ab</td>
<td>13.02f</td>
<td>1.40a</td>
</tr>
<tr>
<td>568</td>
<td>11.4f</td>
<td>6.30f</td>
<td>10.00ab</td>
<td>11.88def</td>
<td>1.00a</td>
</tr>
<tr>
<td>569</td>
<td>7.86a</td>
<td>5.54def</td>
<td>8.60a</td>
<td>10.24bcde</td>
<td>1.20a</td>
</tr>
<tr>
<td>570</td>
<td>11.26ef</td>
<td>6.96hi</td>
<td>11.20ab</td>
<td>12.66def</td>
<td>1.00a</td>
</tr>
<tr>
<td>572</td>
<td>9.06abcd</td>
<td>5.08bcdef</td>
<td>8.60a</td>
<td>11.70cdef</td>
<td>1.80b</td>
</tr>
<tr>
<td>576</td>
<td>13.26h</td>
<td>5.50def</td>
<td>13.40bc</td>
<td>12.84def</td>
<td>2.00b</td>
</tr>
<tr>
<td>578</td>
<td>8.96abc</td>
<td>7.22i</td>
<td>15.40cd</td>
<td>11.62cdef</td>
<td>1.80b</td>
</tr>
<tr>
<td>Total</td>
<td>10.18</td>
<td>5.56</td>
<td>12.06</td>
<td>10.84</td>
<td></td>
</tr>
</tbody>
</table>

*Means for groups in homogeneous subset are displayed using Duncan, subset for alpha=0.05

Seed characters

Thousand seed weight and seed length and width

The weight of one thousand seeds of the DWh landrace 522 and Td populations of Zaatar (570) and Tafeila/East of cement factory (576) was the highest among all populations (Table 4). However, the weight of thousand seeds of the DWh landraces 289 and 505 was the lowest, but were not significantly different from that in the rest of Td populations (Table 4). Seeds of DWh landraces were significantly wider than all Td populations (Table 4). However, there were no significant differences in seed length among DWh landraces and the Td populations Tafeila/East of cement factory (347 and 576), Ibbin (568), and Zaatar (570). Seed length in the rest of Td populations was significantly different from that in DWh landraces.

Discussion

Continuous gene exchange between the wild progenitor T. dicoccoides and cultivated wheat are quite possible (Blumler, 1998), and gene introgression from wild diploid and tetraploid progenitors could be achieved through conventional crossing methods (Valkoun, 2001). In Jordan, plants of wild emmer wheat, Triticum dicoccoides, grow at the borders or within durum wheat fields, allowing gene flow to occur. Gene flow was estimated in Td populations to occur within 5-7m distances Golenberg (1987). Introgression in this research was measured by similarities in certain morphological characters which are genetically controlled. The results of this research indicated that various levels of introgression took place in several Td populations collected from different sites in Jordan. The highest level of introgression appeared in Td
populations 554, 533 and 558. These populations were similar to either *DWh* landraces in more than 8 morphological characters (Table 5). The lowest level of introgression was in *Td* population 560, as this population was similar to DWh in four to six morphological characters. The remaining populations were similar to either DWh landraces in five or more characters (Table 5). Morphological similarities between *T. dicoccoides* and durum wheat cultivars are believed to be a result of gene flow from durum wheat cultivars into *T. dicoccoides* (Blumler, 1998). Within each population, there were various levels of variability in any one character. Such heterogeneity could also be attributed to the occurrence of introgression within these populations (Harlan *et al.*, 1973).

Table 4. Seed characters of wild emmer wheat populations and durum wheat landraces*

<table>
<thead>
<tr>
<th>Collection number</th>
<th>1000 Kernel weight</th>
<th>Seed L</th>
<th>Seed w</th>
</tr>
</thead>
<tbody>
<tr>
<td>289</td>
<td>15.66a</td>
<td>0.64a</td>
<td>0.38c</td>
</tr>
<tr>
<td>347</td>
<td>19.34ab</td>
<td>0.80abcd</td>
<td>0.20ab</td>
</tr>
<tr>
<td>505</td>
<td>17.90ab</td>
<td>0.70ab</td>
<td>0.40c</td>
</tr>
<tr>
<td>522</td>
<td>30.98d</td>
<td>0.70ab</td>
<td>0.40c</td>
</tr>
<tr>
<td>553</td>
<td>20.60abc</td>
<td>1.02f</td>
<td>0.20ab</td>
</tr>
<tr>
<td>554</td>
<td>19.34ab</td>
<td>0.82bcde</td>
<td>0.18ab</td>
</tr>
<tr>
<td>555</td>
<td>18.76ab</td>
<td>1.02f</td>
<td>0.20ab</td>
</tr>
<tr>
<td>557</td>
<td>16.86a</td>
<td>0.98ef</td>
<td>0.22ab</td>
</tr>
<tr>
<td>558</td>
<td>19.14ab</td>
<td>0.96def</td>
<td>0.22ab</td>
</tr>
<tr>
<td>559</td>
<td>22.14bc</td>
<td>0.96def</td>
<td>0.20ab</td>
</tr>
<tr>
<td>560</td>
<td>19.70ab</td>
<td>0.98ef</td>
<td>0.24b</td>
</tr>
<tr>
<td>562</td>
<td>24.64c</td>
<td>0.96def</td>
<td>0.18ab</td>
</tr>
<tr>
<td>567</td>
<td>19.48ab</td>
<td>0.90cdef</td>
<td>0.16a</td>
</tr>
<tr>
<td>568</td>
<td>20.02abc</td>
<td>0.76abc</td>
<td>0.18ab</td>
</tr>
<tr>
<td>569</td>
<td>20.60abc</td>
<td>0.94def</td>
<td>0.18ab</td>
</tr>
<tr>
<td>570</td>
<td>30.48d</td>
<td>0.84bcde</td>
<td>0.18ab</td>
</tr>
<tr>
<td>572</td>
<td>18.34ab</td>
<td>0.88cdef</td>
<td>0.18ab</td>
</tr>
<tr>
<td>576</td>
<td>30.22d</td>
<td>0.74abc</td>
<td>0.18ab</td>
</tr>
<tr>
<td>578</td>
<td>17.22ab</td>
<td>0.96def</td>
<td>0.20ab</td>
</tr>
<tr>
<td>Total</td>
<td>21.13</td>
<td>0.87</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*Means for groups in homogeneous subset are displayed using Duncan, subset for alpha=0.05*

Regarding similarities to *DWh* landraces in vegetative characters; many *Td* populations were as early emerging i.e., Natifa *Td* population (557), *Td* populations; Naimeh (558), Balila (559), Um AlAmad (562), Ibbin (568) and Tafeila/Ain Tareek (578). The latest emerging population was Ibbin *Td* population (560). Early emergence could be a positive character in cultivated varieties. Earlier plants can be more competitive than later emerging plants, as they occupy space and benefit from soil resources to grow a more vigorous stand.

Early heading is a favorable character in crops. Breeders favor short periods to heading in cultivars grown in areas exposed to late drought. Long periods to heading stage endow adaptation to wild habitat (Arbuzova *et al.*, 2000). Early maturing populations can escape drought, which is normally present during spring and summer in the Mediterranean regions. Populations of *Td* Zaatari (553) and Sakhra (554) had fewer days to heading, and they were not significantly different from *DWh* populations (Table 2). Days to heading character is a quantitative trait which is controlled by two genes on chromosome 5A and 5D (Law *et al.*, 1976). As wild emmer wheat populations are similar to durum wheat cultivars in being early maturing encompass introgression (Blumler, 1998). Zaatari *Td* population (570) was the latest to reach the heading stage (Table 2). Confidence intervals (CI 95%) showed wide variations within
each population in days to heading (Figure 1), which indicate the occurrence of introgression (Harlan et al., 1973).

Early growth vigor varied widely within any Td population (Figure 2). Samta Td population (567) was the most heterogeneous population in early growth vigor (range 0.4-8.5) followed by Tafeila/East of Cement factory (347) population, with a range of 2-6.9 (Figure 2). Tafeila Tafeila/East of Cement factory (347), Afana (555), Natifa (557), Samta (567) had significantly weaker vigor than DWh land races (Table 2). Early growth vigor is considered a desirable qualitative trait in breeding for drought conditions (Humeid and Jaradat, 1989). The vigor of Zaatari (553 and 570), Sakhra (554, 569), Naimeh (558), Balila (559), Ibbin (560, 568), UmAlAmad (562), Tafeila Qadesieh (572), Tafeila/East of cement factory (576) and Ain Tareek (578) Td populations were similar to DWh indicating that these populations were introgressed.

Table 5. Character similarities between Triticum dicoccoides populations with durum wheat land races.

<table>
<thead>
<tr>
<th>Durum wheat land races</th>
<th>ICARDA collection numbers of Triticum dicoccoides populations collected from Jordan*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>347 553 544 555 557 558 559 560 562 567 568 569 570 572 576 578</td>
</tr>
</tbody>
</table>

Abbreviations in columns indicate the following: De=Days to emergence, Dh=Days to heading, V=Early growth vigor, Ph=Plant height, Tn=Number of tillers, P=Presence of pigmentation, Pl=Peduncle length, Spl=Spike length, Sps=Number of spikelets per spike, Al=Awn length, Ac=Awn's color, Ths=Thousand seed weight , Sl=Seed length.
Although plant height and fertile tiller number could be responsive to the environment, these characters are controlled by chromosome 7B (Shah et al., 1999). Similarity in number of fertile tillers between durum wheat landraces and *T*/*d* populations of Tafeila/East of cement factory (347 and 576), Zaatari (553 and 570), Sakhra (554 and 569), Afana (555), Naimeh (558), Ibbin (560 and 568), UmAlAmad (562), Samta (567), Tafeila/Qadesieh (572), Tafeila/Ain Tareek (578) indicated possible introgression occurrence (Table 2).

Comparing the growth habit of *D*/*Wh* landraces which were erect throughout the growing season, all *T*/*d* populations were prostrate until the start of heading, and then became semi-erect, except for Afana *T*/*d* population (555) which was significantly different from other *T*/*d* populations by being more prostrate during heading (Table 2). It seems that genes responsible for erect growth were not introgressed in *T*/*d* populations.

Pigmentation of the first leaf was evident in most *T*/*d* populations, while it was rarely encountered in *D*/*Wh* landraces. Populations of *T*/*d* collected from Balila (559), Qadesieh (572), Sakhra (554 and 569) and Samta (567) lacked pigmentation of the first leaf resembling cultivated durum landraces. The appearance of pigments could be a result of direct environmental influence (Chawla et al., 1999 and Arbuzova et al., 2000). Anikster et al. (1991) attributed the presence of anthocyanin pigmentation to cold effect. Leaf pigmentation was attributed to the effect of two genes in maize cultivars. The expression of one gene requires the presence of the second to direct the synthesis of pigments in the leaves of maize (Happer and Lee, 2001). Since all plants were grown under the same environmental conditions, the effect of the environment could be ignored, and similarities in lack of pigmentation could be attributed to introgression in *T*/*d* populations of Balila (559), Qadesieh (572), Sakhra (554 and 569) and Samta (567).

Similarities in inflorescence characters were found between some *T*/*d* populations and DWh landraces; in peduncle length (Zaatari (553), Sakhra (554), Afana (555), Natifa (557), Naimeh (558)); spike length (Tafeila Tafeila/East of cement factory (347) and Sakhra (554) *T*/*d* populations)); number of spikelets per spike (Qadesieh (572) and Tafila/Ain tareek (578) *T*/*d* population)); awn length (Neimeh (558); Samta (567) and Natifa (557) followed by Tafeila Tafeila/East of cement factory (347); Ibbin (560); Zaatari (562), and Sakhra (569) (Table 3));
Awn color (Zaatari (553), Sakhra (554), Afana (555), Natifa (557), Naimeh (558), Balila (559), UmAlAmad (562), Ibbin(568)).

Spike length is an important trait in wheat breeding for dry areas (Urazaliev and Kohmentova, 1999) as this quantitative character is correlated to yield and it is genetically controlled (Shah et al., 1999). Higher number of spikelets per spike is also preferred for dry areas (Urazaliev and Kohmentova, 1999). Awn length is another qualitative character, which affects grain yield and was considered as a drought tolerance trait (Humeid and Jaradat, 1989; Duwayri, 1984). Awn length varied within each population widely (Fig. 3).

![Awn length of wild emmer wheat and durum wheat accessions](image)

Fig 3: Awn length of wild emmer wheat and durum wheat accessions

Similarities in seed characters (Table 4) between DWh landraces and Td populations were detected for one-thousand seed weight ((Td populations of Assalt Zaatari (570) and Tafeila (576) resembling to DWh landrace 522, and the rest of Td populations resembling the DWh landraces 289 and 505 (Table 4)); and for seed width (the Td populations of Tafeila/East of cement factory (347 and 576), Ibbin (568), and Zaatari (570)).

Similarities in such character could be attributed to introgression. Even though they are genetically controlled, they can be influenced by various environmental factors. Grain weight is controlled by genes on chromosome 3A (Shah et al., 1999), but drought during filling brings about drastic reduction of kernel weight (Anikster et al., 1991; Blum, 1988). High air temperature during anthesis may result in failure of pollination causing seed abortion (Siddique et al., 2000). The number of seeds per spike is genetically controlled by genes on chromosome 7B (Shah et al., 1999) but seeds are subject to environment influence and bird damage.

Genetic interaction among individuals of different Td and durum wheat landraces could have taken place during the process of durum wheat domestication. Genetic interaction could be expressed either by gene flow, or some genetic mutations due to prevailing micro-site environment (Briggs et al., 1999; Johns and Keen, 1986; Jarvis and Hodgkin, 1999). As the transfer of genes from cultivated crops to the wild relatives may alter fitness in wild populations (Darmency and Vigouroux, 2000), introgressed Td populations could be of importance to breeders. Introgression could also result in serious changes in the original wild populations with consequent ecological impact. Resulting populations with introgressed genes add to the
biodiversity of genomes in wheat wild relatives, with wider adaptation and increased fitness. However, the original genome in wild wheat could be diluted. Heterogeneity within wild emmer wheat populations indicate that Jordanian gene pool of wheat is still evolving.

References
Comparison of Genetic Variability for Root Rot Tolerance in Durum Wheat Crosses Involving Wild Relatives

N. Nsarellah\textsuperscript{1} and M. Nachit\textsuperscript{2}

\textsuperscript{1} INRA, Breeding, Valorization and Conservation of Plant Genetic Resources Unit, P. O. Box: 415, Rabat, Morocco
\textsuperscript{2} International Center for Agriculture Research in the Dry Areas (ICARDA), P. O. Box 5466, Aleppo, Syria.

Keywords: Durum wheat, root rots tolerance, landrace, genetic evaluation

Abstract
Durum wheat is grown on over 1.3 million hectares in Morocco. Root rot tolerance is lacking in durum wheat varieties and chemical control is not efficient in controlling the disease. The objective of this work was to evaluate the introgression of potential tolerance to root rot from wild relatives into durum wheat. Durum wheat was crossed with several wild relative accessions possessing field tolerance to root rot. The F2, F3 and F4 generations were grown in the field with mild selection for adaptation and productivity as well as for stress tolerance. At the F6 generation, the \textit{Fusarium} and \textit{Helminthosporium} infected towel method was used to evaluate root rot tolerance using bread wheat as tolerant checks. The variability in root rot tolerance of F5 and F6 lines derived from crosses with wild relatives were compared to that of crosses made between elite durum lines. The result showed an improvement in root rot tolerance and high yield potential in the lines derived from crosses with wild relatives.

Introduction
In the past, durum wheat has benefited from less genetic improvement efforts in comparison to common wheat due to the relative economic importance. Dryland root rot is among the most important constraints that are hampering productivity of durum wheat. Bread wheat is suspected to owe its better tolerance to root rot to its D genome. Among the strategies used in improving tolerance to root rot in durum wheat are the interspecific crosses with wild relatives and searching for resistance in old landraces (Mergoum \textit{et al.}, 1994 and 1997. El Yousfi \textit{et al.}, 1998). The objective of this work was to incorporate root rot tolerance from old landraces and by using inter-specific hybridization with wild relatives. This paper presents an evaluation of the genetic evolution of tolerance at the F6 generation.

Material and Methods
Crosses involving landraces selected for root rot tolerance, elite lines and lines with related wild germplasm parentages were made at ICARDA Aleppo, Syria and grown and advanced using pedigree method (F3 to F6) at Sidi-El-Aydi experiment station of INRA-Morocco (Institut National de la Recherche Agronomique) for four seasons. Tables 1, 2 and 3 show the cross names of the three groups of genotypes used in this study. Mild indirect selection may have occurred in the advancing process F3 to F6. At F6 generation, 40 plants per entry were evaluated for root rot tolerance using the towel method. The towels were infested with \textit{Fusarium culmorum} and \textit{Helminthosporium sativum}. The root growth and root rot symptoms were evaluated on a scale of 0 to 100 (0 no symptoms and, 100 completely damaged). Three to five F6 families were evaluated per F5 relatives. Variances were computed within and between F5 families. Estimates of additive variances and heritability values were deduced (Horner \textit{et al.}, 1955).
Table 1: Names of crosses involving North African landraces

<table>
<thead>
<tr>
<th>Cross Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>242 BEZAIZ-AHF //SD-19539 (USA)/Ch1</td>
<td></td>
</tr>
<tr>
<td>245 BEZAIZ-SHF/HFN94N MOR NO 10</td>
<td></td>
</tr>
<tr>
<td>246 BEZAIZ-SHF/HFN94N MOR NO 61</td>
<td></td>
</tr>
<tr>
<td>248 BEZAIZ-SHF/HFN94N MOR NO 61</td>
<td></td>
</tr>
<tr>
<td>250 BEZAIZ-SHF/3/SD8036/Mtl-1//Awa bit-3</td>
<td></td>
</tr>
<tr>
<td>252 F4 20 J.S/BEZAIZ-SHF</td>
<td></td>
</tr>
<tr>
<td>255 F4 13 J.S/3/Arthur 71/Lahn/Bk2/Lahn</td>
<td></td>
</tr>
<tr>
<td>257 2265 CATAL ICDW01440ETH/4/Brach/KS79238-2//Ch1/3/Albit3/5/Bcr/Sbl5</td>
<td></td>
</tr>
<tr>
<td>259 2325 CATAL ICDW01546ETH//Mtl-1//JavariC8626(Por)/3/Ch1/Brach</td>
<td></td>
</tr>
<tr>
<td>261 2325 CATAL ICDW01545ETH/3/Brach/KS79238-2//Ch1/3/Albit3/5/Ch1/Brach</td>
<td></td>
</tr>
<tr>
<td>263 2326 CATAL ICDW01546ETH/3/Bcr//Badri/Sapi/4/Zeina-1</td>
<td></td>
</tr>
<tr>
<td>265 2326 CATAL ICDW01546ETH/3/Arthur71/Lahn/Bk2/Lahn/4/Heican-1</td>
<td></td>
</tr>
<tr>
<td>268 Cam Abou173 7510CAT POR/3/SD8036/Mtl 1//Albit3/4/Besnima</td>
<td></td>
</tr>
<tr>
<td>269 Cam Abou173 7510CAT POR/3/Arthur71/Lahn/Bk2/Lahn/4/Bedibrach</td>
<td></td>
</tr>
<tr>
<td>571 Casa 7580 CATAL POR/Mtl1/JavariC8626 Por/3/Heina</td>
<td></td>
</tr>
<tr>
<td>572 Casa 7580 CATAL POR/4/Ort6/Arkan/Sbl2/3/Brach/5/Chacan</td>
<td></td>
</tr>
<tr>
<td>573 Casa 7580 CATAL POR/4/Sfag/WA007494//Daki/3/Ort6/Ch1</td>
<td></td>
</tr>
<tr>
<td>574 Casa 7580 CATAL POR/3/Saada 3/Dds//Mtl1/4/Besnima</td>
<td></td>
</tr>
<tr>
<td>575 Rubia0 9053 7600 CATAL POR/3/Bcr//Badri/Sapi/4/Zeina-1</td>
<td></td>
</tr>
<tr>
<td>576 Rubia0 9053 7600 CATAL POR/5/Mrb14/4/Ruff//Jo/Cr/3/GdoVZ578/6/ Gerbrach</td>
<td></td>
</tr>
<tr>
<td>578 A.B.B 7610 CATAL POR //Ch1/Brach/3/Gerbrant</td>
<td></td>
</tr>
<tr>
<td>579 A.B.B 7610 CATAL POR/3/SD8036/Mtl1//Albit3/4/Bcr/Sbl5</td>
<td></td>
</tr>
<tr>
<td>581 S.Marta2442V76 7615 CATAL POR/Atlal//Besnima</td>
<td></td>
</tr>
<tr>
<td>582 S.Marta2442V76 7615 CATAL POR/5/Mrb14/4/Ruff//Jo/Cr/ 3/GdoVZ578/6/Heina</td>
<td></td>
</tr>
<tr>
<td>583 S.Marta2442V76 7615 CATAL POR/3/SD8036/Mtl1//Albit3/4/Heina</td>
<td></td>
</tr>
<tr>
<td>584 S.Marta/4/Ort6/Arkan/Sb 2/3Bra/5/21760/dic55132//Ch1/3/Tour</td>
<td></td>
</tr>
<tr>
<td>585 Mourisco F.7619 CATAL POR/Bk2//Gerbrach-1</td>
<td></td>
</tr>
<tr>
<td>587 Mourisco F.7619 CATAL POR/4/Sfag/WA007494//Daki/3/Ort6/Ch1/3/Tour</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Names of crosses involving elite breeding lines

<table>
<thead>
<tr>
<th>Cross Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>596 Bu/Chr//Pr//3/Pvn/4/Mrb5/5/Bedibrach</td>
<td></td>
</tr>
<tr>
<td>605 Sbu/3/Baw/Pr//Pcr/6/4/Zeina-1</td>
<td></td>
</tr>
<tr>
<td>606 Mrb5/4/Buc/Chr//Pr/3/Pvn/5/Gerbrach-1</td>
<td></td>
</tr>
<tr>
<td>607 Brach/4/Buc/Chr//Pr/3/Pvn/5/Gerbrant</td>
<td></td>
</tr>
<tr>
<td>614 HFN94N MOR NO 8/Mrf-2//Chst</td>
<td></td>
</tr>
<tr>
<td>620 HFN94N MOR NO 16/Mrb5//Chacan</td>
<td></td>
</tr>
<tr>
<td>625 HFN94N MOR NO 22/Bk2//Zeina-1</td>
<td></td>
</tr>
<tr>
<td>628 HFN94N MOR NO 26/Mrb5//M 20/Mrb5</td>
<td></td>
</tr>
<tr>
<td>629 HFN94N MOR NO 26/Brln/3/az/a/Sfag//Bcr</td>
<td></td>
</tr>
<tr>
<td>633 HFN94N MOR NO 30/Mgan//Chst</td>
<td></td>
</tr>
<tr>
<td>634 HFN94N MOR NO 31/Mrb5//Sebah</td>
<td></td>
</tr>
<tr>
<td>637 HFN94N MOR NO 35/Chst//Heina</td>
<td></td>
</tr>
<tr>
<td>639 HFN94N MOR NO 37/Brln//Zeina-1</td>
<td></td>
</tr>
<tr>
<td>640 HFN94N MOR NO 39/Brln/3/Brach/T.dic 20017//Hcn</td>
<td></td>
</tr>
<tr>
<td>649 HFN94N MOR NO 64/Chst//Zeina-1</td>
<td></td>
</tr>
<tr>
<td>651 HFN94N MOR NO 75/Bk2/5/Ruff//Troby/3/Yav/4/Fillo</td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Names of crosses involving wild *Triticum* and *Aegilops* species

| No. |Crosses |Species |Parentage | Year | Codes  
|-----|--------|---------|----------|------|--------  
| 690 | Mrb5/ICDW 22715 (CSK) | *T. monococcum* |3//Hau/Ae. kotschyi -Sy 20224/Ch1 | |  
| 691 | Blm/ICDW 22709 | *T. monococcum* |5/CD 21760/T. dicoccoides 55132/Ch1/3/Tour-1/4/Shwa/Pl | |  
| 692 | Chst/ICDW 22715 (CSK) | *T. monococcum* |Ch1/Brach  | |  
| 694 | Mrf-2/ICDW 22709 (MAR) | *T. monococcum* |Ch1/Brach  | |  
| 697 | Mrb5/T. dicoccoides 600548/3/Brach/T. dicoccoides 20017/Hcn | | | |  
| 700 | Mrf-2/T. dicoccoides SY 20123/3/Hau/Ae. kotschyi -Sy 20224/Ch1 | | | |  
| 702 | Dra2/Bcr/T. dicoccoides SY 20123/3/Ch1/Brach | | | |  
| 704 | Ch1/Brach/T. dicoccoides SY 20123/3/Chst | | | |  
| 706 | Ch1ICWT 500159 T. dicoccum/Bcr/Sbl5 | | | |  
| 707 | Sbu/T. dicoccum IC 12558/Sebou | | | |  
| 713 | Krf/Ae. ovata 401667/Ch1/Ae. vavilovii 400236 (DW Type) | | | |  
| 714 | Mrb5/Ae. kotschyi IC 400063/Mrb5 | | | |  
| 718 | Bcr/Sbl5/Ae. peregrina 401047/3/Bcr | | | |  
| 722 | Ch1/Ae. vavilovii 400236/Blk2/3/Ch1/Brach | | | |  
| 724 | Ch1/Ae. vavilovii 400236//Atal/3/Brh/T. dicoccoides 20013/Bcr | | | |  
| 726 | Dra2/Bcr/Ch1/Ae. vavilovii 400236(Ae.type)/3/Brch/T. dicoccoides 20017/Hcn | | | |  
| 727 | Bcr/Gf/Ch1/Ch1/Ch1 vavilovii 400236/4/Hau/Ae. kotschyi -Sy 20224/Ch1 | | | |  
| 728 | Ch1/Brach/Ch1/Ae. vavilovii 400236(DW type)/3/Bcr | | | |  
| 730 | Bcr/Lks 4/Hadrashes/3/Ch1 | | | |  
| 731 | Bcr/Sbl5/Hadrashes/3/Zeina-1 | | | |  
| 732 | Ch1/Brach/Hadrashes/3/BRACH/T. dicoccoides 20017/Hcn | | | |  
| 733 | Hcn/Ae.400020/Mtl-1/3/Ru/Pelis/4/Ambral/Dds/T. carthlicum 9811/3/... | | | |  
| 738 | Lgt1/Ae. vavilovii 400236/Sbu/3/Ch1 | | | |  
| 739 | Lahn/Ae. kotschyi 400703/Lahn/3/Ch1/Brach | | | |  
| 740 | T. polonicum/Skt/Blm/3/Brach/T. dicoccoides 20017/Hcn | | | |  
| 741 | Sbl1/A.IC400007/Mart/3/G17/5/Leila/T. dicoccoides/Ch1/3/ICD77-245/4/ | | | |  
| 742 | Wdza2/Ae. vavilovii col BR/Ch1/3/Sbu/4/Heican-1 | | | |  
| 743 | Wdza2/Ae. vavilovii col BR/Ch1/3/Sbu/4/Ch1/Brach | | | |  
| 851 | Gra-1/Ae.SY20150/3/Hau/Ae. kotschyi -Sy 20224/Ch1 | | | |  
| 853 | Brach/Ae. kotschyi IC400063/Ch1/Ae. vavilovii 400236 (DW type) | | | |  
| 855 | Brach/Ae. kotschyi 400797/3/Mrb9/T. compactum/Brach | | | |  
| 861 | T. polonicum/Ch1/Hau | | | |  
| 862 | T. polonicum/Ch1/Lahn | | | |  
| 865 | Ch1/Ae.400007/Lago-1/6/T. dicoccoides-20017/Reno de gra/Ch1/3/Ch1/4/HAD-19/5/... | | | |  

Results and Discussion

The means and standard errors values as well as narrow sense heritability values are shown on Tables 4, 5, and 6 for the three respective groups. Root rot mean scores were lowest for the group of germplasm with wild relatives parentage followed by the group with old landraces. The range of variation and the variation within and between families were greatest for the group involving the elite lines. Heritability estimates were also highest for the group involving elite lines followed by the wild relative crosses. The data also showed that crosses involving wild relatives had a good level of tolerance to root rot and also a good level of both total variation and useful genetic variation. The elite lines used in these crosses had a long history of selection and adaptation to root rot and dry conditions. The lines derived from crosses involving landraces were in their first cycle of selection after the cross involving a root rot tolerant landrace. The lines derived from crosses involving wild germplasm were in their second or third round of selection and hybridization after the initial cross involving a wild parent tolerant to root rot.
Table 4: Statistical attributes and heritability values for root rot scores in the F5 derived F6 lines from crosses involving landraces.

<table>
<thead>
<tr>
<th>Mean root rot score</th>
<th>Within Family Std. Error</th>
<th>Among family Std. Error</th>
<th>Heritability estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean 30.64</td>
<td>14.17</td>
<td>8.81</td>
<td>0.06</td>
</tr>
<tr>
<td>Max 50.36</td>
<td>26.84</td>
<td>20.77</td>
<td>0.26</td>
</tr>
<tr>
<td>Min 13.87</td>
<td>2.6</td>
<td>1.18</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 5: Statistical attributes and heritability values for root rot scores in the F5 derived F6 lines from crosses involving elite lines.

<table>
<thead>
<tr>
<th>Mean root rot score</th>
<th>Within Family Std. Error</th>
<th>Among family Std. Error</th>
<th>Heritability estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean 38.06</td>
<td>20.54</td>
<td>18.74</td>
<td>0.18</td>
</tr>
<tr>
<td>Max 76.24</td>
<td>48.19</td>
<td>45.85</td>
<td>0.48</td>
</tr>
<tr>
<td>Min 15</td>
<td>7.91</td>
<td>7.26</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Table 6: Statistical attributes and heritability values for root rot scores in the F5 derived F6 lines from crosses involving wild relative species.

<table>
<thead>
<tr>
<th>Mean root rot score</th>
<th>Within Family Std. Error</th>
<th>Among family Std. Error</th>
<th>Heritability estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean 26.51</td>
<td>11.45</td>
<td>10.02</td>
<td>0.11</td>
</tr>
<tr>
<td>Max 53.87</td>
<td>30.51</td>
<td>24.37</td>
<td>0.35</td>
</tr>
<tr>
<td>Min 14.39</td>
<td>2.39</td>
<td>0.6</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Conclusion**

The considerations made about the history of the breeding of the material used in this study and the results herein obtained point out the potential of both landraces and the wild relatives in improving root rot tolerance in durum wheat.

**References**


Exploitation of Lentil Genetic Resources

A. Sarker and W. Erskine

International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria. Email: a.sarker@cgiar.org

Keywords: Lentil, genetic resources, utilization of genetic variability

Abstract

Lentil (Lens culinaris Medikus subsp. culinaris) is an important grain legume crop for food and feed in dry-land farming systems in many countries of Asia and Africa. Despite its importance, concerted efforts on genetic enhancement at national and international levels started only about two decades ago with the collection of diverse genetic resources from various parts of the world. The value of germplasm collection, characterization, documentation and conservation lies in its potential use to develop improved varieties. The International Center for Agricultural Research in the Dry Areas (ICARDA) is located in the Center of Origin of lentil, and has a worldwide mandate for its improvement. The Genetic Resources Unit (GRU) of ICARDA has assembled 9935 cultivated and 585 wild accessions of lentil. Of these, 7624 accessions have been characterized for important economic traits, and information is available as an international public good. Considerable variability has been observed for agro-morphological, phenological, and biotic and abiotic stress factors among cultivated and wild collections, which is the key platform for genetic improvement. Accessions with desirable traits, such as seed yield, disease resistance, plant type, maturity period and seed traits are being used for genetic enhancement of the crop to develop new genetic stocks targeted to various stresses and for specific agro-ecological regions. A major breakthrough was made to widen the genetic base of lentil in South Asia by the introgression of genes from ICARDA germplasm for early flowering and maturity, large-seed size, plant growth habit, resistance to diseases and abiotic factors into South Asian germplasm. In addition, new plant type with good standing ability has been constructed for machine harvest in West Asia. New breeding lines are developed with resistance to multiple diseases and winter-hardiness. Gene mining for key traits revealed that drought and cold tolerance, resistance to vascular wilt and Ascochyta blight diseases are also possessed by wild Lens species. Overall, to date, 29 national programs have released 91 lentil varieties, emanated from ICARDA-supplied genetic materials.

Introduction

Lentil (Lens culinaris Medikus subsp. culinaris) is an annual diploid (2n = 14) species originated in the Near East arc and Asia Minor (Zohary, 1972; Williams et al., 1974; Ladizinsky, 1979 and 1993; Zohary and Hopf, 1973). It is one of the early-domesticated crops of the Fertile Crescent of the Near East and plays an important role in human, animal and soil health improvement. Through its spread, domestication and use, lentil became an important pulse crop of West and South Asia, East and North Africa, and to a lesser extent, in southern Europe. Recently, it became a potential pulse crop for South and North America, and in Oceania. The domestication of lentil occurred during the Neolithic Agricultural Revolution, which is thought to have taken place in the eastern Mediterranean around the 8th and 7th millennia BC (Zohary and Hopf, 1973). From there, lentils spread rapidly with that of Neolithic agriculture to the Nile Valley, Europe and Central Asia. It was part of the Harappan crop assemblage in Indian subcontinent between 2250 and 1750 BC (Zohary and Hopf, 1993). After 1500 AD, the Spanish...
introduced lentil to South America via Chile (Solh and Erskine, 1984). Through domestication and cultivation in diverse habitats, human selection for specific needs and role of natural forces, enormous variability has been created at molecular level, which is reflected at morphological, phonological and agronomic traits. For the last few decades, lentil genetic resources comprising both wild and cultivated types have been collected, characterized and documented at national levels and at the International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. Genes associated with desirable traits were identified and have been utilized by breeders to improve and stabilize yields of lentil, and for specific trait improvement.

**Lentil phylogeny**
The taxonomy of *Lens* has undergone numerous changes in recent years. Several authors have used biochemical and molecular methods to supplement traditional taxonomic methods of identification and also to study taxonomic relationships within the genus *Lens*. Analyzing previous findings based on origin and spread, morphological, cytological, cytogenetic observation and more recently on the basis of isozyme and molecular studies, *Lens* taxonomy has been re-assessed (Ferguson *et al.*, 2000). The genus now consists of seven taxa split into four species.

* Lens culinaris* Medikus subsp. *culinaris*
  * subsp. *orientalis* (Boiss.) Ponert
  * subsp. *tomentosus* (Ladiz.) M. E. Ferguson *et al.*
  * subsp. *odemensis* (Ladiz.) M. E. Ferguson *et al.*

* Lens ervoides* (Brign.) Grande
* Lens nigricans* (M. Bieb.) Godr.
* Lens lamottei* Czefr.

The progenitor of the cultivated lentil is *Lens culinaris* Medikus subsp. *orientalis*, which is distributed from Greece to Uzbekistan. The oldest archaeological remains of lentil are from Franchthi cave in Greece dated at 11,000 BC.

**Status of genetic resources**
The Genetic Resources Unit (GRU) of ICARDA has organized numerous collection missions since 1977 and assembled highest number of accessions in its collection. To date, a total of 11,708 lentil accessions are conserved in long-term storage at ICARDA, and of them, 7624 cultivated and 375 wild have been characterized.

- **Cultivated:**
  * Genetic resources*: 9997 accessions were collected from 72 countries. Major originating countries are: Afghanistan, India, Turkey, Syria, Ethiopia, Nepal, Pakistan, Jordan and Chile.
  * Breeding lines*: 1128 developed at ICARDA and shared with national programs through international nurseries. These are consisting of elite lines with high yield potential and components of stress nurseries. Genes from multiple parents are used to develop these lines.

- **Wild relatives:**
  Six wild species including the progenitor, *Lens culinaris* ssp. *orientalis* were collected from 24 countries, originated in different ecologies.
  * Lens culinaris* subsp. *orientalis*: 271 (24 countries)
  * Lens culinaris* subsp. *odemensis*: 66 (4 countries)
  * Lens culinaris* subsp. *tomentosus*: 11 (2 countries)
  * Lens ervoides*: 164 (15 countries)
  * Lens lamottei*: 10 (3 countries)
  * Lens nigricans*: 63 (8 countries)
Gene mining among cultivated and wild relatives is underway for improvement of the crop and for basic genetics studies.

**Variability in important traits**
Characterization of germplasm revealed that enormous variability exists within cultivated and wild relatives. Studies on genetic variability have been conducted since early 1980s among germplasm of diverse origin. Morphological traits were critically evaluated in variable climatic conditions for use in breeding and selection programs (Sindhu and Mishra, 1982; Erskine and Witcombe, 1984; Shahi et al., 1986; Lakhani et al., 1986; Baidya et al., 1988; Sarwar et al., 1982; Erskine et al., 1985; Erskine and Chaudhury, 1986 Erskine et al., 1989; Ramgiry et al., 1989, Sarker et al., 2006), responses in flowering to temperature and photoperiod (Erskine et al., 1990; Erskine et al., 1994), and tolerance to abiotic stresses (Erskine et al., 1981, Sarker et al., 2004, Erskine et al., 1993, Yau and Erskine, 2000, Srivastava et al., 2000, Hamdi et al., 1996, and Malhotra et al., 2004. Genetic variability and sources of resistance to fungal diseases (Khare et al., 1981; Agarwal et al., 1993; Bayaa et al., 1994, 1995 and 1998; Nasir and Bretag 1998; Sarker et al., 2004) and viruses (Makkouk et al., 2001) were reported. Considerable variability for many of these traits exists within the crop gene pool allowing manipulation through plant breeding. On the contrary, several other important traits, such as nitrogen fixation, resistance to pea leaf weevil (*Sitona* spp.), aphids and the broomrape (*Orobanche* spp.) are not currently addressable by breeding because of lack of sufficient genetic variation.

A comprehensive evaluation of wild lentil genetic resources for resistance to key stresses included winter hardiness, drought tolerance, and resistance to lentil vascular wilt and Ascochyta blight. Sufficient variability was observed for these traits. Additionally, variation in agronomic characters was also explored. For grain yield, straw yield and seed mass, there was no striking variation within the wild species for transfer to the cultivated lentil. Clearly, direct selection of wild lentil germplasm for biomass yield under dry conditions is of little value.

**Utilization of genetic variability**

*a. Improving biotic stress resistance*  
Among biotic stresses, commendable progress has been made on genetic enhancement for disease resistance caused by fungal pathogens. Resistance to Fusarium wilt caused by *Fusarium oxysporum* f.sp. *lentis* has been identified among landraces and resistance sources have been utilized from multiple parents to develop resistant cultivars (Sarker et al., 2004a). Lentil rust caused by *Uromyces fabae* is also a devastating disease limiting crop productivity substantially. Using parents of Argentinian and West Asian origins, rust resistant genotypes have been developed and released as commercial cultivars in Bangladesh, Ethiopia, Pakistan and Morocco (Bakr 1993; Tufail et al., 1995, Bejiga et al., 1998). Genes for Stemphylium blight resistance present in ILL 4605 and ILL 6002 are transferred to landraces from Bangladesh and India. Additionally, Ascochyta blight resistance genes from ILL 5588 became the key sources of all resistant cultivars globally including in Australia and Canada. Several breeding lines developed at ICARDA possess Botrytis Grey Mold (BGM) resistance as reported in Australia (CIPAL, 2006). Resistance sources to multiple viruses have been identified and are being used in breeding program at ICARDA (Makkouk et al., 2001).

*b. Enhancing abiotic stress tolerance*  
Drought and winter hardiness are important among abiotic stresses. Development of drought tolerant cultivars became a key research issue in ICARDA’s crop improvement strategy (Sarker...
et al., 2001). Traits like early seedling establishment, early growth vigor and ground coverage, high biomass, early flowering and maturity were taken into consideration to select drought tolerant genotypes. Selection in drought-prone sites is the key to success in identification of drought tolerant genotypes. Seedling shoot and root traits such as taproot length and lateral root number are important traits for drought tolerance (Sarker et al., 2005). Parents with these traits were used in hybridization and the resulting drought tolerant lines are under test with NARS (Malhotra et al., 2004). Similarly, parents of USA and Turkish origin possess genes for winter-hardiness and have been used to develop phenologically adapted winter-hardy lines that thrive well under −20°C in cold-prone areas of Turkey and Iran (Sarker et al., 2004b). Although resistance sources to soil salinity, iron deficiency, boron toxicity and deficiency, water-logging have been identified, but are yet to be utilized in cross-breeding programs.

c. Altered in plant growth habit

Lentil cultivation is threatened in West Asia and North Africa (WANA) region due to high cost of hand harvest and unavailability of agricultural laborers. Most of the landraces/local cultivars from the region are semi-spreading type and lodging prone with weak stem, and are unsuitable for mechanical harvest. ICARDA has developed and promoted with national programs in the region a lentil production package that includes harvest mechanization and the use of improved cultivars with erect plant type having good standing ability. Such cultivars include Idlib-2, Idlib-3 and Idlib-4 in Syria, Hala and Rachayya in Lebanon, IPA-98 in Iraq, Saliana and Kef in Tunisia, and Firat-87 and Sayran-96 in Turkey which have been developed through aggregation of genes conferring erect growth from multiple parents. On average, mechanical harvesting combined with improved cultivars having good standing ability reduces cost of cultivation by USD 100 per hectare (Sarker and Erskine, 1998).

d. Broadening genetic base in South Asian lentils

In general, lentils from South Asia are short statured with narrow genetic base particularly to morphological, phenological, agronomic, and biotic and abiotic stress resistance traits. Lack of marked variability in desirable traits restricted breeders to achieve any breakthrough in yield improvement for long. However, since late 1980s the South Asian national programs used exotic germplasm supplied by ICARDA in their breeding programs. Early, bold-seeded, disease resistant accessions from Latin America and West Asia were the prime source of useful variability, which were efficiently used in widening the genetic base of lentils in the region (Erskine et al., 1998) This led to the development of improved cultivars and a yield jump in Bangladesh (Barimasur-2 and Barimasur-4) (Sarker et al., 1999a; Sarker et al., 1999b), Nepal (Shekker and Sital) and Pakistan (Manshera-98, Shiraz-96, Masoor-93 and Masoor-2002). Bold seeded and early maturing lines are now available in India and are being used by various programs. Early and extra-early materials are very important to fit in various cropping system niches, most particularly in rice fallow system. There is a scope to replace fallow after monsoon rice in about 400,000 ha in north and northeastern India. Bold and extra-bold (up to 3.5 gms compared to 1.8 gms/100-seeds of the locals) lentils are liked by farmers and consumers of Indian sub-continent.

e. Varietal development

Breeders assembled the genes for yield contributing traits through single, double or multiple crosses using agronomically desirable parents. Various stress resistance genes also contributed to stabilize yield of new cultivars. For example, varieties with combined resistance to rust and Stemphylium blight diseases have been released in Bangladesh, rust and wilt resistant cultivars now available with Ethiopian farmers, Morocco released rust resistant varieties and Syria, Iraq, Lebanon and Turkey released fusarium wilt resistant varieties. Drought tolerant and winter-hardy lentil varieties are released in Syria and Turkey respectively. In this endeavor, 94 lentil varieties have been released by 29 national programs, which emanated from ICARDA-supplied genetic
Some varieties have desirable seed traits, which are liked by farmers and consumers.

Table 1: Lentil varieties emanated from ICARDA-supplied materials released by NARS

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>No. of varieties</th>
<th>Key traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>Bangladesh, India, Nepal, Pakistan, China, Afghanistan, Iran, Iraq, Syria, Lebanon, Jordan, Yemen, Turkey</td>
<td>39</td>
<td>High seed and straw yield; wilt, rust and Ascochyta blight resistance; good standing ability, high biomass, early maturity, winter-hardiness</td>
</tr>
<tr>
<td>Africa</td>
<td>Ethiopia, Egypt, Morocco, Libya, Tunisia, Algeria, Lesotho, Sudan</td>
<td>33</td>
<td>High yield; wilt and rust resistance, early maturity, tolerance to excess moisture</td>
</tr>
<tr>
<td>The Americas</td>
<td>Argentina, Canada, Ecuador, USA</td>
<td>7</td>
<td>High yield; rust and A. blight resistance, good standing ability</td>
</tr>
<tr>
<td>Oceania</td>
<td>Australia, New Zealand</td>
<td>12</td>
<td>High yield, A. blight resistance, good standing ability</td>
</tr>
<tr>
<td>Europe and the Caucasus</td>
<td>Portugal</td>
<td>3</td>
<td>High yield, large seed, suitable to mechanical harvest</td>
</tr>
</tbody>
</table>

f. Development of micronutrient-dense lentil lines/varieties

More recently emphasis has been put forward to develop lentil cultivars with high Fe, Zn and B- Carotene to address micronutrient malnutrition, most particularly in Southeast Asia and Africa. Preliminary studies show that enormous variability exists for Fe (41-81 mg/kg) and Zn (22-60 mg/kg) contents. Higher contents of these nutrients are mostly present in the breeding lines, where 3-4 parents were involved in their parentage (HarvestPlus, 2005). High Iron content varieties Idlib-2 (ILL 5883) (Fe -73 mg/kg) and Idlib-3 (ILL 6994) (Fe-72 mg/kg) are released in Syria and Beleza (ILL 7711) (Fe-74 mg/kg) is released in Portugal. High Zinc content variety Beleza (56 mg/kg) is released in Portugal; Ada’a (52 mg/kg) released in Ethiopia and Meyveci-2001 (53 mg/kg) released in Turkey

Conclusion

ICARDA holds the largest lentil collection in the world. Although currently the Center is involved in collection in Central Asia and the Caucasus countries, it needs to expand its collection missions in other unexplored areas, and where collection missions were conducted long time ago. Newly assembled germplasm and breeding lines need to be critically characterized to enhance gene mining and genetic enhancement for important traits. International Crop Information System (ICIS) for lentil is under construction as international public good. Information on useful traits is the key for genetic enhancement programs both at national and international levels. Although commendable progress has been made in releasing improved varieties/re-construction of new genetic stocks with key specific traits, still there is a need for new gene/allele mining and their utilization in breeding programs. Introgression of yield genes from wild relatives crossable with the cultivated species appears promising and we look forward to the future impact of 'wild' genes to sustainable production of this ancient crop on farmers' fields. Use of wild species for key traits like disease resistance, cold tolerance, and drought tolerance needs to be intensified.
References


CIPAL. 2006. Coordinated Improvement Program for Australian Lentils, DPI, Horsham, Victoria, Australia.

Erskine, W., Myveci, K. and Izgin, N. 1981. Screening a world lentil collection for cold tolerance. LENS Newsletter, 8 : 5-8.


Genetic Diversity of Durum Wheat Landraces and their Potential for Use in Breeding

M. Taghouti\textsuperscript{1}, A. Amri\textsuperscript{2}, M. Boujnah\textsuperscript{1}, M. Nachit\textsuperscript{2}, F. Gaboune\textsuperscript{1}, F. Maataoui\textsuperscript{1}, and S. Saidi\textsuperscript{1}

\textsuperscript{1} National Institute of Agronomic Research (INRA), Rabat, Morocco
\textsuperscript{2} International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria

Keywords: Durum wheat, landraces, breeding, genetic diversity.

Abstract
In Morocco, landraces of durum wheat are still cultivated especially by farmers in the mountains and arid regions. These landraces are still highly appreciated by farmers for their adaptation to some abiotic stress and for their good grain and straw qualities. Landraces represent a promising gene pool for durum wheat breeding efforts. To preserve this germplasm, this study aimed to measure and describe the diversity in the Moroccan durum wheat landraces, to identify good quality genes to be used in breeding programs and to determine options for adding the value to promote their on-farm conservation.

Landraces collected from the regions of Errachidia and Taounate were characterized for agromorphological traits. The results indicated a large genetic diversity within and between those landraces for the majority of the traits. Agronomic evaluation of nearly 800 durum wheat lines originated from the previous landraces showed a great variability, especially for the characters which had high heritability. Quality evaluation of 150 durum wheat lines showed a large variability in gluten strength, yellow pigment and proteins content. Furthermore, electrophoretical analysis of seed storage proteins in 8 durum wheat lines showed that 94\% of the local durum wheat lines possessed the gamma gliadin-45 band. The majority of these lines presented the component gamma gliadin-45/omega gliadin-33-35-38/LMW2 which represents a genetic indicator for good quality. Results on the evaluation of landraces performances showed a yield advantage of the landraces over modern varieties in farmers’ fields in their areas of cultivation. A yield advantage was also noted for the new multilines extracted from the original landraces. Some techniques like seed cleaning and treatment against seed born diseases showed possibilities for increasing the productivity of these landraces. These results, proved the possibility of using this germplasm as parental material in breeding programs especially for improving grain quality criteria and the possibility of improving landraces productivities through multiline approach and low-cost agricultural packages.

Introduction
Landraces are populations of crop plants that are genetically heterogeneous. These genotypes have been developed over many generations through a long process of domestication and natural and farmers’ selections (Harlan, 1992). Landrace diversity (shape, color, yield or quality of end-product) is generated by farmers and farming communities under traditional practices, crude selections and human manipulations. Farmers have mixed, selected and cultivated special types to suit their own local requirements and tastes. Gradually, landraces became adapted to the local environment and cultural conditions under which they are grown. This type of germplasm is still cultivated and maintained by farmers in marginal agroecosystems and under low input environments, especially in developing countries.

Morocco is one of the major centers of genetic diversity for many important crops such as, wheat and barley. The country’s crop diversity resulted from long-term adaptation to drought, cold, and
saline growing conditions. This crop diversity is largely represented by landraces that still remain in mountainous areas and in the Oasis at the edge of Sahara desert. Durum wheat landraces are highly favored by farmers of these regions for their adaptation to some biotic and abiotic stresses and especially for their good grain and straw qualities. Therefore, durum wheat landraces represent a promising gene pool for crop improvement. However, the broad range of genetic diversity existing in Morocco is increasingly subject to serious genetic erosion and irreversible losses. This threat resulting from the interaction of several factors including the displacement of indigenous landraces by new and genetically uniform crop cultivars, changes and development in agriculture, and the frequent droughts.

The loss of genetic resources led to the creation of conservation programs to preserve crop genetic resources for future use. The in situ conservation is now being more widely considered as complementary to ex situ strategies for conserving genetic diversity (FAO, 1984; CBD, 1992; Ford-Lloyd, and Maxted, 1997). The in situ conservation or on-farm maintenance of local cultivars is a way to conserve a larger genetic variability of landraces as well as to take the advantages of the process of natural selection (Maxted et al., 2002). The in situ conservation represents a process, where farmers are crucial partners that secure the continuing availability of genetic variation. Some researchers advised to select lines within local populations as a way to conserve the adaptation attributes (Agorastos and C. Goulas. 2005; Ceccarelli, et al., 1987). Morocco is one of the nine countries where the global project on in situ conservation project was implemented and durum wheat is among the species studied (Jarvis, et al., 2000). The goal of in situ conservation project was to encourage farmers to continue to select and manage local durum wheat populations. One method for reaching this goal is the determination of technologies that can increase the landraces productivity and ensure them a better added value. Any increase of the performance of the local crop varieties and value addition to their products will result in an increase in farmers’ income.

In order to preserve this valuable germplasm from extinction and to use it as parental material in the genetic improvement programs, this study aims at:

1. Evaluate the potential of Moroccan durum wheat landraces originated from Taounate site situated in the Pre-Rif mountains and from Rich site located in the semi-desert area;
2. Determine the influence of anti-fungi seed treatment and early stage weeding on durum wheat landraces yield in farmers’ fields in the two sites;
3. Evaluate the “composite” landraces yield potential; and
4. Assess the amount of landrace line diversity to identify possible sources for breeding programs particularly for improving grain quality.

Materials and Methods

The Rich site located in the semi-desert area and Taounate site situated in the pre-Rif Mountains were chosen to conduct the trials. These regions present favorable characteristics for in situ conservation especially because of the predominance of traditional farming systems and the large use and appreciation of durum wheat landraces. At the two sites, landraces seed stocks are auto-produced and maintained on the farm. In Taounate site, landraces are grown exclusively under rainfed conditions but in the Rich site, supplementary irrigation is usually applied by farmers to improve their yields.

1. Evaluation of performance of durum wheat landraces:
The evaluation of local durum wheat populations was conducted on farm at the two sites (Taounate and Rich) using the usual farmers’ practices and at Merchouch, INRA’s experiment research station under recommended agricultural package.
Four durum wheat landraces from each site were used in these trials carried out during 2000-2001 cropping season. A randomized complete block design with three replications was adopted. The plot size was 9 m² (6 rows x 2.5 m long x 0.3 m apart) in the experimental station and 7 m² in farmers’ fields. Two durum wheat improved cultivars (Karim and Oumrabiaa) were included as checks.

For each type of material, heading time, maturity time, plant height, grain yield, and straw yield were recorded.

2. Determination of the influence of fungicide seed treatment and early stage weeding on grain yield of durum wheat landraces:

Five to 10 kg of seeds of landraces were collected from five farmers at each of the two sites. The seeds were divided into a sample treated with a fungicide and a sample not treated. The fungicide treatment was combined with chemical weeding of the crop against mono and dicotyledons weeds. The weeding was made at the beginning of tillering stage.

On farm trials were subsequently installed, during 1999-2000 cropping season, in the fields of the farmers who provided the seeds of landraces. A randomized complete design with two replications was adopted. At each trial grain yield was recorded for:

- Treated seeds on weeded plot;
- Treated seeds on non weeded plot;
- Untreated seeds on weeded plot;
- Untreated seeds on non weeded plot.

3. Evaluation of grain yield of “new composite” landraces:

Three types of genotypes were used in this investigation:

- Composite landrace constructed with promising durum wheat lines extracted from one landrace from Rich and another from Taounate;
- Original landrace; and
- Improved variety Oumrabiaa.

This material was conducted in trials at farmers’ fields and at the Merchouch experimental station during 2002-2003 cropping season using a randomized complete block design with two replications. The plot size was 9 m². Grain yield was recorded for each type of populations.

4. Assessment of genetic diversity:

4-1 Agronomic evaluation

Over 750 durum wheat accessions belonging to landraces originated from the Rif Mountains and Pre-Saharan oasis sites were evaluated during 2002-03 cropping season at Merchouch, INRA’s research station. Given the limited amount of seed available, an augmented design (Federer, 1956) was adopted. Each entry was planted in a plot consisting of two rows, 2.5 m long and 0.30 m apart. One local population and the improved durum wheat varieties “Karim” and “Oumrabiaa” were used as checks and replicated within the experiment. The following characters were recorded:

- Number of days to heading;
- Number of days to maturity;
- Plant height measured from the ground to the tip of the spike on the main tiller;
- Spike length measured from the collar to the tip of the apical spikelet;
- Awn length;
- Number of kernels per spike.

The last three traits were measured on three randomly selected spikes per plot.
4-2 Quality evaluation
   a- Quality traits assessment
   The quality parameters were tested on 200 durum wheat lines; 150 lines from landraces, and 50 advanced lines. The traits analyzed were:
   - Sulfate Dodecyl Sedimentation test (SDS ml);
   - Protein content percentage (PC %);
   - Yellow pigment content (YP ppm);
   - Vitreousness (VT %);
   - Ash content (AC %).

   b- Protein electrophoretic analysis
   Gliadins and glutenins are the major seed storage protein fractions of durum endosperm, and their relationship with quality is known. The presence of certain seed storage components has a bearing on gluten strength of durum wheat.
   Electrophoretic separation of seed storage proteins was evaluated in the Durum Wheat Quality Laboratory at ICARDA on 80 durum wheat lines originated from landraces to check the presence of specific electrophoretic bands of gliadins and glutenins. The ICARDA durum wheat varieties “Korifla” and “Waha” and the Canadian bread wheat cultivar “Marquis” were used to provide standard reference electrophoregrams.
   Gliadins proteins were extracted from single seeds with 1.5 M dimethylformamide (DMF) and fractioned at pH 3.1 in aluminum lactate buffer by polyacrylamide gel electrophoresis (A-PAGE) as described by Ciaffi et al., 1991; 1993).
   For glutenin extraction, the SDS-PAGE technique was adopted. The SDS-PAGE was run on gradient gel (T= 8-14%, C=1.27).

   Statistical analysis
   The SAS statistical software program was used to analyze the data.

Results and Discussion
   1- Evaluation of durum wheat landraces potential:
   The analysis of results showed differences between the durum wheat landraces for both grain and straw yields according to the growing conditions (Tables 2 and 3).

Table 2: Grain and straw yields (qx/ha) at Taounate site of durum wheat landraces and improved varieties during 2000-2001 season.

<table>
<thead>
<tr>
<th>Taounate site</th>
<th>Type of material</th>
<th>Grain yield</th>
<th>Straw yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Landraces (n=12)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>2.84</td>
<td>5.48</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>1.88</td>
<td>3.60</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>4.01</td>
<td>9.99</td>
<td></td>
</tr>
<tr>
<td><strong>Improved varieties (n=4)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>2.57</td>
<td>3.33</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>1.86</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>3.52</td>
<td>4.22</td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Grain and straw yield (qx/ha) at Rich site of durum wheat landraces and improved varieties, 2000-2001.

<table>
<thead>
<tr>
<th>Type of material</th>
<th>Grain yield</th>
<th>Straw yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Landraces</strong> (n=12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>8.98</td>
<td>17.18</td>
</tr>
<tr>
<td>Min</td>
<td>7.61</td>
<td>11.64</td>
</tr>
<tr>
<td>Max</td>
<td>10.60</td>
<td>20.89</td>
</tr>
<tr>
<td><strong>Improved varieties</strong> (n=4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Means</td>
<td>13.83</td>
<td>12.96</td>
</tr>
<tr>
<td>Min</td>
<td>12.84</td>
<td>12.09</td>
</tr>
<tr>
<td>Max</td>
<td>14.92</td>
<td>14.92</td>
</tr>
</tbody>
</table>

Under improved conditions, at Merchouch experimental station, the improved cultivars were more productive than the landraces collected from the two sites (data not reported). The reduction of the landraces potential can be explained by their long cycle which exposed them to final drought and to long stature which caused lodging. Under farmers’ conditions in Taounate, the data show a yield advantage of landraces over modern varieties. This superiority could be explained by the adaptation of landraces to low input conditions and to harsh environmental conditions. Similar results were found for barley under dry environments (Ceccarelli and Grando, 1996), which could explain the limited adoption of modern varieties under traditional farming systems. In Rich site, the yield potential of the two types of material was high, but the yield potential of modern cultivars was higher than that of landraces. This can be explained by the irrigation and inputs (fertilizers) applied by the farmers for the trial.

2- Determination of the influence of fungi seeds treatment and early weeding on yield of durum wheat landraces:

Fungi seed treatment before sowing combined with chemical weeding of the crop at early stage had significant influence on grain yield of the landraces (Table 4). The results showed an improvement of grain yield of about 1.0 t/ha at Taounate site and allowed an increase of 33% by the application of fungicide application at Rich site (Table 5). The treatment of the seed with fungicide seems to reduce seed borne diseases like smuts and bunts which cause important losses in durum wheat landraces yield. Similar results were reported on barley’s landraces which showed an increase of grain yield due to the fungicide treatment of the seeds (Rhrib et al., 2001). Yield improvement through fungicide seed treatment and weeding at early stage are example of low-cost technologies which could enhance yields of landraces while maintaining their genetic diversity.

Table 4: Effect of seed treatment and chemical weeding on grain yield in Rich and Taounate sites

<table>
<thead>
<tr>
<th>Effect</th>
<th>Taounate</th>
<th>Rich</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F^1 value</td>
<td>Probability</td>
</tr>
<tr>
<td>Seed treatment combined to weeding</td>
<td>5.28</td>
<td>0.0052**</td>
</tr>
<tr>
<td>Seed treatment weeding</td>
<td>4.50</td>
<td>0.0429*</td>
</tr>
<tr>
<td>weeding</td>
<td>10.74</td>
<td>0.0038**</td>
</tr>
</tbody>
</table>

*signification level of ANOVA test: * significant at 0.05, ** significant at 0.01, *** significant at 0.001
Table 5: Grain yield (t/ha) of local populations in Rich and Taounate sites

<table>
<thead>
<tr>
<th>Cultural conditions</th>
<th>Taounate</th>
<th>Rich</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated seeds on weeded plot</td>
<td>2.84</td>
<td>0.54</td>
</tr>
<tr>
<td>Treated seeds on non weeded plot</td>
<td>2.09</td>
<td>0.61</td>
</tr>
<tr>
<td>Untreated seeds on weeded plot</td>
<td>2.39</td>
<td>0.43</td>
</tr>
<tr>
<td>Untreated seeds on non weeded plot</td>
<td>1.84</td>
<td>0.43</td>
</tr>
</tbody>
</table>

3- Evaluation of “composite” landraces yield potential
Durum wheat landraces are genetically heterogeneous and represent a mixture of several pure lines. Developing “composite” landraces constructed with promising lines extracted from landraces represents a form of population improvement which can help in promoting in situ conservation of indigenous durum wheat. Figures 1 and 2 report the productivity of the different genotypes studied at the experimental station of Merchouch and at Rich site. The results showed that the composite landraces made up of promising lines selected from Taounate and Rich landraces were quite higher in term of productivity than the original landraces from which they were extracted. Therefore, the genetic manipulation of landraces through extraction of new multilines could lead to yield enhancement without affecting much the genetic diversity of the original landraces.

4- Assessment of genetic diversity:
4-1 Agronomic evaluation
Table 6 reports the overall mean values of all traits recorded, the minimum, the maximum landraces values and the mean of the cultivars used in the experiment as checks. Wide range of variation was found in the durum wheat landraces. Generally, landraces lines seemed taller and less early both in heading and maturity than the varieties “Karim” and “OumRabiaa”. They are, however, characterized by long spike and long awns and had high values for number of kernels per spike.

The differences between landraces lines were wide suggesting that further selection for relevant characters could be possible and, therefore, directly useable in breeding programs, especially for those traits which have a rather high heritability such as kernel number per spike and spike and awn length.

Table 6: Means, standard errors, ranges of variation of agro-morphological traits for lines of durum wheat landraces and improved checks

<table>
<thead>
<tr>
<th>Traits</th>
<th>Durum wheat landraces lines</th>
<th>Checks</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Days to heading</td>
<td>108.62</td>
<td>0.35</td>
<td>86</td>
<td>135</td>
</tr>
<tr>
<td>Days to maturity</td>
<td>165.27</td>
<td>0.26</td>
<td>137</td>
<td>196</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>111.72</td>
<td>0.55</td>
<td>75</td>
<td>145</td>
</tr>
<tr>
<td>Awn length (cm)</td>
<td>21.6</td>
<td>0.14</td>
<td>15</td>
<td>28</td>
</tr>
<tr>
<td>Spike length (cm)</td>
<td>7.88</td>
<td>0.041</td>
<td>5.61</td>
<td>16.33</td>
</tr>
<tr>
<td>N grain/spike</td>
<td>61.05</td>
<td>0.27</td>
<td>33</td>
<td>93.67</td>
</tr>
</tbody>
</table>

4-2 Quality evaluation
The means and ranges of quality traits evaluated for the accessions of each type of durum wheat lines are shown in Table 7. Wide ranges were recorded in durum wheat landraces. Durum wheat landraces lines exceeded advanced lines in some quality parameters. The highest protein content mean as well as the highest SDS and the highest yellow pigment content were found in the landraces. This germplasm is characterized by a combination of favorable grain quality traits like
protein content, SDS and yellow pigment making them valuable parental material in breeding programs to improve grain quality, considering that the quality of the current cultivated durum wheat improved cultivars needs further improvement.

Table 7: Means, standard errors, ranges of variation of quality traits in durum wheat landraces lines and advanced lines

<table>
<thead>
<tr>
<th>Durum wheat landraces lines</th>
<th>Traits</th>
<th>Mean ± SE</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SDS</td>
<td>71.65 ± 1.12</td>
<td>40</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Vitreousness</td>
<td>94.02 ± 0.50</td>
<td>48</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Yellow pigments</td>
<td>8.62 ± 0.12</td>
<td>4.18</td>
<td>12.55</td>
</tr>
<tr>
<td></td>
<td>Ash content</td>
<td>1.92 ± 0.012</td>
<td>1.69</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>Proteins content</td>
<td>12.31 ± 0.11</td>
<td>10.41</td>
<td>15.88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Durum wheat advanced lines</th>
<th>Traits</th>
<th>Mean ± SE</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SDS</td>
<td>38.10 ± 1.79</td>
<td>17</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Vitreousness</td>
<td>93.75 ± 0.0065</td>
<td>71</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Yellow pigments</td>
<td>6.85 ± 0.26</td>
<td>2.53</td>
<td>9.32</td>
</tr>
<tr>
<td></td>
<td>Ash content</td>
<td>1.77 ± 0.02</td>
<td>1.55</td>
<td>1.99</td>
</tr>
<tr>
<td></td>
<td>Proteins content</td>
<td>12.80 ± 0.14</td>
<td>11.07</td>
<td>14.96</td>
</tr>
</tbody>
</table>

4-3 Electrophoretic evaluation
Electrophoretic separation of gliadin and glutenin components is reported in Fig. 3. Two major groups were distinguished, the band Rm45-type which comprises the gamma gliadin component designated 45 and the Rm42-type comprising the gamma gliadin component 42. The results show also that 94% of landrace lines possess the gamma gliadin 45. Glutenin analysis indicated that the majority of the landrace lines possess low-molecular weight glutenin subunits indicated as LMW-2. These results confirm the good grain quality of durum wheat landraces.

Conclusion
Yield potential evaluation of durum wheat landraces from Rich and Taounate sites showed that local populations, well-adapted to their environment, were more productive than improved varieties in their own area. But in favorable conditions, the improved varieties exceeded landraces in terms of productivity.

Fungicide seed treatment against seed-transmitted diseases and chemical weeding of the crop are technologies that can increase the landraces productivity and ensure their on-farm conservation by farmers. These results encouraged many farmers in Taounate and Rich sites to use these techniques. The Moroccan component of the global IPGRI in situ/on-farm conservation project has provided to farmers in the two sites with several small equipment for seed treatment

Composite landraces made up of promising lines selected from Taounate and Rich landraces were quite higher in term of productivity than the original landraces from which they were extracted. This genetic manipulation could be another technique for improving the productivity of durum wheat landraces. Furthermore, the assessment of genetic diversity of landraces lines for agro-morphological and quality traits indicated that some of those durum wheat lines are valuable parents in durum wheat breeding programs.

References


SESSION FOUR

TECHNOLOGICAL AND MANAGEMENT OPTIONS
OF AGROBIODIVERSITY WITHIN NATURAL AND SEMI-
NATURAL HABITATS INCLUDING RANGELANDS, FORESTS AND
PROTECTED AREAS
Management of Natural Habitats for *In Situ* Conservation of Wild Relatives of Crop Plants

N. Maxted

*School of Biosciences, University Of Birmingham, Edgbaston, Birmingham, B15 2TT, UK.*

**Keywords:** Conservation, *ex situ*, *in situ*, natural habitats, wild relatives.

**Abstract**

The Convention on Biological Diversity (CBD) refocused conservation action on the *in situ* conservation of biodiversity including agro-biodiversity. *In situ* conservation of agro-biodiversity may be divided between the conservation of crop landraces in traditional agri-silvicultural systems and the wild relatives of crops conserved in natural habitats. If the Conference of the Parties (COP) to the CBD are to achieve their stated 2010 Biodiversity Target: “by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level as a contribution to poverty alleviation and to the benefit of all life on earth.” Crop wild relatives are critical because they are an important socio-economic resource, that is currently being eroded or even extinguished through careless human activities, and they also meet the CBD goal of combining conservation with poverty alleviation. A definition of a crop wild relative is provided and illustrated in the light of Gene Pool and Taxon Group concepts. The management of natural habitats for crop wild relative conservation is set in the context of genetic resource conservation. Methodologies for the location, designation, management and monitoring of priority target taxon population are reviewed. The fundamental role of the management plan is established and a draft format is proposed. The link between *in situ* and *ex situ* conservation is highlighted and the ultimately goal of target taxon use is underlined.

**Introduction**

The Convention on Biological Diversity (Convention on Biological Diversity, 1992) and the subsequent International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2001) have proved a watershed in plant genetic resources (PGR) conservation in many ways, particularly by re-focusing conservation activities onto *in situ* conservation. *In situ* conservation, using the definition provided in the text of the CBD (Convention on Biological Diversity, 1992), incorporates two distinct approaches: conservation of wild species in natural habitats and on-farm conservation of domesticated varieties or breeds. Within the context of socio-economic plant diversity conservation, the change of emphasis away from further collecting of cultivated material for *ex situ* conservation in genebanks towards the *in situ* conservation of locally adapted landraces and the wild relatives of crops within existing protected areas or natural habitats, has necessitated the research and development of new conservation methods (Hawkes, 1991; Maxted *et al.*, 1997a).

The focus of crop wild relatives (CWRs) maintenance is conservation in natural habitats, primarily due to the large numbers of species included and the difficulty of collecting and conserving *ex situ* this vast array of species and their entire genetic diversity. It seems obvious to note that CWRs are those wild plant species related to a crop, but what actually constitutes a CWR and how closely related to a crop does a taxon have to be to be considered a CWR? In the
light of contemporary biotechnological advances in GM technology, most if not all species are potential gene donors to a crop. However, within the utilitarian sense of conservation for food and agriculture it remains important to be able to accurately define the relationship between a crop and its close wild relatives, so that conservationists competing for limited conservation resources may objectively prioritise taxa for study (Kell and Maxted, 2003; Meilleur and Hodgkin, 2004). This is a particularly pressing need given the current threats to genetic diversity from genetic erosion and extinction, as recognized by the Conference of the Parties (COP) to the CBD 2010 Biodiversity Target (www.biodiv.org/2010-target), as well as a number of other strategies and treaties, such as the Global Strategy for Plant Conservation, the International Treaty on Plant Genetic Resources for Food and Agriculture and the European Plant Conservation Strategy.

To meet many of the 2010 biodiversity targets and the requirements of other relevant strategies and legislation, we need to be able to assess biodiversity change. Therefore, a clear baseline against which to assess change is essential; there is first a need to agree on what constitutes a crop wild relative. Although lists of crop wild relatives exist, notably those proposed for Europe by Zeven and Zhukovsky (1975) and Heywood and Zohary (1995), and for individual countries by Schlosser et al. (1991) for the former German Democratic Republic and by Mitteau and Soupizet (2000) for France, they provide no precise definition of what constitutes a crop wild relative. The taxa included have been selected subjectively on the basis of expert knowledge. Therefore, first CWRs will be defined, and then their conservation in natural habitats will be discussed, followed by an introduction to how CWRs are used.

2. Crop wild relatives: A vital plant genetic resource

One approach to defining a CWR would be to apply the Law of Homologous Series and Crop Gene Pool Concepts. From his observations of crops and their wild relative diversity Vavilov (Vavilov, 1920 and 1922) noted that similar patterns of variation were found between crops and their wild relatives in unrelated crop complexes. Comparative genomics have more recently revealed that both gene content and gene order are conserved widely across related species and genera, and this has been most thoroughly demonstrated in the grasses (Devos and Gale, 1997). However, Vavilov’s Law of Homologous Series, which preceded modern molecular genetics, was proposed to systematize such examples of parallelism (Vavilov, 1920 and 1922) and he illustrated his concept using patterns of variation among vetches, lentils and peas in the Fertile Crescent. The continuing importance of Vavilov’s law is that it has predictive value, in that it can be used to try to identify desirable traits such as disease resistance or drought tolerance in the species related to crops. Thus Vavilov was one of the first to recognise the importance of conserving the breadth of a crop’s genetic diversity, both within the crop itself, but also importantly within the wild species related to the crop, among which there could be natural or artificial introgression. These views were formalized by Harlan and de Wet (1971) as the Gene Pool concept. Within each crop there was a potential pool of genetic diversity available for utilisation and a gradation of that diversity dependent on the relative crossing ability between the crop itself and the primarily non-domesticated species in the primary, secondary or tertiary Gene Pool of the crop.

Therefore if it is accepted that the Gene Pool concept together with the Taxon Group concept proposed above provide the best pragmatic means available to determine whether a species is a CWR, a working definition of a crop wild relative is possible:
A crop wild relative is a wild plant taxon that has an indirect use derived from its relatively close genetic relationship to a crop; this relationship is defined in terms of the CWR belonging to gene pools 1 or 2, or taxon groups 1 to 4 of the crop.

While the CWR definition may most commonly be applied to species used in food and agriculture, the concept is equally applicable to ornamentals, medicinal plants, and forestry species.

3. A model for managing natural habitats

The conservation of CWR in natural habitats will involve the establishment of a genetic reserve or area that is managed to maintain the genetic diversity of the target CWRs. The genetic conservationist's objective is to ensure that the maximum possible range of genetic diversity is represented within the minimum number and size of in situ genetic reserves. This is, however, a complex goal to achieve because detailed information on the amount of genetic variation, population structure, breeding system, habitat requirements and the geographical distribution of the target taxon is required and these data are commonly unavailable for even the most well studied CWRs. To successfully manage the reserve it is also important to understand the autecology of the target taxon's 'niche' and the target taxon synecological relationship with other member of the community. Maxted et al. (1997a) defines genetic reserve conservation as the location, management and monitoring of genetic diversity in natural wild populations within defined areas designated for active, long-term conservation. However, the conservation of CWR in natural habitats is known under many synonyms: genetic reserve management units, gene management zones, gene or genetic sanctuaries, crop reservations, all of which are essentially equivalent to genetic reserves.

Considering these problems and in conjunction with the genetic conservationist's central objective defined above, the primary goal of a general methodology for genetic reserve conservation would be to monitor and maintain diverse populations of the target taxon within a specifically designated wild habitat. Maxted et al. (1997b) outlined some basic requirements for establishing a genetic reserve for crop plant relatives (Fig. 1). It should be noted that this specific model for genetic reserve conservation fits within the general model of plant genetic conservation. The model for genetic reserve conservation is divided into three phases: reserve planning, reserve management and reserve utilisation.
Fig. 1. A model for genetic reserve conservation. (Taken from Maxted et al., 1997b).
4.1 Reserve planning and establishment

*Site assessments*

Although ecogeographic techniques, especially when used in conjunction with geographical information systems, will identify broad areas of potential genetic diversity where genetic reserves could be sited, they will not provide the precise location for reserves. The ecogeographic survey may suggest one relatively large reserve area or several smaller reserve areas. To establish which is most appropriate, the potential sites will require a survey of taxonomic diversity (numbers of taxa and variation within taxa) and may increasingly involve assessment of genetic diversity using molecular techniques. This allows assessment of the variation present at a particular site, as well as comparison between alternative sites. The overall criterion is to maximise the conserved genetic diversity of the various taxa and actual population sizes, as it will not always prove possible to determine the minimum effective population size and hence the minimum viable population size necessary for conservation.

To facilitate security of conservation into the future it is advisable that more than one reserve is established for any target taxon and that the reserves should be purposely selected to complement each other. This will permit the conservation of diverse ecotypes within the conservation of the gene pool. Where possible, sites should be selected to encompass the widest possible range of ecogeographic conditions in which the target taxon is located.

When considering potential sites for establishing genetic reserves it would be advisable to bear in mind other conservation interests. In the wider conservation movement the types of protected areas are fairly well understood as defined by the IUCN Commission on National Parks and Protected Areas and also by international networks and conventions. As far as possible genetic reserves should be designed within this general framework. If the ecogeographic data suggest locating the reserve in a particular area, it may be that this area or a closely adjacent one contains an existing protected area, such as a nature reserve or national park. In this case the management plan could be adapted to permit genetic conservation in a portion of the wider reserve, therefore saving some of the costs of genetic reserve establishment and maintenance. However, it is worth noting that many CWR species are commonly found in disturbed, pre-climax habitats, particularly annuals. Therefore it may on occasion be expedient to site genetic reserves in sites not normally associated with long-term conservation such as roadside verges or field margins. There is an obvious link here between the conservation of CWR and the conservation of landraces as the later thrive under traditional farming conditions that may equally favor weedy CWR species. The ecogeographic survey should conclude with a clear statement of the habitat requirements of the target taxa, which will need to be reviewed in the light of the potential sites being considered. If the habitats of the potential sites match those required by the target taxa then these are those that would be selected.

The relative cost of reserve establishment will also affect selection of alternative sites. If faced with a choice of equally suitable sites and differing establishment costs, there would be little justification for selecting a site other than the least expensive. The same logic would also apply to the running costs of the reserve once established. This may necessitate the application of some form of cost-benefit analysis prior to actual reserve selection. Finally, the reserve site must also be sustainable as a reserve for the foreseeable future. The reserve must be accessible to the reserve manager and potential germplasm utiliser, while being secure from deleterious changes caused by human or natural intervention (e.g. increased or decreased levels of fires, wild grazing animals or roads).

*Assessment of local socio-economic and political factors*
Constraints ranging from economic to scientific and organizational ones will affect the implementation of the model for *in situ* conservation. The simplest way forward in economic and political terms is for countries to take action on establishing a series of national parks or heritage sites, since in this case there is likely to be some benefit to the people of the countries concerned, and in many instances the benefits may be more apparent when there is a strong forestry sector. Such areas are often managed in a minimal way, using normal forestry practices. In many cases these areas can also include genetic reserves even when the prime designation of the area is for broad ecosystem conservation.

There are clearly major costs involved in delineating and appropriating broad reserve areas, and many reserve area networks are established on a voluntary basis, while other networks do have a legal obligation. Even though moral and legal obligations may have been recognised, government policies will often need adjustment because many such policies provide incentives to mismanage the environment, especially in the agriculture and forestry sectors. At present, with widespread debate on trade protection, external debt and other international problems, developing countries will need to produce national development strategies incorporating economic and environmental objectives, while all countries are being required to promote sustainable development.

Soundly-based *in situ* conservation of crop gene pools with intensive management may well show only slow progress, but two actions will be clearly helpful: firstly in terms of economics, the availability of outside funding for the initial planning, whether from national donors or the Global Environmental Facility, and secondly, in terms of organisation, the widespread knowledge of standard blueprints and summaries of organisational needs to national governments, such information could form part of the national biodiversity action plan.

If genetic material is going to be used it will need to be available to some extent from *in situ* reserve areas. The Convention on Biological Diversity states that access needs to be determined by sovereign governments but contracting parties should facilitate this access for environmentally sound uses, subject to prior informed consent and on mutually agreed terms. Any scientific research on *in situ* genetic resources should therefore include participation of the user and, where possible, be conducted in the country concerned. Furthermore, the users of the resources should share in the results of research and development and the benefits arising from possible commercial utilization. Finally, when *in situ* conservation work becomes ongoing, there will be a need for adequate curation of the resources in the *in situ* reserves. Internationally trained specialists will need to be identified to conserve and manage the genetic materials *in situ*. Appropriately qualified and experienced staff remains in short supply or unavailable in certain countries. Otherwise the availability, utilisation and flow of benefits resulting from conservation may be constrained.

**Reserve design**

The previous stages of the model have highlighted how the reserve site is selected, but now having identified the potential site, we must design the reserve appropriate for the target taxon at that location. This involves consideration of various factors, such as structure, size, whether a single large or multiple smaller sites are best for the target taxon, the use of corridors, reserve shape, environmental heterogeneity and potential user communities, see Hawkes, *et al.* (1997). Each of these factors is associated with a copious and controversial literature, but it is possible to draw some overall conclusions.

The current consensus view of reserve structure is that based on the UNESCO Man and the Biosphere programme (Batisse, 1986), see Figure 2. This establishes a central core area with a stable habitat, surrounded by a buffer zone and outside this, where possible, a transition zone.
shielding the reserve core from general areas of human exploitation. This plan assumes that the core area is sufficiently large to accumulate 1000 -5000 potentially breeding individuals of the target taxon. Rather than focus on the actual size of the reserve, it is more appropriate to target the numbers of individuals that form a viable population and thus the effective population size, which will ensure the effective conservation of genetic diversity in the target species for an indefinite period.

![Figure 2. Model for Reserve Design (Cox, 1993).](image)

The reserve design debate is often centered on the relative advantage of single large versus several small reserves, the so-called SLOSS debate (Single Large Or Several Small), see Soulé and Simberloff (1986). For example, is it better to have one large reserve of 15,000 ha or a network of five each of 3,000 ha? Large reserves enable a more ecogeographically diverse environment to be included within a single location with minimal edge effect. Alternatively, if a network of smaller reserves is established, each reserve could be sited in a distinct environment, which would better enable conservation of different ecotypes. So the conservation value of multiple small reserves may be greater than the sum of its individual components. However, if reserves are too small or too isolated the populations of the target taxon they contain may become unviable. The current consensus is that the optimal number and size of reserves will depend on the characteristics of the target species. Large reserves are better able to maintain
species and population diversity because of their greater species and population numbers and internal range of habitats but small, multiple reserves may be more appropriate for annual, inbreeding plant species, which are naturally found in dense but restricted stands.

In practice, the vast majority of the wild relatives of crop plants are rather widely distributed. In such cases a single reserve (or a single cluster of sites) would not suffice. A number of reserves, located in different segments of the distribution area of the target species would be required to cover its ecogeographic divergence and to deal adequately with the genetic changes which occur over its geographic range. If multiple small reserves are selected, which are close to each other, their potential conservation value can be enhanced by using habitat corridors to link individual reserves, thus facilitating gene flow and migration between the component reserves. In this way individual populations can be effectively managed at a meta-population level.

The edge to area ratio of a reserve should be kept to a minimum to avoid deleterious micro-environmental effects including changes in light, temperature, wind, the incidence of fire, introduction of alien species, grazing, as well as deleterious anthropogenic effects. Therefore a round reserve will have the minimum edge to area ratio. Fragmentation of the reserve by roads, fences, pipelines, dams, agriculture, intensive forestry and other human activities will necessarily diminish and limit the effective reserve size, multiply the edge effects and may leave populations in each fragment unsustainable.

The concept of environmental heterogeneity should be built into the design. When selecting sites for establishing a genetic reserve, sites with spatial or temporal (e.g. taxa contained in the reserve with different flowering times) heterogeneity should be given priority over homogeneous areas. The wider the range of habitat diversity included in the potential reserve site the better for conservation of CWRs. This will ensure that the target species will preserve the various genes and genetic combinations associated with any ecotypic differentiation.

As will be discussed in more detail below, the ultimate rationale behind conservation is potential human utilisation; therefore the user communities must be considered when designing the reserve, whether in terms of permitting sustainable exploitation within the buffer or transition zone by traditional farmers or building appropriate facilities for eco-tourists or scientific visitors. Each user community will have a different view of the reserve and a different set of priorities. The requirements of each group of users should be surveyed before the reserve is established and their needs considered when establishing the management regime.

**Taxon and reserve sustainability**

Sustainability is a fundamental concept for genetic reserve conservation. *In situ* conservation is not an inexpensive option compared to *ex situ* conservation. Nevertheless, the reserve once designated and established will require active and consistent population monitoring, habitat management and site security for a substantial period of time. This will necessitate the commitment of substantial levels of resources for a similar time period. *In situ* conservation is unlike *ex situ* conservation, where, if the original collection from one gene bank is lost the curator may either obtain a sample of the duplicate collection placed in another gene bank or possibly return to the original collection site and re-collect from the original or a similar population, both of which options may be associated with relatively minor costs. If the material is lost from an *in situ* reserve, however, unless there is a backup reserve somewhere else, the large quantity of resources expended on establishing the reserve would have been wasted and the cost of rehabilitating populations using materials stored *ex situ* would have to be considered. The latter option is commonly expensive and may require extensive research to ensure the reintroduced materials do not likewise go extinct. Therefore it is important that both the target taxon and the reserve are sustainable.
Taxon sustainability means that the taxon is suitable for conservation over an extended period in an *in situ* genetic reserve. A highly mobile species or a weed associated with human disturbance, such as many crop relatives, may not be suitable for genetic reserve conservation. These may be better conserved as part of an on-farm conservation regime. The reason for this is that although large populations may be initially found in the reserve site, over time the population may migrate, due to changes in the associated plant and animal populations or environmental conditions. Concomitant with this the management plan can probably only be reviewed in the short or medium term. Sites and therefore population stability can never be fully guaranteed indefinitely because of possible unforeseen or unavoidable long-term influences, even if that is the goal. IUCN has defined a viable population as one which (a) maintains its genetic diversity, (b) maintains its potential for evolutionary adaptation and (c) is at minimal risk of extinction from demographic fluctuations, environmental variations and potential catastrophe, including over-use (IUCN, 1993).

There is little value in establishing a genetic reserve unless it is unlikely to be effected by any form of human development project (Ingram and Williams, 1984). Reserves near settlements may be encroached on for building, amenities, etc. and even remote sites may be used in time for dumping human waste, or for example, the sitting of national military or nuclear installations. It may be difficult to assess the short term requirements for land use, but checks for development plans for potential sites should be routinely undertaken. It is, however, impossible to assess the long term human requirements in one or two hundred year's time. Legislation ensuring that once conservation sites are designated they are maintained and not developed for other uses may assist with the security of the site. Experience has shown, however, that legislation can be circumvented if the political will is sufficiently strong. Evidence of this is provided, for example, by the destruction of Sites of Special Scientific Interest (SSSI) in Britain by road building programmes. On the whole, legislation to protect individual habitats and ecosystems is not common. This does raise the question: are any reserves sustainable over a long period? An answer might be to strengthen the legislation protecting reserve sites, but this will only be an answer if there is the equally long term public and political will to support the legislation. In the short term one approach is to designate multiple reserve sites. If multiple reserves are established for each target taxon, then the destruction of any one reserve will obviously have less overall impact. Moreover, if a species is extremely rare and restricted, *ex situ* techniques, must assume greater importance. In fact *ex situ* approaches are absolutely essential if the population size of the species has become so low that survival *in situ* cannot be guaranteed or when ecosystems in which the species occurs are so degraded that survival of the target species is doubtful. Even if this were not the case it would always be advisable to provide *ex situ* backup for as many target taxa as possible.

*Formulation of the management plan*

The site will have been selected because it contains abundant and hopefully genetically diverse populations of the target taxon. Therefore the goal will be to maintain anthropogenic, biotic and abiotic dynamics of the site. Therefore, the first step in formulating the management plan is to observe the biotic and abiotic dynamics of the site. It should be surveyed so that the species present in the ecosystem are known, the ecological interactions within the reserve should be understood, a clear conservation goal should be decided and a means of implementation agreed.

The actual content or style of a management plan will vary depending on the location, target species, organisation, staff, etc. that are involved. There is no standard format, but items generally included are: conservation objectives, site biotic and abiotic description, site history, public interest, factors influencing management, management prescription (what work needs to be carried out and precisely how and when to do it), ecological and genetic survey and
monitoring schedule, budget and manpower. As the specific focus of establishing the genetic reserve will be to conserve a specific target taxon, the management plan will require details associated with the target taxon (e.g. taxonomy, phenology, habitat preference, breeding system, minimum population size, etc.) and description of the target populations at the site (e.g. mapping of populations and density within the site, autecology within the reserve, synecology with associated fauna and flora). Possible elements of a genetic reserve management plan has been summarised by Maxted et al. (1997b) as follows:

1. **Preamble:** conservation objectives, reasons for sitting of reserve, place of reserve in overall conservation strategy for target taxon, site ownership and management responsibility.

2. **Taxon description:** taxonomy (classification, delimitation, description, iconography, identification aids), wider distribution, habitat preferences, phenology, breeding system, genotypic and phenotypic variation, biotic interactions (e.g. pollinators, dispersal agents, herbivores, pests, pathogens, symbionts), local name(s) and uses, other uses, present conservation activities (*ex situ* and *in situ*), threat of genetic erosion.

3. **Site evaluation:** evaluation of populations of the target taxon, reserve sustainability, factors influencing management (legal, constraints of tenure and access), externalities (e.g. climate change, political considerations), obligations to local people (e.g. allowing sustainable harvesting) and anthropomorphic influences.

4. **Site description:** location (latitude, longitude, altitude), map coverage, photographs (including aerial), physical description (geology, geomorphology, climate, hydrology, soils), human population (both within reserve and around it), land use and land tenure (and history of both), vegetation and flora, fauna, cultural significance, public interest (including educational and recreational potential), bibliography and register of scientific research.

5. **Status of target taxon in the reserve:** distribution, abundance, demography, and genetic structure and diversity of the target taxon within the site, autecology within the reserve, interaction with associated fauna and flora, specific threats to population(s).

6. **Site objectives and policy:** site objectives, control of human intervention, allowable sustainable harvesting by local people and general genetic resource exploitation.

7. **Prescription:** details (timing, frequency, duration etc) of management interventions that will need to be carried out, schedule of ecological and genetic monitoring, population mapping, staffing requirements and budget, project register.

Changes in population levels and density are a natural component of community dynamics. The management plan must allow for natural fluctuations due to stochastic (severe weather, floods, fire and epidemics), as well as cyclical and successive changes as long as they do not threaten the long-term viability of the target taxon. Stochastic and cyclical changes in the short term may be quite dramatic, but will rarely lead to species extinctions (Hellawell, 1991), although they are likely to lead to genetic drift (Gillman, 1997). The management plan should contain actual limits for the target taxon populations, which take into account potential natural changes in population size, but beyond which management action is triggered. Having emphasized the natural changes seen in plant populations, humans undoubtedly have the most dramatic effect on communities, through incipient urbanisation and pollution, or changes in agricultural and forestry practice, for example. Therefore the management plan must be flexible enough to accommodate superficial anthropogenic factors, but recognise those factors that could seriously threaten the levels of the target population.
Given (1994) stresses that it is important to realize that preserving communities is not necessarily the same as preserving genes. It is quite possible to preserve a community type and still lose genetic diversity, if not species. Therefore, it is vital that the reserve is designed and managed in an appropriate manner to maintain genetic diversity of the target taxon or taxa and if this objective is threatened that corrective action is automatically taken.

4.2 Reserve management and monitoring

The management of any genetic reserve will involve an element of experimentation, and it is unlikely that the ideal management regime will be known when initially establishing the reserve. For example, how can one accurately estimate the appropriate level of grazing in the reserve prior to initiating the management plan? Knowledge of the area and the current and historic grazing level will be important, but the actual level of grazing recommended once the reserve is established can only be known through scrupulous experimentation. Thus the initiation of the management plan will require careful introduction combined with evaluation, revision and refinement in the light of its practical application. Therefore, the initial level of management will be high, with intensive and extensive monitoring procedures and the plan will need to be flexibly applied.

Changes in the structure or size of populations of the target species within the reserve will obviously affect the conservation integrity of the reserve. Thus, the populations of the target species in the reserve will require regular monitoring to identify any actual or incipient change and if detected, appropriate management review and amendment will be required. The monitoring process is likely to involve: defining objectives, identifying key associated taxa and sample quadrat locations, selection of data for quadrat recording, determination of desirable frequency and timing of quadrat recording, accumulation of data sets, statistical analysis and production of recommendations on the management plan. The management plan should include a minimum and maximum number for the population size and the population monitoring process should act as a feedback mechanism indicating when these levels are reached. This would allow management changes to be made, thus ensuring the secure conservation of the target taxa.

It is impossible to record and monitor every species or individual plant within the reserve, so the conservationist is forced to take samples of data that if effectively selected will reflect the overall picture in the reserve as a whole. Key indicator taxa and sites within the reserve are selected for monitoring on a regular basis. This form of monitoring usually involves the establishment of both fixed and random quadrats or transects within the reserve. The key indicator taxa are likely to include the target taxon, but may also include the other plant and animal species, such as those without which the population of target taxa would decline, such as primary herbivores or necessary pollinators, etc.

There are numerous methods of assessing species abundance or diversity. The most commonly used is presence or absence linked to some estimate of density of a species (vegetative, flowering or fruiting) in a particular quadrat. Absolute measures of the quantity of a given taxon may be assessed in the form of number of individuals, demographic structure, reproductive fecundity (particularly for a long-lived perennial), proportion of ground cover, distribution pattern and biomass or yield (this has the advantage that it is accurate, but the drawback that it is destructive). There is no recommended size for the quadrats. However, the quadrates should be small enough to be searched easily and permit a larger number of quadrates to be taken overall, but large enough to lessen any quadrat edge effect and enable the quadrat to include large specimens or patches. Having begun monitoring, the quadrate size should obviously be kept constant to permit easy comparison of data from subsequent surveys. The actual number of to be
recorded will be a compromise between the resources required to record the quadrates and the information gained from recording extra quadrates. Monitoring is most likely to occur annually, once in a season's growth, though for a long-lived perennial species the monitoring may be less frequent. It is important to monitor at similar stages in the target species life cycle on each occasion to be able to record comparable results.

Increasingly, molecular methods of measuring genetic diversity will have an important role within conservation programmes whether *ex situ* or *in situ*. Within *in situ* programmes the monitoring of any change in the pattern of diversity within a reserve can be effectively undertaken using molecular markers, and cannot be approached at all if such markers are not employed. The technologies involved in the use of these markers and the acquisition of data derived from such markers can be criticised for being time-consuming and expensive, but this is rapidly becoming much less so. Consequently, if not now, then soon, we can expect that not only will data be collected *vis a vis* species lists, and density and range of individual species, but target populations within any reserve will also be assessed in terms of their true genetic diversity. Whether genetic markers will prove practical for repeated monitoring of populations within reserves is currently unknown. Their immediate value lies in establishing accurately the levels of genetic diversity between and within the potential populations and aiding the selection of populations to be conserved in a genetic reserve. Following the establishment of the reserve, loss of diversity could be directly deduced if the extent is known to which population numbers vary in sequential monitoring operations.

Having collected the data for a particular survey the conservationist will want to compare the population characteristics of the survey with previous surveys to draw conclusions about any significant changes that may have occurred in the target populations. Routine statistical analysis of the data sets will indicate whether there has been significant change in population density from the previous surveys and over the longer term whether a trend is becoming apparent. However, care must be taken to distinguish between the natural ranges for population characteristics and those induced by management or other intervention.

Invasive plants can pose a serious threat to target populations (Cronk and Fuller, 1995; Maxted, *et al.*, 1997c). Careless introduction of alien keystone species can quickly out-compete native species and totally alter the nature of the habitat and therefore its species composition. Frankel *et al.* (1995) list four ways in which alien introductions can radically alter the community structure, by: altering natural geomorphic processes, changing nutrient cycling and balances, changing fire regimes and altering seedling recruitment. It is difficult to predict in advance the result of any of these forms of alien introduction to a reserve; some may assimilate well, while others can totally disrupt the community. Therefore, the general rule is to try to exclude new alien species from the reserve. In contrast the beneficial effect of established keystone plant species may be essential to the target taxon. Keystone species are usually the dominant species within a habitat which tend to define the general habitat in which the other species exist and without which the target taxon may not be able to survive (Mills *et al.*, 1993). So the encouragement of the established keystone species may be essential to the health of the target taxon.

The introduction or invasion of exotic animals to a reserve can have a deleterious effect by directly altering the grazing regime or indirectly altering the carnivore/herbivore balance within the reserve. However, as discussed above, animals may also have a beneficial effect by not only grazing and maintaining a population at a pre-climax vegetation state, but by acting as pollinators, seed dispersal agents, fertilizers, etc. The spread of pathogens or pests to the reserve can directly harm the target taxon or indirectly the species that have a relationship with the target taxon and without which the target taxon may decline. For example, the decimation of elm forest...
by Dutch elm disease has undoubtedly led to a decline in the species with an obligate relationship with the various *Ulmus* species.

5. Use of protected natural habitats

The establishment and management of the reserve is not an end in itself. Throughout this text an explicit link has been made between genetic conservation and utilisation: genetic conservation must facilitate utilisation, either now or in the future. This point is highlighted in the Convention on Biological Diversity and in this context any utilisation should be "sustainable" and "meet the needs and aspirations of present and future generations".

The utilisation of the material conserved in the reserve may be divided among traditional, general and professional users. Reserves are very rarely established in an anthropogenic vacuum. There are likely to be local farmers, land-owners and other members of the local population who may wish to utilise the proposed reserve site and who are likely to remain as neighbouring communities. Their traditional use may be disrupted by the establishment of the reserve. These local people may have historically harvested or collected from, hunted over or may simply have enjoyed visiting the site on which the reserve has been established. It is unlikely that any *in situ* conservation project could succeed in the absence of local support and it will definitely fail if the local population opposes the establishment of the reserve. Therefore where traditional utilisation is compatible with conservation objectives, sustainable exploitation of the buffer or transition zones by local, traditional user communities should be encouraged. However, to avoid negation of the conservation objectives their access and any harvesting, hunting, etc. may need to be regulated. There may be a need to compromise between traditional utilisation and conservation objectives to ensure success of the reserve (Shands, 1991). The involvement of local people should not be considered as a distraction or disadvantage; they may be able to assist through volunteer schemes in the routine management and monitoring of the reserve. The personal experience of the author has indicated that local people are very proud to find that their environs contain "important" plant species and are very willing to assist in their conservation. This applies to rural communities both in developing and developed countries. It facilitates the development of good will between the professional conservationist and local communities neighbouring the reserve. However, in some cases there may be a need to provide other incentives to engender good will. The second user group is the population at large, and whether local, national or international, their support may be essential to the long-term political and financial viability of the reserve. As discussed earlier, the ethical and aesthetic justification for species conservation is of increasing importance to professional conservationists, and commonly the general public will ultimately finance the establishment and continuation of the reserve through taxation. Some members of the general public may wish to visit the reserve and this should be clearly encouraged as an educational exercise. If local people who traditionally utilised the reserve site are opposed to the reserve, they may be converted to supporters, if they can see direct financial benefits to their community resulting from eco-tourists, school and other groups of visitors to the reserve. The reserve design should take into account the needs of visitors, by way of visitor centers, nature trails, lectures, etc. They are also likely to bring additional income to the reserve itself through guided tours and the sale of various media reserve information packs.

Professional utilisation of germplasm conserved in the genetic reserve need to be on a similar basis to professional utilisation of *ex situ* conserved germplasm. One of the main disadvantages of *in situ* as opposed to *ex situ* conservation is that it is more difficult for the plant breeder to gain access to the germplasm (Hawkes, 1991). To avoid or lessen this problem those managing the
reserve should ensure that they characterise, evaluate and publicise the germplasm held in the reserve. The onus is surely on reserve managers, just as it is on gene bank managers, to promote utilisation of the material in their care. Just as gene banks and botanical gardens publish catalogues of their collections, so the reserve manager should regularly publish a catalogue and description of the germplasm held in the reserve to inform potential users of what CWR species are available. The level of documentation of passport, characterisation and evaluation data recorded should be just as extensive for in situ as for ex situ conserved germplasm (see Ford-Lloyd and Maxted, 1997). The quantity and level of documentation has a direct relationship with the potential of the germplasm for exploitation. Nevertheless, it is unlikely that the plant breeder will ever have such easy access to material conserved in a genetic reserve as in a gene bank, especially if the gene bank is located in a plant breeding institute, which is often the case. Seasonality, for instance, limits access to germplasm in a genetic reserve, since the seed can only be collected during the fruiting season of the plant, whereas germplasm is available throughout the year from the ex situ collection. In many cases, the work of professional users, the general public and local people can be linked through partnership within Non Governmental Organisations, especially those involved in sustainable rural development, conservation volunteers or use of resources in accordance with traditional cultural practices. All partners will therefore share the goals of sustainable use of biological resources taking into account social, economic, environmental and scientific factors which form a cornerstone to the nations' proposals to implement Agenda 21.

To provide a back-up to the conservation of the germplasm in the genetic reserve the germplasm should also be sampled and deposited in appropriate ex situ collections. Although both ex situ and in situ techniques have their advantages and disadvantages (Maxted et al., 1997a), the point is re-emphasised here that they should not be seen as being alternatives or in opposition to one another. The two strategies are complementary and just as a good gene bank manager will duplicate his or her collection in other gene banks the reserve manager should also duplicate his or her collection in ex situ collections. By definition it is not possible to duplicate material from one reserve to another without the material being taken ex situ. But it is worth repeating here that it would be foolish to entirely focus in situ conservation effort on a single reserve. Multiple reserves should be established, where possible, to duplicate effectively the conservation of the material in situ. In this context, if the germplasm user does not have a specific requirement for material from a reserve, the gene bank may be seen to act as a staging post for those wishing to utilise the germplasm originally conserved in situ. A clear protocol establishing where the material is to be duplicated should be included in the management plan of the reserve.

A well founded reserve should act as a research platform, as genetic reserves make ideal locations for field experimentation. There is a real need for a better understanding of intra-reserve species dynamics to aid the sustainable management of the specific taxa included within the reserve, but also as a general tool for experimentation of ecological and genetic studies of in situ conserved species. Research activities based on the material conserved should be encouraged as they provide another use for the material conserved and another justification for establishing the reserve. However, it may be that these activities should take place in the inner buffer zone not the core reserve itself, so that they cannot threaten the populations of the target taxa.

Discussion
There has been a growing interest among genetic conservationists toward in situ conservation techniques, both because of the urgent need to protect ecosystems threatened with imminent change and also for other political reasons. In recent years there has been extensive political and
ethical discussion concerning the export of germplasm from Developing Countries, which contain the bulk of biodiversity, to international or regional gene banks, which are primarily located in the Northern Developed Countries (Juma, 1989; Fowler and Mooney, 1990; Cooper et al., 1992). This discussion has become particularly heated since the application of biotechnological techniques and the advent of widespread bio-prospecting in the tropics, which has resulted in increased economic value being placed on wild species. The transfer of germplasm out of the country of origin is generally associated with a transfer of political and economic control over the material, which has undoubtedly resulted in external exploitation of biodiversity without economic benefit to the country of provenance. The problems of sovereignty and patenting of biological diversity is currently a matter of extensive international debate.

Leaving the largely political arguments to one side, both in situ and ex situ conservation strategies have advantages and disadvantages (Maxted et al., 1997a). Scientifically the two strategies should not be seen as alternatives or in opposition to one another, but rather as being complementary, as is stated in Article 9 of the Convention on Biological Diversity (Convention on Biological Diversity, 1992). One conservation strategy or technique will act as a backup to another, the degree of emphasis placed on each depending on the conservation resources available, the aims and the utilisation potential for that target taxon. This has led conservationists pragmatically to adopt a more "holistic" approach to conservation (Withers, 1993). The conservationist when formulating an overall conservation strategy should think in terms of applying a combination of different techniques, including both in situ as well as ex situ, where the different methodologies complement each other. If a complementary approach to conservation is to be adopted, both ex situ and in situ genetic conservation must have a firm scientific base.

**Conclusion**

To conclude there is growing interest throughout the world and particularly in the Fertile Crescent because of its wealth in CWR of international importance in the management of natural habitats for CWR Conservation. This is currently particularly vital due to the urgent need to protect ecosystems and the species they contain from careless species extinction or genetic erosion due to human environmental mismanagement. There is an obligation under CBD, ITPGRFA and GSPC for the region as whole but also individual countries to act and conserve and make available for utilisation their genetic resources of CWRs. Although the majority of plant genetic conservation research and application in the region has thus far focused on ex situ techniques of crop diversity, the requirement and emphasis has now shifted to in situ genetic conservation of the diversity of CWR along with crop landraces. This has necessitated the development of novel in situ protocols and techniques but these are now available and tested in the region so there should be no bar to CWR conservation in natural habitats. However, as with any form of in situ conservation sustainability is fundamental, there remain too many short term projects with no effective exit strategies! It also should be remembered that in situ conservation is not an end in itself and as with accessions in gene banks CWR conservation in natural habitats must be used or their future is likely to be as equally threatened as wild populations and the conservation resources would have been wasted.

**Acknowledgements**

During the course of “Conservation and Sustainable Use of Dryland Agrobiodiversity of the Fertile Crescent” project I was fortunate enough to work alongside Dr A. Amri, Dr J. Valkoun,
Mr A. Shehadeh, the national coordinators and their project teams, as well as the farmers of the region. As such I would like to express my thanks to these individuals who generously discussed ideas on how best to manage natural habitats for crop wild relative conservation.

References


IUCN, (1993). Protected areas of the world: A review of national systems. Volume 1:


Biodiversity Conservation in Rangelands through the Utilization of the Indigenous Forages of Kuwait

J. Peacock, S. Omar, E. Ebrahim, T. Thomas, S. Zaman and A. Al-Nasser

Kuwait Institute for Scientific Research (KISR), P.O. Box 24885, Safat 13109, Kuwait. E-mail: jpeacock@safat.kisr.edu.kw

Keywords: Kuwait, rangelands, biodiversity, forages, conservation

Abstract
Rangelands represent 96% of the land area of Kuwait. Unfortunately they highly degraded and their native plant biodiversity are being rapidly depleted. The primary cause of depletion is overgrazing, excessive removal of plants for fuel, off-track vehicle movement and, more recently, military activities. Kuwait’s vegetation is of particular scientific interest as it represents a transition between semi-desert and desert vegetation in the Arabian Peninsula. Annuals account for up to 90% of the total higher plant species. Rhanterium epapposum, Haloxylon salicornicum, Panicum turgidum and Cyperus conglomeratus are the most common perennial communities.

In 1975, KISR established an enclosure that was protected from animals by a 2-m high fence and by daily patrols of local Bedouin security guards. The area was 20km² which was increased to 40km² in February 2004

A serious bottleneck to rangeland restoration is the lack of seeds of indigenous forage species. A major objective of KISR’s research has been to increase seed collection of native species for utilization and multiplication. Seeds are harvested by hand and machines. After threshing and cleaning, seeds are stored. Small amounts of seeds are kept in the newly built seed genebank unit. Seeds of over 40 different species, with amounts from a few grams to over fifty kilograms, have been collected. A necessary step towards further propagation and seed multiplication was to determine seed dormancy characteristics and germination percents. Germination percents were substantially increased by subjecting the seeds of different species to different treatments, mainly by mimicking the outside environmental conditions from seed drop to the next rains. Sowing of large degraded areas is done with a commercially available rangeland pitter and contour seeder. Transplanting vegetative cuttings and seedlings, of certain species, was also successful. A small pilot project, covering an area of 750m x 500m, within a heavily degraded Rhanterium epapposum ecosystem, utilizing the above techniques, is described.

Introduction
Kuwait is a relatively small country (c. 17,600 km²), situated in the north-eastern part of the Arabian Peninsula, between Iraq and Saudi Arabia. The landscape is flat to gently undulating, and rises from sea level to reach a maximum elevation of about 280 m on the western border. Potential evaporation greatly exceeds precipitation throughout the year (Halwagy and Halwagy 1974). The summers are hot, with daytime temperatures often reaching 50°C. The winters are relatively cool, sometimes falling below freezing, with a mean of between 10 and 20°C. Annual rainfall ranges from between 20 and 260 mm and is usually restricted to the period from October to April (Halwagy et al., 1982).

The native vegetation of Kuwait is of particular interest because of its adaptation to low rainfall conditions (ca. 120 mm). Brown and Al-Mazrooei (2003) indicate that it also represents a transition between semi-desert and desert vegetation, corresponding to arid ecosystems.
Perennial vegetation cover of the rangelands is sparse and usually less than 10% (Brown, 2001a). Dwarf shrubs are the most common, characterized by many types of plant communities and sub-communities; *Rhanterium epapposum*, *Haloxylon salicornicum*, *Panicum turgidum* and *Cyperus conglomeratus*, are the main types. Native trees are virtually absent in Kuwait, with *Acacia pachyceras* being the only species. In the years of adequate rainfall, the rangelands are covered with many different species of annual forbs. Annuals make up about 90% of the species in Kuwaiti ecosystems (Brown, 2001a).

Rangelands represent 96% of the land area of Kuwait and are an integral part of the heritage of its people, providing forage, green cover, meat, fiber, water, recreation and, when properly managed, can reduce sand erosion, halt sand encroachment, and hence combat desertification (Khalaf, 1989; Omar, 1990; Schuster, 1998). Unfortunately these rangelands and their native plant biodiversity are being rapidly depleted and degraded. The causes of this degradation include overgrazing (Schuster, 1998), worsened by the generalized practice of supplementary feeding, excessive cutting or removal of plants for fuel, quarrying, off-track vehicle movement and more recently military activities (Brown, 2003; Omar and Zaman 1998).

One of the major objectives of KISR’s revegetation research programs is to reverse the negative trends of ecosystem degradation by scientific means and to better understand the dynamics of restoration and to conserve the biodiversity of these important ecosystems. Currently restoration and revegetation projects, covering over 200 km², are being conducted in three areas; (i) the Burgan oil field (0.5 km²); (ii) Al-Liyah (165 km²); and (iii) Sulaibiya (40 km²), where the ecosystems have been markedly affected by (i) oil pollution following the Iraqi war, (ii) gravel extraction, and (iii) off-track vehicle movement due to military activities, respectively.

This paper describes the initial stages of a restoration and revegetation project at the Sulaibiya Agricultural Research Station (ARS), where the rangelands were heavily damaged by military activities and overgrazing.

**Materials, Methods and Strategies**

**Study Site and Location**

The Sulaibiya Agricultural Research Station (ARS) was first established in 1975, within the Kuwait Institute for Scientific Research (KISR) Range Management Project (Taha et al., 1980). It has since been protected from human interference and excessive livestock grazing by a 2-m high fence, and ongoing daily patrols by local Bedouin security guards. In its first phase, (1975 to 2004) the enclosure covered 20 km² (5 x 4 km). The northern and western boundaries are subjected to mobile sand movement that intrudes inside the boundary fence (Omar et al., 1988). When it was first fenced in 1975, the area at ARS was severely degraded. The area would have been dominated by *Rhanterium epapposum* before overgrazing, which is a composite shrublet (Halwagy and Halwagy 1974). This degradation led to reduced litter and organic matter production, and lower productivity (Le Houérou, 1986). It had also reduced structural stability of the soils, water permeability and infiltration, diminished microbial activity and soil fertility (Le Houérou, 1992). After initial recovery, the fenced area was managed with livestock and detailed grazing studies and measurements were made from 1980 to 1989 (Omar, 1991). These studies included details on species diversity, frequency, ground cover and meteorological data (Taha et al., 1980). Data recording and management were interrupted during and after the Iraq invasion of Kuwait, but more recently 2002 to 2005, both vegetation and wildlife monitoring has resumed and a recovered *Rhanterium epapposum* ecosystem is now the main feature of this area. Other important perennials include *Farsetia aegyptia* (which is almost extinct throughout the rest of Kuwait), *Calligonum polygonoides*, *Centropodia forskalii*, *Helianthemum lippii*, *Panicum turgidum* and *Stipagrostis plumosa*. However, *Cyperus conglomeratus* and *Moltkiopsis ciliata*,

290 | Page
which were the first colonizing perennial species, have almost completely disappeared from the original fenced area.

Soils
Generally the soils are rather coarse sands and are classified as Typic Torripsamments (Omar et al., 1988). A sedimentomorph map of ARS prepared by Khalaf et al. (1980) and confirmed by Asem et al. (1982) shows that the area lies to the south-east of Al-Huwaimliyah, which is the main source of mobile sand in Kuwait. The amount of sand transported along the Al-Huwaimliyah belt is estimated at 175,000 m³ yr⁻¹ (Omar and Zaman 1998).

Ordnance clearance
In February 2004, the start of phase two, the enclosure was doubled to 40 km². The revegetation work reported here is from this area. Because the new area was used extensively damaged during the war and there were obvious signs of military structures, it was again thoroughly checked for ordnance before any revegetation work has started. This was carried out by the explosive ordnance dispersal (EOD) experts with the Kuwait Ministry of Defense.

Experimental layout
After the perimeter fence was completed in February 2004, an experimental area was identified and marked out. The area was aligned exactly NW, at right-angles to the prevailing wind direction. The area is approx. 750 x 500 m² and comprises different treatments for (i) sand stabilization, (ii) sowing of native species, and (iii) fresh water application. These various treatments will allow us to examine the effects and interactions on the long-term restoration of a degraded *Rhanterium epapposum* ecosystem.

Plant species
The new area was heavily affected by both overgrazing and vehicles movement. Apart from very short stems (2 cm high) of heavily grazed *Cyperus conglomeratus* plants, the experimental area was devoid of any plant species. After one year of protection, the vegetation comprises predominately of two perennial plant communities (i) *Moltkiopsis ciliata*, a low lying, purple flowered shrub and *Cyperus conglomeratus*, a sedge. There are very few other perennials, except for *Cornulaca aucheri* and those sown by machine, in November 2004 (see later). The desert winter annuals, after over 110 mm of rainfall since October 2004, are also flowering in abundance. The most predominant of the self sown annuals are *Arnebia decumbens*, *Astragalus* spp., *Cutandia memphitica*, *Horwoodia dicksoniae*, *Plantago boissieri*, *Schrimpera arabica*, *Schismus barbatus* and *Silene villosa*. In the sown areas, in addition to the above, annual seedlings of *Brassica tournefortii*, *Cakile arabica*, and *Plantago boissieri* are abundant.

Sand stabilization
As mentioned earlier, ARS is in Al-Huwaimliyah belt and is therefore subject to sand deposition throughout the year. Sand stabilization of the experimental area is being assisted by the erection of impounding fences, a vegetation tree belt and a thin layer of gravel.

Two impounding fences (250 meters long) 2 m high, with slats to further reduce sand movement were erected. Between the two fences, there is a vegetation wind-break of native trees and shrubs. Before transplanting the tree belt rows, the soil was deep ripped to 50 cm. Along the same ripped line pits were dug at 5-meter intervals, filled with pure peat and then soaked by drip irrigation. Three species, *Zizyphus spina-christi* (Z), *Prosopis cineraria* (P) and *Lycium shawii* (L) were planted in a ratio of 3:2:1. i.e. three plants of *Z. spina-christi* to two *P. cineraria* to one *L. shawii*. They were planted in five rows, five meters apart and each adjacent row was staggered by two and a half meters. After transplanting, irrigation was applied for two days to fully saturate the soil profile (Peacock et al., 2004b).
Gravel (8 mm grade) was also used to reduce sand movement on the leeward side of the impounding fence closest to the experimental area. Two areas of 3125 m² were covered. The gravel was laid to a depth of approximately 3 cm. Sand traps were installed to measure the effects of these various sand stabilization treatments.

To ensure seedling establishment in years with low rainfall (< 40 mm) an irrigation system was installed. It comprises of (i) drip irrigation for the vegetation wind break, (ii) sprinkler irrigation for 33% of the area (SS1-SS8), and (iii) drip irrigation for 33% of the revegetation area (SD1-SD8). The area (ST1-ST 8) received only rainfall. In addition a 20,000-gallon water tank was installed along with three pumps and a diesel driven 40 KVA generator. The sprinklers in each block cover an area of 250 x 200 m². The sprinkler lines run exactly NW and rows are 10 m apart with 10 m between each riser. Similarly, the drippers cover an area of 50,000 m². Each dripper line is 2.5 m apart. Drippers are at 50 cm and 1 m spacing, in alternate rows. Irrigation was only applied in the months when it rains (October-May) and usually after a rainfall event.

Native seed collection and processing
The availability of sufficient quantities of native seeds is the key factor to the success of any restoration and revegetation program. The lack of native seeds has always been the major bottleneck for all restoration programs in the Arabian Peninsula (Peacock et al., 2003a). With the abundant rainfall in 2003/2004 (250 mm) and 2004/2005 (114 mm), native plants flowered profusely and seed set and grain fill were high during 2004. As a result, frequent collections were made during March 2004 to April 2005 in the old ARS enclosure and other known seed collection areas in Kuwait. In 2004, over 600 kg of seed material of selected species was collected (Table 1). Seeds of over 40 species were harvested, sun-dried and stored in cloth sacks in the newly prepared air-conditioned seed store for short and medium term storage. For long-term storage, seeds are kept in the KISR Gene Bank (Zaman et al., 2004).

In the 2002/2003/2004 seasons, most seeds were harvested and cleaned by hand; however, *Launaea mucronata* and *Rhanterium epapposum* were collected using a mechanical seed harvester. In 2004/2005, seeds were collected in a similar way, but all cleaning was done by seed processing equipment purchased from Kimseed Pty. Ltd., Australia. Also small areas at ARS were irrigated with fresh water, allowing a number of desert annuals to germinate easily. Seeds of *Brassica tournefortii*, *Launaea mucronata*, *Picris babylonica* and *Senecio glaucus* were harvested in large quantities during March and April 2003 and 2004. Attempts were made to speed up the process of harvesting using a vacuum harvester (Kimseed Pty. Ltd.) and in 2005 a brush harvester was used to collect seeds of *Stipa capensis* and will be further used to collect seeds of other short native grasses and *Cyperus conglomeratus*.

Table 1. Summary of quantities of native plant seed material collected.

<table>
<thead>
<tr>
<th>Species</th>
<th>Gross wt. kg.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Brassica tournefortii</em></td>
<td>58</td>
</tr>
<tr>
<td><em>Calligonum polygonoides</em></td>
<td>14</td>
</tr>
<tr>
<td><em>Cenchrus ciliaris</em></td>
<td>3</td>
</tr>
<tr>
<td><em>Centropodia forskalii</em></td>
<td>7</td>
</tr>
<tr>
<td><em>Cyperus conglomeratus</em></td>
<td>64</td>
</tr>
<tr>
<td><em>Farsetia aegyptia</em></td>
<td>7</td>
</tr>
<tr>
<td><em>Gynandriris sisyrinchium</em></td>
<td>70</td>
</tr>
<tr>
<td><em>Helianthemum lippii</em></td>
<td>2</td>
</tr>
<tr>
<td><em>Launaea mucronata</em></td>
<td>1</td>
</tr>
<tr>
<td><em>Moltkiopsis ciliata</em></td>
<td>5</td>
</tr>
</tbody>
</table>
Seed germination and dormancy characteristics

A necessary step towards restoration and seed multiplication of native plant species was to determine the seed dormancy and germination characteristics of the selected species. Knowledge of seed germination capacity is essential as it helps to better calculate the seed rate required to achieve optimum plant densities as seeds of native desert plants are very valuable and must be used sparingly. Previous studies conducted in Kuwait provided little information on the dormancy and germination behavior of the native plant species used in this revegetation program. Seed germination experiments were conducted from 2002 to 2005 on the following species:

- Perennial grasses: *Cenchrus ciliaris*, *Panicum turgidum*, *Pennisetum divisum*, *Stipagrostis plumosa*;
- Perennial shrubs: *Lycium shawii*, *Farsetia aegyptia*, *Rhanterium epapposum*;
- Annual forbs: *Brassica tournefortii*, *Launaea mucronata*, *Picris babyonica*, *Senecio glaucus* and *Gynandriris sisyrinchium*.

Twenty-five seeds of each species were sown in a disposable petri-dish lined with double filter paper discs, moistened with fresh and brackish water. Final data on germination percentages were calculated when no more seeds germinated after 7 days. The seeds were then subjected to growth-room temperatures that simulated both the very hot desert summer months of May, June, July, August and September in Kuwait (>48°C) and the cooler winter conditions of November, January and early February (<5°C). Germination percentage was then determined after exposure to these various high and low temperature treatments.

For the high temperature treatments, seeds were kept at 50°C for varying number of days in a growth chamber (Brown and Al-Mazrooei, 2001). The germination percents of many species were substantially increased by subjecting the seeds of some species to temperatures of +50°C, for example, with *Brassica tournefortii* maximum germination occurred at a pre-treatment of 60 days at +50°C. In contrast, *Rhanterium epapposum* reached its maximum germination percentage after 150 days exposure to a cold (+5°C) moist temperature (Peacock et al., 2004a). Similar results were obtained by Brown and Al-Mazrooei (2001) for *Haloxylon salicornicum*, where maximum germination occurred at +5°C and +10°C, which again corresponds to temperatures when germination occurs normally in the desert.

Seed germination, and subsequent seedling establishment, was also shown to be strongly affected by water quality. The brackish water (3,500 ppm TDS) was collected from the reservoir at ARS. In general, germination was markedly reduced, and in *Brassica tournefortii* and *Rhanterium epapposum* no germination was observed when brackish water was used. Additional glasshouse experiments have shown that the best germination and seedling establishment occurs when rain-water is used. Germination is further enhanced if the potting soil used is inoculated with mycorrhizae from soils where the same species is growing in the desert (Peacock et al., 2003b;
Peacock et al., 2003c; Peacock et al., 2004a). Priming the seeds by soaking in water for 24 hours prior to sowing markedly increased germination rate and in the case of *Haloxylon salicornicum* by almost 100%. An addition of 1% organic matter by volume, in the form of peat moss, markedly increased the germination percentage of all primed seeds (Peacock et al., 2003b). Using KNO3 increased the percent germination and a 0.5% KNO3 solution gave better germination than 0.1% KNO3 solution (Peacock et al., 2003b). Another successful method for seedling propagation was from vegetative cuttings. *Lycium shawii*, *Nitraria retusa* and *Panicum turgidum* were successfully established by planting cuttings directly into sand (Peacock et al., 2003b). It was found that with *Panicum turgidum*, establishment was highest when cuttings were taken from the desert in the autumn months rather than during either spring or summer (Zaman et al., 2003). *Panicum turgidum* plants were found to survive throughout the hot summer without additional water when transplanted into the desert. These “mother” plants are now being used for seed multiplication.

**Restoration and revegetation**

After all the seeds had been cleaned and the irrigation equipment installed, seed lots were weighed out and sown in the revegetation areas using a rangeland pitter. The seeds were sown in two distinct blocks of plots. Natural Succession Plots, Block 1, comprised of 12 plots SS1 to ST4, each plot is 100 x 62.5 m². In Block 1, seeds of 6 annuals and two perennials, *Cyperus conglomeratus* and *Citrullus colocynthis* were sown (Table 2), simulating the first stages of succession in a long-term revegetation program (Omar et al., 2000).

| Species Group Life Form Plant population/species Seeds sown/ha |
|------------------|------------------|------------------|------------------|
| *Citrullus colocynthis* | F | P | 1000 | 10000 |
| *Cyperus conglomeratus* | G | P | 1000 | 10000 |
| *Brassica tournefortii* | F | A | 1000 | 10000 |
| *Cakile arabica* | F | A | 1000 | 10000 |
| *Launaea mucronata* | F | A | 1000 | 10000 |
| *Plantago boissieri* | F | A | 1000 | 10000 |
| *Plantago ovata* | F | A | 1000 | 10000 |
| *Senecio glaucus* | F | A | 1000 | 10000 |
| Total | | | 8,000 | 80,000 |

Note: Key, G= Grass, F= Forb, P= Perennial, A= Annual

The number of seeds to be sown per species per hectare was calculated to achieve a plant population of 8,000 plants per hectare, using the following data: (i) the required plant population per hectare, (ii) the mean minimum germination percentage for all the species, and (iii) estimated losses due to predators and extreme weather conditions and (iv) the number of species being used. As the germination percentage of the seeds is rarely 100%, the amount of seed to achieve this population of plants will always be larger. A mean minimum germination percentage of 20% was used, which meant that five times more seeds than plants were required, i.e. 40,000 seeds. We also know that there will be considerable losses from predators, such as insects and birds, and the weather, particularly wind and extremes of temperature. Most desert annuals manifest fractional germination (Brown, 2002; Pake and Venable, 1996; Claus and Venable, 2000) and, although a very useful survival mechanism under harsh environments, this can keep the germination percentage low even under ideal conditions. We made an assumption that 50% of the seeds would not germinate this year, for one reason or another. Therefore, for a hectare to be seeded to achieve a plant population of 8,000 plants per
hectare, the numbers of seeds estimated to achieve this are 80,000 seeds per hectare (Table 2). In Block 1, 8 species were used therefore the number of seeds per species is (80,000/8), i.e. 10,000. To obtain the correct number of seeds for each species, a 100 seed weight was measured.

In the 12 Rehabilitation/Restoration plots in Block 2 (SS8-ST5), the same 8 species were sown as in Block 1, together with 8 more perennials, giving a total of 16 species (Table 3). The overall plant population was the same as in Block 1 and the total numbers of seeds sown is given in Table 3. Once this estimate was made, the weight of seed for a specific area was calculated, mixed with fine dry sand and placed in the seeder chamber of the Kimseed rangeland planter. The Kimseed rangeland planter was calibrated prior to use. Calibration is a function of the tractor speed and the seed port size. In Block 2, organic matter at a rate of 1% v/v and fertilizer at a rate of 157 kg/ha were added at the time of planting. Once all the seed and amendments were applied, some perennial species (marked with an asterisk in Table 3), raised in a glasshouse/shade house complex, were transplanted into Block 2 (SS8 to ST5). The 12 recovery plots, Block 3, (SS9-ST12) were not sown. These plots will be monitored to determine if plants will establish from wind blown seed, from Blocks 1 and 2.

### Table 3. Species, required plant population and actual seed numbers sown in Block 2

<table>
<thead>
<tr>
<th>Species</th>
<th>Group</th>
<th>Life Form</th>
<th>Plant population/species</th>
<th>Seeds sown/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calligonum polygonoides</td>
<td>S</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Farsetia aegyptia</td>
<td>S</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Rhanterium epapposum*</td>
<td>S</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Citrullus colocynthis</td>
<td>F</td>
<td>P</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Moltkiopsis ciliata</td>
<td>F</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Cyperus conglomeratus</td>
<td>G</td>
<td>P</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Cenchrus ciliaris</td>
<td>G</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Panicum turgidum</td>
<td>G</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Pennisetum divisum*</td>
<td>G</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Helianthemum littii*</td>
<td>F</td>
<td>P</td>
<td>333</td>
<td>3330</td>
</tr>
<tr>
<td>Brassica tournefortii</td>
<td>F</td>
<td>A</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Cakile arabica</td>
<td>F</td>
<td>A</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Launaea mucronata</td>
<td>F</td>
<td>A</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Plantago boissieri</td>
<td>F</td>
<td>A</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Plantago ovata</td>
<td>F</td>
<td>A</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Senecio glaucus</td>
<td>F</td>
<td>A</td>
<td>667</td>
<td>6670</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>8,000</td>
<td>80,000</td>
</tr>
</tbody>
</table>

**Notes:**
- Key: S= Shrub, G= Grass, F= Forb, P= Perennial, A= Annual
- * Species transplanted

### Monitoring

Baseline data for the whole area were collected in February 2004, immediately after the enclosure fence was completed. Monitoring commenced early in April 2005, when phenological development of most of the annual vegetation was complete and dry matter production was at its highest. As vegetation cover was not uniform and two distinct vegetation communities exist, viz. (i) *Moltkiopsis ciliata*, and (ii) *Cyperus conglomeratus*, a stratified random sampling procedure was used (Brown and Al-Mazrooei, 2003). Within each 100 x 62.5 m² plot, five quadrates (5 x 5 m) were selected from each of the two main vegetation communities on a diagonal from the north corner of each plot to the south. Quadrates were marked at 20 m intervals on the diagonal, giving a total of ten sub-plots for each main plot, and five sub-plots for each vegetation community. The sub-plots in blocks 1 and 2 all contain four furrows sown previously with native seeds (No furrows in block 3 as it was not sown). These sub-plots were
used to measure and calculate (i) total perennial species cover, as a percentage of the whole plot (5 x 5 m), (ii) total percentage cover of all species in each perennial vegetation group, and (iii) number of perennial seedlings growing in the furrows.

To measure the annual species cover, three 0.5 x 0.5 m quadrates within the three sub-plots (1, 3 and 5), for each vegetation community were selected. Measurements of percentage cover, species diversity and dry matter production of annuals were made. The protocols used are described by Brown and Al-Mazrooei (2003). In brief, each 0.5 x 0.5 m quadrat was divided into 25 equal-sized sub-plots (0.01 m²), and all vascular plants were recorded in each of these twenty-five 0.1 x 0.1 sub-sub-plots, on a presence-absence basis. Presence-absence data of the sub-plots were used to indicate the frequency of occurrence (incidence) of each species (Brown and Al-Mazrooei 2003).

**Initial results and conclusions**

Initial results show that exclusion of animals, people and vehicles from the 5 x 4 km² area has a dramatic impact on recovery of many plant species. The main perennial species to recover from degradation were *Moltkiopsis ciliata* and *Cyperus conglomeratus*.

It is too early to see the impact of any of the sand stabilization treatments. However, observations from similar impounding fences, erected over ten years ago, adjacent to the same area, would suggest that impounding fences with slats, although holding back the sand, could negatively impact on some of the restoration processes, if a large proportion of wind-blown particles are excluded from the restoration area. It is clear from observations and data collected, in these first stages of recovery, that the sand, brought in by the predominately NW prevailing winds, deposit vital wind blown seed and organic matter. The plants and the accumulated sand then develop into micro-nebkas (Brown and Porembski 1997; Brown and Porembski 1998), which in turn produce habitats for other plant species and small animals, nesting birds and insects. Data also show (not shown) that when the sand accumulates behind established plants like *Cyperus conglomeratus*, *Citrullus colocynthis* and *Cornulaca aucheri*, there is a marked increase in organic matter from almost zero to over 1%, and most importantly soil moisture is retained following good rains (Snyman, 1999). This seems to be an essential step in the restoration cycle as described by Omar et al. (2000). The gravel covering, which is both expensive and environmentally unsuitable, may not be a practical sand stabilizer, although it seems to be good mulch.

The annuals *Cakile arabica* and *Brassica tournefortii* have germinated and established well in both blocks and in block 2, the perennials, in particular, *Farsetia aegyptia* and *Calligonum polygonoides* under all water treatments. It also seems that different species colonize different soil types, with annuals growing predominantly in the sandy areas. For example, *Cakile arabica* appears only to colonize those areas where fine sand has accumulated, whereas the perennials, *Helianthemum lippii* and *Moltkiopsis ciliata* do not establish on areas covered by sand, preferring harder more clayey soils.

Although over 110 mm of rain has fallen since sowing in October to the present day, an additional 14 mm of water added by sprinkler irrigation appears effective compared to similar amounts applied by drip-irrigation; if quick revegetation recovery, with vigorous growth of annuals is an important criteria in the early months of restoration.

KISR is currently setting up the infrastructure, equipment and tools to develop a native seed production facility for selected indigenous native plant species of the Arabian Peninsula, particularly those of the north-eastern region. The KISR projects at Sulabiya could be regarded as a success. The benefits of this study site are many, and are briefly listed as follows:
i. The protected areas present excellent educational facilities and demonstrate to others, particularly Kuwaiti school children, how the landscape once looked, and what can now be done to restore the rangelands for the future;

ii. It has become a haven for wildlife and has contributed to biodiversity conservation, and may have prevented the local extinction of some species of fauna and flora;

iii. It attracts and maintains migrating birds which are very important, as Kuwait is within an important migratory corridor between eastern and western Europe and Asia and Africa. Already birds, which have not nested in this part of Kuwait before, are nesting in the plots (G. Gregory KISR 2005 pers. comm.);

iv. It is rich in plant biodiversity;

v. It is an excellent facility for conservation, grazing and rangeland management research in harsh deserts;

vi. It has become a very important source of seed for native desert plant species, and finally,

vii. as a result of the success of this project, the government has already put aside another large (165 km²) degraded area for KISR scientists to help restore.

Acknowledgements
The authors would like to thank all the KISR revegetation team for their invaluable work under these very harsh conditions, in particular Mr P.T. Ramos, G. Shabbir and F. Ahmed. We are particularly grateful to the Consortium of International Consultants (CIC), for all their support. Without the financial support of CIC from the PAAC (Public Authority for Assessment of Compensation for Damages Resulting from Iraqi Aggression) funded Monitoring and Assessment Program it would not have been possible to carry out this research.

References


Processes of Community Involvement for Promoting the Conservation of Rangelands Agrobiodiversity in West Asia

M. M.W. Abu-Zanat\(^1\) and A. Amri\(^2\)

\(^1\) Faculty of Agriculture, The University of Jordan, Amman-Jordan. Mahfouz@ju.edu.jo
\(^2\) International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, a.amri@cgiar.org

**Keywords:** rangelands, biodiversity, community participation, conservation, West Asia

**Abstract**
Extensive areas of rangelands in West Asia and North Africa (WANA) region are highly degraded through activities associated with uncontrolled grazing, dryland farming and mining. Many projects were conducted in the WANA region to rehabilitate the degraded grazing resources, but unfortunately, most of these projects were not sustainable because they emphasized the technical aspects more than the social and economical aspects. The Global Environmental Facility (GEF) funded a regional project on the “Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria”, coordinated by ICARDA to promote the conservation of wild relatives of food and feed plant species originating in West Asia center of diversity. For rangelands, the ultimate goal of the project is the self-management or “sustainable empowerment” of local communities to ensure the conservation and sustainable use of rangelands, which are the storehouses of plant genetic material. The local community was effectively involved in the planning and implementation processes of the approved management plan. The project succeeded in adopting participation as a goal to empower the local communities, which was reflected in the adoption of community-based grazing management at the sites in Syria and Jordan. The sustainability of projects especially those dealing with communal natural resources are highly dependent on the effective participation and empowerment of local communities.

**Introduction**
Rangelands are geographical regions dominated by native vegetation (grasses, grass-like plants, forbs and with or without scattered woody plants) that are extensively managed with livestock grazing (FAO 2004). These rangelands are occupying vast areas of arid and semi-arid regions and containing many natural habitats, which harbor a wide array of plant species that are the basis for grazing animals and provide other medicinal and herbal plants with industrial benefits (Harlan 1992). The rangelands represent a large storehouse of genetic resources and a basis for livelihood, employment and a source of income for rural and pastoral communities. However, the fragile grazing resources in arid lands have undergone severe degradation over the past decades, which takes the form of depletion of native vegetation, loss of biodiversity and threatening the socioeconomics of pastoral communities (AOAD 1994, Le Houerou 1992). The inappropriate use of rangelands could be attributed to a set of inter-linked factors including population growth and increased pressure on natural resources, breakdown of traditional systems of management, promoted governmental policies (settlement of pastoralists and subsidized feeds for livestock production), and land tenure problems (Le Houerou 1981).

The agrobiodiversity in West Asia and North Africa (WANA) region has a global significance to food security and sustainable agricultural development and is important to the livelihoods of local communities in the dry areas. The GEF-UNDP funded a project on the “conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and
“Syria” to promote the conservation of wild relatives of cereals, food and feed legumes and of fruit trees originating in West Asia region. In each participating country, two target areas representing different ecosystems that are harboring the targeted food and feed plant species were selected to evaluate the status of agrobiodiversity, demonstrate alternative practices and suggest reasonable recommendations to ratify the current land use policies to promote the conservation of agrobiodiversity.

Concerning rangelands, the project focused on the rehabilitation of natural ecosystems through the application of technical and non-technical options. The non-technical options focused on the organization and empowerment of pastoral communities. The traditional institutions used to be the key elements in organizing and controlling the affairs of pastoral communities. The establishment of non-governmental organizations (NGO) and site management committees (SMC) were encouraged to ensure the validation and sustainability of project activities aiming to conserve the agrobiodiversity in the rangelands. The demonstrated technical options included range treatments (soil amendments, plantations of native fodder plant species, water harvesting structures, and manufacturing of feed blocks) and range management through the demonstration of alternative community-based grazing practices.

The objective of this paper was to highlight the different processes adopted by the agrobiodiversity project to involve the targeted communities for promoting the in situ conservation of agrobiodiversity on rangelands.

**Methodology**

**Characterization of sites and communities**

Updated and geo-referenced data pertinent to the status of agrobiodiversity at the potential locations within each ecosystem and the targeted communities were collected from literature review, field visits and surveys. The data included biophysical characterization of ecosystems and of selected sites, factors threatening the local agrobiodiversity, and alternative land uses for promoting agrobiodiversity. For rangelands, the attributes of native vegetation and its contribution to the feeding calendar of small ruminants in the targeted ecosystems were emphasized. The details of characterizing the targeted areas and local communities are included in country reports.

**Participation of local communities**

Figure 1 shows the flowchart of the main steps of the participatory approach adopted by the agrobiodiversity project. The participatory process is dynamic and differs slightly among different communities. The following paragraphs discuss the main steps of the participation process.
Data Collection
Bio-geophysical and socioeconomic information was collected from literature review, technical reports of previous projects executed in the targeted areas, and field visits and surveys.

Community
Meeting with local institutions (tribal leaders, village chiefs, and Mukhtars), followed by open meetings with community members to discuss the main problems especially those pertinent to the degradation of grazing resources and natural habitats within the rangeland ecosystems.

Management Plan
Proven technical interventions were discussed thoroughly with community members before finalizing the community-approved management plan.

Sites Selection
Several sites/locations were selected within the targeted ecosystems with full participation of the respective local communities.

Demonstration of Interventions
The technical options of the community-approved management plan were demonstrated at the selected pilot sites with full participation of local communities.

Site Management Committee
For each site, a committee from local community was initiated and trained to manage the improved sites and to act as a link between Project Management Unit and community members for solving conflicts and problems.

Fig. 1: General flowchart followed by the Agrobiodiversity project for community involvement in the rangeland rehabilitation.
Collection of data: The preliminary information about the targeted communities was collected to select a potential community or more within each ecosystem for the demonstration of project activities. The information was collected from governmental institutions (Ministries of Agriculture, Planning, Social Affairs) and National, Regional and International research centers and organizations (Universities, National Agricultural Centers, ICARDA and ACSAD). The information included village area, population, sources of income, farming systems, grazing resources, conflicts and land tenure.

Meeting with local institutions: The local institutions of the targeted villages (Governor, Parliament members, Director of Agriculture, Mukhtars and NGOs) were met to explain the objectives of agrobiodiversity project, and to assess the possible collaboration or threats to project interventions. The support of the local institutions is an essential requirement for the success of the project.

Meeting with communities: Several meetings with local communities were conducted to increase their awareness about the agrobiodiversity benefits and to explain the project objectives and strategy. Through the meetings, more information was derived directly from the community members especially those related to potential success (willingness for participation) and potential risks (social and land tenure conflicts), present leadership and potential collaborative farmers and herders. The analysis of the collected primary and secondary information revealed several gaps in the information that necessitate to conduct several field surveys, to collect the lacking information for a proper characterization of the targeted communities. The Rapid Rural Appraisal (RRA) tool was used to collect more information about the socioeconomics of the targeted communities.

Discussing with communities the issues of rangelands: Community members raised several issues related to grazing resources and livestock production during the meetings. The issues included (i) degradation of rangelands productivity, (ii) increased costs of water hauling for animals, (iii) uncontrolled grazing “free access of all to all areas of land”, (iv) barley cultivation in rangelands, (v) and the necessity for water harvesting. The above issues were thoroughly discussed with communities to rank the most pressing ones.

Discussing with community the potential interventions: Several technical packages were suggested and negotiated with local communities. The interventions centered on both the rehabilitation of degraded rangelands and on the future grazing management of the improved sites. The range treatments consisted of plantations of native species including shrubs, combined with water-harvesting and soil amendments techniques, whereas the range management focused on possible changes in the present grazing practices. The community approved some of the suggested interventions especially plantation of fodder shrubs and barley in the alleys. The project technical staff discussed with the communities the issue of barley cultivation and highlighted the drawbacks of barley cultivation on the properties of both the native vegetation (cover, production and diversity) and soils (fertility, soil seed bank and erosion). Barley cultivation in rangelands is a fact and it is spreading. This practice cannot be changed by issuing a law by the Government. Therefore, it was important for the project to use barley cultivation as a mean to reintroduce the species of native vegetation through cultivating barley in the alleys or in the catchment areas of water harvesting structures.

Sites selection: The communities and project staff in Syria and Jordan participated in the selection of several sites to conduct the approved interventions. Several criteria were suggested for the selection of sites, which included representation of degraded habitats, sizable area, accessibility, communal/private property, lack of conflicts related to land tenure and willingness of farmers/herders to collaborate in the implementation and management of the selected sites.
- Establishment of sites management committees: The collaborative farmers/herders formed the first nucleus towards the organization of community. After the selection of the project technical team and the related Governmental institutions/agencies joined the collaborative farmers/herders to discuss and approve the workplans including the training needs.

**Demonstration of project interventions**

The technical options were demonstrated at small scale (50 ha) in the first year to show the collaborating farmers/herders the benefits of such interventions and were extended to larger areas exceeding 150ha. The demonstrated technical options included:

- **Plantations:** In the first year, transplants of native fodder shrubs (*Atriplex halimus* and *Salsola vermiculata*) were planted in micro-catchments (contour ridges, semi-circular bunds) and local variety of barley were broadcasted into the spaces between the micro-catchments. In the second year, barley was sown in half of the spaces between the micro-catchments, leaving 50 percent of the spaces without cultivation to promote recovery of native vegetation. Barley planting was confined to contour ridges in the third year to reduce the disturbance of natural rangelands.

- **Alternative feed resources:** The information on available agricultural residues (straws, crop residues) and agro-industrial by-products was collected from literature and field visits. The information included production, nutritive value, seasonality, prices, and problems associated with handling, storage and feeding (Salman and Amri 2006). The products of local agrobiodiversity including wild fruits were also considered. Feed blocks were manufactured from these products and distributed to farmers/herders for feeding their animals. The positive feedback received from the communities encouraged the project to improve the design of a machine for manufacturing of feed blocks using hydraulic press.

- **Grazing management:** Rest-rotation grazing (RRG) was demonstrated at Mhareb site in Jordan and Saana site in Syria (Fig. 2) as an alternative to the traditional uncontrolled grazing. The stocking rate was based on the data of dry matter production. The collaboration of local communities especially the local herders was crucial to a proper implementation of the proposed RRG.

- **Training:** Several training workshops were conducted for both the technicians and farmers/herders on water harvesting, multiplication of targeted plant species, plantation of fodder shrubs, calculation of stocking rate, grazing management, manufacture of feed blocks, improving flock husbandry through proper nutrition and para-vet actions, and processing of milk and dairy products.

<table>
<thead>
<tr>
<th>Year</th>
<th>Grazing no</th>
<th>Grazing no</th>
<th>Grazing no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>Year 2</td>
<td>R</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Year 3</td>
<td>G</td>
<td>R</td>
<td>G</td>
</tr>
<tr>
<td>Year 4</td>
<td>G</td>
<td>G</td>
<td>R</td>
</tr>
</tbody>
</table>

Fig.2: Rest-rotational grazing plan demonstrated at rangelands of Mhareb in Jordan and Saana in Syria (R: resting, G: grazing).

- **Establishment of pasture nurseries:** The participating countries established pasture nurseries to provide seedlings of native shrubs needed for the rehabilitation of degraded rangelands. The communal and private pasture nurseries were not competitive to the Governmental ones because of high costs that were associated with the establishment and running of these nurseries.

- **Establishment of Agrobiodiversity Units/Programs:** In each participating country, a unit or Program on conservation of agrobiodiversity was established either at National Agricultural Centers or at the Ministries of Agriculture or at both as in Jordan and Palestine. The staff of the units was trained to be able to draft master plans for validation of agrobiodiversity at the National level.
Incentives: Several types of in-kind incentives were provided for the collaborating farmers/herders which included contracting veterinarians to supervise the flocks of farmers/herders, providing medicines for animals, providing herders with shearing machines, distribution of feed blocks, providing seeds of some forage species (local varieties of medics, clovers, *Vicia* and barley) for cultivation at communal and private lands.

**Results and Discussion**

**Community participation**

The project succeeded in increasing the awareness of local communities regarding the different issues of agrobiodiversity. The good collaboration of farmers/herders and the establishment of NGOs/cooperatives at the different project sites (Mushanaf, Saana in Syria and Mhareb in Jordan) reflected the positive attitude of local communities to collaborate with the project.

**Field surveys**

- Grazing resources: Based on surveys, the contribution of grazing resources to sheep and goat flocks feeding calendars averaged 44, 68, 55 and 22% in project sites of Jordan, Lebanon, Syria and Palestine, respectively, estimated using the number of grazing days. The information furnished by the farmers/herders concerning the number of grazing days did not differentiate between actual grazing from those just roaming in the different grazing areas. The low contribution of grazing resources in PA could be attributed to the enclosures imposed in the West Bank, which limited the availability of these resources to grazing animals. The significant contribution of rangelands to livestock feeding puts greater pressure on grazing resources which conservation necessitates urgent actions for rational management. As mentioned before, the grazing resources especially the rangelands contain valuable genetic resources (wild relatives of feed and food crops) and medicinal plants. Sustained productivity and diversity of grazing resources could be achieved through appropriate technical, institutional and policy options.

- Grazing practices: In the four countries, sheep and goat flocks utilized the native vegetation of project sites for a considerable part of the year; from early spring to early summer. Grazing season ranged between 2 to 7 months, being longer in sites with more favorable environmental conditions. Early and over-grazing are the main features of grazing practices in these areas. In Sweida, the cold conditions that start prevailing in October oblige herders to move their animals from villages to the Badia, knowing that the native vegetation is scant. Trucking feed stuffs to the Badia with flocks is a common practice to secure a suitable location where animals are fed the concentrates and straws waiting for the rainfall and then the growth of range plants. Herders try to minimize the cost of feeding; consequently early and over-grazing are unavoidable. Because of the limited feed resources at project sites, native vegetation is expected to be more vulnerable to excessive grazing. Alternative feed resources are of great importance to alleviate pressures on grazing resources and consequently help in promoting the conservation of natural habitats within rangelands.

**Technical interventions**

Effect of water harvesting, reseeding/transplanting, and fertilization on shrub survival, cover, productivity and diversity of range plants are presented in Tables 1, 2 and 3.

- Shrubs survival: The high survival percentage of the planted fodder shrubs indicated that the micro-catchments technique proved to be effective in harvesting substantial amounts of rain. This indicates the importance of water harvesting techniques for increasing rangeland forage production (Schreiber *et al.*, 1987, Suleman *et al.*, 1995, Abu-Zanat *et al.*, 2004). The planted fodder shrubs represented an alternative forage resource to alleviate some of grazing pressure on
native vegetation. Moreover, the established fodder shrubs act as a refuge for endangered plant species because of overgrazing and continuous ploughing of rangelands. It is recommended to use native shrub species already tested or identified based on local knowledge of herders’ communities. When rainfall is less than 200 mm the transplantation and initial irrigation are recommended. Use of seeds can be done in higher rainfall areas.

- Plant cover: The highest values of foliar cover were observed at project sites, where water-harvesting structures were established compared to those lacking these structures (control) (Table 1). Harvesting rainfall increased the coverage of both total vegetation and forage plants by 36% and 48%, respectively. The non-forage plants cover decreased by 55% as a consequence of shrub plantation. Water harvesting structures increased soil water storage substantially, which enhanced plant growth; consequently increasing the coverage of native vegetation (Suleman et al., 1995). The application of P₂O₅ increased the foliar cover of both total vegetation and forage plants by 32% and 39% without and with water harvesting, respectively. In dry areas, soil amendments with phosphorous is not recommended if annual rainfall is less than 250 mm (Osman and Cocks 1997). The combination of phosphate fertilizers and reseeding with native species increased the cover of total vegetation by 11% compared to 42% for forage plants without and with water harvesting, respectively. In general, foliar cover of total vegetation and forage plants were both enhanced in response to all applied treatments (water harvesting, fertilizer application of P₂O₅, and reseeding) compared to the control.

Table 1. Mean vegetation cover (%) in response to different range treatments at project sites.

<table>
<thead>
<tr>
<th>Range Treatments</th>
<th>Total</th>
<th>Vegetation Cover (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Forage Plants</td>
</tr>
<tr>
<td><strong>Water Harvesting:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>31.7 ± 14.7</td>
<td>24.2 ± 11.7</td>
</tr>
<tr>
<td>Water harvesting structures</td>
<td>49.5 ± 18.5</td>
<td>46.8 ± 18.2</td>
</tr>
<tr>
<td><strong>Application of P₂O₅:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without water-harvesting</td>
<td>38.3 ± 13.7</td>
<td>32.5 ± 12.1</td>
</tr>
<tr>
<td>with water-harvesting</td>
<td>56.7 ± 20.8</td>
<td>53.3 ± 23.1</td>
</tr>
<tr>
<td><strong>Application of P₂O₅ and reseeding:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without water-harvesting</td>
<td>45.0 ± 7.7</td>
<td>27.5 ± 12.9</td>
</tr>
<tr>
<td>with water-harvesting</td>
<td>50.8 ± 12.8</td>
<td>47.5 ± 8.8</td>
</tr>
</tbody>
</table>

- Plant diversity: In general, the number of leguminous species at project sites was low (Table 2). Reseeding with native species especially the legumes was necessary to enhance the diversity and quality of the degraded vegetation. Regardless of treatment, mean number of plant species was higher at sites without water harvesting compared to those having water-harvesting structures. This increase in species richness was mainly due to the high number of other plants, mostly herbs with very low forage value and to the soil disturbance when establishing water harvesting structures. Plant species at sites where soil disturbances had occurred were more vulnerable to damage, which explains the relatively low plant diversity at these sites. With reseeding, the number of target species was increased at the expense of other plants at the site. It is recommended then to combine water harvesting with reseeding of native species.
Table 2. Mean species richness in response to different range treatments at project sites.

<table>
<thead>
<tr>
<th>Water Harvesting:</th>
<th>Legumes</th>
<th>Grasses</th>
<th>Others</th>
<th>Plant Species*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No %</td>
<td>No %</td>
<td>No %</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>3.0 27.9</td>
<td>2.7 26.9</td>
<td>4.5 45.3</td>
<td>10.2</td>
</tr>
<tr>
<td>Water harvesting structures</td>
<td>2.0 31.2</td>
<td>2.0 31.7</td>
<td>2.4 36.7</td>
<td>6.4</td>
</tr>
<tr>
<td>Application of P₂O₅</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without water-harvesting</td>
<td>2.5 36.0</td>
<td>2.5 31.3</td>
<td>2.7 34.4</td>
<td>7.7</td>
</tr>
<tr>
<td>With water-harvesting</td>
<td>2.1 22.9</td>
<td>2.0 29.3</td>
<td>2.3 47.8</td>
<td>6.4</td>
</tr>
<tr>
<td>Application of P₂O₅ and reseeding:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without water-harvesting</td>
<td>2.0 21.3</td>
<td>2.2 27.1</td>
<td>4.0 51.6</td>
<td>8.2</td>
</tr>
<tr>
<td>with water-harvesting</td>
<td>2.2 17.1</td>
<td>1.7 9.2</td>
<td>1.7 13.1</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*: mean number of plant species per plot (0.25 m²).

- Biomass production: In general, plots with harvesting rainfall had higher mean biomass production than the control ones (Table 3). Similar results were found by Schreiber and Frasier (1987). Water harvesting alone increased dry matter production of total vegetation and forage plants by 21 % and 27 %, respectively. When water harvesting was combined with phosphate fertilizers, the DM production of total vegetation and forage plants increased by 35 % and 49 %, respectively. The combination of all treatments had slight increase of DM production of total vegetation (13 %) and forage plants (27 %).

Table 3. Mean dry matter production of range plants in response to different range treatments at project sites.

<table>
<thead>
<tr>
<th>Range Treatments</th>
<th>Total Plants</th>
<th>Dry Matter Production (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Forage Plants</td>
<td>Non-ForagePlants</td>
</tr>
<tr>
<td>Water Harvesting:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>533</td>
<td>460</td>
</tr>
<tr>
<td>Water harvesting structures</td>
<td>651</td>
<td>626</td>
</tr>
<tr>
<td>Application of P₂O₅</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without water-harvesting</td>
<td>580</td>
<td>447</td>
</tr>
<tr>
<td>With water-harvesting</td>
<td>902</td>
<td>880</td>
</tr>
<tr>
<td>Application of P₂O₅ and reseeding:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without water-harvesting</td>
<td>767</td>
<td>600</td>
</tr>
<tr>
<td>with water-harvesting</td>
<td>880</td>
<td>827</td>
</tr>
</tbody>
</table>

Lessons learned

- Role of local community: Farmers and herders are the traditional custodians of natural resources and being the real managers of natural resources, the community approach is the most effective tool to ensure rangeland resource management and sustainability. Future training should focus on community participatory approaches in the development and transfer of technical and management options. These approaches should include the discussion of needs, establishment of management plans and their implementation and the monitoring and evaluation of the activities.

- Community-based grazing management: The various technical interventions (water harvesting and fodder plantations) that were demonstrated in pilot sites need government support and full involvement of communities for large replication and outscaling. The grazing management should be more emphasized along with technical options as remedy for rehabilitation of the degraded rangelands.

- Reducing the area of disturbed rangelands: The plantations of fodder shrubs and barley in the micro-catchments (ridges/furrows/bunds) reduced the area that is commonly planted with barley
substantially. Sparing areas of disturbed rangelands provide a good opportunity for recovery of native species. Moreover, the formation of rills and gullies were substantially reduced, consequently reducing soil erosion.

- Promotion of agrobiodiversity conservation: The major pre-requisites for sustainable conservation of agrobiodiversity in rangelands include empowerment of pastoral communities, availability of plant material needed for rehabilitation, and amendments of current land tenure. In the short-run, developing alternative feed resources is necessary to alleviate pressures on grazing resources. The feed block technology based on residues of crops and other by-products available in the target areas should be encouraged. Alternative sources of income and adding value technologies (dairy products, honey production) could also contribute to the improvement of the livelihoods of local communities.

References
FAO. 1995. Sustainable range-dependent small ruminant production systems in the Near East Region. FAO Regional Office for the Near East, Cairo, Egypt.
Main Aspects of the Development of Plant Genetic Resources: *In Situ* Conservation Strategy for Russia

T.N. Smekalova, S.M. Alexanian and I.G. Chukhina.

*N.I. Vavilov All-Russian Research Institute of Plant Industry (VIR), 42-44 Bolshaya Morskaya St., 190000 St. Petersburg, Russia.*

**Key words:** Agrobiodiversity, plant genetic resources, crop wild relatives, *in situ* conservation, priority species, GIS, databases

**Abstract**
Ensuring food security and raising life standards are essential for national security of a country. To this end, well-planned plant collection and safe conservation of agrobiodiversity is important for national food security especially in the centers of origin and in the areas rich in genetic diversity. Increasing genetic erosion in plants due to human activities and global climatic change warrants development of a comprehensive *ex situ/in situ* strategy for agrobiodiversity conservation. It is especially important for areas with extreme environments, such as mountainous, arid, boggy or saline areas. With the adoption of the Convention on Biological Diversity, *in situ* conservation of agrobiodiversity has become a matter of the highest national priority in Russia. For many decades the Vavilov Institute (VIR) has been collecting and studying plant genetic resources in different regions of the world and ensuring their safe conservation both in the genebank and in natural habitats. At present, the Institute is implementing an integrated strategy for *in situ* conservation of cultivated plants and their wild relatives in Russia. The major elements of this strategy are: formulation of priority objects for conservation using the principle of inequivalence of plant species according to various parameters; selection of areas for *in situ* conservation; development of guidelines on monitoring and management for different objects including specific measures to reintroduce separate taxa and socioeconomic considerations (e.g., working with local communities to raise awareness for exercising caution for utilizing traditional natural plant resources).

Development of specific conservation strategy should be preceded by a detailed study of the target area and species, as well as a detailed description of the morphological, ecological, taxonomic, geographic and other relevant attributes. Research materials include the seed and herbarium collections of VIR and other national institutes, archives of collecting missions conducted in different years in the former Soviet territories, and publications, etc.

Technology-based approaches are very important for developing *in situ* conservation strategy. The most important research tool is the database, “Wild Relatives of Cultivated Plants in Russia”. This document contains a wealth of information, including indigenous knowledge, “Vascular Plants of Russia’s Natural Reserves” database and GIS maps of the distribution of plant species in the former USSR. The strategy may serve as a model for different countries and separate territories.

**Introduction**
Ensuring food security and raising living standards of the population are essential components of national security in any country. Targeted collecting of agrobiodiversity, especially in the centres of origin and richest diversity of plant genetic resources, and its safe conservation may be regarded as a pledge of national food security.
The notion of agrobiodiversity conservation entered the scientific terminology in the mid 1990s, but a precise and comprehensive definition of this term that is universally accepted has not yet been developed. Ambiguous identification of agrobiodiversity was the subject of numerous disputes in various scientific and public circles and caused difficulties in allocating responsibilities for conservation of different agrobiodiversity components. Today the concept of agrobiodiversity tends to engulf all the biodiversity related to agricultural production. With this in view, the main functions and characteristics of its conservation are agroecosystem (in situ), agroproduction (on farm, as a component part of in situ), and agroresource (ex situ) trends. The latter implies utilization of genetic resources as source material for breeding. The most important elements of agrobiodiversity are plants, namely cultivated plants and their wild relatives.

The increasing threat of genetic erosion for biodiversity in general and plant resources in particular, caused by negative anthropogenic effect and subsequent global climatic changes, calls for a vital need to develop a universal strategy of agrobiodiversity conservation – both in genebanks (ex situ) and in natural plant communities (in situ) including maintenance of local populations representing cultivated and wild species (on farm) (Ford-Lloyd and Maxted, 1997; Maxted et al., 1997). Selection of a scientifically justified conservation strategy adapted to certain ecological, social and economic conditions is of special importance for the areas with extreme ecological environments: mountainous, arid, boggy, saline, etc. After the Convention on Biological Diversity (CBD) came into effect in 1994, in situ conservation of agrobiodiversity has acquired topmost priority for the whole (Convention on Biological Diversity, 1992). The Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture (PGRFA), adopted in 1996, outlined in situ conservation strategies for each nation, embodied in a group of 4 priority activity areas.

In 2002, the Conference of the Parties (COP VI) approved the STRATEGIC PLAN of plant diversity conservation with the Global Plan as its most important element. All countries of the world started working out their PGR conservation strategies on the basis of this Strategic Plan. In most of the states biodiversity conservation is implemented by many different organizations:

- botanical gardens, nurseries, in vivo collections and genebanks preserve separate components of plant biodiversity;
- scientific institutions on the basis of their research efforts give recommendations on the protection of individual plant species (by publishing “Red Books”, issuing special lists, etc.);
- ministries (of nature, ecology, resources), agencies and committees work out legal acts, adopt resolutions concerning the protection of separate plant species and populations, establish protected natural areas of various categories, and launch special programmes and projects to conserve separate biodiversity components.

At the national level, the strategy of in situ conservation and sustainable utilization of biodiversity components are regulated by a National Program, developed with regard to national specific features and adopted by the government.

For Russia, as for all other countries, the problems of PGR in situ conservation are of primary importance. On the one hand, the country experiences constant and ceaseless depletion of agrobiodiversity components which unconditionally need to be saved for the benefit of future generations, specifically:

- in the past decades local crop populations have been constantly and often unreasonably substituted by modern breeding cultivars;
- the present situation, after the disintegration of the Soviet Union, is marked by drastic changes in the structure of agricultural production, land management and territorial distribution of crops between plant cultivation areas; replacement of the traditional
assortment of cultivated varieties is accompanied by disappearance of associated weedy plants, most of which are close relatives of cultivated crops; the increasing anthropogenic effect reduces the genetic potential of the species representing wild relatives of cultivated plants (WRCP), which serve as an indispensable source of continuous enrichment of crop gene pools with valuable genes; local administrative authorities are often not interested in the establishment of new protected areas within their territories, being much more concerned with further intensification of commercial land management (construction, profit-yielding agriculture, etc.).

All these processes require urgent and thorough examination of the current status of agrobiodiversity and, if necessary, development of specific recommendations and taking measures to preserve its separate components. Nowadays, however, especially after the transformation of the Soviet Union (USSR), the country lacks clear coordination between different agencies involved in plant diversity conservation and needs a unified national conservation strategy. Neither of such agencies and organizations is specifically responsible for protecting separate components of agrobiodiversity, except for the Vavilov Institute of Plant Industry (VIR) based in St. Petersburg. It is VIR that has recently been working out a scientifically justified integral strategy of plant genetic resources for food and agriculture (PGRFA) conservation.

The role of the Vavilov institute in PGRFA conservation

Since the time of its establishment in 1894, the Vavilov Institute has been dealing with the problems of collecting, studying and preserving cultivated plants and their wild relatives both in genetic collections and within natural plant communities. This work was initiated by R.E. Regel, who dedicated 20 years of his life to the establishment and study of the first genetic resource collections, having started with barley germplasm. In 1910, owing to the planned construction of Volkhov Hydroelectric Power Station and possible flooding of water meadows, VIR carried out a study of meadow grasses within their natural coenoses and made recommendations concerning conservation of a number of their species. Major part of the in vivo collection in those years was represented by seed samples and herbarium of wild and weedy plants. Later, in the following 20 years, the talented scientist N.I. Vavilov not only continued the establishment of the PGR collections, but also developed scientific principles of its replenishment and management. Thanks to his foresight, by 1930’s the genebank of VIR comprised a collection of plant genetic resources from the sites where in several years they would be irrevocably lost. All the materials collected by Vavilov and his colleagues were thoroughly studied at VIR. The results of such research allowed his followers to work out conservation guidelines, including those for crop taxa and their wild relatives within natural plant communities. The first annotated list of wild crop relatives for the USSR territory was published in 1975 (V.V. Nikitin and O.N. Bondarenko: Wild Relatives of Cultivated Plants and their Distribution over the Territory of the USSR), while 1986 was marked by publishing a summary of the species of wild crop relatives occurring in the protected areas of the former USSR. (D.D. Brezhnev and O.N. Korovina: Natural Genetic Diversity of Wild Relatives, 1986). Those publications reported 763 species of WRCP within the territory of the USSR. Only about one half of them (390 species) were growing inside the existing 135 natural reserves. The research work carried out by R. Regel, N. Vavilov, O. Korovina, P. Zhukovsky and other Russian scientists laid the foundation of the modern strategy for in situ conservation of PGR.
Plant conservation types (material and methods of research)
During the past 5-10 years diverse countries offered variegated models for PGR conservation. In our opinion, the most universal and scientifically justified is the model proposed by N. Maxted, B. Ford Lloyd and D. Hawkes (1997). This model, if amended and corrected in accordance with national specificity, is quite suitable for a majority of the countries in the world. The authors subdivided the *in situ* strategy into 3 types of conservation: in nature (natural habitat), on farm (as cultivated stock by farmers) and in home gardens (private orchards). Some scientists arguably associate with *in situ* conservation only the first type (in nature) of conservation. Nevertheless, each conservation type has its own specific features in identifying objects and territories and setting priorities for conservation.

<table>
<thead>
<tr>
<th>Types of <em>in situ</em> conservation</th>
<th>Genetic reserves (in nature)</th>
<th>On farm</th>
<th>Home gardens</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>in protected natural areas, in special reserves</td>
<td>landraces maintenance in farmers’ fields</td>
<td>growing in orchards and home gardens</td>
</tr>
<tr>
<td><strong>Objects</strong></td>
<td>species of natural vegetation including crops wild relatives, forest and range species</td>
<td>landraces of field crops, dryland fruit trees planted in extensive areas</td>
<td>landraces of vegetables, herbal and medicinal plants and fruit trees planted most often near the houses</td>
</tr>
<tr>
<td><strong>Human factors</strong></td>
<td>human intervention (monitoring, guarding) is absent or minimized except in protected areas</td>
<td>Application of traditional agricultural techniques with possibility for irrigation</td>
<td>application of traditional agricultural packages</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>within natural plant communities; subject to <em>natural selection</em></td>
<td>in man-made environments; subject to farmers’ selection</td>
<td>in man-made environments; subject to <em>artificial selection</em> and special care including irrigation and weeding</td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td>does not require significant inputs, funding, time, etc.</td>
<td>requires some funding, time, etc</td>
<td>requires more funding, time, etc</td>
</tr>
</tbody>
</table>

The essential difference between these three types of conservation lies in the fact that conservation of the first type (in nature):
- goes on without human intervention or with minimized intervention, while the other two are implemented directly by man;
- goes on in natural environments and evolves under natural selection, while the other two are carried out in man-made environments and are subject to artificial selection;
- does not require significant funding or time costs from man, while the other two are costly and time-consuming.

This presentation is dedicated to the development of the strategy for *in situ* conservation of wild relatives of cultivated plants in Russia.

The materials for the development of WRCP conservation strategy for Russia included: the genetic collection stored and studied at VIR for 110 years; materials of Russia’s 14 different herbarium collections; published maps of the areas of distribution of WRCP species; results of plant explorations undertaken by VIR in various years; floristic lists from various regions of Russia; guideline keys and monographic summaries. The basic method used to develop the strategy was the geomorphological one. In addition, the work required application of standard
GIS-based techniques to map the areas of species’ distribution, methods of analyzing local plant populations, etc.

Implementation of *in situ* conservation strategy for WRCP: In order to implement the *in situ* conservation strategy for WRCP in Russia, a number of tasks have been specified:

- selection of optimal methodologies;
- preliminary complex study of conservation objects (WRCP species, their morphological, ecological, taxonomic, geographic and other features), territories and existing conservation strategies;
- development of databases (DB) and an information retrieval system (IRS) for storage and analysis of the collected information;
- definition of conservation priorities (objects, territories);
- analysis of local populations representing priority species for conservation, with identification of conservation priorities among the populations;
- monitoring of individual species and individual populations;
- development of specific recommendations and measures for conservation and management.

These tasks are implemented on phase-by-phase basis. The strategy incorporates 6 phases.

1. **Definition of the concept of wild relatives of cultivated plants (WRCP)**

There are different concepts and definitions of WRCP. More common is a narrower understanding of WRCP, when they are considered to include the species of natural vegetation that directly participated in the formation of cultivated species. But, the a broader meaning of WRCP is preferred, assuming that they should include “...the species of natural vegetation, evolutionally and genetically related to cultivated ones, being within the same genus with cultivated plant species, domesticated or potentially capable of domestication, participating or potentially capable of participation in crosses or other applications (as seedling stock) with the purpose of obtaining new cultivars or improving the existing ones” (T.N. Smekalova, I.G. Chukhina & N.N. Luneva: Problems of the botany in Southern Siberia and Mongolia. Barnaul, 2002).

2. **Development of a complete list of WRCP species for Russia**

It is impossible to start conservation work without an accurate and comprehensive inventory of WRCP species growing in the studied territory. This list continues to be adjusted in the course of further revision of the composition of Russia’s flora and domesticated plant species. The development of such list should be preceded by thorough analysis of the species’ nomenclature and taxonomy, when the scope, structure and name of each species are verified. Today the list comprises 1610 species, representing 43 families and 195 genera. The chart (Fig. 1) presents 10 families and genera with the highest number of WRCP species. The list is not just an enumeration of updated nomenclature combinations; it provides information on the distribution of the species, their taxonomic composition, growing habits, ways of utilization, etc. Such information on every species is loaded into the database “Wild Relatives of Cultivated Plants in Russia”. This database serves as a multifunctional tool for further analysis of WRCP.

The latest version of IRS contains the data of nomenclature (Latin and Russian names of the taxa, including nomenclature synonyms) and general characteristics of WRCP species occurring in Russia (Fig. 2). General characterization includes: the rank according to the degree of relationship with cultivated plants, distribution pattern (general and more specific within Russia), most typical habitats, life form category, ways of utilization, and conservation criteria (Fig. 3). At present, the description of each species is being supplied with digital photos of a
specimen from the VIR’s Herbarium collection, an image of the plant in its natural habitat, and a map of its area of distribution (this work has already begun). All the information in IRS is provided with references to the publications concerned. The system makes it possible to search and select data concerning nomenclature, geography (regions, administrative provinces and districts of Russia, natural reserves), utilization characteristics, ranking groups according to the degree of their relationship to cultivated plants, and conservation criteria. It is also possible to make a search of species on multiple queries. The results of the analysis of WRCP species according to the ways of their utilization showed that unquestionable leadership belongs to forage plants, followed by food (fruits, berries and vegetables), and industrial plants (Fig. 4).

Geographic analysis demonstrated (Fig. 5) non-uniform distribution of WRCP species over different regions of Russia. From floristic point of view, the European part of Russia is very diverse, blending together floras of various genera; that is why the greatest number of WRCP species (838) occur within this territory. Most of these species are those widespread throughout the Holarctic floristic realm. The Caucasus, on the whole, cannot be numbered among the largest by its size, but this region is one of the richest as far as WRCP species are concerned (738). The flora of the Russian Far East is influenced by the East Asiatic centre of species’ formation, therefore the local range of WRCP is quite unique and contains numerous species which occur only within this territory (223 out of 598). The least in number of WRCP species is Western Siberia (529).

3. Selection of a conservation object, i.e., priority species for conservation

In order to select a conservation object we identified criteria of conservation priority for Russia’s WRCP species. There are two criteria:

a) The relationship and economic value, consisting of the following parameters:
   – participation in the breeding process (direct utilization, participation in hybridization, utilization as a donor of useful properties or as seedling stock, etc.);
   – the extent of applicability for economic purposes; and
   – systematic closeness to a cultivated species.

b) The rarity and vulnerability.

Each species from the WRCP list needs to be analyzed according to both criteria. The analysis based on criterion (a) has divided (classified) the list into 5 groups (Table 2).

Table 2. Ranking groups of WRCP in Russia (Total of 1610 species)

<table>
<thead>
<tr>
<th>Ranking group</th>
<th>What species are included?</th>
<th>Number of spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The species is cultivated, contains varieties and is economically important</td>
<td>189</td>
</tr>
<tr>
<td>2</td>
<td>The species participates in crosses and is used as seedling stock or a source of genes</td>
<td>72</td>
</tr>
<tr>
<td>3</td>
<td>Promising for utilization; closely related to a cultivated species (within one section or one subgenus)</td>
<td>169</td>
</tr>
<tr>
<td>4</td>
<td>Other useful species of the same genus, objects of plant hunting and folk breeding (no varieties)</td>
<td>350</td>
</tr>
<tr>
<td>5</td>
<td>All other species of a given genus</td>
<td>856</td>
</tr>
</tbody>
</table>

It appears that among all WRCP species only 189 fall into the first ranking group, which means that only one tenth of the national useful plant genetic diversity is intensively utilized in agricultural production. The plants of the first two groups (261 species) are most actively used in crop breeding work. The species of the third and fourth groups represent potential reserve for economy, hence they
are also potentially important, interesting for researchers, and hold promise for utilization. In each ranking group the following plant families comprised the largest numbers of species (Table 3).

Table 3. Results of the analysis of WRCP ranking groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Family</th>
<th>Number of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Poaceae</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Rosaceae</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Fabaceae</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Brassicaceae</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Apiaceae</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Fabaceae</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>Poaceae</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Rosaceae</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Poaceae</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Fabaceae</td>
<td>19</td>
</tr>
<tr>
<td>III</td>
<td>Rosaceae</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Grossulariaceae</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Alliaceae</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Poaceae</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Rosaceae</td>
<td>38</td>
</tr>
<tr>
<td>IV</td>
<td>Fabaceae</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Alliaceae</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Grossulariaceae</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Poaceae</td>
<td>218</td>
</tr>
<tr>
<td></td>
<td>Fabaceae</td>
<td>147</td>
</tr>
<tr>
<td>V</td>
<td>Rosaceae</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Alliaceae</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Papaveraceae</td>
<td>53</td>
</tr>
</tbody>
</table>

In terms of significance of criterion (b), rarity and vulnerability are most important. WRCP species have unequal degrees of rarity, vulnerability, threat of extinction, etc. Some of them are listed in the international and regional “Red Books” and attributed to different categories of rarity according to the IUCN classification. Such species are accorded top-priority for in situ conservation. They should also include local endemics and subendemics of various regions as well as, in some cases, relics of different epochs, and WRCP species having only a small part of their areas of distribution within Russia.

Having analyzed the ranking list of WRCP according to both criteria, we identified a group of WRCP species requiring urgent conservation measures (priority objects for conservation) within their natural coenoses (in situ). This group comprises the species of WRCP referred to the above-mentioned categories of rarity and local endemics and subendemics of different regions of Russia; the most important from economic viewpoint are those included in the 1st and 2nd ranking groups. At present the list of priority conservation objects contains about 340 species of WRCP.

4. Selection of conservation sites. In order to determine which territory should be assigned for conservation of priority species, it is necessary to analyze their areas of distribution. Mapping of the areas of priority species for conservation is based mainly on the geographic data on the labels of herbarium specimens, information from the sites where collection accessions were found, published maps of plant species’ areas of distribution, and literary references concerning their distribution. The process of area mapping has several components. Crucial principles of mapping are the following ones:
a) The areas are drawn with the help of GIS technologies, making it possible to superimpose points or contours of the areas of distribution with the maps of vegetation types, soils, climate conditions, and any other layers.

b) The areas are drawn on the background of the vegetation map because it helps, on the one hand, to outline the regions of plant distribution more precisely and, on the other, to predict promising sites for WRCP exploration, collecting and conservation.

c) The areas are drawn on the basis of the map of the former USSR. It would help to set the boundaries of the areas and analyze them more correctly.

Superimposition of the area maps of priority taxa for conservation makes it possible to identify the places of their highest concentration – the so-called “concentration zones”.

It is impossible to conserve all priority species not only throughout all their natural habitats in Russia and adjacent countries, but even within the limits of the identified areas in Russia. There is also no possibility to arrange special reserves for their conservation even at the sites where there is maximum concentration. A group of WRCP species are now under threat of extinction and require urgent protection. The most realistic possibility is to preserve these species within the existing network of Protected Natural Territories (PNT) which has been functioning in Russia. For this purpose, we have made a conjugate analysis of the databases “Wild Relatives of Cultivated Plants in Russia” and “Vascular Plants in Russian Reserves”, which allows us to investigate WRCP within the national network of natural reserves. It appeared that the territories of 91 reserves (out of 100 functioning in October 2004) harbour 1147 species of wild crop relatives from 39 plant families, i.e. 71.2% of their total number. About 29% of all WRCP (463 species) do not occur in any of Russia’s natural reserves (they have not yet been spotted). The ranking scale of the species is presented below:

Table 4. Ranking scale of WRCP.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Number of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>158</td>
</tr>
<tr>
<td>II</td>
<td>45</td>
</tr>
<tr>
<td>III</td>
<td>112</td>
</tr>
<tr>
<td>IV</td>
<td>245</td>
</tr>
<tr>
<td>V</td>
<td>587</td>
</tr>
</tbody>
</table>

The WRCP most actively used by breeders (those of the first two ranking groups) are represented in the reserves by 203 species (approximately 18% of the total number of WRCP). A very high number of WRCP species (408, or 36% of their total number), was found at the site of only one of Russia’s natural reserves. The greatest number of WRCP species occurs in the reserves of the Caucasus, southern mountains of Siberia, maritime areas the Far East, and the southern areas of the European part of Russia (Table 5).

Table 5. WRCP species in the reserves of Russia (the total numbers of species in the protected flora are indicated below in parentheses)

<table>
<thead>
<tr>
<th>Reserve</th>
<th>Total Number of Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kavkazsky</td>
<td>246 (1439)</td>
</tr>
<tr>
<td>Altaisky</td>
<td>237 (1357)</td>
</tr>
<tr>
<td>Khopersky</td>
<td>231 (1159)</td>
</tr>
<tr>
<td>Lazovsky</td>
<td>230 (1272)</td>
</tr>
<tr>
<td>Tsentralno-Chernozemny</td>
<td>228 (1036)</td>
</tr>
<tr>
<td>Bolshekhekhtsyrsky</td>
<td>175 (944)</td>
</tr>
<tr>
<td>Ilmensky</td>
<td>173 (936)</td>
</tr>
<tr>
<td>Sikhote-Alinsky</td>
<td>172 (1064)</td>
</tr>
<tr>
<td>Privolzhskaya Lesostep</td>
<td>171 (824)</td>
</tr>
<tr>
<td>Sokhodinsky</td>
<td>169 (988)</td>
</tr>
</tbody>
</table>
18 species of WRCP were included in the Red Book of the RSFSR (1988) (Table 6).

Table 6. WRCP species included in the Red Book of the RSFSR (1988).

<table>
<thead>
<tr>
<th>Species</th>
<th>Red Book 1988</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Allium altaicum</strong> Pall.</td>
<td></td>
</tr>
<tr>
<td><strong>Allium pumilum</strong> Vved.</td>
<td></td>
</tr>
<tr>
<td><strong>Armeniaca mandshurica</strong> (Maxim.) Skvortsov</td>
<td></td>
</tr>
<tr>
<td><strong>Asparagus brachyphyllus</strong> Turcz.</td>
<td></td>
</tr>
<tr>
<td><strong>Corylus colurna</strong> L.</td>
<td></td>
</tr>
<tr>
<td><strong>Elytrigia stipifolia</strong> (Czern. ex Nevski) Nevski</td>
<td></td>
</tr>
<tr>
<td><strong>Festuca sommieri</strong> Litard.</td>
<td></td>
</tr>
<tr>
<td><strong>Ficus carica</strong> L.</td>
<td></td>
</tr>
<tr>
<td><strong>Juglans ailanthifolia</strong> Carr.</td>
<td></td>
</tr>
<tr>
<td><strong>Lathyrus litvinovii</strong> Iljin</td>
<td></td>
</tr>
<tr>
<td><strong>Lespedeza tomentosa</strong> (Thunb.) Maxim.</td>
<td></td>
</tr>
<tr>
<td><strong>Medicago cancellata</strong> Bieb.</td>
<td></td>
</tr>
<tr>
<td><strong>Poa radula</strong> Franch. et Savat.</td>
<td></td>
</tr>
<tr>
<td><strong>Prinsepia sinensis</strong> (Oliv.) Bean</td>
<td></td>
</tr>
<tr>
<td><strong>Rheum altaicum</strong> Losinsk.</td>
<td></td>
</tr>
<tr>
<td><strong>Secale kuprijanovii</strong> Grossh.</td>
<td></td>
</tr>
<tr>
<td><strong>Staphylea colchica</strong> Stev.</td>
<td></td>
</tr>
<tr>
<td><strong>Viburnum wrightii</strong> Miq.</td>
<td></td>
</tr>
</tbody>
</table>

Six species were found to be included in the International Red List of Threatened Species: *Allium altaicum* Pall., *Allium pumilum* Vved., *Elytrigia stipifolia* (Czern. ex Nevski) Nevski, *Secale kuprijanovii* Grossh., *Medicago cancellata* Bieb., and *Staphylea colchica* Stev. Thus, the future of the species within the boundaries of protected areas seems more favorable than the future of the species that occur beyond these boundaries. The species that never occur in any of the reserves have already been identified. Among them are the wild persimmon *Dyospirus lotus* and pomegranates, *Punica granatum*, that are growing wild.

The sites outside the protected areas where WRCP are concentrated could be transformed into microreserves and used either to establish new protected areas or expand the existing ones. WRCP species will be the major objects of protection within these sites. We consider these components of the strategy more or less developed. The next stage of work is already underway including development of a monitoring programme in order to formulate specific conservations measures.

5. Further study with the purpose of formulating conservation measures.

Development of specific conservation measures should be preceded by a thorough and comprehensive study of the conservation objectives, including their morphological, taxonomic, biological, geographic, ecological and other features. Therefore, in order to work out a monitoring programme, it is necessary to conduct complex (geobotanical, phytocoenotic, populational, etc.) research on each of the priority species. Most important are complex populational studies which should include not only the analysis of quantity, structure and productivity, but also the assessment of the value of a population and prognosis of its viability. Special attention needs to be paid not only to the populations in the centre of a species’ area of distribution or (when such area is disjunctive by nature) in the centres of separate subareas, but also to marginal heterogeneous populations, as they incorporate original or, quite often, unique genetic information.

The results of these research efforts should be used to develop a system of monitoring for all priority species and specific measures of their conservation. Analysis of populations is to be performed on a yearly basis for annual species, once in 3-5 years for perennial herbaceous plants,
and once in 3-7 years for perennial trees and shrubs, depending on the object’s specificity and the status of its population.

6. Development of specific recommendations and conservation measures.  
In order to make a list of specific in situ conservation measures it is recommended:

- To address the staff of the natural reserves with the proposal to attribute the status of conservation objects to WRCP species; on the basis of floristic inventories of the reserves make the lists of WRCP priority species to be conserved in definite natural reserves;
- To supply the reserves with information on biological, geographical and ecological features of the species offered for conservation;
- To prepare documentation and other materials for the nature protecting authorities in order to justify the need to include WRCP in the lists of top-priority objects for in situ conservation within the protected natural areas, expand the territories of the existing protected areas and, in individual extraordinary cases, establish new protected areas of various ranks where WRCP species will be the major conservation objects;
- To make prognoses on the basis of monitoring results about the viability of local populations of the priority species within the protected natural areas; in the case when a population is reduced in number or threatened, provide local authorities, environmental agencies and staff members of the protected areas with recommendations concerning its conservation, maintenance in a balanced state and, in some cases, restoration of the population’s components;
- Issue recommendations for each object concerning the choice of conservation strategies, in situ or ex situ.

The experience accumulated by the world community observes that the most optimized solution of the problem is the application of a complimentary strategy of ex situ and in situ (including on farm) conservation, especially for the species whose populations are in an unbalanced state or under an actual physical threat of extinction. This strategy can be used as a model for different countries and other separated territories.

References


**In situ and Ex situ Conservation and Monitoring of Biodiversity in Arid and Desert Regions of Tunisia**

M. Neffati¹, and A. Ouled Belgacem²

¹Laboratory of Range Ecology, Institut des Régions Arides, 4119 Médenine, Tunisia. Email: Neffati.Mohamed@ira.rnrt.tn
²Laboratory of Range Ecology, Institut des Régions Arides, 4119 Médenine, Tunisia. Email: Azaiez.Ouledbelgacem@ira.rnrt.tn

**Keywords:** Rangeland, biodiversity, conservation, arid and desert, Tunisia

**Abstract**

Many research activities aiming at conserving and long-term monitoring of biodiversity in arid and desert regions of Tunisia were undertaken by the Laboratory of Range Ecology of the Institut des Régions Arides, Médenine (IRA). Established in 1986, the genebank of IRA safeguards and conserves plant genetic resources of species collected in arid and desert areas, characterizes and assesses the accessions in order to select the most promising accessions and to domesticate the most promising taxa. Continuous experiments on seed viability as well as the effects of the different abiotic stresses (drought, temperature and salinity) on germination capacity are carried out in order to study the germination characteristics and to optimize the conditions for seed conservation.

On the other hand, as Tunisia has established many national parks and natural reserves in different bioclimatic zones of the country, our program is concerned with the dynamic monitoring of plant diversity within the four arid and desert observatories (at Bouhedma, Sidi Toui, Oued Dekouk and Jbil). Each year, field data are collected both inside and outside the protected areas in order to assess plant cover index, density, vigor as well as biomass and range value of the plant cover. For plant communities’ dynamics assessment, periodic vegetation maps are also charted by using GIS tools. In this paper the main results of biodiversity conservation and monitoring in arid and desert zones of Tunisia are presented and some suggestions for a sustainable use of plant biodiversity are proposed.

**Introduction**

More than 80% of the rangelands which cover about the third of the agricultural area of Tunisia are steppe under arid and semi-arid bioclimates, receiving a mean annual rainfall of less than 350 mm (Neffati and Akrimi, 1996). Their plant species diversity, expressed as number of plant species per 1000 km², was considered as the highest in Northern Africa (Le Houerou, 1992). However under the combined effects of the regression of their habitat (Le Houerou, 1969; Le Floc’h et al., 1992) and ever-increasing livestock numbers (Chaieb and Zaafouri, 2000), plant species diversity is declining rapidly. In fact, covered essentially by very sparse steppic plant communities (Floret et al., 1983), the arid and desert areas of Tunisia are actually more or less marked by various human activities impact (Le Floc’h, 1995). This impact is more important under the combined effect of the sedentary growth of rural population (Le Houerou, 1984; Neffati et al., 1986; Akrimi and Neffati, 1993). In addition to the decrease of the rangeland areas due to cultivation, overgrazing has been the most important cause of the rangeland qualitative deterioration as expressed by the disappearance of palatable species (‘decreasers’) and the expansion of ungrazed species (‘increasers’) (Ayyad and El-Kadi, 1982; Akrimi and Neffati, 1993; Le Floc’h, 1995).
The combination of all these factors leads to a certain standardization of the structure and the plant community composition, which presented a high diversity of species and a complex mosaics of vegetation. To limit damages generated by different constraints and disruptions on plant cover as well as on physical environment and to encourage the auto-regeneration of natural habitats, it seems absolutely necessary to reduce the human pressure on these precariously balanced ecosystems. The application of restoration techniques to ecosystems (Aronson et al., 1993), still resilient and threatened in their existence is possible by assuring total protection during variable periods according to the degree of the deterioration. This could be able to, in some situations, become the means of natural regeneration of these ecosystems (Zaafouri and Chaieb, 1999). The creation of a substantial number of well-managed natural parks and natural reserves constitutes one of the necessary conditions, therefore, to assure durability of ecosystems and genetic heritage and therefore contributes to in situ conservation of species and varieties (Ramade, 1997; Le Floc'h and Aronson, 1995).

The management technique, based on the in situ conservation, has been applied extensively throughout the world and mainly in the European countries (Ramade, 1997), and in the arid zones of Australia and United States and in dry tropical Africa (Grouzis, 1988). In Tunisia, fencing has achieved various ends (rangeland improvement, sand dune stabilization, national parks,...) as well as some more encouraging results according to conditions of their application (soil conditions of the target site, stage of deterioration) (Le Houerou, 1977; Telahigue et al., 1987). Sandy steppes, which do not reach an irreversible degradation stage, are characterized by a faster resilience capacity than loamy or gypsum steppes. Indeed, until a certain stage in the deterioration of the plant cover is reached, it is possible to encourage its regeneration. Especially in case of the most palatable species such as, grasses and legumes according to the protection period length.

In order to promote in situ conservation of the genetic resources of the country, Tunisia has created a set of national parks and nature reserves within different bioclimatic zones. These parks constitute a shelter for plant and animal species. They offer to those involved in ecosystem rehabilitation the possibility to identify and to protect threatened species, and sometimes, even to help the reforestation of degraded areas. In some cases, qualitative and quantitative deterioration of plant cover has led to desertification in Tunisia. The results of introducing exotic species intended to restore and improve degraded rangelands have been discouraging so far (Zaafouri, 1993). This failure and the genetic erosion of plant diversity have led to an increased interest in indigenous multi-purpose plants since few years ago.

A gene bank for indigenous plant species of the arid and desert zones was created in 1986 at the “Institut des Régions Arides” (IRA) in Médénine, Tunisia. The program has been considered as one of Tunisia’s national priorities and has received important financial and technical support from international, regional and national institutions. It was retained as one of the highest priority programs within the framework of the National Strategy to Combat Desertification and the National Program of Biodiversity Conservation. The objectives of this genebank can be defined as follows:

- Safeguard and conserve multi-purpose genetic resources in the arid and desert zones;
- Characterize and assess collected plant material in order to select the most promising accessions;
- Domesticate the most promising taxa.

In this paper, the main activities related to both in-situ and ex-situ conservation of plant biodiversity undertaken in the Laboratory of Range Ecology as well the other main results achieved are presented.
Methodology

*In situ conservation and long term monitoring of vegetation*

Three national parks: Bou Hedma, Sidi Toui and Oued Dekouk located in a region laying within aridity and continentality gradients (Fig. 1), represent excellent *in-situ* conservation sites and are considered as observatories for biodiversity long-term monitoring. The main characteristics of these parks are presented in Table 1.

---

Fig. 1. Geographical location of the three studied national parks.

Table 1. Characteristics of the studied National parks

<table>
<thead>
<tr>
<th>National park</th>
<th>Date of creation</th>
<th>Area (ha)</th>
<th>Mean annual rainfall (mm)</th>
<th>Dominant plant species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bou Hedma</td>
<td>1980</td>
<td>16,480</td>
<td>150 (in plain) – 300 (in mountains)</td>
<td>Pseudo-savanne of <em>Acacia raddiana</em>, <em>Cenchrus ciliaris</em>, <em>Hammada scoparia</em>, <em>Rhanterium suaveolens</em></td>
</tr>
<tr>
<td>Sidi Toui</td>
<td>1991</td>
<td>6000</td>
<td>100</td>
<td>Steppes of <em>Rhanterium suaveolens</em>, <em>Antyllis sericea</em> &amp; <em>Stipagrostis plumosa</em>, <em>Helianthemum kahiricum</em> &amp; <em>Gymnocarpos decander</em></td>
</tr>
<tr>
<td>Oued Dekouk</td>
<td>1994</td>
<td>6000</td>
<td>Less than 100</td>
<td>Steppes of <em>Hammada scoparia</em> &amp; <em>Helianthemum kahiricum</em>, <em>Hammada schmittiana</em> &amp; <em>Antyllis sericea</em>, &amp; <em>Retama raetam</em> &amp; <em>Stipagrostis pungens</em>.</td>
</tr>
</tbody>
</table>
Concerning the national park and biosphere reserve of Bou Hedma, it should be noted that only results of the plant biodiversity inside the zone 3, called Haddej protected since 1990 are presented in this paper. All of these parks contain a large number of endogenous plant and animal species, among them several rare species. The evolution of floristic diversity in these parks is being monitored and assessed. The results of this survey will be of great interest for in situ conservation of phytogenetic resources and for arid and desert rangeland management. It will be possible to assess the ability of the phytocenoses to auto-regenerate and to understand how the physical environment evolves according to the management methods. To meet the objectives, quantitative and qualitative measurements related to plant cover and diversity were periodically undertaken. In this paper, we will limit ourselves to presenting the main results of the last three years’ (2002-2004) investigation period about means of plant cover, flora richness and specific diversity indices as well as range value both inside the protected areas and in the grazed areas, considered as controls and located close to each park.

**Ex situ conservation**

**Target species**

Although the role of each single species in fragile ecosystems cannot be underestimated (Neffati and Akrimi, 1996), the above-defined objectives obliged us to rationalize the choice of target species. It would be unthinkable to use all of the 1300 species reported in southern Tunisia. We have, therefore, deliberately limited ourselves to perennials (and some biannual species that were interesting), which make up the bulk of the steppic vegetation in Tunisia. This choice had to do with the climatic particularities of the arid regions and the biology of the established plant species (Le Floc’h, 1990; Neffati, 1994). At the beginning, we favored range species, by giving more weight to criteria that define a good pastoral plant. But, recently, we are also interested in other species that exhibit other uses (medicinal, aromatic, herbal, sand dune fixation, etc.) and can be classified as multi-use plants. Some toxic species, previously considered useless, are now being conserved and studied because of their medical or industrial potential. Several steppic perennials have already many uses as pastoral, medicinal, aromatic, culinary (as condiments) or ornamental plants. Others, besides their ecological value for the desert ecosystems, are used in soil fixation, rangeland restoration and rehabilitation of neglected water and land resources. Among these species, we focused more on those of immediate interest, threatened by disappearance, or endemic to the region, especially those presenting an intra-specific diversity.

**Methods of conservation**

**Live conservation of spontaneous plants: the pastoretum and the genetic collection**

The field genebank is a live collection of spontaneous plants of arid and desert regions that we called “pastoretum”. In addition to its educational purposes, the pastoretum provided plant material for our research activities. After identification of the target species, we localized the sites where they were well represented and we organized field missions to collect seeds and vegetative material. So far, we collected 300 accessions (species, subspecies and varieties). These accessions were installed in a field near the headquarters of IRA in Médenine. The climate here is Mediterranean of the lower arid type with a temperate to mild winter. The soil is a shallow (40-50 m) calcareous loam sandy sierozem, over-laying a gypsic crust horizon. The accessions were established in 3-m long lines, 1 m apart. Irrigation was necessary during the establishment period, which generally did not exceed the first growing season for most species. Some species such as *Argyrolobium uniflorum*, *Ebenus pinnata*, *Launaea resedifolia*, *Diplotaxis harra*, and *Cleome Arabica* showed little persistence and needed to be regenerated every 2-3
years. Other species could self-propagate vegetatively so they extended beyond the sowing lines (*Plantago albicans* and *Anvillea radiata*). Grasses and legumes dominate the collection because of their high pastoral value. But the collection hosted also a large number of other species such as *Stipa lagascae*, *Cenchrus ciliaris*, *Argyrolobium uniflorum* and *Lotus creticus* which could prove valuable in rangeland rehabilitation. We are in the process of assessing their intra-specific genetic diversity. The collection is being also enriched with exotic species from seeds provided from international institutions. These species came from other arid regions in the world and can be of high range value for Southern Tunisia.

### Seed collecting

Campaigns to collect seeds have been organized in different bioclimates of the arid and desert zones of Tunisia. Depending on species, either we collected seeds or the whole aerial part of the plant. The seeds were air-dried, then threshed and cleaned manually or mechanically, depending on their size, shape, and availability of appropriate equipment. In all, seeds of 150 of the most promising species have been collected during the last twenty years. Owing to the poor state of the most Tunisian rangelands, most seeds were collected from protected areas and remote and inaccessible sites. Quantities of collected seeds varied from year to year due to erratic weather conditions and changes in criteria for selecting target species. During the last few years, we focused our attention on fewer species because of what we know about their range value and the possibility to domesticate them.

### Results

The main results achieved by the program of *ex situ* conservation were:

- Development of suitable techniques for collecting, cleaning and storage of seeds of several promising species (a manuscript describing these techniques is under preparation);
- Monitoring seed viability;
- Determination of optimal germination and growing conditions (resistance to different stress types such as drought, high temperature and salinity) for some target species;
- Supply of standard plant material of some promising species (*Rhus tripartitum*, *Periploca laevigata*, *Stipa lagascae*, *Atriplex* spp., etc.) to commercial operators. Two shrub species, *Periploca laevigata* and *Rhus tripartitum*, are currently used on a large scale to replace introduced species in rangeland reseeding programs. However, demand for their seed exceeded available stocks and a nursery for seed production is badly needed;
- Technical assistance to Forest Services;
- Exchange of plant material with national and international partners;
- Increasing public awareness about the importance of plant diversity through field days with farmers and participation in local cultural activities;
- A searchable electronic database on the biology and ecology of the target species was established. In addition to the wealth of information it contains, the database helped us to better manage the collections of the seed bank. We kept records of the various activities of the seed bank, passport data of target species, information on collection sites, uses of plant material and routine maintenance activities. A numerical and sequential labeling system has been established as well.

### In situ conservation

*Plant cover*
The results of global plant cover determined both in the protected and in the neighboring grazed areas (used as controls) of the three national parks during the period 2001-2003, are presented in Table 2. This table shows that the pant cover is varying from the simple, in the grazed area, to the double in the protected area. The gap would be higher during the dry years, when the annual species, constituting the bulk of the plant cover in the grazed areas, are rare. The use of protection turned out to be beneficial on the total plant cover even though such effect decreases with the aridity gradient. In every case, the results shows that cover of the majority of species is higher inside than outside the three parks, and that good range value species (mainly grasses and legumes) are rarely represented outside the parks due to selective grazing.

Table 2. Evolution of mean global plant cover in the protected and in the grazed areas of the studied national parks during 2002-04 period.

<table>
<thead>
<tr>
<th>National park</th>
<th>Management</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bou Hedma</td>
<td>Protected area</td>
<td>55.3</td>
<td>56.78</td>
<td>84.11</td>
<td>65.39</td>
</tr>
<tr>
<td></td>
<td>Grazed area</td>
<td>32</td>
<td>28.15</td>
<td>43.8</td>
<td>34.65</td>
</tr>
<tr>
<td>Sidi Toui</td>
<td>Protected area</td>
<td>53</td>
<td>53</td>
<td>61</td>
<td>55.66</td>
</tr>
<tr>
<td></td>
<td>Grazed area</td>
<td>22.4</td>
<td>31.7</td>
<td>29.3</td>
<td>27.8</td>
</tr>
<tr>
<td>Oued Dekouk</td>
<td>Protected area</td>
<td>44.6</td>
<td>48</td>
<td>34.4</td>
<td>42.33</td>
</tr>
<tr>
<td></td>
<td>Grazed area</td>
<td>32</td>
<td>32</td>
<td>17</td>
<td>27</td>
</tr>
</tbody>
</table>

**Flora richness**

Concerning the diversity of plant species, Fig. 2 shows that the creation of national parks and natural reserves permitted the saving of more than the third of the flora of the area. For example, *Acacia raddiana* and *Periploca laevigata*, respectively, the two key species of Bou Hedma and Sidi Toui national parks are rare or have even disappeared outside the protected areas. Besides, and contrary to the common belief, the plant diversity seems to be higher in the more arid protected area (Fig. 2). This may probably be explained by the fact that the most arid park is subject to the combined effect of both Mediterranean and desert bioclimates in addition to the heterogeneity of its landscape and its geomorphology (sand, plain, mountains, saline depressions, etc.).

![Flora richness graph](image)

Fig. 2. Variation of the flora richness inside and outside the protected areas of the three national parks.

**Specific diversity indices (alpha diversity and equitability)**

The alpha diversity is defined as the diversity of species within the same plant community (Whittaker, 1972). Such diversity was assessed by using indices on the basis of some relative
parameters (specific frequency, relative abundance). The relative abundance of species permits us to determine the equitability (or the component of dominance of the specific diversity) which is very useful to detect changes of anthropic origin in species composition (Jauffret, 2001). The results of the variation of the specific diversity indices and the equitability determined both inside and outside the protected areas of the studied national parks are presented in Fig. 3.

![Graph](image)

Fig. 3. Variation of mean specific diversity parameters inside and outside the three national parks.

The analysis of this figure shows differences in both specific diversity parameters due to management practices, protection duration as well as aridity gradient. Diversity indices of Shannon-Weaver (alpha diversity) and of equitability were more important inside the less arid park (Bou Hedma); what translates in to an important abundance of species inside this park and therefore a higher ecological stability of the available plants. Indeed, an important equitability index corresponds to the favorable conditions for the establishment of many species and the dominance of some of them (Dajoz, 1975; Zala et al., 1997). It mainly corresponds to a high dominance of some species at the expense of others (Akpo et al., 1999). However, the more numerous the species, the higher the Shannon-Weaver index so that, at least, some of them may dominate whatever are the conditions. The ecological systems having more species should be steadier. If a disruption occurs in the environment, the dominant species will be able to protect the whole community.

Outside the parks, the low specific diversity indices reflect a rarefaction or even a disappearance of some plants, mainly those of good range value. This decrease of the indices, observed outside as compared to the inside of the parks, can be explained by a more fragile homogeneous system in its ecological contributions (Zala et al., 1997). According to Dajoz (1975), a low specific diversity index means unfavorable life conditions and the environment is characterized by few species, but each of them has generally many individuals. It can be explained by a very irregular distribution of the species cover and, their phenomena of high dominance (Akpo et al., 1999). In the case of inter-species competition for the appropriation of resources such as space, water and minerals, each gain achieved by a species is made to the detriment of one or several other less competitive species. This shows, that at the level of the ecosystem functioning, disturbance generated by overgrazing is not as harmful, because losses undergone by a given species (even of high range quality) are compensated by gains that it allows others to achieve (extension of undesirable species).
Range value
Measurements of the global vegetation cover and the species composition (perennials and annuals) and their palatability indices, permit the calculation of the range value both inside and outside of the three national parks. This parameter constitutes a good indicator of the rangeland quality. Means of three year investigation of the range values calculated inside as well as outside the protected areas are presented in Fig. 4. This figure shows that the range value is, in all parks, higher inside than outside the protected areas. Means determined in the grazed areas constitute, in fact half of those recorded in the fenced areas.

Fig. 4. Variation of the range value means inside and outside the three national parks

The considerable improvement of the quality of rangelands inside the three national parks can be explained by the fact that protection favors the development of good pastoral value species (especially the grasses). These results are similar to those obtained in the southern Tunisia by Waechter (1982) who observed a decrease of the range value under the effect of a high animal pressure. Deiri (1990) has, also, noted an increase of this parameter under the effect of protection. In the same way, Le Houerou (1995), in a survey carried out in Libya (mean annual rainfall of 120 to 250 mm) in five areas of severely degraded vegetation totaling 140,000 ha, showed that after five years protection, the range value of vegetation had tripled. The decrease of this parameter in grazed areas shows the degree of the specific selectivity that manifest livestock who graze there and provides indicators on the process of deterioration of the ecosystem (Yonkeu, 1991).

Conclusion
The study reports the main activities undertaken by the Laboratory of Range Ecology of the “Institut des Régions Arides” (IRA), Tunisia, in monitoring and assessment of the ex-situ and in-situ conservation of plant biodiversity. The main results show that:

- The creation of a genebank and a reference collection for the spontaneous plants of the arid and desert zones of Tunisia has proved to be of prime importance. They permit not only conservation of threatened species but also study of their seed viability and biology, and therefore their suitability for domestication and their use in revegetation programmes.
- The creation of national parks and protected areas allow us to conserve plant diversity and to improve plant cover and the productivity of the plant communities. The results of this survey are of great interest for in-situ conservation of phytogenetic resources as well as for rangeland management.
References


Wadi Sair Genetic Reserve Management Plan in Palestine

N. Al-Atawneh¹, A. Amri² and N. Maxted³

¹Ministry of Agriculture, Ramallah, the Palestinian Authority
²Biodiversity Project Coordinator, ICARDA, Amman, P.O. Box 950764, Amman 11195, Jordan
³School of Biological Sciences, University of Birmingham, Birmingham B15 2TT, UK

Keywords: Natural habitat, wild relatives, in situ conservation, management plan

Abstract
Biodiversity and agrobiodiversity in the Palestinian Territories is undergoing changes at an alarming rate and the extent of damage is making most of the land prone to degradation and desertification which is threatening the livelihoods of rural communities. Forage legumes have economic and agricultural values and are playing an important role as a fodder for animals with rangelands contributing 17-27% to their feeding calendar. Referring to the importance of these legumes, the Wadi Sair site was chosen to be a reserve for in situ conservation of forage legumes species mainly *Medicago*, *Trifolium*, *Vicia*, and *Lathyrus* species. Management plan of the reserve should be formulated to achieve the conservation objectives of the reserve. A decision must be made as to what sort of management interventions, if any, will be necessary to fulfill those objectives.

The management plan was formulated based on the eco-geographic survey which was carried out by the GEF/UNDP Project “Conservation and sustainable use of dryland agrobiodiversity in West Asia” in Palestine, and based on the data which was collected from the site, and based on the discussions with local community and the other key stakeholders. This was done to ensure the sustainability of the genetic diversity conservation at the site. This research has resulted in formulation of a management plan for this site which contains the preamble, conservation goals and obstacles, site description, information about the current status of the target taxa at the site, and the plan prescription which shows the suggested options and operational interventions that may be needed. Institutional and management arrangements and policy, add-value and alternative sources of income options for local communities among with designation process were also included in the management plan. A monitoring process should be conducted in the site to assess the temporal changes as well as the effectiveness of management options on diversity of target species and of the eco-system in general.

Introduction
Palestine lies within the Fertile Crescent where agriculture began more than 10,000 year ago. This area is also where species of global importance, such as wheat, barley, lentils, olives, etc., have been domesticated and subsequently spread to other parts of the world. Landraces and wild relatives of these and others species are still found in few remote areas of Palestine following the rapid loss of agrobiodiversity in recent times. During the latter period, agricultural land use has intensified and expanded, leading to degradation of natural resources including natural vegetation cover, agrobiodiversity, soil, and water. The valuable plant genetic resources have been seriously eroded due to the destruction of natural habitats through overgrazing of rangelands and the poor management of agricultural land. The population of Palestine is nearly 3 million, with an average growth rate of 3.6%. The population is expected to double by 2025
according to the Palestinian Central Bureau of Statistics. Agriculture is the major activity of most of the people living in the rural areas with livestock contributing significantly to their livelihoods and incomes. Natural habitats destruction and overuse of vegetation cover are threatening sustainability of the livelihoods of local herders and their pastoral communities in addition to the loss of valuable plant genetic resources that are essential to sustaining agricultural development and the overall food security. Overgrazing poses a particular threat to herbaceous species including wild relatives of crops like wheat, barley, vetch, clover and alfalfa. Species such as *Triticum turgidum* subsp. *dicoccoides* and wild *Lens* are already very difficult to find in the areas where they were reported in abundance earlier. Some of the wild relatives of the targeted species are now confined to field and road edges. Intensive agricultural practices following the field de-stoning using heavy machinery led to serious habitat destruction and fragmentation which are threatening the remaining populations of wild vetch, clover, alfalfa, wheat, barley and lentil in the region.

Traditionally, farming systems have maintained diversity in order to preserve stability of production under climatic, disease, and pest risks. The replacement of the traditional farming systems by modern agriculture is endangering these wild relatives and the landraces which are replaced by improved varieties or by newly introduced crop species. Land management plans are designed to preserve the remaining plant biodiversity rich areas while allowing for benefits to accrue in a sustainable manner to local communities and users. Wadi Sair pilot reserve is recommended within the exit strategies of the regional project on “Conservation and Sustainable Use of Dryland Agrobiodiversity Project in Jordan, Lebanon, the Palestinian Authority and Syria” to promote the in situ/on-farm conservation and sustainable use of wild relatives and landraces of agriculture species of local and global significance still found in the Palestinian Territories. The Project is funded by the Global Environment Facility (GEF) through United Nations Development Programme (UNDP) and is regionally coordinated by the International Centre for Agricultural Research in the Dry Areas (ICARDA). In the Palestinian Authority, the UNDP Program of Assistance to the Palestinian People (UNDP/PAPP) and the Ministry of Agriculture (MoA) are implementing the project in Hebron and Jenin districts.

**General characterization of Hebron target area**

Hebron is located in the southern part of the West Bank and constitutes three different ecosystems. Rainfall, temperatures, altitude, population, predominant land use and agricultural activities, are determined for the protected areas.

**Characterization of Sair selected area**

Forage legumes have economic and agricultural value and play an important role as fodder for animals. Rangeland contributes 17-27% to the feeding calendar. Hay is an important feed mostly for small ruminants and the Barseem (clover) and alfalfa are used as green fodder for cattle. Forage legumes species have the ability to grow vigorously under a wide range of environments including harsh conditions with poor soils. Wadi Sair with its topographic variation reflects high diversity of species especially of *Medicago* (Medics), *Vicia* (Vetch) and *Trifolium* (Clover). The distribution, abundance and frequency of these species are affected by various factors of genetic erosion, the main causes are: Overgrazing, urbanization, misuse of agricultural lands and unsustainable agricultural practices, and destruction of natural habitats. The on-going political situation and the lack of appropriate legislations are additional factors responsible for the degradation.
Management plan for Wadi Sair reserve

The management plan is designed to promote community-driven *in situ* conservation of species threatened in Wadi Sair area by demonstrating and recommending technological innovations, better management, added-value, that can generate alternative sources of income. This initiative can be supported by policy and legislation options. This management plan is the first of its kind dealing with the management and sustainable use of a designated site to conserve distinct species of global importance for food and agriculture. The plan has followed the framework proposed by N. Maxted, *et al* (1997).

The conservation objectives

1. To ensure long-term conservation and availability of agrobiodiversity especially of *Medicago, Lathyrus* and *Vicia* species which are still present at the site;
2. To promote alternative land uses which facilitate the conservation of target species while improving the livelihoods of local communities;
3. To increase national research capacity and provide training on *in situ* conservation techniques;
4. To encourage local authorities and empower local communities to contribute to integrated management of the ecosystems including the preservation of local agrobiodiversity;
5. To assess and monitor the trends in agrobiodiversity and understand better the major causes of its loss;
6. To combine conservation, management with eco-tourism as an alternative source of income for livelihood improvement.

Place of reserve in overall conservation strategy for the target taxa

The conservation of the globally significant agrobiodiversity is a priority for the MoA in the Palestinian Authority. *In situ* conservation strategy is considered as complementary to the *ex situ* strategy in conserving biodiversity in the area. Wadi Sair is one of the few spots remaining in Palestine that are rich in biodiversity. The trends observed in loss of local agrobiodiversity and land degradation call for the establishment of natural reserves with management plan to allow for conservation of the rich biodiversity in a sustainable manner. *In situ* conservation will complement target species collections that are stored *ex situ* while at the same time preserving the ecosystems as a whole and to benefit from the continuous effects of natural selection and evolution. This reserve in the southern part of Palestine will serve the conservation of the target species and will complement the Tayaseer genetic reserve in the northern part of Palestine (Jenin District). The Tayaseer site is owned by the church, and although the climate condition is some how different from the Sair site, the target Taxa are the same.

Target taxa

Wadi Sair natural reserve was designed to conserve feed legumes species but through the proposed management plan will allow the conservation of all ecosystem components including the targeted species. This approach will allow preservation of species richness and the related genetic diversity as well as the environmental benefits. This reserve will also serve, through rehabilitation and restoration efforts, to conserve wild fruit tree species endangered in the neighbouring areas. Special attention will be devoted to the conservation of the following species:

- *Medicago* (including Alfalfa):
Medicago is one of the major legume genera, that plays an important agricultural role as a nitrogen fixation agent and thereby improving the soil characteristics. The value of alfalfa (Lucerne) as animal feed is unparalleled. The quality of animal feed is measured by the Total Digestible Nutrients (TDN), which is a measure of the relative energy value of the feed. The crop with highest TDN is the best as a fodder for the animals. The TDN of the alfalfa hay per acre is higher than any other hay forage (Gateway organization). Animals can consume alfalfa as a food in different ways, depending on the methods of production used. It can be used as fresh green fodder; it can be used as silage (a moist feed which is preserved by fermentation in anaerobic conditions); it can be used as fields pasture on rangelands; and it can be used as alfalfa hay which the most common way.

Alfalfa is generally grown alone but can also be mixed with grasses or other legumes. It is used for green fodder, for hay or silage, and for pasture, although it does not tolerate grazing very well. The leaves are highly nutritive and are often dried for 2.5-5% inclusion in animal feeds as a source of vitamin A and other nutrients.

Most of the Medicago species recorded in Palestine are highly palatable pasture herbs which have been introduced as such into many other countries. They also constitute an important part of the grazing resources in the Middle East. The annual species of Medicago have been used as a source of germplasm for the alfalfa breeding programs to improve the productivity and for supplying nitrogen to other crops. Annual species have been extensively used as winter forage and green manure crops in the Mediterranean region. They have the potential for producing a high yield of quality forage, and could be used as short-season annual crops for harvest in autumn and summer when forage supplies may be inadequate.

- **Clover (Trifolium L.)**

Clover is a perennial but usually grows as a biennial, and in some situations it behaves as an annual. It is intermediate in size between white and red clover. Many smooth stems, bearing smooth trifoliolate leaves, arise from its crown. The non-creeping stems may grow to a height of 5 feet but usually reach about 2 feet. They bear flower heads along their entire length, the youngest always toward the top. It is a good hay, pasture, and green manure crop, and like other legumes, it improves the soil through nitrogen fixation and contributes towards reduction in soil erosion. In general, clovers inhabit temperate regions of the world. Cool moist climate is required, or growth is confined to the season of the year when cool climatic conditions prevail. Clovers will grow on many different soils if climatic conditions are favorable.

The beneficial effects of clovers have not always been known or appreciated by farmers. Bare fallow was a common practice (particularly among British farmers), and its replacement with clover met with some resistance. The clovers are among the most important plants for honey production. There are three main types of clovers that are of interest to beekeepers: white Dutch clover *Trifolium repens* L, red clover, and the sweet clover *Trifolium pratense* L. However, many other clovers are also important to bees.

A large number of the 46 clover species recorded in Palestine are very important as fodder and pasture plants. Some of them, e.g., *T. repens, T. fragiferum, T. alexandrinum, T. resupinatum, T. subterraneum*, have been in cultivation since ancient times. The others are basic components of natural pastures and potential fodder plants of the future. About 250 *Trifolium* species are described mostly in temperate Eurasia, Africa and America; the Mediterranean region is the main centre of distribution of the genus.
• **Vetch (Vicia L.)**

The genus *Vicia* contains several economically important foods and forage legumes species that have a centre of distribution in the Easter Mediterranean. Many species of this genus are well known forage plants. Some, *V. ervilia, V. narbonensis, V. sativa, V. villosa* and others are widely cultivated and most of their wild progenitors are indigenous to Palestine. Some of the species are highly polymorphic and not always clearly delineated. A most intricate complex is that of *V. sativa* and *Vicia villosa*. According to the abundance of the local forms of the species, they seem to be at present in the full process of speciation. Kupicha (1981) considers *Vicia* L. to comprise approximately 140 species, chiefly located in Europe, Asia and North America, extending to temperate South America and tropical East Africa. The genus is, however, primarily distributed throughout the Mediterranean and Irano-Turanian regions. Allkin et al. (1986) have increased the estimated number of accepted species to 166, which possibly errs on the conservative side.

• **Lathyrus L. (Grasspea)**

The genus is well placed to help meet the increasing global demand for animal feed and to provide crops for a diversity of farming systems, particularly when low neurotoxin lines are more widely available. To prevent genetic erosion and extinction, *Lathyrus* conservation has been given priority by the International Plant Genetic Resources Institute (IPGRI, now Bioversity International) since 1985. Many national programs and international bodies have launched germplasm collection and conservation activities of this under-utilised genus (Sarker et al., 2001). However, to date, an extensive and systematic approach to collect, conserve and evaluate *Lathyrus* has not been adopted and this deserves further attention. Furthermore, it is necessary to study the genetic diversity of the available collections in order to understand their full utilisation potential (Maxted et al., 2002). *Lathyrus*, which includes some 170 species (ILDIS, 2003), is distributed throughout temperate regions of the northern hemisphere and extends into tropical E Africa and into S America. Its main centre of diversity is in the Mediterranean and Irano-Turanian regions, with smaller centres in North and South America (Kupicha, 1981)

**Status of target taxa in Wadi Sair reserve**

The target taxa are distributed in almost all sites of the reserve area. Different populations of the target taxa are found in different places of the reserve. However, the density and frequency of the species is different from one place to another. We can find very good populations near the field borders and in the non-grazing areas. In general, the best populations of the target taxa are found along the valley that have deep and fertile soil, and good moisture content. Fortunately, these populations are protected to a large extent from animal grazing by local customs. These customs include leguminous species surrounded by the fruit tree orchards at the site.

The poor populations found along the hill tops of the site, grow on shallow soils that are not fertile, and these plants have suffered from severe animal grazing. This is so because most of the hill top areas are not cultivated hence they are not protected from grazing.

The *Medicago* species are observed in the southern and northern parts of the reserve area. However, the diversity tends to be higher in the southern part than in the northern part of the site. The following species are found at the site: *Medicago coronata, M. orbicularis, M. polymorpha; M. radiata, M. rigidola, M. rotata, M. tuberculata, M. doliata and M. scutellata.*

The *Trifolium* species are observed in the genetic reserve areas. The valley and the northern hillsides of the site tend to have the highest diversity with 8 different species of *Trifolium*
observed there. The following species are found at the site: *Trifolium campestre*, *T. clusii*, *T. lappaceum*, *T. leucaanthum*, *T. nigrescens*, *T. purpureum*, *T. scabrum*, *T. spumosum*, *T. stellatum* *T. tomentosum*, *T. repens*, *T. palaestinum* and other *Trifolium* spp.

The *Vicia* species were observed in the southern and northern hillsides of the site areas. They were observed heavily in the valley under the shrubs and the spiny bushes and at the borders of the fruit orchards, the species *Sarcopoterium spinosum* also playing an important role in protecting the *Vicia* species from the sheep and goat grazing. The following species of *Vicia* species were observed: *Vicia palaestina*, *V. peregrina*, *V. narbonensis*, *V. ervilia*, *V. sativa* and other *Vicia* sp.

*Lathyrus* taxa exhibit only three types showing the lowest diversity among the different targeted species in the monitoring sites in the reserve. The species are only observed in the southern part of the project monitoring areas of the reserve. The following species of *Lathyrus* species were observed: *Lathyrus aphaca*, *L. blepharicarpus* and *L. marmoratus* and few other *Lathyrus* sp.

The targeted species populations at the site are faced with different kinds of threats as mentioned earlier. However, the greatest specific threat is overgrazing followed by land reclamation for cultivation. Some of the farming practices such as weeding and ploughing play a major role in the genetic erosion of the target populations. Also, some areas of the reserve have been converted into fruit orchards resulting in habitat destruction. This has destroyed the target populations that were native to these places. The farmers reclaimed their land by removing the big stones from inside the fields and by building retaining walls using the same stones. This was followed by planting introduced or local fruit trees like apricot, grape, plums, almonds, etc. The stone cutting and quarries that are also present inside the site and the neighbouring fields threatened the through destruction of the habitats and the abundant dust generated by stone industry which causes pollution and decrease in the fertility of the flowers.

**Site evaluation and description**

**Site evaluation**

- **Populations of target taxa**

  The populations of the target taxa at the site are healthy and the frequency is good. Most of the populations of the target taxa can be found along the sides of the site, located mostly at the strips and the borders of fields. They are protected under the shrubs of other plants. Farmers’ practices like weeding, cleaning and ploughing can not reach these borders of the orchards. Also, these borders are protected from animal grazing by the farmers themselves. Hence, many of the target populations can be found along the borders at a high frequency. The populations that are growing on poor soils (low depth) seem to be weak because these shallow soils dry early after the rains. Also, these populations are suffering from grazing animals since they are located in open pasture lands.

- **Reserve sustainability**

  Local farmers over use is the main factor that can affect the sustainability of the Wadi Sair reserve as it consists of privately owned lands. The farmers have total control over these lands. A special committee of owner-farmers was formulated to represent all the farmers having land in the reserve with the responsible staff from the Directorate of the Natural Protected Areas in the MoA. However, there are many other factors playing important roles in the reserve sustainability such as government regulations and policy, legislation of the MoA, the strategies of the Ministry of Environment, the strategies of the Ministry of Industry and local government. There is awareness among all stakeholders of the importance of this reserve for future generations as a
source of genetic recourses. Therefore, it is crucial to protect this reserve from damage. Public awareness programs for all levels of people and local communities is an essential activity to be done along with implementation of the management plan for the reserve.

Monitoring system for the reserve was formulated by the GEF project staff and will be submitted to the MoA. The system will monitor the management activities to be carried out by the MOA staff and the farmers committee mentioned above. Monitoring is an important and effective step to ensure the validity of the management options of the reserve. Monitoring results will be used to check if the management options are playing a positive role in insuring the stability of the target populations frequency and abundance. The management plan needs to be revised regularly to achieve a good performance of the target populations at the site. Management options can be modified and improved based on the monitoring results.

• **Major constraints influencing reserve management**
  1. *Land tenure*: Wadi Sair reserve is located on privately owned land and this may play a negative role in implementing the proposed managing activities. For example, sometimes there may be a need to carry out some task at a designated place on the site. If the owner has any objection on the planned task, one cannot implement it accurately. The government needs to improve its legislation in order to align itself with the goals and objectives of the conservation, and also to protect the genetic resources from erosion.
  2. *Local farmers*: As mentioned before, local farmers are key to the development and implementation of the management plan.
  3. *Political consideration*: If the site is controlled by the Israeli authorities which have different goals, such as requisitioning the land to build settlements, the site will not be sustainable.
  4. *Industrial projects*: The site area is rich with the high quality of industrial stones so there is competition to establish stone quarries in the area. This constitutes the greatest threat factor of the reserve and is responsible for the genetic erosion in the area.
  5. *Agricultural practices*: Farmers like to use the land as fruit orchards to generate income. This requires the application of chemical fertilizers, and use of different kinds of pesticides. The introduction of new orchard species also is an unfavorable act and encourages the local variety replacement and this too does not contribute towards the conservation activities.
  6. *Land development (reclamation)*: The local communities in the Sair are likely to reclaim the virgin lands which are covered by natural grasses to convert them to terraced lands where different kinds of new varieties of fruit trees and field crops are cultivated. This causes changes in land cover and further erosion of the genetic recourses of the target taxa.

**Site description**

• **Site location**

Sair is located in the North-eastern region of the Hebron area. The area is dominated by strongly dissected hills. The main agricultural activities in this area are the cultivation of grapes, stone fruits, field crops and grazing of the natural grasslands. The Wadi Sair genetic reserve is located to the east of Sair town and extends from the middle of Sair village to Al-Baqaa plain and Tequoe in the east. The wadi has a fertile soil and the site there has an area of about 2 sq km. The area has a steep-sided north slope and less steep south slope. The dominant plant cover is wild grasses and shrubs such as: *Aegilops peregrine, Ae. ovata, Avena sterilis, Poa bulbosa,*

In the center of the wadi the soil depth exceeds 80 cm while on the steep sides the soil gets shallower. Wadi Sair has “Brown Rendzinas and Pale Rendzinas” as the dominant types of soil.

- **Climate**
  Wadi Sair is located in Hebron with a semi-arid climate and has an average rainfall around 400 mm and it decreases from the west of the valley toward the east considerably (Fig. 2) and the mean annual temperature varies from 19.4°C to 15.5°C, respectively.

- **Topography and soil**
  The area borders a narrow and steeper sloped strip. In that strip the altitude rises from 450 to 950 m above sea level. The average slopes vary between 17 and 23 degrees (Fig. 3). The area is dominated by Regosols. A total of 80% of the Wadi Sair area showed a soil depth of 10 to 15 cm. Of the remaining area, 10% had a shallow soil depth between 0 and 10 cm, and 10% had a soil depth of more than 50 cm. The soils in the Wadi Sair area are well drained. Wadi Sair area had a stoniness percent varying from 5% in the Valley to 40% in the hills and mountains. The maximum altitude in the Wadi Sair monitoring site is 883 meters whereas the minimum altitude is 742 m.

- **Land tenure**
  Wadi Sair is located on privately owned lands by the farmers from different groups in the village. All the land, whether it is cultivated, uncultivated, or rangeland, is owned by the local farmers from Sair village. Around 150 farmers have the rights over the land in the site. However, the project dealt with a committee which represented the farmers while discussing the management options of the site.

- **Land uses**
  There is currently no protection of biodiversity in Wadi Sair area. However, many of the local farmer’s practices are playing an indirect role in protecting the biodiversity. For example, the cultivated fruit trees orchards in the valley play a positive role in protecting the orchard edges from grazing. This is so because grazing is completely prohibited at these orchards so all kind of target grasses and weeds are indirectly conserved in their habitats. Also, most of fruit trees are landraces and local varieties, and they are conserved on-farm by the farmers. In total nearly 40% of the Wadi Sair site was located in cultivated land. Human management of this area was cultivation. The remaining was covered by shrub land and Grassland-Batha. This area was mainly managed by grazing and hunting.

- **Agricultural practices**
  The main agricultural practices at the site is the management for the cultivated lands which is being undertaken by the farmers themselves. The main focus is on traditional practices for the fruit trees orchards, like ploughing the land, fertilizing, pruning, and harvesting. Most of these practices are carried out by the farmers and their families. Some of the practices like using
chemicals need to be managed and modified to serve the biological conservation through the site management plan options.

- **Grazing pressure:**
  The cultivated part of the valley had a low grazing pressure as it is protected by the local farmers’ cultural practices and by the social customs in the area. However, the remaining part of the valley that is the largest suffers from high grazing pressure. The area of Sair, which is the area around the site, has many herders and several families depend on animals production. According to the MoA statistics there are around 5185 heads of local sheep and 3200 local goats which depend mainly on grazing, 300 improved sheep which depend partially on grazing, and 145 different other local animals. The area also has around 135 beehives inhabited by local bee colonies. These can play a positive role on the fertilization process of the wild plants and landraces on the site by increasing the efficiency of the pollination process.

- **Factors of degradation:**
  The site suffers from several kinds of degradation factors which affect the population of the target taxa. Also, the frequency and the abundance of the other plant populations at the site is affected. The natural habitat in general could be negatively impacted by these factors. The continuous presence of these factors will cause genetic erosion at the site which will lead to great loss of the useful genes and gene combinations from the target and non-target plant populations. The management plan should play a vital role to decrease this erosion and bring it to the minimum level, and to decrease if not to stop the harmful effects of the degradation factors. We can summaries the following degradation factors in Wadi Sair site: Use of improved varieties, over use, grazing, urbanization, decreasing farming, fire, land reclamation and quarries.

### Site objectives and prescription

**Management objectives are:**

1. To increase the benefits to local communities;
2. To protect the target populations from erosion and to enhance their spread and frequencies;
3. To create or improve habitats as to increase native species richness;
4. To make provision for scientific research and survey;
5. To act as a reservoir of biodiversity from which plants and animals my colonies newly-created habitats within the site;
6. To make provision for education, advice and dissemination of knowledge;
7. To welcome visitors for the quite enjoyment of the countryside; and
8. To involve local communities by encouragement of volunteers and maintaining liaison with neighbors communities.

**Management interventions**

To achieve these objectives there is a need to implement the management plan for the reserve site, which will control human intervention at the site. There are many farmers’ operations which are detrimental to local agrobiodiversity and they need to be changed: Cultivation, including ploughing, rotating, harrowing in the natural habitat of the site, overgrazing and overstocking, cutting of trees and over-harvesting of medicinal and herbal plants, excessive use of fertilizers and pesticides, burning and introduction of new crops. The site is also affected by the extension of urbanization and quarries. The farmers (local people) have the right to use their land freely and exploit the full production capacity of their fields at the site. However, this exploitation
should be in a wise and sustainable way, so that they should benefit from the use of the conserved plant genetic resources.

Management prescription

• Operational objectives and management options:
This section discusses the best technological and management options that can combine the preservation of local agrobiodiversity while enhancing the community returns and benefits.

• Target populations at the site

Overall objective: The main goal in designating Wadi Sair as a reserve is to conserve and maintain the genetic resources of the target taxa. The maintenance of numbers and diversity within target species is the basic goal of all in situ genetic reserves.

• Natural habitat improvement:

Overall objective: To rehabilitate and restore natural habitats and increase the genetic diversity within the site. The target populations are not the only ones at the site. There are many other populations around and there is interaction between them. Hence, the maintenance of the natural habitat at the site will support the conserved of the target populations.

• Research/Survey

Overall objective: To increase the knowledge of the importance of conserving plant genetic resources to provide data on which to base management decisions and to monitor the effects of management on habitats and species within the demographic and genetic context. Research and scientific studies are requested at the site as some of these studies will be related directly to management, and the drawing up of a research program will provide information on species and management techniques needed to enable the full potential of the site to be realized. Monitoring the effects of the present management is clearly an area where more work is needed. Ideally, a programme of plant monitoring is required to enable comparisons to be made between the various management regimes.

• Access

Overall objective: To allow access to visitors where it will not compromise the nature conservation of the site. The MoA, which is the national body responsible of the site, recommended that visitors should be encouraged wherever possible to promote agritourism. In response to this, the project team should produce various guidelines to help local teams realize the potential of the Wadi Sair site for public use without disturbing the conservation interest of the site.

Operational management objectives and prescriptions

• Operational objective: Maintain target population

Outline prescription:
1. Manage grazing by prohibiting any kind of grazing on the site from January until June every year.
2. Stop the introduction of alien species.
3. Halt the introduction of exotic germplasm and local landrace replacement.
4. Maintenance of field’s borders and strips.
5. Maintain good relationship with neighbouring farmers.
6. Assist the farmer’s agricultural practices, to decrease dependence on chemicals which have a detrimental effect on the target populations (herbicides) and stopping weeding and destroyed population by green harvesting of the target species.

7. Collect mature seed of the target species to be reseeded it in the next season to increase the frequency of the individuals.

- **Operational objective:** Improve the natural habitat at the site

**Outline prescription:**
1. Improve the grazing system at the site area and avoid overgrazing.
2. Stop the conversion of lands of the site to fruit trees orchards or any other kind of cultivation at the site.
3. Stop the industrial project and do not giving licenses to establish new stone cutting quarries.
4. Rehabilitate the old and failed quarries.
5. Stop wood cutting, medical plant collecting and the over use of other useful plants.
6. Encourage local farmers to keep bees at the site and thus promote plant diversity.

- **Operational objective:** Conserve the species diversity

**Outline prescription:**
Prepare collection mission from the specialized conservationists to collect mature target seeds, packaging the seed and store these seeds in the seed gene banks (ICARDA) under low temperature for long term conservation. This conserved material work as backup to compensate the genetic loss if happened because of any catastrophic reason.

- **Operational objective:** Make provision for scientific research and study

**Outline prescription:**
1. Compile list of topics for possible research and encourage use of the reserve for researching / survey with priority given to projects of direct relevance to the management of the reserve.
2. Design the monitoring system and the methodology of data collecting in order to benefit from the resulting analyses of the collecting data.

- **Operational objective:** Make provision for education, advice and dissemination of knowledge

**Outline prescription:**
Encourage educational programs by responding to requests for educational use of the reserve and provide interpretative material and guide walks as appropriate.

- **Operational objective:** Make provision for public access

**Outline prescription:**
1. Welcome visitors to the site by using a kind of propaganda for the public to visit the reserve for enjoyment.
2. Observe the effect of the public pressure and implement management projects to protect the sensitive protected areas.
3. Provide interpretative material and give guided walks and talks to increase public awareness of Wadi Sair reserve importance.

- **Operational objective:** Maintain safety of visitors to the reserve

**Outline prescription:**
1. Walkways, bridges, gates etc. regularly maintained in good order.
2. Remove dead or fallen trees from the walkways.
3. Provide the visitors with guide maps.
4. Provide the visitors with rented hats to protect from sun harm.

References
LRC, Arab Studies Society, 2002. The establishment of land information System for the purpose of enhancing municipal planning and supervision of the land and environmental in Hebron District.
Biodiversity Management of Forage, Pasture, Medicinal and Aromatic Species and Micro-organisms in Morocco

N. Saidi, C. Al Faiz and I. Thami-Alami

INRA, breeding and conservation of plant genetic resources unit, P. O. Box: 415, Rabat, Morocco
Emails: n_saidi@hotmail.com , faiz@awamia.inra.org.ma , thamialami_ma@yahoo.fr

Keywords: Genetic diversity, pasture, forage, species, medicinal and aromatic species, soil micro-organisms, ex situ conservation, Morocco

Abstract
As for the other Mediterranean countries, Morocco has a rich flora with an important number of endemic species which makes the country targeted for collection missions of plant genetic resources. These resources are undergoing genetic erosion at a speedy rate. In order to limit the loss of valuable genetic resources, the INRA-Forage unit has conducted many collection missions to gather pasture, forage, medicinal and aromatic plant species for further use and conservation. The collection maintained by the Forage unit is around 12,000 accessions conserved for medium term and 7000 accessions for long-term. Most of the collected material is of leguminoseae (77%) and less are of gramineae (23%). During the last two years more attention was given to collect medicinal and aromatic plant species. In addition to plant species, many surveys were conducted to gather micro-organisms related to some taxa mainly Medicago species.

Introduction
Morocco has a strategic geographical position which has engendered a great environmental diversification. Hence, Moroccan flora is considered as the richest and most diversified of the North African countries (Quezel, 1987) with for a total of 3675 native vascular plant species, of which 625 species are endemic to Morocco (Batke and Saidi, 1992). Around 200 endemic species are found to be rare or highly threatened. During the last decades, this diversity is undergoing genetic erosion due to several factors: Overgrazing of pastoral resources, drought, use of high yielding varieties and changes in cultural practices. All these factors have resulted in the loss of diversity in many plant species even before being catalogued, and in the rapid degradation of ecosystems and lands. In order to alleviate to the loss of economically important taxa and to decrease the tendency of plant species erosion, collecting and conserving the remaining biodiversity have become a necessity. INRA-Forage unit has granted a high priority to the plant genetic resources conservation and utilisation, especially for forage and pasture legume species and recently to medicinal and aromatic plant taxa. INRA has established a national genebank in Settat to gather a duplication of all accessions existing at different research units for medium and long-term storage. This paper gives an overview of the management of plant genetic resources at INRA-Forage and the constraints for long-term conservation.

Seed collection
During the last twenty years, many efforts were undertaken by INRA-Forage unit in collaboration with many foreign and international institutions to gather spontaneous forage and pasture species. Aware of the importance of medicinal and aromatic plant species, more attention was given lately to these taxa for further ex situ conservation and use. Therefore, many collection
trips have been conducted from 1983 to 2004 in different regions of Morocco (Table 1). All the collection missions were achieved in collaboration with national and international centres and institutions such as GTZ, ICARDA, IPGRI, CLIMA-WA, etc. In order to enrich the forage genebank and develop collaborative contacts, genetic resources were widely exchanged between INRA and international genebanks. Around 12,000 accessions are maintained for medium-term and 7000 accessions for long-term storage. Most of the collected materials are represented by pasture legumes mainly *Medicago* sp., *Trifolium* sp., *Vicia* sp., *Lupinus* sp., *Lathyrus* sp., etc. Gramineae species are of minor presence in our collection, the most occurring genus is *Avena*.

Table 1. Collection of forage and pasture plant species undertaken in Morocco by INRA-Forage unit

<table>
<thead>
<tr>
<th>Year</th>
<th>Collectors</th>
<th>Prospected regions</th>
<th>Sampled taxa (number of populations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>342</td>
<td>1994 P. Cunningham (APVI), L. Robertson (ICARDA), C. Francis, B. Reid (CLIMA), M. Bounejmate, N. saidi, A. Lahlou (PF)</td>
<td><em>L. angustifolius</em> (22), <em>L. atlanticus</em> (14), <em>L. cosentinii</em> (6)</td>
</tr>
<tr>
<td>1993</td>
<td>1994 L. Robertson (ICARDA), C. Francis (CLIMA), M. Bounejmate, N. saidi, A. Lahlou (PF)</td>
<td><em>Medicago</em> spp. (293)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1994 S. Sato, K. Tsurumi (KNAES) et E. El Ksiba</td>
<td><em>Festuca arundinacea</em> (10)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 C. M. Francis (WADA), M. Bounejmate, B. Baya (PF) et M. Derkaoui (CRRAS)</td>
<td><em>Festuca arundinacea</em> (43)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 M. Bounejmate (PF)</td>
<td><em>Medicago</em> (299), <em>Trifolium</em> (78), other legumes (43)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 M. Bounejmate (PF)</td>
<td><em>Medicago</em> (411)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 M. Bounejmate (PF)</td>
<td><em>Medicago</em> (270)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 M. Leggett (WPBS), Obani (IAV H II), S. Saida (PF)</td>
<td><em>Avena</em> species (1)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 M. Beuselink, J. Kirkbride (USDA/ARS), W. Graves (UC), C. Roberts (UM), A. Lahlou (PF), M. Derkaoui, S. Christiansen (CRRAS)</td>
<td><em>Lotus</em> (76), <em>Medicago</em> (36), <em>T. subterraneum</em> (9), <em>F. arundinacea</em> (16), other species (14)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 C. Al Faîz, A. Soulila (PF)</td>
<td><em>Avena</em> (812)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 B. Dourou et al.</td>
<td><em>Avena</em> (64)</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>1993 C. West (UA), S. Saida (PF)</td>
<td><em>Medicago</em> spp. et Hât Atlas (23)</td>
<td></td>
</tr>
</tbody>
</table>
Collection of micro-organisms

In addition to seed collection, INRA-Forage unit has at its disposal a collection of micro-organisms of around 150 strains. This collection is mainly of *Rhizobium* strains associated to *Medicago sp.*, *Lotus sp.*, *Scorpiurus sp.*, *Hedysarum sp.* and *Astragalus sp.* Also some strains of *Bradyrhizobium* for *Lupinus* species and lactic bacteria for silage are conserved. These strains were collected from different regions with different soil pH, and were selected for different characters such as: acidic and alkaline pH, high and low temperatures, salinity, resistance to antibiotics and heavy metals. The collection is maintained for medium-term in agar medium at 4°C and for long-term in glycerin at -20°C or by lyophilization (Table 2).

Table 2: Inventory of *Rhizobium*, *Bradyrhizobium* and lactic acid bacteria strains available at INRA-Forage unit

<table>
<thead>
<tr>
<th>Strains</th>
<th>Number</th>
<th>Characteristics</th>
<th>Storage form</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Rhizobium meliloti</em></td>
<td>24</td>
<td>Tolerant to low pH for <em>Medicago</em> spp. cultivation</td>
<td>Lyophilized ampulla</td>
</tr>
<tr>
<td><em>Rhizobium meliloti</em></td>
<td>18</td>
<td>Tolerant to soil salinity for <em>Medicago</em> sativa cultivation</td>
<td>Agar medium at 4°C and glycerin at –20°C</td>
</tr>
<tr>
<td><em>Rhizobium meliloti</em></td>
<td>5</td>
<td><em>Medicago arborea</em> cultivation</td>
<td></td>
</tr>
<tr>
<td><em>Rhizobium meliloti</em></td>
<td>8</td>
<td>Tolerant to frost for <em>Medicago aculeata</em> cultivation</td>
<td>Agar medium at 4°C</td>
</tr>
</tbody>
</table>

Avena species**:

Vicia species**:

Lathyrus species**:
- Lathyrus aphaca (7), L. articulatus (63), L. cicer (17), L. ochrus (5), L. sativus (9), L. t. tingitana (9), Lathyrus sp. (5).

Medicago species**:
- M. orbicularis (2), M. polymorpha (3), M. tornata (4), M. truncatula (1).

Trifolium species**:

Vicia species**:
- V. ervilia (15), V. faba (15), V. hirsuta (1), V. lathyroides (1), V. lutea (7), V. onobrychis (1), V. sativa spp. sativa (24), V. sativa spp. nigra (21), V. tenusina (1), V. villosa spp. dasyarpa (9).

Vicia species**:
- V. sativa spp. sativa (21), V. sativa spp. amphicarpa (1), V. sativa spp. nigra (8), V. lutea spp. lutea (17), V. lutea spp. hirta (9), V. hybrida (5), V. faba (2), V. villosa (3), Vicia sp. (2).

Lathyrus species**:
- L. cicera (11), L. clymenum (2), L. aphaca (1).

Medicago species**:
- M. littoralis (14), M. aculeata (14), M. polymorpha spp. polymorpha (11), M. laciniata (9), M. truncatula (4), M. orbicularis (1), M. tornata (1).
**Landraces collection**

Around 50 alfalfa local populations were collected from Moroccan oasis and mountain areas. These populations were characterised for agronomic traits (morphology and seed production) and for disease and salinity resistance.

**Database management**

In order to conserve all the information related to the collected and conserved genetic material, all passport data of the accessions, site description as well as evaluation and characterisation data are managed in a database using software packages. The aim of INRA-Forage unit is to make easier the access to the information to all scientists and to widen its database by sharing the information with national and international institutions and centres. Within the framework of collaboration projects between the INRA-Forage unit and international centres and institutions, we had some softwares which some were developed by our collaborators in order to exploit more the available information such as: Climex and ArcView programmes from CLIMA-UWA, and MF programme from ICARDA. In 1999, our database has served as a model to generate a software program 'GRIS' with IPGRI for data mapping. For safety storage, a duplication of our database is transferred to INRA National genebank in Settat.

**Maintenance of seed viability**

Over years, The INRA-Forage unit has accumulated thousands of accessions in its genebank. Most of the maintained accessions were characterised following the IBPGR descriptors, and safeguarded under international genetic resources standards of storage. In order to maintain the viability of the genetic material during storage, periodical seed germination tests of all the stored accessions according to ISTA standards are undertaken (Draper et al., 1985). The results of the test permits to detect the accessions in which seed viability has decreased and therefore should be regenerated in the field. Also, in order to satisfy seed requests and to update seed stocks, we permanently insure seed increase of the stored genetic material.

**Constraints for maintaining the collected genetic material**

The INRA-Forage unit genebank is holding a huge collection of different taxa of 12,000 accessions stored for medium-term and 7000 accessions for long-term. The INRA-Forage unit objectives are to safeguard genetic material for an *ex situ* conservation for future generations, maintain the material in best conditions of storage, update seed stock permanently to assess the viability of the seeds and have sufficient seed stock to respond to the requests made by national and international collaborators. However, many constraints are encountered to fulfill these goals mainly:

- Insufficient budget to maintain storing rooms and to repair equipments which insure storage conditions.
- Lack of qualified technical staff to undertake stock updating.
- Insufficient budget to cover systematic collection trips and field visits.
• Lack of scientific expertise specialised in plant taxonomy to help to collect new plant species, in seed physiology to help to understand the process of seed physiology during storage and also of alive collections, in plant ecology to understand the relation between plant taxa and their habitat.
• Assistance in database management by providing new software packages and training of the genebank staff to renew their knowledge, to well monitor the database and exploit all the available information.

Conclusion
Most of the undertaken collection missions were targeting essentially annual leguminoseae (77%) and less gramineae (23%). Occurring legumes are Medicago (38%), Trifolium (30%), Vicia, Lupinus, Lathyrus etc. The gramineae are mainly Avena (67%), Festuca (18%) and Dactylis (8%), the other genera are of minor presence. In general, perennial gramineae are almost rare in comparison to the other taxa. This status does not reply to our real needs because collections were mainly realised to respond more to international research programmes needs. From the Australian experience, the reduced size of the collection and the concentration on only some specific taxa has engendered the neglect of other plant species which can potentially be valuable alternatives (Francis, 1999). As the case of an ecotype of Bisserula pelicinus which CLIMA has registered as Casbah cultivar. This cultivar was released directly from a locally collected ecotype from Morocco and was sampled for its good performance. This taxa was not a target plant species during the collection trip but was gathered just because it was encountered on one of the prospected sites on which collectors were prospecting Trifolium species.

The collection data accumulated over years coupled with the information obtained from floras concerning species distribution, Robertson and Bounejmate (1999) have concluded that in Morocco, genetic erosion has already occurred for medic species. This is an alarming situation because other taxa are certainly affected by genetic erosion but not recorded. Therefore, urgent measurements should be taken to save as much as possible the remaining biodiversity by prospecting new areas which were inaccessible before and nowadays. Road constructions are improved, encouraging to access more sites for collection. Also, in order to well safeguard the collected genetic material, a duplicata of all the collections should be kept in another genebank. For that reason, INRA has established a national genebank at Settat in which all the genetic material which INRA holds in different research units will be gathered. Almost 40 % of the forage, pasture, medicinal and aromatic plant species of the Forage unit was already transferred to this national genebank along with the related information.

Plant genetic resources are the raw material of sustainable development of agriculture and forestry. These genetic resources are highly threatened by severe genetic erosion which has occurred in Morocco as in the whole Mediterranean region. Lately, a national study on the status of biodiversity was conducted, but this study does not concern all the taxa which exist in Morocco. Therefore, the INRA-Forage unit should contribute at some extent to complete the study by gathering the information on forage pasture, medicinal and aromatic plant genetic resources in Morocco by:
• Developing a baseline of the remaining diversity of pasture, forage, medicinal and aromatic plant species for measuring present rates and extent of genetic erosion.
• Undertake systematic collection missions of plant species as well as of their wild relatives in the same regions to assess the level of genetic diversity through years and determine any changes or shifts over time.
• Draw a map of pasture and forage species and determine the regions with high species diversity for further in situ conservation.
- Utilize the germplasm as a genebank not as a ‘Museum of genes’
- Use biotechnology techniques as new tools for research and exploration of genes of interest at a large scale (protection through patenting, PBR, etc.).
- Financial support is essential to contribute to efficiently conserve of genetic resources of local and global importance.

References
Promotion of Caper Production in the Northern Bekaa Valley of Lebanon

M. Mcheik, A. Assi, L. Awad, D. Mneyer, C. Khoury

Rural Development Project of the upper Bekaa Valley, Center of Irrigation Technologies and Divulgation, Jabouleh, Telefax 00 961 8 23 50 71, e-mail: http://www.lari.gov.lb
Lebanese Agriculture Research Institute, Tal Amara, P.O.Box 287 Zahleh, Lebanon, Phone 00 961 8 90 00 37 Fax 00 961 8 90 00 77, web site: www.rdpbekaa.org

Keywords: Caper, Capparis spinosa, production, conservation, uses, Lebanon.

Abstract
Caper (Capparis Spinosa L.), also known as caper-bush or Alcaparro, Caper is grown in some Mediterranean countries as a ‘weed crop’. It is cultivated for its flowering buds in some parts of Italy, Spain and Morocco. It is used as condiment in cooking and for flavoring in canapés, gravies, salads, and sauces, and steeped in vinegar as pickle for an appetizer. Medicinally, caper is known to be alterative, analgesic, anthelmintic, aperient, aphrodisiac, astringent, diuretic, stimulant and a tonic. Capers can be used also against rheumatism, scurvy, enlarge spleen etc.

Caper is found abundantly in the northern Bekaa Valley of Lebanon. It grows in calcareous soil in the arid and semi-arid regions, and is adapted to dry climates. The Rural Development project funded by Cooperazione Italiana has been working in collaboration with the Lebanese Agricultural Research Institute, and Caritas-Liban, towards strengthening the role of the rural communities in northern Bekka Valley, mainly promoting the role of rural women. In the village of Jabboulé, the support team works together with local farmers to produce wild capers as dried salted and pickled. In winter, a demonstration plot was cleared, then all the old and died branches were removed. To each plantlet, 400g of NPK fertilizer (17-17-17) was applied manually. Flowering buds were harvested before opening in June. Harvested buds were separated into three different sizes. Two different processing techniques, drying and pickling, were applied. In the drying technique, salt was added at a rate of about 30% of the weight of capers, and agitated daily for 8 days. Salt was added again to about 25% of caper weight and agitated for 10 days, when the dried and salted capers were ready for use as flavoring. In the pickling technique, five experiments were performed with different concentrations of salt and vinegar. It was found that 25% of salt and vinegar (0.5%) produced the best flavor and taste.

The difficulty of harvesting and the time-consuming processing make caper products commercially unprofitable. However, it may be profitable when new spineless varieties and better propagation methods are used for intensive cultivation. Should the market conditions improve, caper can play an important role in Lebanon by increasing household income, especially in the northern Bekaa Valley. The Rural Development Project has been focusing on the promotion of caper production through training and technical assistance to farmers, and on packaging and marketing of this food product.

Introduction
Caper (Capparis spinosa L.), also known as caper-bush or Alcaparro, is a 10 to 100 cm high shrub, with erect or ascending stems, which are divaricately branched. Leaves are petioled, ovate to orbicular obtuse ending in a prickle; uncultivated caper plants are more often seen hanging, draped and sprawling as they scramble over soil and rocks. The caper’s vegetative canopy covers
soil surfaces which helps to conserve soil water reserves; flowers broad fruit berry and are borne on first-year branches.

Caper can be found in some Mediterranean countries as a weed crop. It is cultivated for its flower-buds in some parts of Italy (1000 ha), Spain (2600 ha) and Morocco. It also can be used as condiment in cooking and for flavoring in canapés, gravies, salads and sauces. They are also, steeped in vinegar and used as a pickle for an appetizer. Sometimes caper sprouts are eaten like asparagus. The buds and shoots are also eaten in the same way. They are also grown for the large ornamental white and purple flowers. The roots and bark are used in medicine to prepared variously poultices and cataplasms. It is also drunk with wine or used with vinegar. Medicinally, capers are said to reduce flatulence and to be anti-rheumatic in effect. Capers have reported uses for arteriosclerosis, as analgesic, anthelmintic, aperient, aphrodisiac, astringent, diuretic, stimulant and tonic, and is also used in rheumatism, scurvy, and enlargement of the spleen. Infusions and decoctions from caper root bark have been traditionally used for dropsy, anemia, arthritis, and gout. Capers contain considerable amounts of the anti-oxidant bioflavonoid rutin. Caper extracts and pulps have been used in cosmetics, but there has been reports of contact dermatitis and sensitivity as side-effects associated with their use.

In Lebanon, caper is found in the northern Bekaa Valley in large quantities. It grows in calcareous soil in arid and semi arid regions, and dry heat and intense sunlight make the preferred environment for caper plants. Capers are productive in zones having around 350 mm annual precipitation and easily survive summertime temperatures higher than 40ºC. However, caper is a cold-tolerant, tender plant and has a temperature hardness range similar to the olive tree (-8ºC). In their native habitat, plants grow spontaneously in cracks and crevices of rocks and stone walls. Plants grow well in nutrient poor, sharply-drained, and gravelly soils. Mature plants develop large extensive root systems that penetrate deep into the earth. Capers are also tolerant to soil salinity and flourish along sandy shores including sea-spray zones. They are propagated from seeds or by vegetative cuttings.

The Rural Development Project, a development program of the Cooperazione Italiana in Lebanon, in collaboration with the Lebanese Agricultural Research Institute (LARI), and Caritas-Liban, is working towards strengthening communities in northern Bekaa Valley, and promoting the role of rural women. In the village of Jabouleh, where the project is centered, the support team works together with local women farmers to produce wild capers in dried, salted, and pickled forms. Rural women are the largest group whose participation should receive special consideration in the design and implementation of development projects. They participate unequally in all aspects of most development programs in the region; in decision–making, in implementation of new technologies, in deriving their benefits, and in evaluation of the programs. They play a major role in the agricultural production of societies, providing as much as 80 percent of the food supply in some community groups. Over half of the region’s population in the upper Bekaa Valley are women. However, the majority are illiterate and their opportunity for education is not equal to that of men. They are under-represented in the formal sector of the economy and in professional and managerial positions. Contrarily they are over-represented in the informal sectors: cultivation (45%), small scale trading and labor (10 %), and very few of them describe themselves as homemakers. The women have been integrated as producers of labor power, producers of subsistence foodstuffs for family consumption, and very often as unremunerated familial labor.

The objectives of this study were to point out the role of the Rural Development Project in the upper Bekaa Valley in promoting caper cultivation and to underline the future steps to be taken towards encouraging this cultivation in the northern Bekaa Valley.
Materials and Methods

Jabouleh village is in northern Bekaa Valley, 40 km from Baalbeck. It is a semi-arid region with an average annual rainfall of about 350mm. The mean altitude is about 850m above sea level, and the temperature ranges between 10°C-38 ºC in summer and 20ºC to -6ºC in winter. The daily evapotranspiration is about 6mm/day and the relative humidity ranges between 15-90 %. The average wind velocity is between 6 km/hr in summer and 30 km/hr in winter, its direction in general is south-north. The exposure to the sun is north-east in morning and west in the evening. Sometimes, especially in winter, there is fog.

The demonstration plot of caper is located in Jabouleh project area. This area is divided into 4 sectors, the total surface being about 88 ha. Every sector has a lack with 2000m³ capacity and all these lands are irrigated from Laboueh source, every farmer has 16 hours of water rights every 15 days and the flow rate irrigation is about 60 l/s. These lands are divided among 7 farmers, there are 61.8 ha cultivated areas, the big parts are plant trees and the rest are wheat crops and vegetables crops. According the test of soil analysis of samples that were taken from different parts of different sectors at different depth 30-60-90 cm: the soil grouped as clay-loamy, the average pH is 8, and their chemical constituents are: calcareous soils, medium presence of organic matter and there is deficiency of available nitrogen, potassium and phosphorous and it is very poor in iron and rich in magnesium. In winter, a demonstration plot was cleared, then all the old and dried branches were pruned, and this is to eliminate all the dried decade from the last production which is not necessary to the growth of capers and to reduce the quantities of backbone in branches in time of harvest, and for each plantlet a 400 g of NPK as percentage (17-17-17) was hand-placed. In June, the flowering buds were harvested by hand about every 8 to 10 days, resulting in 9-12 harvest times per season, then, three different sizes of caper flowering buds were taken.

Dried technique: the capers were washed and put in strainer, 30%-40% of salt (thick salt) of capers weight was added, for example for one kilogram of capers 300 grams of salt, and then the capers with salt were agitated at a daily-scale for a period of 8 days. Then, salt was added with another concentration, 25% of capers weight, were agitated for a period of 10 days. After 18 days the dried salted capers were ready for use as flavor in pizza, barbecue. In the pickling technique, four experiments were performed with different concentrations of salt and vinegar.

Results

From these experiments, the fresh capers with 25% of salt and vinegar (0.5%) were found to have a better taste and flavor (Table 1, Figs. 8 and 9). The time consuming and the difficulty of harvest caper make this product not profitable, so that it is better to considered it as a familial crop (Luxury product). However, caper can be profitable when varieties have been selected for spinelessness, round firm buds, and flavor and high-yielding caper, if the market conditions will permit it; caper can play an important role in Lebanon for increasing income per household per year, especially in the northern Bekaa valley due to its wide natural distribution under natural habitats. Currently, the rural development project is focusing on the promotion of caper production through training and technical assistance to farmers, and on packaging and marketing of this food products.

Table 1: Experimental caper processing techniques

<table>
<thead>
<tr>
<th>Experience</th>
<th>Salted capers</th>
<th>Fresh capers</th>
<th>Salt as brine (%)</th>
<th>Vinegar as brine (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+</td>
<td>-</td>
<td>20%</td>
<td>0.5%</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>+</td>
<td>25%</td>
<td>0.5%</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>-</td>
<td>5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>+</td>
<td>5%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Salted; 18 days in dry salt (250-300g in one kg capers), (+) presence and (-) absence
**Discussion**

The availability of caper with its high price in the entire supermarkets, its high food value, the suitable climatic conditions in northern Bekaa valley for the cultivation and the existence of wild caper in the region encouraged the RDP project to promote its cultivation and production by providing technical assistance and necessary brochure to explain methods of cultivation and its economic value to local communities. The cultivation of caper and the sustainable use of caper in wild will contribute to the preservation of natural habitats through diversification of incomes of local communities.

**References**


SESSION FIVE

TECHNOLOGICAL AND MANAGEMENT OPTIONS FOR CONSERVING AGROBIODIVERSITY INSIDE FARMERS’ FIELDS
The Relevance of On-farm Conservation of Landraces in Ecologically Sensitive Areas Under Low Input Conditions

L. Holly, Á. Gyovai, G.M. Csizmadia, and I. Már

Institute for Agrobotany, H-2766 Tápiószele, Hungary. Email: lholly@agrobot.rcat.hu

Keywords: On-farm, conservation, landraces, ecology, intensive agriculture

Abstract

Conservation of agro-biodiversity in ex situ collections and on-farm is the main concern of the Hungarian National Program for Plant Genetic Resources for Food and Agriculture maintenance and use. During the last 50 years, comprehensive collections of landraces and ecotypes of native field and vegetable crop species have been established as a result of systematic collection of locally adapted populations. In order to minimize selective changes, a backyard multiplication network was established and used for iso-climatic rejuvenation of landraces near the places of origin in the early sixties. As a result of the recognition of environmental problems created by the intensive, high input agricultural practices during the last decades, an initiative has been launched to establish appropriate measures in order to avoid further deterioration of soil, water and natural flora and fauna, especially in the fragile, marginal areas in Hungary. Several factors have been considered in a detailed survey, including soil, water and climatic parameters, in order to classify the lands into different categories and zones. It has been concluded, that approximately 1.5 million hectares should be withdrawn from intensive cultivation and 500 thousand hectares (so called Environmentally Sensitive Areas) should be converted into extensive, low-input cultivation in Hungary, in order to avoid further degradation and deterioration of the agricultural environment. The Institute for Agro-botany is undertaking a survey on the landraces earlier collected or still cultivated in three selected Environmentally Sensitive Areas. It has been concluded that these areas are especially suited for on-farm conservation of landraces originated in similar agro-ecological conditions. Their specific adaptation, tolerance to abiotic stresses, specific chemical composition, and taste and flavor may result in the successful cultivation under environmentally friendly, low input conditions. Our experiences could be utilized in other stress-prone sensitive areas for improving the maintenance of agro-biodiversity.

Introduction

Crop genetic resources are an integral part of overall biodiversity and represent indispensable resources for plant breeding, crop research, and education. In addition to their static (ex situ) conservation, it is considered increasingly more important to maintain them under dynamic conditions (e.g., in situ, on farm), which allows evolutionary changes to occur. Conservation of agrobiodiversity in ex situ collections and on farm is the main concern of the Hungarian National Programme for PGRFA maintenance and use.

Within the framework of the International Plant Genetic Resources Institute project on “Strengthening the scientific basis of in situ conservation of agricultural biodiversity” a country component for Hungary has been developed including research to assess species and genetic diversity in locally grown crops and sociological, economic and environmental (soil and climate) factors influencing the level of agrobiodiversity in three selected environmentally sensitive areas, viz., Szatmár-Bereg, Dévaványa, Órség-Vend regions. The potential role of these areas in sustainable use of plant genetic resources is summarized in this paper.
**Intensive agriculture**

“In the recent decades the development of the Hungarian agriculture was characterised by the drastic increase of the direct and indirect energy input. As a result of fast development, the yield per unit area has doubled in 25 years, the annual variance of yields has significantly decreased. While the intensive, industry like agriculture characterised by increasing industrial inputs and energy uptake has resulted in significant increases in yields the number of problems with adverse effects on the yields, local society and the global human environment grew sharply. Most of these negative signs were the results of the energy-intensive land use and the resulting pressure on the environment from direct (fuel propellants) and indirect (artificial fertiliser, chemicals) energy inputs, however problems outside the agriculture (industrial and communal pollution etc.) also played a major role. The first signs of these – interrelated – negative symptoms have been apparent in Hungary since the early 1970’s” (Ángyán et al., 2000).

**System of Environmentally Sensitive Areas (ESAs)**

As a result of the recognition of environmental problems created by the intensive, high input agricultural practices during the last decades, an initiative has been launched to establish appropriate measures in order to avoid further deterioration of soil, water and natural flora and fauna, especially in fragile marginal areas in Hungary. During the European Union (EU) harmonisation, the acceptance and application of the 2078/92 EU agri-environmental regulation on the support of agricultural production methods that are environmentally friendly, aims at the preservation of rural areas as the basis for Hungary to develop its National Agri-environment Programme (NAEP). For preparation of NAEP it was essential to establish the zonation system of land use of Hungary. Several factors have been considered in a detailed survey in order to classify the lands into different categories and zones. Relief, soil and climatic parameters were used for the evaluation and qualification of agricultural suitability, while for evaluating environmental sensitivity nature, soil and water parameters were taken into account. The study also took the available land use and land cover databases into consideration as well. The result of land use study was the determination of the position of each land unit (one unit is one hectare) on the scale determining agricultural suitability – environmental sensitivity. According to this there is a need to change production category, production systems, and intensity in significant parts of the country (Ángyán et al., 2000).

It has been concluded, that approximately 1.5 million hectares should be withdrawn from intensive cultivation and 500 thousand hectares should be converted into extensive, low input cultivation in Hungary, in order to avoid further degradation and deterioration of the agricultural environment (Ángyán et al., 2000). The schemes of the NAEP supporting environmentally friendly agricultural land use were divided into two groups: 1) horizontal or national schemes, that cover the total area of national agricultural land use, and 2) regional schemes, which assist the environmental and nature protection focused land use of the given region. The regional schemes are equivalent to Environmentally Sensitive Areas (ESAs). ESAs are also called High Nature Value Areas in the Nation Rural Development Plan of Hungary (Figs below).
During the last 50 years, comprehensive collections of landraces and ecotypes of native field and vegetable crop species have been established as a result of systematic collection of locally adapted populations. The Institute for Agrobotany between 1958 and 2002 collected 13,664 accessions at 1114 collecting sites in Hungary. In order to minimise selective changes, a backyard multiplication network was established and used for isoclimatic rejuvenation of landraces near their places of origin in the early sixties. In 2002, the Institute undertook a survey on the landraces collected in earlier years, or that are still cultivated in the three selected Environmentally Sensitive Areas as follows:

1. Dévaványa ESA is located in the centre of the Hungarian Great Plain. The landscape is flat and consists of a mosaic of cultivated lands and grasslands. Soil and climatic conditions of this region are well suited to intensive agricultural production. Dévaványa region is the most urbanised region among the three selected sites, with the most developed road and other infrastructure and food markets. Unlike the other two sites selected, migration from the region is not a major problem, though the number of inhabitants is stagnating (Gyovai, 2002). The aim of agri-environmental measures in Dévaványa ESA is to protect the rich wildlife of the area, especially of the great bustard (Otis tarda L.) population by supporting the conservation of special habitats (Ángyán et al., 2003).

2. Órség-Vend ESA is located in the south-east of Hungary and supports a heterogeneous agricultural landscape with knolls, valleys, forests, grasslands, and arable lands. Poor soil conditions of this ESA render intensive agricultural production methods impossible. Villages in this region are very small both in size and population. Population in Órség-Vend is also declining and ageing. Most of the villages are far from towns and road
density is very low (Gyovai, 2002). In this ESA (where a National Park was also established) the aim is to conserve the unique landscape, which is a tourist attraction as well, by supporting traditional farming practices and thereby creating prospects for agritourism (Ángyán et al., 2003).

3. Szatmár-Bereg ESA is at the north-east part of the country, and has a diverse landscape with a mosaic of grasslands, forests, arable lands and moors. This region consists of settlements that are small in both area and population. The main economic problem of this region is it’s declining and ageing population, mainly due to lack of investment in this isolated region due to its distance from the economic hub of the country (Gyovai, 2002). Consequently, this region supports low quality roads. The aim here is to promote nature and landscape conservation by supporting traditional farming to develop natural habitats (Ángyán et al., 2003).

4. Turján ESA, even if was not a target area of our survey, could be one of the regions where conservation of landraces with special adaptation to drought and sandy soils could be undertaken. Due to the various soil types, the natural vegetation of this area consists of species that are typical to wetlands and sandy soils. Revitalisation of traditional farming is very important here and offers opportunity for the cultivation of landraces.

**Agro-biodiversity research**

In 2002 we collected seed samples from locally grown plant varieties. These accessions were compared to those that had been collected earlier by the Institute for Agrobotany and stored in the gene bank. Our collection missions to ESAs resulted in finding new varieties that were not in the gene bank, especially of field and horticultural crop species (Table 1).

<table>
<thead>
<tr>
<th>Table 1. Number of species and accessions collected earlier and during research period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of species/accessions</strong></td>
</tr>
<tr>
<td><strong>Number of species</strong></td>
</tr>
<tr>
<td><strong>Number of accessions</strong></td>
</tr>
</tbody>
</table>

Source: Holly et al., 2002

For describing and comparing taxonomical diversity among regions we calculated diversity indices. We have evaluated species diversity and botanical family diversity using frequency of species and accessions.

<table>
<thead>
<tr>
<th>Table 2. Diversity indices based on research data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diversity index:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Species</strong></td>
</tr>
<tr>
<td>Shannon-index</td>
</tr>
</tbody>
</table>
Conclusions
Our results clearly show that ESAs are suitable for on-farm conservation of biodiversity based on the following:

1. In these areas of hundreds of years of agriculture has resulted in special cultivation directives and rules that farmers still apply, especially in home gardens and small field plots.
2. Landraces have specific adaption to low external input cultivation. Landraces are the only way to go in areas that have significant disadvantages in term of suitability to intensive agricultural production.
3. In Hungary’s National Rural Development Plan, there will be an opportunity for farmers to apply for mainly EU financed support to cultivate rare crop species and varieties. This measure can attract organic farmers and those ones whose fields are in ESA or in regions where there is a need of crops that can adopt to drought.
4. In some ESAs, especially in marginal areas, the socio-economic conditions are significant. In other words, the number of farmers that are willing to conserve landraces are higher.
5. Those ESAs that are close or part of national parks, have an added incentive to safeguard landraces as their agricultural heritage is higher, and because traditional varieties could attract more visitors.
6. Conservation of landraces have a combination of private and public benefits. Hence, not only the farmer himself benefits directly (food, feed, fodder, etc.), but they also serve the society by maintaining the Hungarian agricultural heritage.
7. However, in recent decades farmers try for higher yields even if the agro-ecological conditions are not suitable for intensive production. It is especially typical for ESAs where today there are many opportunities and support for environmentally friendly agricultural practices.

References
Á. Gyovai, 2002. “Site and sample selection for analysis of crop diversity on Hungarian small farms”. In Smale, M. I. Már and D.I. Jarvis (Eds) The Economics of Conserving Agricultural Biodiversity on-Farm: Research methods developed from IPGRI’s Global Project ‘Strengthening the Scientific Basis of In Situ Conservation of Agricultural Biodiversity’. International Plant Genetic Resources Institute, Rome, Italy.
Technological Options for Promoting On-Farm Conservation of Landraces of Cereals and Legumes Grown in West Asia Region

M.M. Ajlouni1, A. Amri2, R. Assi3 and Y. Sbeih4 and A. Saad5

1, 3, 4, 5 Respectively National coordinators of dryland agrobiodiversity project in Jordan, Lebanon and Syria
2 Regional Coordinator West Asia Program, International Center for Agricultural Research in the Dry Areas (ICARDA), Amman

Keywords: Landraces, cereals, legumes, on-farm conservation, yield improvement, technological options

Abstract
Landraces of wheat and barley are still used within the traditional farming systems in the drylands and mountainous region of West Asia and North Africa. These landraces constitute a valuable germplasm for further and future genetic improvement at national and international levels. On-farm conservation of local agrobiodiversity, including the landraces, should allow for competitive yields and better income for landraces to be sustained. Several experiments were conducted at farmers’ fields and experiment stations by the components of the GEF-UNDP “Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestine and Syria” to demonstrate the benefits of landraces and the possibilities for improving their performance. The results showed that some landraces of wheat and barley are given higher grain and straw yield than the best available improved varieties under low inputs and harsh conditions. Grain and straw yields gains were obtained after one cycle of selection by farmers within durum wheat landraces. These gains were not observed when attempts were done by breeders to select pure lines and new multilines out of the wheat and barley landraces in Lebanon. Seed cleaning and treatment showed significant grain and straw yield increases for cereal and legume landraces. Other technologies such as early planting and cereal/legume rotation can contribute to increase and sustain good performances of landraces under rainfed in the dryland and mountainous regions. More research is needed to reconcile between yield increases and the conservation of the genetic base of the landraces and for developing low-costs technological packages.

Introduction
Agrobiodiversity comprises the whole plant and livestock resources diversity that human societies use and manage for agriculture, food and livelihood sustainability. It includes the enormous diversity of crops and crop varieties that small-scale farmers conserve and cultivate, representing both the basis for their subsistence and source of income. To some extent, it also embraces wild food and medicinal plants that rural populations use for nutrition, healthcare and livelihood purposes. The genetic diversity of traditional varieties of crops is the most immediately useful and economically valuable part of the global biodiversity. Traditional varieties (landraces) are directly used by subsistence farmers as a key component of their cropping systems. Such farmers accounts for 60% of agricultural land use and provide approximately 15-20% of the world food (Francis, 1986). In addition landraces are the basic raw materials used by plant breeders for the development of modern varieties (Wood and Jillian, 1997). Traditionally, farming systems have maintained diversity in order to preserve stability of production under various biotic and a biotic constraints. Increasing food demands have encouraged the replacement of the locally adapted varieties of both fruit trees and field crops.
with higher-yielding cultivars, hence hindering the gene pools of these crops. Over time, genetic diversity had eroded and agricultural production is now based on fewer crops and, within crops, on fewer cultivars. The genetic uniformity of modern cultivars and a tendency towards monoculture make them more vulnerable to both biotic and abiotic stresses. Broad base traditional local varieties are often more adapted to harsh environments and to low inputs traditional production systems and have better qualities for local uses. Conservation and management of broad-based genetic diversity within domesticated species have been improving agricultural production for 10,000 years, however diverse natural populations have been providing food and other products for much longer.

It is generally agreed that a dramatic loss of plant genetic diversity is occurring, and this process seems likely to worsen in the future (Raven and McNeely, 1998; Crucible II Group, 2000). Genetic erosion (loss of genetic diversity) is particularly severe among landraces of crop species which are being replaced by improved cultivars which calls for concerted efforts for the conservation of the remaining landraces of major crops (FAO, 1998). This is reflected in the objectives of the Convention on Biological Diversity (CBD) which calls for the conservation, the sustainable use and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Article 1- CBD (UNCED 1992).

Maxted et al. (1997a) have proposed a model which attempts to make explicit the fundamental elements of genetic resource conservation, and the interrelations among them. This model distinguishes two primary complementary conservation strategies, *ex situ* and *in situ*, each of which includes a range of different techniques that can be implemented to achieve the aim of the strategy. *In situ* conservation has the advantage of continuing evolution and adaptation of the material and conserving wider range of diversity. *In situ* conservation complements *ex situ* conservation by way of i) conserving the processes of evolution and adaptation of crops to their environments, ii) conserving diversity at all levels - the ecosystem, between the species and within species, iii) improving the livelihood of resource-poor farmers, iv) maintaining or increasing control and access of farmers over their genetic resources, and v) integrating farmers into the national plant genetic resources system for conservation. Conservation of genetic resources under *in situ* conditions would ensure that evolutionary dynamic forces continue to influence plant adaptation and survival. (Hoyt 1992; Holden et al. 1993; Cohen et al. 1997; Maxted et al. 1997; Merezhko 1998 ; Maxted et.al. 2002). On-farm ( *in-situ*) conservation involves the maintenance of traditional crop varieties (generally known as “landraces”) or cropping systems by farmers within traditional agricultural systems (Altieri and Merrick 1987; Oldfield and Alcorn 1987; Bush 1991).

The Convention on Biological Diversity has given a clear mandate for on-farm conservation. However, very little formal research has been done and no agreed set of scientific principles are available for on-farm conservation of genetic resources. This lack of knowledge has not prevented an explosion of recommendations on how to conserve agrobiodiversity on-farm. The recommendations were to increase the diversity available for farmers and to enhance his capacity to manage this diversity dynamically. Increasing genetic diversification, combined with farmers’ experimental abilities, and underpinned by the formal system, will ensure greater on-farm conservation of useful genetic resources. (Wood and Jillian, 1997). On-farm conservation programs could empower further the farmers to participate in research and development. Farmers make decisions in the process of planting, managing, harvesting and processing their crops that affect the genetic diversity of the crop populations. Over time, a farmer may modify the genetic structure of a population by selecting plants with preferred agro-morphological and quality characteristics. Each season farmers select a sample from its harvested crop to retain as seeds for next season (Machado 2000). The farmers’ selection of seeds for planting in the following year
are likely to be directed toward and favor characteristics that enhance the crop’s production in the local environment where the farmer lives or even for different fields within the farm or production for different markets (Jarvis et al. 2000). Therefore the landrace is selected by the farmer to be highly adaptive to the local environment, is likely to contain geographically specific, ecotypically adapted alleles or genes complexes, which may be unique within the gene pool as a whole and this is why they have such conservation and utilization potential. The continuing use of landraces contributes to stabilizing food production and income, especially in marginal environments where impact of modern varieties is limited.

This contribution presents the results of technological packages demonstrated to farmers for promoting the sustainable use of landraces of wheat.

**Materials and Methods**

The Global Environment Facility (GEF) through the United Nations Development Programme, funded in 1999-2005 the project on “Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestine and Syria” regionally coordinated by the International Center for Agricultural Research in the Dry Areas (ICARDA). The project was implemented at the national level by the National Research Institutes in Jordan (NCARTT), Lebanon (LARI), Syria (GCSAR) and by the Ministry of Agriculture and UNDP/Programme of Assistance to Palestinian People in Palestine. The strategy adopted included the development and demonstration of technologies aiming at increasing the productivity of landraces of filed crops, fruit trees and forages. Many experiments were conducted either at framers fields or at the experiment stations to demonstrate the benefits of landraces and the possibilities for improving their productivities including:

- **Performance of landraces**
  Landraces of durum wheat were collected from farmers' fields and included with the improved checks in comparative yield trials at the experiment stations or farmers fields in Jordan, Lebanon, Syria and Palestine. Seeds are planting during the fall and the usual cultural practices done by farmers are followed. The average performance over three years is presented.

- **Effect of selection within landraces**
  Farmers were asked to select within the landraces and the grain and straw yields for selected samples were compared to the original populations. This is done in Lebanon and Palestine. New multilines were formed from selected lines from landraces and were compared to original populations and pure lines in Lebanon.

- **Seed cleaning and treatment**
  The seeds of wheat, barley, lentil and chickpea landraces were cleaned and treated with fungicides controlling seed born diseases and grown side by side with non cleaned and non treated seed lots in respective farmer fields. These trials were conducted at farmers' fields in Jordan, Lebanon, Palestine and Syria. The average and range of grain and straw yields are calculated over three years.

- **Other experiments**
  Other trials were conducted to demonstrate the effects of low costs agronomic packages on performances of landraces (rotations, effects of planting dates). These trials were conducted at farmers' fields in Jordan and Palestine.

**Results and Discussion**

The interventions demonstrated can be classified in two categories: the technologies which improve the productivities of landraces while maintaining its genetic integrity (seed quality
improvement, technological packages), and the genetic manipulation of landraces which could affect slightly the genetic base of landraces (participatory selection, development of multilines).

- **Performance of landraces**
  The results for barley showed that there are at least one landrace which outyielded the best available improved check (Table 1). In Jordan, higher grain yields were obtained because of the good conditions in Ajloun compared to dry conditions in Aarsal in Lebanon and semi-arid conditions in Palestine. In Ajloun, all landraces have given at least 0.3 tons/ha more grain yield than the barley improved checks. In Palestine, one landrace outyielded the barley variety used as check and in Aarsal three landraces have given similar yield as Rihane 03 which used as the best check.

<table>
<thead>
<tr>
<th>Landraces</th>
<th>Jordan</th>
<th>Lebanon</th>
<th>Palestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4767</td>
<td>1087</td>
<td>2270</td>
</tr>
<tr>
<td>2</td>
<td>3683</td>
<td>591</td>
<td>2249</td>
</tr>
<tr>
<td>3</td>
<td>4317</td>
<td>513</td>
<td>1590</td>
</tr>
<tr>
<td>4</td>
<td>4650</td>
<td>176</td>
<td>2710</td>
</tr>
<tr>
<td>5</td>
<td>3967</td>
<td>641</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3450</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4567</td>
<td>943.8</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4133</td>
<td>732</td>
<td></td>
</tr>
<tr>
<td>Improved variety 1</td>
<td>3333</td>
<td>389</td>
<td>2572</td>
</tr>
<tr>
<td>Improved variety 2</td>
<td>3817</td>
<td>1033</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1. Grain yields (kg/ha) of barley landraces compared to improved varieties in Jordan, Lebanon and Palestine.

In case of durum wheat, higher grain yields were obtained in Palestine compared to the sites in Jordan and Lebanon (Table 2). Similarly, there are several landraces which have given equal or superior yields than the improved checks. In Ajloun, four varieties have given similar performance as the check. In Aarsal, four varieties have given grain yield similar to the best check. In Palestine, the improved variety has given the lowest grain yield compared to the landraces and some of the later have given twice or three folds the yield of the check.

<table>
<thead>
<tr>
<th>Landraces</th>
<th>Jordan</th>
<th>Lebanon</th>
<th>Palestine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1097</td>
<td>1047</td>
<td>2059</td>
</tr>
<tr>
<td>2</td>
<td>1060</td>
<td>1048</td>
<td>2598</td>
</tr>
<tr>
<td>3</td>
<td>450</td>
<td>918</td>
<td>2048</td>
</tr>
<tr>
<td>4</td>
<td>1350</td>
<td>813</td>
<td>5051</td>
</tr>
<tr>
<td>5</td>
<td>734</td>
<td>735</td>
<td>2111</td>
</tr>
<tr>
<td>6</td>
<td>890</td>
<td>999</td>
<td>1266</td>
</tr>
<tr>
<td>7</td>
<td>1200</td>
<td>961</td>
<td>2651</td>
</tr>
<tr>
<td>8</td>
<td>1056</td>
<td>1074</td>
<td>2479</td>
</tr>
<tr>
<td>9</td>
<td>940</td>
<td>971</td>
<td>3333</td>
</tr>
<tr>
<td>10</td>
<td>470</td>
<td>1041</td>
<td>1591</td>
</tr>
<tr>
<td>Improved variety 1</td>
<td>920</td>
<td>850</td>
<td>1399</td>
</tr>
<tr>
<td>Improved variety 2</td>
<td>-</td>
<td>1305</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2. Grain yield (kg/ha) of durum wheat landraces compared to improved checks in Jordan, Lebanon and Palestine.

In Syria, the landraces collected from the farmers have outyielded both the improved check Sham 3 and the landrace widely used Hourani (Graph 1). The variety Zaraa collected from seven
farmers showed different yields showing the diversity existing among the local populations having the same local name, particularly Zaraa 7 has the highest grain yield which is more than double that of the checks. Bou Said and Anakid Jamal landraces have also outyielded the checks.

The results for both barley and durum showed that there are several landraces that are outyielding or having similar grain yields as the best checks. These findings explain why farmers in these regions are still widely using their landraces which are more adapted for the harsh conditions. The low performance of some landraces at the site of evaluation could be explained by their specific adaptation to the area of growth. Similar results were found by Ceccarelli et al. (1987) when testing landraces and improved germplasm under low yielding environment. The results in Syria for the variety Zaraa showed the large variation in grain yield which could be due to the selection by farmers. It should be noted that the landraces have an advantage of grain and straw qualities and this is why they are still preferred to available improved varieties. This yield advantage could allow the conservation of these landraces at the farm level, but, it appears that their acreage is reduced because of the replacement by introduced plantations of olive in all countries and apples in Sweida and cherries in Aarsal. These fruit trees have improved the income of farmers in these regions.
Effect of selection within wheat landraces

The results of one cycle of selection among the wheat landraces collected from Palestine showed the possibility for improving both grain and straw yields (Table 3). The grain yield increase ranged from 4.1% to 24.7%, while the straw yield increase ranged from 1.2% to 20%. The gains depend on the landrace used, and the highest grain and straw yield gains were obtained for the highly heterogeneous landraces Debbiya Bida, Kahatat and Menka. The lowest gains were obtained for the widely used varieties Anbar and the variety 870 which could be less old varieties or even improved ones. These results show the relevance of involving farmers in the selection process within the landraces and also the possibilities for improving the grain yield level of landraces by this selection process. Increases in grain yield through selection within landraces were reported for mungbean by Bosch (1987) with 24% gain after three cycles of selection, for wheat by Agorastos and Goulas (2005) and for tomatoes by Carrijo et al. (2005). This selection should not be extended to the level where the population buffering of the landraces is affected and its genetic diversity reduced significantly.

Table 3. Effects on grain and straw yield of one cycle of selection done jointly by farmers within their respective durum wheat local populations.

<table>
<thead>
<tr>
<th>Landrace</th>
<th>Grain Before selection</th>
<th>Grain After selection</th>
<th>% change</th>
<th>Straw Before selection</th>
<th>Straw After selection</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debiya Soda</td>
<td>1130</td>
<td>1300</td>
<td>15</td>
<td>2520</td>
<td>2750</td>
<td>9.1</td>
</tr>
<tr>
<td>Debiya Bida</td>
<td>1700</td>
<td>2120</td>
<td>24.7</td>
<td>3000</td>
<td>3600</td>
<td>20</td>
</tr>
<tr>
<td>Kahatat</td>
<td>1650</td>
<td>2050</td>
<td>24.2</td>
<td>2450</td>
<td>2700</td>
<td>10.2</td>
</tr>
<tr>
<td>Hattia Safra</td>
<td>2100</td>
<td>2300</td>
<td>9.5</td>
<td>3000</td>
<td>2770</td>
<td>8.3</td>
</tr>
<tr>
<td>Ambar</td>
<td>2840</td>
<td>3000</td>
<td>5.6</td>
<td>3650</td>
<td>3800</td>
<td>4.1</td>
</tr>
<tr>
<td>870</td>
<td>2400</td>
<td>2500</td>
<td>4.2</td>
<td>3150</td>
<td>3200</td>
<td>1.2</td>
</tr>
<tr>
<td>Ariel</td>
<td>2330</td>
<td>2500</td>
<td>7.3</td>
<td>3000</td>
<td>3230</td>
<td>7.7</td>
</tr>
<tr>
<td>Menka</td>
<td>1450</td>
<td>1800</td>
<td>24.1</td>
<td>2230</td>
<td>2600</td>
<td>17</td>
</tr>
<tr>
<td>F8</td>
<td>1760</td>
<td>1900</td>
<td>8</td>
<td>2750</td>
<td>3100</td>
<td>12.3</td>
</tr>
</tbody>
</table>

The selection work undertaken in Lebanon by the breeders to develop new multilines from bread wheat landraces showed that the new multilines constructed from few lines selected from the original landraces in Nabha, Ham and Aarsal did not show an improvement in grain and straw yields and protein content (Table 4). These results could be due to the selection of few lines which were used to form the new multilines. Similar results were obtained in case of original and new multilines of barley (Table 5). The pure lines derived from original barley populations of Nabha, Ham and Aarsal showed significant difference in grain yield and in 1000 kernel weight. Some lines of barley showed better resistance to lodging than others. The results showed that new multilines as well as the pure lines have given during the subsequent year less grain yields than the original landraces and the improved cultivar Rihane 03. Significant differences were also found for the number of spikes per m² and for plant height but not for straw yield. Similar results were obtained for chickpea and vetch landraces and multilines (results not presented). These results are contradictory to the finding of Cascarilla et al (1987) who concluded that the selection within landraces can lead to higher yielding pure lines and new multiline in case of barley. In conclusion, conserving and utilization of landraces on-farm can provide the base for sustainable livelihood of rural communities and the landraces can play a vital role in increasing and diversify the farmer’s income sources. Especially if we know that the dryland areas witness along drought period where improved varieties sometimes fail to produce any crop for 2-3 years while the landraces known of their buffering capacity against such conditions can produce...
annually. This type of activities will require longer time of evaluation and more research to be able to reconcile between high yielding multiline with adequate genetic diversity.

Table 4. Comparison of grain and straw yields (Kg/ha) and percent of proteins between the original populations and the new selected multilines of durum wheat grown at Tel Amara experiment station during 2002-03 season.

<table>
<thead>
<tr>
<th>Type of populations</th>
<th>Grain yield</th>
<th>Straw yield</th>
<th>% proteins</th>
</tr>
</thead>
<tbody>
<tr>
<td>New multiline-Nabha</td>
<td>1570</td>
<td>6080</td>
<td>13.5</td>
</tr>
<tr>
<td>New multiline-Ham</td>
<td>1460</td>
<td>6390</td>
<td>13.8</td>
</tr>
<tr>
<td>New multiline-Aarsal</td>
<td>1480</td>
<td>6180</td>
<td>13.3</td>
</tr>
<tr>
<td>Mixture all multilines</td>
<td>1710</td>
<td>6310</td>
<td>13.8</td>
</tr>
<tr>
<td>Original landrace-Nebha</td>
<td>1640</td>
<td>6500</td>
<td>14.3</td>
</tr>
<tr>
<td>Original landrace-Ham</td>
<td>1770</td>
<td>6980</td>
<td>14.3</td>
</tr>
<tr>
<td>Original landrace-Aarsal</td>
<td>1860</td>
<td>6780</td>
<td>12.3</td>
</tr>
<tr>
<td>Tanour improved check</td>
<td>1770</td>
<td>6230</td>
<td>13.8</td>
</tr>
<tr>
<td>F-test</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Table 5. Comparison of grain and straw yields of new multilines, pure lines and the original populations and improved check of barley at Tel Amara station during 2002-03 season.

<table>
<thead>
<tr>
<th>Type</th>
<th>Genotypes</th>
<th>Grain</th>
<th>Straw</th>
<th>Spikes/m2</th>
<th>Plant height</th>
</tr>
</thead>
<tbody>
<tr>
<td>New mixtures</td>
<td>M 5G</td>
<td>2730</td>
<td>6380</td>
<td>513</td>
<td>76.2</td>
</tr>
<tr>
<td></td>
<td>M 18G</td>
<td>3110</td>
<td>5850</td>
<td>544</td>
<td>80.4</td>
</tr>
<tr>
<td>Pure lines</td>
<td>14-9*</td>
<td>2960</td>
<td>7010</td>
<td>555</td>
<td>79.2</td>
</tr>
<tr>
<td></td>
<td>16-2*</td>
<td>2800</td>
<td>6630</td>
<td>511</td>
<td>81.4</td>
</tr>
<tr>
<td></td>
<td>25-2*</td>
<td>3180</td>
<td>6730</td>
<td>545</td>
<td>80.6</td>
</tr>
<tr>
<td></td>
<td>30-1</td>
<td>3240</td>
<td>6490</td>
<td>547</td>
<td>84.2</td>
</tr>
<tr>
<td></td>
<td>30-2</td>
<td>3130</td>
<td>6700</td>
<td>513</td>
<td>81.7</td>
</tr>
<tr>
<td>Original landraces</td>
<td>Aarsal</td>
<td>3750</td>
<td>6510</td>
<td>630</td>
<td>80.0</td>
</tr>
<tr>
<td></td>
<td>Nabha</td>
<td>3300</td>
<td>6170</td>
<td>557</td>
<td>80.0</td>
</tr>
<tr>
<td>Improved</td>
<td>Rihane o3</td>
<td>3940</td>
<td>5950</td>
<td>345</td>
<td>95.8</td>
</tr>
<tr>
<td>F-value</td>
<td>**</td>
<td>NS</td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

- **Seed cleaning and treatment**

These types of experiments were conducted for durum wheat in the four countries and for lentil and chickpea in Syria (Table 6). Most of these experiments showed grain and straw yield gains by cleaning and treatment of seed lots. The gains depend on the quality of seed lots obtained from farmers. In case of durum wheat the average grain yield increase ranged from 4 to 54% with a maximum gain of 70% in Syria and for straw yield, the seed cleaning and treatment gave 22 and 72.5% yield increase on the average respectively in Jordan and Syria with a maximum increase of 100%. Even more striking increases were observed in case of lentil and chickpea. For lentil, the grain yield was increased by 40% and straw yield by 83% on the average and these average increases were respectively 83 and 347% in case of chickpea. These results show the importance of seed cleaning and treatment in enhancing the grain and straw yields of landraces of cereals and legumes. Based on these results, the dryland agrobiodiversity project helped to establish village-based seed production systems either with lead individual farmers or farmers...
cooperatives to produce and supply seeds of landraces with good quality. Farmers and extension staff were trained in seed production and processing and mobile seed cleaning and treatment units were provided to collaborating farmers. More than 10 and 76 tones of quality seeds of landraces of targeted cereals and legume species were distributed to farmers respectively in Lebanon and Palestine.

Table 6. Mean and range Percent grain and straw yield increases of durum wheat, lentil and chickpea landraces after cleaning and treatment of seed lots.

<table>
<thead>
<tr>
<th>Crops</th>
<th>Country (No farmers)</th>
<th>% increase of grain yield</th>
<th>% increase of straw yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average</td>
<td>Range</td>
</tr>
<tr>
<td>Durum wheat</td>
<td>Syria (3)</td>
<td>54</td>
<td>33-70</td>
</tr>
<tr>
<td></td>
<td>Palestine (5)</td>
<td>4</td>
<td>0-7</td>
</tr>
<tr>
<td></td>
<td>Jordan (5)</td>
<td>13</td>
<td>1-53</td>
</tr>
<tr>
<td></td>
<td>Lebanon (4)</td>
<td>15</td>
<td>3-25</td>
</tr>
<tr>
<td>Lentil</td>
<td>Syria (5)</td>
<td>40</td>
<td>7-104</td>
</tr>
<tr>
<td>Chickpea</td>
<td>Syria (5)</td>
<td>84</td>
<td>60-322</td>
</tr>
</tbody>
</table>

() number of farmers

- **Other technologies**

There are many low-cost agricultural practices which can increase the productivities of landraces. Early planting date could result in significant yield increase for the crops to take advantage of good growing conditions early in the season (Table 7). The trial conducted in Palestine showed that early planting of cereals and legumes allowed an average grain yield increase of 55.3% while the straw yield decreased on average by 10.7%. Early planting has also increase the productivity of rainfed onion by 11%.

Table 7: Effects of planting dates on productivity (kg/ha) of some target crops at Tayassir, Palestine during 2002-03 season

<table>
<thead>
<tr>
<th>Crops</th>
<th>Grain/fruit yield</th>
<th>Straw yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early</td>
<td>Late</td>
</tr>
<tr>
<td>Vetch</td>
<td>1550</td>
<td>980</td>
</tr>
<tr>
<td>Lathyrus</td>
<td>850</td>
<td>450</td>
</tr>
<tr>
<td>Lentil</td>
<td>750</td>
<td>440</td>
</tr>
<tr>
<td>Wheat K</td>
<td>2200</td>
<td>1800</td>
</tr>
<tr>
<td>Wheat N</td>
<td>2050</td>
<td>1400</td>
</tr>
<tr>
<td>Wheat H</td>
<td>2500</td>
<td>2200</td>
</tr>
<tr>
<td>Means</td>
<td>1650</td>
<td>1063.3</td>
</tr>
<tr>
<td>% change</td>
<td>+ 55.2</td>
<td></td>
</tr>
<tr>
<td>Onion</td>
<td>16,700</td>
<td>15,500</td>
</tr>
</tbody>
</table>

Crop rotations could also contribute to increasing and sustain the productivity of landraces. Under rainfed conditions in the drylands cereals/legumes rotations are recommended. The trial conducted at Samta, Ajloun in Jordan showed that wheat/lentil and wheat/vetch rotations gave better wheat grain yield than wheat/wheat and wheat/chickpea rotations (Graphs 2). In case of barley, the introduction of vetch could allow better crop-livestock integration in the drylands (Graph 3).
Fig. 2. Effects of different wheat and legumes rotations on grain and straw yields (kg/ha) of durum wheat landraces at Samta, Ajloun, Jordan during 2002-03 season.

Graph 3. Effects of barley and vetch rotation on grain and straw yields (kg/ha) of two and six row landraces of barley grown at Muwaqqar, Jordan, 2002-03 season.

There are many other low-costs technologies that can be used to enhance the productivity of landraces under harsh environment. Among these, the control of weeds and the use of low quantities of fertilizers. More research is needed to develop adequate technologies for ensuring
good and stable grain and straw yields of field crops in the drylands and mountainous ecosystems where landraces are still predominately used within the traditional farming systems. This study shows clearly that it is possible to increase the productivities of landraces while maintaining their genetic base and the development and transfer of low-cost technologies will allow the promotion of on-farm conservation of landraces. On-farm conservation will require in addition to yield increases, better marketability and prices of local products and the empowerment of the custodians of local agrobiodiversity though alternative sources of income, equitable benefit sharing and designing rural development projects targeting the conservation of local agrobiodiversity.

References
On-farm Improvement of Some Palestinian Local Vegetable Varieties in a Participatory Approach

T. Hijawi¹ and A. Saleh²

¹Department of life sciences, Faculty of science and technology, Al-Quds University, Abu Deis, P.O.Box 20002, Jerusalem
²Arab Agronomist Association (AAA)/Palestinian Agricultural Relief Committee (PARC), P.O.BOX 25128 Shufat- Jerusalem

Keywords: On-farm, local vegetable, participatory approach, Palestinian.

Abstract
Due to natural aridity and Israel-imposed limitations on water use, over 90 % of the cultivated land in Palestine is rainfed. These harsh conditions dominate in the highlands and semi-coastal areas of the West Bank, affecting about 70 % of the population, partly or fully. Traditional vegetable production is still a major income generating activity in these areas. Local varieties of vegetables are grown in some 80,000 dunums (8000 ha) of land annually, providing livelihood basis to about 120,000 people in 12,000 farm families. Area-specific locally adapted vegetable varieties are grown mainly under two conditions: (a) partially irrigated, and (b) entirely rainfed in rotation with cereals and/or legumes. The partially irrigated vegetable production occurs in the fertile valleys using spring water, cisterns or wells for supplementary irrigation. In this system, rainfed vegetables, such as local lettuce, turnip, radish, garlic, green onion, faba beans, cabbage and others are rotated with irrigated summer vegetables, such as local varieties of squashes, eggplants, tomato, hot peppers, runner beans and Jews mellow.

The totally rainfed vegetable production is practiced in the traditional dryland crop rotation system, where cereals (wheat or barley) and legumes are rotated with summer vegetables. This practice helps to maintain soil fertility and generate cash income for farmers. Important dryland vegetables include several kinds of squashes, eggplants, faqoos, wild cucumbers, onion, tomatoes, okra, beans and cauliflower. Since about 85 % of cereal cropland is rotated with summer vegetables on a triennial basis, the cultivation of drought resistant varieties extends to an estimated area of 350,000 dunums, and involves some 32,000 family holdings. Growing local vegetable varieties have many advantages over imported varieties. Some of the most significant merits are listed below: 1) Better adaptation to local conditions and tolerance of major diseases and pests; 2) Economy of production using traditional methods and local inputs; 3) Easily marketable locally for fresh and preserved food; 4) Stable market demand and higher price; 5) Multiple uses; 6) Development of local food industry, 7) Minimal overproduction; 8) Socio-cultural acceptance and political prudence.

For the abovementioned and several other reasons, production of local varieties of vegetables helps to achieve food security and self-confidence of rural people. We will discuss our recommendations and prospects for improving this agricultural sub-sector in Palestine.

Introduction
The importance of local seed varieties of vegetables in Palestine

Due to natural aridity and limitations enforced by Israel on Palestinian water use, rain-fed (dryland) agriculture predominates on more than 90 % of cultivated lands. Cultivation stretches over the highlands and semi-coastal areas of the West Bank and involves, fully or partially, 70 % of the population. Traditional vegetable production remains a major income generating activity
of these areas. Local vegetables are cultivated on some 80,000 dunums (8000 ha) and about 12,000 farming families with some 120,000 family members earn a living from this activity each year. Specific varieties that cater to the local needs are used by these farmers. Agricultural vegetable production takes place within the traditional dryland crop rotation system, where cereals (wheat or barley) and leguminous crops are rotated with summer vegetable crops in order to maintain the soil’s fertility and to generate the main cash income from agriculture. Important dryland vegetables cultivated include diverse kinds of local squashes, eggplants, faqoos (wild cucumber), onions, tomatoes, okras, beans and cauliflowers. Since 85% of cereal fields are rotated with summer local vegetables on a triennial basis, the cultivation of these drought resistant varieties is related to a total area of 350,000 dunums and directly involves some 32,000 farming families.

Horticultural vegetable production takes place in the more fertile valleys using water from springs, cisterns, or wells for supplementary, irrigation. Here, winter rainfed vegetables such as, local lettuce, turnip, radish, garlic, green onion, faba beans, cabbage, etc. are rotated with irrigated summer vegetables such as local types of squashes, eggplants, tomatoes, hot peppers, runner beans and Jews mellow. The above activity is undertaken with the aim of preserving the diversity of local landraces, and ensuring better efficiency and sustainable use of resources, and thus preventing the environmental damages brought about by the excessive use of pesticides and fertilizers.

This research project contributes to the preservation of the environmentally-safe traditional agricultural practices that ultimately will contribute towards the development of organic farming in Palestine.

**Methodology and project implementation approach**

1. **Conducting on-farm and participatory crop improvement**
   Farmers are involved in the process of restoring the characteristics of landraces that were affected by the gene flow from introduced improved varieties. Mass selection with progeny testing was used on the original populations and in a few cases crosses followed by selection based on progeny testing was adopted. The selection criteria were based on landrace ideotypes and on resistance to diseases and pests. The selection and yield trials are conducted in farmers’ fields with the participation of a large number of farmers including their families, and extension workers.

2. **Development of seed supply system**
   - Establishing on-farm seed production on a small scale in order to ensure quality and supply for occasional seed regeneration. Positive and negative mass selection methods were used with the full participation of farmers who received training on seed increase and field inspection techniques.
   - Complementary activities were conducted at the experiment stations, when required, in order to manage risks of on-farm seed production.

3. **Seed distribution**
   - Promoting seeds produced by the farmers themselves thus ensuring isolated seeding and quality seed crop management.
   - Establishing simple facilities for seed testing, adequate storage, and seed packaging.

4. **Information and knowledge dissemination**
   Workshops and on-job training were arranged for the farmers and extensions workers and leaflets and field-guides were developed and distributed.
The research design, management and time-frame for implementation followed a regional and “modular” concept, that would allow a gradual expansion of geographic coverage and widen the beneficiaries base and enlarge the coverage of local crops under development. The research was implemented with a group of selected farmers, seed development workers and extension workers which participated in all the phases of project planning, implementation and evaluation. The indicators of success of the project were developed and these include availability of good quality seeds, development of varieties with desirable characteristics, and increased higher adoption rate and market competitiveness.

**Highlights of achievements**

- **Overall achievements**
  1. Since the year 2000, the project has successfully been implemented in Northern Central and Southern West Bank for 27 local varieties selected from the 35 most important local varieties used in Palestine. Important gains were achieved for many squashes and faqoos landraces with different types and colors (faqoos baladi white, faqoos sahouri short type, faqoos baladi green), red gumbos green gumbos, water melon, melon, eggplant (red short, eggplants tall Bateery), hot pepper baladi long, pepper, beans, wild cucumbers, okra, tomatoes, local cauliflower, turnip, cucumber, beans and runner beans crops. These selected types are highly adapted to their niches and appreciated by farmers. They are helping to generate additional and substantial incomes to farmers. The approach has been actually extended to three other varieties.
  2. More than 600 farmers tried out and evaluated the selected varieties and were satisfied with the results, especially in case for eggplants, squashes, faqoos, okra, cucumbers and tomatoes. There is now a high demand from farmers to provide them with good quality seeds of these varieties. Farmers’ evaluation of the performance of these varieties has led to the generation of a net increase of $50 to $300 in income per dunum (1000 m²) due to improved crop quality and yields.
  3. On-farm seed production was also developed for the 27 selected varieties in their original areas of cultivation. Farmers produce seeds under a voluntary field inspection and seed growing control system provided by the research team from the project, which can guarantee the seed quality and purity. The seeds and seedlings thus distribution benefited 500 to 800 families.
  4. Because small amounts of seeds were distributed initially, farmers are highly motivated to save their own seeds and subsequently provide seeds to their neighboring farmers which has led to the rapid adoption and spread of the varieties developed. Annually, the estimated additional area planted to these varieties exceeds 300 hectares, benefiting more than 600 families and generating additional income totaling about $50,000 to $200,000.

- **Achievements per crop**

  **Green “Baladi” squash**
  This local squash is favored for its taste and sweetness and this variety is extensively cultivated in Ram Allah - Jerusalem - Bethlehem, Jenin, Tulkarem and Hebron regions, both under rainfed and irrigated conditions and as summer vegetable (cultivated area: up to 20,000 dunum). The variety has a trailing plant habit and tolerates well drought and poor soil conditions. Long vines produce a few green, shiny, and characteristically striped blotchy fruit. The sweet and creamy flesh has exceptional cooking quality. This variety is economically one of the most important vegetable crops in Southern West Bank and successfully competes with the introduced hybrid varieties due to high local market demand and selling price, and cheap traditional techniques of production. Nevertheless, there have been serious problems which need to be addressed, such as:
(a) Complete loss of the unique identity of the local variety as its characteristics have been mixed up with features of introduced hybrid varieties and, (b) Sensitivity to virus diseases. Relevant to the complexity of needs, different breeding programs were conducted with the aim of:
1. Restoring original features of Baladi squash (trailing plant - green fruits) and then to select for higher yield. Breeding method used was positive mass selection.
2. Producing a new bush type of Baladi squash, giving an intensive higher yield. Breeding method: initial crosses made with a more productive white fruit – dwarf plant variety, which produced dwarf plant having intensive fruit-set, but yielding the favored Green Baladi fruits. And then, in the following generations, single plant selections were performed with progeny testing methods in order to stabilize these desirable green fruit – dwarf plant features. The breeding process involved winter selection in Jericho and summer progeny tests in the Uplands.

Examples on the achievements:
1. New bush type of green Baladi squash: B 20
   This new variety produces up to six fold more vegetables than the original one. It grows as a bush variety giving an early and good yield and after that shows semi-trailing characteristics, but still setting fruit at each nodes. On the other hand the original variety gives fruits after the tenth leaf, has long stature and takes 60 days to harvest. Excellent yield and economic performance both under irrigated and rain fed conditions were obtained:
   Hilly rainfed conditions: 1000 – 1500 kg/dunum, with sowing in March-April.
   Hilly irrigated conditions: 1800 – 2200 kg/dunum, depending on growing conditions and calendar; with very late sowing and harvest in October: 900 kg/dunum
   Jericho area: 800 - 1500 kg/dunum with sowing September.

   Average income: the price was 3 NIS/kg for landrace, compared to standard hybrid varieties with 1.5 NIS/kg. This generates an extra income of $500-800/dunum in comparison with the original trailing variety. The selected variety needs a well-structured and fertile soil with application of high amount of organic manure (7-10 m³per dunum). For rainfed production, timely spring planting and a well-prepared soil are essential for good production. Under these conditions, the new variety is prolific and tolerates excessive heat - drought conditions even better than the original local variety. Planting in highly calcareous white soils should be avoided. Over-watering and overuse of urea has an adverse effect, such as inducing fruit rot and tendency towards a lighter green fruit color. The variety also has good prospects for crop diversification in Jericho. But, this new variety is sensitive to virus diseases, but easily escapes when practices allow a vigorous initial growth, has 1-2 % off-type plants with white fruits, and has up to 20% of lighter green fruit color under irrigation.

   There is a huge demand from farmers of seeds of B20 variety that at present stage the research project is unable to meet through its ‘commercially’ produced seed supply of only 20 kg. Therefore, the research project is attempting to satisfy the highest number of farmers by providing them with seed samples and extension advice for seed saving measures. Progress has been made in improving the efficiency of seed production in the hilly areas. Annually, the project target is to assist in the production of 60 kg seeds of commercial quality in addition to the basic-seed maintenance activities using negative mass selection and progeny testing method. Since 1997 this new variety is very popular among farmers in Central and Southern West Bank and is cultivated on several hundred dunums which has allowed that this vegetable produce abounds in the markets.

2. New bush type of green Baladi squash: H19
Similar to the B20 type, the H19 gives an early and good yield, but with less vigor to renew itself on semi-trailing vines at the end of season, therefore there is a shorter harvest period: 30 days (as in commercial varieties). In comparative trial with hybrids, the H19 Baladi variety showed a lower rate of occurrence of powdery mildew and virus symptoms and over 25 days of harvest generated a 45% higher income, while its yield were only 13% less. The performance in hilly irrigated conditions: 1600 kg – 1800 kg/dunum taking 25 days to harvest, with spring-summer sowing with income generation of an average price of 3.5 NIS/kg. This variety is suitable for farmers who wish a short, but good harvest period, in order to realize different land use and growing cycles in a year. However, it needs a well-structured and fertile soil and the use of large amount of organic manure and is not recommended for planting in white chalky soils.

The project aims to produce an annual seed amount of 20 kg of seeds besides basic seed maintenance activities. Actually, the research project distributes seed samples to farmers and provides advice for seed saving activities.

3. **Improved trailing Baladi squash**

The aim was to restore the true green fruit-trailing plant’s ‘Baladi’ characteristics of the deteriorated rain-fed variety and then to select for better yield. At present, the purity of the variety is 98% and delivers a stable performance under rainfed conditions. The variety sustains itself on poorer soil and under drought conditions of the South West Bank. It produces 500 - 700 kg/dunum in the Hebron under rainfed conditions, with planting distance of 2m x 2m. This variety is still the best adapted to dryland hilly agriculture using the ‘usual’ amounts of organic manure for soil preparation. The variety is most particularly recommended to those farmers who wish to cover a large area with squash, have no access to large amount of organic manure, and have the labor force to harvest only dryland related yields. The established quality seed production (20kg) meets the local demand for occasional seed renewal. Seed production uses negative mass selection technique. Since 1997, the improved variety is known and widely cultivated in Hebron region (a few hundreds dunum). The produce is sold 2-4 NIS/kg generating an extra income of up to $100/dunum, as compared to the initial quality of the same variety in 1994.

4. **Trailing round squash (Qar’a)**

This local variety, cultivated only in Jerusalem-Bethlehem-Hebron areas, is a kind of pumpkin whose fruits are harvested when small and are favored for stuffing. Economically and ecologically it is an important rainfed crop (cultivated area up to 2000 dunums), as it tolerates well both drought and fragile soils of Southern West Bank. Only uniformly light green and round fruits are appreciated in markets and sold at a high price. The aim was to purify the strongly deteriorated plant material (only 20-40% of the yield was with market desired characteristics) and this was successfully attained through positive mass selection followed by negative mass selection for seed production.

5. **Improved trailing round squash (Qar’a)**

At present, the unwanted yellow color is eliminated and fruits are predominantly round without protuberant apex (about 90% of the yield). The variety gives a stable rain-fed performance with yield of 400-600 kg/dunum under rainfed condition in Hebron region and with the estimated income of 2-4 NIS/kg produce. This variety is recommended for hilly dryland agriculture, under the same conditions as the trailing green squash and also for crop diversification in irrigated in Jericho areas (can also adapt to alkaline-salty soils). Seed production scheme was introduced on a limited scale (2 dunums) to ensure seeds for renewal.

**Wild cucumbers (Faqoos)**

In 1998, wild cucumber or “faqoos” became the most widely cultivated dryland vegetable crop in Palestine (around 20,000 dunums), because it generates a good income, while tolerating...
drought conditions. Wild cucumber is favored in the same manner as field cucumber: fresh or pickled. But, the plant habit, foliage and flowering characteristics show great similarity with local melon crop. In the past, there were two distinct varieties: the one favored for its sweetness “Sahuri” found in Southern West Bank and the one more productive “Baladi”, nowadays favored mainly in Northern West Bank. The ‘Sahuri’ type itself had distinct local strains: the Long type (in Hebron) and the Short type (in Ramallah-Beit Sahur areas). The ‘Baladi’ type had distinct strains of white and green fruit color. Natural crosses took place between all these landraces leading to various types with white and blocky fruit characteristics, green and thin fruit characteristics and with other distinctly ribbed, hairy and tendency towards bitterness characteristics.

The initial aim to restore the Sahuri type, to eliminate bitterness and to improve yield, was successfully achieved. And, recently the project extended its crop development activities to northern provinces involving White Baladi and Green Baladi varieties. Positive mass selection and single plant selection with progeny testing were used for genetic improvement and negative mass selection used for seed production. The achievements are described below:

1. Improved “Sahuri” wild cucumber - Long Hebron's type

Now, no bitterness occurs and this important variety which performs up to three times better than the original variety. Variety purity is 99%, having whitish, sweet and predominantly straight fruits. The fruit shape is characteristically “Sahuri” with ten vertical ribs; 20-22 cm long and 2.5-3 cm wide. Yield ranges from 700-1200 kg/dunum with planting distance 1.5m x 2m in Hebron region. Under irrigation in Jericho, the yield ranged from 1000-1500 kg/dunum, with October sowing. Fusarium infected field should be avoided. Farmers income is estimated to 2-4 NIS/kg of produce which generates up to 150 $/dunum more than the original variety used 1994. This improved variety is recommended for traditional dry-land farming in Hebron region and for crop diversification in Jericho area. There is a high demand of seeds of this variety from farmers and the project was able supply quality seeds. In general, the quality seed production model of the wild cucumber face no economic constraints (good seed yield and good seed price). Since 1997, the improved variety is popular and widely cultivated in Hebron region on several hundreds of dunums. But since 1997, the increasing infections with Fusarium and viruses were observed in the West Bank which call for selecting for more tolerance to these diseases and for applying an integrated pest management approach.

2. Improved “Sahuri” wild cucumber – Short type (Ramallah-Beit Sahur)

Now, this type is pure for essential “Sahuri” white features: bear short (10-12 cm) and wide (2.5-3 cm) blochy fruits with sweet taste. Some bitterness can occur only with late sowing. It becomes prolific if timely rainfed sowing is done along with good soil preparation. Actually, this variety is being introduced in large-scale evaluation trials in farmer’s fields. The variety is recommended for dry-land cultivation in Ramallah, Jerusalem and Bethlehem districts. Quality seeds are produced on a limited scale, but the quantities are enough to meet the present needs. Further efforts are needed to improve tolerance to Fusarium wilt.

3. “Baladi” wild cucumber – White type (under development since 1999 - present)

This type is favored and cultivated in Salfit-Tulkierim area, bearing long (20-25 cm) and thin fruits with whitish color and rough skin. The purity of landrace has been fairly well preserved in Der Ballout area. Therefore, directly seed production scheme was introduced by the project, where all off-type plants (10 %); and Fusarium and virus infected plants (40 %) were removed from the field before seeding. Further development of this landrace is targeted through production of pure seeds for large distribution, and through conducting more verification and demonstration trials in farmers’ fields in different regions. Its quality is highly appreciated.
4. “Baladi” wild cucumber – Green type (under development since 1999 - present)
Green types are widely favored in Jenin, Tobas, Tulkarem, and Nablous areas. No well-preserved plant material was found. The Green Baladi should yield straight, long 20-25 cm and thin fruits with rough skin and grass-green color with sweet taste. But only 30% of the plants displayed all these features in the fields. Therefore, selections were conducted at four localities to restore the identity of the completely diluted variety and to eliminate bitterness in taste. We obtained an initially improved plant material, where 70% is already homogenous for the desired characteristics. Further breeding will continue while seeds of the improved populations will be distributed to farmers.

Local eggplants –“Tall Batteery”
Well-favored in Jerusalem-Bethlehem markets, the “Tall Battery” sweet variety with elongated fruit and attractive color comes from Bethlehem region. It became economically the most important crop in some fertile valleys of Bethlehem-Ramallah regions where spring water abounds. Despite its economic competitiveness (local demand and selling prices up to three times higher), the cultivated area has decreased during the last 15 years, due to (a) the appearance of Rhizoctonia soil born disease destroying 70-80% of plants and yield; (b) high occurrence of plants with white fruit color and curved shape, and (c) showing other off-type features in plant habit an fruit color. The efforts of breeding using positive mass selection within the progeny of 10 single selected plants were successful in restoring the features of the original variety and also to improve the tolerance to Rhizoctonia.

1. Improved “Tall Battery” eggplant at Ein Sinia (for Ramallah region)
Excellent purity and homogeneity with no off-type occurs were achieved in the new variety. Plants are very tall and bear long (20-25 cm), predominantly straight fruits with a bulbous extremity and having an attractive bright reddish fruit color overlaid with gray vertical strips. The white flesh is sweet, tender and has exceptional cooking quality. The variety has expressed Rhizoctonia tolerance since (a) in all cases no early dumping-off occurs, (b) strong infection is observed only on 12% of the plant population at the end of July and this rate of occurrence does not evolve on medium infected fields, and (c) on heavily infected fields (with no crop rotation applied for several years) light symptoms evolve to heavy infection on 30-40% of the plant population up to October. The productivity is estimated to 3 to 6 tons/dunum/season. The variety has a very high income-generating potential, if cultivated in deep and well fertilized soils with intensive irrigation and where eggplants (or tomatoes) are not planted in the same plot for a minimum of 4 years. Farmer’s income is estimated to 3-6 NIS/kg of produce generating an extra income of 500 - 1000 $/dunum, as compared to the initial quality of the variety in 1994. The seeds produced at Ein Sinia can meet needs.

2. Tolerant “Tall Battery” eggplant in Wa’di Fukeen (for Bethlehem region)
Since 1997, “Tall Battery” plant materials from different origins were evaluated in Wa’di Fukeen in order to develop a Rhizoctonia tolerant variety for this heavily infected site. It was observed that the variety improved at Ein Sinia (Ramallah region) displayed a better initial tolerance on medium-infected fields: no early dumping-off or wilting symptoms occurred up to July, while the comparative local plant material was highly affected. Therefore, the improved “Tall Battery” at Ein Sinia has been further selected to reinforce its site-specific Rhizoctonia tolerance to Wa’di Fukeen. More than 20,000 plants with good tolerance to Rhizoctonia were selected to produce seed stocks distributed for evaluation in large-scale trials in farmers’ fields. Very recent results are encouraging and improvement similar to Ein Sinia’s level is expected.

Small types of eggplants
1. New “Small Battery” eggplant (variety for stuffing and pickling purposes)
This new variety was selected from a heterogeneous “Tall Battery” population based on its wide-spread growth, intensive fruit-set even under heat stress, and less sensitivity to powdery mildew as compared to the tall variety. It bears small (10 cm), mini Battery fruits with a bulbous extremity and has a distinct bright reddish color overlaid with gray strips. The white flesh is tender. Initially, the research project developed this new variety for Southern Upland agriculture as it needs less irrigation water than the tall one. Positive mass selection was used amongst the progeny of 5 single plants selected as parents. Since 1998, the cultivation of this variety expands well into the Jordan Valley and the Northern provinces, because of its suitability for stuffing and the advantage of color over the more prolific types obtained from Israel. Its yield is estimated to 2-4 t/dunum/season in well fertilized soils, realizing an income of 1-3 NIS/kg to farmers. Still some variability in fruit width is observed but does not an effect on marketability. Despite some weakness, the variety is expanding as some nurseries promote the variety and save seeds. However, further improvement and basic seed maintenance are still needed and are being carried out by the project.

2. New “Small Red” eggplant: (variety for stuffing or pickling purposes)

This variety has a more vigorous wide-spread growth, bears small (10 cm) bulbous fruits, slightly flatted, and with two ribs on both sides. The skin has a glossy deep-red color. A similar variety is known in Northern West Bank as ‘Naboulsi’, but our new type was selected in the same manner as the “Small Battery”, and for similar purposes. Now, the new variety is expanding well in the Jordan Valley. It produces 2-4 tons/dunum/season, and performs well on well nourished soils. The price of produce is 1-3 NIS/kg. But under poor or cool conditions, tendency to whitish spots at fruit apex are observed. The variety expands, as being promoted by some nurseries, but the needed basic seed maintenance and production is still done by the project.

**Runner bean**

Runner beans are favored and cultivated all over the West Bank on small-irrigated parcels (0.2-0.5 dunum) since they generate a high income for farmers. The main issue was to reduce the variability of the local variety cultivated in Ramallah region and to increase its earliness. The efforts of improving the earliness and yield performance of the local variety was successfully achieved by the selection of an improved variety which gives an early and intensive yield over one month and then the productivity decreases. This variety produces wide long type green pods, much favored in the markets in the Central West Bank. At maturity seeds have a beige color. The yield is estimated to 2 t/dunum over 30 days of harvest, if the variety is cultivated in fertile soils and supplied with full irrigation. The variety is recommended for timely spring sowing in irrigated, fertile valleys of Ramallah–Bethlehem regions. Still, up to 3% off-type plants are detected. Farmer earns 3-6 NIS/kg of produce. For controlling the bacterial infections observed in West Bank fields, farmers are advised to use simple organic means of spraying (copper-oxy-chloride before the flowering stage, especially when seeds are saved by farmers themselves.

**“Lubia” beans**

Lubia beans is a widely favored local crop all over the West Bank and Gaza Strip. Ecologically and economically it is an important dryland summer vegetable, since it generates a good income, while can stand drought and poor soil conditions. Lubia is a self-pollinating crop; therefore it has not been subject to variety dilution process. But, there is a lack of easily available seed supply from reliable sources and in adequate packing and amounts. The white seeded type with ‘black eye’ has been introduced for quality seed production program in Hebron region since 1998. Seed production was needed in order to satisfy demand from women groups for home gardening.
Limited amount of seed was produced on one dunum to serve this purpose and for promoting the farmer’s own seed saving. The research project produced limited seed stock (20 kg), which is devoted to disseminate the variety through farmer's trials and promoting seed saving activities and to extend the variety cultivation in Jenin region. Further selection is needed to eliminate off-types.

**Rainfed local okras**

Okra is a widely favored and cultivated vegetable in Palestine as summer dry-land crop (cultivated area up to 15,000 dunums) or with supplementary irrigation. Mainly ‘green pod’- more productive types, and ‘reddish pod’- more tasty types are distinguished within the population. However, each growing area has its own variety with distinctive features as to pod shape and spinniness. Varieties also differ in plant habit: tall vigorous plants or less tall plants cultivated in rows. A natural cross took place between all these landraces, leading to a loss of distinctness of many local types. In Hebron, the okra has narrow, elongated fruits (which shed seeds when fully ripe) while the more productive Ramallah population has short, wide and more spiny fruits (retaining seeds after full ripening). The initial aim was to reduce the variability and to improve the yield of both populations, since they have to sustain the very poor dry-land conditions of Uplands. Good results were obtained with the Hebron type by selecting for increased tendency to branch and bear fruits more compactly on every branch. A limited amount of improved seed was distributed and returned to farmers up to 1998. In view of the fact that consumers demand is changing, the seed production of a different type from Beit Ula (Hebron region) was promoted by the Women’s Unit. The established small-scale seed production serves distribution purpose in order to support home gardening issues. The project is maintaining seeds of improved type of Hebron Green okra, selected Beit Ula’s type of Green okra (Hebron region), selected Reddish type of okra in Maitheloon (Jenin region), and selected Green type of okra in Der Ballout (Salfit region). Since 1995, efforts are undertaken to extend the cultivation of Green and Reddish okra varieties to northern regions.

**Dryland tomatoes**

Rainfed tomato was the most widely cultivated vegetable crop in the West Bank. But, in the 1990’s, its area decreased to about 15,000 dunums due to the quick development of plastic-house production in concentrated areas. In addition, and even in rainfed fields, landraces were replaced by Israeli improved hybrid varieties. These hybrid varieties outperformed the landraces, but only in years with good winter rainfall. Field survey data of past 20 years clearly shows that there has been no increase in average productivity on rainfed fields. Therefore, the project aim was to prevent the loss of the last remaining landraces of this crop, by improving competitiveness and promoting their greater use. Single plant selection was used to derive high yielding pure lines from the landraces.

1. **Improved Hebron's type of tomato**

This local variety is cultivated in Hebron region and favored for its juicy flesh with sub-acid flavor. Plants have an upright growth, with small leaves, and very large irregular fruits. The main reason for this variety losing competitiveness has been: very low yield (7-10 fruits per plant), deteriorated and unattractive fruit shape (unclosed pericarp) and short shelf life. The selection was therefore aiming at doubling the number of fruits per plant with a more attractive shape of fruits. Participating farmers were all satisfied with the improvements achieved. However, they evaluated its potential as not competitive with Israeli hybrids. Under rainfed conditions, the yield of local tomato variety is around 500 kg/dunum in Hebron region, with dense planting (250 plants/dunum). Despite its low yield, farmers are still cultivating the local varieties for domestic or local demand and the seeds needed are produced.
2. Improved ‘Jiljilaweh’ tomato
This local variety is known in Ramallah region. Plants show a broad-spreading growth and the vines have thin with long internodes. The aim of the project was to improve the average productivity of the crop, since some plants produced 40-50 fruits, whereas others only 10–20 while some vigorous plants were sterile. The selection efforts led to plants setting 30-50 medium-sized, round, firm and very attractive tomatoes with long shelf life. Currently, the selected variety is being promoted for farmer and home garden trials. After further selection seed supply will be able to satisfy demands at the current development stage.

3. ‘Marmand’ type of tomato
This type of tomato, widely favored in the past, yields tasty and meaty giant fruits that are up to half kg per piece, with very small seed cavities inside setting only few seeds. Weak seed setting and the lack of quality seed were probably the cause of sudden genetic erosion of this type.

4. Pure line # 2520
This line was obtained from an early producing heterogeneous rainfed plant material that is found in Jenin region and designated as’ local’ and reproduced as such. The new line is now stabilized and has a vigorous but compact plant habit that produces a concentrated set of high yield on determinate vines. Round and firm fruits are medium-sized with a good taste. Despite the good yield, the line is not recommended for market-oriented production. This is because when picking, the calyx detaches from the fruit. Therefore, the line is maintained for its prospects as a home garden vegetable and for food processing purposes.

Hot pepper
With its attractive long, straight and bright green fruits the aim of participatory breeding for this crop was to improve the productivity of the hot pepper and reduce the variability of the local variety cultivated mainly in the Jordan Valley. Single plant and positive mass selection methods were followed. Seed production used a positive mass selection method.

1. Improved “Baladi” hot pepper – Long type
Breeding work eliminated the variability in fruit shape and plant habit and the average fruit number per plant was increased. The improved variety is now homogenous and prolific in the region. The very attractive and market favored long fruits (12–15 cm) with a broad width of (2.5-3 cm wide) are continuously set on tall, strong, and upright plants. Plants continue to grow and yield fruits up to the onset of winter. Actually, the improved variety is at the stage of farmer’s evaluation in Ramallah, Jericho and Tulkarem areas and has successfully proven its competitiveness both in the case of indoor as well as outdoor cultivation. The variety in outdoor cultivation outperformed the comparative Israeli hybrid variety. Seed supply development and promoting the variety for large-scale use are undertaken.

2. Improved “Baladi” hot pepper
This new variety is very similar to the Long Baladi type described above since it was selected from the same origin. It continues to grow up to winter and is highly productive, but fruits are less elongated (8-11 cm). The variety in outdoor organic farming outperformed the Israeli hybrid variety and was more resistant to diseases. Actually this variety is promoted basically for home gardening and the produced seed satisfies this demand.

Rainfed cucumber (under development since 1999 - present)
During the last decade greenhouse cucumbers and irrigated outdoor varieties replaced the ‘Green Baladi’ and ‘White Baladi’ dryland types. But greenhouse production does not satisfy local demand for pickling cucumbers; and therefore, pickling produce obtains a high selling price than the salad type. This is where the renewed farmer’s interest for dryland cultivation of green type of cucumbers comes in. Therefore, the project has aimed at finding germplasm from the Green
Local type, and evaluating and improving its potential and to develop adequate seed supply. The initial evaluation of collected germplasm showed that the variety (Green type) sustains drought and poor dryland conditions, while giving a consistent rainfed yield, estimated at 300-500 kg/dunum. The homogeneity of the variety has been well-preserved and plants produce deep green, straight, and thin fruits with excellent crispiness and flavor. Seed production scheme was directly introduced in order to increase seed stock. Selection was aimed at eliminating some off-type plants with different fruit shape (5%) and to produce seeds from continuously prolific plants.

**Rainfed field melon (under development since 1999 - present)**
During the last decade, dryland cultivation of local melon, once famous in Jenin region, declined to a few hundred dunums. The main reason was the unfair competition of cheaper irrigated produce from Israel. Nevertheless, there is a renewed interest in the more tasty rainfed local types. Therefore, the project has started improvement and seed production of local types. The selected “Baladi” melon is cultivated in Maitheloon area. It yields few oval types of very sweet and flavored fruits, up to 2 kg per fruit. The deep green rind changes to deep orange when mature. Initial selection has aimed at eliminating plants bearing ‘wild cucumber like’ elongated fruits (up to 30% of the produce) and seed was produced from plants with desired characteristics. Actually this plant material is being evaluated in comparison with other local seed sources. Further improvement of the landrace is needed.

**Rainfed cauliflower**
This vegetable is very favored for its very large and tasty head. The winter maturing variety is widely cultivated as a summer dryland crop (planted in May). Economically it is an important crop mainly in Southern West Bank and successfully competes with the introduced early maturing varieties due to consumers preference for the local type. High selling prices (up to 12 NIS/head) are obtained and the added advantage is the fact that the variety tolerates poor dryland conditions of the Southern provinces. The quality of the variety has been well preserved by a few knowledgeable old farmers, but local inherited knowledge and the reliable sources of seeds of this variety are unfortunately disappearing. Therefore, the project targeted the preservation of the valuable indigenous knowledge to produce quality seed from reliable sources. Quality seed production scheme was introduced which allowed flowering and seeding only those with early maturing and desired plants. These seeds are promoted amongst local nurseries and interested individual farmers.

**Turnip**
This vegetable is favored in Southern area. The flat local type has been well-preserved by some farmers. However the rate of early bolting (developing flower stem and flowering instead of root development) is high and there is some variability in root form. Quality seed production scheme was introduced, allowing for flowering and seeding only of the early maturing and plants with perfect roots.

**References**
Planning with Stakeholders the Management of Genetic Resources of Date Palm in the Oases in the Maghreb

N. Nasr¹, M. Belguedj², A. Rhouma³ and A. Zirari⁴

IPGRI CWANA ; Maghreb date palm project coordinators
¹ Regional Coordinator, International Plant Genetic Resources Institute, Tunisia: n.nasr@cgiar.org
² National Coordinator, International Plant Genetic Resources Institute in Tunisia
³ National Coordinator, International Plant Genetic Resources Institute in Algeria
⁴ National Coordinator, International Plant Genetic Resources Institute in Morocco

Key words: Oases, date palm, participatory approach, in situ conservation.

Abstract
Date palm is the basis of agriculture in the Sahara of the Maghreb region. In the oases, farmers produce under date palm trees various crops including fruit trees, cereals, vegetables, industrial cultures (henna, tobacco, etc.) and forage such as alfalfa. The oases of the 3 countries (Tunisia, Algeria and Morocco) cover an area of about 181,000 ha with around 21 millions date palm trees producing on average 432,000 tons of dates. In these oases, several varieties and ‘Khalt’ of date palm are threatened of disappearance due to different factors. To safeguard this diversity as well as the oases ecosystems, the project GEF/UNDP RAB 98 /G31 on “Participatory management of genetic resources of date palm in the oases of the Maghreb” was implemented by IPGRI in collaboration with the research institutes of Algeria, Morocco and Tunisia to conserve on-farm the genetic diversity of date palm.

Participatory approach for planning and management of genetic resources has been developed and applied in project sites. This approach has allowed the mobilization of key stakeholders from different structures (research, development: GO, NGOs, CBO, profession, etc.) as well as the private sector and farmers.

An important program of awareness (radio, television, newspapers, newsletter, conferences, workshops, field trip of farmers, fairs, website, etc.) and training of research and development staff, members of NGOs and farmers, etc. have allowed the involvement of different actors in the rehabilitation of oases and the marketing of different products of date palm.

An inventory and selection of genetic resources of date palm have been realized with an active participation of farmers. Laboratories for in vitro multiplication of local clones were developed and are now capable of multiplying more than 40 cultivars in the three countries.

Marketing studies have been conducted and alternative markets for alternative products of date palm have been identified and concept notes have been developed for project and micro-project for private sector and NGOs.

Finally, existing legislations (relating to trade for genetic resources and plant health and safety) are reviewed and the experts developed recommendations to encourage material transfer and exchange.

Introduction
Date palm (Phoenix dactilifera L.) is the main crop cultivated in the Maghreb oases. Several fruit tree, vegetables, field and forage crop species are planted under date palms; their diversity and their importance vary from one oasis to another: olive trees, fig trees, pomegranate trees, citrus, apricot tree, banana tree, etc. Underneath the date palms and fruit trees, several vegetable species, forage crops and commercial species such as henna and tobacco are often cultivated (Rhouma et al. 2003, 2004). The oases of these three countries cover an area of approximately
181,000 ha comprising 21 million date palms and producing around 432,000 t of dates. In these oases, many varieties are named by farmers but a large number, commonly called *khalt* or *Sayer* (cultivars issued from unknown cross-pollination), are threatened with disappearance owing to different biotic, abiotic and socioeconomic factors (IPGRI *et al.* 2004, 2005).

Genetic resources cultivated in the oases have been the object of selection for centuries by farmers. This selection is directed to respond to the needs of oasis communities and to adapt to the predominant biotic and abiotic stresses. In the Maghreb region farmers have selected a large number of date palm varieties with a range of maturities covering an important part of the year (end of June to January) to supply fresh fruits along the period. They have also selected cultivars that can be preserved to be consumed as dried dates long after the harvest (Benkhalifa *et al.* 2003; Martin *et al.* 2003; Nasr 2004; IPGRI *et al.* 2002, 2003). Unfortunately and for various reasons, especially fungi disease, markets, national policies, farmers were constrained and encouraged to plant fewer number of varieties such as (Deglet Nour in Tunisia and Algeria, Majhoul and Boufeggous in Morocco). As example, in Tunisia, Deglet Nour represents less than 10% of number of date palm trees in early 1900 but now it’s around 65 to 70%.

The GEF-UNDP, RAB98/G31 project on “Participatory management of genetic resources of date palm in the oases of the Maghreb region (2001–2005)”, executed by IPGRI and INRAs’ (National Agricultural Research Institutes) of Algeria, Morocco and Tunisia, have participated in the preservation of diversity of date palm (www.maghrebdatepalm.org). This paper presents highlights of the projects' results and achievements.

**Methodology**

The project will remove barriers towards combating genetic erosion of date palm in the Maghreb, namely (1) the replacement threat from national programs cultivars that are multiplying and distributing only few cultivars and (2) market forces that are encouraging farmers to grow only few high value cultivars of date palm at the expense of a wide range of other cultivars. Together with the number of baseline programs described, the project will form an integrated ecosystem approach to the management of the oases sites. Project activities cover (1) *in situ* pre-screening to speed up the process of variety selection for multiplication; (2) adapting techniques to multiply a greater range of date palm cultivars; (3) develop alternative markets for date palm products creating value addition to encourage the use of a wider range of cultivars by farmers; (4) develop national capacity to negotiate genetic property rights concerning win/win partnerships; and (5) replicate project best practices at other sites. The project aimed at knowing and conserving *in situ* of date palm diversity in the oasis of the Maghreb region.

The project had four major outcomes:
**Outcome 1:** Increased national capacities to multiply and exchange a larger number of date palm varieties.

**Outcome 2:** Enhanced legal exchange of germplasm using appropriate regional agreements.

**Outcome 3:** Identified alternative markets for alternatives products of date palm to combat genetic erosion of date palm cultivars.

**Outcome 4:** Ensured conditions of sustainability and duplication of successful results of project at policy makers and farmers levels.

The date palm project adopted a participatory and multi-stakeholders approach at all levels of its implementation:

- Local operational committees at the project sites were formed to plan, monitor and implement the project;
- National steering committee at national level to plan and monitor the project;
- Regional steering committee (tripartite) to monitor the project.

Participatory diagnostics at project sites, farmers and R&D staff study tours, workshops, conferences, fairs, involving R&D staff at national and local levels, farmers, NGOs and CBOs and farmers were organized at local, national and regional levels.

**Results and discussion**

**National capacities increased to multiply and to exchange a larger numbers of date palm varieties**

A regional diagnosis of capacities of date palm tissue cultural laboratories was made during 2002 and a regional workshop was organised in Marrakech where results of the study were presented. The outcome of the workshop was a regional programme to empower capacities of date palm tissue culture laboratories and their staff to be able to multiply an important number of date palm. This programme was executed during 2002-2004 (training, equipments, experimentation, etc.). Participatory diagnosis in project sites allowed to:

- Identify more than 200 new varieties in the project sites;
- Identify 100 endangered varieties and the risks associated with their genetic erosion;
- Select with farmers, NGOs, CBOs and R&D staff endangered varieties to be multiplied through tissue culture techniques. Seventy-one out of hundred endangered varieties were selected by farmers to develop their *in vitro* propagation techniques.

Waiting for *in vitro* plants, the project carried out with NGOs and CBOs (in east Algeria and Tunisia, free of Bayoud), actions for the plantation of 10,000 offshoots of endangered varieties in project sites. These 10,000 offshoots include 35 different varieties witch represent 35% of endangered varieties. For the other 65% they are Moroccan varieties for witch we didn’t make any transfer of offshoots because of Bayoud disease and Tunisian and Algerian varieties for which it was impossible to get offshoots. The solution here is to wait for date palm *vitro* plants from Maghreb tissue cultural laboratories.

**Legal exchange of date palm germplasm using regional agreement**

The prevailing legislation related to terms of trade and circulation of date palm genetic resources and plant health and safety in Tunisia, Algeria and Morocco were reviewed by national experts and the reports are available on projects’ web site. Legal experts formulated recommendations to encourage material transfer and exchange. These recommendations were validated in national workshops. A regional workshop of experts was organized in June 2005 to discuss and validate national recommendations and a draft Material Transfer Agreement was developed to promote
the exchange and facilitate the access to date palm germplasm between the 3 Maghreb countries. The MTA is sent to policy makers of the 3 countries for consideration. A Plan to implement MTA and to train staff was drafted by regional experts during a regional workshop held in Tunis. The descriptors list of date palm was published and wildly diffused during early 2006.

**Identification of alternative markets for alternatives products of date palm**

Marketing studies were conducted at local, national and European Markets of date palm products during 2003. The results of these studies were approved at national and regional levels for traditional varieties and for alternatives products of dates. Several ideas and micro projects to develop new markets for new varieties and new products of dates were proposed. Several alternative products were identified and tested in new markets in partnership with private sector including the production of bio-alcohol with a factory in Ghardaia (Algeria). New markets have been developed for different varieties. Different varieties of dates and products made of dates commercialized in the hypermarket Carrefour in Tunis, and during fairs in Algeria, Morocco and Tunisia.

**Sustainability and replication of projects’ successful results**

Trainings were organized at project sites to test methodologies and tools and several reports and methodological guides were developed and distributed widely in the participating countries. Raising awareness of actors of the chain of dates was increased through fairs, workshops, conferences, newsletters, articles, calendars, TV and radio programmes, visits of policy makers to project sites, project webpage www.maghrebdatepalm.org, etc. The methodological guide on participatory approaches is currently under review and 1000 local R&D staff have been trained in participatory management of genetic resources in the oasis. A manual on best practices of date palm cultivation is edited and disseminated. Public awareness tools to conserve genetic resources of date palm prepared and diffused.

By end 2005, the date palm project activities were replicated in nine additional sites and more than 30 NGOs are actually working on conservation of genetic resources of date palm through mobilization of additional funds from different partners (GEF Small Grants Program, Swiss Cooperation, French Cooperation, Spanish Cooperation, Canadian Cooperation, National funds from Ministries, etc.). These new projects are helping in sustaining the project goals and approaches. In Tunisia and Algeria, the date palm project is contributing to a change in the national management policies regarding oases. The Ministries of Agriculture are now more aware about the biodiversity issues and benefits of its conservation both *ex situ* and *in situ*.

**Best practices:**

- Partnership with NGOs and CBOs and their partners allowed to conserve *in situ* date palm diversity (over 10,000 offshoots planted) and the policy makers, farmers and population are now more aware of the importance of conserving date palm biodiversity;
- Partnership with private sector had developed economic projects based on date palm products;
- The regional and international marketing study have given the project ideas to promote further *in situ* conservation of date palm diversity.
- Building R&D programmes and activities of date palm project on indigenous knowledge to understand and to conserve *in situ* date palm diversity had generated good results;
- The participatory and integrated approach developed has helped in developing sustainable actions for continuing project goals and approaches;
- A Public Awareness Network on Agrobiodiversity was created by the date palm project for working on conservation of genetic resources;
Oasis management policies are changing in Tunisia and Algeria where the respective Ministries of Agriculture are taking into account biodiversity issues. Tunisia is currently preparing a strategy to rehabilitate oases.

The date palm project team advised and supported FAO in the selection of the Maghreb oasis ecosystem to be included in the Globally Indigenous Heritage Agriculture System (GEF project);

As a result of the date palm project advocacy activities, the GEF Small Grants programme in Tunisia has considered the oasis ecosystem as a strategic priority in the region;

Over 30 NGOs were trained in participatory R&D approach to conserve genetic resources of date palm and in fund raising. Thus, NGOs are able to design micro-projects funded by the GEF Small Grants Programme, the Suisse Cooperation, the Spanish Cooperation, the Canadian Cooperation and other national funds.

**Lessons learned**

- Participatory Rural Appraisals (PRA) have been conducted in the project sites. These PRA have been very successful and all stakeholders have been active partners in these events. Stakeholders and policy makers are more aware about biodiversity and related participatory approach to identify and select cultivars jointly with farmers. Technical staff from development agencies is applying the date palm project approach in other sites;

- The active involvement of the Project Team in local events/seminars has facilitated the implementation process as well as the successful establishment of the national offices in the respective countries;

- Radio broadcasting on Project’s activities is taking place regularly at the national and regional radio stations with the close and enthusiastic collaboration of farmers, researchers and extension workers. Gafsa and Ghardaïa regional radios give regularly (once a week for Gafsa radio) news of the project activities. From these radios broadcasting, the project collects data (date palm cultivars, different uses, knowledge, innovation and innovators). At Gafsa radio station, an award is offered (once a month) for the winner (The listener who gives the right answer to a question about the date palm);

- A strong partnership is being developed with the GEF Small Grants Programme in Tunisia and in Morocco and provided support to NGOs to conserve date palm genetic resources with over 700,000 US $ during 2002-2006;

- Up to now, twenty agreements were signed with NGOs (16) and farmer organizations (4) to work on conservation of genetic resources of date palm. Civil society participation is crucial for the success of the project and its duplication;

- Methods and tools developed by the date palm project as a model for Participatory Planning and Management of Genetic Resources is considered an example to be followed in future projects by ICRA and IPGRI. Links established between these two institutions through the project efforts have led to the singing of a MoU.

**References**


In Vitro Conservation of Plant Genetic Resources

R. A. Shibli, W. S. Subaih and M. M. Ajlouni

Biotechnology Section, College of Agriculture, Jordan University of Science and Technology, Irbid, Jordan. phone 962-2-7201000, fax: 962-2-7095069, email: shibli@just.edu.jo

Keywords: In vitro conservation, preservation, osmoticum, cryopreservation, pre-freezing treatments.

Abstract

In vitro conservation of plant genetic resources is becoming a complementary approach to the conventional conservation methods. In vitro conservation could save plant material for short, medium or long-term in small space and under controlled conditions. It is cost-effective and stored material can be simply exchanged between countries. Slow growth and cryopreservation are discussed in this paper with emphasis on the involved factors during the preparation of plant material or through storage. Survival and regrowth of preserved material are discussed.

Introduction

Sexually propagated plants may be stored as seeds and are not in danger of loss when compared with vegetatively propagated plants stored in vitro (Bajaj, 1986; Pierik, 1987; Dodds, 1983). Clonally propagated plants are usually maintained in botanical gardens. Some of those plants are usually preserved by continuous multiplication of tubers, roots, cuttings or bulbs. Such a procedure is laborious and exposes plants to pests and environmental stresses. Tissue culture has proved to be a useful tool for storage of vegetatively propagated commercial crops like potato, palm trees, forest trees, and other species (Jones et al., 1979; Bajaj, 1986; Dodds, 1983; Dodds and Roberts, 1985; George and Sherrington, 1984).

Conservation of plant genetic resources via tissue culture has had an immense success due to research efforts during the last three decades (Bajaj, 1986; George and Sherrington, 1984; Neitzche, 1983; Pierik, 1987; Wilkins and Dodds, 1983; Tahtamouni, 1999; Al-Ababneh, 2001; Moges et al., 2003). Storage of shoot tips or meristem derived explants under slow rate of growth has a significant use in the international germplasm resources units. This procedure makes germplasm available at any need for international distribution (Wilkins and Dodds, 1983). Several types of plant materials have been used for in vitro preservation of clonally propagated crops. Meristem derived explants such as shoot tips and buds were mostly suggested for their genetic and generative stability (Bajaj, 1986; Shibli, 1994).

1. In vitro preservation

Slow growth in vitro preservation

The main objective of in vitro germplasm preservation is to limit the number of subcultures and maintain the genetic diversity of a species in a sterile condition without endangering plant stability (Shibli, 2000; Moges et al., 2003). In slow growth in vitro preservation, germplasm is cultured under normal growth or growth limiting conditions (Tahtamouni et al., 2001; Moges et al., 2003). The growth rate of in vitro cultures can be limited by various methods including incubation at reduced temperature and/or low light intensity, manipulation of the nutritive elements in the cultures medium, and the use of osmotic agents and growth retardants (Tahtamouni et al., 2001; Moges et al., 2003).

Preservation using osmoticums
Osmotic agents are materials that reduce the water potential of cells (Pierik, 1987; Bajaj, 1986). The addition of osmotica to the culture has been proved to be efficient in reducing growth and increasing the storage life of many in vitro grown tissues of different plant species (Shibli et al., 1992; Wilson et al., 2000). According to the hypothesis for turgor-driven growth and cell expansion (Zimmerman, 1978), high levels of osmotic agents in the medium would act against the creation of a critical turgor pressure, which must be established before cell expansion can occur. This stress condition will inhibit both callus growth and shoot formation (Brown et al., 1979). Mannitol, sucrose, sorbitol (George and Sherrington, 1984; Shibli, 1990; Shibli et al., 1992), tributyl-1,4 dichlorobenzylphosphonium chloride (Phosphon D), malic hydrazide, succinic acid-2,2-dimethyl hydrazide (B-995), CCC and ancydrole (Dodds and Roberts, 1985) were reported to be good materials to lengthen the storage life of in vitro grown tissues.

Sucrose is a major component of most tissue culture media. It functions as both a carbon/energy source and osmotic agent (Shibli, 2000; Shibli and Al-Juboory, 2000). Sucrose can be used to reduce plant growth in vitro (Orlikawasa, 1992; Moges et al., 2003). However, the growth of explant is dependent on sucrose concentration (Sarkar and Naik, 1998). The use of high concentrations of sucrose was reported to inhibit shoot proliferation and restrict callus growth in tobacco (Tahtamouni et al., 2001; Moges et al., 2003). Microplant elongation was decreased in potato (Sarkar and Naik, 1998) and wild pear (Tahtamouni et al., 2001) with increasing concentration of sucrose. For tobacco callus cultures, 30 g/l reduced the capacity of the culture to form shoots which was completely inhibited when sucrose level reached 150 g/l (Brown et al., 1979).

Mannitol can also be used as an osmotic agent (Swan et al., 1999; Tahtamouni, 1999). It is a sugar alcohol, which is produced as a primary photosynthetic product by some plants and can be metabolized by them (Trip et al., 1964; Tahtamouni et al., 2001; Moges et al., 2003). The use of mannitol did not support tissue growth in tobacco (Lipavska and Vreugdenhil, 1996), but reduced shoot growth of chrysanthemum (Shibli et al., 1990; Moges et al., 2003) and bitter almond (Shibli et al., 1999a). Sorbitol is another sugar alcohol that inhibited shoot growth of in vitro grown chrysanthemum when it was added to the proliferation (Shibli et al., 1992) and modified MS rooting media (Shibli, 1991). Shibli et al. (1999a) reported that elevated sucrose, sorbitol or mannitol reduced growth of bitter almond microshoots significantly and extended the subculture interval to four months when cultures were kept at room temperature.

**Preservation at low temperature**

Storage under low temperature is one of the major tissue culture techniques used for preservation of genetic resources (Shibli, 2000; Tahtamouni and Shibli, 1999; Moges et al., 2003). Elimination of disease problems and reduction of genetic modification as well as low labor and space requirements are major achievements of cold preservation of plant material (Ballester et al., 1997; Reed et al., 1998a). Under such condition, accumulation of unsaturated lipids on the cell membrane would cause cell membrane thickening and retard cell division and elongation (Hopkins, 1995). Cold preservation depends on ecology and geographical origin of plants, but usually temperature in range of 0-5 °C is employed with cold tolerant species (Engelmann, 1997). In general, tropical and subtropical plants are less tolerant to cold temperature than temperate plants (Ford-Lloyd and Jackson, 1986). For instance, coffee (Coffee spp.) was successfully preserved at 20 °C (Bertrand-Desbrunais et al., 1992) while apple germplasm was preserved at 1-4°C (Orlikowska, 1992). In vitro raspberry (Rubus spp.) (Reed, 1993) and mint (Mentha spp.) (Reed, 1999) cultures were also best preserved at 4 °C with a 12h photoperiod. Pear (Pyrus communis) is usually preserved at temperature between 4-10 °C (Dereuddre et al., 1990) although shoots can be also preserved at 1-4°C for 1-5 years depending on the genotype (Reed et al., 1998b). Microshoots of in vitro grown wild pear were also preserved at 8 °C for 12 weeks (Tahtamouni and Shibli, 1999). Shoot tips of apricot (Prunus armeniaca) were
successfully preserved at 3°C for 24 weeks (Perez-Tornero et al., 1999) while potato germplasm was preserved at 10 °C (Kwaitkowski et al., 1988). Meristem cultures of some root and tuber crops and shoot-tips of banana (Musa spp.) were preserved for up to 18 months at 18°C (Wang and Charles, 1991). Kiwifruit (Actinidia chinensis planch. cv. Hayward) shoot tip cultures were stored in the dark successfully at 8 °C. After a year, their fresh weight had increased 8-fold and they produced more shoot tips than at the start of storage. Cold treatment of donor carnation plants (Dianthus caryophyllus L.) at 4°C for 3 days or more resulted in doubling in the percentage of excised, frozen shoot apices which survived freezing and a 6-to-7-fold increase in the percentage which formed leaf primordia or shoots (Seibert and Wetherbee, 1977).

Plant species differ in their requirement for light or dark during storage (George and Sherrington, 1984). Most cold preservation protocols were performed under either low light intensity or complete darkness (Tahtamouni et al., 2001; Wang and Charles, 1991; Zandvoort, 1994), but still several plant species were cold preserved under light conditions (Hvoslef-Eide, 1992). In vitro cultures of coffee (Bertrand-Desbrunais et al., 1992), citrus (Marin and Duran-Vila, 1991), banana (Banerjee and de Langhe, 1985) and potato (Sarkar and Naik, 1998a) were preserved successfully under light conditions while apple rootstocks (Orlikowska, 1992) and apricot shoot tips (Perez-Tornero et al., 1999) were best preserved in the dark.

Several types of plant materials including shoot tips, nodal segments and rooted shoots are used for low temperature preservation of plants such as apple and pear (Dereuddre et al., 1990; George and Sherrington, 1984; Orlikowska, 1992). Shoot tips were most successful for in vitro preservation due to their high survival and regrowth percentage and high genetic stability (Ballester et al., 1997). Callus, embryo and cell suspension cultures can also be used for cold preservation of plant materials (Anandarajah et al., 1991; George and Sherrington, 1984).

2. Cryopreservation

Cryopreservation is a long-term storage of biological material in liquid nitrogen (LN) at –196 °C (Towill, 1996b; Helliot and de Boucaud, 1997). During cryopreservation, cell division and metabolic and biochemical processes are halted (Niino et al., 1995) and thus the cells are allowed to retain their properties unchanged (Mannonen et al., 1990; Paul et al., 2000) for an almost indefinite period of time (Engelmann, 1997; Tessereau et al., 1994). Also, cryopreservation offers maximum stability of phenotypic and genotypic characteristics of the stored germplasm (Engelmann, 1997). The development of cryopreservation for plant cells and organs has followed the advances made with mammalian species. The first report on survival of plant tissues to exposure to ultra-low temperatures was made by Sakai in 1956 when he demonstrated that very hardy mulberry (Morus spp) twigs could withstand freezing in liquid nitrogen after dehydration mediated by extra-organ freezing (Engelmann, 1997). In recent years, several new cryopreservation techniques have been developed which allow application of cryopreservation to larger range of tissues and organs, in varying infrastructural situations (Kartha and Engelamann, 1994; Withers and Engelmann, 1998). Shoot tips, 1-3 mm long, are widely used due to their high genetic stability, high survival and regrowth percentages (Al-Ababneh, 2001; George and Sherrington, 1984; Tahtamouni, 1999; Moges et al., 2003). Shoot tips are characterized by their small dense and actively dividing cells (George and Sherrington, 1984) and it would insure rapid multiplication rates after thawing (Tahtamouni, 1999). Also the low water content of shoot tip cells would propose a strong reason for choosing them as a basic plant material for cryopreservation (Al-Ababneh, 2001; George and Sherrington, 1984; Tahtamouni, 1999). A freezing tolerance of shoot tips of grapevine (Vitis vinifera L.) was independent of their position on the stem (Plessis et al., 1993). Embryogenic cell suspensions of grapevine (Vitis vinifera L.) were successfully cryopreserved by encapsulation-dehydration and
subsequently regenerated into plants (Wang et al., 2002). Scottez et al. (1992) found that during encapsulation-dehydration, axillary shoot tips gave higher survival and regrowth percentages than did apical shoot tips. Many plant species including pear, apple, mulberry, citrus and herbaceous plants have been successfully preserved in LN (Dereuddre et al., 1990; Niino and Sakai, 1992; Sakai et al., 1991). Cell suspension could be used at the exponential phase of growth (Shibli et al., 1999b, 2001; Withers, 1979; 1991), in which cells are small in size and have relatively small vacuoles and low water content (Engelmann, 1997). Also small cell aggregates have a higher freeze-tolerance than large cell aggregates (Ashmore, 1997). The embryo and the embryonic axis of some recalcitrant seeds are too large to survive without serious structural damage after exposure to liquid nitrogen (Engelmann, 1997). This problem could be overcome either by using immature embryos or by using zygotic embryo (Withers, 1991). Embryonic axis of *Camellia japonica* was cryopreserved more easily than somatic embryos, due to the differences in the degree of differentiation and water content (Janeiro et al., 1996). Organs are not recommended for freeze preservation, due to their large size and the fact that they contain different type of cells (Withers, 1991). These different cells require different protocols to be preserved without damaging the organ (Engelmann, 1997; Shibli et al., 2001).

Somatic embryos were successfully cryopreserved in some plant species including black iris (Shibli, 2000), and olive (Shibli and Al-Juboory, 2000). Organized tissues such as shoot tips are preferred over cell and callus cultures for preservation of germplasm of many plant species (George and Sherrington, 1984; Shibli, 2000) due to high genetic stability and high survival and regrowth percentages (Paul et al., 2000).

A key element to the successful development of any cryopreservation protocol is the selection of the optimal physiological state at which explants should be used for freezing (Wu et al., 1999; Zhao et al., 1999). One of the most important requirements for successful cryopreservation is avoiding formation of ice crystals inside the cells during freezing and thawing (Towill, 1996b). This could be achieved by various pretreatments including cold acclimation, exposure to abscisic acid (ABA), immersion in concentrated sugar solutions, or extensive bead dehydration (Al-Ababneh, 2001; Shibli, 2000; Shibli et al., 2001; Tahtamouni and Shibli, 1999). Although cryopreservation has many advantages, freezing and thawing injuries related to membrane structure and function that would result in low survival percentages are still the major limiting factors (Ford-Lloyd and Jackson, 1986; Towill, 1988). In addition, the inability to put general guidelines for cryopreservation for all plants had made it impossible to state a cryopreservation protocol as every plant has its own unique needs for cryopreservation (Brown and Thorpe, 1995; Towill, 1996b). Since there is no single protocol or method for wide range of species or even genotypes (Ashmore, 1997), several cryopreservation protocols for germplasm conservation have been developed (Ashmore, 1997; Engelmann, 1997). The first protocol is the classical two-step freezing technique in which the tissue is pretreated and cooled slowly at a controlled rate for tissue dehydration followed by rapid freezing in LN (Engelmann, 2000; Scottez et al., 1992; Towill, 1996a; Withers, 1979). The adjustment of freezing rate and prefreezing temperature allows the modification of the amount of residual intracellular water and thus reduces the damage caused by crystallization of this water (Villalobos and Engelmann, 1995). However, this technique is time consuming and complex, and requires an expensive cooling apparatus that would give the required cooling temperature accurately (Engelmann, 2000; Wang et al., 2002). Ice formation could also occur mostly during the slow cooling step that would kill the cell (Lambardi et al., 2000; Niino et al., 1992). Moreover, this technique provides low survival percentage (Ashmore, 1997; Engelmann, 1997). The new techniques, which are based on vitrification, have been developed over the past 10 years (Ashmore, 1997). Included among these are encapsulation-dehydration, vitrification, encapsulation-vitrification, desiccation, pregrowth, pregrowth-desiccation and droplet freezing (Ashmore, 1997; Engelmann, 1997). In all of these
methods a very rapid freezing process is used, with samples being plunged directly into liquid nitrogen once the pretreatment stages have been completed (Ashmore, 1997). As a result, the internal solutes vitrify and deleterious intracellular ice formation is avoided (Engelmann, 1997). Since the freezing process in these methods is extremely simple, a programmable freezer is not required and the cryopreservation can be achieved using simple equipment. In addition, larger organ structures may be more readily cryopreserved when compared with the use of classical approaches (Ashmore, 1997; Engelmann, 1997; Withers and Engelmann, 1998).

**Encapsulation-dehydration**

Encapsulation-dehydration includes encapsulation of plant material in calcium alginate beads, followed by pregrowth treatment in a medium containing high levels of sucrose ranging from 0.3 M to 1.5 M for at least one day (Ashmore, 1997; Niino and Sakai, 1992; Shibli, 2000; Shibli and Al-Juboory, 2000; Shibli et al., 1999b; 2001). The alginate beads are then dehydrated before freezing using either air-drying in a laminar flow hood or by exposure to silica gel (Ashmore, 1997). Encapsulation of plant material with calcium alginate induced a short delay only in the development of meristems (Paulet et al., 1993). Encapsulation-dehydration is widely used because it is applicable to many plant species (Al-Ababneh, 2001; Shibli 2000). Encapsulation-dehydration was described to have many advantages over vitrification (Niino and Sakai, 1992; Shibli et al., 2001). Vitrification method involves very delicate steps to handle compared to Encapsulation-dehydration (Engelmann, 1997). Also cryoprotectant solution used in vitrification is complex and it is composed of cryoprotectant cocktails while sucrose is the most used in Encapsulation-dehydration method (Shibli et al., 1999, 2001). Toxicity caused by cryoprotectants especially DMSO is a major problem in vitrification and is eliminated by Encapsulation-dehydration method as sucrose is not toxic (Ashmore, 1999; Engelmann, 1997; Niino and Sakai, 1992). Also Encapsulation-dehydration is not expensive and does not need expensive cooling apparatus (compared to two-step freezing) and avoid ice formation during cooling (Al-Ababneh, 2001; Niino et al., 1995).

Encapsulation-dehydration cryopreservation methods are based in a successive osmotic and evaporation dehydration of plant cells (Swan et al., 1999, Shibli et al., 2001). Dehydration techniques allow more flexibility when handling large sample numbers because the processing is less time-critical than with vitrification (Sakai et al., 2000, Shibli et al., 2001). Survival and regrowth of the cryopreserved plant material is dependent on preculture duration and residual water content after desiccation (Al-Ababneh, 2001, Engelmann, 1997). The water content of the empty beads is determined by drying it in oven at 100 °C or 90 °C for 16 h (Scottez , 1992). Hirata et al. (1998) found that root tips of horse radish (*Armoracia rusticana*) which encapsulated in calcium alginate beads with 0.5M glycerol and 0.3M sucrose and proper dehydration up to 33% moisture content was cryopreserved successfully.

Optimal survival was achieved with cryopreserved shoot tips excised from preconditioned stock shoots of ‘Troyer’ citrange (*Poncirus trifoliata x Citrus sinensis*) with 0.22M sucrose and dehydrated to 17.1% moisture content (Wang et al., 2002). The highest survival or regrowth rates were also obtained with cryopreserved shoot tips excised from 5-week cold acclimated bitter almond and pretreated with 0.75 M sucrose and then dried for 4 or 6 h (Al-Ababneh, 2001). Gonzalez-Arnao et al. (1998, 1999) also obtained high survival rate when encapsulated sugarcane apices were pretreated with 0.75 M sucrose and desiccated to 20-25% moisture content. Similar observations were reported in Spanish plant (*Antirrhinum microphyllum*) nodal explants (Gonzalez-Benito et al., 1998), almond apices (Shatnawi et al., 1999) and olive (*Olea europaea*) shoot tips (Martinez et al., 1999). Root tips of horse radish (*Armoracia rusticana*) encapsulated in calcium alginate beads containing 0.5 M glycerol and 0.3 M sucrose with proper dehydration up to 33% moisture content were cryopreserved successfully (Hirata et al., 1998). Somatic embryos of coffee (*Coffea canephora*) were also successfully cryopreserved using
Vitrification
Vitrification techniques have been developed over the past ten years for different plant species (Ashmore, 1997; Tahtamouni, 1999) in which tissues are dehydrated by high osmoticum concentration to avoid the risk of ice formation during cryopreservation and thawing (Bachiri et al., 1995; Tahtamouni, 1999; Al-Ababneh, 2001; Moges et al., 2003). It consists of three major phases: the loading phase, dehydration with highly concentrated vitrification solutions, and the unloading phase (Engelmann, 1997; Moukadiri et al., 1999; Tahtamouni, 1999; Tahtamouni and Shibli, 1999; Al-Ababneh, 2001). Loading phase involves treatments of samples with cryoprotectants or diluted vitrification solutions (Withers, 1991). By using a highly concentrated vitrification solution, samples will be dehydrated (Sakai et al., 1991) this method is simple, does not need expensive cooling apparatus and can be applied to a wide range of plant material (Niino et al., 1992; Matsumoto et al., 1994; Al-Ababneh, 2001).

Plant vitrification solution (PVS2) is an aqueous cryoprotectant solution in which living systems can be cooled slowly to below the glass transition temperature without appreciable ice formation either intra or extra cellularly (Fahy et al., 1987). It exhibit protective properties, as well as increasing the osmotic potential of the external medium (Reed, 1995), water will then tend to flow out of the cells and dehydration of tissues will occur (Ashmore, 1997). Cryoprotectants must be non-toxic at proper concentrations (Withers, 1991), have low molecular weight, readily miscible with water, and have the ability to penetrate cells rapidly (George and Sherrington, 1984; Reinhoud et al., 1995). Among those materials the most used cryoprotectants are dimethyl sulphoxide (DMSO), glycerol, ethylene glycol (EG), polyethyl glycol (PEG), amino acids, and sugars (Al-Ababneh, 2001; Sakai et al., 1990). Most vitrification solutions employed are derived from those elaborated by Sakai et al. (1990), which comprise 22% (w/v) glycerol, 15% (w/v) ethylene glycol, 15% (w/v) polypropylene glycol, 7% (w/v) DMSO, and 0.5 M sorbitol. Another PVS2 stock solution which contains 30% (w/v) glycerol, 15% (w/v) DMSO, 15% (w/v) ethylene glycol in standard liquid medium containing 0.15 M sucrose was reported by Benson (1994). The duration of contact between explants and the vitrification solution is a critical parameter, in view of their high toxicity (Engelmann, 1997). The dehydration period generally increases with the size of the explant used (Engelmann, 1997). Performing the dehydration step at 0°C instead of room temperature allows to reduce the toxicity of vitrification solutions and thus to broaden the window of exposure duration ensuring survival of samples (Engelmann, 1997). This also allows manipulation of a large number of samples at the same time (Engelmann, 1997). Survival of asparagus embryonic cell suspensions dropped rapidly after 5 min of dehydration at 25°C but high survival was obtained for dehydration periods between 5 and 60 min if it was performed at 0°C (Nishizawa et al., 1993). Unloading starts after rapid warming, whereby vitrification solution is drained out of the cryogenic vials and replaced with sucrose at elevated concentrations (Ashmore, 1997; Moges et al., 2003). Unloading aims at removing progressively the vitrification solution by adding liquid medium containing 1.2 M sucrose or sorbitol to dilute the vitrification solution and reduce the osmotic shock (Withers, 1991; Engelmann, 1997).

Encapsulation-vitrification
The encapsulation-vitrification technique is a combination of encapsulation-dehydration and vitrification procedures whereby samples are encapsulated in alginate beads, then submitted to...
freezing by vitrification (Ashmore, 1997; Hirai and Sakai, 1999; Engelmann, 1997, 2000). Hirai et al. (1998) found that osmoprotected in vitro grown meristems of strawberry (*Fragaria ananassa* Duch.) with 2.0 M glycerol plus 0.4 M sucrose produce more shoot formation than using 0.4 M sucrose only. In case of carnation, encapsulated apices were pregrown for 16 h with progressively more concentrated sucrose solution, then incubated for 6 h in a vitrification solution containing ethylene glycol and sucrose and frozen either rapidly or slowly, where maximum survival was 100% and 92% after rapid and slow cooling, respectively (Engelmann, 1997). The encapsulation-vitrification method is easy to handle, saves greatly the time needed for dehydration (Hirai et al., 1998; Al-Ababneh, 2001), and the recovery growth is much earlier than encapsulation-dehydration techniques (Hirai and Sakai, 1999; Shibli and Al-Juboory, 2000). Hirai et al. (1998) observed that encapsulated-vitrified meristems of *Fragaria ananassa* cooled to –196°C produced higher shoot formation than encapsulated dried meristems. Encapsulation-vitrification has also been described (Hirai et al., 1998, Shibli and Al-Juboory, 2000) as a cryogenic protocol with high potential for large-scale cryopreservation.

**Factors affecting cryopreservation**

The cryopreservation procedure comprises a number of steps including preculture in media with osmotically active compounds, treatment with cryoprotective agents, cooling, and storage at –196°C, thawing, post-thaw treatments, and recovery of growth (Withers, 1991; Moges et al., 2003). Each step influences the success of cryopreservation (Razdan and Cockling, 1997).

- **Physiological conditions of plant material**
  The capacity to survive storage in liquid nitrogen (LN) is dependent upon many factors including genotype, physiological status and pre- and post-frieezing manipulations (Towill, 1996a; Engelmann, 1997; Moges et al., 2003). The type of explant as well as its physiological state when entering storage can influence the duration of storage achieved (Engelmann, 1997). Type and nature of cells determine the ability of cells to withstand freezing stress (Engelmann et al., 1995; Swan et al., 1998). The survival of cryopreserved shoot tips of taro (*Colocasia esculenta*) increased gradually as the age of the donor plants increased [from 46% in 1-week-old plants to 75% in 3-week-old plants] (Takagi et al., 1997). Shibli (2000) reported that selection of embryo of the proper size was of a significant importance to increase survival in black iris (*Iris nigricans*). In general it is recommended to take explants from rapidly growing cultures since actively dividing cells have dense cytoplasm and little developed vacuolar system which makes them more likely to withstand freezing and remain viable (Engelmann et al., 1995; Moges et al., 2003).

- **Prefreezing treatments**
  Extracellular freezing is considered as effective method of dehydrating living cells (Sakai et al., 1991). Freezing tolerance of plant material can be increased by cold hardening and/or preculturing in media with high levels of osmotic agents before exposure to LN (Niino and Sakai, 1992; Niino et al., 1992). Usually, the pretreated stored plant materials show higher survival percentages after thawing than non-pretreated materials (Niino et al., 1992; Towill, 1996b). The effects of prefreezing and re-warming rates upon the survival of cortical tissues of winter mulberry twigs immersed in liquid nitrogen shows that the cortical cells frozen slowly to –120°C survived subsequent rapid re-warming by direct immersion in water at 30°C, although cortical cells from less hardy plants are well known to be sensitive to rapid thawing (Sakai et al., 1991). Cold hardening for five weeks at 5°C along with 0.3 M sucrose preculture significantly increased survival and regrowth percentages of cryopreserved shoot tips of bitter almond (Al-Ababneh et al., 2003). Cold hardening of in vitro grown mother plants of pear for one week at –1°C (Reed, 1990) and wild pear for three weeks at 4°C (Tahtamouni, 1999; Tahtamouni and Shibli, 1999) before excision of shoot apices improved the recovery after cryopreservation.
Shibli (2000) reported the importance of preculturing of the embryos of black iris (*Iris nigricans*) for 3 days on medium containing 0.75 M sucrose, fructose, or glucose. Pretreatment involves the cultivation of biological materials to be stored in the presence of a cryoprotective agent such as sucrose, sorbitol, mannitol, dimethylsulfoxide (DMSO) or polyethylglycol (PEG) which may have an osmotic action or may also protect membranes, proteins and enzymatic binding sites from the freezing stress (Villalobos and Engelmann, 1995). The concentration and duration of exposure to the osmotic agents depend on the plant species and samples of plant material (Ashmore, 1997; Engelmann, 1997). The pregrowth condition must allow the decrease of as much as possible of the water level of the tissues in order to avoid the detrimental formation of intracellular ice crystals in the tissues (Engelmann *et al*., 1995; Moges *et al*., 2003).

Pretreatment using sucrose plays a major role in improving the resistance of apices to both dehydration and freezing in LN (Swan *et al*., 1998; Shibli, 2000; Moges *et al*., 2003). Swan *et al.* (1998) reported that encapsulation-dehydration technique, sucrose pretreatment played a major role in the tolerance of apices to dehydration and further freezing. On the other hand Mycock *et al.* (1995) found that somatic embryos of date palm (*Phoenix dactylifera*) and (*Pisum sativum*) showed similar recovery after cryopreservation, irrespective of the pretreatment additive. Besides its osmotic effect, sucrose act by stabilizing membranes and proteins during desiccation (Towill, 1996; Shibli *et al*., 2001). High sugar concentration in the cell cytoplasm help to establish a vitrified state during cooling and enables cells to tolerate dehydration that can cause freezing damage (Al-Ababneh, 2001; Shibli *et al*., 2001). Mannitol can be also used as an osmoticum agent (Swan *et al*., 1999; Tahtamouni, 1999). It is a sugar alcohol, which is usually produced as a primary photosynthetic product by some plants and can be metabolized by them (Trip *et al*., 1964). Swan *et al.* (1999) found that cell fresh weight of *Helianthus tuberosus* increased after mannitol and sucrose preculture treatments, with or without cryoprotection. Sorbitol is another sugar alcohol that inhibited shoot growth, but increase cell content of solutes (Shibli *et al*., 1992; 2001; Tahtamouni *et al*., 2001; Moges *et al*., 2003). Dehydration is another factor which affects the sensitivity of the cryopreserved plant material to freezing with liquid nitrogen (-196°C) (Shibli, 2000; Shibli *et al*., 2001, Tahtamouni and Shibli, 1999). Partial dehydration is usually achieved by using osmoticum or cryoprotectants in the medium before or during cryopreservation (Bachiri *et al*., 1995). Sufficient dehydration before freezing is achieved by exposure of plant material to air flow under the laminar cabinet (Al-Ababneh *et al*., 2003; Shibli *et al*., 2001) or by using silica gel (Shatnawi *et al*., 1999). For different duration depend on plant species. Dumet *et al.* (1993) found that the recovery of the cryopreserved somatic embryos of oil palm (*Elaeis guineensis* Jacq) was markedly improved by completing the 7- day pregrowth period in 0.75M sucrose with the additional dehydration period carried out by placing the embryos in the airflow of the laminar cabinet. Dehydration for 4 hrs was reported to be essential for survival of cryopreserved *Catharanthus* (Bachiri *et al*., 1995), *Vaccinium pahalae* (Shibli *et al*., 1999b) and alfalfa (*Medicago sativa* L.) (Shibli *et al*., 2001) cells.

- **Cryoprotection**

The development of a simple and reliable method for cryopreservation would allow more wide spread use of the cryopreserved cultured cells, meristems, and somatic embryo (Al-Ababneh, 2001; Dumet *et al*., 1993; Hirata *et al*., 1998; Martinez *et al*., 1999; Shibli, 2000). Plant materials are subjected to a cryoprotective treatment using various cryoprotective substances including DMSO, glycerol, ethylene glycol (EG), polyethylene glycol (PEG), amino acids and sugars before freezing (Bachiri *et al*., 1995; Engelmann, 1997; Sakai *et al*., 1991; Towill, 1996b; Withers, 1991). In a few exceptional cases, a single cryoprotectant (usually dimethyl sulfoxide-DMSO) is effective, however, a cryoprotectant mixture consisting of DMSO, glycerol (each at 0.5 M) and a third component such as sucrose, proline, mannitol or sorbitol (at 1.0 M), is usually far more effective (Withers, 1991). Cryoprotectants must be non-toxic at the proper
concentrations (Withers, 1991; Moges et al., 2003), have low molecular weight, readily miscible with water, and able to penetrate cells rapidly (George and Sherrington, 1984; Moges et al., 2003). They are able to reduce the size of ice crystals and lower the freezing point of intracellular contents which enable cells to withstand very low temperatures without disruption of the cell membrane or contents (Ford et al., 2000). Amino acids can be grouped into three categories according to their ability to protect thylakoid membranes against freeze damage, the protective amino acids (group 1) include proline, threonine, γ-amino- butyric acid, arginine and lysine amino acids that provide intermediate protection (group 2) include serine and non-protective amino acids (group3) include valine, leucine, isoleucine, methionine, tyrosine and phenyl-alanine (Touchell and Dixon, 1994).

In all cases cryoprotectants are more effective when prepared in culture medium rather than in water, pH of the mixture should be adjusted to that of the standard culture medium, filter sterilized, chilled, and then applied to the cell suspension culture. The cryoprotectant and cells are mixed thoroughly and left to incubate for approximately 1 h (Withers, 1991). Sucrose plays a role in cryoprotection at the cellular level due to the colligative action of relatively small molecules which depresses the freezing point (Bachiri et al., 1995; Moges et al., 2003). Such compounds may also protect proteins or membrane phospholipids during freezing or drying by replacing the extensive shell of water molecules which is oriented around proteins (Moges et al., 2003).

- **Cooling rate**

Slow cooling is necessary to enable the process of protective dehydration to occur (Withers, 1991). During slow freezing, cooling to very low temperature or prolonged exposure to low temperature before transferring the plant materials to LN may be injurious to cells because of excessive cellular dehydration and the formation of damagingly large crystals (Gnanapragasam and Vasil, 1992). Once the pretreatment stages have been completed, rapid freezing is used by directly plunging tissue into LN (Withers, 1991). As a result, the internal solutes vitrify and deleterious intracellular ice formation is avoided (Engelmann, 1997). Gonzalez-Arnao et al. (1993) reported that the survival of sugarcane apices was achieved with both rapid freezing and slow freezing using a programmable freezer, but it was generally higher after rapid cooling. In the case of cell suspension cultures, an effective dehydrating procedure is to freeze at a rate of $1\,^\circ\text{C}$ per minute to approximately $-35\,^\circ\text{C}$, followed by holding at that temperature for approximately 40 minutes (Withers, 1991). Reed (1990) reported that the survival rates of pear apical meristems increased as cooling rate decreased while Scottez et al. (1992) found that the resistance of encapsulated and dehydrated plant material to LN did not depend on the cooling rate.

- **Storage**

The storage duration in liquid nitrogen is not a critical factor affecting the recovery of cryopreserved plant material (Withers, 1991). Once the plant material is plunged into LN, the internal solutes will be vitrified and no longer will biochemical or biophysical events occur (Ashmore, 1997). It is not possible to improvise adequate storage conditions and cryopreserved material must be held at a suitably low temperature in a vacuum-insulated refrigerator (Withers, 1991).

- **Thawing**

This is normally carried out rapidly, to avoid any risk of ice damage by crystallization, by agitating the ampoules in a container of sterile warm water at approximately 40 $^\circ\text{C}$ (Withers, 1991). The zone of recrystallization could be passed so rapidly during rapid thawing that there would be no time for recrystallization and thus cell injury could be prevented (Gnanapragasam and Vasil, 1992). Therefore, rapid thawing is recommended after the plant material picked out
from LN to avoid any risk of ice damage by recrystallization (Engelmann, 1997; Withers, 1991). Thawing can be done either at room temperature under laminar airflow cabinet (Gonzalez-Arnao et al., 1993; Al-Ababneh, 2001), or in a water bath (Engelmann, 1997; Shibli et al., 1999b; 2001). The use of a wide range of water bath temperatures has been suggested to be used (Reed, 1995). Lambardi et al. (2000) reported that the best survival of cryopreserved Populus alba L. shoot tips was observed after the cryovials were maintained at room temperature for 5 seconds and then plunged into a water bath at 40 °C. Withers (1991) reported that freshly thawed cells are extremely susceptible to injury, particularly by deplasmolysis.

**Reculture**

After warming to room temperature, thawed materials have to be washed several times to remove the cryoprotectants to avoid any deplasmolytic injury to cells due to loss of membrane surface area during dehydration and shrinkage. The washed material will then be recultured on a fresh medium following the standard tissue culture procedure (Seibert and Wetherbee, 1977). The effect of the post-culture medium composition on the viability of dehydrated and cryopreserved cells of grape vine (Vitis vinifera L) was studied by Wang et al. (2002), all liquid media tested greatly reduced viability compared with solid media, where as the addition of activated charcoal (AC) to the solid post-culture medium promoted the viability of cryopreserved cells and promote the viability of dehydrated cells but this effect was less significant compared to solid medium devoid of AC. Engelmann et al. (1995) demonstrated that increased survival of cryopreserved immature embryos was obtained by culturing on a modified medium supplemented with 100 mg/l GA3. However, Withers (1979) observed that incorporation of GA3 into the growth medium, either in the presence or absence of 2,4-D, failed to promote growth of the cryopreserved meristems of carrot (Daucus carota L). Sarkar and Naik (1998b) reported that post-thaw culturing of vitrified shoot tips of potato on a medium containing up to 0.2 M sucrose under diffuse light for the first week enhanced the survival rate.

**Survival and regeneration testing**

Various rapid techniques have been used to detect viable plant cells, including fluorescein diacetate (FDA) staining (Withers, 1991), and a triphenyl tetrazolium chloride reduction assay (TTC test) (Shibli et al., 1999b; 2001; Wang et al., 2002). The TTC test distinguishes between survived and non-survived plant cells, tissues and organs (Bachiri et al., 1995), on the basis of their respiration rate (Benson, 1994). The test utilizes the activity of dehydrogenase as an index of respiration rate of the viable plant material (Steponkus and Lamphear, 1967). Tetrazolium salt solution reduced to formazen by hydrogen ions released by respiration of the viable plant material (Benson, 1994). As a result, the red color will develop (Swan et al., 1999). These vital staining techniques are usually used specifically whether the cells were from cultures of different ages, different species, and different plant treatment even with toxic material if it is still alive (Widholm, 1972). Regrowth of the cryopreserved plant material is another indicator for plant viability (Ashmore, 1997; Tahtamouni and Shibli, 1999; Moges et al., 2003). It was indicated by cellular growth and greening of the apical regions (Tahtamouni and Shibli, 1999), or in the form of callus (Kuo and Lineberger, 1985).

**3. Genetic stability**

The combination of somatic embryogenesis, artificial seed technology and cryopreservation is considered to be a potentially fruitful new approach to the genetic conservation of problem subjects including both root and tuber crops and other clonally propagated material through to recalcitrant seed-producing species (Withers, 1991). Cryopreservation ensures future availability of plant material, it also retains viability, thereby reducing the risk of any loss of genetic diversity (Al-Ababneh, 2001; Gonzalez-Arnao et al., 1999; Shibli et al., 2001). Genetic stability of the regenerated plant materials has been observed (Sakai et al., 1991; Shibli, 2000). Shibli et
al. (1999b) reported that cryopreservation by encapsulation-dehydration did not diminish the capacity of ohelo (Vaccinium pahalae) cells to produce anthocyanins and other flavonoids. Benson et al. (1996a) studied cryopreservability of potato shoot tips and the competence and ploidy stability in the recovered plants. They found that, cytological studies revealed plant ploidy status was maintained and chromosomal abnormalities were not observed. Chen et al. (1984) reported that alkaloid-producing cells of Catharanthus roseus retained their alkaloid producing capability after cryopreservation and alkaloid content maintained unchanged. Leaf morphologies of plants regenerated from cryopreserved cells of grapevine also appeared to be similar to those plants from control cells (Wang et al., 2002).

References


Hvoslef-Eide A.K. Effects of pre-storage conditions on storage of in vitro cultures of (Nephrolepis exallata L.) and (Cordyline fruticosa L.), Plant Cell, Tissue and Organ Culture, 28, pp. 167-174.


Shibli R.A. 1990. Physiological studies of in vitro and in vitro water requirements and water relations of (Chrysanthemum morifolium Ramat), Ph. D. Disseration, University of Illinois, IL, USA, pp. 13-18, 44-50.


Investigation by basic conditions of the vitrification procedure, Plant Cell Reports, 16, pp. 594-599.
Use of Participatory Plant Breeding to Promote On-farm Conservation of Landraces of Durum Wheat

H. Hasasneh¹ and A. Amri²

¹Crop breeder in “Conservation and Sustainable use of Dry land Agro biodiversity in Palestinian Authority land” project.
²International Center for Agricultural Research in the Dry Areas. West Asia Regional Program, Amman, Jordan

Keywords: Durum wheat, landraces, on-farm conservation, participatory breeding, Palestine

Abstract
Landraces of durum wheat in Palestine are still used under low input agriculture but their acreage is increasingly affected by the introduced improved varieties. The dryland agrobiodiversity project is trying to promote the conservation of these landraces through demonstrating appropriate technologies for increasing their productivities and adding the value to their products. Farmers’ participatory selection within durum wheat landraces was conducted and the original populations were compared to the selected bulks at two experiment stations during two seasons. The results showed significant increases in grain and straw yields that show the relevance of involving farmers in the selection process and the possibilities for extracting better performing multilines from landraces.

Introduction
Agriculture constitutes the basis of the livelihoods of local communities in Palestine contributing to 14% to GDP and playing an important role by providing jobs to thousands of Palestinians affected by the prevailing political situation (Ministry of Agriculture, 2003). Cereals are the major annual crops in the West Bank, but the large distribution of introduced semi-dwarf varieties has drastically affected the acreage planted to landraces. The farming surveys conducted in Jenin and Hebron showed that landraces are only cultivated in less than 25% of the durum wheat acreage and improved varieties introduced from Israel are largely adopted. Landraces are still highly appreciated for their grain and straw qualities in all countries of North Africa and West Asia where a price premium is offered for their grain compared to improved varieties (Amri, 1997). These landraces are valuable germplasm for improvement of wheat over the world and their adaptation to low input agriculture provide low risk strategy for farmers living under harsh conditions. Landraces are composed of a large number of lines which give the whole population a genetic buffering against fluctuations of environments. Ceccarelli et al (2001) has recommended the use of participatory breeding and landraces in developing varieties for marginal environments. Potential exist to improve the yields of landraces through low-cost technological packages and through genetic manipulation including participatory selection of new multilines. This contribution shows the relevance of involving farmers in the selection within the landraces.

Materials and methods
The Project on “conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestine and Syria” is trying to promote the on-farm conservation and sustainable use of dryland agro-biodiversity through the testing and demonstration of appropriate and low-cost technological packages which will allow the preservation and the increase of productivity of
landraces on-farm. For cereals many activities were conducted among which the initiation of farmers participatory approach for selection and improvement of durum wheat landraces. The project staff trained 30 farmers from different project sites in Jenin and Hebron districts on participatory breeding approach. These farmers were involved with project staff and extension agents in the evaluation and selection of the landraces. Neighboring farmers have also participated in the selection process. More than 400 farmers have attended the demonstration trials to show the value of participatory selection within landraces.

Ten wheat varieties were subject to participatory selection process: these include five landraces and four old released varieties of durum wheat and old released variety of bread wheat (Arael). The selection was done in the lead farmers fields and neighboring farmers participated in the selection. The original population and the selected bulks were grown for two seasons 2001-02 and 2002-03 respectively at Al-Aroub and Beit-qad experiment stations. Grain and straw yields were measured on the original population and the selected bulks. Percents of grain and straw yield increases were calculated.

**Results and discussion**

Farmers were very interested to participate in the selection process. The selection criteria differed from herders and farmers. Herders were selecting tall and high tillering plants, as they are mainly interested in forage and straw productions. Other farmers and seed producers selected short, long spike and amber grain colored plants. Women expressed their interest for varieties with good bread making qualities which are mainly the landraces. The results in table 1 show clearly the benefits of selecting bulks out of the original heterogeneous landraces and varieties. Anbar, old released variety with similar phenotype as landraces, has given the highest grain and straw yields. Among the landraces, the variety Nab Al-Jamal has given similar yields as Anbar and has out yielded significantly many of the old released varieties still in use in the West Bank. The other landraces have given grain and straw yields not significantly different from the check varieties 870 and Nemra 8. The yield gains through farmers selections have ranged from 6.8 to 24.2% for grain yield and 1.6 to 25% for straw yield. The highest gains are obtained for bulks selected from the varieties Anbar, Khatat and Menka. This study shows the possibility of selecting new multilines from landraces which give higher grain and straw yields while maintaining a large part of the diversity of the original landraces.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Treatment</th>
<th>Production Kg/ha</th>
<th>% of increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain Straw</td>
<td>Grain Straw</td>
</tr>
<tr>
<td>Debiya soda</td>
<td>Before selection</td>
<td>1360 2760</td>
<td>14.0 6.2</td>
</tr>
<tr>
<td></td>
<td>After selection</td>
<td>1550 2930</td>
<td></td>
</tr>
<tr>
<td>Debiya bida</td>
<td>Before selection</td>
<td>2050 4700</td>
<td>15.1 9.6</td>
</tr>
<tr>
<td></td>
<td>After selection</td>
<td>2360 5150</td>
<td></td>
</tr>
<tr>
<td>Anbar</td>
<td>Before selection</td>
<td>3620 6920</td>
<td>21.5 25.0</td>
</tr>
<tr>
<td></td>
<td>After selection</td>
<td>4400 8650</td>
<td></td>
</tr>
<tr>
<td>870</td>
<td>Before selection</td>
<td>2200 3770</td>
<td>6.8 12.7</td>
</tr>
<tr>
<td></td>
<td>After selection</td>
<td>2350 4250</td>
<td></td>
</tr>
<tr>
<td>Arael</td>
<td>Before selection</td>
<td>2560 4000</td>
<td>11.3 6.8</td>
</tr>
<tr>
<td></td>
<td>After selection</td>
<td>2850 4270</td>
<td></td>
</tr>
<tr>
<td>Kahatat*</td>
<td>Before selection</td>
<td>1650 2450</td>
<td>24.2 10.2</td>
</tr>
<tr>
<td></td>
<td>After selection</td>
<td>2050 2700</td>
<td></td>
</tr>
<tr>
<td>Hetti safra*</td>
<td>Before selection</td>
<td>2100 2770</td>
<td>9.5 8.3</td>
</tr>
</tbody>
</table>

Table 1: Average grain and straw yields (Kg/ha) of durum wheat original populations and new bulks selected by farmers during 2001-02 and 2002-03 season at two experiment stations.
<table>
<thead>
<tr>
<th>Variety</th>
<th>Before selection</th>
<th>After selection</th>
<th>Gain</th>
<th>Grown in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Menka*</td>
<td>1450</td>
<td>1800</td>
<td>24.1</td>
<td>Bet-qad</td>
</tr>
<tr>
<td>Nemra 8*</td>
<td>1760</td>
<td>1900</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>Nab Al-Jamal**</td>
<td>3600</td>
<td>4100</td>
<td>13.9</td>
<td>Aroub</td>
</tr>
</tbody>
</table>

This study shows that:

- Some landraces are performing as good as the improved varieties while conserving the advantage of quality attributes well appreciated by women;
- The relevance of involving farmers in the selection process is demonstrated;
- Significant gains in grain and straw yields are obtained in new multilines developed after two cycles of selection from landraces and heterogeneous varieties without much effect on the genetic constitution of the local populations.

Based on the feedback from farmers, landraces suit better the quality needs of the households and consumers in local communities in addition to their better adaptation to low input agriculture and to harsh environmental conditions.

Reference


Development of Community-based Informal Seed Production System for Promoting the Conservation of Durum Wheat Landraces in Palestine

Y. Sbeih¹ and A. Amr²

¹ National Project Manager, the Palestinian Authority, UNDP/PAPP, Ministry of Agriculture, Ramallah
² International Center for Agricultural Research in the Dry Areas (ICARDA), West Asia Regional Program, Amman, Jordan

Keywords: Durum wheat, landraces, on-farm conservation, seed production, informal system, Palestine

Abstract
Landraces of durum wheat and other field crops and fruit trees are still widely used by farmers in areas with harsh conditions. Their conservation and sustainable use are threatened by the increasing replacement with improved varieties and by the widespread of introduced fruit trees and vegetables within the prevailing cereal-based farming systems. The West Asia Dryland Agrobiodiversity project, implemented in Jenin and Hebron areas in Palestine is working towards the promotion of on-farm conservation of landraces of field crops and fruit trees through the testing with local farmers of technological packages and organizational arrangements for increasing the productivity and the incomes from landraces. In the absence of formal seed production system, the project is working with local communities to initiate community-driven seed production activities. The meetings with farmers and their training have simulated interest of farmers to work with the project on multiplying the seeds of durum wheat landraces. Fifty-nine farmers were selected to collaborate in seed increase of seven landraces grown in the project areas. These landraces are multiplied in farmers’ fields and at two experiment stations. The benefits of seed cleaning and treatments were shown to farmers through trials conducted at both farmers’ fields and experiment stations. The data showed significant grain and straw yield gains which has reached 32% in 2001-02 season. Two mobile seed cleaning units were provided to support this activity and a scheme was developed for the production and distribution of seeds of durum wheat landraces. More than 70 tons of seeds of landraces of durum wheat were distributed during 2001-04 cropping seasons benefiting more than 600 farmers. The area directly planted to these seeds is estimated to more than 600 hectares which allowed the regain of acreage by local varieties.

Introduction
Agriculture is a vital sector of the Palestinian economy contributing up to 14% towards the national gross domestic product (GDP) and providing a basis of livelihood for most of the rural population (Ministry of Agriculture, 2004). Wheat and barley are important commodities in Palestine that are sown annually over 40,000 ha of land, and contribute greatly to human diet and to livestock feed. But, their area of cultivation is decreasing each year due to their replacement by fruit trees (mainly olives) and vegetables. However, landraces of durum wheat are still cultivated in the drylands and marginal areas and are threatened by the introduced improved varieties in recent years. The farming survey conducted by the GEF/UNDP project on “conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestine and Syria” showed that landraces of durum wheat are currently used only by 25 % and 32% of the farmers in Jenin and Hebron areas, respectively.
Certified seeds of improved varieties introduced from Israel are bought by Palestinian farmers from private sector and seed company representatives. The national agriculture strategy has recommended the development of a reliable seed production system. Most of the farmers in Jenin and Hebron districts are using their own seeds or they buy their seeds from neighboring farmers.

Informal seed production is an important provider of seeds in most of the countries in Central, West Asia and North Africa countries (CWANA) as most of the farmers rely on known farmers to renew their seed stocks (ICARDA, 2004). The International Center for Agricultural Research in the Dry Areas (ICARDA) is working with many countries of CWANA region to strengthen both formal and informal seed production systems. Ceccarelli et al (2003) have reported the importance of informal seed production to support participatory plant breeding efforts. This contribution describes the steps undertaken in Palestine to initiate an operational informal community-based seed production and supply system to promote the conservation and sustainable use of landraces of field crops with durum wheat as an example.

**Materials and Methods**

Seeds of seven durum landraces (Kahattat, Debiya Bida, Debiya Soda, Nab Al-Jamal, Hetah Safra, Numra 8 and Anbar) were collected from collaborating farmers in Jenin and Hebron districts in year 2000. Numra 8 and Anbar are varieties used by farmers for more than 50 years in these areas. The seeds collected from farmers were cleaned and treated and part of them were planted in farmers fields and the remaining planted at the experiment stations at Beit Qad and Al-Aroub. The seeds harvested were cleaned and treated against seed borne diseases and then distributed to 15 farmers at each of the four project sites (viz. Tayassir and Deir Abu Deif in Jenin and Sair and Dahriya in Hebron) and planted over 35 ha in the 2001/02 cropping season. In 2002/03 season, 391 farmers have received the cleaned and treated seeds harvested from previous season and these were planted in 253 ha. In the 2003/04 season, the number of farmers planting the seeds of landraces multiplied through the agrobiodiversity project efforts increased to 425 farmers and the area planted to 278 ha (Table 1). Grain and straw yields were recorded at both the experiment stations and at farmers’ fields to assess the yields of landraces in comparison to the improved varieties (Arael, 870 and Menkah), and the positive effects of seed treatment and cleaning. Agronomic and morphological characteristics were also recorded for the varieties. Discussion were initiated with the local communities, the Ministry of Agriculture and the project team to develop and institutionalise an informal seed production system. Grassroots associations were formed in Dahriya, Deir Abu Deif and Tayassir to be responsible for further developing and sustaining this activity.

**Results and Discussion**

**Initiation of informal seed production system**

Farmers have reported growing many durum landraces as can be verified by various local names reported by collaborating farmers, however, the project has concentrated its efforts on the most commonly used varieties which farmers all agreed to possess great potential and quality characteristics. Interested farmers were selected following several meetings on the basis of their keen interest to become seed providers at local level, the availability of land and their previous expertise in seed production. Fifty-nine farmers were selected and with the exception of one have been involved in seed production activities in the past demonstrating the opportunities for sustaining the informal seed production in the target areas. These farmers have decided to create farmers’ associations in their respective project sites (Dahriya and Deir Abu Deif) and for Tayassir, the Women’s Center has taken the responsibility to work on seed production and
distribution. The project’s support was provided through in-kind incentives in the form of initial seeds of landraces, two stationary seed cleaning-treatment units and bags for packaging their seed production. The participating farmers have established contracts with the grassroots associations in the presence of the District Agricultural Extension Departments, to distribute at least 25% of their seed production to neighboring farmers and to return the same quantities provided by the project to the grassroots associations. These later seed quantities are redistributed to other new farmers who subsequently join in seed production efforts. This process has allowed having more than 425 farmers working on seed production of durum wheat landraces by the third year (Table 1). The evolution of quantities of seeds and of the areas planted to landraces of durum wheat during the last three seasons are reported showing that this process has contributed significantly to the promotion of the conservation and use of landraces of durum wheat. This process and institutional arrangements could also serve to promote the use of landraces of other crops.

Table 1: Evolution of number of collaborating farmers, quantity of seeds (tons) and areas covered (ha) by durum wheat landraces during 2001-02, 2002-03 and 2003-04 seasons

<table>
<thead>
<tr>
<th>Cropping seasons</th>
<th>Number of farmers</th>
<th>Quantities of seeds</th>
<th>Areas covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001-02</td>
<td>59</td>
<td>4.8</td>
<td>35</td>
</tr>
<tr>
<td>2002-03</td>
<td>391</td>
<td>32.5</td>
<td>253</td>
</tr>
<tr>
<td>2003-04</td>
<td>425</td>
<td>36.4</td>
<td>278</td>
</tr>
</tbody>
</table>

Comparison of productivities of landraces and improved varieties

The quantities of monthly precipitation and distribution over the three seasons at Beit Qad and Al-Aroub experiment stations are presented Graphs 1 and 2. The total amounts of rains have exceeded 350 mm at both stations but the highest quantities and best distribution were recorded during 2002/03 season. The 2003/04 season was characterized by extensive late droughts which has affected the yields of durum wheat. At the project sites Deir Abu Deif, Tayassir, Dahriya and Sair, the total rainfall amounts showed similar trends with highest quantities received in 2002/03 season and lowest during 2000/01 and 2003/04 seasons.

Fig. 1: Monthly rainfall (mm) at Al-Aroub experiment station during 2001-2004 seasons
The grain and straw yields of landraces and improved varieties for three cropping seasons are reported in Tables 1 and 2. The three year averages of straw and grain yields are presented in the Fig. 5 and the results showed that the old varieties Anbar, Numra 8 and the old landrace Nab Al-Jamal have given similar grain and straw yields than the best improved checks 870 and Arael. Kahattat, Debiya Soda and Debiya Bida gave the lowest average grain yields that can be explained by the effects of late droughts experienced in 2001/02 and 2003/04 seasons that favored the early varieties. These results show that some landraces can give similar grain and straw yields than the best improved varieties. The improvement of grain and straw yields of landraces can be achieved through participatory breeding and selection of best lines within each landrace to either be released as new variety or to form new multilines which can preserve most of the genetic constitution of the original landraces. Landrace grains have a price premium of at least 25% over the improved varieties and any yield advantage of improved varieties not exceeding this rate will justify the continuity of using landraces at local level mainly for their adaptation to low input agriculture and to the popularity of local dishes such as frikeh and burghul, and provided that seed needs are met. Women are unanimous about the quality superiority of landraces over the available improved varieties.

Effects of seed cleaning and treatment
The trials conducted at farmers fields were designed to demonstrate the benefits derived from improving the seed lots quality through seed cleaning and fungicide treatment to control seed transmitted diseases. The results obtained during 2000/01 and 2001/02 seasons showed that the effects of seed cleaning and treatment varied between the two seasons. The grain yield advantages for treated seeds ranged from 1.8 to 11.8 in 2000/01 season while these gains ranged from 13.6 to 32.1 % during 2001/02 season (Tables 3 and 4). These results show clearly the positive effects of seed cleaning and treatment on the performances of landraces. This strategy could help in the conservation and sustainable use of landraces of durum wheat and other field crops which justify the development of informal seed production system in the absence or complementary to the formal seed production program.

Table 3: Effects of seed cleaning and treatment on grain yields at farmers’ fields (kg/ha) of durum wheat varieties at four project sites during 2000/01 cropping season

<table>
<thead>
<tr>
<th>Variety</th>
<th>2000/2001 season</th>
<th>Village</th>
<th>Treated</th>
<th>Non-treated</th>
<th>% of increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debiya bida</td>
<td></td>
<td>Dahriya</td>
<td>2400</td>
<td>2320</td>
<td>3.4</td>
</tr>
<tr>
<td>Debiya soda</td>
<td></td>
<td>Saer</td>
<td>3800</td>
<td>3620</td>
<td>5.0</td>
</tr>
<tr>
<td>Kahatat</td>
<td></td>
<td>Tayaseer</td>
<td>2700</td>
<td>2500</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dahriya</td>
<td>2830</td>
<td>2780</td>
<td>1.8</td>
</tr>
<tr>
<td>870</td>
<td></td>
<td>Tayaseer</td>
<td>1900</td>
<td>1700</td>
<td>11.8</td>
</tr>
</tbody>
</table>

Table 4: Effects of seed cleaning and treatment on grain yields of durum wheat varieties at farmers’ fields (kg/ha) at four project sites during 2001-02 cropping season

<table>
<thead>
<tr>
<th>Variety</th>
<th>2001/2002 season</th>
<th>Village</th>
<th>Treated</th>
<th>Non-treated</th>
<th>% of increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debiya bida</td>
<td></td>
<td>Tayaseer</td>
<td>2500</td>
<td>2200</td>
<td>13.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dahriya</td>
<td>2200</td>
<td>1750</td>
<td>25.7</td>
</tr>
<tr>
<td>Debiya soda</td>
<td></td>
<td>Der-abudeef</td>
<td>2500</td>
<td>2000</td>
<td>25.0</td>
</tr>
<tr>
<td>Kahatat</td>
<td></td>
<td>Tayaseer</td>
<td>3500</td>
<td>2650</td>
<td>32.1</td>
</tr>
<tr>
<td>Numra 8</td>
<td></td>
<td>Der-abudeef</td>
<td>3800</td>
<td>3200</td>
<td>18.8</td>
</tr>
</tbody>
</table>
Conclusion
The success of any efforts aimed at conserving local agrobiodiversity will require the full involvement of farmers who are the main custodians of agrobiodiversity, and the increase of benefits to arise from continuing to use landraces. This study has shown that some landraces yields as much grain and straw yields as the best available improved varieties under the traditional agricultural systems while conserving the advantage of grain quality. The seed cleaning and treatment can increase significantly the grain yields of landraces of durum wheat justifying the necessity for development of informal seed production system to contribute to the conservation and sustainable use of landraces. The seed production and distribution system developed within the agrobiodiversity project has allowed the empowerment of local communities and has contributed to the use of landraces and their recovery of large acreages within a short period.

Acknowledgements
The authors would like to thank GEF-UNDP/PAPP for their financial support through the West Asia Dryland Agrobiodiversity (RAB/97/G32), the Ministry of Agriculture for providing land at the experiment stations and for their technical assistance, and the farmers for their cooperation and in-kind contributions.

References


Farmers’ Welfare Improvement through Participatory Barley Breeding

A. Jilal¹, N. Benbrahim¹, S. Saidi¹, and S. Grando²

¹ National Agricultural Research Institute (INRA), P.O.Box 415, Rabat, Morocco
² International Center for Agricultural Research in the Dry Areas (ICARDA), P.O.Box 5466, Aleppo, Syria

Keywords: Barley, landraces, participatory breeding, Morocco

Abstract
Barley (Hordeum Vulgare L.) is the most widely grown annual crop in Morocco, located especially in arid and semi-arid areas, due to its large adaptation to harsh environments and to low input agriculture. It contributes largely to animal feed and is also used as human food. Moroccan farmers still widely use local landraces which provide them a significant production in green forage, grain and straw, and the adoption of improved varieties is limited. A new breeding approach, based on reducing G*E interaction and involving farmers in the selection is launched in Morocco in collaboration with ICARDA. This approach is applied to improve the productivity and stability of barley landraces from Azilal and Taounate regions of Morocco as a mean for their on-farm conservation and for improving the livelihoods of local communities. The results obtained are encouraging and the farmers’ selection criteria have been identified.

Introduction
In Morocco, barley (Hordeum vulgare L.) is the most important cereal crop with an annual acreage of 2.2 millions hectares. About 80% of barley crop is cultivated in arid, semi-arid and highland areas. Barley is well adapted to harsh environments and to low inputs agriculture and considered a low risk aversion crop. Barley production represents nearly 45% of total cereal production. It is especially used for feed (80% of grain production) and as straw which provides 30% of required animal feed. Still 20% of the grain production is used for human consumption. Arid and semi-arid areas are characterized by a low and erratic rainfall with more frequent droughts observed during the last decade. Local landraces are widely used due to their specific adaptation to farmers’ conditions and to dry environments (climate, soil, agronomic practices, farming system). Landraces are composed of a mixture of lines which provide them the capacity to buffer against the unfavorable conditions. They have been conserved through ages under both natural and artificial selection. INRA-Morocco has released more than 23 new varieties with yield potential exceeding largely the performance of landraces. The area covered by these improved varieties is estimated to 25% of the barley acreage.

The relevance of decentralized and farmers participatory breeding was tested in a joint research activity between ICARDA and INRA-Morocco (Ceccarelli et al. 2001).

This contribution reports on the preliminary results of the application of participatory breeding to the improvement of landraces of barley in two regions of Morocco.

Materials and methods
A trial was conducted during the cropping season 2003/04 in two regions Azilal and Taounate. In each region, four farmers’ fields were selected. The genetic material used was composed of local landraces previously collected in the regions in 1985, 1998 and 2002, advanced lines from the national barley breeding program and two released varieties (V1: Oussama and V2: Laanacceur) (Table 1). Each entry was sown in 6 lines of 4m length with 0.3 row spacing.
Table 1: Genetic material used in farmers’ field trial

<table>
<thead>
<tr>
<th>Azilal</th>
<th>Taounate</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 local populations</td>
<td>30 local populations</td>
</tr>
<tr>
<td>1 farmer’s own population</td>
<td>1 farmer’s own population</td>
</tr>
<tr>
<td>8 advanced lines (L1 – L8)</td>
<td>8 advanced lines (L1 – L8)</td>
</tr>
<tr>
<td>2 improved varieties (V1, V2)</td>
<td>2 improved varieties (V1, V2)</td>
</tr>
</tbody>
</table>

Azilal site is located in High Atlas Mountains where barley is cultivated in 67% of cropped land exclusively using local landraces. The climate is semi-arid with frequent drought periods. Taounate site is located in the Pre-Rif region where barley represents 20% of cropped land and landraces are still widely used by farmers.

Participatory selection was done at maturity stage during field days organized in each region and involved both farmers and breeders. The assessment of genetic material was based on: scoring the populations’ performance (A: low; B: medium; C: good; D: excellent) and justifying their choice through a set of farmers’ criteria. The data, collected from each site, have been analyzed using the correspondence analysis method.

Results and discussion

The following graphs illustrate the correspondence analysis of data from each region (average of the four farmers' trials).
Fig. 1: Correspondence analysis of Azilal data (90.35% of inertia)

Fig. 2: Correspondence analysis of Taounate data (90.93% of inertia)
Farmers’ criteria have been related mainly on the following characters (long heads, grain size, straw productivity, lodging resistance, growth habit and varietal uniformity).

![3D Sequential Graph (Azilal criteria)](image)

**Figure 3:** Barley selection criteria used by farmers in Azilal region

![3D Sequential Graph (Taounate criteria)](image)

**Fig. 4:** Barley selection criteria used by farmers in Taounate region.

Farmers agreed to take part in a participatory barley breeding activity to improve their barley production. The genetic material evaluated in farmers’ fields showed a net variability linked to the type of material used. Fifty percent of Azilal’s landraces were appreciated by all farmers and rated as good while all advanced lines were discarded and the two released were less appreciated, rated in B and C categories (Fig. 1). In Taounate site, about 30% of Taounate’s landraces were highly appreciated by farmers while none of the advanced lines was selected. The two released varieties were more adapted in Taounate site and were selected by farmers and this could be explained by better growing conditions (Fig. 2).

These results confirm landraces’ adaptation in farmers’ conditions. Concerning Azilal landraces, most of the selected populations were collected in 1985. They appeared to have acquired an
adaptation in space. About Taounate landraces, all selected populations were recently collected in 2002 and they appeared to have acquired adaptation both over time and over space. Both advanced lines and released varieties were not highly appreciated by farmers and gave lower yields compared to landraces while under improved conditions in the experiment stations, they had outyielded significantly the landraces showing their high G*E interaction and adaptation to good conditions.

The participatory plant breeding approach involving farmers in the selection process by emphasizing farmers’ criteria is relevant. According to the Figures 3 and 4, all farmers commonly use as main criteria long heads, large grain size and high straw productivity. These criteria are linked to the main uses of barley production in Morocco. Other criteria such as growth habit, stand homogeneity and lodging resistance were differently taken into consideration by farmers in the two regions. Lodging resistance was mainly stressed by farmers in Taounate due to the good growing conditions expressing this trait. Based on the results, it appears advantageous to decentralize barley breeding program by exploiting the specific adaptation of local landraces characterized by their better adaptation level to less favorable and low inputs environments. The resulting improved populations would be rapidly adopted by farmers. The improved local landraces with different diversity level are available and being tested. Through this approach, we can satisfy farmers’ requirements by increasing and stabilizing efficiently barley production in the adverse environments. Thus, farmers’ welfare will be enhanced.

Reference
Gender Role in the Conservation and Sustainable Use of Agrobiodiversity in West Asia

M. Martini\textsuperscript{1}, A. Amri\textsuperscript{2} and K. Shideed\textsuperscript{3}, N. Atawneh\textsuperscript{4}, A. Badr\textsuperscript{4}, M. Monzer\textsuperscript{4} and A. Assaf\textsuperscript{4}

\textsuperscript{1} International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria. Email: m.martini@cgiar.org

\textsuperscript{2} Regional Office, International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 950764, Amman, Jordan. Email: a.amri@cgiar.org

\textsuperscript{3} International Center for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 5466, Aleppo, Syria. Email: k.shideed@cgiar.org

\textsuperscript{4} National counterparts in Palestine, Syria, Lebanon and Jordan

Abstract

The GEF-funded project on “Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria” aimed at promoting the in situ and on-farm conservation and sustainable use of landraces and wild relatives of field crops, fruit trees and forage species. Research on livelihoods and poverty emphasizes the importance of biodiversity products for rural communities. As part of a larger study on the sustainable use of agro-biodiversity in relation to livelihoods of the rural communities in the region, this paper looks at the challenging gender dimensions considered significant and critical due to the confirmed and important role of women, men and children in agrobiodiversity management. Both women and men, through their involvement in agricultural activities, contribute to many activities related to conservation and sustainable use of dryland agrobiodiversity including the selection, multiplication and processing of landraces and wild relatives of medicinal value. Knowledge associated with the different responsibilities in production represents important potential capital for conservation. Women are active in crop production mainly in weeding and harvesting, whereas men are responsible for land preparation and planting. Women’s contribution in the collection and use of wild species is important in the eight project target areas. In addition to holding different types of knowledge about important species, biodiversity products contribute substantially to their livelihoods both through consumption and sale of products generating additional incomes.

Introduction

The region under consideration is located in the West Asia mega-center of diversity where crops of global significance have evolved and been domesticated over the last 10,000 years (Harlan, 1992). This region is also characterized by high population growth rates and rapid urbanization putting high pressure on the remaining natural resources. Traditional farming is diminishing in importance and natural habitats are being degraded causing alarming loss of local agrobiodiversity and the depletion of natural resources which will have adverse effects on the livelihoods of rural communities. Local agrobiodiversity continue to support the livelihoods of local communities under harsh environment including dry areas and mountainous ecosystems. However, with the shrinking of the resource base, poverty focus becomes one of the most appealing threats likely to face future generations. Therefore, among the important natural resources, agrobiodiversity has received more attention from researchers during the last few decades in terms of management and use.
Women are usually among the poorest in West Asia and North Africa region, mainly due to illiteracy and economic dependency within the household and the society. Their role in conserving and managing local agrobiodiversity was often neglected and not recognized or not enough stressed to reflect the reality. Padmanabhan (2004), reported that the contribution of women in the social system for maintaining and enhancing crop diversity is necessary, as women’s contributions make the difference and the analysis of their institutional situation appears as a key to the understanding of agrobiodiversity management. Additionally, women and the elders are the main holders of local knowledge related to many aspects mainly those related to quality attributes and specific uses. Ticsay and Toquero (2001) stressed the need to know how men and women’s perceptions are changing as livelihoods are in transition (from home- to market-oriented economy) and as education and market forces are affecting people’s aspirations. This contribution aimed at identifying the gender roles including children, in agricultural and agrobiodiversity production, analyzing the knowledge associated with the different responsibilities of production and its relation with agrobiodiversity conservation, and analyzing the benefits from agriculture and agrobiodiversity and their role in the livelihoods of rural communities through home consumption and sale of products.

Methodology
The dryland agrobiodiversity project is aware of the importance of the gender dimension in the conservation and management of local agrobiodiversity and thus, has reserved special attention to promote the participation of women and girls in most of the project implemented activities. The project was collaborating with individual women, women NGOs, cooperatives and women union in case of Syria. It has helped in establishing other women cooperatives in Nabha and Ham/Maaraboun in Lebanon with the financial help of YMCA to initiate food processing and handcraft units focusing on technologies to add-value to local products. This institutional change will contribute to the empowerment of women in these remote areas by linking them to marketing opportunities. Two female groups “Banat Al Jord” in Lebanon and “Friends of biodiversity” in Jordan were also created.

The project focused on providing training to local communities on various aspects related to improvement of quality of locally processed products and on alternative sources of income. These include home gardening, cultivation of medicinal and herbal plants, mushroom production, dairy production, nursery development, food processing with emphasis on hygienic aspects and packaging and labeling. More than 1480 women were trained over five years. Some of the training is continued by individual women and NGOs trained by the project.

The project provided technical backstopping and in-kind incentives to women in the form of seedlings of medicinal and herbal plants, containers for local processed products, and to create new businesses. Successful examples of financial returns are already observed. In Syria, local products of women union at Al-Haffeh are sold in the agrobiodiversity shop created close to Salaheddin castle. In Palestine, the distribution of 278,000 seedlings of medicinal plants has led to the self-sufficiency of 2240 households in these commodities and the excess is sold in local market. Similarly, the introduction of honey production and the introduction for the first time of Shinglish, a special cheese used in Lebanon, have allowed additional sources of income to groups of women in Sair and Tayassir communities in Palestine. In Jordan, seedlings of medicinal plants were distributed to women and the project provided technical backstopping to female farmers to establish a specialized agrobiodiversity nursery and both activities were able to secure additional and significant income to the beneficiaries. In Lebanon, the processing units established in Ham/Maaraboun and Nabha contributed to the cohesion of the groups and to value local products including the processing of wild prunes initiated for the first time by the project.
Regarding the enhancement of the contribution of youngsters to agrobiodiversity conservation, the project has initiated environmental clubs in Palestine, and has worked with the Ministries of Education to introduce biodiversity conservation into school curricula. Additional curricula activities undertaken by the project include the creation of school gardens, the documentation of parental knowledge, and the participation to reforestation and forest cleaning efforts.

The regional project on “conservation and sustainable use of dryland agrobiodiversity” was implemented during 1999-2005 in two target areas in each of the participating countries: Muwaqqar and Ajloun in Jordan, Aarsal and Baalbeck in Lebanon, Jenin and Hebron in the Palestinian Authority, and Sweida and Al-Haffeh in Syria. A total of 26 communities were collaborating in the implementation of project activities. The baseline household survey and a rapid rural appraisal were conducted in 2000 to assess the farming systems and the existing local knowledge with emphasis on management of local agrobiodiversity and the identification of major threats. The investigation tools included rapid appraisals, formal surveys, and qualitative data collection through gender analysis tools. The gender disaggregation of responsibilities, work and knowledge is considered as a starting point to examine and explain the multiple roles of women and men as resource users/managers. Accordingly, additional qualitative data and information was collected in 2004 using gender analysis tools of investigation such as the activity analysis, the benefits analysis, and the gender distribution for activities related to agrobiodiversity and their management.

The households’ surveys were conducted at 147 farm households in Syria, 138 in Lebanon, 145 in Jordan and 140 in the Palestinian Authority (i.e. at approximately 70 farms in each of the eight target areas). The samples included three groups: farmers collaborating with the project and hosting its activities, farmers who are aware of the project activities through attending field days and workshops, and a third group which did not hear about the project. The sample included different groups such as women farmers although limited in number and poor as well as better-off farmers.

Results
Rapid appraisals and socio-economic surveys conducted previously in the four countries have identified the wide involvement of women in agrobiodiversity, although these have not conducted specific investigations to measure the intensity of women’s involvement and the related impact in terms of activities and knowledge. The integration of gender analysis into research on agrobiodiversity has an important dimension that addresses strategic livelihood issues and sustainable conservation of the resource base.

A – Household’s characteristics and financial capital
The average household size in the study area is 8 persons in Jordan, Lebanon, Syria and 11 in Palestine. Education level of household members vary from one area to another, the persons holding a university degree in the whole research area vary from 13.7% in Aarsal- Lebanon, to 57.3% in Ajloun-Jordan. In addition to family labor, the availability of hired labor varied from 22.9% in Muwaqqar-Jordan to 92% in Ajloun-Jordan. According to their perceptions of poverty, farmers in all sites except in Ajloun-Jordan, classified themselves mainly as moderately well-off. The local customs’ effect was strongly apparent in this regard.

In the absence of the male head of the household, wives, elder sons or other relatives manage farms in the study area. More women hold this responsibility in Lebanon (51%) and in Syria (43%), in contrast to more elder sons taking over the responsibility of the household in Palestine representing 50% of the cases (Table 1). In Jordan, Egyptian workers are hired to manage the farms in the absence of the owner.
Table 1: Farm management in absence of the household head (percentages)

<table>
<thead>
<tr>
<th>Individuals</th>
<th>Jordan</th>
<th>Lebanon</th>
<th>Palestine</th>
<th>Syria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wife</td>
<td>35</td>
<td>51</td>
<td>33</td>
<td>43</td>
</tr>
<tr>
<td>Elder son</td>
<td>37</td>
<td>31</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Other relatives</td>
<td>28</td>
<td>18</td>
<td>17</td>
<td>27</td>
</tr>
</tbody>
</table>

**Women’s contribution to household’s income**

The contribution of women in household income is mainly concentrated in crop and livestock production in the four countries. Women’s contribution in crop production constitutes 19% in Jordan, 18.5% in Lebanon, 35 in Palestine and 10% in Syria respectively. In livestock production, the highest proportion in the household income was found in Palestine with 19%, followed by Jordan with 13.4%, then Syria with 11% and Lebanon with the lowest contribution of 4.7%. The highest women’s contribution in household income from live animals was found in Palestine with 7.3%, followed by Jordan with 1.6%, and Lebanon with 1.4% and Syria with the lowest contribution of 0.6%. The contribution from off-farm work in agriculture is particularly important in Palestine with 25%, then in Lebanon with 3.5%, and 3.3% in Syria (Table 2). Furthermore, women were involved in income generating activities such as bee keeping in Palestine, Lebanon and Syria.

Table 2: Women’s contribution to household’s income by income sources (percentages)

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Jordan</th>
<th>Lebanon</th>
<th>Palestine</th>
<th>Syria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Muwaq-</td>
<td>Ajloun</td>
<td>Aarsal</td>
<td>Baalb-</td>
</tr>
<tr>
<td>Crops</td>
<td>30.7</td>
<td>6.7</td>
<td>19</td>
<td>10.4</td>
</tr>
<tr>
<td>Livestock production</td>
<td>5.9</td>
<td>21.4</td>
<td>13.4</td>
<td>11.4</td>
</tr>
<tr>
<td>Live animals</td>
<td>2.5</td>
<td>0.6</td>
<td>1.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Off-farm agriculture</td>
<td>0.33</td>
<td>0</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Government job</td>
<td>15.4</td>
<td>8.5</td>
<td>12</td>
<td>2.3</td>
</tr>
<tr>
<td>Remittances</td>
<td>0.6</td>
<td>0.3</td>
<td>0</td>
<td>1.3</td>
</tr>
<tr>
<td>Other sources</td>
<td>0</td>
<td>0</td>
<td>4.5</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Source: survey conducted in 2004

In the eight target areas, both women and men adults control the cash derived from the above income generating activities. The survey shows that the income is mainly used for household’s needs and for investment in agriculture. Income from agriculture does not allow large investments although agricultural households invest remittances in agriculture especially in Jordan where a large proportion of the agricultural households’ members have governmental jobs including women. Decision-making within the households of the study area is shared among household members including women and adult children.

**B - Involvement of women in activities related to agrobiodiversity conservation**

The study areas had many similarities in terms of cropping patterns. Agricultural production is divided into four categories of crops; namely cereals, legumes, olive and fruit trees in Jordan, Syria and Palestine. In Lebanon, the same crops exist except olive trees. Wheat and barley are grown in all sites with difference in planted areas. Legumes are mainly lentil, chickpea and some forage legumes. Fruit trees include apricot, cherry, apple, grapes, figs, in addition to other fruit
trees. Olive trees are grown in all sites except in Lebanon (Table 5). Farming of these crops involves women, men and children, performing different activities, according to their expertise and availability.

Table 5: Main crops in the study area

<table>
<thead>
<tr>
<th>COUNTRIES</th>
<th>CROPS</th>
<th>LEGUMES</th>
<th>OLIVE TREES</th>
<th>FRUIT TREES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lebanon</td>
<td>Wheat, barley</td>
<td>Lentil, chickpea and forage legumes</td>
<td>Apricot, apple, cherry, fig, pear, plum, grapes</td>
<td></td>
</tr>
<tr>
<td>Jordan</td>
<td>Wheat, barley</td>
<td>Lentil and chickpea</td>
<td>Olive trees</td>
<td>Apricot, apple, fig, plum, grapes</td>
</tr>
<tr>
<td>Syria</td>
<td>Wheat, barley</td>
<td>Lentil and chickpea</td>
<td>Olive trees</td>
<td>Apple, apricot, fig, plum, cherry, grapes</td>
</tr>
<tr>
<td>Palestine</td>
<td>Wheat, barley</td>
<td>Lentil and chickpea, clover, <em>Lathyrus</em>, vetch</td>
<td>Olive trees</td>
<td>Apricot, apple, grapes, plum, grapes</td>
</tr>
</tbody>
</table>

2. Gender distribution of activities in the study area

The participation of women and men in different agricultural activities of crops including trees is important in the study area. Activity analysis (Feldstein, 1990a and 1990b) reveals the differential roles assigned to men, women, and elder children who participate intensively in these activities. It highlights activities where men are the most active, while women take over different responsibilities such as a range of domestic and agricultural activities, including the collection and cultivation of indigenous vegetables for home consumption and market sale. However, men migration is also an important indicator of the type of activities women do in the absence of men, and this is apparent from the proportion of off-farm income in the research sites (see Table 1). Wherever possible the data collected for the activity analysis was disaggregated by gender (women alone, men alone, women and men together).

In cereal production, men are much more active than women for all agricultural operations (82.3% in Lebanon, 62.3% in Syria, 75% in Jordan and 84.3 in Palestine) with the exception of weeding where women are involved in Lebanon, Syria and Palestine. However in Jordan the women do participate to cereal production (25%), and this was mainly in Ajloun area located on the mountains and where mechanization is not introduced for all activities. This reinforces the results of other studies where men perform mechanized activities and women are more involved in manual operations (Abdelali-Martini *et al.* 2003a). Because cereal production has been mechanized in these countries, the only exceptions where women and men share these activities are found on mountainous (Haffeh in Syria, Aarsal in Lebanon, Ajloun in Jordan) areas where mechanization is difficult to use either because the plots are too small or because the accessibility to the area is difficult. However, women are more involved in legumes, olive and fruit tree production where they perform some activities alone and some with men, most of them concentrated in fruit trees weeding (67.5% in Palestine) and harvesting (47.5% in Lebanon) although field planting and chemical application are also important in some areas, 50% in Jordan for legumes and 40% for fruit trees in Lebanon (Table 6).

Table 6: Activity analysis of labor in agriculture in the eight target areas (percentages)

<table>
<thead>
<tr>
<th>Crops</th>
<th>Gender</th>
<th>Women’s contribution average/crop</th>
<th>Women alone and/or with Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
As a complement, the qualitative information shows that women have an important participation in most agricultural activities especially those performed manually. Both women and men perform activities related to legume production with a heavier load on men for land preparation and irrigation and a heavier load for harvesting on women. This is mainly due to family labor performing agricultural activities together, as where hired labor is involved in these countries, the results differ considerably and men and women have distinct responsibilities in operations related to the same crop. Interestingly women are active in nursery planting in legumes (50% in Jordan) and tree production (40% in Lebanon), and share more operations related to legume production with men mainly because most products are also for direct consumption by the household members than operations related to trees, and even less in cereals’ production. Here again, where mechanization is involved, women are less responsible about the production of the crop. The qualitative information also indicated the involvement of women in the seed selection and cleaning of field crop landraces who have a decision role in the selection of varieties for different purposes.

Important similarities were found in these countries about gender roles in agricultural production. Women and men’s involvement in agricultural activities differ according to the customs of these countries where women and men work together as family labor but work separately when hired to work on other farms. This is an important distinction that is recommended through this research to be taken into account when addressing issues related to introduction of technology interventions. Also, both family and hired labor hold knowledge about the work they perform; in this case women are more knowledgeable than men in weeding and manual harvesting in seed cleaning and in quality of landraces and their best end-use, whereas men are more knowledgeable about land preparation, pesticides and herbicides applications. Thus issues about agrobiodiversity conservation, land degradation and environment protection should also be addressed to both of them.

Because of the use of mechanization in cereal production, activities are shared between men and women in the eight target areas with some slight differences due to working environments.

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
<th>Both</th>
<th>Planting</th>
<th>Harvesting</th>
<th>Weeding</th>
<th>Fertilizer Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cereals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>1.5</td>
<td>82.3</td>
<td>16.2</td>
<td>3</td>
<td>34</td>
<td>16.5</td>
<td>0</td>
</tr>
<tr>
<td>Jordan</td>
<td>25</td>
<td>75</td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Syria</td>
<td>0</td>
<td>62.3</td>
<td>37.7</td>
<td>6.8</td>
<td>34</td>
<td>7.5</td>
<td>4.3</td>
</tr>
<tr>
<td>Palestine</td>
<td>13.1</td>
<td>84.3</td>
<td>2.6</td>
<td>0</td>
<td>72</td>
<td>70</td>
<td>49.5</td>
</tr>
<tr>
<td><strong>Legumes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>0</td>
<td>74.3</td>
<td>25.7</td>
<td>3</td>
<td>33.5</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Jordan</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Syria</td>
<td>0</td>
<td>58.3</td>
<td>41.7</td>
<td>3.3</td>
<td>33.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Palestine</td>
<td>16</td>
<td>62</td>
<td>22</td>
<td>12</td>
<td>21</td>
<td>80</td>
<td>12</td>
</tr>
<tr>
<td><strong>Olive trees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jordan</td>
<td>5.7</td>
<td>80.9</td>
<td>13.4</td>
<td>29</td>
<td>16</td>
<td>30</td>
<td>2</td>
</tr>
<tr>
<td>Syria</td>
<td>1.7</td>
<td>72.3</td>
<td>26</td>
<td>0</td>
<td>23.3</td>
<td>14.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Palestine</td>
<td>15</td>
<td>64</td>
<td>21</td>
<td>4.5</td>
<td>56</td>
<td>61</td>
<td>2</td>
</tr>
<tr>
<td><strong>Fruit trees</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>13.18</td>
<td>74.50</td>
<td>12.32</td>
<td>40</td>
<td>47.5</td>
<td>4.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Jordan</td>
<td>24.14</td>
<td>71.14</td>
<td>4.72</td>
<td>10.5</td>
<td>19</td>
<td>11.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Syria</td>
<td>3</td>
<td>75.7</td>
<td>21.3</td>
<td>0</td>
<td>33.5</td>
<td>16.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Palestine</td>
<td>7</td>
<td>61</td>
<td>32</td>
<td>0</td>
<td>50</td>
<td>67.5</td>
<td>0</td>
</tr>
</tbody>
</table>
Legume production is also shared with more women involved in harvesting in Syria and more involved in weeding in Palestine. Olive and fruit production has always been shared between males and females. Olive picking, a particular activity mainly paid in kind, is the responsibility of whole families including children, despite that it takes place at the time of schooling. All these activities leave women and men busy with agricultural activities in rural communities over the year except during a short time in winter between December-February.

This suggests that women and men have knowledge in the activities in which they are more involved. Accordingly, there is a need to consider these gender roles in technology development and dissemination for better targeting the beneficiaries.

3. Involvement of women in activities related to agrobiodiversity

Information collected from the target areas (Table 7) show that mainly women and children are responsible for the collection of medicinal plants, representing 100% in Lebanon, 88% in Syria and 87.5% in Jordan. This shows the importance of capital knowledge that women and children have on medicinal plants.

Food processing also falls under the responsibility of women. Nearly 100% of food processing in Lebanon and Syria, and 98% in Jordan are done by women. This responsibility represents valuable opportunities for added value from crop and livestock production as well as from medicinal plants and wild species, a dimension the project has encouraged. The same argument applies for processing and using wild species into edible. However, when it comes to selling these products, and due to the local customs, it was found that depending on the sites, marketing is shared between men and women. Eighty seven percent (87.5%) of women in Jordan, 65% in Syria and 60% in Lebanon women sell their production, whereas in Palestine only 42% of women sell their production, a fact that may be due to security reasons in these areas.

Seed selection, cleaning and storage are also among the activities where women play an important role. Their indigenous knowledge could be exploited further to improve and multiply these species, which could generate more income.

Table 7: Gender responsibility for the collection, processing and preparation of plants for food and medicinal uses (%)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Countries</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jordan</td>
<td>Lebanon</td>
</tr>
<tr>
<td>Collection of edible and medicinal plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women &amp; children</td>
<td>87.5</td>
<td>100</td>
</tr>
<tr>
<td>Men</td>
<td>12.5</td>
<td>0</td>
</tr>
<tr>
<td>Food processing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td>Men</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Processing and use of wild plants into edible</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Men</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Selling med. plants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women &amp; children</td>
<td>87.5</td>
<td>60</td>
</tr>
<tr>
<td>Men</td>
<td>12.5</td>
<td>40</td>
</tr>
</tbody>
</table>

421 | Page
C - Benefits analysis of wild species in the four countries

Benefits analysis provides in-depth examination and analysis of different kinds of knowledge related to local agrobiodiversity and its management. It reveals crucial information about who is responsible for the collection, processing, use, and sale of different products, such as medicinal plants, and the related types of local knowledge that women and men possess. This is also used for the identification of different types of biological, chemical, and environmental knowledge of different species and varieties, and knowledge of the potential use, processing and market value of such resources that different individuals possess. The different forms of knowledge need then to be situated within local/cultural perceptions of the environment (and perhaps forests in particular), and the ways in which individuals perceive their role as collectors and providers of food and medicines. Also examining the extent to which local people rely upon natural habitats mainly forests for survival and the different products and by-products that collectors use/sell is a critical issue (IDRC, 1998 and Fernandez et al., 2000).

For the sake of this paper, information about the benefits from wild species is summarized in Table 8. The table is not exhaustive; it represents an indicator for women’s involvement in the management and use of biodiversity species. Women and children especially girls are the most active in the collection of wild species in Jordan and Syria, whereas both women and men collect species in Lebanon and to a lesser extent in Palestine. Children are involved in the collection of wild species in all countries, although more girls than boys due to the fact that those girls accompany to and participate with their mothers in the collection process.

All species are used either as herbal tea for medicinal purposes or as a hot drink, and as food consumed as salad such as *Silypum marianum* and *Raphanus sp.* in Syria, or as food dish in the four countries such as “Khobbayzeh” and as spices such as Sumac (*Rhus coriaria*) in Jordan, Lebanon and Syria. However, when it comes to marketing, the collected information shows that it is mainly performed by men. This is also an important indication that the knowledge about these species is shared between men, women and children, a result that suggests that awareness, development actions and research should take into account all stakeholders who will provide the needed information for better targeting interventions aiming at the protection and sustainable use of agrobiodiversity.

Market access is also an important indicator of poverty especially for women (DFID 1999) who need to sell their products to the closest markets. In the study area, 50% of the respondents in Lebanon sell their products in the village market, which shows the degree of services available in the villages. In Palestine, more than one-third of the sample farms (35%) sell their products in
their village markets, but nearly 26% of them still use the city market. In Syria most people use the city market or a combination of the available markets close to the village. Syria is the least advantaged in terms of the availability of a village market as only 8% of its sample can sell their products to a city market. This situation affects women more than men and limits their independence in generating incomes from their products (Table 9). Also, about 10 to 20% of the sample households sell their production to individuals inside the village at low prices due to the absence of competition.

Table 8. Benefits analysis of wild species collection in the four countries

<table>
<thead>
<tr>
<th>Local name</th>
<th>Scientific name</th>
<th>Jordan</th>
<th>Lebanon</th>
<th>Palestine</th>
<th>Syria</th>
<th>Marketing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gender</td>
<td>Use</td>
<td>Gender</td>
<td>Use</td>
<td>Gender</td>
</tr>
<tr>
<td>Wild Thymes</td>
<td>Thymus vulgaris, Thymus sp.</td>
<td>♀♂</td>
<td>HT</td>
<td>♀♂</td>
<td>HT</td>
<td>♀♂</td>
</tr>
<tr>
<td>Artemisia</td>
<td>Artemisia herba-alba, Artemisia glacialis L.</td>
<td>♀&amp; Girls</td>
<td>HT</td>
<td></td>
<td>♀&amp; Girls</td>
<td>HT</td>
</tr>
<tr>
<td>Jaeda</td>
<td></td>
<td>♀&amp; Girls</td>
<td>HT</td>
<td></td>
<td>♀</td>
<td>HT</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>Crataegus azarolus, Crataegus sp., Crataegus Oxycantha L.</td>
<td>♂&amp; Child.</td>
<td>FC</td>
<td></td>
<td>♀♂</td>
<td>FC</td>
</tr>
<tr>
<td>Midlar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samaq</td>
<td>Rhus coriaria</td>
<td>♀♂</td>
<td>FC</td>
<td>♀♂</td>
<td>FC</td>
<td>♀♂</td>
</tr>
<tr>
<td>Akkoub</td>
<td>Silypnum marianum</td>
<td>♀♂</td>
<td>FC</td>
<td>♀♂</td>
<td>FC</td>
<td>♀♂</td>
</tr>
<tr>
<td>Wild mint</td>
<td>Mentha officinalis, Mentha sylvestris L., Menthasp.</td>
<td></td>
<td></td>
<td>♀♂</td>
<td>HT</td>
<td>♀♂</td>
</tr>
<tr>
<td>Silifa</td>
<td>Gundelia tourniforrti</td>
<td>♀&amp; Girls</td>
<td></td>
<td></td>
<td>♀&amp; Girls</td>
<td>FC</td>
</tr>
<tr>
<td>Zoufa</td>
<td>Micromerica rupestris L.</td>
<td>♀♂</td>
<td>HT</td>
<td>♀</td>
<td>HT</td>
<td></td>
</tr>
<tr>
<td>Mayramia</td>
<td>Salvia syriaca</td>
<td></td>
<td></td>
<td>♀</td>
<td>HT</td>
<td>♀</td>
</tr>
<tr>
<td>Louf</td>
<td></td>
<td>♀&amp; Girls</td>
<td>HT</td>
<td></td>
<td>♀♂</td>
<td>FC</td>
</tr>
<tr>
<td>Khobbayzeh</td>
<td></td>
<td>♀♂</td>
<td>FC</td>
<td>♀♂</td>
<td>FC</td>
<td>♀♂</td>
</tr>
<tr>
<td>Chamomile</td>
<td>Chamaemelum nobile, Matricaria chamomilla</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dandelion Leaves</td>
<td>Taraxacum officinale</td>
<td>♀&amp; Girls</td>
<td>FC</td>
<td></td>
<td>♀&amp; Girls</td>
<td>FC</td>
</tr>
<tr>
<td>Tokha</td>
<td></td>
<td>♂</td>
<td>HT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roses</td>
<td>Rosa sp.</td>
<td>♀</td>
<td>HT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dardar</td>
<td></td>
<td></td>
<td></td>
<td>♀</td>
<td>HT</td>
<td></td>
</tr>
<tr>
<td>Milfoil</td>
<td>Achillea fragrantissima, Achillea millefolium L.</td>
<td>♂</td>
<td>HT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hindba</td>
<td>Cichorium sp.</td>
<td>♀</td>
<td>FC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khetmiya</td>
<td>Althaea officinalis L.</td>
<td>♀</td>
<td>HT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rashad</td>
<td>Raphanus sp.</td>
<td>♀</td>
<td>FC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wild</td>
<td>Coriandrum</td>
<td>♀</td>
<td>FC</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9: Market access in the four countries (percentages)

<table>
<thead>
<tr>
<th>Location of market</th>
<th>Jordan</th>
<th>Lebanon</th>
<th>Palestine</th>
<th>Syria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village market</td>
<td>25</td>
<td>50</td>
<td>35</td>
<td>8</td>
</tr>
<tr>
<td>Sell to individuals inside the village</td>
<td>12</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Neighboring village market</td>
<td>15</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>City market</td>
<td>43</td>
<td>16</td>
<td>26</td>
<td>35</td>
</tr>
<tr>
<td>Combinations of access</td>
<td>5</td>
<td>21</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Conclusion

This study analyzed the gender division of labor within agricultural activities in the target areas of the four countries, and to a lesser extent the gender responsibility for post-production activities, including selection, processing, and preservation of seed varieties. The gender involvement in the collection of wild plants (such as medicinal plants, indigenous vegetables, herbs, and other plants), and their responsibility for the processing and preparation of plants for food and medicinal uses constituted another dimension of this analysis. The results show that both women and men have distinct responsibilities in agricultural operations and tasks, resulting in possessing different knowledge about these important species that constitute a crucial role in their livelihoods, through consumption and sale of these products. However, detailed analysis of the gendered income from these activities is not available in this research, but could be obtained through an additional investigation in the research sites.

Although the present research was limited in providing detailed information on all aspects related to agrobiodiversity management, it has provided the identification of important sources of livelihoods that have been analyzed and the gender dimension has been crystallized. It opens up areas for further research investigation on analysis of the gender roles including the links with other important variables such as the productive and reproductive activities that women and men perform individually or jointly; the spaces, environments, and resources that they are able to
access, control, use, and benefit from; and the social backgrounds impacting the roles of individuals in the different locations. This would allow better understanding of the opportunities and constraints of gender in the management of the biological resources and maintain sustainable livelihoods.

As indicated by Satheesh (2002), in many parts of the South, leadership in talking about and supporting biodiversity has come from individual women and women's groups, which give a sense of an invisible thread that ties past biodiversity with the present. She argues that the issue itself is so inextricably gendered that in all articulation of the issue, women will take the lead. In the four countries studied, this constitutes an area for future focus especially where women’s groups are active.

Gender roles in agrobiodiversity conservation, management and use identified and analyzed in the paper show the potential knowledge available with women, men and children. The project has impacted positively these roles in terms of awareness and better use of products, and this will improve their use of agrobiodiversity products and they will use this awareness to better protect the species under degradation/threat. Important value-added agricultural and agrobiodiversity activities were generated by the project in the research sites.

It is anticipated that the project activities will help in improving the life of rural communities in the study area in the short term and the neighboring rural communities in the long run. Women and children targeted by the project will play a considerable role in agrobiodiversity conservation, especially that the project has introduced agrobiodiversity in school courses.

The training provided by the project to local communities on the improvement of quality of locally processed products and alternative sources of income has generated important awareness, and has contributed to the improvement of their incomes through further cultivation of herbal and medicinal plants. Furthermore, processing for better quality and hygiene has resulted in increased selling prices.

The potential for improvement of livelihoods exist, and its development depends not only on the local communities including women, but also on the stakeholders concerned with agrobiodiversity. Research institutes and many of the new and on-going research development projects by adopting participatory approaches with particular emphasis on women involvement, will show more the crucial role played by women and will allow also their empowerment. Many international donors are putting the involvement of women as a prerequisite for funding different projects.

Additional attention to markets chains in the different sites including the real demand for processed products, medicinal and organic plants both from inside as well as outside markets. The success of such big initiatives would consider collaboration with the already existing cooperatives and associations at the community level.

The considerable involvement of women in agricultural and agrobiodiversity activities needs to be complemented with better access of information for rural households particularly to women, and strengthen the links between concerned stakeholders. In line with other research findings (e.g. FAO), this paper shows gender differences in the roles of women, and men in different socio-economic groups in farming communities. Furthermore, their important knowledge critical in biodiversity and their skills in dealing with biodiversity products suggests that the West Asian countries’ governments involved in this paper recognizes the value of this knowledge and puts suitable mechanisms in place that will enhance the right of the different groups to benefit from their knowledge and efforts.

The different countries are encouraged to put in place policies that would encourage the sustainable use of agrobiodiversity especially through incentives accompanied with awareness and training in the domain of in-situ conservation in collaboration with ex-situ conservation. The investigation has unveiled that many species are under threat, and recommendation is to conduct
further investigations especially through the elders in the communities to assess retrospectively the level of these species both in the research sites, and in other sites as well. Future research should consider including participatory approaches in the investigation and involve more women scientists.

Implications
- Income sources
- Women role in farm management in absence of household head.
- Women’s contribution to household income.
- Women' involvement in agricultural activities and agrobiodiversity.
- Benefit analysis of wild species.
- Targeting women in technology development and dissemination.
- Livelihood implications and policy implications.

References
DFID 1999 International Convention on agro-biodiversity
Fernandez, M., P. Shrestha and Eyzaguirre (2000). Integrating Gender Analysis for Participatory Genetic Resources Management: Technical Relevance, Equity and Impact, in Participatory Approaches to the Conservation and Use of Plant Genetic Resources. Esbern Friis-Hansen and Bhuwon Sthapit Editors, IPGRI, Rome, Italy.
Friis-Hansen, E. and Sthapit B. Editors (2000). Participatory Approaches to the Conservation and Use of Plant Genetic Resources. IPGRI, Rome, Italy.
SESSION SIX

ADDED-VALUE AND ALTERNATIVE SOURCES OF INCOME FOR THE IMPROVEMENT OF THE LIVELIHOODS OF THE LOCAL CUSTODIANS OF AGROBiodiversity
Enhancing the Value Chain for Markets for Traditional Producers of Neglected and Underutilized Aromatic, Vegetable and Fruit Species in the Near East: A Pilot Study in Syria

A. Giuliani1, S. Padulosi2

1International Plant Genetic Resources Institute (IPGRI), Via dei Tre Denari, 472/a- 00057 Rome, Italy. E-mail: a.giuliani@cgiar.org
2IPGRI, Regional Office for Central & West Asia and North Africa, c/o ICARDA P.O. Box 5466 Aleppo, Syria. E-mail: s.padulosi@cgiar.org

Abstract
Neglected and Underutilized Species (NUS) are often termed “minor” because in global production and market values these plant species are of minor importance when compared with major staple crops and other agricultural commodities. Nevertheless, they are source of food, herbal remedies and income for poor rural communities. Analysis of socio-economic and marketing aspects is one of the areas for research to foster their sustainable conservation and use. The paper presents a pilot study that has been recently conducted in Syria on some selected wild and cultivated species from Dryland agrobiodiversity environment, to depict the market organization and the characteristics of the actors involved, as well as to identify initial, local-level constraints to generating greater market value for these species. The study approach considers (i) the value chain analysis, to look at the production-to-consumption chain, the organization of production system and the roles of the actors involved in the collection, cultivation, processing, value-adding and trading of the products; and (ii) the livelihood approach to look at the impact of the activities related to these plant species on the livelihoods of rural communities. Data confirm the strategic role played by these traditional and underutilized species in the livelihood strategies of rural households in the region, and the importance of strengthening markets if these strategies are to be supported and these species conserved in situ. Yet, interventions at different level to increase the market potentials, such as capacity building and knowledge sharing on cultivation practices and marketing strategies, reorganization of the market relationships, private sector partnerships are needed. Generating market value would serve dual goals of supporting rural livelihoods and biodiversity maintenance.

Introduction
Ethnobotanic surveys indicate that, although modern crop production is based on a few plants (Prescott-Allen and Prescott-Allen 1990), hundreds of useful species are still grown and managed in agricultural systems, particularly in developing countries (IPGRI 2002). These species are considered Neglected and Underutilised (NUS) and are often called “minor” because of their low total economic value in production and trade compared to other agricultural commodities. They are considered underutilised since they were once grown more widely or intensively but are now falling into disuse for a variety of agronomic, genetic, economic and cultural reasons. Farmers and consumers are using them less due to the fact they are not competitive with other species in the same agricultural environment. However, NUS have demonstrated comparative advantages in terms of adaptability to low input agriculture and marginal lands (Padulosi et al. 2002). Some species are globally distributed, but occupy special niches in the local ecology and in production-consumption systems. While they continue to be maintained by traditional farmers, they remain inadequately documented and neglected by research and conservation (Eyzaguirre et al., 1999). They are referred to as neglected as they
receive little attention by national agricultural and biodiversity conservation policies and by scientific research and development agencies, and very limited information is actually available. The gradual global recognition towards NUS was initiated by the awareness raising process launched by the Convention on Biological Diversity (1992) and the FAO IV International Technical Conference on Plant Genetic Resources for Food and Agriculture (1996) (Padulosi et al., 2002). Many NUS are still managed by poor communities in remote and marginal areas but their potential economic value remains underexploited (Padulosi et al., 2002). This limits their private and public diversity value\(^\text{23}\) (Smale et al., 2004). The undervaluing of the economic value of NUS used by rural people also contributes to loss of crop genetic diversity and erosion and simplification of ecosystems, thus restricting options that might benefit future generations of rural people and urban consumers who would be willing to pay for these products of biodiversity.

The Consultative Group on International Agricultural Research (CGIAR)’s strategic priorities recognize the importance of markets and market access for delivering increased incomes and welfare to farmers. Improvements in production and productivity must be linked to increased access and efficiencies in markets in order to improve the livelihoods of the poor (CGIAR 2004). This is in line with the major attempt to accomplish the Millennium Development Goals (in particular, rural poverty reduction). Increasingly, the lack of access to markets is seen as key constraint to the eradication of rural poverty (Hellin et al., 2005). Strengthened market systems are thus crucial in particular to the promotion of NUS. CGIAR system enlarged the agricultural research to include the underutilised species, recognizing their contribution to the rural livelihoods. Better commercialisation of these species may result in greater opportunities for additional income generation for the resource-poor farmers (Padulosi et al., 2004).

The analysis of the livelihood assets and strategies of small-scale producers, processors and traders is a starting point in making markets “work for the poor” and sensitive to the diversity that farmers use to produce goods for the market. However, with the recognition that in the conceptualization of livelihood approaches there is often inadequate emphasis on markets and their roles in livelihood development and poverty reduction (Dorward et al., 2002), research and development organizations also focus on market chain methods, in particular with integrated and participatory approaches (Lundy et al., 2004, Bernet et al., 2005) to provide a more complete perspective on market and development.

The new strategy of the International Plant Genetic Resources Institute (IPGRI, now Bioversity International) aims at improving the link between farmers and markets, through interventions addressing livelihoods and markets, where the attention is particularly paid to the functioning of the chains and the actors involved, using biodiversity as the entry point. Important research questions are ‘how is the biodiversity linked to markets and how this link is affecting the people’s livelihoods?’.

In this analysis, some of the challenges that need to be addressed in order to make markets work for the poor are small-holders and farmers’ organizations competitiveness (Biènabe and Sautier 2005), institutional capacity building, in particular in terms of access to information, (Kydd 2002) and the reinforcement of links and trust among actors in the market chain (Best et al., 2005). With the objective to contribute to a better understanding of livelihood options and deployment of NUS, a pilot study was recently conducted in Syria, focusing on just six species selected among several others important to the dryland agro-biodiversity and production systems.

\(^{23}\) Private value is measured in terms of objectives the farmer pursues for his or her own personal benefit. Public value of genetic diversity refers to the welfare of society rather than its individuals (value for future generations, for potential disasters and unforeseen events) (Smale et al., 2004)
The study aimed at exploring the role of some NUS in the livelihoods of rural communities in Syria and to look at ways at generating market value of the products derived from these species to serve the dual goals of 1) supporting rural livelihoods as well as 2) maintenance of their genetic diversity through their use. The study outlined the market chains and the actors for the selected species, characterised livelihood assets of the actors and identified constraints to generating greater market value for the species.

This paper reports the results on the value chain analysis of three of the six studied species and some results of the livelihood survey on chain actors from the six species.

**Material and Methods**

Choosing the right species to focus on from a broad group of potential candidates was a necessary step to make the best use of limited resources available for this study. Selecting species and using them in case studies, as the present one, will help to build up a knowledge base in the promotion practice of other NUS. The selection of the six species of the local dryland agro-biodiversity was made in consultation with local users, farmers and researchers, from a list of species identified as NUS, using various criteria (Table 1) (von Maydell 1989, de Groot and Haq 1995, GFU 2002). The target species are wild and cultivated plants: two fruit trees- jujube and fig-, two functional herbs- caper and laurel-, and two vegetable plants- purslane and mallow.

Table 1: List of criteria characterizing NUS, considered for the selection of the species in this study

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Developed by</th>
</tr>
</thead>
<tbody>
<tr>
<td>They should have low risk</td>
<td>von Maydell</td>
</tr>
<tr>
<td>They should be easy and safe to establish, with low inputs</td>
<td>von Maydell</td>
</tr>
<tr>
<td>The crops should be compatible with other land use</td>
<td>von Maydell</td>
</tr>
<tr>
<td>Low external inputs for production required</td>
<td>GFU</td>
</tr>
<tr>
<td>Suitable for organic production</td>
<td>GFU</td>
</tr>
<tr>
<td>Adaptable to various environmental conditions (marginal lands)</td>
<td>GFU, von Maydell</td>
</tr>
<tr>
<td>Suitable to stabilize fragile ecosystems</td>
<td>GFU</td>
</tr>
<tr>
<td>Fit into smallholders’ farming systems</td>
<td>GFU</td>
</tr>
<tr>
<td>Possess traditional, local and/or regional importance</td>
<td>GFU, von Maydell</td>
</tr>
<tr>
<td>Easy to store and process by resource poor communities</td>
<td>GFU</td>
</tr>
<tr>
<td>Market opportunities available (meet the demand)</td>
<td>GFU, von Maydell</td>
</tr>
<tr>
<td>Possess high nutritional and/or medicinal value</td>
<td>GFU</td>
</tr>
<tr>
<td>Offer multipurpose uses</td>
<td>GFU</td>
</tr>
<tr>
<td>Traditional knowledge</td>
<td>GFU</td>
</tr>
<tr>
<td>Cultivated locally, but underutilized</td>
<td>De Groot and Haq</td>
</tr>
<tr>
<td>Commonly cultivated for which new uses can be identified</td>
<td>De Groot and Haq</td>
</tr>
<tr>
<td>Cultivated in a region but valued elsewhere under similar climatic conditions</td>
<td>De Groot and Haq</td>
</tr>
</tbody>
</table>

Very little or no secondary data were found in literature with regard to the market of these species. Primary data were collected with two methods:

1. **Market chain analysis**

At first, checklists were used in focus group interviews designed to elicit information about actors and the structure of the market chain. Informal interviews were carried out with key
informants, such as academics, researchers, traders of selected species and policy makers. The value chain methodology (Kaplinsky and Morris 2001) was used and adapted for the analysis of the information of the chain of the target species. The activity organisation of the chain was identified together with the actors involved. A map of the flows of the products along the chain and the links among the actors was depicted. Constraints and opportunities in the market chain were drawn.

2. **Livelihood assets of the chain actors**
In the second step, four semi-structured household questionnaires were implemented with individual actors in the market chain (collectors, growers, processors and traders) to gather both qualitative and quantitative data on their livelihood assets, income shares and the constraints they face. The aim of a four-questionnaire survey was to highlight differences in the perception of the same issues/same species from the chain actors; as well as to identify at which level barriers and opportunities are placed.

➢ **Sampling**
Respondents were selected through the non-probability methods of snowball and maximum variation sampling since too little was known about the population to draw random samples. These two methods were useful to reach a population that was hard to find and to capture information across a deal of variation (Patton 2002) in sites, species, and actors groups. A total of 251 households were interviewed. The study was conducted in five areas of Syria in the Aleppo, Lattakia, Homs, Damascus and Raqqa Provinces. The effort was made to cover regions representing different morpho-geographic, as well as social and economic characteristics, where the target species are present (Fig. 1).

![Fig. 1: Survey sites in Syria: Aleppo, Lattakia, Homs, Damascus and Raqqa Provinces](image)

**Description of species and their market chains analysis**
The value chain analysis of 3 of the 6 studied species, derived from focus group interviews, are reported below.

**Jujube**

Jujube (*Ziziphus jujube* Mill.) is a deciduous fruit tree growing wild in the coastal areas of Syria. Its small round dark red fruits, harvested in October, are eaten fresh and dried only in these areas. The jujube tree resists extreme temperatures and is tolerant to salinity, alkalinity as well as to drought (*Magness et al.*, 1971). Collection is done from the wild trees. Cultivation of jujube is limited to home gardens, where they receive limited irrigation and no special care. Growers and collectors do not recognize more than one variety of cultivated or wild harvested jujube trees. Fruit – both fresh and dried – are eaten only in North-western areas. Dried fruits are rich in vitamin C and are used as remedies for throat infections, pulmonary ailments, flues and fevers. The most important area for jujube cultivation is that of Al-Rabie, situated in Al Haffeh (near Lattakia). About 4,000 trees have been planted in this area by about 10 farmers (ICARDA 2000). Ninety-five per cent of the fruit harvested from both wild and cultivated trees are sold fresh. Fresh jujube berries are not available in local markets, but are offered for sale by subsistence farmers, or collectors, along the highways and across the Lebanese border. Sometimes, traders buy fruits from farmers and sell them directly to consumers, to Lebanese wholesalers but seldom to local restaurants. The price is determined by the demand and supply?, which is higher at the beginning of the harvesting season in September. The price also responds to changes in export taxes to Lebanon. The traders’ commission is quite high when they manage to sell the produce directly to the consumers. The remaining 5% of the harvested jujube fruits are dried in the sun or the shade or on the tree and stored on the farm. These fruits are usually of a lower quality or those that have been harvested last. Fruits can also be dried on the tree. Dried fruit is used for household consumption or is given as gifts to families in the community. It is also sold to traders who then sell it to herbal shops in major towns as herbal remedy. Fig. 2 shows the value chain of the jujube. The major constraints are the low consumption due to the lack of awareness about the jujube and its fruit, the lack of proper packaging and quality control of the produce. There is a lack of research and formal training on cultivation and processing. Jujube fruit jam represents a potential new product for the Syrian market and also for export.

![Fig. 2: Jujube value chain map (SP = Syrian Pound, 1 USD=51.5 SP)](image)

**Laurel**

Laurel (*Laurus nobilis* L.) is an evergreen forest tree of the Laureaceae family, which grows wild along the coastal areas of Syria to which environment it is well adapted. It grows wild at an altitude of over 200m. Laurel is known for its resilience to pests and abiotic stresses (*Simon et al.*, 2003).
Its fruits are small, round, and very dark berries that ripen between October and December each year. In 2002 there were 1,097 laurel trees covering about 1,374 ha (in average 3% of the forest area) in Syria (MAAR 2002). Growers and collectors do not formally recognize more than one variety of cultivated or wild harvested laurel trees. However, they say that the quality of laurel oil differs according to its fatty acid content, which varies according to the genetic diversity of laurel used. Each variety is in fact characterized by a well-defined type of berry differing in scent, size and color. In Syria, laurel is an example of the dryland agro-biodiversity that has been exploited by rural communities for centuries using their indigenous knowledge. Well known, traditional laurel products have been produced in response to great demand by the local market that has remained stable for decades: laurel leaves are used extensively like in most Mediterranean countries for cooking and also as herbal remedy, laurel oil used in cosmetics as a body and hair balsam and laurel soap, with its distinctive qualities of skin nourishing, softening, deodorizing and antiseptic properties. Leaves and berries are collected from wild laurel trees by forest community members. The collection is regulated by law no. 7, 1994, enacted by the Ministry of Agriculture and Agrarian Reform (MAAR), which identifies the laurel tree as a forest species. These regulations restricted both harvests of the wild and cultivated laurel trees. However, calls for better regulatory systems have already been voiced by local community members and soap manufacturers. Few farmers grow laurel trees in their home gardens. The value chain (Fig. 3) involves the following activities: collection and trade of laurel leaves; collection, processing into oil and trade of laurel berries; and laurel soap production and trade. Leaves are dried by the collectors and sold in the markets or to traders in bulk without the benefit of any sort of packaging. The traders subsequently sell them to herbal shop retailers or to foreign traders. Berries collectors extract the oil with a traditional manual process that is mainly carried out by women. They sell the oil to local soap makers and middlemen in the employ of soap factories in Aleppo, and to herbal shop traders who come to their farms as well as sell the oil at city markets in Aleppo and Damascus. The commercialisation of laurel (berry) oil, in particular for soap making, is an important source of secondary and seasonal income for collectors.

Laurel soap is believed to have been developed in Syria some 2,000 years ago. Here, soap makers operate in about 70 small-scale factories, using very traditional technology mainly concentrated in the Aleppo Province (SEBC 2003). Since the local supply is insufficient for the needs of the industry, laurel oil is imported mostly from Turkey (about 80%). The percentage of laurel oil in the oil mix ranges between 10% and 60%. The higher the amount of laurel oil, the higher the price of the soap to the end users.

One of the market development constraints is determined by the lack of awareness and concern amongst community members about the legislation regulating the utilisation of forest products. There is a lack of research in the cultivation and processing of laurel. Quality control is often lacking. Support for efficient market strategies is missing and there is little understanding of consumer/importer requirements. Only a small quantity of the soap produced is sold to foreign traders, but the potential export demand is still untapped due to lack of marketing strategies and quality control.
**Caper**

Caper (*Capparis spinosa* L.) is a spiny perennial shrub, which can be found growing wild everywhere in Syria, around dry and rocky areas, at road sides and on old walls. The plant probably originated from dry regions in West or Central Asia. The caper is adapted to dry heat and intense sunlight and can survive in temperatures of over 40°C (Alkire 1998).

In Syria caper is a wild species and is cultivated only on an experimental level in research nurseries. Caper is widely cultivated in other Mediterranean countries (Italy, Spain, France, Algeria, Cyprus, Greece, and Morocco). The main caper product for trade in Syria is the young flower bud that is collected before the flowers have formed. Unlike other Mediterranean countries the product is not eaten in Syria but there is small market for the plant parts in herbal medicine.

Collection of caper flower buds started only recently in Syria mainly by nomadic communities. It takes place from June to August each year and represents a secondary source of income. Collectors are usually young children and women. One individual is responsible for a group of collectors in each area. Those individuals liaise with a manager of a private enterprise who provides them with implements for the collection of the capers (plastic boxes, etc.) and a fixed price per kg of buds. Part of the money is used to pay the collectors and the rent of the premises where the first processing takes place. Processing the caper buds involves entire families and consists of mixing the capers with salt and stocking them into plastic containers, after having sorted them by size without any added value. These caper buds are then collected and stored by the private enterprise who will then sell the capers mainly to Turkish traders. Finally, the Turkish factories bottle the capers, adding preservatives and vinegar. After branding the product they sell it on the European market with a high mark up that is concentrated at the end of the value chain. The amount of capers collected, their price and the number of people involved in the collection depend on the yearly Turkish demand that fluctuates extensively. The biggest constraint is the lack of market transparency and market information and trust among the market chain actors. There is a lack of awareness amongst collectors about the final use of the product and there is no organised community structure dealing with the collection, processing and trade. Working conditions are very difficult during collection (heat and thorns). Research on cultivation and support for efficient value-adding processing is lacking. The harvesting method of the wild caper plants is often unsustainable and it represents a threat for the conservation of the species. Horizontal integration through cooperatives of collectors represents an opportunity to increase benefits for the rural communities dedicated to the collection of capers. Vertical integration of
collectors and traders through the intervention of the business sector could prompt the market benefiting the rural communities.

**Livelihoods assets of chain actors**
The following results have been obtained by the four household questionnaires and analysed at the chain actor level (growers, collectors, processors and traders).

- **Human and social capital**
There is no significant difference in average family size, composed by parents and children, among actors (7.54 persons); with no difference between rural areas and urban areas. The lowest level of education has been found among the collectors, with an average illiteracy rate of 64.15%, compared to 53.42% for illiterate growers, 17.86% for processors and 27.84% for the traders. Despite the fact that most of these species and the activities around them are considered traditional, the mean of years of experience of the chain actors reveal that they have relatively short experience in the activity that their household carries out (i.e., between 16 and 35 years). From Table 2 it can be seen that illiteracy rate and experience of the chain actors are negatively correlated.

Table 2: Average of family size, illiteracy rate and year of working experience in their activity related to target species, among the market chain actors

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Collectors</th>
<th>Growers</th>
<th>Processors</th>
<th>Traders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family size</td>
<td>7.21</td>
<td>7.34</td>
<td>8.28</td>
<td>7.33</td>
</tr>
<tr>
<td>Illiteracy rate (%)</td>
<td>64.15</td>
<td>53.42</td>
<td>17.86</td>
<td>27.84</td>
</tr>
<tr>
<td>Years of experience in the chain activity</td>
<td>16</td>
<td>20</td>
<td>35</td>
<td>21</td>
</tr>
</tbody>
</table>

As shown in Table 3, the average labor share of one year of the actors in the chain, dedicated to these species, is 19.9% for growers, 13.4% for collectors, 16.5% for processors and 18.0% for traders. Caper and laurel collectors reported the highest average percentage among the collectors (up to 30%). A possible explanation for this is that laurel collection is very well remunerated. Growing these species is the most labor demanding activity in the market chain. A good part of the workers are family members (Table 3), but there are external workers as well. Collection is very labor-intensive as well, family members comprising clear majority of workers involved in this activity (i.e. 97.38%). This can be explained by the fact that collection is the least structured activity carried out without funds and facilities. Processing is a labor-demanding activity also and once again mainly conducted by family members. Only in the case of the laurel soap factories we find a considerable share of labor is provided by external workers. The survey reveals a great presence of women and children (under the age of 12) in the market chain activities particularly for collection and growing (53% and 29%, respectively) (Table 3). Women play a major role in processing but not in trading.

Table 3: Average no. of total workers, of women workers, of children workers and average ratio to total workers for market chain actors

<table>
<thead>
<tr>
<th>Chain actors</th>
<th>Average no. tot workers</th>
<th>Average ratio family memb. /tot workers</th>
<th>Average no. women</th>
<th>Average ratio women/tot workers</th>
<th>Average no. children</th>
<th>Average ratio children/tot workers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collectors</td>
<td>5.26</td>
<td>97.38%</td>
<td>2.77</td>
<td>52.59%</td>
<td>1.53</td>
<td>29.03%</td>
</tr>
<tr>
<td>Growers</td>
<td>6.15</td>
<td>67.45%</td>
<td>2.33</td>
<td>37.81%</td>
<td>0.30</td>
<td>4.91%</td>
</tr>
<tr>
<td>Processors</td>
<td>6.61</td>
<td>59.64%</td>
<td>2.27</td>
<td>34.31%</td>
<td>0.00</td>
<td>0.00%</td>
</tr>
<tr>
<td>Traders</td>
<td>3.00</td>
<td>77.86%</td>
<td>0.35</td>
<td>11.49%</td>
<td>0.62</td>
<td>20.56%</td>
</tr>
</tbody>
</table>
Collectors do not have any formal training. Growers, including a few women, receive training from household members or from other farmers in the community (Table 4). Workers engaged in laurel soap processing activity are trained by the factory owner. Respondents’ training needs are: cultivation practices, storage, packaging, manufacturing, and marketing.

Table 4: Training source and common training needs pointed out by chain actors (\(HH=\text{households}\))

<table>
<thead>
<tr>
<th>Chain actors</th>
<th>Source of training</th>
<th>Training needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collectors</td>
<td>No training</td>
<td>sustainable harvesting</td>
</tr>
<tr>
<td>Growers</td>
<td>HH, community farmers</td>
<td>storage, packaging, cultivation, manufacturing</td>
</tr>
<tr>
<td>Processors</td>
<td>HH, factory owner</td>
<td>improved processing methods</td>
</tr>
<tr>
<td>Traders</td>
<td>HH, members from other communities</td>
<td>packaging, marketing</td>
</tr>
</tbody>
</table>

- **Physical capital**

  Ninety-six per cent of the growers own the land where they grow these species on a small scale (average holding 0.44 ha), only the 4% rent the land. Among the interviewed collectors 34% are landless. Collectors and growers are more impacted by transport cost and time spent to reach the market. Lands exploited for the collection of wild species are usually far from the villages or cities where the products are sold compared to the farms. This might explain why – on an average – collectors take more time to reach the market place. Traders are less affected by transportation cost and time since they carry out the trading functions in a more restricted area.

- **Natural capital**

  Collectors gather the wild species either from communal or state land not knowing how many hectares they harvest, though they have a perception of how many hours they walk to harvest the product. Twenty-three per cent of the collectors stated that the quality of the species has improved over the past decade, while 13% think that the quality has decreased (Table 5). Regarding quantity, 32% of the collectors think that the species are becoming less available which may be result of unsustainable harvesting and over exploitation.

Table 5: Perception of the collectors on the availability of the wild species in terms of quality and quantity comparing to 10 years ago

<table>
<thead>
<tr>
<th></th>
<th>More</th>
<th>Same</th>
<th>Less</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>23.9%</td>
<td>63%</td>
<td>13%</td>
</tr>
<tr>
<td>Quantity</td>
<td>0%</td>
<td>67.4%</td>
<td>32.6%</td>
</tr>
</tbody>
</table>

- **Financial capital (wealth)**

  With a self-assessment based on a list of wealth indicators developed for a self-appraisal (availability of land, food, livestock, water, etc.), shows that 57.41% of the collectors consider themselves ‘poor’, while most of the growers (66.67%) and processors (60.72%) are reported to live as middle-class citizens. Almost 30% of traders considered themselves ‘well-off’ or rich.

**Destination of the product, income and labor share**

The sales share is very important compared to household consumption: traders (95.24%), growers (86%) and processor (79.35%). Household consumption (mainly for nutrition, medicinal use and animal feed) is quite significant among collectors (30.82%). Yearly income share from NUS activity varies from 10% for processors to 11.25% for collectors, to 22% for traders, and 23% for growers (Table 6).
Table 6: Average share of species sales in total yearly household income

<table>
<thead>
<tr>
<th>Chain actor</th>
<th>Average % income share</th>
<th>Coefficient of variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collectors</td>
<td>11.25</td>
<td>0.65</td>
</tr>
<tr>
<td>Growers</td>
<td>23.05</td>
<td>0.78</td>
</tr>
<tr>
<td>Processors</td>
<td>9.86</td>
<td>0.53</td>
</tr>
<tr>
<td>Traders</td>
<td>21.81</td>
<td>0.87</td>
</tr>
</tbody>
</table>

The average time spent in one year is 19.9% for growers, 13.4% for collectors, 16.0% for processors, and 18.0% for traders. Income generation was given as the main reason for the actors in the chain to be engaged in their activities. Other reasons reported are domestic use, nutrition and medicinal purposes, tradition, imitation of the neighbors, ease of operations and diversification.

**Main constraints**

Table 7 shows the major constraints reported by the chain actors. Growers are mostly concerned about problems in the cultivation practices. Collectors’ main bottleneck is the labor intensity of their activity due to the lack of facilities, infrastructure and labor organization. Traders’ major problems are represented by the packaging that is not up to satisfy the requirements of the end-users. As for the indication on how to improve the quality of the products it was revealed that packaging, appearance, taste and size are the key-factors.

Table 7: Main constraints identified by the market chain actors and their proposed improvement to develop their activities on target species

<table>
<thead>
<tr>
<th>Chain actors</th>
<th>Constraints</th>
<th>Improvements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collectors</td>
<td>Labor conditions and lack of infrastructure</td>
<td>Improve the appearance of the product</td>
</tr>
<tr>
<td>Growers</td>
<td>Cultivation practices, packaging</td>
<td>Improve the taste and appearance of the product</td>
</tr>
<tr>
<td>Processors</td>
<td>Labor conditions, demand constraints</td>
<td>Apply different processing methods, change marketing channel</td>
</tr>
<tr>
<td>Traders</td>
<td>Lack of suitable packaging</td>
<td>Improve the packaging, boost the demand</td>
</tr>
</tbody>
</table>

**Conclusions and Discussion**

In a livelihood perspective, the side-income derived from the activities on NUS, though subsidiary for the overall national economy, can be considered important revenue for the rural communities. Very high percentage of sales (70-95%) of the product confirms the key role that markets play in the livelihood strategies related to NUS. These results confirm the role that diversity plays in the lives of all the market chain actor groups. Human and social capital is the main livelihood asset that small-scale producers rely on. In order to improve the households of local communities, the actors should be empowered and biodiversity conservation should be further strengthened and sustainably used. Particular attention should be paid to the collectors who were found to be the most vulnerable chain actors in terms of livelihood assets.

From a market angle the main constraints impeding the functioning of the market chains for the benefit of the rural communities’ livelihood should be overcome through the intervention of the government in collaboration with the business sector or through public investments or by international organisations. Building trust among the chain actors, fostering a horizontal and vertical integration of the activities, enhancing market transparency and market literacy and
investing in infrastructures related to the chain activities can be of great benefit for improving the livelihoods of the communities involved. In addition, capacity building on agronomical practices (for sustainable harvest from the wild and cultivated plants), value-adding processing technologies, quality storing, packaging and product diversification, should be brought to the chain actors through farmer-to-farmer training, extension services, product fairs, and rural theatres.

The capacity building efforts together with the reorganisation of the market chain could help facilitate the opening of small-scale processing factories and/or the development of a local market (and, in few cases, international niche markets). Policy instruments should support the enhancement of market performance of NUS by supporting their sustainable conservation. Some implications would be the provision of planting material, the development of standards for processing and commercialisation and relative certification, and the reformulation of regulations for a sustainable harvesting of the wild species.

Acknowledgements
The authors wish to express their sincere thanks to the members of the local communities who agreed to be interviewed, the survey assistants, and to the colleagues Melinda Smale and Pablo Eyzaguirre for their various contributions to this work.

References
Global Facilitation Unit for Underutilized Species (GFU). 2002. Conceptual framework of the multi-stakeholder initiative established under the umbrella of the Global Forum on Agricultural Research (GFAR) and hosted by the International Plant Genetic Resources Institute (IPGRI) www.underutilized-species.org/.


Promoting Lebanese Olive Oil from Local Varieties and Value-added to Wild Oregano Populations in Lebanon

W. Khoury

_Agriculture specialist, SRI International-Lebanon, Project on the "Expanding Economic Opportunities in Lebanon" funded by USAID_

**Keywords:** Landrace, olive, wild oregano, value addition, agrobiodiversity, conservation

**Abstract**

Through the USAID-funded project on "Expanding Economic Opportunities in Lebanon", SRI International, a US-based non-profit research and consultancy company, is supporting the development of the Agribusiness sector in Lebanon. The project focuses on promoting exports of Lebanese commodities with growing international markets and a comparative advantage for Lebanon in these markets. Lebanese olive oil has special organoleptic characteristics, as praised by international experts. Working with grower groups from 10 different regions of Lebanon, the project developed "Traditions du Liban", a trademark for high quality Lebanese extra virgin olive oil with distinct labels reflecting the stories and taste characteristic of each respective region. The brand was introduced in international fairs and directly attracted distributors for the US market. This innovative marketing idea soon attracted the interest of a reputable agro-food private company that will eventually take over the trademark while keeping the concept of traceability of the suppliers, fair pricing to growers and highlighting the differences in flavors of the regions. An initial order has already been made for the local and international markets. Involved in this process is a local development of NGO that has the role of linking the growers with the private sector and ensuring quality. Another initiative of the project was adding value to _Origanum syriacum_, an herb native to the East Mediterranean region and locally known as "Zaatar", which is traditionally collected from the wild and sold in the local or international market. Laboratory test results on cultivated populations that were originally selected from the wild showed very high essential oil quality (both quantity and oil profile), which is an important criterion for grading and pricing oregano in international markets. Several wild populations previously studied for their agronomic characteristics were further characterized for their essential oils, and the most promising populations are now being multiplied in local nurseries to be sold at cost to an expanding number of interested growers. In parallel, the project is working on establishing international markets for this native herb.

**Introduction**

Since 2002, SRI International, a US non-profit research and consultancy company, has been implementing a 3-year USAID-funded project on "Expanding Economic Opportunities in Lebanon". This development Project is involved in expanding job opportunities and developing markets and hence growth in three major economic sectors in rural Lebanon, namely agribusiness, rural tourism and information and communication technology. SRI International is working with its local NGO partner “the Social and Cultural Development Association (INMA)”. Within the Agribusiness sector, the project is market-oriented focusing on promoting exports of products with already growing international markets where the Lebanese products have, or could have, comparative advantages. Accordingly, a series of international studies were undertaken by SRI International to identify potential export markets for Lebanese products.
Among the identified markets were those of olive oil, herbs and spices, organic products and the typically Mediterranean processed foods (SRI International, 2003a; SRI International, 2003b).

Case Study 1: Promoting Lebanese olive oil from local varieties:
A logical step was to study the Lebanese olive oil sector and identify its comparative advantage and potential competitiveness to enter the international markets. Lebanon, an East Mediterranean country, is known for its topographic, environmental, biological and cultural diversity. Despite its small size, the diversity of its microclimates makes it suitable for almost all types of crop production. However, among the trees cultivated in Lebanon, olives are the most important. The olive tree, originating from the Mediterranean region, is an integrated part of the Lebanese landscape and forms the basis of its provincial and local cuisine. Olive trees cover an estimated area of 52,000 ha, or approximately 20% of cultivated area in the country. The olive production area extends over a large area of the country, with 40% of orchards in the South, 39% in the North, 15% in Mount Lebanon and 6% in the eastern Bekaa (National Agricultural Census, 2000). Olives are grown in a wide spectrum of agro-ecological conditions and at elevations ranging from sea-level to over 1,300m. With an estimated number of 103,000 Lebanese families involved in the field of olive production, the social, economic and ecological magnitude of this crop becomes obvious.

The majority of Lebanese olive groves are several decades to several hundred years old, and some of the trees are even claimed to be from the Roman period. With such old groves, most of Lebanese olive trees are of local varieties that are highly adapted to the environmental conditions of the local terrain. They are almost exclusively rainfed. Some Jordanian, Italian, Spanish, French, and other European varieties have been introduced in recent years, but their cultivation area is still very limited. The scientific information on the characterization of the local olive varieties is limited, but the available description refers to the following types: 1) "Soury" (Beladi, Ayrouni, Bayadi): the most common variety, widespread with a high oil content, 2) "Beladi" (Bayadi, Khoudri, Zeitouni): very common variety in the North also with high oil content, 3) "Ayrouni" (small Soury bizri, Soummaki): a vigorously growing tree, cultivated all over the country, also with high oil content, 4) "Chamy" (Big Soury): widespread in the North, mostly grown as table olives rather than for oil, and 5) "Samakmaki" (Small Ayrouni): variety cultivated in the South and Mount Lebanon with a small fruit size and acceptable oil content (Gasparini and Mezher, 2002). On the average, 30% of all olive production in Lebanon is destined for fresh consumption and the remaining 70% is transformed into oil. The oil produced is 18-25% of the total olive weight, depending on olive variety and harvesting time (Munoz, 2002).

Among the most important constraints for the competitiveness of the Lebanese olive oil is the high cost of production (Khoury, 2004). The most critical factors resulting in the high production costs are:

1. High costs of land and small land holdings: commonly around 3-5 dunums (1 dunum=0.1 ha);
2. Old groves: trees usually over 50 years old;
3. Limited agricultural practices supporting the productivity of the trees: pruning once in 2-4 years; fertilization once/year or once every 2-3 years;
4. Limited application of pesticides against the major pests (olive moth, olive fruit fly and peacock's eye disease);
5. Almost exclusively rainfed production: trees are rarely provided with supplemental irrigation in drought periods;
6. Harvesting often by hitting the trees, resulting in the destruction of emerging buds;
7. Severe alternate bearing: lack of improper pruning and harvesting techniques and absence of irrigation being direct causes;
8. High labor costs: especially in the difficult steep terraced regions.

The high costs of production and low tree productivity have led several Lebanese merchants in this sector to preach for a complete rejuvenation of the Lebanese groves by grafting all the local varieties with newly introduced varieties with higher productivity and less alternate bearing characteristics. However, experience showed that the special taste characteristics of the Lebanese oil that is a direct result of the interaction between these local varieties and the local microclimates which makes this oil attractive to consumers, both nationally and internationally. Accordingly, the competitiveness of the Lebanese olive oil in the international markets originates basically from its special organoleptic qualities, rather than from its present production cost and market prices.

Several factors affect the characteristics and specific tastes of olive oil. The special qualities of olive oil vary with the genetic characteristics of the olive trees as well as environmental factors such as sun exposure, temperature, humidity, soil characteristics and land topography. Other factors affecting oil quality include tree management, harvesting method and time, pressing and preservation conditions. It is therefore clear, why olive oil taste and quality are highly related to a special region. Local varieties of olive in Lebanon through their interaction with specific microclimate conditions in each region result in taste differences of the oil specific to these regions. The special taste and aroma give the Lebanese olive oil a comparative advantage as confirmed by international experts from Italy, Spain, and France.

Results of international market studies indicated that there has been a major and steady increase in the international demand for olive oil over the last decade. Key trends in the consumer preferences in the EU and the North American markets have recently induced the growth of oil consumption, and particularly olive oil. These trends have created several new high-growth, high-value market niches for these products. The demand is growing for bottled specialty oils from non-EU geographic origins with novelty appeal. Special price premiums are going to organic oils, the sales of which are expected to increase, with prices that are generally double of those of conventional oils (SRI International, 2003a; SRI International, 2003b). Within that perspective, Lebanese olive oil, particularly high quality extra virgin olive oil with regional geographical indications has a considerable export potential, not as bulk but as specialized regional bottled oil. Already Rene Moawad Foundation has been successful in introducing high quality Lebanese extra virgin olive oil in the collection of Oliviers & Co., one of the most prestigious and sophisticated olive oil markets worldwide. This oil, which originates from the Batroun region, in North Lebanon, is on the shelves of 60 Oliviers & Co. stores in Europe, USA, and Japan. Lebanese extra virgin olive oil is among the most popular newly-introduced oils within their collection (F. Yarak, Executive Director, Rene Moawad Foundation, Beirut, Lebanon 2004, Pers. Comm.).

In 2003 and 2004, SRI International and its local partner in Lebanon INMA, has test-marketed the potential of extra virgin olive oil from 10 different regions in Lebanon at international food shows in the USA and France. The response of buyers was extremely encouraging, whether with respect to taste, or to potential prices offered for that special taste. Accordingly, the SRI project developed the concept in 2003 and registered a new brand of high quality extra virgin Lebanese olive oil: "Traditions du Liban" (TDL). Under the same brand and quality assurance, TDL presently produces specialty oil from eight different regions of Lebanon. Each bottle bears a label indicating the characteristic of the specific region and its oil. The oil is supplied by a network of growers or grower groups from these different regions working with SRI/INMA. The oil quality required by SRI/INMA is based on international chemical and organoleptic standards and specifications of extra virgin oil and the source of the oil is traced to every single grower. The price provided to the growers for the oil is judged fair and is very profitable in the long run.
considering the expected continuous demand for this oil in high volumes for international markets. Many of the growers were also supported technically by SRI/INMA through sub-contracts and close cooperation with NGOs already actively working with olive oil growers in the field (Rene Moawad Foundation "RMF" and the Institute for University Cooperation-Rome "ICU"). Several awareness sessions were held with growers to help them understand the importance of commitment to continuous supply of high quality products for international markets, investing in proper storage facilities, testing their oil, accepting reasonable market-driven oil prices in return for a long term and stable market. SRI/INMA is still committed financially to the training and extension services to growers, to paying the cost of the bottles, chemical and organoleptic tests, and the marketing support in international food shows.

At the 2003 Fancy Food Show in NY, USA, one of the largest food shows worldwide, SRI International contracted two distributors for the TDL oil for East and West Coasts of the US. Test shipments of the products followed. Through the test shipments and distributors, a highly reputable Lebanese agrofood company, Wadi Al Akhdar (WAK) was introduced to the concept of TDL. WAK immediately saw the potential market benefits in owning such a brand. What was attractive for WAK was the brand name in itself, the concept of a product of 100% Lebanese origin (very rarely found in Lebanese agrofood products), the concept of separating regions and indicating them on the label (attracting Lebanese expatriates), and having a range of products (regions and tastes in this case) of the same high quality and brand that fill a larger space in the shelves in stores (a typical marketing strategy). The company was further encouraged by the support for quality guarantee and reputation of SRI/INMA. Accordingly, a 3-way agreement was completed by SRI/INMA, RMF and WAK whereby WAK is committed to purchase and market in the first year 50 tons of TDL from seven regions, under a joint TDL/WAK label. This condition, if valid for another year will allow WAK to own the trademark. RMF is responsible for the follow-up on contracts with growers and payments, extension services, quality control, bottling of oil within their modern facilities and administration of the process. SRI/INMA will support, as long as their Project is running in Lebanon, by networking with growers, management of processes and agreements and full support in international marketing, including in-store promotions. The agreed cost of the final product to WAK, includes the cost of the oil to the growers, as well as cost of bottles, labels, transportation of oil from the various regions, storage, depreciation of equipment and administrative costs, thus rendering the operation sustainable on the long term. Presently, the oil has been tested, purchased and collected from the growers, stored in stainless steel tanks for bottling upon market request by WAK. It is expected to be launched on the market in May 2005.

Case Study 2: Value-added to wild oregano populations from Lebanon

Among the internationally growing markets is that of herbs and spices (SRI International, 2003c; SRI International, 2003d). Lebanon's climate makes it most suitable for the production of typical Mediterranean herbs. The diversity of Lebanon's wild plants is tremendous, especially in aromatic and medicinal plants, many of which are indigenous and endemic to the area. One in particular is of economic importance, the wild oregano, *Origanum syriacum*, which is mainly characterized by its wide use in the typical Lebanese diet.

In Lebanon, *Origanum syriacum* is the plant commonly known as "Zaatar" or often "zouba’a", when in it is at green fresh stage. Commonly, the term “Zaatar” is falsely often translated to English and other languages as thyme. However, it is not the only plant that is called Zaatar, this Arabic name is given to several plant types and species, whether cultivated or wild, with a similar taste and aroma, commonly originating from the presence of high levels of carvacrol or thymol in the essential oil of these plants. Zaatar in Lebanon also refers to the cultivated plants used in the mezza as salad or leafy vegetable (*Satujera hortensis*), the fresh wild plants used as
sharp-tasting salad (*Origanum syriacum*, *Thymbra spicata*, or *Thymus vulgaris*), the pickled wild herb with olives or other vegetable (usually *Thymbra spicata*, less commonly *Thymus sp.*), and the ground dried herb (leaves and/or flower) alone or in a mixture that includes sumac, sesame seeds and salt used for “manakeesh” (commonly *O. syriacum* but could be mixed with *Thymbra, Thymus or Coridothymus capitatus*, depending on its abundance in the region). Another plant that is included within the wild Oregano family in Lebanon is *O. libanoticum* that grows at higher altitudes but seems to have limited potential for use at present, probably as an ornamental plant (Abi Antoun *et al*., 2003).

Lebanon consumes annually an estimated 1500 tons of local Zaat ar and still imports oregano from Syria, Jordan and Turkey. However, the quality of the imported plants does not suit the Lebanese requirements for the typical "manakeesh" meal due to its limited heat resistance. (Abi Antoun *et al*., 2003). On the other hand, and for the past several decades, Lebanon was exporting large quantities of its dry wild oregano estimated at 500 tons/year mostly to the US, Europe and some countries of the Gulf. This excessive harvesting of wild plants led the Ministry of Agriculture to issue decrees prohibiting and later regulating the collection of "zaatar" from the wild for exports. However, the decrees do not clearly specify the species of what is known as "zaatar" nor was the Ministry of Agriculture able to control illegal collections and smuggling to neighboring countries.

The potential productivity of several wild *O. syriacum* biotypes collected from different locations in Lebanon and cultivated was evaluated at the Fanar station of the Lebanese Agriculture Research Institute (Abi Antoun, 2003). The experiments tested the various populations for their total production over 3 years, with the addition of organic and/or mineral fertilizers, with or without irrigation and for the resulting total essential oils produced per dunum. Results indicated a clear effect of different populations and planting location on total production. The average production ranged from 27.5 kg/ha to 70.6 kg/ha during the 1st year of cultivation, and the essential oil content was found to be very high in some populations, and it ranged between 2.5 and 7.6 % of dry matter. Other studies on cultivated oregano populations from Lebanon resulted in yields of 80 kg/ha during the second year of planting (Noon, 2003).

Several attempts have also been made in recent years by local NGOs and development organizations to cultivate *O. syriacum* in farmers’ fields in various regions of Lebanon. Among the most important activities in this respect was the "Jezzine Economic Opportunities" Project of the World Rehabilitation Fund, whereby support was provided to growers to cultivate in their fields several herbs including local oregano and tri-lobed sage with or without irrigation. The Project also built distillation facilities for essential oil extraction of these herbs. Some of the growers have been very successful in obtaining high production of *O. syriacum*, especially when using drip irrigation. On the other hand, and in response to the need for availability of propagative material, several nurseries by local NGOs started producing seedlings of such herbs, which mostly originated from seeds obtained from random populations in the field. However, propagation of such material obtained from seeds of wild oregano populations resulted in large variability of the resulting seedlings.

The price value of oregano in the international market is separated into quality classes that are directly dependent on the essential oil content. For the Turkish oregano for example, the prices paid for one ton of dried oregano FOB Izmir are $US 2,600, $US 2,300 and $US 2,050 for the categories "Extra fancy" (essential oil = 2.5% v.o.), "Fancy" (essential oil = 2% v.o.) and "Regular" (essential oil = 1.5% v.o.), respectively (American Spice Trade Association, 2004, Pers. Comm.). Though the Lebanese oregano is known for its higher essential oil content, the material exported would be actually priced similarly to any other unclassified European or Turkish oregano. This under-estimation of the value of the local oregano is due to the fact that the material exported is collected from the wild, with quality that is neither uniform nor tested
for its essential oil content. Even the cultivated and harvested product that originated from seed multiplication is valued as any product collected from the wild as long as it is non-uniform in quality and unevaluated for its essential oil content. Accordingly, an attempt was made by SRI/INMA in close cooperation with several local partners to add value to the wild populations of *O. syriacum* through population selection and cultivation of uniform plants with known tested characteristics.

The plant material used by this initiative was selected from the research work of Dr. Jihad Noun, whose work was technically and financially supported by the International Plant Genetic Resource Institute (IPGRI), and was part of a research program on "Neglected and Under-utilized Lebanese Wild Species". This program was launched by IPGRI in 1999 with the aim of assessing the biological diversity of wild species and evaluating their agro-economic potential. It included ethno-botanical and domestication studies (1999-2003) carried out over an area of study of 100 km square in the Damour river basin, an area representative of the Mediterranean ecosystem of Mount-Lebanon (Noun, 2003). Through his research, Dr. Noun was able to select over 195 accessions of *O. syriacum*, which were then planted over 2 years in experimental plots in the field. Detailed agronomic studies were undertaken of these cultivated populations. Data collected included: seed morphology, plant and inflorescence morpho-agronomic traits (height, surface, ramification, total biomass, fresh weight, dry weight, ration of stems to inflorescence, ratio of commercialized part (flower + leaves to the total biomass, ratio of flower to biomass and leaves, ratio of rejected material (woody stems), number of nods per stem, etc. (Noun, 2003). Through the support of SRI/INMA, dried oregano leaf samples from one of these cultivated accessions were sent to the certified laboratory of Rutgers University, USA to test their quality characteristics. The results obtained were extremely encouraging and are quoted as follows:

“The color of the oregano was light/pale green. The aroma was pleasant and spice, the taste strong and sharp. This sample contained very low amounts of foreign matter. The essential oil content was 8%, which is a very high level, and was characterized by high levels of carvacrol (75%) with lower amounts of para-cymene (9%), g – terpinene (2%) and thymol (5%). This Lebanese oregano was of superior quality since it met and exceeded international standards. As the essential oil yield was so high and the total phenolics content so rich, the plant may be a promising source of essential oils, independent of its application and current use as a culinary spice” as quoted from the test report.

Accordingly, the next step was to evaluate the essential oil content and profile of all accessions collected by Dr. Noun and already studied for their morpho-agronomic characters. Based on the available literature, a protocol for essential oil profile analysis was jointly developed by Dr. Noun and Mr. Amer Sakr from the Analytical Testing Laboratories (ATL) in Beirut using the GCMS techniques. A total of 60 samples that were harvested from the original 60 accessions were steam distilled and tested at ATL for the % oil content and oil profile. Based on specific agronomic and chemical characteristics, 10 populations of *O. syriacum* were selected for future multiplication in nurseries. The characteristics used for the selection included: high biomass, high essential oil content, and the levels of carvacrol, thymol, para-cymene, and terpinene. The characteristics of the accessions selected are presented in the following table 1.

<table>
<thead>
<tr>
<th>Accession Code</th>
<th>Biomass g/plant fresh weight</th>
<th>Essential Oil g/g %</th>
<th>Carvacrol %</th>
<th>Thymol %</th>
<th>Cymene %</th>
<th>Terpinene %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NNV85</td>
<td>320</td>
<td>2.4</td>
<td>79</td>
<td>&lt;1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMZY85</td>
<td>107.5</td>
<td>1.6</td>
<td>75.8</td>
<td>&lt;1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PMZY72</td>
<td>165</td>
<td>1.6</td>
<td>69.2</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>-------</td>
<td>-----</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>NNV80</td>
<td>246</td>
<td>3.6</td>
<td>68.2</td>
<td>&lt;1</td>
<td>9.5</td>
<td>11.4</td>
</tr>
<tr>
<td>ZTS81</td>
<td>110</td>
<td>1.4</td>
<td>2.86</td>
<td>72.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZNN98</td>
<td>587.5</td>
<td>2.45</td>
<td>3.1</td>
<td>67.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NNV96</td>
<td>na</td>
<td>1.98</td>
<td>3.3</td>
<td>67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ZW295</td>
<td>1050</td>
<td>1.5</td>
<td>33.65</td>
<td>4.13</td>
<td>29.9</td>
<td>17.8</td>
</tr>
<tr>
<td>ZWZ95</td>
<td>1050</td>
<td>1.76</td>
<td>37.98</td>
<td>12.21</td>
<td>34.2</td>
<td>6.7</td>
</tr>
<tr>
<td>PMZY66</td>
<td>715</td>
<td>1.96</td>
<td>46</td>
<td>28.4</td>
<td>8.5</td>
<td>6.4</td>
</tr>
</tbody>
</table>

The multiplication of the selected accessions was followed in two nurseries in Lebanon. The nurseries selected for that purpose are managed by non-profit organizations, one belonging to Caritas (in Deir el Qamar, Chouf area), and the other belonging to the Rene Moawad Foundation (RMF) in the Zgharta, North Lebanon. Both nurseries have good facilities and several years of experience in growing herbs. Agreements were prepared and signed between SRI/INMA and these nurseries. Though no regulation is still applicable in Lebanon on the protection of local genetic material, the signed agreements commit the nurseries not to sell any of the material to be multiplied to for-profit private nurseries or to foreign countries in order to protect the local genetic material. On the other hand, the agreement commits SRI/INMA to regularly provide the nurseries, through Dr. Noun, with cuttings from each of the selected 10 populations from the field. These would be used for direct rooting and vegetative propagation as well as for establishing mother plants to be used by the nurseries for further multiplication, especially in case the original material in the field is lost through habitat change. The nurseries are also provided with a description of the basic quality characteristics of the populations being multiplied that should be distributed to the growers requesting the seedlings. Also, per the agreement, the seedlings will be sold to growers at cost, without any additional profit. The nurseries will keep record of all growers receiving seedlings, the number of plants purchased and the location where they will be planted (whenever possible). Such records will help the estimation of the potential production capabilities of these cultivated oregano populations. Such production estimates would be needed for future international markets. The records may also eventually serve to support lobbying for a modification of the decree inhibiting the export of oregano, to allow for exports and sales of material from cultivated rather than wild plants.

Presently, growers have started setting their orders for the oregano seedlings from these nurseries. The first batch of seedlings was available for sale in May 2005, while the large nursery production was used for planting in the fall 2005 season. As a support service to the growers, SRI/INMA organized workshops on oregano cultivation and marketing to inform potential growers on the importance of cultivation of oregano, on methods of cultivation and harvesting and on local and international market potentials for dried oregano or its essential oil.

References


Current Activities on Conservation and Sustainable Use of Underutilized Plant Resources

M. Abi Antoun, H. Chehabeddine and C. Ojeil

Agricultural Department, Agricultural Research Institute, P.O.Box. 90-1965 Jdeidet El-Metn, Fanar, Lebanon. E-mail: mabiantoun@yahoo.com

Keywords: Underutilized species, *Origanum syriacum*, Salvia, Laurus, *Micromeria*, *Ceratonia siliqua*, conservation, domestication.

Abstract
The Rio Summit in 1992 prompted action towards understanding, conserving and sustainably using plant genetic resources. In recent research and development activities attention is focused on the healthy environment providing continuity of living organisms. In Lebanon, many wild plant species are being studied for their genetic potential, medicinal uses, industrial, cosmetics, food and feed purposes. The present study focuses on dryland plant species of economic importance to farmers and rural communities. These plants include Zaatar (*Origanum syriacum*), Carob (*Ceratonia siliqua*), Sage (*Salvia fruticosa*), Laurel (*Laurus nobilis*), Zoufa (*Micromeria barbata*), Inula (*Inula viscosa*), Myrtle (*Myrthus communis*), Mint (*Mentha piperita*). Various studies on *Origanum syriacum*, starting 1994, have indicated its use as condiment, in medication and other agricultural and environment qualities. Agronomic studies revealed its ease of domestication and its high yielding potential. Its perennial nature, drought tolerance and wide distribution in Eastern Mediterranean areas give it unique adaptation to harsh environments. Yield of dry material of 1 Ton/dunum, oil yield of 30 Kg/dunum and net profit of 2000 US $ per dunum (1 dunum=0.1 hectare) were obtained. Work on Carob ecology and agronomy indicated the existence of four local varieties distributed over localized areas in Lebanon, and the good response of the species to improved agricultural practices. Studies on Sage indicated sensitivity to cutting and to the domestication process. Laurel responded well to maintenance activities of pruning and fertilizers. Seed germination of laurel is simple and its oil extraction using solvents is introduced in the development process. *Micromeria barbata* is being evaluated and present results indicate the perennial nature, rapid germination and good response to nutrients of the species. Plant extracts, mostly volatile oils of Inula, Myrtle, Mint, Laurel and Salvia were tested as well as the intact plant for nematicid action. Inula extract and plant parts showed high activity against nematodes. Its possible use as alternative to methyl bromide has a very high potential.

Introduction
Lebanon is a small country with rich flora. Each geographical region is characterized by its sociological and topographical features, and by a group of special plant species that reflect particular ecological conditions and local uses. However, this species richness and diversity is under increasing threats due to over-exploitation and destruction of natural habitats. Regarding the terrestrial flora in Lebanon, half of the wild species are subject to several threats of social, economical, agricultural and cultural levels. The main objective of this work is to give elements for the promotion of conservation and sustainable use of several under-utilized species in Lebanon mainly through their in situ management, domestication and development of add-value technologies. The species belong to the genera of *Ceratonia, Origanum, Laurus, Salvia, Micromeria, Inula, Mentha, and Myrthus*. Various studies have reported medicinal, agronomic and environmental values of a large number of local wild plant genetic resources. Noun (2003)
evaluated *Origanum syriacum*, *Cichorium intybus*, *Gundelia tourneforti* and *Salvia* and listed 74 uses of *Origanum*, 8 medicinal uses of *Gundelia*, 82 for *Salvia* and 48 for *Cichorium*. These uses include medicinal, food, beverage and cosmetic aspects. Asmar (1999) studied the optimal growing conditions of *O. syriacum* and its best methods of propagation for commercial production and found that seed viability was 60% which includes 40% capable of germination after 10 days and 20% in dormancy state subject to 1-naphtalacetic acid (NAA3) treatment to germinate. Working on biopesticides of plant origin effective to control Mediterranean fruit fly (*Ceratitis capitata* Wiedemann), Wehbé (2003) showed that *Foeniculum vulgare* controlled 91.11%, *Thymbra spicata* 56.66%, *Artemisia herba alba* 55.44%, *Origanum syriacum* 52.22% and *Ruta chalepensis* 46.66% of the fly population. Abi Fadel (1994) worked on Carob tree (*Ceratonia siliqua*) and found that Carob tree does not need much care and attention; only some manure and little pruning are enough to increase pod size and yield. Plant propagation by seed gave over 50% success. Eid (2001) identified four local varieties of *C. siliqua*: Ahmar, Kheshabi, Mudassi, and Sandali. Hilan and Sfeir (2000) found that the percentage of essential oils in *Salvia libanotica* ranged from 0.35 to 0.65%. The oil kills gram (+) and some gram (-) bacteria. Salvia oil destroys 18 million fungi *Candida albicans* in 10 minutes only. *Hypericum thymifolium* contains 0.5% essential oils with bacteriostatic activity against Hepatitis (C) and Sida. Also, this oil attenuates Staphylococcus germs. *Lavandula stœchas* and *Rosmarinus officinalis* oils can kill 3100 E. coli in 10 minutes. *Nigella sativa* volatile oil attacks resistant strains of *Staphylococcus aureus*. Fahed (2004) worked on plant extracts and plant parts (ground leaves) of *Mentha piperita*, *Myrthus communis*, *Salvia fruticosa*, *Laurus nobilis* and *Inula viscose*. Best results were obtained from *I. viscose* extracts (85%), *M. communis* (83%), and *M. piperita* (83%) at 3000 ppm. When plant parts were used as organic manure, at the rate 10% of farmer's application, *Mentha* reduced infection to 12% and Inula to 5%. As a soil preventive treatment, plant extracts have limited the infection to 10% (*Salvia extracts*) and 6.67% with *Inula*. Chalak *et al.* (2000, 2002) have genetically evaluated a number of fruit tree genetic resources like almonds, cherries and found notable variability. Abou Jaoudeh (2003 pers. comm.) have found good fungicidal activity for plant extracts of basil, mint, *Micromeria*, *Hypericum* etc. Hanna and Bassal (2002) processed *Origanum* under different conditions and found that shade drying conserved volatile oils in the marketable product. Medicinal, aromatic and edible plants of Lebanese nature were economically evaluated by Medawar (2001) and high economic values were indicated. In the present study, the overutilized sage as well as several underutilized species are considered.

**Materials and Methods**

**Zaatar (Origanum syriacum)**

Being a popular native wild plant, *Origanum* attracted villagers to move plants from the wild to their home gardens especially in Southern Lebanon. Since 1993 research on this plant started with the objective of practical domestication. Genetic resources were collected from a number of local ecological regions, and from Egypt, Syria and Greece. The genetic resources (Ecotypes) were tested for seed germination, vegetative and clonal propagation. Seedlings were prepared from both, germinated seeds and from clones and experimental plots were established at Fanar, Lebaa, Kfarshakhna and Tel Amara experiment stations of the Lebanese Agricultural Research Institute. Experiments included seven to nine ecotypes planted in 10 rows at 50x50 cm² spacing. Plots received either organic (400 Kg/dunum) or chemical (20 Kg N,P,K per dunum) fertilizers or both. They were irrigated bi-weekly or weekly, respectively. Vegetation was harvested at 50%
flowering, weighed and dried. Volatile oils were measured using recycling distillation machinery prepared from local material. Zaatar plants continue to produce since five years.

**Carob tree (Ceratonia siliqua)**
A neglected orchard of 16 trees of about the same age was taken in the area of Jeddayel and a factorial combination of treatments on pruning (T₁, T₀), weeding (D₁, D₀), fertilizer (F₁, F₂) application was applied resulting in eight treatments in two replications. Ten kilograms of goat manure were added in November to F₁ trees and one Kg of compound fertilizer (15-15-15) and one Kg of NH₄NO₃ fertilizer were added in March and April respectively. Light pruning was made on (T₁) trees in February and weeding was done in the spring (April) using total herbicide (D₁) (Gramoxone 50 cc per 20 L). Propagation by seed and propagation by cuttings were also studied. Seed germination consisted of the following treatments: soaking in water at 60°C and 100°C, as well as in KNO₃ (1%) and H₂SO₄ (1%). While soft-wood, semi-hard and hard-wood of stem were used as types of cuttings for plant propagation made in spring time. IBA rooting hormone was used at doses between 5000 and 10000 ppm for all cuttings. Data were collected on percent germinated seeds and growing cuttings, length of new growth and pod size characters.

**Sage (Salvia fruticosa)**
This plant is being subject to very intensive harvest which makes it among the most endangered species in Lebanon. Traditional methods of testing its potential in intensive agriculture included moving the plants and their seeds to the field. Transplants were planted at the LARI Fanar station and in the Bekaa valley from various ecological sources. Plant growth in size and weight, oil yield and survival from one season to another were noted.

**Laurel (Laurus nobilis)**
To produce transplants for increasing tree populations, germination of seeds was tested using various seed physiology techniques. The Tetrazolium test was carried out on seeds to test their viability. Vegetative propagation was tried on new and old wood cuttings. Field work in "Kaouzah" natural forest consisted of five plots of one dunum each, where pruning and cleaning are done in the first plot, cleaning without pruning in the second plot, pruning, cleaning with chemical fertilizers in the third, the fourth plot was prepared for organic fertilizers application, and the fifth one was kept as control. Oil extraction was made on berries and flowers using steam distillation for the volatile oil of flowers and the traditional method of long time boiling for berries. Solvent extraction was also used to replace the traditional method.

**Nematicid effect**
Five plant extracts were collected from (Mentha, Myrthus, Laurus, Salvia and Inula) to study their effect on nematodes, especially on, Meloidogyne sp.. To get plant extract, steam or hydro-distillation was used for Laurus, Mentha, Myrthus, and Salvia while, Inula plant parts were macerated in ethanol (96°C) for 24 hours and the pure extracts were kept at 4°C. Nematodes from soils or roots were isolated according to Southey method (1970). Concentrations of 1000, 2000, and 3000 ppm, extracts were tested in aqueous medium against Melodogyne nematodes. Percent mortality was recorded. The variety "Saif 840" of tomatoes was used as tester plant in the infected soils. Data were collected on degree of infection, biomass, plant height, number of clusters and number of fruits.

**Aromatic plants as organic manure**
Pots of 12 cm diameter, were filled with a mixture of 450 g of infected soil, 18 g of peat moss and 2 g of the proper leaf powder used as nematicides. Tomato seedlings were planted and after eight weeks, the plants were uprooted and galls counted. A similar experiment used the plant extracts as possible natural nematicides.
Results and Discussion

Zaatar (Origanum syriacum)

The name refers to both an herb, as well as a spice blend containing the herb. A form of wild oregano, “zaatar” has a flavor that is cross between Greek oregano and thyme. During the past ten years various studies have been conducted on *Origanum syriacum* under the Lebanese environment conditions. The results indicate very high variability in *Origanum* ecotypes and their response to different environments in a number of geographic areas. The results of the trials at the experimental stations gave measurable differences in marketable plant yield, volatile oil, yield cost and revenues. Marketable yield is presented in Table 1 for plants two years old. It is evident that Bekaa valley has an excellent potential as a future area for *Origanum syriacum* production. South Lebanon is very popular for quality products but the yield is not very high, though it competes noticeably with harvest yield obtained in the North, Kfarshachna station. The variability is seen between ecotypes for productivity with Rmeich ecotype giving the lowest yield. Differences in oil yield are not as evident (Table 2) as compensation between yield and oil is clear. Lebaa is an area suitable for oil production and the ecotype of Mechref appears to be a good oil producer.

<table>
<thead>
<tr>
<th>Ecotype</th>
<th>Locations</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tel Amara</td>
<td></td>
</tr>
<tr>
<td>Mechref</td>
<td>3995</td>
<td>2547</td>
</tr>
<tr>
<td>Chouf</td>
<td>5269</td>
<td>3216</td>
</tr>
<tr>
<td>Rmeich</td>
<td>2893</td>
<td>2080</td>
</tr>
<tr>
<td>Annaya</td>
<td>3790</td>
<td>2202</td>
</tr>
<tr>
<td>Mean</td>
<td>3987</td>
<td>2511</td>
</tr>
</tbody>
</table>

Table 2: Volatile oil yield (kg/dn) of *Origanum* population collected from four locations and tested in three LARI experiment stations (Year 2)

<table>
<thead>
<tr>
<th>Ecotype</th>
<th>Locations</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tel Amara</td>
<td></td>
</tr>
<tr>
<td>Mechref</td>
<td>15.5</td>
<td>21</td>
</tr>
<tr>
<td>Chouf</td>
<td>19.4</td>
<td>18.2</td>
</tr>
<tr>
<td>Rmeich</td>
<td>16.9</td>
<td>20.6</td>
</tr>
<tr>
<td>Annaya</td>
<td>27.5</td>
<td>20.9</td>
</tr>
<tr>
<td>Mean</td>
<td>19.8</td>
<td>20.2</td>
</tr>
</tbody>
</table>

*Origanum syriacum* responds to fertilizer and manure treatments (Table 3). Best results were observed on green *Origanum* when organic manure and chemical fertilizers are provided. Healthier and longer plants were observed under more nourishing conditions. This wild plant behaves almost as cultivated crop.

The response of *Origanum* to irrigation water is shown in Table 4. Weekly irrigation gave higher plant responses as measured by volatile oil and green marketable products. Though this plant appears to be dormant in warm and dry season, its response to irrigation is similar to cultivated vegetables.

*Origanum* economy is important to the producer and consumer. The economic costs and revenues are shown in Table 5. Net profit ranges between 400 and 1117 $ per dunum on annual basis, with two cuts or more per season for plants in their second year of production. Their profits compare favorably with other more intensive crops such as fruits and vegetables. *Origanum* is not a demanding and profitable plant as it gives much more than it takes. Interested
farmers can make early and suitable profits if they invest in this plant. The cultivation will help take pressure on native populations which are frequently uprooted by local communities. More efforts are needed for the domestication of this species along with processing technologies.

Table 3: Green Origanum yield and oil yield (Average five sources in three locations) under two irrigation regimes.

<table>
<thead>
<tr>
<th></th>
<th>Weekly Irrigation</th>
<th>By weekly Irrigation</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green (T/dn)</td>
<td>1.7</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Oil (kg/dn)</td>
<td>11.3</td>
<td>10.7</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 4: Green *Origanum* yield and oil yield (Average five sources in three locations) under different fertilizer treatments.

<table>
<thead>
<tr>
<th></th>
<th>Manure+chemical</th>
<th>Manure</th>
<th>chemical</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green (T/dn)</td>
<td>1.8</td>
<td>1.4</td>
<td>1.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Oil (kg/dn)</td>
<td>9.8</td>
<td>4.7</td>
<td>9.1</td>
<td>7.8</td>
</tr>
</tbody>
</table>

Table 5: Cost of production and net benefit of *Origanum* (Air dry marketable yield) in dollars per dunum in three locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Tel Amara</th>
<th>Kfarshakhna</th>
<th>Lebaa</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of production</td>
<td>1490</td>
<td>1028</td>
<td>2867</td>
<td>1795</td>
</tr>
<tr>
<td>Net Profit</td>
<td>1117</td>
<td>400</td>
<td>580</td>
<td>700</td>
</tr>
</tbody>
</table>

*Carob tree* (*Ceratonia siliqua*)

The Carob, a Mediterranean tree, generous, least demanding and robust in nature, is a leguminous evergreen plant with ornamental nature and many agricultural uses. The roughest terrain could be utilized for Carob production. Few pests are reported on Carob under specific environments according to Lecq and Rivière (1924). In hot years and low areas fruits are attacked by *Myelois ceretonica* insects, branches are subject to attack by *Cossus ligniperda* borers and leaves are attacked by *Septoria carrubi* fungus. The tree may be considered as a tolerant host. It is evident from Table 6 that pruning, fertilizer application and weeding -in single or in any combination- have resulted in an increase in all of the parameters tested. Any treatment has given a positive increase in meristematic stem length, pod length, width, thickness and pod volume. Of interest to the farmers and their practices, the treatment requiring only weeding gave the highest pod volume (13.68 cm³), in comparison to the neglected trees (control) which gave only 8.33 cm³ pods. All other treatments and combinations gave values within the mentioned range. The assumptions in this approach are based on the fact that larger pods give higher yield, more molasses and possibly better quality “Debbs”, which is carob sugar, honey or molasses of Carob. Pods give about 45% “Debbs” which is extracted by cracking, pressing, fermenting with water and leaching. The water-molasses leachate is gently boiled to remove excess water and microbial hazards. Modern machinery could make the processing easier and new technologies may make more use of “Debbs” in processed foods. Reforestation, landscaping and rehabilitation of the Carob industry require simple and efficient propagule production methods.

Being a legume seed with hard coat, the carob seed requires scarification for germination. Hot water and boiling water gave germination values lower than 80%. For vegetative propagation, if semi-hard wood is used for cuttings, no rooting hormone would be needed. If used, the hormone (IBA) should be at the rate of 7000 to 8000 ppm. Carob wood, roots and shoots are very sensitive to physical damage causing rotting and death which requires the use of plastic bags to minimize root injuries during transplantation process. It also implies minimum pruning for the trees. This approach saves on grafting or budding to have uniformity in new plants.
Table 6: General observations of Carob trees under the effects of pruning (T), fertilizer (F) and weeding (D).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Terminal Branch length (cm)</th>
<th>Pods characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Length cm</td>
</tr>
<tr>
<td>T₁F₁D₁</td>
<td>29.12</td>
<td>10.42</td>
</tr>
<tr>
<td>T₁F₁D₀</td>
<td>25.71</td>
<td>9.16</td>
</tr>
<tr>
<td>T₁F₀D₀</td>
<td>29.4</td>
<td>9.33</td>
</tr>
<tr>
<td>T₁F₀D₁</td>
<td>28.83</td>
<td>8.5</td>
</tr>
<tr>
<td>T₀F₁D₁</td>
<td>29.33</td>
<td>9.83</td>
</tr>
<tr>
<td>T₀F₁D₀</td>
<td>29.5</td>
<td>9.37</td>
</tr>
<tr>
<td>T₀F₀D₁</td>
<td>28.87</td>
<td>9.83</td>
</tr>
<tr>
<td>T₀F₀D₀</td>
<td>26.66</td>
<td>9.37</td>
</tr>
</tbody>
</table>

**Sage** (*Salvia fruticosa*)

Salvia is a woody perennial shrub with a large number of uses in food conservation, perfumes, antiseptics, insect repellents and a wide scope of traditional medicinal uses (headache, hair-fall, gastrointestinal infections, antibiotic action, female sterility, pulmonary problems, menstrual regulator and arthritic pains). The smell of salvia is astringent and strong. Pilot study indicated a robust plant size of one meter height by one meter diameter down to (0.5x0.4 m²) for transplanted stock (Table 7). The plants responded vigorously to spacing and irrigation especially in the Bekaa valley. The yield of green vegetation ranged on single plants at spacing (0.5x0.5 m²) between 1.0 and 2.5 tons/dn and volatile oil content between 0.5 and 1.5%. The phenomenon of mortality in artificial or agricultural environments is observed and ranged from zero to 66% in one season indicating a high variability among different populations. Fusarium and verticillium wilts could be the cause of the mortality which needs further investigation.

Table 7: Agronomic characteristics of Sage (*Salvia fruticosa*)

<table>
<thead>
<tr>
<th>Source</th>
<th>Plant Height</th>
<th>Plant Size diam. (cm)</th>
<th>Yield (T/dn)</th>
<th>Mortality %</th>
<th>Oil %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amchit</td>
<td>96</td>
<td>39</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fanar</td>
<td>72</td>
<td>54</td>
<td>-</td>
<td>66</td>
<td>-</td>
</tr>
<tr>
<td>Bleibel</td>
<td>48</td>
<td>77</td>
<td>1.01</td>
<td>14</td>
<td>1.32</td>
</tr>
<tr>
<td>Aiat</td>
<td>85</td>
<td>41</td>
<td>2.28</td>
<td>12</td>
<td>0.66</td>
</tr>
<tr>
<td>Maghdouchi</td>
<td>75</td>
<td>99</td>
<td>-</td>
<td>28</td>
<td>-</td>
</tr>
<tr>
<td>Miziara</td>
<td>52</td>
<td>45</td>
<td>-</td>
<td>55</td>
<td>-</td>
</tr>
<tr>
<td>Ibrine</td>
<td>64</td>
<td>50</td>
<td>-</td>
<td>9</td>
<td>-</td>
</tr>
<tr>
<td>Lebaa</td>
<td>86</td>
<td>54</td>
<td>2.56</td>
<td>36</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**Laurel** (*Laurus nobilis*)

Laurel is an evergreen dioecious forest tree very popular in history for valuing kings with laurel crown and as medicinal and industrial plant. Laurel oil (non-volatile) is used in soap making and is heat extracted by boiling for 48 hours or more. The flowers have a good smell issued from light volatile oils which is biologically active. Work on this forest tree focused on development activities as tree maintenance, propagation and low cost and labor oil extraction process. Vegetative propagation was a success under the following conditions: cuttings eight to 12 cm of new wood, treated with rooting hormone (5 secs. dip), planted in fertile soil, in a green house at 24°C, with misting gave 40% rooting in 35 days. Seed germination tests indicated that seeds germinate easily when the outer rind looses its inhibiting effect. When berries were peeled, up to 48% germination was observed. The question
remains, how to identify female and male plants after germination, a problem similar to date palms and molecular markers could be used for this purpose.

Tree maintenance activities such as pruning, weeding, fertilizer application resulted in larger berries, healthier plants and favorable harvesting conditions.

Laurel berries store oil in the central part that is why after boiling for 24 hours, they are crushed to liberate the oil which floats over the hot water and is decanted. This process uses a lot of wood for boiling, is time consuming and is labor intensive. The oil obtained is not clear and smells smoke. When berries were crushed and the oil was extracted with hexane, and Rota-vapor separated, clear oil similar to olive, soya, and sunflower oils was obtained. This industrial process is simple, quick, labor and wood saving and the end product is of excellent quality. Two machines are now available for this technique in Southern Lebanon.

Table 8: Seed germination of Laurel under different conditions

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Germination %</th>
<th>Treatment</th>
<th>Germination %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>56</td>
<td>1% NaOH</td>
<td>8</td>
</tr>
<tr>
<td>1% H₂SO₄</td>
<td>2</td>
<td>1% KNO₃</td>
<td>4</td>
</tr>
<tr>
<td>1% NaHCO₃</td>
<td>6</td>
<td>1% KOH</td>
<td>2</td>
</tr>
<tr>
<td>Vernalization</td>
<td>2</td>
<td>Berry peeling</td>
<td>80</td>
</tr>
</tbody>
</table>

Nematicid effect:

The analysis of the results of extracts in aqueous media showed in the three treatments and after 24 hours that *Mentha’s* extract had the highest Nematicid effect. After 48 hours, the mortality has increased. *Inula* gave a rate close to *Mentha* 40%, at a concentration of 1000 ppm, more than 70% at 2000 ppm, and 85% at 3000 ppm. The three extracts of *Inula, Myrtus* and *Mentha* have given a rate of mortality better than the commercial nematicide Dazitol. Laurel showed the lowest percentage of mortality in different concentrations (2000 and 3000 ppm), after 24 and 48 hours. Condor gave the highest number of dead nematodes, and sometimes mortality of 100% was recorded. These results are in accordance with those of Oka et al. (2001) and show the potential of local wild plants as future contributors to safer agriculture and cleaner environment. *Inula’s* powder gave results similar to Condor. We noticed that *Mentha* (11%) was better than *Myrtus* (18%) and *Salvia* (20%) in this experiment (Fig. 1). This result is supported by Walker and Melin (1996) study which showed similar trend. Contrary to expectations, the mixture of plant material for all five species did not give a synergistic effect as is usually observed in the microbial world. It would pay economically to expand work on the cheapest source of local plant as nematicide with other potential uses.

Good results (Fig. 2) were observed with *Inula* and *Salvia*. *Salvia, in vitro*, did not show this rate of mortality. We can deduce that this kind of plant volatile oil had a preventive effect from nematodes when mixed with the soil. This places Sage as good candidate for further studies. *Laurus* oil had mainly no effect on nematodes as the tomatoes were highly infected (85%). True myrtle had given results very close to Dazitol (36% infection), while Condor showed better results than Dazitol. The rate of infected roots was as low as 6.67%. *Inula, Myrtle* and *Salvia* are those species with promising future in nematode control and management, as possible alternatives to Methyl bromide and as sources of natural products for medicine, industry and food. *Inula* is highly available and is not susceptible to overharvesting yet.
Fig. 1: Percent infection by nematodes of tomato roots in soils treated with plant parts of species applied as organic manure compared to control and chemical nematicide treatments.

Fig. 2: Percent infection with nematodes of tomato roots treated with plant extracts from different species compared with the control and available nematicides.

References
Hanna, L., A. Bassal, 2002. Optimisation des Conditions de Séchage pour la Maîtrise de la Qualité de l'*Origanum syriacum*. DEA, AUF.


Wild Plant Extracts on Nematodes, Méloidogyne sp. Thesis of Holy Spirit University, Kaslik.
Local Community Participation at Anaqeed Al-Khair Project

R. Al-Tabini and I. Hawamdeh

Jordan Badia Research and Development Center (JBRD), Jubiah, Amman, Jordan Development

Keywords: Local community, participatory approach, Multiple Stakeholders, Jordan.

Abstract
The paper focuses on the challenges and opportunities facing community-based initiatives towards socio-economic and environmental transformation in the northeastern villages cluster of the Badia. A new development project has been initiated as an effort to encourage and support the local communities to participate in creating and reshaping their own sustainable futures. The cluster project seeks to sustain the clusters environmental conditions by initiating income-generating projects (sheep selection farm, bee-keeping and honey production, wool and Bedouin tint manufacturing, sun dried tomato and forage production).

The participatory research methods employed in this project revealed that significant traditional socio-cultural perceptions, values, and practices influence the level and manner of engagement in the development process. Therefore, factors such as formal education, untraditionally leadership, age and gender play crucial role in the process. In addition, the study emphasizes the importance of recreating credibility and reliability in development initiatives to regain the trust of local communities towards development and to endorse participation in the development process.

In terms of the development project itself; this paper reveals the importance of adopting and implementing new progressive approaches towards sharing roles, responsibilities, and accountabilities among the multiple stakeholders involved in the process. This paper indicates that the proposed framework for collaboration allows all of the partners to maximize their participation and commitment towards their various roles in achieving socio-economic transformation; this paper supports the notion that the local communities are more than willing to assume their obligations towards developing their own futures. In this collaborative approach to development, government, local NGOs, and research institutions assume the function of providing advice, training, and support to these local community-based and lead initiatives.

The paper contributes to the limited discourse associated with project especially with regard to the importance of the local cooperative of Anaqeed Al-Khair and critical role of its strategic partner, the Badia Research and Development Center.

Introduction
The Anaqeed Al-Khair project is located in Jordan’s northeastern Badia, the country’s arid and semi-arid zone. The Badia, which makes up approximately 80% of Jordanian territory (Al-Tabini, 2002) and is inhabited mainly by the Bedouin tribes, may be divided into two major areas based on rainfall and vegetation cover, i.e., the steppe and the desert. The steppe (home to Anaqeed Al-Khair) has potential for providing animal feed as it receives average annual rainfall between 100mm and 200mm. The desert, on the other hand, receives less than 100mm of rain annually and has limited grazing resources. The Badia experiences huge seasonal temperature fluctuations. In winter, the minimum mean temperatures may drop to $2^\circ$-$9^\circ$C and snowfall and sub-zero temperatures may also occur. The summer maximum mean temperature is around $35^\circ$-$38^\circ$C. Low humidity causes high levels of evaporation. The rain falls between December and March each year with great differences in the intensity of showers and storms. Generally
described as spatial and temporal, maximum annual precipitation ranges from 250mm in the northwest to 50mm in the south (Allison et al., 1998).

The Anaqeed Al-Khair project is an agricultural development project funded by Jordan’s Ministry of Planning and is implemented by the Badia Research and Development Center (BRDC) and Jordan River Foundation (JRF). The project’s goal is to improve the local community’s socioeconomic status. A cooperative was established to ensure that the local community actively participates in the project and that benefits flow directly to them. The cooperative was established late in 2002 with 16 member households. Membership has increased to 174 households.

**Project goal**

Improve the socioeconomic status of the local community. This goal can be achieved by the following objectives:

1. Generate diversified and sustainable income flows for the cooperative members and the community;
2. Improve local sheep breeds;
3. Encourage organic farming activities;
4. Encourage the local processing.

**Targeted villages**

The Anaqeed Al-Khair project targeted 14 villages for development. These villages were assimilated into one group, called the Northern Badia Villages cluster, and then grouped into four sub-clusters according to geographical distribution. The Northern Badia Villages cluster’s population is 7,829 individuals belonging to 1,259 households.

The cluster’s population is on the youthful side, with 55% of the population below age 21. The gender ratio is 49% female to 51% male. The work force is considered to be between the ages of 15 and 65, with 80% employed in the public sector, showing a high dependency on governmental support. In contrast, the private sector provides only 11% of work opportunities in the Badia, reflecting low levels of commercial investment in the area. The unemployment rate is calculated to be 40% and is attributed to the lack of job opportunities and vocational training. The total monthly income of 189 Jordanian Dinars (JD) reflects a high poverty rate when compared to 337 JD in all rural areas and 401 JD throughout Jordan. The livestock industry is a key income source for Northern Badia Villages, and livestock number is approximately 38,735 heads (BRDC, 2002).

### Table 1: Northern Badia Cluster villages

<table>
<thead>
<tr>
<th>Number</th>
<th>Village</th>
<th>Families</th>
<th>Populations</th>
<th>Sheep</th>
<th>Goats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Khishaa</td>
<td>154</td>
<td>1081</td>
<td>469</td>
<td>128</td>
</tr>
<tr>
<td>2</td>
<td>UmAlQoutain</td>
<td>386</td>
<td>2389</td>
<td>1308</td>
<td>1010</td>
</tr>
<tr>
<td>3</td>
<td>AlMazola</td>
<td>19</td>
<td>129</td>
<td>686</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>AlMkaiftah</td>
<td>286</td>
<td>1966</td>
<td>22888</td>
<td>391</td>
</tr>
<tr>
<td>5</td>
<td>Manshiatkino</td>
<td>19</td>
<td>121</td>
<td>113</td>
<td>73</td>
</tr>
<tr>
<td>6</td>
<td>Rawdat amir</td>
<td>120</td>
<td>533</td>
<td>3145</td>
<td>459</td>
</tr>
<tr>
<td>7</td>
<td>Meissa</td>
<td>30</td>
<td>196</td>
<td>2358</td>
<td>413</td>
</tr>
<tr>
<td>8</td>
<td>Al-Thalaj</td>
<td>19</td>
<td>69</td>
<td>871</td>
<td>74</td>
</tr>
<tr>
<td>9</td>
<td>UmHussien</td>
<td>23</td>
<td>173</td>
<td>4580</td>
<td>2221</td>
</tr>
<tr>
<td>10</td>
<td>Kasim</td>
<td>78</td>
<td>433</td>
<td>4139</td>
<td>574</td>
</tr>
<tr>
<td>11</td>
<td>Al-Refiat</td>
<td>104</td>
<td>604</td>
<td>2704</td>
<td>1101</td>
</tr>
<tr>
<td>12</td>
<td>Ghadiernaqa</td>
<td>6</td>
<td>17</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>13</td>
<td>Arainba</td>
<td>10</td>
<td>69</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>14</td>
<td>Rifaiatshamalia</td>
<td>27</td>
<td>112</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1259</td>
<td>7829</td>
<td>32261</td>
<td>6474</td>
</tr>
</tbody>
</table>

BRDC, 2002
The Bedouin families of the Northern Badia villages cluster share a perspective on their way of life and cultural identity with the rest of the Bedouin in Jordan. They closely identify themselves with the Badia’s environment, the camel as their traditional means of transportation, the Beit sha’ar (tent) as their dwelling and, individually, as the sons of the Badia (Hawamdeh, 2004). The identification is not only important as an expression of self-identity but is also extended to express the individuality of their traditional lifestyle as nomads, even though that lifestyle is shifting in recent years to a semi-nomadic and, even, fully settled pastoral way of life (Millington et al., 1999).

**Concept of clusters**
The concept of villages cluster is creating new dimensions that redefine the relationship between the community members on one hand and between the community and the developmental organizations on the other. The concept also brings deeper understanding of the conditions and circumstances of residents in other villages. It eliminates sensitivities among members of different villages to cooperate together for the benefit of the larger cluster community.

**Project management**
After several community meetings, participants chose a cooperative for the management structure of the project. This approach provides flexibility and assurance that the local community actively participates in the project and that benefits flow directly to them. The cooperative was established late in 2002 with 16 member households. At the current time, membership is 174 households. The Anaqeed Al-Khair Cooperative bases planning and development decisions on members’ perspectives and knowledge. Thus, the local community is empowered to explore possible areas of community development, discuss scenarios of future aspirations, and define the direction and shape of social transformation, making that transformation more likely to be sustained (Al-Tabini et al., 2006).

The nature of collaboration between the local community and Anaqeed Al-Khair project implementers reflects concern for the impact that development initiatives have on reshaping the socio-cultural, economic and environmental future of the Bedouin community. The collaboration helps to mitigate the negative perceptions and attitudes that community members may have toward development efforts because not only does the Cooperative management structure generate income, it also provides an avenue for community members to share information and responsibilities. Furthermore, collaboration between the community and the project team reflects the willingness of the government’s official vision to incorporate multiple participants in the development design process and to support new forms of organizational structures (i.e. local cooperatives, NGOs and research centers) in its new policies for sustainable development programs. It also reflects the capability of these organizations to employ effective development designers and implementers who can learn more and adapt effectively through the collaboration process. Finally, collaboration reflects the capacity and competence of each partner, particularly local community members, to play a role in engaging, initiating and adapting local ideas into the design process (Hawamdeh, 2004).

**Role of the cooperative**
Anaqeed Al-Khair cooperative, as a community-based initiative brings an insider’s perspective, knowledge and comprehension to inform the decision-making of development and planning. The engagement of the local cooperative as a key stakeholder is crucial in empowering the local community in researching areas of community development, discussing narratives of future aspirations, and defining the direction and shape of social transformation. From a socio-cultural perspective, the project stimulates the local community’s participation by endorsing new grassroots initiatives that reflect socio-cultural relationships and powers through new organizational structures such as the Anaqeed AL-Khair cooperative. The cooperative then is encouraged and supported to participate at every stage of the implementation process. The plan...
is that the cooperative will eventually become the long-term manager and owner of the project.

**Need for a participatory approach**

It is evident that the top-down development approach has not been effective. The people need to participate in planning, formulating, implementing and evaluating rural development programmes. Giving the local community a role in decision-making that influences the shape of their future is an effective way to delegate responsibility, authority, and accountability in order to sustain critical decisions. Through such participation, development initiatives are genuinely engaging the local communities as full partners and allowing them the opportunity to express their socio-cultural and environmental context in their own voice.

**Participatory action research**

One of the methods applied to engage the local community in the development process design is participatory action research (PAR) which seeks to engage local communities on a cooperative effort to initiate and discover new possibilities for Socio-cultural and economic transformation. PAR allows local community members to become inside co-researchers who are capable of generating transformation and collaborating in a self-learning, collective experience. It readjusts the community’s position as the primary stakeholder and the direct concerned partner in the process.

It is recognized that solving community constraints requires a participatory approach to effectively work with and empower the community to diagnose and prioritize their problems, identify and test solutions and adapt them to their area and socio-economic environments. Participatory approaches seek to enhance community skills and help them to develop their capacity to develop & disseminate their own technologies according to their needs.

**Multiple Stakeholders**

**Anaqeed Al-Khair cooperative**

In July 2002, the Anaqeed Al-Khair cooperative was established during the first phase of the project implementation. One of its goals is to represent local community inhabitants within the domain of the villages cluster and to act as a principal stakeholder in the design and implementation process of the project. The cooperative was formed with sixteen leading members of the community including schoolteacher’s sheikh’s volunteer’s retired army members and many of the young educated generation. They are all residents of the targeted villages sub-clusters. The members of the cooperative are key persons more likely to help the BRDC to introduce the project proposal to the community for their feedback on the content and implementation. A total of six women are also subscribed as members in the cooperative mainly close family and relatives of the male members.

**Badia Research and Development Centre (BRDC):**

BRDC was created as an effort for combating desertification and the depletion of natural resources. BRDC has been working in the Badia region of Jordan since 1992. The main residents of the region are the Bedouin. Previously the majority was nomadic, but recent years have seen the settlement of many to pursue new livelihoods. The aim of the BRDC is to contribute to the improvement of the livelihoods of all communities in the Badia. BRDC is involved in gathering accurate information on the Badia’s human and natural resource bases, and presenting that information to decision makers at two levels: at national level in ways which most readily facilitate its use in the preparation of policies, strategies and activities for development, and at the local level so that individuals and communities can make direct use of the resources and information to improve their quality of life. Initially, the emphasis was on multi-disciplinary research but in recent years there has been an equal emphasis on “action research” – field-testing ideas to improve the livelihoods of the people of the Badia.
Recently, the BRDC has become a more active partner, which translates -based findings into applied pilot projects that adopt sustainability as an approach to effective environmental and socio-economic development. The BRDC puts strong emphasis on the sustainability as a mean for reducing the deteriorating situation in the Badia. This emphasis is highlighted in the BRDC’s original framework document (Dutton, 1998, p.16), which states stresses sustainable development and sustainable use of natural resources.

**Jordan River foundation (JRF)**

The Jordan River Foundation a non – profit NGO, was established in 1995 and headed by H.M Queen Rania of Jordan. It aims at endorsing the dynamics of the Jordanian society through establishing and supporting sustainable social, economic, and cultural actions derived from the national needs and priorities, empowering individuals and communities and improving the quality of living and work environments. JRF aims to be a catalyst for developing local communities through increasing the level of the individual’s participation in deciding and prioritizing socio – economic needs within his/her local community. Their methodology is built around focusing on communities that share similar geographical, social or economical characteristics. JRF then supports local committees or groups within these communities to prioritize, design, and implement development projects, the goal is to improve the local primary infrastructure and create opportunities to improve income, medical services, education, quality of life, and to address local environmental problems.

**Ministry of Planning: Social productivity program unit (SPPU)**

The social productivity program unit (SPPU) is a division of the Ministry of Planning that deals with issues of poverty and unemployment in Jordan, and is concerned with developing and supporting log-term polices and programs to deal with these problems. The national survey conducted in 1997 concluded that 313 Jordanian Dinars per person per year is the baseline for poverty, consequently putting 31% of the Jordanian population within the confines of this line. The program defined poverty pockets in the country according to the quality of available infrastructure services, the kind of people receiving financial support from the nation provision fund, and the percentage of poverty within these pockets (Mr. Omar Al-Rafie, director of the unit, personal communication, October, 2002 ). Accordingly, needy areas such as sporadic residential areas and some poor municipalities were selected for immediate intervention in order to provide them with the minimal requirements of infrastructure that would allow the people to live within appropriate and hygienic environments.

**Dynamics of collaboration**

The Anaqeed Al – Khair project is instigated through the cooperation of multiple stakeholders that share mutual interests and aspiration to create income – generating project that would enhance socio – cultural, economic and environmental development of the Badia within its particular context. They also aspire to open new realms and possibilities for social transformation for a better future for native communities.

**The Anaqeed Al-Khair project**

The Anaqeed Al-Khair project has several components: sheep selection and management; honey production; sun-dried tomatoes; forage production; and improved sheep wool and goat hair processing.

**Sheep selection and management**

Since 2004, the Cooperative has adopted improved sheep feeding, a veterinary regime, selection and culling, and synchronization of ewe pregnancies to result in higher flock lambing and weaning percentages and greater twinning. This project was based on selecting the best sheep in the Badia region. Best sheep were defined as those with high milk productivity and breeding abilities. Indicators in the Badia, based on BRDC research, illustrate that good management with
typical sheep is a profitable project. The 150 sheep purchased in May 2004 had increased to 250 by November 2005.

**Honey production**

Since 2003, honey, produced from bees foraging on local desert plants, has been available for sale to the community or marketed in Amman. The next steps are to expand production and develop a more sophisticated marketing strategy, including a “Badia Honey” brand name.

**Sun-dried tomatoes**

The cooperative has promoted organic production of a tomato variety with greater dry-matter content. A greater profit from dried tomatoes has convinced two local farmers to adopt production. The next steps include certification of organic production, better packaging and possible implementation of a brand name.

**Improved sheep wool and goat hair processing**

The Cooperative tried to spin the wool locally instead of selling raw material to Turkey and, in turn, buying spun wool and goat hair. The hand spinning by local women proved to be too time consuming. The next steps include importation of a semi-mechanical spinning machine from Australia to improve efficiency and decrease of labor costs.

**Results and discussion**

Technology and skill development is another important focus of the project. Therefore new approaches to organic farming and raising sheep flocks are introduced to gain a competitive marketing edge. This situation can be possible only through training and effective communication between cooperative members, farmers, and experts. The project incorporated surface water irrigation for the alfalfa fields by renovating and making use of traditional old water pools, and by incorporating local knowledge to identify and utilize natural water catchments.

With limited resources, stakeholders in the cooperative were faced with the need for strengthening financial performance and operational efficiency and for expanding the socio-economic impact of the Cooperative. As the cooperative becomes stronger internally, calls from peripheral community members for increased benefit must be addressed. The process of making cooperative decisions must thus take into account not only the profit line, but also social objectives. So the cooperative might decide – particularly in light of the demonstrated benefits to livestock-owners, temporary workers, and the increased empowerment and inclusion of women in the cooperative – which the wool-making project should continue despite currently unimpressive profits. It could be subsidized, balanced, by the livestock operations which have resulted in greater profits but less noted social benefits.

Projects like Anaqeed Al-Khair do not seem capable of making a sizable impact on the extensive number of people without steady work. Talking extravagantly about what projects will do sets them up to be seen as failures when in the end they can't make an impact big enough to substantially benefit everyone. The cost of such failure may make it even more difficult to solicit community engagement in the future. It may be more accurate to consider Anaqeed Al-Khair as a 'pilot project' that only begins the process of development.

Working together with the BRDC, the cooperative has demonstrated that successfully implemented ideas are often attractive to cooperative members and the surrounding communities and that the activities are subsequently adopted after the cooperative demonstrates success over a trial and error period. These models of technology transfer are vitally important to sustain the livelihoods of the Bedouins living under fragile rangeland ecosystems.
Conclusion
1. Experience has shown that the larger community is monitoring the project activities and then adopting the ideas by watching the experiences of the cooperative.
2. The cooperative members and the community can purchase higher quality lambs from the cooperative as breeding stock. The next steps include greater focus on diversification of lamb and goat dairy products in a newly constructed dairy processing facility.
3. Experiences to date suggest that an expansion of activities using the same community-driven methodology is possible, with great potential for replication in other areas of the Badia. The cooperative has decided to concentrate on sheep, honey and sun dried tomatoes because of their positive income generation and potential for improvements in marketing.
4. Cooperative projects are valuable for their impact on participants and demonstration of new viable livelihood strategies. However, the benefits have not spread appreciably to the community at large or impacted the ways of life for a significant percentage of the community members.
5. Seasonal and temporary work has provided notable benefits to peripheral community members, but these benefits are unlikely to increase in scope without strategic planning with inclusion of this specific goal.
6. Although the cooperative is still in beginning stages, it has made progress toward reducing vulnerability through component demonstrations and strengthening residents' connections to formal institutions.

References
The Relevance of Durum Wheat Landraces to the Quality of On-Farm End Products and Consumers’ Preference in Tunisia

S. Rezgui\(^1\), O. Daaloul and A. Daaloul

\(^1\) Institut National Agronomique de Tunis, 43 Avenue Charles Nicole, Tunis, Tunisia
E-mail: salahrezgui08@yahoo.fr

Keywords: Durum, wheat, landraces, on-farm, Tunisia.

Abstract
Durum wheat landraces contain important agronomic and quality traits and play a major role in sustainable agricultural systems in marginal environments and low-input farming systems. The adoption of traditional durum wheat cultivars is attributed to the greater nutritional quality traits of end-products such as color, flavor, protein and taste. These traits are characteristics of Chili, Biskri and Mahmoudi landraces that are widely grown in niches. Data from on-farm durum wheat processing surveys showed several end-products with various levels of consumption frequencies where bread and couscous constitute the daily diet in rural areas. The assessment of consumption rates of on-farm durum wheat end-product was equivalent to 230 kg to 120 kg of grains in rural and urban areas respectively. The main factors underlying consumer perception and preferences for on-farm processed products derived from durum wheat landraces included along the sensory attributes an important awareness of prevention of nutrition-related diseases and disorders. Increased levels of fibers, carotenoids and superior physico-chemical properties existing in landraces were among the parameters perceived by consumers. Data on post-harvest processing technologies at the farm level and expectations of consumers’ preference analysis suggested the development of marketable of value added end-products from these landraces. However, links between small scale producers and potential markets are not fully exploited. Improving on-farm durum wheat processing to meet specific quality and nutritional standards for potential market demands would be an alternative to promote the conservation of landraces on-farm and make them suitable candidates to organic agriculture and for improving farmers’ income.

Introduction
Research programs have generated production technologies that were beneficial to large-scale cereal growers in favorable environments. These technologies were not equally beneficial to the poor subsistence farmers who could not afford to apply all the components of these technologies. Recently, there is evidence to show that these technologies were not appropriate for cereal growers and particularly small farmers located in unfavorable environments. Limited adoption of these newly generated technologies, including certified seed of improved varieties, were often ascribed to inefficiency of the extension services, non availability of certified seeds, and partly to farmers’ ignorance. Poor farmers in marginal environments are often confronted with chronically low returns, although they developed cultural practices adapted to their own growing conditions. These farmers tend to maintain several landraces and populations of durum wheat (\textit{Triticum durum} Desf.) and other field crops by producing their own seeds. Such diversity is intended by farmers to alleviate the risk of crop failure due to environmental variations. However, several of these cereal growers were reluctant to adopt new and modern cultivars and resisted to abandon traditional durum wheat landrace varieties because of the inherent superior quality traits of derived end products. Moreover, these landraces and populations performed better than the modern cultivars under the low input
conditions characterising the prevailing farming systems in dry areas and mountainous regions. Hence, durum wheat landraces are extensively grown under harsh and unfavorable growing conditions where high yielding modern cultivars can not express their potential. These landraces contain agronomic and quality traits fit better to the needs of rural communities living under harsh conditions. The use of these landraces was found to be associated with on-farm transformation and consumption. However, current trends show that there is a significant shift toward greater consumption of on-farm and home made durum wheat end products. This shift of consumers in both urban and rural areas could be attributed to dissatisfaction with products of intensive farming systems and therefore the rise of specific niche markets for non conventional food products. These concerns about intensive farming systems have led to the demand for ‘quality farm food’ (Gilg and Battershill, 1998) and to the ‘rise of private food quality and safety standards’ (Holloran et al., 1999; Reardon and Farina, 2002). The trend toward greater demand of quality food is driven by rising real incomes, demographics, lifestyle shifts, and greater emphasis on nutrition (Barkema et al., 1993; Becker et al., 2000). Analysis of consumers’ preference for home-made products and their perception of food quality is a cornerstone that could provide insights regarding factors determining demand for food in general (Kotler and Dubois, 1997).

The demand for on-farm end product quality could be perceived as a component of the growing trend for consumption of natural and healthy food and is linked to greater awareness of health issues and increased interest in the environment. Zeithaml (1988) defines consumer’s quality perception as an overall judgment related to the superiority of the product. However, there is no generally agreed definition of what constitutes ‘quality’. Gilg and Battershill (1998) evaluated food quality using criteria pertaining to: i) intrinsic value of the food such as, taste, etc.; ii) its wholesomeness; iii) contribution to good health, and iv) conditions of production. These factors influencing demand for product quality are found to be linked to the social, economic, cultural context, and other factors affecting diet habits. This investigation aims to:

- assess the adoption rates of landraces and attempt to investigate the demand for home-made durum wheat derived products from these landraces;
- assess consumers’ attitude and perception of quality; and
- identify the determinants of quality perception.

Material and Methods
A survey was conducted in the semi-arid areas of Bargou, Siliana in Tunisia. A random sample of 121 small to large farmers was interviewed using a questionnaire that has been previously corrected and validated. The questionnaire was aimed at estimating the proportion of the adoption rates of modern durum wheat cultivars and landraces along with common farmers’ cultural practices. The other component of the survey included the inventory of durum wheat end products processed at the farm level, consumption rates, and processing related factors, techniques, and hygienic conditions along with distribution and supply.

To determine consumers’ preference, a survey with structured questionnaire was conducted using 56 small and large distribution units located in the capital, Tunis. The questionnaire that was prepared was divided into three parts: i) personal information and characteristics such as, sex, age, income, number of kids, frequency of purchase, and location, etc.; ii) knowledge of and attitude to quality signals (brands, labels, etc.); and, iii) determining factors of quality perception (such as taste, appearance, etc.) and willingness to pay for superior quality. Sampling was based on the latest statistics available (Census, 2000) of the district of Tunis but those aged more than 50 compared to those of age less than 30 were favored as it was presumed that those categories would be more concerned with shopping for food. The sample included 30 women and 26 men. These surveys were carried out from end of July to mid-August. The choice of this period was
based on the fact that on-farm durum wheat processing and demands are more frequent during this post harvesting period.

Results and Discussion

1- Distribution and adoption rates of modern cultivars versus landraces

Results of landraces distribution and factors affecting their adoption are summarized in Table 1. These results showed that all farm sizes devote an area for landraces. The proportion of landraces areas ranged from 10%, noted for large scale farmers, to 64% for small farmers. The greater area devoted to landraces in small scale farming is attributed to higher yields observed for landraces compared to modern cultivars. This perception may suggest that small scale farmers located in marginal environments have developed their own cultural practices that are adjusted to their growing conditions where modern cultivars will not perform well under low-input use. Moreover, these farmers tend to use landraces and populations of durum wheat to alleviate the risk of crop failure due to unpredictable seasons. The unpredictable environmental conditions, the poor soils, and low level of crop management have made it difficult to introduce new cultivars in these areas. Hence resource-poor farmers are still using landraces or old varieties that are adapted to these specific environments and confer highly valuable quality traits to the end product. These results showed also that there is a general agreement among cereal growers located in these areas that landraces are characterized by high quality derived end products. The average proportion of this attribute as a factor for adoption of landraces is 70%, with greater percentage observed in the case of large scale farmers. However, data from the survey showed, with sufficient evidence, that farmers are aware of differences among landraces not only for tolerating stressed growing conditions, but also for quality properties of derived end products. Hence, among the landraces cultivated, it was found that Chili, Biskri and Mahmoudi are particularly preferred for on farm food processing than Jenah Khettifa, Hamira, Swabaa Algia, and INRAT 69.

Table 1. Proportion (%) of areas devoted to landraces (ADL) and indicators of adoption per farm size

<table>
<thead>
<tr>
<th>Farm size (ha)</th>
<th>Rate of adoption of landraces</th>
<th>Yield basis</th>
<th>Quality attributes</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-20</td>
<td>64</td>
<td>42</td>
<td>52</td>
<td>6</td>
</tr>
<tr>
<td>21-35</td>
<td>23</td>
<td>24</td>
<td>69</td>
<td>7</td>
</tr>
<tr>
<td>36-50</td>
<td>18</td>
<td>12</td>
<td>83</td>
<td>5</td>
</tr>
<tr>
<td>&gt;50</td>
<td>10</td>
<td>7</td>
<td>89</td>
<td>4</td>
</tr>
</tbody>
</table>

2-Average consumption of durum wheat grain end products

Durum wheat grain end products, consumption frequencies, and season of high consumption are summarized in Table 2. Results from the survey showed that there are more than 27 derived durum wheat end products that could be classified into four classes such as pasta (11 types), bread (8 types), cake (5), and grain (3), with variable consumption rates and frequency where bread and couscous represent the most consumed forms (Table 2). These data indicated that bread made from durum wheat is composed of at least six types for which Tabbouna is commonly consumed on a daily basis. Other durum wheat bread types are occasionally consumed mainly in early mornings and spring time. Durum products are traditionally made by the rural women at the farm level for local consumption or to be sold in the nearby village markets. These products include Couscous, Bread, Hlalem, Malsouka, Barkoukech, Bourghol, Mhammas and Richta. They represent a particular interest for urban consumers along with semolina. In recent years, a growing demand trend for these products in rural as well as urban areas was noted. The annual consumption rate
of derived durum wheat end products depended on the family size and location averaging about 238kg per household in cities. Typically, about 350kg are consumed in rural households suggesting that durum wheat derived end products represents the bulk of staple food.

Table 2. Durum end products and consumption frequencies

<table>
<thead>
<tr>
<th>End product</th>
<th>Common name</th>
<th>Consumption frequency</th>
<th>Season of high consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread</td>
<td>Tabbouna</td>
<td>daily basis</td>
<td>during whole year</td>
</tr>
<tr>
<td></td>
<td>Melioui</td>
<td>frequent</td>
<td>w-sp-sum</td>
</tr>
<tr>
<td></td>
<td>Ftaier/Roggag</td>
<td>frequent</td>
<td>w-sp-sum</td>
</tr>
<tr>
<td></td>
<td>Mbesses</td>
<td>frequent</td>
<td>sp-sum</td>
</tr>
<tr>
<td></td>
<td>Mebbga</td>
<td>less frequent</td>
<td>w-occasional</td>
</tr>
<tr>
<td></td>
<td>Mahjouba</td>
<td>less frequent</td>
<td>w-occasional</td>
</tr>
<tr>
<td>Grain</td>
<td>Bsissa</td>
<td>daily</td>
<td>whole year</td>
</tr>
<tr>
<td></td>
<td>Bourghol</td>
<td>less frequent</td>
<td>w-ram</td>
</tr>
<tr>
<td></td>
<td>Frik</td>
<td>less frequent</td>
<td>w</td>
</tr>
<tr>
<td>Gateau (Cake)</td>
<td>Ghraief</td>
<td>occasional</td>
<td>sp</td>
</tr>
<tr>
<td></td>
<td>Baklaoua</td>
<td>occasional</td>
<td>aid-oc</td>
</tr>
<tr>
<td></td>
<td>Makroudh</td>
<td>occasional</td>
<td>aid-oc</td>
</tr>
<tr>
<td></td>
<td>Assida</td>
<td>less frequent</td>
<td>w-sp-oc</td>
</tr>
<tr>
<td></td>
<td>Rfissa</td>
<td>occasional</td>
<td>sp-sum</td>
</tr>
<tr>
<td>Pasta</td>
<td>Couscous chamsi</td>
<td>very frequent</td>
<td>all year</td>
</tr>
<tr>
<td></td>
<td>couscous brun</td>
<td>weekly</td>
<td>all year</td>
</tr>
<tr>
<td></td>
<td>Mhammes</td>
<td>frequent</td>
<td>w</td>
</tr>
<tr>
<td></td>
<td>Nouasser</td>
<td>occasional</td>
<td>ram</td>
</tr>
<tr>
<td></td>
<td>Hlalem</td>
<td>occasional</td>
<td>w-ram</td>
</tr>
<tr>
<td></td>
<td>Richta</td>
<td>occasional</td>
<td>w-ram</td>
</tr>
<tr>
<td></td>
<td>Barkoukech</td>
<td>occasional</td>
<td>w</td>
</tr>
<tr>
<td></td>
<td>Sder</td>
<td>less frequent</td>
<td>w</td>
</tr>
</tbody>
</table>

W = winter; ram = ramadan; sp = spring; sum = summer; oc = occasionally

Estimated durum wheat quantities used to produce end products show that the bulk of the grain is used for bread and couscous representing 81% of the total consumption of durum wheat. These two end products constitute the main staple food in rural areas. The remaining 19% of the consumed durum wheat represent various end products that are processed at the farm level but are occasionally consumed. The supply of durum wheat derived products is investigated using data from a survey carried out in urban areas and is illustrated in Table 3. Four sources of the durum wheat end products have been identified; the retailers outsource these products directly from the farm or from households (short circuit) or from mechanized production (direct marketing). It is clear that direct marketing is more important for products such as Bread, Couscous, Mhammes, Nouasser, Hlalem, Richta, Bourghol and Malsouka.

Marketing margins are relatively important for the latter products (Bread, Mhammes, Nouasser, Hlalem, Richta, Bourghol and Malsouka) which show the benefits of direct marketing. Margins are as high as 0.600 TD for Hlalem and 0.400 TD for Nouasser. For some products the price variations are very high that we presented the range instead of an average price of surveyed sales centers. This is particularly shown for Richta and Chorba. This result shows a great willingness to pay higher prices by consumers located in some suburbs. These results suggest that there is a
potential to develop and promote on-farm durum wheat products aimed to improving household incomes of small farms, and increase the role of the rural women in income generation.

Table 3. Marketing of durum end products by origin of production

<table>
<thead>
<tr>
<th>End Products</th>
<th>Quantity (Kg/year)</th>
<th>Retail price in DT/kg</th>
<th>Wholesale price DT/kg</th>
<th>Frequency of origin of derived durum wheat products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Farm</td>
</tr>
<tr>
<td>Couscous</td>
<td>142085</td>
<td>1.110</td>
<td>0.810</td>
<td>0.1</td>
</tr>
<tr>
<td>Pâte</td>
<td>24004</td>
<td>0.598</td>
<td>0.566</td>
<td>0.1</td>
</tr>
<tr>
<td>Semoule</td>
<td>242900</td>
<td>0.380</td>
<td>0.348</td>
<td>0.05</td>
</tr>
<tr>
<td>Bread</td>
<td>44300</td>
<td>0.200</td>
<td>0.167</td>
<td>0</td>
</tr>
<tr>
<td>Mhammes</td>
<td>53995</td>
<td>1.240</td>
<td>0.950</td>
<td>0.1</td>
</tr>
<tr>
<td>Nouasser</td>
<td>29674</td>
<td>1.500</td>
<td>1.100</td>
<td>0.1</td>
</tr>
<tr>
<td>Barcoukech</td>
<td>32700</td>
<td>1.530</td>
<td>1.233</td>
<td>0</td>
</tr>
<tr>
<td>Hlalem</td>
<td>24809</td>
<td>2.000</td>
<td>1.400</td>
<td>0.1</td>
</tr>
<tr>
<td>Richta</td>
<td>26704</td>
<td>1.1-1.8</td>
<td>0.84-1.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Bourghol</td>
<td>38446</td>
<td>1.600</td>
<td>1.120</td>
<td>0.1</td>
</tr>
<tr>
<td>Chorba</td>
<td>26604</td>
<td>0.56-1.6</td>
<td>0.49-1</td>
<td>0</td>
</tr>
<tr>
<td>Malsouka</td>
<td>24283</td>
<td>0.450</td>
<td>0.290</td>
<td>0</td>
</tr>
</tbody>
</table>

3- Criteria for consumers’ quality perception

The sample of consumers interviewed shows a balance with regard to shopping places, among them are included souk (traditional market), epicerie (small local retailer), and modern supermarkets. Greater proportion of consumers are supplied from small distribution units and souks (72.5%). Only a lower proportion prefer to be supplied from a supermarket. Demand for durum wheat end products varies according to the season and type. There is greater demand for pasta derived products and particularly Couscous, Richta, Hlalem and Nouasser. The average demand for these types represents more than 55% of the total durum wheat end products consumed annually. However, demand for bread represents 30% whereas demand for Bourghol, malsouka and barkoukech represents only 15% of the total consumption. For durum wheat derived products our results show the following facts as given in Table 4: Most consumers give “good taste” as the main criterion for their choice of the derived durum wheat products. This criterion is also linked to “biological products” as indicated by consumers mainly for Hlalem (38%), Bourghol (30%), bread (28%), and Macaroni (25%). The color and smell, particularly of Couscous, is another criteria used for preferences in durum wheat end products. However, most farmers tend to consume durum wheat end products that were processed from traditional durum wheat varieties and landraces.
Table 4. Criteria for selection of home made durum wheat end products

<table>
<thead>
<tr>
<th>Product</th>
<th>Criteria for selection</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Couscous</td>
<td>Taste</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Price</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Biological product</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Color and smelling</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Smell and good taste</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Smell, taste and biological product</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Smell</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Taste</td>
<td>11</td>
<td>50</td>
</tr>
<tr>
<td>Pains</td>
<td>Color and taste</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Taste and biological product</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Color and smell</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Ferme</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Taste</td>
<td>8</td>
<td>50</td>
</tr>
<tr>
<td>MHammus</td>
<td>Color and taste</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Taste and biological product</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Biological product</td>
<td>6</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Ferme</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Macarouni</td>
<td>Taste and price</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Price</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Nouasser</td>
<td>Color and taste</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Taste and price</td>
<td>6</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Price and biological product</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Taste</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Ferme</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Taste and biological product</td>
<td>8</td>
<td>38</td>
</tr>
<tr>
<td>Hlaalem</td>
<td>Color</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td>Barcoukech</td>
<td>Taste and biological product</td>
<td>4</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Color</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Taste</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Richta</td>
<td>Taste and price</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Taste and biological product</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Price and biological product</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Biological product</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Color</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Taste</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Bourghol</td>
<td>Color, taste and biological product</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Smell and taste</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Taste and biological product</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Color</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Taste</td>
<td>16</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Price</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Malsouka</td>
<td>Color and taste</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Taste and price</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Taste and biological product</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

These cultivars include Chili, Biskri, Hmira, and Mahmoudi that are commonly grown by both large and small farmers in marginal areas of the semi-arid zones. The bulk of the production is used mainly for grain sales to neighboring households to prepare couscous; for seed production to be sold to neighboring farmers; and, for on farm end product processing for either local consumption at the farm level or to be sold to retailers located in cities. An assessment of quality
related traits using samples from these cultivars and modern durum wheat cultivars collected over several sites indicated that landraces are associated with greater protein content, greater semolina yield, and lower yellow berry percentage as compared to cultivated durum wheat cultivars such as Karim; Omrabia, Razzak and Khiar (Table 5). These characteristics could explain partly the consumers’ preference in using derived end products from landraces instead of newly released cultivars.

Table 5 Mean values of quality: specific weight (SW), humidity (H), proteins, ashes, yellow berry (YB) and semolina yield (Sem) related traits of landraces and modern durum wheat cultivars

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>SW</th>
<th>H</th>
<th>Proteins</th>
<th>Ashes</th>
<th>YB</th>
<th>Sem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chili</td>
<td>83.65</td>
<td>11.90</td>
<td>13.79</td>
<td>2.01</td>
<td>13.29</td>
<td>56</td>
</tr>
<tr>
<td>Biskri</td>
<td>82.45</td>
<td>11.35</td>
<td>15.78</td>
<td>2.14</td>
<td>8.41</td>
<td>55</td>
</tr>
<tr>
<td>Mahmoudi</td>
<td>82.75</td>
<td>11.30</td>
<td>15.61</td>
<td>1.97</td>
<td>6.64</td>
<td>52</td>
</tr>
<tr>
<td>Karim</td>
<td>82.10</td>
<td>9.55</td>
<td>12.62</td>
<td>1.16</td>
<td>15.23</td>
<td>48</td>
</tr>
<tr>
<td>OmRabia</td>
<td>84.35</td>
<td>10.30</td>
<td>12.67</td>
<td>1.76</td>
<td>13.35</td>
<td>45</td>
</tr>
<tr>
<td>Razzak</td>
<td>83.30</td>
<td>10.35</td>
<td>13.05</td>
<td>1.74</td>
<td>31.13</td>
<td>45</td>
</tr>
<tr>
<td>Khiar</td>
<td>81.90</td>
<td>9.65</td>
<td>13.45</td>
<td>1.86</td>
<td>6.18</td>
<td>47</td>
</tr>
</tbody>
</table>

4- Buy at the market vs prepare it at home
More than half of interviewed consumers indicated a preference to buy these traditional products at the small distribution units. In the urban areas lack of know how and the perception that on farm products are organically grown are among the decision criteria to purchase these products. However, lack of time and force of habit explained most of these consumers’ behavior. These results suggest that on farm durum wheat end products are competitive to those manufactured and sold through supermarket. This could offer another opportunity to derived end products from durum wheat landraces since manufactured pasta are mostly derived from modern cultivars.

Table 6 Proportion of on farm durum wheat end product (DWE) purchased and reasons for buying durum wheat end products from small distribution units

<table>
<thead>
<tr>
<th>Proportion of DWE purchased</th>
<th>Reason</th>
<th>Frequency</th>
<th>Proportion of DWE purchased</th>
<th>Reason</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Couscous 55%</td>
<td>1.2</td>
<td>18</td>
<td>Richta 72.5%</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td></td>
<td>3</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>35</td>
<td></td>
<td>1.3</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td>1.2, 3</td>
<td>14</td>
<td></td>
<td>4.3</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>18</td>
<td></td>
<td>2.3</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>Nouasser 70%</td>
<td>1</td>
<td>21</td>
<td>Bread 50%</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td></td>
<td>2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>36</td>
<td></td>
<td>3</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>21</td>
<td></td>
<td>3.2</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>MHammas 30%</td>
<td>1</td>
<td>33</td>
<td>Bourghol 50%</td>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td>3</td>
<td>66</td>
<td></td>
<td>1.3</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Macarouni 60%</td>
<td>1</td>
<td>30</td>
<td>Malsouka 92.5%</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td></td>
<td>3</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td></td>
<td>1.3</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td></td>
<td>4.3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>8</td>
<td></td>
<td>2.3</td>
<td>19.5</td>
<td></td>
</tr>
<tr>
<td>Hlalem 52.5%</td>
<td>1</td>
<td>19</td>
<td>Barcoukech 37.5%</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>9.5</td>
<td></td>
<td>2</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>52.5</td>
<td></td>
<td>3</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>19</td>
<td></td>
<td>2.3</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

The lack of know-how (1), habit (2), time (3), better raw semolina(4).
5- Willingness to pay for higher quality products
Consumers are aware of the importance of quality labels but it seems that their confidence and trust to home made products and good taste may substitute these labels. Moreover, a main reason for consuming on farm durum wheat processed products is attributed to the belief that end products are characterized by better flavor, greater amount of fibers, and therefore are considered organic and healthy products. Most consumers stated durum end products derived from landraces in particular may alleviate several disorders and gastric related diseases (Graham and Welch, 1994). This was attributed to the natural process of drying of the processed food, the use of natural ingredients during the processing, and particularly to the greater semolina quality of landraces. Hence, consumers’ perceptions of quality would imply also consumers’ willingness to pay extra for “higher quality” durum wheat end products. This has been investigated using an index representing the percentage increment to the actual price (Table 7). Results show that 55 % of the interviewees were willing to pay from 10 to 20% higher than the current price. This class of interviewees represents the most frequent durum wheat end products consumers. However, 12.5 % of the total sample is willing to pay 20 to 30% higher and only 2.5 % in the range of 30 to 40 percent price increase. These latter represent the most wealthy durum wheat consumers and generally are more exigent in terms of product labeling and hygiene of the distribution units.

Table 7. Current price of homemade durum wheat end products (Unit: DT/KG or DT/DOZN)

<table>
<thead>
<tr>
<th>Product</th>
<th>Min</th>
<th>Max</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Couscous</td>
<td>1.000</td>
<td>1.400</td>
<td>1.200</td>
</tr>
<tr>
<td>Bread</td>
<td>0.190</td>
<td>0.250</td>
<td>0.240</td>
</tr>
<tr>
<td>MHammas</td>
<td>0.900</td>
<td>1.400</td>
<td>0.970</td>
</tr>
<tr>
<td>Macaroni</td>
<td>0.540</td>
<td>0.800</td>
<td>0.740</td>
</tr>
<tr>
<td>Nouasser</td>
<td>1.000</td>
<td>2.000</td>
<td>1.600</td>
</tr>
<tr>
<td>Hlalem</td>
<td>1.300</td>
<td>2.200</td>
<td>1.600</td>
</tr>
<tr>
<td>Barcoukech</td>
<td>1.200</td>
<td>2.000</td>
<td>1.400</td>
</tr>
<tr>
<td>Richta</td>
<td>1.200</td>
<td>2.000</td>
<td>1.600</td>
</tr>
<tr>
<td>Bourghol</td>
<td>1.500</td>
<td>2.000</td>
<td>1.900</td>
</tr>
<tr>
<td>Malsouka</td>
<td>0.350</td>
<td>0.600</td>
<td>0.450</td>
</tr>
</tbody>
</table>

Most consumers are confident of the level of cleanliness and hygiene of the end products. About 70% agree that the level of cleanliness is satisfactory. Nevertheless, some problems are worth discussing in order to improve the quality of the on farm processed durum wheat end products. Problems represent potential areas of improvement are pertaining to handling and storage conditions during the transformation and processing.

Conclusion
The adoption of traditional durum wheat landraces is attributed not only to their specific adaptation to low input cultural practices and difficult growing conditions but also to the greater nutritional quality traits of derived end products such as color, flavor, protein content, and taste. These traits are encountered in Chili, Biskri and Mahmoudi cultivars that are widely grown in these niches and are more suited to on farm food processing. Various end products are processed at the farm level in the rural area where bread and couscous constitute the daily diet. However, in the cities, the main factors underlying consumer perception and preferences for on farm processed products derived from durum wheat landraces included along the sensory attributes, i.e., the awareness of prevention of nutrition-related diseases and disorders that are limited when using on farm processed pasta derived from durum landraces. Greater levels of fibers, carotenoids, and superior physicochemical properties existing in landraces are the most
important factors driving consumers’ preferences to specific durum wheat end products such as, couscous and other pasta derived from landraces. Moreover, results from this investigation suggested the development of marketable of value added end products from these landraces could be achieved by promoting hygienic related components during transformation and food processing. Promoting and labeling of these products and establishing links between small scale producers and potential markets could enhance sustainable rural development along with in situ conservation of highly valuable genetic resources of durum wheat.

References
Barkema, A., M. Drabenstott and M. Cook. 1993. The industrialization of the U.S. Food system. Food and agricultural marketing issues for the 21st century. FAMC, 93-1, Texas A&M University, College Station, Texas, USA.
Reclaimed Water Reuse in Jordan – The Bedouin Experience in Wadi Mousa

M. Al-Ayyash\(^1\), R. S. Shatnawi\(^2\) and R. Al-Tabini\(^3\)

\(^1\)Hydrologist, Jordan Badia Research and Development Programme, Safawi, Jordan. Email: s_ayyash@yahoo.com
\(^2\)Water Scientist, Ministry of Environment, Amman, Jordan
\(^3\)Rangeland Specialist, Jordan Badia Research and Development Programme, Safawi, Jordan

Keywords: Rehabilitation, desert areas, reclaimed water, agrobiodiversity, conservation, Jordan.

Abstract

With the alarming scarcity of water resources in Jordan, the use of non-conventional resources such as reclaimed wastewater is increasingly getting more attention for agricultural use. Wadi Mousa Wastewater Treatment Plant (WMWWTP) is one of the sites that were targeted to demonstrate the potential use of reclaimed in controlled agriculture.

Wadi Mousa project has two main objectives. The first is focusing on research and demonstration activities where a 69 dunums demonstration farm was established next to the WMWWTP with various types of trees and forage grasses and is used to study the effects of irrigating these crops with reclaimed water and the change in soil properties. The second objective is to improve the economic status of the local people and improve the awareness for using reclaimed water in limited farming activities such as forage production. In this approach, two non-governmental organizations (NGO’s) were contacted to be part of the project. Farmers from these NGO’s cultivated the land using the reclaimed water from WMWWTP to produce mainly forage for their livestock. A total of 14 land units of areas between 18-30 dunums were identified next to the demonstration farm, the irrigation network for each one of these units was designed and the piping were installed so they can be irrigated with reclaimed water.

This paper will discuss the various steps of the project, its initial objectives and the limitations and difficulties that were faced. Also, lessons and recommendations of this experience will be presented.

Introduction

As consumer demand for potable water increases, alternative practices and resources become a priority for the decision makers in the water industry. The level of challenge varies from one region to another. It is of great importance in the arid countries such as Jordan, where available water resources are very limited and most of the time the underground sources are often exhausted due to over-pumping.

One of the good candidates to make more water available for agriculture is the use of reclaimed water from wastewater treatment plants. The use of this water is limited due to health and social constraints but some of the acceptable uses are:
1. Irrigation of forests, industrial crops and some forage crops.
2. Discharge to streams and catchment areas to enhance natural ecosystem.
3. Artificial recharge of groundwater.
4. Irrigation of public parks.

In Jordan, there are several waste water treatment plants that discharge reclaimed water of acceptable quality for many uses, including controlled farming. In Wadi Mousa, Water Authority
of Jordan (WAJ) with the support from United States Agency for International Development (USAID) has completed the construction and operation of a Waste Water Treatment Plant (WATP) with a capacity of 3000 m³/day. The available reclaimed water from the plant varies between 700 and 1000 m³/day depending on the volume of tourists in the area. This amount is enough to irrigate an area of 300 to 600 dunums cultivated with forage crops and trees.

The Wadi Mousa WWTP uses a biological reactor treatment system. It consists of preliminary treatment, secondary treatment, and 3 polishing ponds. The plant effluent is prepared with distributing system for the reuse of reclaimed water. Table 1 shows the water quality of the reclaimed water coming out of Wadi Mousa WWTP.

Table 1, Wadi Mousa WWTP effluent water quality (Source: WAJ Files, 2003)

<table>
<thead>
<tr>
<th>Test</th>
<th>Units</th>
<th>Jordanian Standard 893/2002Cash Crops/Field Crops</th>
<th>Effluent Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>200/300</td>
<td>3</td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>500/500</td>
<td>31</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>150/150</td>
<td>9</td>
</tr>
<tr>
<td>Turbidity</td>
<td>units</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Cl₂ Res</td>
<td>mg/L</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

The Jordan Badia Research and Development Centre (BRDC) in association with Petra Regional Authority (PRA), Water Authority of Jordan (WAJ), and PA Government Services Inc. started a project funded through the USAID to use the reclaimed water from Wadi Mousa WWTP in controlled farming and monitor this use and come up with a model that can be copied at other WWTP’s. The project aims at preserving the precious fresh water through the use of reclaimed water or treated waste water (TWW) to increase agricultural products, protect the environment and generate income for the local communities as well as demonstrating economical and environmental benefits for reclaimed water use and creating a model that can out-scaled.

The Specific objectives of the project are:
1. Build personnel capacities in using and utilizing reclaimed water for producing profitable agricultural commodities; and Monitor the quality of TWW for safe handling.
3. Minimize negative environmental impacts of utilizing TWW.
4. Improve agricultural practices and build farmers capabilities on the use of TWW including improving on-farm water management.
5. Monitor the environmental impacts of such practices.
6. Disseminate information and knowledge for the public
7. Enhance income generation aspects for the local community based on profitable agriculture regarding the potential of TWW reuse and considering marketing potential.
8. Study and evaluate the project social impact.

Materials and Methods
To achieve these objectives a set of activities and methodologies were designed and implemented. The project was divided into two main areas. The first area, the demonstration site, which was designed and operated by the experts in various agricultural areas to study and monitor the impact of using reclaimed water on soil and plants. The second area, the farmers’ sites, was designed in a way that involves the local community in the project where a number of farmers will use the reclaimed water in cultivating specific crops under the supervision of the project experts. The methodology and the steps followed to run the project are as follows:
1. Establish a pilot station to carry out demonstrations directed towards testing the performance of different crops irrigated with reclaimed wastewater. The pilot Station covers an area of
about 69 dunums. It is used for demonstration purposes for testing different cultural practices and plant species and it will be used for farmers training and extension. An agricultural engineer is responsible for managing the station under the supervision of university consultants.

2. Design a master plan for the area, which includes on-farm irrigation systems and cropping patterns, directed towards the beneficiaries.

3. Training the local community to manage and operate the existing pilot wastewater reuse areas around the wastewater treatment plant. This part will be done in cooperation with the Water Authority and University experts and extension.

4. Training of technicians, extension services staff and farmers to enable them to adopt new water management and irrigation technology.

5. Special training will be provided to stakeholder on the provision of reclaimed wastewater use regarding the value and use of such sustainable source of water.

At the start of the project, the different resources in the area were identified and three types of surveys were completed to establish baseline information for these resources. The three types of surveys are: Vegetation survey, baseline soil properties and socio-economic surveys. And over the project period, other tests were carried out to study and identify the impact of using the reclaimed water. These tests included soil tests, plant analysis for the crops and water quality analysis.

**Demonstration Site**

The demonstration site covers an area of about 69 dunums planted with various types of trees and forage crops. This site is used for demonstration purposes, for testing different farming practices and crop species and as a training and extension site for farmers, local community members and interested groups. A team of consultants from the University of Jordan (UoJ) designed and implemented this site as part of their work on the project. Approximately 2000 trees belonging to various species, 400 shrubs and flowers and various types of forage crops have been planted at this site. Tables 2 and 3 show the number of the trees and forage crops planted in the demonstration site. Fig. 1 shows an example of the forage production in the demonstration site.

Table 2: Tree species planted in the demonstration site

<table>
<thead>
<tr>
<th>Trees Type</th>
<th>Number of trees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pistachio</td>
<td>150</td>
</tr>
<tr>
<td>Almond</td>
<td>189</td>
</tr>
<tr>
<td>Date Palms</td>
<td>52</td>
</tr>
<tr>
<td>Lemon</td>
<td>50</td>
</tr>
<tr>
<td>Poplar</td>
<td>580</td>
</tr>
<tr>
<td>Spruce</td>
<td>400</td>
</tr>
<tr>
<td>Juniper</td>
<td>500</td>
</tr>
</tbody>
</table>

Table 3: Forage crop species and areas cultivated in the demonstration site

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area cultivated (dunums)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>10</td>
</tr>
<tr>
<td>Sorghum</td>
<td>10</td>
</tr>
<tr>
<td>Sudan Grass</td>
<td>6</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>4</td>
</tr>
<tr>
<td>Millet</td>
<td>9</td>
</tr>
</tbody>
</table>
Fig. 1. Forage crops grown with waste treated water at the demonstration site in Wadi Mousa

Most of the trees showed significant growth: The Poplar trees had the highest growth rate whereas pistachio trees had slow growth and its stand establishment was affected. The forage crop was cut and sold to a local farmer to be used as a feed for livestock.

**Farming site**

Next to the WWTP, the PRA assigned about 1000 dunums for the project as a farming site. The area was divided into small units with areas varying between 18 to 30 dunums depending on topography. A total of 34 units were identified as good areas for cultivation. Due to the limited amount of available reclaimed water coming out of the WWTP that can be used in farming, only 14 units will be used. The remaining 20 units will be cultivated with barley and wheat under rainfed conditions.

Two local Non-Governmental Organizations (NGO’s) were approached to participate in the project where member farmers will farm the 14 units using the reclaimed water under the supervision of the experts. The two NGO’s are Sad al-Ahmar Society (SAS) and Wadi Mousa Army Veterans Society (WMAVS). The 14 selected farmers that participated in the project included 10 farmers from SAS and 4 from WMAVS. They were trained for five days on the use of reclaimed water for agricultural production. The training workshop covered various related topics including health and social aspects. After attending the sessions, the trainees had a site tour to the demonstration site where they practiced some of the techniques and methods they had learned on the session.

The 14 units were prepared with all the necessary requirements for farming as part of the support to the farmers. These preparations included the establishment of piping and on-farm irrigation networks. Under rainfed conditions, the 20 units that could not get reclaimed water were assigned to 20 farmers, viz 14 from SAS and 6 from WNAVS and provided with improved barley seeds, fertilizers and the of cultivation costs.

**Management plan for the farming site**

An initial topographic survey was done at the start of the project. The total area was divided after proposing streets and walkways to help farmers in reaching their plots. The surveyor was asked to help in dividing the land into farming lots of around 20 dunums each. The first farming phase consisted of 14 farming units with an area ranging from 18 to 35 dunums depending on topography, arability and suitability for supporting a household.
Each unit was assigned a number and a special cropping pattern was established depending on topography, soil type and depth as well as water availability, especially during summer. Water availability was considered for the perennial crops such as alfalfa and fruit trees, which require a constant water supply, unlike seasonal crops that require water only during the growing season.

The following table represents the summary of the proposed cropping pattern of the farming units. The fruit tree list includes, but is not limited to: olives, almonds, peaches, nectarines, apples, grapevines on arbors, pistachio and citrus. The field crops include winter crops such as wheat, barley, and vetch and summer crops such as corn, sunflower, sorghum and Sudan-grass. For this purpose, 3600 fruit trees of the above species were purchased and distributed to collaborating farmers.

Table 4: Suggested cropping patterns for the 14 farming units.

<table>
<thead>
<tr>
<th>Farm unit no.</th>
<th>Total area (dunums)</th>
<th>Rocky area (du.)</th>
<th>Proposed cropping pattern (dunums)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter field crops</td>
<td>Summer field crops</td>
<td>Fruit trees</td>
</tr>
<tr>
<td>20</td>
<td>22.1</td>
<td>2.1</td>
<td>8.0</td>
</tr>
<tr>
<td>21</td>
<td>20.6</td>
<td>-</td>
<td>6.6</td>
</tr>
<tr>
<td>22</td>
<td>20.7</td>
<td>2.0</td>
<td>5.7</td>
</tr>
<tr>
<td>23</td>
<td>24.5</td>
<td>2.0</td>
<td>8.0</td>
</tr>
<tr>
<td>24</td>
<td>24.6</td>
<td>-</td>
<td>8.0</td>
</tr>
<tr>
<td>25</td>
<td>20.0</td>
<td>-</td>
<td>5.0</td>
</tr>
<tr>
<td>26</td>
<td>18.3</td>
<td>-</td>
<td>6.3</td>
</tr>
<tr>
<td>27</td>
<td>20.7</td>
<td>2.0</td>
<td>5.7</td>
</tr>
<tr>
<td>28</td>
<td>21.7</td>
<td>2.0</td>
<td>8.0</td>
</tr>
<tr>
<td>29</td>
<td>20.7</td>
<td>3.0</td>
<td>6.7</td>
</tr>
<tr>
<td>30</td>
<td>23.0</td>
<td>8.0</td>
<td>5.0</td>
</tr>
<tr>
<td>31</td>
<td>18.4</td>
<td>-</td>
<td>6.4</td>
</tr>
<tr>
<td>32</td>
<td>18.4</td>
<td>-</td>
<td>6.4</td>
</tr>
<tr>
<td>33</td>
<td>35.1</td>
<td>15.0</td>
<td>5.1</td>
</tr>
</tbody>
</table>

**Results and Discussion**

One of the main objectives of this project is to increase the awareness and acceptance of using reclaimed water in general and specifically in farming. This project provided valuable knowledge to various involved parties. The most important output is that the use of reclaimed water in farming became acceptable to people mainly the local community in the area that represents one of the most conservative societies.

Another output is the economical advantage for a community with very limited resources for income. Many people from the locals worked in the project at various stages. But, the most important aspect is that a significant number of families will farm the project area and create continuous income for themselves. Credits and loans can be provided to local communities to continue their activities.

This study showed the possibility of using treated waste water in agriculture. This type of water can also be used to rehabilitate degraded rangelands and forest areas and consequently could contribute to the conservation of local agrobiodiversity mainly if landraces and wild relatives of species originating from Jordan are used.
References
International Water Resources Management Association, XI World Water Congress,
Madrid, Spain, October 5 – 9, 2003.
Assessing the Potential Uses of Wild Fruit Trees in Northern Drylands of the Beqa’a in Lebanon

M.A. Akl, W. Khoury, R. Baalbaki, O. Obeid, R. Zurayk, F. Freiji, and S. Talhouk

Lebanese Agricultural Research Institute (LARI), Tel Amara Station, P.O. Box 287, Zahle, Beqa’a, Lebanon. Email: miroakl@yahoo.com

Keywords: Underutilized species, wild fruit trees, conservation, potential uses, drylands, Lebanon.

Abstract
Biodiversity is important by the fact that it contributes to ecosystem stability as well as to human welfare through its contribution to food security and the potential economic benefits related to uses of plants. The approach adopted for this purpose is that of supporting traditional in situ biodiversity management by creating incentives to local communities and governments to reduce the over-exploitation of economically valuable resources. In this context rural people, which have acquired indigenous knowledge through resource use and observation rather than through formal training, are considered as a valuable source of information for plant conservation purposes. The overall objective of this study was to find incentives for conserving tree genetic resources in the drylands of the northern Beqa’a (Agrobiodiversity Project Area - Baalbak Casa). For this purpose objectives were set to assess indigenous knowledge related to potential uses of wild species, determine the potential nutritive value of selected wild species and characterize the floristic richness of the project area associated with them.

A questionnaire addressed to the local populations indicated that there is very little interest in conserving and/or using the current woody wild species despite stated past uses of many of the these trees. Chemical analyses including sugar and acid content and vitamins A (Retinol), E (α-Tocopherol), B1, B2, and C did not reveal unique properties that would render any of the species desirable for marketing purposes. The conclusion from the assessment in this study suggests that there is a need to integrate in situ conservation of wild fruit trees in the context of reforestation and biodiversity conservation since these trees are associated with a flora containing a large percentage of different families. In addition, there is a need to categorize the remaining flora of the study area to assess their conservation status and potential uses.

Introduction
Plant biodiversity represents the primary source for food, feed, shelter, medicines and many other products and means that make life on Earth possible and enjoyable. However, the shrinking of agricultural biodiversity has reduced both the intra- and inter-specific diversity of crops (Padulosi et al., 1999) compounded by a loss of the indigenous knowledge of people whereby many species are becoming neglected or underutilized (Padulosi, 1996). To encounter this loss, biodiversity conservation should focus on species and genes as well as on human culture with which biodiversity coevolved since traditional methods of resource management can provide important insights into techniques for sustainable resource management (Reid and Miller, 1989).

Wild fruit trees are important since they harbor many potential uses with regard to the natural processes they carry out. They also play an important role in plant breeding and in traditional and medicinal uses (Hodgkin, 1993).
The aims of this study were part of the broader objectives of the Conservation and Sustainable Use of Drylands Agrobiodiversity of the Near East project in Lebanon. Within the context of the project, the specific objectives of this study were:

- To assess potential uses of wild trees growing in the Agrobiodiversity Project Area (Baalbak Casa) by assessing indigenous knowledge related to the use and distribution of these trees;
- To determine the potential nutritive value of selected wild species of Agrobiodiversity Project Area (Baalbak Casa);
- To characterize the floristic richness associated with the wild trees of Agrobiodiversity Project Area (Baalbak Casa).

**Biodiversity conservation through use**

The loss of biodiversity not only affects habitat quality and resilience but it also has a direct impact on quality of life of the present population and that of future generations. The innovative approach adopted for the purpose of conservation through use is that of supporting traditional in situ biodiversity management by creating incentives to local communities and governments to reduce the over-exploitation of economically valuable resources (Rhoades and Nazarea, 1999; Wilkie et al., 2001). If local people are to be sympathetic to conservation, maximum long and short-term benefits must be given to those who live near these natural resources. A way of ensuring this is by combining protection with controlled cropping of wildlife. Local people can also be involved in gardening and managing the utilization of goods and services from protected areas. Biodiversity conservation must be based on transfer of ideas between resource users, researchers and resource managers. Knowledgeable rural people who have learned through resource use and observation rather than through formal training are, therefore, a highly valuable source of information for plant conservation purposes (Matowanyika and Hyntley, 1994; Cunningham and Huntley, 1994). This knowledge transmitted from generation to generation has allowed indigenous people to develop a stake in conserving and enhancing biodiversity in order to ensure the sustainability of resources (Gadgil et al., 1993). A successful conservation program also needs to consider the role of women in the process of decision-making and implementation since women play an important part in maintaining food security, practicing family planning, socializing and the transfer of indigenous knowledge to the next generation (Domoto et al., 1994).

**Potential uses of wild trees**

Wild progenitors and the genetic variation within them have made them an important resource in breeding for improved characters such as drought, heat and disease resistance. The loss of indigenous knowledge in relation to local wild trees has led ethnobotanists to conduct investigations into traditional uses of plants.

Difficulty when considering potential values of tree species: While some traits that benefit the farmer are relatively easy to identify, there are undoubtedly others that are important to the food, pharmaceutical or other industries that have not yet been investigated. Another problem is revealed in the divergence between the local community and national governments whereby the first group focuses on consumptive use value while the second tend to be most interested in productive use value often in terms of the foreign exchange earned (McNeely et al., 1990). In this study, five species and three varieties were targeted to assess their potential use in the Agrobiodiversity Project Area (Baalbak Casa). These included: *Crataegus azarolus aronia*,
Crataegus azarolus azarolus, Prunus ursina ‘large yellow fruit’, Prunus ursina ‘small yellow fruit’, Prunus ursina ‘red fruit’, Prunus microcarapa and Rosa canina.

Materials and Methods

- Description of study sites
The study sites are located in the northern part of Anti-Lebanon mountain range, an area that is known to be dry and arid and is characterized by fluctuating day and night as well as seasonal temperatures. Three villages and their associated common lands were selected as study sites and these are: Arsal, Ham-Maaraboun, and Nabha. The lands of Arsal, located in the northern part of the anti-Lebanon mountain range are characterized as mountainous arid zones receiving annually 300-500 mm of precipitation with predominantly grayish soil types associated with yellow sub-desertic one. Ham-Maaraboun lands are located in a mountainous semi-arid zone in the central part of the Anti-Lebanon chain with an estimated precipitation of 500-600 mm/year. The main soil types found in this site are discontinuous red soils and yellow mixed soils including sandy patches as well as basaltic patches. Located on the eastern slopes of the Lebanon mountain range, the Nabha site consists of mountainous areas as well as a plain and receives an estimated precipitation of 400-700 mm/year. The dominant soil type in Nabha is discontinuous red type interspersed by patches of yellow mountain soils (Zurayk, 2000).

- Vegetation characterization and collection
The vegetation was characterized in each study site by performing an ecogeographical survey adapted from the International Plant Genetic Resources Institute (IPGRI). The collected information included: latitude, longitude and slope, (Table 1).

Table 1. Description of target species habitats and associated geographic information in the study sites of Arsal, Ham-Maaraboun, and Nabha

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Target Species</th>
<th>Number of Trees Collected</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsal</td>
<td><em>Crataegus azarolus aronia</em></td>
<td>3</td>
<td>34°06.856'</td>
<td>36°21.626'</td>
<td>30 %</td>
</tr>
<tr>
<td>Arsal</td>
<td><em>Crataegus azarolus azarolus</em></td>
<td>2</td>
<td>34°06.856'</td>
<td>36°21.626'</td>
<td>30 %</td>
</tr>
<tr>
<td>Arsal</td>
<td><em>Prunus microcarapa</em></td>
<td>8</td>
<td>34°10.378'</td>
<td>36°23.916'</td>
<td>1%</td>
</tr>
<tr>
<td>Arsal</td>
<td><em>Rosa canina</em></td>
<td>20</td>
<td>34°08.280'</td>
<td>36°21.772'</td>
<td>20 %</td>
</tr>
<tr>
<td>Ham</td>
<td><em>Crataegus azarolus azarolus</em></td>
<td>20</td>
<td>33°52.906'</td>
<td>36°13.616'</td>
<td>20 %</td>
</tr>
<tr>
<td>Ham</td>
<td><em>Prunus ursina ‘large yellow fruit’</em></td>
<td>20</td>
<td>33°52.951'</td>
<td>36°13.571'</td>
<td>1%</td>
</tr>
<tr>
<td>Ham</td>
<td><em>Rosa canina</em></td>
<td>20</td>
<td>33°52.951'</td>
<td>36°13.571'</td>
<td>1%</td>
</tr>
<tr>
<td>Nabha</td>
<td><em>Crataegus azarolus aronia</em></td>
<td>10</td>
<td>34°12.381'</td>
<td>36°11.675'</td>
<td>40-50%</td>
</tr>
<tr>
<td>Nabha</td>
<td><em>Crataegus azarolus azarolus</em></td>
<td>17</td>
<td>34°12.381'</td>
<td>36°11.675'</td>
<td>40-50%</td>
</tr>
<tr>
<td>Nabha</td>
<td><em>Prunus ursina ‘large yellow fruit’</em></td>
<td>20</td>
<td>34°12.381'</td>
<td>36°11.675'</td>
<td>1%</td>
</tr>
<tr>
<td>Nabha</td>
<td><em>Prunus ursina ‘small yellow fruit’</em></td>
<td>13</td>
<td>34°12.381'</td>
<td>36°11.675'</td>
<td>1%</td>
</tr>
<tr>
<td>Nabha</td>
<td><em>Prunus ursina ‘red fruit’</em></td>
<td>3</td>
<td>34°12.381'</td>
<td>36°11.675'</td>
<td>1%</td>
</tr>
<tr>
<td>Nabha</td>
<td><em>Rosa canina</em></td>
<td>15</td>
<td>34°12.381'</td>
<td>36°11.675'</td>
<td>40%</td>
</tr>
</tbody>
</table>

The methodology adopted for selecting trees depended on population distribution and density for each species and in every site. In most cases, the populations consisted of few scattered individuals or scattered populations extending over relatively large areas. When trees were not limited in number (*Crataegus azarolus azarolus*, Nabha; *Prunus ursina* ‘large yellow fruit’,...
Nabha and Ham; and *Rosa canina* in all study sites) 15-20 trees were sampled. In cases were trees were limited in number then all encountered individuals were sampled (Table 1).

- **Review of the floristic richness, conservation status, and reported uses of native species in the study area**
  A review of the Flora of Syria, Palestine and Sinai (1932) was conducted to extract from the document all species reported for the study area. A percentage of the total flora was determined by dividing the obtained information over the total number of families, genera, and species reported in the document for Lebanon.
  With respect to the conservation status of the compiled species list, Post and Dinsmore (1932) and Mouterde (1970) have reported the endemism of many of the Lebanese species whereas the investigation based on the national published information (Anonymous, 1996) categorized species as: common, very common, rare, very rare, in decline, unknown, localized, threatened, protected, abundant, endemic and extinct. As for the potential use of the species, it was restricted to medicinal or forage.

- **Assessment of indigenous knowledge related to target wild tree species**
  A questionnaire was designed to unveil past and current indigenous knowledge and use of native wild trees in the target study areas and to assess current and future prospects for these species. For this purpose, a semi-structured questionnaire with six question categories addressing the following topics were developed: characterization of plant genetic resources, characterization of the area occupied by native wild fruit trees, assessment of potential uses, management practices, marketability of wild fruit trees and future prospects. The total number of interviewee was 116 and these were stratified according to gender and age: between 20 and 35, between 35 and 60 and above 60. Analysis of the results was conducted by taking into consideration the divergence between gender, age categories, and the divergence between villages.

- **Morphological characterization of selected wild trees: yield estimates (Fruits), and fruit characterization**
  Yield estimates were calculated by visually dividing the canopy of selected trees and shrubs into four sections and collecting all the fruits from one of these sections then extrapolating the data to total canopy. The collected fruits were subsequently placed in nylon bags and stored at –70°C until further analysis.
  Width, length and weight of fruits were measured on all collected fruits (20-50) per tree from all target species and from all study sites.

- **Chemical characterization of selected wild trees: Sugar content, titratable acidity, vitamin A (Retinol), vitamin E (α-Tocopherol), B1, B2, and C**
  1. **Sugar Content**
     The sugar content of collected fruits was calculated as percentage of Total Soluble Solids as determined using a refractometer (Leica Brix Scale Refractometers). The juice was extracted by putting the fruits in a blender and straining out the juice.

  2. **Titratable Acidity**
     Titratable acidity was determined using a 0.1 N NaOH solution with phenolphthalein as an indicator. The fruit solution was prepared by homogenizing 3-4 fruits in 50 mL distilled water. Calculations were performed according to the following formulas:
Percent acidity = \( \frac{100}{1000} \times \frac{N_1 \times V_1}{V_2} \times \text{Acid factor} \) (citric acid)

where \( N_1 = \text{Normality of NaOH} \), \( V_1 = \text{Volume of NaOH} \), \( V_2 = \text{Volume of juice used} \) and the Acid factor = 0.64 for citric acid.

### 3. Vitamin A (Retinol) and E (α-Tocopherol) contents

Five grams of fruits were homogenized in 10 mL of pyrogallol 6 % (w/v) and 0.2 ml of the internal standard solution (52µg/ml for vitamin A and 850 µg/dl for vitamin E). The homogenate was flushed with \( \text{N}_2 \) air, and then heated at 70 °C for 10 minutes in a water bath after which 2 mL of KOH (60 % w/v) were added to initiate digestion under constant flushing with \( \text{N}_2 \) for 30 minutes at 70°C in a water bath. Following digestion, the samples were vortexed for 5 minutes, allowed to cool at room temperature, then 1 mL sodium chloride solution (1% w/v) was added to each. The obtained solution was extracted three times in n-hexane 0.1 % BHT by adding 10 mL to the samples and vigorously mixing then removing the supernatant and re-extracting the remaining lower phase two additional times. The three supernatants were pooled (30 mL total) and 0.5 g MgSO4 were added, and the solution was mixed then filtered through Millipore filtration apparatus (Whatman # 2 filter paper).

Twenty µl were injected onto a reverse phase HPLC column (25 cm x 4.6 mm, Lichrosorb Si60, 5 µm) connected to a ultraviolet (UV) detector and the extract was run at a flow rate of 1 mL/min at room temperature. The mobile phase was that of the Vitamin A/E by HPLC Reagent Kit Catalog Number 195-5869, Bio-Rad. Detection of the target compound was done at a fixed emission wavelength of Ex \( \lambda = 290 \) nm. The concentration was calculated while taking into consideration the external standard, the internal standard and the peak area (Eitenmiller and Landen, 1999).

### 4. Vitamin B1 and B2 Contents

Ten grams of fruits were homogenized in 50 mL of HCl 0.1 N and the mixture was autoclaved at 121 °C for 30 minutes to free riboflavin or thiamin. After cooling, the pH of the solution was adjusted to 4.5 with sodium acetate (2 N) and the final volume was adjusted to 100 mL with distilled water. The solution was then filtered (Whatman # 2) and four ml were mixed with 3.0 mL potassium ferricyanide (1 % prepared in 15 % NaOH) and the tubes were set aside to allow for oxidation to take place. After one minute, 3 mL of 3.75 N HCl were added and the solution was vortexed. Twenty µl of this solution were injected in a C18 column (30 cm x 3.9 mm, µBondapak) at a flow rate of 1.5 mL/min at room temperature. The mobile phase was ammonium acetate (pH = 5): methanol (72:8). B1 and B2 were detected by excitation fluorescence wavelength of Ex \( \lambda = 370 \) nm and emission wavelength, Em, of \( \lambda = 435 \) nm and \( \lambda = 520 \) nm respectively. Calculations were done taking into consideration the external standard of 100 µg/mL and the peak area (Eitenmiller and Landen, 1999).

### 5. Vitamin C Content

Ten grams of fruits were homogenized in 100 mL extraction solution (meta-phosphoric acid, 3% in 8% acetic acid v/v). The suspension was then transferred to 250 mL flasks containing 2 g Norit (activated charcoal) to allow oxidation of ascorbic acid into dehydroascorbic acid. After 30 seconds of shaking, the suspension was filtered (Whatman # 2) and 2 mL were transferred to 10 mL volumetric flask containing 0.5 mL sodium acetate solution (500 g NaOAC.3H2O per l) and 5.5 mL methanol (extra pure) and the volume was adjusted to 10 ml by adding distilled water. The obtained solution was filtered and two mL were transferred to 10 mL volumetric flask.
containing 1 mL of o-phenylenediamine (OPD solution, 2.5 mg/ml) to form fluorescent derivatives and the volume was adjusted to 10 ml with the mobile phase solution (methanol:water, 55:45). Twenty µL were injected into C18 column (30 cm x 3.9 mm, µBondapak) at a flow rate of 1 mL/min at room temperature. Ascorbic acid was detected by fluorescence with a fixed Ex λ = 350 nm and Em λ = 430 nm and the concentrations were calculated while taking into consideration the external standard, 100 µg/mL and the peak area (Eitenmiller and Landen, 1999).

- **Statistical analyses**
  Diversity within and between populations was assessed using Shannon Index (Guarino et al., 1995). Mean and standard deviation of the quantitative traits were calculated for each population. Phenotypic diversity was calculated by organizing the data of each continuous variable into three categories (less than X-1SD, between X-1SD, and X+1SD and greater than X+1SD, where X is the mean and SD is the standard deviation). The phenotypic diversity index is a heterogeneity measure as it takes both evenness of distribution and richness into account. The following formula was used for calculating $h_{s,j}$ for the $j^{th}$ trait with n categories:

$$h_{s,j} = -P_i \ln P_i$$

where $P_i$ is the relative frequency in the $i^{th}$ category of the $j^{th}$ trait (Guarino et al., 1995).

In addition, cluster analysis using the unweighted pair-group method (UPGMA) was performed to determine similarity between sites (Romesburg, 1984).

**Results and Discussion**

**Review of the floristic richness, conservation status, and reported uses of native species in the study area**

Conservation priorities are highlighted by a set of criteria based on factors such as persistence, taxonomic distinctiveness and potential economic or ecological importance and utility (Holsinger, 1992). A review of the species found in the Agrobiodiversity Project Area (Baalbak Casa) indicated the presence of 285 species, 148 genera, and 40 families constituting 9.7 %, 19.5 % and 31 % of the total taxon richness of Lebanon, respectively (Post and Dinsmore, 1932). These results indicate a relatively low species frequency but a high family representation in the study area. Concurrent field studies in the Baalbak Casa indicated the presence of several species that were not included in our compiled list indicating a need to update the flora of the study area specifically and the country as a whole (El-Saliby, 2000; Hajj Hassan, 2001). In addition, a review of the conservation status of the compiled species list in investigated documents (Post and Dinsmore, 1932; Mouterde, 1970; Anonymous 1996) indicated that very little information is available on the conservation status and/or use of these species (Table 2). Based on the currently available documents, out of the 285 recorded species only nineteen had a reported status, i.e., fourteen species were reported as endemic, one as localized, one as rare, and three as abundant. Moreover, the nationally published information with respect to conservation status is not aligned with current conservation categories adapted worldwide and therefore did not allow us to cross reference with other databases (Taylor, 2000). This finding suggests a need to generate an updated report of the current status of biodiversity in the Agrobiodiversity Study Project area.
Table 2. Reported conservation status of species found in the Agrobiodiversity Project area (Baalbak Casa) ( Adapted from Post and Dinsmore, 1932; Mouterde, 1970; Anonymous, 1996)

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caryophyllaceae</td>
<td>Bufonia</td>
<td>B. kotshyana</td>
</tr>
<tr>
<td>Compositae</td>
<td>Scorzonera</td>
<td>S. makmeliana</td>
</tr>
<tr>
<td>Linaceae</td>
<td>Linum</td>
<td>L. carnulosum</td>
</tr>
<tr>
<td>Malvaceae</td>
<td>Althaea</td>
<td>A. hohenakeri</td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Astragalus</td>
<td>A. trifoliolatus</td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Astragalus</td>
<td>A. angulosus</td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Medicago</td>
<td>M. scutellata</td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Medicago</td>
<td>M. rigidula</td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Vicia</td>
<td>V. ervilia</td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Vicia</td>
<td>V. peregrine</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Amygdalus</td>
<td>A. agrestis</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Pyrus</td>
<td>P. syriaca</td>
</tr>
<tr>
<td>Umbelliferae</td>
<td>Bifora</td>
<td>B. testiculata</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Hyoscyamus</td>
<td>H. reticulates*</td>
</tr>
</tbody>
</table>

With respect to reported potential uses and/or agricultural importance, five species had medicinal uses and six have no reported uses but are wild relatives to cultivated crops (Table 3) (Hamze et al., 1996).

Table 3. Plant Species With Reported Uses and/or Potential Agricultural Importance (Adapted from Anonymous, 1996; Hamze et al., 1996)

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
<th>Medicinal Uses</th>
<th>Wild Relatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boraginaceae</td>
<td>Anchusa</td>
<td>A. azurea</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Compositae</td>
<td>Inula</td>
<td>I. viscosa</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Medicago</td>
<td>M. rigidula</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Medicago</td>
<td>M. scutellata</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Vicia</td>
<td>V. peregrina</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Papilionaceae</td>
<td>Vicia</td>
<td>V. ervilia</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ranunculaceae</td>
<td>Adonis</td>
<td>A. aestivalis</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ranunculaceae</td>
<td>Anemone</td>
<td>A. bland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Pyrus</td>
<td>P. syriaca</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Rosaceae</td>
<td>Rosa</td>
<td>Rosa spp.</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Solanaceae</td>
<td>Hyoscyamus</td>
<td>H. aureus</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Assessment of indigenous knowledge related to target wild trees species: Conservation priority must take into consideration people and their preferences as well as legal and environmental constraints (Jakobsson and Dragun, 2001; Weber and Stoney, 1986). If local people are to be
sympathetic to conservation, maximum long and short-term benefits must be given to those who live near these natural resources. A way of ensuring this is by combining protection with controlled cropping of wildlife. It is therefore clear that there is a need to take into consideration the relationships between indigenous people and the threatened vegetation that surrounds them (Burgess, 1994).

In light of the above, a survey of indigenous knowledge in relation to types of trees present in their area was conducted. Interviewed villagers cited a total of thirty-three trees and shrubs. However, the majority reported six, viz., Pyrus syriaca, Prunus ursina, Crataegus azarolus, Quercus spp., Rosa canina and Pistacia atlantica (Table 4).

Table 4. Indigenous survey on the woody plant genetic resources of the Agrobiodiversity Project area (Baalbak Casa, N=116, data reported as % respondents)

<table>
<thead>
<tr>
<th>Species</th>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A*</td>
<td>H*</td>
<td>M*</td>
</tr>
<tr>
<td>Acer spp</td>
<td>39</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Amygdalus communis</td>
<td>46</td>
<td>23</td>
<td>29</td>
</tr>
<tr>
<td>Anabasis articulata / Viscum cruciatum</td>
<td>0</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Artemisia herba-alba</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Asphodelus</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Atraphaxis sinaica / Rhamnus palaestina</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Berberis vulgaris</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ceratonia siliqua</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Corylus avellana</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Crataegus azarolus</td>
<td>89</td>
<td>87</td>
<td>93</td>
</tr>
<tr>
<td>Cupressus sempervirens</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Eryngium barrelieri</td>
<td>0</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Juniperus drupacea</td>
<td>0</td>
<td>50</td>
<td>27</td>
</tr>
<tr>
<td>Juniperus excelsa</td>
<td>85</td>
<td>50</td>
<td>47</td>
</tr>
<tr>
<td>Olea europea</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Onosma spp</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Origanum maru</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pistacia atlantica</td>
<td>85</td>
<td>73</td>
<td>60</td>
</tr>
<tr>
<td>Poterium spinosum</td>
<td>0</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Prunus mahaleb</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Prunus prostrata</td>
<td>19</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Prunus ursina</td>
<td>50</td>
<td>93</td>
<td>96</td>
</tr>
<tr>
<td>Pyrus aquilina</td>
<td>39</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Pyrus syriaca</td>
<td>96</td>
<td>73</td>
<td>84</td>
</tr>
<tr>
<td>Quercus aegilops</td>
<td>0</td>
<td>43</td>
<td>53</td>
</tr>
<tr>
<td>Quercus spp.</td>
<td>27</td>
<td>77</td>
<td>78</td>
</tr>
<tr>
<td>Quercus spp.</td>
<td>8</td>
<td>30</td>
<td>44</td>
</tr>
<tr>
<td>Rhamnus ziziphus</td>
<td>15</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>Rhus Coriaria</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Rosa canina</td>
<td>85</td>
<td>87</td>
<td>91</td>
</tr>
<tr>
<td>Rosa indica</td>
<td>0</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Solanum nigrum</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vigna luteola / Rubus spp</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*A = Arsal; H = Ham; M = Maaraboun; N = Nabha; ** M = Male; F = Female
The interviewed local communities consistently reported that in the past trees covered the surrounding mountains and that forest cover has decreased noticeably. Main causes for this noted deforestation was the cutting of trees for timber production, fuel wood purposes, and charcoal production (Table 5). One interesting result is the fact that the two villages that reported over-grazing as a cause for loss of forests were also those with most degraded common lands.

Table 5. Local survey regarding past and current forest cover in the Agrobiodiversity Project area (Baalbak Casa) and causes of deforestation (N=116; data reported as % respondents)

<table>
<thead>
<tr>
<th>Trends and causes of degradation</th>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A*</td>
<td>H*</td>
<td>M*</td>
</tr>
<tr>
<td>Forest Cover in the Past</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50%</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;50%</td>
<td>46</td>
<td>77</td>
<td>20</td>
</tr>
<tr>
<td>No Response</td>
<td>23</td>
<td>0</td>
<td>46</td>
</tr>
<tr>
<td>Current Area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreasing</td>
<td>62</td>
<td>90</td>
<td>56</td>
</tr>
<tr>
<td>Same</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increasing</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>No Response</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Causes of Deforestation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood Cutting for Subsistence</td>
<td>89</td>
<td>93</td>
<td>68</td>
</tr>
<tr>
<td>Warmer Climate</td>
<td>12</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Grazing</td>
<td>4</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td>Land Exploitation</td>
<td>12</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Erosion due to Flash Floods</td>
<td>4</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>Poverty</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No Care</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No Response</td>
<td>42</td>
<td>17</td>
<td>32</td>
</tr>
</tbody>
</table>

*A = Arsal; H = Ham; M = Maaraboun; N = Nabha; ** M = Male; F = Female

The approach adopted for conservation through use is that of supporting traditional in situ biodiversity management by creating incentives for local communities and governments to reduce the over-exploitation of economically valuable resources (Rhoades and Nazarea, 1999; Wilkie et al., 2001). In this study, data on past uses of wild tree species indicated that Amygdalus communis, Berberis vulgaris, Crataegus azarolus, Pistacia atlantica, Prunus ursina, Pyrus syriaca, and Rosa canina were the most used species by local communities (Table 6).

Table 6. Wild trees reportedly used in the past in the Dryland Agrobiodiversity Project area (Baalbak Casa), (N=116; data reported as % respondents)

<table>
<thead>
<tr>
<th>Species</th>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Name</td>
<td>Latin Name</td>
<td>A*</td>
<td>H*</td>
</tr>
<tr>
<td>Loz</td>
<td>Amygdalus communis</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Ijas</td>
<td>Pyrus syriaca</td>
<td>27</td>
<td>13</td>
</tr>
<tr>
<td>Khokh al dub</td>
<td>Prunus ursina</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Botum</td>
<td>Pistacia atlantica</td>
<td>62</td>
<td>3</td>
</tr>
<tr>
<td>Zaaour</td>
<td>Crataegus azarolus</td>
<td>65</td>
<td>3</td>
</tr>
<tr>
<td>Ward barri</td>
<td>Rosa</td>
<td>27</td>
<td>33</td>
</tr>
</tbody>
</table>

487 | P a g e
As for the major reported uses, these were for consumption (*Pyrus syriaca*, fresh, dried, or as jam), medicinal uses (*Crataegus azarolus* and *Rosa canina*), and other uses such as manufacturing artifacts (*Pistacia atlantica*), construction (*Pistacia atlantica*), grafting of cultivated varieties on wild rootstocks (*Pyrus syriaca*, *Pistacia atlantica*), for bee-keeping (*Juniperus excelsa*, *Eryngium Barrelieri*), and the use of natural products as pesticides (*Juniperus excelsa*) (Table 7).

Table 7. Past indigenous uses of wild fruit trees in the Dryland Agrobiodiversity Project area (Baalbak Casa), (N=116; data reported as % respondents)

<table>
<thead>
<tr>
<th>Species</th>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Name</td>
<td>Latin Name</td>
<td>Uses</td>
<td>A*</td>
</tr>
<tr>
<td>Loz</td>
<td><em>Amygdalus communis</em></td>
<td>M 0 7 0 3 3 6 0 0 6 0</td>
<td></td>
</tr>
<tr>
<td>Ijas</td>
<td><em>Pyrus syriaca</em></td>
<td>C 32 13 16 1 16 23 27 0.3 30 21</td>
<td></td>
</tr>
<tr>
<td>Khokh al Dub</td>
<td><em>Prunus ursina</em></td>
<td>C 0 13 24 1 10 25 21 0.1 20 22</td>
<td></td>
</tr>
<tr>
<td>Botum</td>
<td><em>Pistacia atlantica</em></td>
<td>C 55 0 0 0 14 4 4 0.2 14 7</td>
<td></td>
</tr>
<tr>
<td>Zaarour</td>
<td><em>Crataegus azarolus</em></td>
<td>M 11 0 32 0.2 11 63 74 1 82 51</td>
<td></td>
</tr>
<tr>
<td>Ward barri</td>
<td><em>Rosa canina</em></td>
<td>O 20 3 0 0 6 10 17 0.2 18 12</td>
<td></td>
</tr>
<tr>
<td>Barbaris</td>
<td><em>Berberis vulgaris</em></td>
<td>C 4 3 4 0.1 3 9 2 0.04 8 3</td>
<td></td>
</tr>
<tr>
<td>Lizzab</td>
<td><em>Juniperus excelsa</em></td>
<td>O 0 0 0 0.1 0 2 5 0 0 13</td>
<td></td>
</tr>
<tr>
<td>Ward jouri</td>
<td><em>Rosa indica</em></td>
<td>O 4 0 8 0.03 3 9 20 0.04 10 12</td>
<td></td>
</tr>
<tr>
<td>Difran</td>
<td><em>Juniperus drupacea</em></td>
<td>C 0 0 4 0.03 1 0 0 0.04 2 0</td>
<td></td>
</tr>
</tbody>
</table>

Some species had economic values in the past, i.e., *Pyrus syriaca*, *Prunus ursina*, and *Crataegus azarolus* were commonly sold in local markets. Today, however, these species have lost their economic value and there is low demand for the products (Table 8).
Table 8. Past commercial uses of species in the Agrobiodiversity Project area (Baalbak Casa) (N=116; data reported as % respondents)

<table>
<thead>
<tr>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
<th>Percent Respondents That Reported a Past Trade of Wild Products</th>
<th>Types of Traded Good</th>
<th>Wood</th>
<th>Pyrus syriaca</th>
<th>Prunus ursina</th>
<th>Crataegus azarolus</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>H*</td>
<td>M*</td>
<td>N*</td>
<td>Mean</td>
<td>20-35</td>
<td>35-60</td>
<td>&gt;60</td>
<td>M**</td>
</tr>
<tr>
<td>54</td>
<td>20</td>
<td>8</td>
<td>49</td>
<td>33</td>
<td>34</td>
<td>32</td>
<td>32</td>
<td>37</td>
</tr>
<tr>
<td>86</td>
<td>0</td>
<td>50</td>
<td>29</td>
<td>20</td>
<td>31</td>
<td>0</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>36</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>15</td>
<td>33</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>*A = Arsal; H = Ham; M = Maaraboun; N = Nabha; ** M = Male; F = Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Furthermore, results showed consistency in the outlook on potential uses of wild resources: those villages that had the highest incidence of response regarding the past uses of wild resources also showed the highest response rate in their willingness to consider selling NWFP in the future. However, even with this claim, support for marketing wild products remained low in these communities. Conditions for successful marketing of NWFP included active government support and availability of information in addition to the protection from competing superior varieties (Table 9).

Table 9. Willingness to sell non-wood forest products (NWFP) in the Agrobiodiversity Project area (Baalbak Casa) (N=116; data reported as % respondents)

<table>
<thead>
<tr>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
<th>Percent of respondents willing to sell NWFP</th>
<th>Stated conditions to sell NWFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>H*</td>
<td>M*</td>
<td>N*</td>
<td>Mean</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>4</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>*A = Arsal; H = Ham; M = Maaraboun; N = Nabha; ** M = Male; F = Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The willingness of local communities to protect and manage surrounding tree genetic resources was assessed (Table 10). It is believed that when local people are involved in gardening and managing the utilization of goods and services from protected areas, further rural development will occur (FAO, 1985). Survey results indicated that half the interviewed villagers in three of the four target areas protected the surrounding forests. Few of the respondents (<10%), however, reported reasons for this protection, which included the landscape value of the forests, their value for nature conservation, and as a source of wood. A discrepancy was noted in the responses and this was reflected by the fact that there was a lack of interest in protecting forested areas because of land ownership (common lands were not protected) and because fruits produced by wild trees had no perceived economic value. In addition, further investigation into which areas were effectively protected (private vs. common lands) and what type of management practices are used, unveiled the fact that neither private nor common lands with wild resources were actively managed or protected. The only significant reported management practice was pruning indicating wood collection rather than forest protection.
Table 10. Past and current protection and management of forest lands by local communities in the Agrobiodiversity Project area (Baalbak Casa) (N=116; data reported as % respondents)

<table>
<thead>
<tr>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A*</td>
<td>H*</td>
</tr>
<tr>
<td>Percent respondents indicating that surrounding forests have been protected</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>Respondents indicating protection of private land</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Respondents indicating protection of common lands</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Respondents indicating management of forest lands</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>No response</td>
<td>58</td>
<td>13</td>
</tr>
</tbody>
</table>

*A = Arsal; H = Ham; M = Maaraboun; N = Nabha; ** M = Male; F = Female

Future prospects regarding the willingness of local communities to protect wild trees revealed that more than half the interviewed villagers were in favor of protecting the woody plant genetic resources (Table 11). Results showed that people were aware of the importance of protecting wild trees and the main reasons behind this interest was related to health and pollution concerns and the aesthetic value of the village area. Other stated reasons included increased rainfall, prevention of soil degradation, shade, tourism, and grafting of wild trees with improved cultivars to improve disease resistance.

Respondents who were pessimistic about the prospects of protection raised many issues as determinant factors in affecting the potential efficacy of such protection. These factors included the necessity of government involvement to assist in issues such as overgrazing, conflicts over land ownership, to regulate urban expansion and help in limiting the replacement of wild fruit trees with improved varieties (Table 11).

Table 11. Future willingness to protect wild fruit trees of the Agrobiodiversity Project area (Baalbak Casa) (N=116; data reported as % respondents)

<table>
<thead>
<tr>
<th>Villages</th>
<th>Ages</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A*</td>
<td>H*</td>
</tr>
<tr>
<td>Percent respondents with positive outlook on forest protection</td>
<td>73</td>
<td>60</td>
</tr>
<tr>
<td>Stated reasons for the need for protection</td>
<td>Health + Pollution</td>
<td>0</td>
</tr>
<tr>
<td>Increased rainfall</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Aesthetic value</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Soil degradation prevention</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Shade</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Tourism</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Grafting</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Stated issues that need to be addressed in relation to protection</td>
<td>Government involvement</td>
<td>33</td>
</tr>
<tr>
<td>Overgrazing</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>Conflict over ownership and use of lands</td>
<td>0</td>
<td>43</td>
</tr>
<tr>
<td>Urban expansion into forest areas</td>
<td>33</td>
<td>14</td>
</tr>
<tr>
<td>Introduction of improved varieties</td>
<td>0</td>
<td>43</td>
</tr>
</tbody>
</table>

*A = Arsal; H = Ham; M = Maaraboun; N = Nabha; ** M = Male; F = Female

- Age category

As biodiversity conservation must be based on transfer of ideas between resource users, researchers and resource managers, knowledgeable rural people who have learned through
resource use and observation rather than through formal training are a valuable source of information for plant conservation purposes (Matowanyika and Hyntley, 1994; Cunningham and Huntley, 1994). This knowledge transmitted from generation to generation has allowed indigenous people to develop a stake in conserving and enhancing biodiversity in order to ensure the sustainability of resources (Gadgil et al., 1993). In our study, stratifying the survey into three age categories allowed us to assessed transfer of knowledge between generations. With respect to knowledge related to the various types of trees in the region there was no noted difference in percent respondents and the number of species reported (Table 4). Similarly, there was an overall consistency in responses across the different age categories regarding various issues raised during the questionnaire (Tables 4-11). Responses from the older category were consistently less in percent respondents indicating either lack of interest or loss of recollection regarding the addressed issues. In contrast, the younger and middle age categories gave similar responses. The fact that the overall percentage of respondents was low is an indication of the lack of interest of the local population of all ages in the potential uses of the woody genetic resources.

- **Gender issues**

A successful conservation program also needs to consider the role of women in the process of decision-making and implementation since women play an important role in food security and family planning, children socialization and the transfer of indigenous knowledge (Domoto et al., 1994). With respect to the information provided by both men and women in this study, it was clear that the knowledge and opinions regarding issues were similar between genders (Tables 4-11). It is worth noting, however, that in all questions the percent male respondents were consistently higher than percent female respondents. During the survey, it was felt that males were more confident and forthcoming in providing information despite the fact that individuals were interviewed separately. It is possible that the individual formal questionnaire format is not conducive to promoting participation by women. A group participatory approach to address these issues might have generated more interest and therefore more information. One surprising result is the low percent of respondents among women, when compared to men, relating to questions of past uses of non-wood forest products. It is clear from this study that the livelihood of the interviewed population does not depend on the woody genetic resources available around the village lands.

- **Genetic diversity of* Crataegus azarolus azarolus* and *Rosa canina***

Variation in the average width, average length and average weight of *Crataegus azarolus azarolus* and *Rosa canina* was utilized to determine whether accessions grouped in distinct clusters according to provenance. With respect to *Rosa canina*, all individuals clustered in different groups regardless of provenance indicating a morphological diversity that is higher within than between populations. Three unique trees clustered separated from the remaining 55 trees and all three of these trees were from Arsal. Similar results were noted for *Crataegus azarolus azarolus* where individual trees clustered in different groups regardless of provenance. One cluster separating five individual trees from the remaining 39 containing specimens from three different villages.

The genetic diversity was assessed for both species using the Shannon diversity index. Diversity indices for *Rosa canina* were highest in the Arsal population for all three parameters measured and were the lowest in Nabha. These results indicate that based on the three measured morphological parameters there is a difference in the genetic diversity between populations in the area under study (Table 21). In contrast, the genetic diversity values for *Crataegus azarolus azarolus* were very similar between villages (Table 22).
Table 21. Shannon Diversity Index of the average width, average length and average weight among the three sites of *Rosa canina*

<table>
<thead>
<tr>
<th>Villages → Parameters ↓</th>
<th>Ham</th>
<th>Arsal</th>
<th>Nabha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average width</td>
<td>0.38</td>
<td>0.45</td>
<td>0.14</td>
</tr>
<tr>
<td>Average length</td>
<td>0.28</td>
<td>0.42</td>
<td>0.12</td>
</tr>
<tr>
<td>Average weight</td>
<td>0.09</td>
<td>0.43</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Table 22. Shannon Diversity Index of the average width, average length and average weight among the three sites of *Crataegus azarolus azarolus*

<table>
<thead>
<tr>
<th>Villages → Parameters ↓</th>
<th>Ham</th>
<th>Nabha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average width</td>
<td>0.43</td>
<td>0.29</td>
</tr>
<tr>
<td>Average length</td>
<td>0.30</td>
<td>0.35</td>
</tr>
<tr>
<td>Average weight</td>
<td>0.43</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Conclusion
The overall objective of this study was to find incentives for conservation of tree genetic resources. For this purpose objectives were set to assess indigenous knowledge related to potential uses of wild species, determine the potential nutritive value of selected wild species and characterize the floristic richness of the project area.

The questionnaire of local populations indicated that there is very little interest in conserving and/or using the current woody genetic resources despite stated past uses of many of the tree species. This was evidenced from the overall low response rate to specific questions related to the use and marketability of wild species. In addition, although fifty percent of respondents indicated that wild trees have been under protection, the survey unveiled that there is no effective protection nor is there any management. The survey also revealed that the local villagers are willing to conserve the wild populations however they raised legitimate issues that will need to be addressed to insure sustainability of conservation. These are government involvement and agroeconomic extension of information. Age and gender difference were not evident in this survey except for the lack of response from the older generation and women. Otherwise most of the related information was very similar in the various groups.

A morphological characterization was performed for target species however chemical analyses including sugar and acid content and vitamins A, E, B1, B2, and C did not reveal unique properties that would render any of the species desirable for marketing purposes. The genetic diversity between and within populations of *Rosa canina* was high while it was low in *Crataegus azarolus azarolus*.

The conclusion from the assessment in this study suggests that there is a need to integrate *in situ* conservation of wild fruit trees in the context of reforestation and biodiversity conservation since these trees are associated with a flora containing a large percentage of different families. In addition, there is a need to categorize the remaining flora of the study area to assess their conservation status and potential uses.

Acknowledgements
I would like to express my deepest gratitude to Dr. Salma N. Talhouk for her continuous support and guidance. The financial support of the Agro-Biodiversity project is acknowledged and highly
The help of the project team, mainly M. Yazbek, M. Monzer, C. Hage-Chahine and M. Yaghi is also acknowledged. I would also like to acknowledge the inhabitants of Arsal, Ham and Nabha, for their time and cooperation during the elaboration of the questionnaire. The help of the chemistry department at American University of Beirut (AUB) for the chemical analysis of vitamin content of wild fruits is also appreciated.

References
Burgess, B.B. 2001. Fate of the Wild. University of Georgia Press, Athens, Georgia, USA.


Antimicrobial Activity of some Medicinal Plants Collected in Lebanon

Hilan C., R. Sfeir, R. El-Hage and D. Jawish

Lebanese Agricultural Research Institute- Fanar, Lebanon, PO Box: 90.1965- E-mail: fanarlab@lari.gov.lb

Keywords: Medicinal plants, antimicrobial effect, essential oils, conservation, Lebanon

Abstract
The Lebanese environments provide conditions for a rich plant diversity including the wild relatives of crops of global importance and many medicinal and herbal species. About 400 species are endemic to Lebanon and Syria and similar number have medicinal or herbal uses. Since 1993, the Lebanese Agricultural Research Institute (LARI) has been carrying out research on the Lebanese medicinal plants in its laboratory in Fanar station. This on-going activity is of vital importance regarding the growing interest at the national and international levels for these plants in income generation and in developing new medicines. The results obtained by LARI (Fanar laboratory) on the composition and the evaluation of anti-microbial activities of essential oil of Salvia libanotica (Sage), Hypericum thymifolium (St. John’s wort), Origanum syriacum (thyme), Malva sylvestris, Lavandulah stoechas, Rosemarinus officinalis, Nigella sativa, Ferula hermonis, Micromeria barbata and Prangos asperula showed strong inhibitory activity against pathogenic bacteria and were more effective than most of the known antibiotics. For example, half of a µl of essential oil from Salvia libanotica killed 18 million of Candida albicans in 10 minutes, the Hypericum thymifolium extract killed 12,000 Staphylococcus bacteria, as compared to 137 only by the common antibiotic. Results showed Ferula hermonis root’s oil extract to be highly effective against Gram-positive bacteria. If proven to have positive effects, ways should be found to cultivate and preserve theses species and to conserve their diversity in their natural habitats. This would enhance women labor in poor rural areas, thus would have a positive impact on rural development.

The composition and the bacterial effects of the essential oils extracted from Salvia libanotica, Hypericum thymifolium and Ferula hermonis are presented in this contribution.

Introduction
Lebanon is especially rich in agricultural biodiversity with a flora counting about 4633 species. About 400 endemic species are reported to exist in Lebanon and Syria (Mouterde, 1963) and the tendency of these plants to grow on different types of soils and climates raise the possibility to exploit them on a larger scale as domesticated alternative high value crops. Medicinal plants in Lebanon are a squandered resource, badly conserved and exploited. Since 1993, the Lebanese Agricultural Research Institute (LARI) has been carrying out research on Lebanese medicinal plants in its Laboratory at Fanar station mainly investigating the composition of essential oils and the anti-microbial actions of many species (Pimpinella anisum, Matricaria chamomilla, Carum carvi, Cerotonia siliqua, Coriandrum sativum, Cuminum cymimum, Foeniculum vulgare, Géranium pélargonium, Laurus nobilis, Lavandulah stoechas, Origanum marjorana, Micromeria myrthifolia, Myrtus communis, Lippia citriodora, etc.). The results obtained on the evaluation of anti-microbial, anti-fungal and antioxidant activities of essential oil of Salvia libanotica (sage), Hypericum thymifolium (St. John’s wort), Origanum syriacum (thyme), Malva sylvestris, Lavandulah stoechas, Rosemarinus officinalis, Nigella sativa, Ferula hermonis, Micromeria barbata and Prangos asperula showed strong inhibitory
activity against pathogenic bacteria and were more effective than available antibiotics. The activities of some of these species are presented below.

**Salvia fruticosa libanotica** Boiss. & Gaill. or Sage, family of Lamiaceae, is known commonly in Lebanon as Kassiin, Mariamia or Kouaiissi in the South. It grows wild in vast areas along the Lebanese coastline and is able to grow up to 900 m altitude. Its flowers resemble violet grape, reaching a height of 12 to 18 mm, blossoming between February and July (Mouterde, 1983). The Lebanese environment provides it with ideal growing conditions. It is not found on sandstone, but grows on chalky and marl slopes. It is most prolific in Lebanon, becoming sporadic in Syria (Tohmé and Tohmé, 2002). Lebanon hosts 19 various sage species.

The local Lebanese communities have traditionally used sage as a herbal medicine for external application as mouthwash and for ulcers, wounds and dermatitis. In internal use, *S. fruticosa* is known as anti-cough, anti-spasmodic, laxative, diuretic and against stomachaches and ulcer. As a result, it is heavily harvested by local communities and widely exported.

**Hypericum thymifolium** is a plant of Hypericaceae family. This plant is commonly called in Lebanon “Dazi”, in English “St. John’s wort” and in French Millepertuis. *H. thymifolium* is native in Lebanon and grows largely and wildly above 1200 m altitude and it is found in dry areas and sunny places. The species of the genus *Hypericum* are widely used in folk medicine to cure warts in humans and livestock by infusion (2 to 4 g dried herb with top flowering daily till the wart disappears). The flowers are regular, yellow petals, which bloom all over the year (Mouterde, 1931). The odor of the flower is fresh turpentine-like, then fruity, attracting honeybees, especially, in the early morning.

**Ferula hermonis** Boiss. (*Fh*) belongs to the family Umbelliferae. It is an endemic plant that can be found in a very restricted eco-geographic area: Mount Hermon in Lebanon, at 2000 m of altitude (Tohmé and Tohmé 2002) or Mount Blodan in Syria; these two places constitute its unique and exclusive natural habitat. The root of *F. hermonis* Boiss., commonly known in Lebanon and Syria as “Shirsh-el-Zallouh”, has been used in folk medicine as an aphrodisiac (Abourashed et al. 2000). It has a very strong reputation as a general stimulant, nervous activator against neurasthenia, general weakness, stress, fatigue and for retardation of the early appearance of symptoms of old age. It is also suspected to have antibacterial and antioxidant activities, which could make it be valorized as a natural food additive to replace chemical ones. Hence, the crude oil from the plant *F. hermonis* was proven to enhance erectile function in rats; however it becomes toxic if used for a long period of time (El-Taher et al. 2001). In 1998, Al-Yahya isolated three anti-bacterial sesquiterpenes from *F. communis*, which exhibited significantly the activity against Gram-positive bacteria as well as against Mycobacterium organisms (Al-Yahya et al. 1998).

**Materials and Methods**

**Sample collection and steam distillation.**

**Sage:** samples were collected from various regions of Lebanon, ranging from 100 to 900m of altitude and during 2 successive periods in June, July, August and September. Green fresh leaves before and after blossoming of the plant were washed in distilled water, then dried at room temperature, macerated in cold distilled water to extract essential oils.

**Hypericum** plant material was identified and collected from east of Sidon, at an altitude between 450-500m, the Chouf Mountain (altitude 950-1000m) and from planted *Hypericum* in the Fanar Laboratory garden (coast), during two successive periods (winter and summer times), over 2 years (Herbarium n°. 0012, Agricultural Faculty Kaslik University).

**Ferula hermonis:** Fresh roots were gathered from El Cheikh Mountain, Mount Hermon, at 1900- 2000m altitude (Lebanese part) and from Blodan (the other versant of the mountain) in
Syria. In autumn season only root parts were available. Flowering tops and seeds were collected in April-May and October respectively. Fresh roots and seeds were washed, grinned, macerated in distilled water. All samples collected were then subjected to steam distillation by Clevenger apparatus (Pharmacopée Européenne, 1989) in order to extract the essential oils. The duration of each extraction was around six hours. The oil was stored in the fridge at 4°C for 24 hours, in dark bottle in order to protect it from light exposure. The yield of essential oils was then measured (v/w) of plant material.

**Identification of the extracted volatile essential oils**

Gas chromatography is a method that consists of separating the various essential oils’ constituents (Pradeau, 1992; Massada, 1978). This method allows a qualitative as well as quantitative evaluation of the oils found in the volatile fraction. The apparatus that was used is Shimadzu 17A, Automatic flow controller, Auto- injector AOC 20. Whilst for the condition that was applied to it, was according to Hilan (Hilan *et al*, 1997). Relative percentage amounts of the separated compounds were calculated from total chromatograms by the computerized integrator. The standard essential oils were from Sigma.

**The bacterial identification and count and the inhibition test**

Reference pathogenic organisms that were tested with the various oil extracts were *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Staphylococcus aureus*, *Streptococcus group D* and *Candida albicans* (Faculty of Public Health of the Lebanese University). They were isolated from patients hospitalized after having been subjected to food born tox-i-infections. Each germ was given a laboratory reference number. These strains were first pre-cultured on specific culture media: Nutrient broth, Mannitol agar, SS agar, Mac Conkey agar, Nutrient agar, Bile-Esculine agar, Kliger Iron agar, and Müller Hinton agar (Biolife s.r.l-V. Le Monza, 272, 20128 Milano-Italy). The method was elaborated by the authors. Each test was repeated three times in order to reduce error and to obtain reliable results (Hilan *et al*, 1997, Hilan and Sfeir, 2001).

**The antibiogram**

This test is conducted in the scope of evaluating the antibiotic resistance of the germs that are used in this study, then to compare it with the antibacterial effect of the extracted essential oils. The antibiotic discs used were: Teicoplanine 10μg (TEC), Pénicilline 10μg (P), Cloxacilline 5μg (OB), Erythromycine 15μg (E), Lincomycine 2μg (MY), Sulfonamide 300μg (S), Ampicilline 10μg (Amp), Tetracycline 30μg (TE), Ciprofloxacine 5μg (Cip), Chloramphénicol 30μg (C), Gentamycine 10μg (GN), Kanamycine 30μg (K), Gentamycine 10μg (CN), Sulphamethoxazole and Trimethoprim 25μg (SxT), Kanamycine 30μg (K), Streptomycine 10μg (S) and Nalidixic acid 30μg (AN). The media used was the Müller Hinton Agar (MHA) (Biomedics). After 24 hours of incubation at 37ºC, the number of total germs in the three count dishes was determined, and then the diameter of the inhibition area of the strain tested with antibiotics was measured using a ruler.

**Results and Discussion**

**Salvia libanotica**

- Composition in essential oils

The distillation of *Salvia libanotica* resulted in light-colored oil when the plant material is harvested in the period of June-July and darker color for August-September harvest. The samples collected gave oil volumes ranging from 0.07% to 0.5% depending on the regions (Verzar-Petri and Then, 1985). A long arid and dry period gave a higher oil production along the coastline reaching 0.52%, while it gave only 0.14% on higher altitudes (Kustrak and Kuflinec, 1985). The difference in the gathered essential oil concentration is due to growth period, to the soil nature and especially to the sunlight (Bellomaria and Arnold, 1992).
The compounds of *S. libanotica* essential oil showed by Gas Chromatography that 1,8-cineol (55-62%) is the major constituent; then camphor (8-10%), borneol (5-4.5%), α-pinene (3.7-4.5%), β-pinene (6-5.2%), camphene (2.6-5%), β-myrcene (3-3.5%). The fact that *S. libanotica* contains cariophyllene (2-1%) endows the oil with olfactive qualities. The α and β-thujone showed low concentration (0.72 - 1.2%) (Table 1).

Table 1: Chromatography profile showing major components of volatile oil of *Salvia libanotica* Boiss.

<table>
<thead>
<tr>
<th>E.O. Standards *</th>
<th><em>Salvia libanotica</em> % **</th>
<th><em>Salvia libanotica</em> % ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (1R)-(+) α-Pinene</td>
<td>3.70</td>
<td>4.50</td>
</tr>
<tr>
<td>2 (-)- Camphene</td>
<td>2.60</td>
<td>5.00</td>
</tr>
<tr>
<td>3 B-Pinene</td>
<td>6.00</td>
<td>5.20</td>
</tr>
<tr>
<td>4 Sabine</td>
<td>-</td>
<td>0.30</td>
</tr>
<tr>
<td>5 β- Myrcene</td>
<td>3.00</td>
<td>3.50</td>
</tr>
<tr>
<td>6 α- Terpinene</td>
<td>-</td>
<td>0.40</td>
</tr>
<tr>
<td>7 (R)-(+) Limonene</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8 1,8- Cineole</td>
<td>62.0</td>
<td>55.0</td>
</tr>
<tr>
<td>9 γ- Terpinene</td>
<td>0.30</td>
<td>0.50</td>
</tr>
<tr>
<td>10 p- Cymene</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>11 Terpinolene</td>
<td>-</td>
<td>0.20</td>
</tr>
<tr>
<td>12 (-)-α- Thujone</td>
<td>1.38</td>
<td>1.80</td>
</tr>
<tr>
<td>13 β- Thujone</td>
<td>0.72</td>
<td>1.50</td>
</tr>
<tr>
<td>14 Camphor</td>
<td>8.00</td>
<td>10.0</td>
</tr>
<tr>
<td>15 (-)- Linalool</td>
<td>0.80</td>
<td>0.80</td>
</tr>
<tr>
<td>16 Linalyl acetate</td>
<td>0.60</td>
<td>0.30</td>
</tr>
<tr>
<td>17 (+)-Trans- Cariophyllene</td>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td>18 Monoterpene</td>
<td>1.26</td>
<td>1.10</td>
</tr>
<tr>
<td>19 (+)- Menthol</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>20 Borneol</td>
<td>5.00</td>
<td>4.50</td>
</tr>
<tr>
<td>21 α-Terpineol</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>22 Geranyl acetate</td>
<td>0.30</td>
<td>-</td>
</tr>
<tr>
<td>23 Geraniol</td>
<td>0.10</td>
<td>0.25</td>
</tr>
<tr>
<td>24 Phytol</td>
<td>0.18</td>
<td>-</td>
</tr>
<tr>
<td>25 Thymol</td>
<td>0.80</td>
<td>0.70</td>
</tr>
<tr>
<td>26 Carvacrol</td>
<td>0.20</td>
<td>0.40</td>
</tr>
<tr>
<td>27 Farnesol</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>28 Trans-trans- Farnesol</td>
<td>0.06</td>
<td>0.15</td>
</tr>
<tr>
<td>Totals Components</td>
<td>45</td>
<td>30</td>
</tr>
</tbody>
</table>

* E.O.: Essential Oil. Hydrodistillation ; Fresh green leaves, flowering top.
** *Salvia libanotica*: South of Lebanon Sour on the coast.
*** *Salvia libanotica*: Lebanese Mountain at 500 m.

- The inhibition test

Gram-positive germs (Table 2):
  * *Staphylococcus aureus*
    - Germs (470) were inhibited after 10 minutes of contact with 5μl of oil concentration.
    - But 47,000 germs were inhibited after 1 h of contact with 10μl of oil.
  * *Streptococcus* group D
    - After 10 min of contact with 10μl of *sage* oil 440 germs were inhibited.
    - The inhibition is complete and definitive after 1 h of contact with 5μl of *sage* oil.
Table 2: N°. of Gram Positive bacteria remaining after inhibition tests with *Salvia libanotica* essential oil

<table>
<thead>
<tr>
<th>Bacteria G(+)</th>
<th>V. O.</th>
<th>5 µl</th>
<th>10 µl</th>
<th>20 µl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
<td>10'</td>
<td>1h</td>
<td>24h</td>
</tr>
<tr>
<td><em>Staphylo. aureus,</em> 47x10⁶/ml</td>
<td>10⁻³</td>
<td>100</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10⁻⁴</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10⁻⁵</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Streptococcus groupe D</em> 44x10⁶/ml</td>
<td>10⁻⁶</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Gram-negative bacteria (Table 3):
*Escherichia coli*, *Salmonella typhi*, and *Pseudomonas aeruginosa* showed temporary bacteriostatic effect in relation to the time of contact and the concentration of *sage* oil.

* E. coli; 157.H7 (resistant bacteria). 100 x 10⁶/ml
- Ten thousand *E. coli* were inhibited after 1h of contact at 5µl of oil concentration. But the inhibition occurred for some number after 10 min at the same oil concentration.
- The bacteria restarted their growth after 24h at the following sage oil concentration 5µl and 10µl.

* Salmonella typhi 0:9.12 Vi-H;d. 300 x 10⁶/ml
- The growth of bacteria was inhibited after 1 hour of contact at 5µl and 10µl of oil concentration. It restarted after 24 h.

* Pseudomonas aeruginosa* (resistant germ). 18 x 10⁶/ml
- Only 18 bacteria were inhibited after 10 min and 1h of contact at any sage oil concentration. The optimum growth of this bacterium was shown after 24 h.

Table 3: N°. of Gram Negative bacteria remaining after the inhibition tests with *Salvia libanotica* essential oil

<table>
<thead>
<tr>
<th>Bacteria G(-)</th>
<th>V. O.</th>
<th>5 µl</th>
<th>10 µl</th>
<th>20 µl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
<td>10'</td>
<td>1h</td>
<td>24h</td>
</tr>
<tr>
<td><em>Escherichia coli,</em> O:157,H7 100 x 10⁶/ml</td>
<td>10⁻³</td>
<td>65</td>
<td>65 h.g.</td>
<td>60 h.g.</td>
</tr>
<tr>
<td></td>
<td>10⁻⁴</td>
<td>6</td>
<td>0 h.g.</td>
<td>2 h.g.</td>
</tr>
<tr>
<td></td>
<td>10⁻⁵</td>
<td>1</td>
<td>0 h.g.</td>
<td>1 h.g.</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa,</em> 18 x 10⁶/ml</td>
<td>10⁻⁶</td>
<td>0</td>
<td>0 h.g.</td>
<td>0 h.g.</td>
</tr>
<tr>
<td><em>Salmonella typhi,</em> 0:9,12 Vi - H: d, 300 x 10⁶/ml</td>
<td>10⁻³</td>
<td>240</td>
<td>h.g.</td>
<td>h.g.</td>
</tr>
<tr>
<td></td>
<td>10⁻⁴</td>
<td>33</td>
<td>h.g.</td>
<td>h.g.</td>
</tr>
<tr>
<td></td>
<td>10⁻⁵</td>
<td>6</td>
<td>55 h.g.</td>
<td>1 h.g.</td>
</tr>
</tbody>
</table>

* h.g. = high growth,

Yeast (Table 4)

* Candida albicans
- The inhibition was complete and definitive with the minimum of time of contact with the minimum of oil sage concentration for the maximum of germs concentration.
Table 4: N°. of Yeast (Candida albicans) remaining after the inhibition tests with Salvia libanotica essential oil

<table>
<thead>
<tr>
<th>Yeast</th>
<th>V.O.</th>
<th>5 µl</th>
<th>10 µl</th>
<th>20 µl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
<td>10'</td>
<td>1h</td>
<td>24h</td>
</tr>
<tr>
<td>Candida albicans</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 x 10⁶/ml</td>
<td>10⁻³</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10⁻⁴</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10⁻⁵</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10⁻⁶</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The antibiogram proved that:
* E. coli is very sensitive to Chloramphenicol at the concentration of 30µg.
* Salmonella is very sensitive to Gentamicin at the concentration of 10µg and sulphamethoxazol at the concentration of 25µg.
* Pseudomonas is resistant to all antibiotics.
* Staphylococcus is slightly sensitive to Chloramphenicol at 30µg.
* Streptococcus is mildly sensitive to Ampicillin (10µg), Chloramphenicol (30µg) and Sulphamethoxazol (25µg).

The Minimum Inhibitory Concentration (Table 5) is evaluated like the minimal volume of the sage oil capable of inhibiting the greatest quantity of germs in a minimum of time (Schilcher H., 1985). Numbers of bacteria were inhibited for E. coli (100), Salmonella (294), Pseudomonas (18), Staphylococcus aureus (470) and Streptococcus fecalis (44) by 5µl of hypericum essential oil within 10 minutes. The same numbers were inhibited by higher concentration of antibiotics Chloramphenicol 30µg, Sulphamethoxazole 25µg and Gentamicine 10µg, Chloramphenicol 30µg, Ampicillin 10µg and Sulphamethoxazole 25µg, respectively and after 24 hours.

Table 5: Efficiency of sage oil against bacterial contaminants. The Minimum Inhibitory Concentration (MIC) showing the number of inhibited bacteria.

<table>
<thead>
<tr>
<th>Germs</th>
<th>Duration of contact</th>
<th>Bacterial concentration</th>
<th>Sage Oil conc/µl</th>
<th>Antibiotic/ conc µg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. coli</td>
<td>10' 1 h</td>
<td>100 10 000</td>
<td>5 5</td>
<td>Chloramphenicol 30µg</td>
</tr>
<tr>
<td>Salmonella typhi</td>
<td>1h. 30 000</td>
<td></td>
<td>5</td>
<td>Sulphamethoxazole 25µg</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>10' 1h 18 18</td>
<td></td>
<td>10 5</td>
<td>Gentamicine 10µg Resistant</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>10' 1h 470 4 700</td>
<td></td>
<td>5 10</td>
<td>Chloramphenicol 30µg (2+)</td>
</tr>
<tr>
<td>Streptococcus groupe D</td>
<td>10' 1h 44 4 4000</td>
<td></td>
<td>5 10</td>
<td>Ampicillin 10µg Chloramphenicol 30µg Sulphamethoxazole 25µg</td>
</tr>
</tbody>
</table>

Hypericum thymifolium
The oil yield from the flower was very low. The hydro-distillation of fresh green leaves yielded 0.5% of the essential oil for the samples from Sidon, 0.4% from the Chouf Mountain and 0.5% from the Hypericum planted at the garden of Fanar Laboratory. The taste and smell of the extract is slightly sweet, bitter and astringent. The odor of this oil is fresh, turpentine like, fruity, and rosy like (Weyrestahl et al. 1995).
Using Gas Chromatography, components were identified by comparing retention times, with those of standards of pure essential oil. A chromatography profile of the essential oil was obtained (for about 80 components) (Table 6): Thymol (18.5%) and its isomer carvacrol (1.5%). Monoterpenes: limonene (6%), β-pinene (5.5%), linalyl acetate (3.3%), geranyl acetate (3%), borneol (3%), α-terpineol (2.75%), trans-caryophyllene (2%), α-pinene (2%), γ-terpinene (1.5%), p-cymene (1.5%). The V.O. comprises several sesquiterpenes as bisabolane up to (25%): α-bisabolol (8%), isomer bisabolol (12.6%) and β-bisabolenal (2%).

Table 6: Chromatography profile showing major components of volatile oil of Hypericum thymifolium

<table>
<thead>
<tr>
<th>E.O. Standards *</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  (1R)-(+)α-Pinene</td>
<td>2.00</td>
</tr>
<tr>
<td>2  β-Pinene</td>
<td>5.50</td>
</tr>
<tr>
<td>3  β-Mycene</td>
<td>0.50</td>
</tr>
<tr>
<td>4  (R)-(+) Limonene</td>
<td>6.00</td>
</tr>
<tr>
<td>5  1,8-Cineole: Eucalyptol</td>
<td>0.75</td>
</tr>
<tr>
<td>6  γ-Terpinene</td>
<td>1.50</td>
</tr>
<tr>
<td>7  para-Cymene</td>
<td>1.50</td>
</tr>
<tr>
<td>8  Isomenthone</td>
<td>0.20</td>
</tr>
<tr>
<td>9  Camphor</td>
<td>0.30</td>
</tr>
<tr>
<td>10 (-)-Linalool</td>
<td>0.10</td>
</tr>
<tr>
<td>11 Linalyl acetate</td>
<td>3.30</td>
</tr>
<tr>
<td>12 α-Caryophyllene</td>
<td>2.00</td>
</tr>
<tr>
<td>13 (-)-Myrtenal</td>
<td>0.15</td>
</tr>
<tr>
<td>14 (+)-Menthol</td>
<td>1.50</td>
</tr>
<tr>
<td>15 Monoterpene</td>
<td>1.15</td>
</tr>
<tr>
<td>16 Borneol</td>
<td>3.00</td>
</tr>
<tr>
<td>17 α-Terpineol</td>
<td>2.75</td>
</tr>
<tr>
<td>18 Monoterpene</td>
<td>2.30</td>
</tr>
<tr>
<td>19 Geranyl acetate</td>
<td>3.00</td>
</tr>
<tr>
<td>20 Anethole</td>
<td>0.50</td>
</tr>
<tr>
<td>21 Aldehyde</td>
<td>0.75</td>
</tr>
<tr>
<td>22 Geraniol</td>
<td>0.20</td>
</tr>
<tr>
<td>23 Not identified</td>
<td>1.85</td>
</tr>
<tr>
<td>24 Phytol</td>
<td>0.20</td>
</tr>
<tr>
<td>25 Thymol</td>
<td>18.5</td>
</tr>
<tr>
<td>26 Carvacrol</td>
<td>1.50</td>
</tr>
<tr>
<td>27 α-Bisabolol</td>
<td>8.00</td>
</tr>
<tr>
<td>28 Isomer Bisabolol</td>
<td>12.6</td>
</tr>
<tr>
<td>29 β-Bisabolenal</td>
<td>2.00</td>
</tr>
<tr>
<td>30 Farnesol</td>
<td>0.50</td>
</tr>
<tr>
<td>31 Trans-trans- Farnesol</td>
<td>0.75</td>
</tr>
<tr>
<td>Totals Components</td>
<td>81</td>
</tr>
</tbody>
</table>

* E.O.: Essential Oil
Hydrodistillation; Flowering top leaf

The results of the antimicrobial activity of Hypericum oil extract are:
Gram Positive bacteria (Table 7).
* Staphylococcus aureus: With any concentration of Ht extract, the inhibition was complete and definitive after 24 h of contact.
* Streptococcus group D: 770 bacteria were inhibited after 1 h of contact with 5µl of Ht extract. The inhibition was complete and definitive after 24 h of contact with 20µl of Ht.
Table 7: No. of Gram-Positive bacteria remaining after inhibition tests with hypericum oil extract (Ht oil).

<table>
<thead>
<tr>
<th>Bacteria G(+)</th>
<th>5 µl</th>
<th>10 µl</th>
<th>20 µl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>10'</td>
<td>1h</td>
<td>24h</td>
</tr>
<tr>
<td>Staphylo. Aureus</td>
<td>10⁻¹</td>
<td>57</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>10⁻²</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>12 x 10⁶/ml</td>
<td>10⁻³</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>10⁻⁴</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Streptococcus fecalis</td>
<td>10⁻¹</td>
<td>100</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>10⁻²</td>
<td>42</td>
<td>13</td>
</tr>
<tr>
<td>77 x 10⁶/ml</td>
<td>10⁻³</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>10⁻⁶</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

h.g. = high growth.

Gram Negative bacteria (Table 8).
A bacteriostatic effect was demonstrated in relation to the time of contact and the concentration of Hypericum thymifolium extract against Escherichia coli, Salmonella typhi and Pseudomonas aeruginosa.

* E. coli, 0:157, H7 (resistant bacteria isolated from a hospitalized patient).
  Seventy-four bacteria were inhibited with 5µl of Ht extract after one hour of contact; and 740 were inhibited after 1h of contact with 20µl of Ht.

* Salmonella typhi, 0:9.12,Vi-H:d. Growth was inhibited after 1h of contact with 5µl of Ht extract; 180 bacteria were inhibited after 1h of contact with 10µl of Ht extract and with 20µl, the inhibition of 1800 bacteria was complete after 24h.

* Pseudomonas aeruginosa, (resistant bacteria). Only 37 bacteria were inhibited after 1h of contact at any Ht extract concentration, and with 10µl of Ht extract the inhibition was complete after 10 minutes of contact.

Table 8: No. of Gram Negative bacteria remaining after the inhibition tests with hypericum oil extract (Ht oil)

<table>
<thead>
<tr>
<th>Bacteria G(-)</th>
<th>5 µl</th>
<th>10 µl</th>
<th>20 µl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>10'</td>
<td>1h</td>
<td>24h</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>10⁻¹</td>
<td>240</td>
<td>300</td>
</tr>
<tr>
<td>74 x 10⁶/ml</td>
<td>10⁻²</td>
<td>37</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>10⁻³</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>10⁻⁶</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>10⁻¹</td>
<td>200</td>
<td>190</td>
</tr>
<tr>
<td>37 x 10⁶/ml</td>
<td>10⁻²</td>
<td>36</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>10⁻³</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>10⁻⁶</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Salmonella typhi.</td>
<td>10⁻¹</td>
<td>200</td>
<td>h.g.</td>
</tr>
<tr>
<td>18 x 10⁶/ml</td>
<td>10⁻²</td>
<td>25</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>10⁻³</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>10⁻⁶</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

* h.g. = high growth
**Candida albicans** (Table 9).
The inhibition was total and definitive after 10 minutes with 20 µl of *Ht* extract.

<table>
<thead>
<tr>
<th>Yeast</th>
<th>Ht oil</th>
<th>5 µl</th>
<th>10 µl</th>
<th>20 µl</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
<td>10'</td>
<td>1h</td>
<td>24h</td>
</tr>
<tr>
<td>Candida albicans</td>
<td>10⁻³</td>
<td>50</td>
<td>37 h.g.</td>
<td>29 24 h.g.</td>
</tr>
<tr>
<td></td>
<td>10⁻⁴</td>
<td>6</td>
<td>4 h.g.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>10⁻⁵</td>
<td>1</td>
<td>1 h.g.</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>10⁻⁶</td>
<td>0</td>
<td>0 1200</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 9: No. of Yeast (*Candida albicans*) remaining after the inhibition tests with hypericum oil extract (*Ht* oil)

The Minimum Inhibitory Concentration (Table 10) is evaluated as the minimal volume of the *Ht* extract capable of inhibiting the greatest quantity of germs in a minimum of time: Number of Bacteria were inhibited *E. coli* (740), *Salmonella* (1 800), *Pseudomonas* (37 000), *Staphylococcus aureus* (117) and *Streptococcus fecalis* (770) by 5µl of hypericum essential oil within 1hour. Less number was inhibited by higher concentration of antibiotics Sulphamethoxazole 25µg (281), Chloramphenicol 30µg (91), resistant, Sulphamethoxazole 25µg (137), and Sulphamethoxazole 25µg (211), respectively and after 24 hours.

Table 10: Efficiency of essential oil of *Hypericum thymifolium* against bacterial contaminants. Minimum Inhibitory Concentration, (MIC) showing the number of inhibited bacteria.

<table>
<thead>
<tr>
<th>Germs</th>
<th>Duration of contact</th>
<th>No of inhibited Germs by oil</th>
<th>V.O. Con/µl</th>
<th>Antibiotic Concentration/µg</th>
<th>No of inhibited Germs by AB</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli</em></td>
<td>1h</td>
<td>740</td>
<td>5</td>
<td>Sulphamethoxazol25</td>
<td>281</td>
</tr>
<tr>
<td><em>Salmonella typhi</em></td>
<td>1h</td>
<td>1 800</td>
<td>5</td>
<td>Chloramphenicol 30</td>
<td>91</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>1h</td>
<td>37 000</td>
<td>5</td>
<td>Resistant</td>
<td>23</td>
</tr>
<tr>
<td><em>Staphylo. aureus</em></td>
<td>10'</td>
<td>12 000</td>
<td>5</td>
<td>Sulphamethoxazol25</td>
<td>137</td>
</tr>
<tr>
<td><em>Strepto. fecalis</em></td>
<td>10'</td>
<td>77 0000</td>
<td>5</td>
<td>Sulphamethoxazol25</td>
<td>211</td>
</tr>
</tbody>
</table>

**Ferula hermonis**
The steam distillation of roots and seeds of (*Fh*) gave a significant yield: 0.5% of essential oil. It has strong smells exuding sometimes small quantities of an orangish resin. The components were identified using Gas Chromatography, by comparing retention times, with those of standards of pure essential oil. A chromatography profile of the essential oil was obtained (Table 11). It is very obvious that flowering top and roots are very rich, where their essential oil comprises about 78 and 71 components respectively, only 32 were identified. A predominance of α-pinene was noticed in the case of flowering top and roots were this component showed the highest area percentage amongst all the others: 38% and 31% respectively. Other 3 major components were identified: carvacrol (5.50%), linalyl acetate (16.0%) and 1,8-cineole (6.0%). The presence of sesquiterpen hydrocarbon was also detected. This was in fact previously proven to exist in the *Ferula hermonis* crude extracts (Galal, 2000) (Galal et al. 2000). On the other hand, in the case of seeds’ essential oil, only 3 components were shown, but high in quantity: the α-pinene (51.3%), B-pinene (42.5%) and camphene (6.2%).
Table 11: Chromatography Profile of *Ferula hermonis* Boiss. (Comparison between E.O. of fresh flowering tops, roots & seeds)

<table>
<thead>
<tr>
<th><em>E.O. Standards</em></th>
<th>E.O. Flowering Top</th>
<th>E.O. Roots</th>
<th>E.O. Seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 <em>α</em>- Pinene</td>
<td>38.0</td>
<td>31.0</td>
<td>51.3</td>
</tr>
<tr>
<td>2 (-)- Camphene</td>
<td>0.50</td>
<td>0.20</td>
<td>6.2</td>
</tr>
<tr>
<td>3 <em>β</em>- Pinene</td>
<td>0.60</td>
<td>1.25</td>
<td>42.5</td>
</tr>
<tr>
<td>4 Sabinene</td>
<td>2.00</td>
<td>1.60</td>
<td>-</td>
</tr>
<tr>
<td>5 <em>β</em>- Myrcene</td>
<td>1.10</td>
<td>0.70</td>
<td>-</td>
</tr>
<tr>
<td>6 <em>α</em>- Terpinene</td>
<td>-</td>
<td>1.20</td>
<td>-</td>
</tr>
<tr>
<td>7 (+) Limonene</td>
<td>2.50</td>
<td>1.50</td>
<td>-</td>
</tr>
<tr>
<td>8 1,8- Cineole</td>
<td>1.50</td>
<td>6.00</td>
<td>-</td>
</tr>
<tr>
<td>9 Verbenol</td>
<td>1.00</td>
<td>0.30</td>
<td>-</td>
</tr>
<tr>
<td>10 <em>γ</em>- Terpinene</td>
<td>0.50</td>
<td>2.50</td>
<td>-</td>
</tr>
<tr>
<td>11 P- Cymene</td>
<td>0.40</td>
<td>0.70</td>
<td>-</td>
</tr>
<tr>
<td>12 (+)- Fenchone</td>
<td>0.05</td>
<td>0.65</td>
<td>-</td>
</tr>
<tr>
<td>13 (+) - α- Thujone</td>
<td>0.10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14 (+) - Menthone</td>
<td>-</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>15 Camphor</td>
<td>-</td>
<td>0.50</td>
<td>-</td>
</tr>
<tr>
<td>16 (-)- Linalool</td>
<td>0.50</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>17 Linalyl acetate</td>
<td>1.00</td>
<td>16.0</td>
<td>-</td>
</tr>
<tr>
<td>18 <em>α</em>- Caryophyllene</td>
<td>0.20</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>19 (-)- Myrtenal</td>
<td>-</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>20 (+)- Menthol</td>
<td>0.10</td>
<td>0.15</td>
<td>-</td>
</tr>
<tr>
<td>21 (±)- Lavandulol</td>
<td>2.50</td>
<td>4.50</td>
<td>-</td>
</tr>
<tr>
<td>22 <em>α</em>- Terpineol</td>
<td>0.15</td>
<td>0.20</td>
<td>-</td>
</tr>
<tr>
<td>23 Bornol</td>
<td>1.50</td>
<td>2.50</td>
<td>-</td>
</tr>
<tr>
<td>24 Geranyl acetate</td>
<td>2.20</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>25 Citronellol</td>
<td>0.06</td>
<td>3.20</td>
<td>-</td>
</tr>
<tr>
<td>26 Nerol</td>
<td>-</td>
<td>0.10</td>
<td>-</td>
</tr>
<tr>
<td>27 Anethole</td>
<td>1.20</td>
<td>0.15</td>
<td>-</td>
</tr>
<tr>
<td>28 Geraniol</td>
<td>0.07</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>29 Thymol</td>
<td>0.08</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td>30 Carvacrol</td>
<td>5.50</td>
<td>3.15</td>
<td>-</td>
</tr>
<tr>
<td>31 <em>α-</em> Bisabolol</td>
<td>0.75</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>32 Trans- Farnesol</td>
<td>0.85</td>
<td>0.06</td>
<td>-</td>
</tr>
<tr>
<td>Totals Components</td>
<td>78</td>
<td>71</td>
<td>3</td>
</tr>
</tbody>
</table>

*E.O.: (Essential Oil)*

The results of the antimicrobial activity

Gram-positive bacteria (Table 12).

**Staphylococcus aureus**: Roots oil extract showed a considerable effect on *S. aureus* growth since the first 10 minutes of contact as it is shown by the very important reduction in bacterial counts when comparing with the initial ones obtained without any addition of extract. The effect was dose dependent; a growing effect was registered after 10’ of contact at $10^3$ bacterial concentration when the dose was increased; same for the other bacterial concentrations at the various times of contact. A total inhibition of 550 bacteria/ml and 5500 bacteria/ml was first reached with $5\mu$g/ml and $10\mu$g/ml respectively of roots oil extract concentration after 24 hours of contact. The effect of *(Fh)* seed oil extract on *Staphylococcus aureus* growth was also dose dependent and started since the first 10 minutes of contact. With $50\mu$g/ml seed oil extract concentration a total inhibition of 550 bacteria/ml started after 1 hour and 5500 bacteria/ml after 18 hours of contact.
Table 12: Number of Gram Positive Bacteria remaining after inhibition test of *Ferula hermonis* roots and seeds essential oil.

<table>
<thead>
<tr>
<th>Time</th>
<th>0'</th>
<th>10'</th>
<th>1h</th>
<th>24h</th>
<th>0'</th>
<th>10'</th>
<th>24h</th>
<th>0'</th>
<th>10'</th>
<th>24h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fh roots essential oil</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5μl</td>
<td>10μl</td>
<td>50μl</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staphylo. aureus:</td>
<td>5500</td>
<td>1200</td>
<td>420</td>
<td>30</td>
<td>130</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5.5x10^6/ml</td>
<td>550</td>
<td>35</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Strepto. fecalis:</td>
<td>16000</td>
<td>h.g.</td>
<td>900</td>
<td>230</td>
<td>h.g.</td>
<td>0</td>
<td>0</td>
<td>1540</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>16x10^6/ml</td>
<td>1600</td>
<td>1430</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

| **Fh seeds essential oil** | | | | | | | | | | |
| Staphylo. aureus: | 5500 | 1300 | h.g. | 100 | 280 | h.g. | 17 | 10 | 0 | 0 |
| 5.5x10^6/ml | 550 | 545 | 250 | 20 | 250 | 40 | 16 | 5 | 0 | 0 |
| Strepto. fecalis: | 16000 | h.g. | h.g. | 1500 | h.g. | h.g. | 620 | h.g. | h.g. | 158 |
| 16x10^6/ml | 1600 | 1600 | 1300 | 540 | 1452 | 1240 | 20 | 1400 | 1230 | 0 |

**Streptococcus fecalis:** The effect of (*Fh*) roots oil extract on *Streptococcus fecalis* growth is also dose dependent. With 5μg/ml and 10μg/ml roots oil extract concentration, 1600 and 16,000 bacteria/ml were respectively inhibited after 1hour of contact. Seed oil extract had nearly no effect, at all of the bacterial dilutions, at the first 10' of contact with the three bacterial concentrations used, but it showed dose dependent effect. Total inhibition was first reached after 24 hours of contact of 160 bacteria/ml with 5 and 10μg/ml seed oil extract concentration.

Gram-negative bacteria (Table 13).

**Salmonella typhi:** The effect of (*Fh*) roots oil extract on *Salmonella typhi* growth was dose dependent: a growing effect was registered after 10 minutes of contact at all bacterial concentration when the dose was increased and at the various times of contact. Total inhibition was first reached after 1 hour of contact of 240 and 24,000 bacteria /ml with 5 and 50μg/ml respectively. The effect of (*Fh*) seed oil extract on *Salmonella typhi* growth was dose dependent: a growing effect was registered after 10' of contact at all bacterial concentration when the dose was increased and at the various times of contact. With 10μg/ml and 50μg/ml seed oil extract concentration, 2400 and 24,000 bacteria/ml was inhibited after 24 hours of contact.

**Escherichia coli:** Once again the effect of (*Fh*) roots oil essential oil on *Escherichia coli* growth was dose dependent. With 5 and 10μg/ml roots oil extract concentration, the only effect registered was a bacteriostatic one. After 24 and 1hour of contact with 50μg/ml roots oil extract concentration, 15,300 and 1530 bacteria/ml were inhibited respectively. With 10μg/ml grain essential oil concentration, total inhibition of 153 bacteria /ml was first reached after 24 hours of contact; and with 50μg/ml seed oil essential oil concentration, total inhibition of 15,300 bacteria/ml started after 24 hours of contact.

**Pseudomonas aeruginosa:** The effect of (*Fh*) roots oil extract on *Pseudomonas aeruginosa* growth was dose dependent. Roots oil extract had nearly no effect, at all of the bacterial dilutions, at the first 10' of contact, with the three concentrations, same for after one hour of contact. Total inhibition was reached after 24 hours. With 50μg/ml seed oil extract concentration, 3300 bacteria/ml were inhibited after 24 hours of contact.
Table 13: Number of Gram-negative Bacteria remaining after inhibition test with *Ferula hermonis* essential oil

<table>
<thead>
<tr>
<th>Time</th>
<th>0'</th>
<th>10'</th>
<th>1h</th>
<th>24h</th>
<th>10'</th>
<th>1h</th>
<th>24h</th>
<th>10'</th>
<th>1h</th>
<th>24h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fh roots essential oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salmonella typhi: 24x10^6/ml</td>
<td>24000</td>
<td>500</td>
<td>420</td>
<td>120</td>
<td>430</td>
<td>389</td>
<td>0</td>
<td>224</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2400</td>
<td>18</td>
<td>13</td>
<td>0</td>
<td>17</td>
<td>10</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>240</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. coli: 15.3x10^6/ml</td>
<td>15300</td>
<td>h.g.</td>
<td>h.g.</td>
<td>h.g.</td>
<td>h.g.</td>
<td>83</td>
<td>1440</td>
<td>1000</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1530</td>
<td>1560</td>
<td>1566</td>
<td>h.g.</td>
<td>824</td>
<td>24</td>
<td>6120</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>153</td>
<td>156</td>
<td>306</td>
<td>h.g.</td>
<td>127</td>
<td>81</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudo. aeruginosa: 33 x 10^6/ml</td>
<td>330</td>
<td>h.g.</td>
<td>h.g.</td>
<td>78</td>
<td>h.g.</td>
<td>h.g.</td>
<td>56</td>
<td>h.g.</td>
<td>h.g.</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>330</td>
<td>380</td>
<td>300</td>
<td>89</td>
<td>360</td>
<td>264</td>
<td>0</td>
<td>310</td>
<td>230</td>
<td>0</td>
</tr>
<tr>
<td>Fh seeds essential oil</td>
<td>33</td>
<td>34</td>
<td>30</td>
<td>0</td>
<td>31</td>
<td>29</td>
<td>0</td>
<td>28</td>
<td>30</td>
<td>0</td>
</tr>
</tbody>
</table>

h.g: high growth

The minimum inhibitory concentration (Table 14)
A comparison between (*Fh*)’s various extracts anti-microbial activity and the antibiogram with usual antibiotic’s discs after 24 hours of contact was done in order to evaluate the efficiency of the extract. The Ciprofloxacine (Cip) showed the highest efficiency, among the other antibiotics used, against the studied germs except for *Streptococcus fecalis* where the highest efficiency was for the Ampicilline.

Table 14: Count of germs that were inhibited by various antibiotics discs and *Ferula hermonis* oil extracts. Minimum Inhibition Concentration, (MIC) showing the number of inhibited bacteria.

<table>
<thead>
<tr>
<th>Germs / ml</th>
<th>Antibiotics</th>
<th>Concentration</th>
<th>Staphylococcus aureus 550/ml</th>
<th>Strepto. fecalis 1600/ml</th>
<th>Salmonella typhi 240/ml</th>
<th>Escherichia coli 1530/ml</th>
<th>Pseudo. aeruginosa 330/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gentamycine GN</td>
<td>(10μg)</td>
<td>5</td>
<td>69</td>
<td>22</td>
<td>101</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Kanamycine K</td>
<td>(30μg)</td>
<td>13</td>
<td>13</td>
<td>22</td>
<td>101</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Chloramphenicol C</td>
<td>(30μg)</td>
<td>41</td>
<td>167</td>
<td>30</td>
<td>213</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Nalidixic acid NA</td>
<td>(30μg)</td>
<td>0</td>
<td>0</td>
<td>22</td>
<td>163</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Ciprofloxacine Cip</td>
<td>(5μg)</td>
<td>41</td>
<td>87</td>
<td>38</td>
<td>230</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Ampicilline Amp</td>
<td>(10μg)</td>
<td>30</td>
<td>194</td>
<td>26</td>
<td>92</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Streptomycin S</td>
<td>(10μg)</td>
<td>24</td>
<td>0</td>
<td>5</td>
<td>75</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(<em>Fh</em>) Roots essential oil</td>
<td>5μg/ml</td>
<td>550</td>
<td>1600</td>
<td>240</td>
<td>1530</td>
<td>141</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10μg/ml</td>
<td>550</td>
<td>1600</td>
<td>240</td>
<td>1530</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50μg/ml</td>
<td>550</td>
<td>1600</td>
<td>240</td>
<td>1530</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td>(<em>Fh</em>) Seeds essential oil</td>
<td>5μg/ml</td>
<td>530</td>
<td>1600</td>
<td>240</td>
<td>1530</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10μg/ml</td>
<td>530</td>
<td>1600</td>
<td>240</td>
<td>1530</td>
<td>330</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50μg/ml</td>
<td>550</td>
<td>1600</td>
<td>240</td>
<td>1530</td>
<td>330</td>
</tr>
</tbody>
</table>

The Minimum Inhibition Concentration.

*Staphylococcus aureus*: The highest efficiency among the anti-microbial discs used was equal for the Ciprofloxacine 5μg and for the Chloramphenicol 30μg where 41 germs out of 550 were killed.
**Streptococcus fecalis:** The highest efficiency among the anti-microbial discs used was for the Ampiciline 10μg where 194 germs out of 1600 were killed.

**Salmonella typhi:** The highest efficiency among the anti-microbial discs used was for the Ciprofloxacine 5μg where 38 germs out of 240 were killed.

**Escherichia coli:** The highest efficiency among the anti-microbial discs used was for the Ciprofloxacine 5μg where 230 germs out of 1530 were killed.

**Pseudomonas aeruginosa:** The highest efficiency among the anti-microbial discs used was once again for the Ciprofloxacine 5μg where 55 germs out of 330 were killed.

It is obvious that the anti-bacterial activity of *Ferula hermonis* strongly exceeds that of usual antibiotics. For gram- positive bacteria the comparison between the effects of the three types of extracts and that of the most effective antibiotic disc used, showed that the highest effect was for the roots oil extract, where at the three times of application the highest number of germs were inhibited at the three concentrations used. (Total inhibition of 5500 and 16,000 germs of *Staphylococcus aureus* and *Streptococcus fecalis* respectively). The final scope of this study being to establish the most effective combination: extract type- concentration – time of application; where the highest number of inhibited germs is obtained with the lowest dose of extract at the shortest period of time, in this case the most effective combination would be:  
*Staphylococcus aureus:* Roots oil extract– 50μg/ml– 10 minutes (total inhibition of 6000 germs)  
*Streptococcus fecalis:* Roots oil extract- 10μg/ml– 1hour (total inhibition of 16,000 germs)

**Conclusion**

In general, the medicinal plants in Lebanon are a squandered wealth, badly preserved and badly exploited. The proper exploitation of this agricultural richness could be beneficial at the industrial and pharmaceutical level. The results have demonstrated a bacteriolytic effect of the sage oil on a number of gram (+) germs and a bacteriostatic effect on some gram (-) germs. When tested on *Pseudomonas aeruginosa, E. coli, Salmonella typhi* bacteria, the inhibition is visible only after one hour of contact with sage oil, after that, the bacterial multiplication resumes in a normal way. Total inhibition lasting between 10’ and one hour on germs like *Staphylococcus, Streptococcus* and *Candida albicans* was observed when bearing a low concentration. The sage oil exhibited a better efficiency than the commercialized antibiotics, especially against resistant germs to antibiotics.

*Hypericum thymifolium* is rich in essential oil. The study demonstrated anti-bacterial activity; the extract has a bacteriolytic effect on a number of gram (+) bacteria, and bacteriostatic effect on some gram (-) bacteria. This compound showed significant inhibitory activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*, and was found to be more effective than Sulphamethoxazole. *Hypericum thymifolium* extract at low concentration showed greater efficiency than commercial antibiotics.

*Ferula hermonis* Boiss., the endemic plant of mount Hermon is a very aromatic one, specially its roots that are known to exhibit exotic smells. In fact the essential oil’s profile of *Ferula hermonis* roots was shown to be very rich in components. The evaluation of (*Fh*) extract proves its anti-bacterial properties, strongly exceeding that of usual antibiotics. The carvacrol, thymol and the sesquiterpen hydrocarbon present in this plant prove to exhibit such activity (Jay, 1999), (Galal, *et al.* 2000). Hence *Ferula hermonis*, besides its established fame as an aphrodisiac, possesses two major biological activities: an anti-bacterial and probably anti-oxidant. These properties are the result of the presence of some secondary metabolites and for their utilization on an industrial scale.
References
Pharmacopée Européenne. 1989 Neuvième éditions. 6. 30. 3.
Wild Species with Medicinal Uses in Aarsal, Nabha, Ham and Maaraboun: Indigenous Knowledge and Plant Characteristics

R. Assi1, W. Khouri1, S. Kanaan2, A. Nassar3, S. Bsat1, M. Monzer1, N. Chamoun1, and M. Yazbeck1

1 Agrobiodiversity Project, Lebanon Agricultural Research Institute, Lebanon
2 American University of Beirut, Lebanon
3 International Center for Agricultural Research in the Dry Areas – Terbol Station, Lebanon

Keywords: Medicinal plants, indigenous knowledge, uses, Lebanon.

Abstract
The use of medicinal and herbal plants in Lebanon goes back thousands of years and forms an important element for the medical remedies and the livelihood of the rural communities. Unfortunately, medicinal plants are increasingly threatened by various environmental and socio-economic factors. At the same time, traditional and indigenous knowledge about these plants is weakening and in many cases disappearing.

The GEF/UNDP Project on “Conservation and Sustainable Use of Dryland Agrobiodiversity in Lebanon”, which is executed by the Lebanese Agriculture Research Institute, has a major study component dealing with promoting the conservation of local agrobiodiversity using alternative sources of income in the project target area (villages of Aarsal, Nabha, Ham and Maaraboun), of which the use of wild species for medicinal values is an important aspect. Accordingly, a survey was conducted to collect the indigenous knowledge on the uses of medicinal plants in the target area. Several plants with potential medicinal use were collected, preserved in the form of herbaria, photographed and catalogued. Seeds of most of these plants were also collected and data on plant characterization was recorded at the ICARDA Terbol experiment station. The potential for their domestication and cultivation is on-going.

Introduction
The use of medicinal and herbal plants in Lebanon goes back thousands of years and forms an important element in the health and for the livelihood of its rural communities. Unfortunately, medicinal plants are increasingly threatened by various environmental and socio-economic problems. At the same time, traditional and indigenous knowledge about these plants is weakening and in many cases disappearing. The GEF/UNDP Project on “Conservation and Sustainable Use of Dryland Agrobiodiversity in Lebanon”, which is executed by the Lebanese Agriculture Research Institute (LARI), has a major study component dealing with promoting alternative sources of income in the project target area (villages of Aarsal, Nabha, Ham and Maaraboun), of which the use of wild species for medicinal purposes is an important part.

Overview of the project sites
The project is active in the drylands of the Baalbeck Caza, Bekaa valley, in three main sites, namely Ham/Maaraboun, Aarsal, and Nabha. They have been identified based on the presence and genetic diversity of landraces and wild relatives of crops native to the region as well as on the willingness of local communities to participate in the implementation of conservation activities of the agrobiodiversity project.
Aarsal is located in the northeastern area of the Bekaa, 180 km from Beirut, with an altitude ranging from 1,400 m to 2,600 m. It is among the most arid areas in Lebanon (average 250 mm annual rainfall). Its estimated area is 360 km²; i.e. about 5% of Lebanon’s overall area. Aarsal owns the largest herd of small ruminants (goats & sheep) in Lebanon. In addition, Aarsal has a wide variety of crops such as fruit trees (apricot, cherry), wheat, barley, etc., as well as plants with medicinal values.

The second site includes the villages of Ham and Maaraboun, which are located at the foot of the western slope of the Lebanese Eastern mountain chains, south of Baalbeck, at an altitude ranging from 1,400 m to 2,200 m with an annual rainfall estimated at 400-500 mm. This region is very rich in its flora, with plants adapted to dry conditions, particularly those with medicinal uses. The region is also known for apiculture and honey production.

The third site is the village of Nabha located at the foot of the Lebanese Western mountain chain, connecting with the Bekaa valley west of Baalbeck, at an altitude ranging between 950 m and 1,900 m above sea level and an annual rainfall estimated at 350-450 mm (lowlands) and 500-700 mm (highlands). Three surrounding villages, Al-Harfoush, Kalila, and Al-Kouddam, are considered geographically, environmentally, socially, and economically part of Nabha. The region of Nabha is known for its richness in edible and medicinal wild plants, as well as wild fruit trees, such as wild almonds, plums, pistachio, pears, etc.

**Description of the plants with medicinal potential**

A survey was conducted to collect the indigenous knowledge on the uses of medicinal plants in the target area. Accordingly, several plants with potential medicinal use were collected, photographed and preserved in the form of herbaria. Seeds of most of these plants were also collected, planted at the International Center for Agriculture Research in the Dry Areas, Terbol station (Bekaa, Lebanon), with the support of the Agrobiodiversity Project. Characterization was done for species planted at Terbol station. The following are the observations as well as the information on the indigenous knowledge related to the medicinal uses of 13 species collected from the project sites (Table 1). Professional photos of these medicinal species are included in a CD produced by the Lebanese Component of the dryland agrobiodiversity project.

**Acknowledgments**

The authors would like to thank GEF-UNDP for their financial support, ICARDA for their technical backstopping and the Lebanese Agriculture Research Institute for the in-kind contribution and technical assistance as well as the local communities for their cooperation and contribution.

Table 1: Plants species with potential medicinal use
<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Life Cycle (A: Annual P: Perennial B: Biennial)</th>
<th>Altitude (m)</th>
<th>% Germination</th>
<th>Average Plant height* (cm)</th>
<th>Days to Flowering**</th>
<th>Flowering Period</th>
<th>Seed Weight (g/100 seeds)</th>
<th>Seed Yield (g/plant)</th>
<th>Indigenous Knowledge on Medicinal Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Achillea aleppica</em></td>
<td>Kayssoum / Kaf Mariam / Assabé'e Al-Arouss</td>
<td>P</td>
<td>1214-1530</td>
<td>100</td>
<td>48</td>
<td>118-132</td>
<td>April - May</td>
<td>0.021</td>
<td>20.5</td>
<td>Alleviates menstrual cramps and pain also helps in reducing the sugar level of diabetic patients. Method: the whole plant is boiled to make an infusion.</td>
</tr>
<tr>
<td><em>Achillea bieberstenii</em></td>
<td>Ghada</td>
<td>P</td>
<td>1653</td>
<td>95-100</td>
<td>39</td>
<td>128</td>
<td>April - May</td>
<td>0.038</td>
<td>21</td>
<td>Alleviates intestinal cramps and pain helps in digestion after heavy meals. It also helps in treating diabetes. Method: the whole plant is boiled to make an infusion.</td>
</tr>
<tr>
<td><em>Achillea santolina</em></td>
<td>Barweh</td>
<td>P</td>
<td>1415</td>
<td>100</td>
<td>25</td>
<td>136</td>
<td>April - May</td>
<td>0.026</td>
<td>1.7</td>
<td>Alleviates intestinal cramps and pain helps in digestions after heavy meals. Method: the whole plant is boiled to make an infusion.</td>
</tr>
<tr>
<td><em>Astragalus deinacanthus</em></td>
<td>Atate</td>
<td>P</td>
<td>1280-1734</td>
<td>10-25</td>
<td>13 -</td>
<td></td>
<td>April - May</td>
<td>0.84</td>
<td>2</td>
<td>Alleviates prostate conditions, pain and renal calculus. Method: the whole plant including the hairy pods is boiled to make an infusion. The roots are crushed and then boiled in water.</td>
</tr>
<tr>
<td><em>Fibigea clypeata</em></td>
<td>Hashishet al-Bole</td>
<td>P</td>
<td>1466-1653</td>
<td>100</td>
<td>32</td>
<td></td>
<td>March - April</td>
<td>0.3</td>
<td>14</td>
<td>Alleviates urinary tract pains and eliminates calculus. Method: the whole plant is boiled to make an infusion.</td>
</tr>
<tr>
<td><em>Hyssopus officinalis</em></td>
<td>Zoufa</td>
<td>P</td>
<td>1249-1530</td>
<td>40-100</td>
<td>32</td>
<td>132</td>
<td>May – June</td>
<td>0.016</td>
<td>4</td>
<td>Cures common colds and coughing. Method: the whole plant is boiled.</td>
</tr>
<tr>
<td><em>Unidentified</em></td>
<td>Khamseh</td>
<td>P</td>
<td>1265-1558</td>
<td>5-15</td>
<td>70</td>
<td>182-189</td>
<td>May - July</td>
<td>0.77</td>
<td>11</td>
<td>Eliminates skin necrotic problems &amp; Eczema. Method: the leaves and green stems are crushed and applied on the skin area then treated for 10-20 minutes.</td>
</tr>
<tr>
<td><em>Lagoecia cuminoidis</em></td>
<td>Hashishet al-Dahab</td>
<td>A</td>
<td>1056-1558</td>
<td>100</td>
<td>20</td>
<td>104-112</td>
<td>April - June</td>
<td>0.047</td>
<td>-</td>
<td>Treats the white part of the eyes in cases of infections. Method: the plant is boiled and used as eye-drops.</td>
</tr>
<tr>
<td><em>Marrubium vulgare</em></td>
<td>Hashishet al-Nafâ’a Aarak Al Boul (Aarsal) / Khouzam</td>
<td>P</td>
<td>1379-1671</td>
<td>5-50</td>
<td>50</td>
<td></td>
<td>April - May</td>
<td>0.11</td>
<td>50</td>
<td>Alleviates intestinal cramps and pain helps in digestions after heavy meals. Also used to treat throat infections. Method: the whole plant is boiled to make an ointment to be applied on the nipples of lactating mothers.</td>
</tr>
<tr>
<td>(Ham)</td>
<td>Species</td>
<td>Common Name</td>
<td>Hardiness</td>
<td>Bloom Time</td>
<td>Height</td>
<td>Anti-microbial Activity</td>
<td>Method</td>
<td>Medicinal Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>-------------</td>
<td>-----------</td>
<td>------------</td>
<td>--------</td>
<td>------------------------</td>
<td>--------</td>
<td>---------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onosma sp.</td>
<td>Hawa Al Jouwani</td>
<td>B</td>
<td>1240-1590</td>
<td>Very Poor</td>
<td>April - June</td>
<td>3.6</td>
<td>106</td>
<td>Eliminates muscular edema and bloat. Method: the plant is macerated and placed on the surface to treat. To treat bloat, roots are boiled and consumed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanguisorba minor</td>
<td>Hashishet al-Rawaiya / Ballan</td>
<td>P</td>
<td>1466</td>
<td>100</td>
<td>58</td>
<td>April - May</td>
<td>0.55</td>
<td>37</td>
<td>Has impressive anti-mucolytic and anti-sneezing effects. Helps in treating Pulmonary infections &amp; Tuberculosis. Method: the whole plant is boiled. The plant is dried in a dark &amp; dry place then boiled in water then consumed 3 times.</td>
<td></td>
</tr>
<tr>
<td>Thymus sp.</td>
<td>Zaatar Barri</td>
<td>P</td>
<td>1690</td>
<td>55</td>
<td>26</td>
<td>June - July</td>
<td>0.11</td>
<td>1</td>
<td>Alleviates stomach cramps. Method: The whole plant is boiled to an infusion.</td>
<td></td>
</tr>
<tr>
<td>Turgenia latifolia</td>
<td>Otrob</td>
<td>A</td>
<td>1193-1658</td>
<td>50-95</td>
<td>April - May</td>
<td>3.45</td>
<td>-</td>
<td>Helps in eliminating renal calculus. Method: the whole plant is boiled and consumed at the rate of 2-3 cups/day for 7-10 days.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* For all perennial plants, the plant height was recorded during the plants’ second life cycle
**From time of planting
SESSION SEVEN

PUBLIC AWARENESS ACTIONS FOR PROMOTING AGROBIODIVERSITY CONSERVATION
Public Awareness: A Tool for Promoting the Conservation of Agricultural Biodiversity

R. Raymond$^1$ and Rami Khalil$^2$

$^1$Head, Public Awareness Research and Support Unit, International Plant Genetic Resources Institute (IPGRI), Via dei Tre Denari 472/1, 00057 Maccarese, Rome, Italy. Email: r.raymond@cgiar.org

$^2$Media and Public Awareness Officer, Regional office for CWANA for International Plant Genetic Resources Institute (IPGRI), r.khalil@cgiar.org

Keywords: Public awareness, agricultural biodiversity conservation, message, communications.

Abstract

In recent years, scientists and development specialists have started to recognize the need to convince ‘the unconverted’ of the value of their work. The factors influencing a growing appreciation of the value of public awareness include the world’s growing development challenges, the revolutionary potential of information to bring about large-scale change, and greater competition for fewer financial resources.

In particular, the phenomenal growth of the Internet over the past decade has not only made the world a much smaller place, it has also transformed us from a society of one-way information providers into a society of communicators that is based on open debate and exchange. At the same time, as the lines between national, regional and international development concerns have blurred, there have been greater incentives to seek common approaches to global problems. Multilateral approaches to problem solving are terrifically complex, hence the need for broad popular support for development activities—including the conservation and use of agricultural biodiversity—is particularly important.

Most recent international agreements concerned with agricultural biodiversity stress the important role that can be played by public awareness in promoting conservation and use. Agenda 21 devotes an entire chapter to the subject. The Convention on Biological Diversity also emphasizes the importance of public awareness. More recently, the Global Plan of Action for plant genetic resources, adopted in Leipzig, Germany in 1996 by 150 countries, identified public awareness as one of its 20 priority activities. But these international commitments to awareness raising have not altered the fact that the public is not really concerned about agricultural biodiversity. Only about 20% of the general public is even somewhat knowledgeable about science.

Public awareness is an important tool for mobilizing popular opinion and for generating and sustaining action and political and funding support within countries and globally. A targeted public awareness programme can promote the development of international linkages and collaborative mechanisms. Public awareness can facilitate efforts to involve communities and local and non-governmental organizations in plant genetic resources activities, thus ensuring a broader base for conservation.

Introduction

Many scientists are not very comfortable with public awareness. They don’t really see its usefulness. Perhaps they think it is slightly undignified. When I joined the International Plant
Genetic Resources Institute, (IPGRI) in 1987, I was the first full-time public awareness officer at any of the Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR). One of my first projects was a large media campaign involving journalists from 20 countries. The project was funded by the Italian government. I remember having some extremely difficult conversations with the Directors General and scientists working in the countries targeted by the project. They questioned the value of spending money that, in their minds could have gone to research, on a large scale communications exercise. How was that going to benefit the poor?

The recognition of the importance of public awareness by the Future Harvest situation has improved since then, although not dramatically. The communications budgets at the Centers is generally inadequate. Research budgets are inadequate as well. The two factors are not unrelated.

**Why bother with public awareness?**

Communications—or public awareness—is one of the most powerful tools in the scientist’s arsenal. The phenomenal growth of the Internet over the past decade has not only made the world much smaller place, it has also transformed us from a society of information providers into a society of communicators that is based on open debate and exchange. At the same time, as the lines between national, regional and international development concerns have blurred, there have been greater incentives to seek common approaches to global problems. The Millennium Development Goals represent huge challenges for the world. Meeting them will require complex multilateral solutions that in turn will require broad popular support. Raising awareness of the importance of development activities—including the conservation and use of agricultural biodiversity—is thus extremely important.

Public awareness can play a vital role in bringing about a change in behavior—or reinforcing positive behaviors—by changing people’s attitudes. Convincing people of the importance of agricultural biodiversity—for their health, their livelihoods, and their food security—is the first step towards convincing them to conserve and use that diversity. Public awareness can facilitate efforts to involve communities and local and non-governmental organizations in crop diversity activities, thus ensuring a broader base for conservation. The fact that crop diversity is at risk all over the world means that we haven’t been very successful in convincing farmers, policymakers and others who have the capacity and/or the influence to ensure that conservation and use decisions are made. We need to do better. Most recent international agreements concerned with agricultural biodiversity stress the important role that can be played by public awareness in promoting conservation and use. Agenda 21 devotes an entire chapter to the subject. The Convention on Biological Diversity also emphasizes the importance of public awareness. The Global Plan of Action for plant genetic resources, adopted in Leipzig, Germany in 1996 by 150 countries, identified public awareness as one of its 20 priority activities. However, these international commitments to awareness raising have not altered the fact that the public is not concerned about agricultural biodiversity. Only about 20% of the public is even somewhat knowledgeable about science.

Public awareness is the way to shape popular opinion and to generate and sustain action and political and funding support. The incredible success of grassroot efforts to bring about political change through campaigns conducted over the Internet suggests that an effective communications campaign could influence a massive change in people’s attitudes towards agricultural biodiversity. Above all, public awareness is about motivation. We use it to convince people to change their attitudes or
their behaviors. Whatever our communications goal, our messages must be summoning and clear. They must convince our audience that doing nothing is not an option. They must motivate, and specifically, motivate our audience to help us reach our goals.

**Identifying goals, audiences, messages**
The starting point for any public awareness campaign should be to ask the following questions:

- What do we hope to accomplish?
- Whose help do we need to accomplish our goal?
- What messages are most likely to compel them to help us?

Too often, people make the mistake of thinking that a nicely illustrated pamphlet or poster, distributed widely, can meet all of their communications needs. They don’t understand that the messages need to be tailored to the particular audience they wish to reach. And that target audience can only be identified once the goal of the awareness campaign is clear. For example, say your goal is to raise funds for your projects or programmes. That would mean that your target audience would include a range of potential donors. The messages you would craft for such donors should focus on how, by funding your work, they will be better able to meet their donor goals. Different donors have different donor goals and it’s a good idea to be aware of these in advance. Messages that focus on the benefits your work will bring to poor countries will not impress a donor whose main motivation for funding an initiative is self-interest. Framing your messages to align with the interests and values that donors care about—be it the Millennium Development Goals or ‘doing well by doing good’—should be central to any communications strategy targeting that audience.

In addition, there is one message that all donors will care about. It relates to your impact. Donors will expect you to prove to them how people’s lives (whether in their constituency or in poor countries depending on their donor goal) have changed as a result of your actions. Another set of messages, which will be particularly important for new donors, is that you are a responsible, professional partner and an expert in your line of work. Stressing your competence and professionalism will raise donor confidence in your ability to deliver.

There will be other audiences with whom you may wish to communicate over the lifetime of your programme. They include, for example, policymakers, your research partners, farming communities. It is important to know what these audiences care about and tailor your messages accordingly. In public awareness, one size (or poster or pamphlet) does not fit all!

**Selling the benefits of crop diversity**
The benefits of crop diversity are not well known, in part because we have not been very good at communicating them. We are used to communicating in a language of science. We feel comfortable using jargon and acronyms. But that will not help us reach most of our target audiences, who are indifferent to or suspicious of science. Simple, straightforward statements linking crop diversity to the things people care about are far more effective than complex arguments relying heavily on scientific shorthand. Put another way, to communicate the benefits of crop diversity, we need to put a human face on science.

*Some examples of effective crop diversity messages follow.*

800 million people go to bed hungry every night. Agriculture is the dominant sector of the economy in most poor countries. Agriculture in poor countries must be improved to end poverty and hunger.
Crop diversity is needed to breed improved varieties that:

- Increase yield and reduce vulnerability to crop pests and extreme climates
- Offer poor farmers options for new ‘high value’ varieties that increase incomes
- Are more nutritious, making a difference between malnutrition and health

One-sixth of the world's land area is degraded because of overgrazing and poor farming practices. Some 12 to 17 million acres of agricultural land are lost every year because of erosion and degradation. Crop diversity lessens the enormous burden of agriculture on the Earth’s natural resources through breeding varieties that:

- Use water—an increasingly scarce resource—more efficiently
- Use fertilizer more efficiently, reducing its polluting load on the environment
- Raise productivity, lessening the demand for new agricultural land. Improved varieties have already saved 600 million hectares of natural landscapes from being converted to farmland.
Project Actions to Enhance Community Participation in Agrobiodiversity Conservation

Y. Sbeih¹ and A. Amri²

¹ National Project Manager, the Palestinian Authority, UNDP/PAPP, Ministry of Agriculture, Ramallah, Palestinian Authority
² International Center for Agricultural Research in the Dry Areas (ICARDA), West Asia Regional Program, Amman, Jordan

Abstract

Agro-biodiversity in West Asia and North Africa region has a global significance to sustain agricultural development and food security in addition to its importance for the livelihoods of local communities living under harsh environments. Farmers in drylands and mountain ecosystems are the main custodians of local agro-biodiversity and any national, regional and international efforts to conserve the valuable genetic resources will require their full involvement as well as their empowerment to sustain the use of local agro-biodiversity. The West Asia dryland agrobiodiversity project, coordinated by ICARDA and implemented in Jordan, Lebanon, the Palestinian Authority and Syria is working towards the development of community-driven approach to promote in situ/on-farm conservation of landraces and wild relatives of cereals, feed and food legumes and many fruit tree species. The strategy adopted for enhancing the participation of local communities is based on the demonstration of low-cost technological packages for improving the productivity of landraces, the investigation and training of local communities on add-value technologies and alternative sources of income, the organization of local communities and development of links to markets and private sector, and the provision of in-kind incentives. Public awareness actions on the importance of conserving local agro-biodiversity and its benefits and policy and legal options for empowering the custodians of agrobiodiversity and for the sharing of benefits are also important elements of the approach. The lessons learned showed that full community involvement is a difficult task which will require designing benefits and digressive in-kind incentives at least in the initiation process. In addition, the government should reserve important assistance for rural development including arrangements for better implication of local communities in the management of natural resources including agro-biodiversity. At the international level, the benefits arising from the use of genetic resources and local knowledge should be channeled to local communities and the special arrangements should be designed for marketing the products of local agro-biodiversity.

The project tested some of these options and this contribution will present the approach along with the successes and failures experienced during the project implementation using the examples from the Palestinian Project Component.

Introduction

Agriculture is vital to the Palestinian economy contributing up to 14% to the national gross domestic product (GDP) and providing livelihood for most of population living in the rural areas (MoA strategy 2004). Farmers and herders in these areas are the main custodians of agro-biodiversity and they are also among the main players responsible for its loss or conservation. No farmer or herder will contribute to the efforts of conservation unless the local agro-biodiversity...
conservation demonstrates its comparative advantages. In case these advantages are threatened by alternative land uses and activities, national and international support will be needed to conserve threatened genetic resources. Therefore, any national, regional and international efforts to conserve the valuable genetic resources will require their full involvement as well as their empowerment.

The GEF/UNDP agro-biodiversity regional project recognizes the role of local communities in conserving and utilizing the local agrobiodiversity of global importance. The project strategy adopted for enhancing the participation of key stakeholders is based on their involvement in all project steps from the inception, implementation of the activities up to the monitoring and evaluation of project achievements and impacts. The project succeed in involving key stakeholders, farmers, herders either as lead individual farmers or as groups, local or national NGOs and cooperatives and unions, government institutions, universities, private sector and other development projects. The processes for this involvement are described in this contribution. Key stakeholders targeted and approaches for their participation. Members of local communities including, farmers, herders, women and children and representatives of local communities and government institutions were among groups collaborating with the project. After the selection of project site based on several including the willingness of local communities to be full partners in the implementation of project activities, participatory rapid appraisal was conducted in the beginning of the project to explain project goals, objective and approach and to assess the expectations, constraints and opportunities for conserving local agrobiodiversity. Training was provided to members of local communities on identification of problems and constraints, their prioritization and the designing of possible and appropriate solutions. The project adopted the following approaches to enhance the participation of different groups within the local communities:

- **NGOs and universities**
  Contracts were established to strengthen partnership with universities and NGOs for the implementation of project activities. For some universities (Annajah and Al Quds), the support of graduate and undergraduate students allowed the implementation of project activities and the introduction of agrobiodiversity conservation within university programs and research agendas. Many NGOs working mainly of agricultural or rural development (ARIJ, PARC) have worked with the project and this has allowed as well the promotion of local agrobiodiversity and project activities within the projects they are implementing all over Palestine.

- **Formation of farmers groups**
  During the first year of project, four project sites were identified in the two target districts Jenin and Hebron. Meetings with local communities led to the establishment of farmers committees, one for each project site and containing 10-15 farmers. One of the groups is composed of women. These groups received necessary training on problems identification and their prioritization, and on development of possible solutions. These farmers were involved the demonstration of technological packages suggested by the project (participatory selection within landraces, seed cleaning and treatments, water harvesting, rangeland improvement and management, ...). However, their role in implementing project activities varies between communities, gender and age. The fields of lead farmers are use to train neighboring farmers on various technological packages. More than 500 farmers followed different demonstration trials and participated in the discussion of proposed options. These farmers groups were
institutionalized and recognized by the Ministry of Agriculture and they were provided with two mobile seed cleaning units, one feed block unit and one food processing unit provided within the incentives of the project or with additional mobilized funds. Based on this approach, more than 400 farmers adopted the new technologies including the seeds of landraces, the seed cleaning and treatments, etc. in their own fields as seed cleaning and treatment with technical support from the project. These grassroot groups are actually playing a lead role in the production and distribution of seeds of landraces within the informal seed system established by the project.

1. Increasing community awareness
   - The project uses the local newspapers, TV and Radio stations to convey specific messages to the local communities as to the value of local landraces.
   - Selected groups are encouraged or asked to participate in the serially televised episodes to talk about the project.
   - School students

Agrobiodiversity and environmental clubs are created in the schools of project sites. The students in these clubs were very active in many extra-curricula activities organized by the project. These activities include: participation to reforestation efforts with natives species, creation of school gardens, documentation of parents local knowledge on agrobiodiversity, paintings and development of wall newsletters. Students and their teachers showed good interest to these activities that will be sustained and expanded to other schools through the Ministry of Education decision to include biodiversity conservation in the school curricula.

2. Provision of in-kind incentives and fund rising:
   - PRA was conducted to assess the needs of collaborating communities and farmers and the information is used to establish Community Development Plans which has helped in providing in-kind incentives and in financial resources leverage and fund rising the in-kind incentives provide by the project include: initial seed of local varieties, technical help for establishment of nurseries, units for seed cleaning, food processing, honey production, feed blocks. For herders, the Ministry of Agriculture provided veterinary services and medicines. Other incentives (seedlings of fruit trees and medicinal plants, beehives, sheep, rabbits) were mobilized through other projects. These incentives were attributed based on the contracts established between the project of Ministry of Agriculture and the NGOs of groups of farmers. These contracts stipulate that.

Conclusion
   - Establishing participatory approaches is a difficult process as most of the stakeholders have high expectations and requesting incentives and subsidies as a condition for their participation. Individuals are sometimes not accepting the proposed group management of shared resources. In addition, the absence of cooperatives or the diversity of NGOs with divergent views and interests are hindering the participatory actions;
   - In-kind incentives should be part of projects to enhance the participation of key stakeholders. These incentives should support group actions rather than individuals and should be business oriented;
   - Involvement of local farmers, institutions, universities and NGOs in the efforts of conservation is highly rewarding as many of the jointly launched activities contribute to the sustainability of the project goals and actions;
- Initiation of community-based actions such as dairy production, feed blocks and seed cleaning units will contribute significantly to the groups actions to maintain local agrobiodiversity;
- In-kind incentives and mobilization of additional funds to NGOs and groups of farmers and other stakeholders will help a lot in sustaining and up-scaling the projects actions and experiences;
- The empowerment of these groups will require the development of policy recommendations for co-management of resources, the development of marketing channels for local products and their involvement in implementing projects.
SESSION EIGHT
OTHER BENEFITS AND VALUES OF LOCAL AGROBIODIVERSITY
Cultural and Religious Keystone Species: The Need to Re-sacralize Nature

M. S. Al Zein¹, L. J. Musselman¹, T. R. Sampson² and K. U. Tennakoon³

¹Dept. of Biological Sciences, Old Dominion University, Norfolk, Virginia 23529, USA
²Edwardes College, Peshawar, North-West Frontier Province, Pakistan
³Dept. of Botany, Faculty of Science, University of Perideniya, Perideniya 20400, Sri Lanka. (present address: Department of Biology, Faculty of Science, University of Brunei Darussalam, Jalan Tungku Link, Gadong BE 1410, Brunei Darussalam)

Keywords: Coran, Pustūn Poetry, the Bible, and Buddhism, Soma, Grape, Bodhi tree, Olive.

Abstract

Well-known images of plants from holy writings and traditions are discussed including olive (Olea europaea) one of two plants by which God swears in the Koran. Cited six times, the olive tree is a symbol of peace and hope. The purity of its oil, used as both a condiment and medicament, caused Sufi interpreters to associate it with the body/soul parity. In Pustūn poetry, a recurrent theme is the soma, probably the mushroom Amanita muscaria, that is important in the central rite of the Vedic culture. There are tantalizing hints of this tradition that continue in Pustūn literature to the present. The habitat of the soma is threatened by deforestation. The most frequently cited plant in the Bible is the grape (Vitis vinifera) which in Jesus’ teachings becomes a preeminent symbol when Jesus says “He is the True Vine”. The religious fig, Ficus religiosa, is an icon of Buddhism. It is the tree under which Lord Buddha achieved enlightenment. Because of its association with the Buddha, no one cuts the tree, even a branch, except for cultic purposes. Though millions of people are aware of these plants and their images, little effort has been made by national workers to incorporate those beliefs into conservation efforts.

Introduction

Science and religion are no longer accepted as being mutually exclusive. During the past decade, there has been a remarkable paradigm shift in which religion and science are considered to be non longer incompatible but rather overlapping magisteria (sensu Gould). While much of these arguments are erudite and academic, those of us working for appreciation of biodiversity are partnering with local people around the globe who believe in a Creator and the value that Creator puts into the creation. It is, therefore, imperative that scientists, government officials, and administrators appreciate the role that religion can play in biodiversity conservation. This, of course, is a vast topic and one of which numerous books have recently appeared. We briefly discuss one aspect of religion and biodiversity, i.e., the role of plant symbols or icons in religion. We approach this topic from the vantage of our own core beliefs as well as extensive field work in diverse cultures with the following assumptions. Assumption 1: Many biodiversity programs are based on the secular Western science pattern. As a result Western scientists (and often western-trained scientists) avoid considering any relation between religion and conservation science. Assumption 2: Most farmers and others closest to agrobiodiversity have some belief in a God or Gods active in creation and nature. Assumption 3: Many decision makers and most
scientists are little aware of the importance of plants in the Quran and other holy and religious writings and how local people value them. As an introduction to the topic, we have selected some cultural keystone species from Islam, Christianity, and Buddhism. The concept of cultural keystone species is based on the term “keystone species” coined by R.T. Paine in 1969 to refer to species essential to “the integrity of the community and its unaltered persistence through time.” Their effect is out of proportion to the keystone species’ abundance or biomass. Derived from this is the idea of cultural keystone species which Garibaldi and Turner (2004) posit as indigenous people of a particular land base identifying with a limited complex of species exceptionally important to their daily lives. These are cultural keystone species. An overly simple taxonomy of cultural keystone species would be national symbols, cultural symbols, and religious symbols. National symbols of plants are often displayed on currency. Most nations have some plant images on their currency, reflecting the role of these plants in the culture. For example, the date palm (*Phoenix dactylifera* L.) on the currency of Saudi Arabia is meaningful because that tree is well known in the Arabian Peninsula and because of its mention in the Quran. Many nations have figures of olive (*Olea europaea* L.) on their currency. There are numerous other examples. Some flags feature plants. Perhaps best known is the flag of Lebanon with cedar of Lebanon (*Cedrus libani* Barrel.) portrayed and Canada with maple (*Acer saccharum* Marsh.). While currency and flags may display cultural plant symbols there are portrayed other ways as well. Garibaldi and Turner (2004) cite several examples from Native Americans including wild rice (*Zizania aquatica* L.) which the Menominee tribe of Wisconsin, USA harvest and include in their ceremonies. Religious symbols are likewise numerous though seldom invoked in conservation efforts. Some religions, like Islam, do not use plant symbols strictly as icons while such icons are common in Buddhism and Christianity. It is these religious plant symbols that we will discuss.

The olive

Olive is directly mentioned six times in the Quran and more than any other tree in the Bible. In the Quran, it is one of two trees by which God swears. Although the origin of olive is thought to be Phoenicia, olive was not uncommon in Mediterranean Europe and Africa at the time the Quran was revealed (Farooqi, 1992).

Olive is also mentioned several times in the traditions of Prophet Muhammad. The Prophet recommends using its oil for anointing the body, as it is the oil of a “blessed tree”. The Prophet also suggests that olive oil is useful in treating seventy diseases, including leprosy and pneumonia (Farooqi, 2001).

Olive is frequently used as a symbol for national and cultural identity; it is commonly used as a symbol for Palestine and is figured on currency in the United States. The dove with an olive branch in its beak is also an international symbol of peace derived from Noah’s story (Farooqi, 1992).
Grape
Perhaps the best known and most widely used Christian plant symbol is grape (*Vitis vinifera* L.) and its product, wine. Grape (including grape products) is the most frequently mentioned plant in the Bible. In fact, Jesus establishes the symbolism between himself and that of the grapevine emphasizing fruit as a symbol of pleasing God. Grape and wine are very important symbols/icons in Christianity.

Soma
The Soma beverage is an important element in Pushtū Sufi poetry. (Pushtū is a dominant language in Afghanistan and parts of Pakistan). Soma is often referred to in the Pushtū poetic form known as tappa. The oldest form of Pushtū poetry is the two-line folk tappa. Tappas are composed with a fixed number of syllables, and are the Afghan equivalent of the Japanese Haiku. Tappas are widely appreciated and frequently used by the Pushtū speaking people. For example,

Sound the bells, O moon, arise and shine!
My love is reaping flowers and may cut her fingers.

The identity of the plant from which soma was extracted is debatable; either it is the mushroom *Amanita muscaria* (Linn.) Hook., widespread in much of the world, or the aquatic lotus plant *Nelumbo nucifera* Gaertn. A recent ethnobotanical study (MacDonald, 2004) comes to the conclusion that *Nelumbo nucifera* is the best candidate for soma based largely on Hindu and Buddhist imagery. However, this study drew heavily on more recent literature rather than the Sanskrit classic, the Rig Veda.

The context in Pushtū poems indicates a forest setting, not an aquatic habitat. This makes *Amanita muscaria* the most likely candidate for soma. What is apparent from the literature is that the soma plant created an ecstatic mental state, and so must have contained a psychoactive component. In the case of soma, botanical research is necessary to determine which plant is indicated. There may be other cultural keystone species that need to be determined.

Bodhi tree
According to Buddhist teaching, Lord Buddha attained enlightenment under a *Ficus religiosa* L. (bodhi tree). As a result, every Buddhist temple and shrine in Sri Lanka has a bodhi tree and the leaf of the bodhi tree is featured on every temple dome. The bodhi tree becomes both figuratively and literally the center of a garden which is the source of plants for Ayurvedic medicinal and cultic use.

How can an understanding of plant religious symbols benefit agrobiodiversity? First, keystone species do not exist in a vacuum. There are other species associated with them which may also be of biodiversity interest. Their value and importance might be enhanced by association with the keystone species. Second, keystone species are already well known by members of local communities. Third, through reference to keystone species, decision makers can respect and learn from local religious and cultural traditions. This is particularly important for workers who are not from the local culture.

In summary, there is, in the words of Sayyed Hossain Nasr (Nasr, 1996), a need to “re-sacralize nature”. This is greatly different than worshipping nature. Rather, it is viewing nature in light of the holy writings. That appealing to religious sensitivities is important is dramatically illustrated by the work from the pen of a leading evolutionary biologist E.O. Wilson. Author of many prize
winning books on natural history, his most recent is an appeal to Christians to consider environmental matters (Wilson, 2006).

References
Social and Economic Challenges in Conservation of Agrobiodiversity

A. Amri¹ and A.B. Damania²*

¹Genetic Resources Unit, ICARDA, P.O. Box 5466, Aleppo, Syrian Arab Republic
²Genetic Resources Conservation Program, Agriculture and Natural Resources (ANR), University of California, Davis, CA 95616-8602, USA. Email: abdamania@ucdavis.edu
*Corresponding author

Keyword: Demographic changes, Migration to urbanization, Globalization, Agrobiodiversity, GDP.

Abstract
As a result of a growing world economy and globalization, over 24 countries in the developing world have increased their per capita income during the last two decades. However, some 2 billion people including those of the non-oil-producing nations in the West Asia did not benefit much from this economic growth and poverty is increasing mainly under rural areas and harsh environments. The reasons for this situation are complex. This paper enumerates some of these including 1) disintegration of social and communal ties, 2) erosion of women’s economic power, 3) a drop in female education, 4) hostile environment brought about by military conflicts, 5) migration to urban areas, 6) out-of-country emigration for better quality of life, 7) demographic changes and loss of agricultural biodiversity and local culture. The evidence considered here suggests that large increases in migration are more likely to worsen rather than ease the problems posed by the above-mentioned factors.

Introduction
A greater part of the world’s population, and a vast majority of the world’s resource-poor live and work in villages with concentration along the coastlines, as was seen during the tragic events of the Tsunami in December 2004. The activities of these peoples are normally centered on the household. However, interactions among households shape the impacts of policy, market, and environmental changes on rural production, incomes, employment, and migration (Taylor and Adelman, 1996). For example, in the state of Andhra Pradesh in southern India, dryland farmers are increasingly migrating away from the villages in pursuit of other sources of income. At the same time, others are further developing their local food resources and sovereignty strategies. In the region of Zaheerabad over 1500 poor and ‘dalit’ (formerly termed as the ‘untouchables’) women now produce a wide variety of crops utilizing local germplasm exclusively. This crop food production is sufficient for all their own needs with a little left over for supporting their communities (Satheesh, 2005). In addition, there are several village festivals that are celebrated, mainly in spring or after the rains. These festivals celebrate diversity of crop varieties and landraces as well as certain gods that are supposed to aid in a bountiful harvest. Over a period of ten years or so, these biodiversity festivals comprising of women’s groups have made tremendous strides. They have moved ecology-friendly agriculture from an environmentalist’s agenda to farmers’ agenda. They have transformed the quest for agrobiodiversity conservation into vibrant community-driven celebrations.

Of the many environmental problems we face today, none is as serious as the loss of landscapes, plant and animal species, and genetic diversity, collectively known as “biodiversity”. The biodiversity particularly pertaining to agricultural production is termed “agrobiodiversity”. And,
for example, agrobiodiversity is being lost at an alarming rate when farmers clear land to increase their arable surface, when loggers clear forests to provide lumber to construct buildings and make furniture. The Industrial Revolution in Europe, that spanned from 1750s to 1850s, came about because of great strides in agricultural production (Solbrig and Solbrig, 1994), with cereal agriculture, including maize, expanding to the vast arable lands in the “new” world, such as North America, Australia and New Zealand, and South America. According to Diamond (1997), new developments and innovations in agriculture led to higher food production, which in turn led to sophisticated political structures, standing armies and navies, and other technological developments that freed the inventors from the burdens of food-production, principally farming and hunting and gathering.

Globalization
Globalization has helped reduce poverty in a large number of developing countries but it must be harnessed better to help the world’s poorest, and most politically marginalized countries improve the lives of their citizens including rural communities. Twenty-four developing countries that increased their integration into the world economy over two decades ending in the late 1990s achieved higher growth in incomes, longer life expectancy and better schooling. These countries, home to some 3 billion people, enjoyed an average 5 percent growth rate in income per capita in the 1990s compared to 2 percent in rich countries. Many of these countries -such as China, India, Hungary and Mexico- have adopted domestic policies and institutions that have enabled people to take advantage of global markets and have thus sharply increased the share of trade in their gross domestic product (GDP). These countries have been catching up with the rich ones – their annual growth rates increased from 1 percent in the 1960s to 5 percent in the 1990s. People in these integrating countries saw their wages rise, and the number of people in poverty declined (Baldwin and Venables, 1994). But not all countries have integrated successfully into the global economy. The report says that some 2 billion people – among them the Middle East – live in countries that are being left behind. These countries have been unable to increase their integration with the world economy; their ratio of trade to GDP either remained flat or actually declined. On average, these economies have contracted, poverty has risen, and education levels have risen less rapidly than in the more globalized countries. Developing countries should be able to take advantage of the benefits of globalization while effectively managing the risks. These countries need to improve their investment climates and put in place better social protection to support poor people in adapting to and taking advantage of opportunities in a changing economic environment. It also calls upon rich countries to open their markets to exports from developing countries and to slash their large agricultural subsidies, which undercut poor country exports. Substantial increase in development assistance, particularly to address problems in education and health is also required (Bordo et al., 2003).

Disintegration of social and communal ties
Although the development of farming began only about 10,000 years ago, this development continues to radically change both human societies and the world’s environment. In order to feed a global population of 5 billion we have completely transformed natural landscapes to make room for large-scale cultivation if a few crops and only a handful of species of domesticated animals. Agriculture has altered the earth’s biosphere and changed its geosphere: Biodiversity has
imperiled; the top soil has been eroded or modified; forests have been felled; swamps have been drained and mangroves have been threatened; and rivers have been dammed and diverted. All this cannot happen without consequences to social and economic fabric of the world’s less affluent peoples and the countries they inhabit.

Early hunting-and-gathering societies appear to have lived first in small nomadic bands and later, in some locations, in larger, more settled, and hierarchically organized communities. Although marital partnerships were formed, hunter-gatherer bands valued compatibility among their members more highly than continuous co-residence with a single band, and individuals might fluidly move from one related band to another. They have been idealized by ecologists for holding values of living in harmony with other life forms instead of striving to dominate and exploit them. However, the integration of such families into modern life tends to be a long and difficult process.

Most herders and pastoral nomads tend to have patriarchal families and a tendency toward polygyny. Women's productive work tends to be limited to herding of small animals, dairying, and food processing and preparation. Where exchange relationships must be set in place over widely dispersed territories, marriage partnerships may be strategically located, and the exchange of daughters in marriage may help to cement economic alliances. These families are difficult to integrate because their mobility interferes with the schooling of their children and the regular health care of their members.

Societies engaged in traditional agriculture, crafts, and trade has been broadly divided into that practicing communal land ownership and that practicing private land ownership. Most populations of Central and West Asia made the transition from communal to private land ownership about 4,000 to 5,000 years ago, in response to the accumulation of significant agricultural surpluses, or possibly wealth from other sources. In sub-Saharan Africa, isolated by the desert, and with growing conditions that did not favor the accumulation of surplus, communal land ownership remained predominant.

The modern family evolved in concert with industrialization, science, and technology. With the growth of specialized wage labor, economically productive work moved beyond the reach of the family compound. Individualized remuneration and liability led to a redefinition of kinship obligations. The family that was engaged in farming or crafts could be expanded because extra hands could produce extra food and other products. Its boundaries were elastic. The resources of the salaried family and the number of people who could be supported by its wage-earners were fixed. Living space in the neighborhood of factories and other specialized worksites was expensive and non-expansible.

Women living alone or with their children are disproportionately represented among the poor. This trend, referred to as the feminization of poverty, may reflect changes in family structure (when nuclear families dissolve, the man usually retains his income and status, whereas the woman and her children enter the lower category of poor female-headed households). But others argue that often the underlying cause is poverty: resources for children living in poor female-headed households may be so inadequate that growth and development are adversely affected.

In general, women's economic power has become eroded with technological changes and with improvements in the market activities of poor rural households, which increase men's control over resources and simultaneously undercut women's control. By unbalancing traditional gender roles, modern agricultural technology may have negative effects on the caring capacity, cooperation between spouses, and emotional climate of families who adopt new cash crops and other technologies (Coakley et al., 1998).
Female education has been shown to have a positive impact on the growth and development of children in many parts of the world. Female education in sub-Saharan Africa, however, leads to the breakdown of the family values and codes of behavior that govern the cooperative relations between co-wives, in which the first wife traditionally has seniority and supervisory duties over later wives, the second wife over the third, and so on. Education creates a different hierarchy: a young educated girl considers herself senior to an older, less-educated co-wife. As a mark of success, men now marry new wives who are more educated, socially presentable, and expensive to maintain than their earlier mate(s). With remarriage they cut off, or greatly reduce, support to children by the previous unions.

In Lebanon, for example, one can easily affirm the existence of a civil society distinct from the State. Yet, this affirmation is superficial if one does not examine the signs attesting to a distinction between civil society and the State, and proving that the ways in which this distinction is manifested reflects the existence of a unified and solid civil society.

In the developing modern Lebanese state, socio-economic institutions and infrastructures took root, as did public educational institutions, unions, professional associations, sport and youth organization, and political parties and organizations. These institutions progressively created new spheres of professional, social, and political activity paralleling the traditional activities which characterized communal society before the establishment of modern Lebanon. These modern institutions came to surpass traditional institutions by attracting citizens towards common interests, projects, and objectives which increasingly bound them together.

Before the war in 1975, organizations appeared that represented the first signs of the formation of a civil society stronger than traditional communal ties. A notable example of this was the nationwide student movement whose national slogans reflected the aspirations of Lebanese youth within a framework of full socio-economic development. Similarly, a labor union movement grew which managed to establish, on various occasions, a new basis for relations between the different actors in Lebanon's economic life. Diverse political parties, acting at the national level, also came into being, giving birth to opposition movements which either opposed those in power, or which rejected the political system outright. Public opinion too became more influential, to the point where it affected the fate of those in positions of authority. At the same time, a dynamic press contributed to shaping this public opinion in an environment of relative liberty.

The most important indicator of the formation of civil society was the existence of a collectivity of political parties which called for a reform of Lebanon's political system and the modernization of the State. The parties acted at the national level and were critical of the State from which they maintained a distance.

During the war, the situation changed somewhat as the political-military conflict took on a confessional and, at some stages, a sectarian coloration. The war undermined the immunity of civil society, pushed it backwards, and caused it to begin to disintegrate as traditional ties were revived. Actions such as the forced displacement of populations, efforts by the different parties to ensure confessional exclusivity in their areas, and the systematic bombardment of civilian and military targets tended to undermine the sense of belonging to a national collectivity, and forced people to fall back and seek refuge in confessional ghettos and even in sectarian islands within the same city. The establishment of demarcation lines between different regions - at times defined by confessional makeup - helped bring back particularistic communal ties at a time when the conditions necessary for developing civil society at a national level were not present.

The trades union movement was made up of employees' and workers' unions from different parts of Lebanon, public school teachers, the union of Lebanese University professors, professional
associations, women's organizations, student's associations, as well as some cultural organizations and clubs. The movement's crowning moment came in November 1987 when it organized a demonstration which brought together some 250,000 Lebanese who crossed demarcation lines and protested against the war and against the State's complacency towards those engaged in it. The movement also engaged in a wide range of other activities, including symbolic strikes, protest sit-ins, and blood-donation drives, and its activities culminated in two national congresses at which resolutions were adopted condemning the war and expressing the attachment of the active forces in Lebanese society to a national collectivity, despite, and with, all its differences.

In addition to the activities of the trades union movement, organizations within the civil society undertook actions having national objectives, organized conferences, round tables, demonstrations, and blood-donation and fund-raising drives, in protest against the abuse of public liberties and in favor of an independent civil society free of sectarian, confessional, regional, or other traditional attachments. Examples of such organizations were the Lebanese Association of Human Rights, the Committee for Women's Rights, the National Council of Women and affiliated organizations, organizations for the handicapped, the Non-Violence Movement, etc.

The circumstances which brought Lebanon back to a state of peace did not, however, place civil society in a preponderant position. The political compromise which brought an end to the war benefited those who had waged the war by bringing them into positions of power, while it neglected or excluded representatives of civil society. Yet this did not lessen the determination of Lebanese citizens to consolidate civil society, which alone is capable of guarding against both public and private abuse of power.

In this postwar period, Lebanese society continues to be pulled between those who would like to see particularistic allegiances predominate, and those who want a national allegiance to prevail. Meanwhile, citizens find themselves at an equal distance between communal society and the emerging civil society. The only way to protect the rights of citizens is precisely through a strengthening of the institutions of civil society which can impose limits on the power of the State, and which can bring the State around to conform to the interests, objectives, and aspirations of its citizens. The alliance between the State and the former participants in the war, who, in reality, represent forces opposed to the State, has increased the conviction that it is necessary to develop and immunize national civil associations.

What may allow a national allegiance to prevail is a national civic education program directed at the younger generations. It is necessary to encourage contacts between people from different regions and social categories in professional, social, cultural, humanitarian, political, and sporting activities, in order that bonds, as well as common interests and aspirations, may develop between them which will transcend traditional particularisms.

Migration to urban areas and out-of-country emigration

Migration long predates the drawing of today’s national boundaries: in parts of North Africa and West Asia population movements still conform to old patterns rather than modern political geography. Yet the estimated more than 125 million people currently living outside the countries of their birth, including refugees and undocumented migrants, represent just over 2 per cent of the world’s population. More significant in modern times is the movement of people from rural to urban areas.
Internal Migration and Urbanization

The world is steadily becoming more urban, as people move to cities and towns in search of employment, educational opportunities and higher standards of living. Some are driven away from land that, for whatever reason, can no longer support them. By the year 2006, urban areas are expected to be home to more than half of the world’s people. Already 74 per cent of Latin American and Caribbean populations live in urban areas, as do 73 per cent of people in Europe, and more than 75 per cent of people in Australia, Canada, New Zealand and the United States. In both North Africa and West Asia, urban dwellers represent about a third of the total populations. However, there are significant variations between individual countries. In North Africa, for example, more than 50 per cent of the populations of Algeria, Morocco and Tunisia reside in urban areas.

In addition, there is a continuing trend towards ever-larger urban agglomerations. By the turn of the century, 261 cities in developing countries had populations over 1 million, compared with 213 in the mid-1990s. In 1994, there were 14 so-called mega-cities, defined as cities with at least 12 million inhabitants. Their number is expected to double by 2015.

Urbanization usually accompanies social and economic development, but rapid urban growth on today’s scale strains the capacity of local and national governments to provide even the most basic of services such as water, electricity and sewerage. Squatter settlements and over-crowded slums are home to tens of millions, like the favelas (or slum shanties) that cling to the hillsides of Rio de Janeiro and the tombs used as homes by tens of thousands in Cairo’s City of the Dead. In some developing countries, notably in North Africa, this growth reflects rural crisis rather than urban-based development.

International Emigration

Although dwarfed by the movements of people within borders, international migration is also increasing. Roughly half of the over 125 million people living outside their countries of origin reside in developing countries. This figure includes the 1997 figure of 12.0 million refugees. International migration includes both permanent migration and so-called temporary or labor migration -- which may be for long periods, even decades -- as well as the movement of refugees and undocumented migrants.

As with migration to the cities, people move in search of a better life for themselves and their families. Income disparities among and within regions is one motivating factor, as are the labor and migration policies of sending and receiving countries. Political conflict drives migration across borders as well as within countries. Environmental degradation, including the loss of farmland, forests and pasture, also pushes people to leave their homes. Most environmental refugees, however, go to cities rather than abroad.

Migration of more educated young people from developing countries to fill gaps in the work forces of industrialized countries has been a feature of development in the recent past. In many receiving countries, industries and infrastructure are built and maintained, in part, by migrant labor. Remittances from migrants are a significant source of foreign exchange and in some countries even account for a substantial share of national income. Remittances are used in many ways: for consumer goods, building homes, for productive investments, for education and health services and, in general, contribute to higher living standards for remittance-dependent households (Higgins, 1998). Richer countries’ investment in health and education in developing countries would help foster long-term cooperation in managing migration pressures and improve the productive capabilities
both of migrants and those who remain at home. While younger adults are more likely to migrate than older people, women make up nearly half of the international migrant population. Family reunification policies of receiving countries are one factor influencing migration by women, but women themselves are increasingly likely to move in search of jobs. Women frequently end up in the low-status, low-wage production and service jobs, and are particularly vulnerable to exploitation and abuse, including sexual abuse (Deaton and Paxson, 1997).

Among refugees, women and children are in the majority. At the end of 1997, the number of refugees outside their countries of origin totaled 12.0 million. The figure does not include people in refugee-like situations who have sought asylum in other countries. Nor does it reflect migration by displaced persons within national borders. In 1997, the United Nations High Commissioner for Refugees (UNHCR) estimated this total population of concern, including returnees and those seeking asylum and/or refugees status, as numbering 22 million; a number which may have increased since. Ultimately, the goal of both sending and receiving countries should be to make the option of remaining in one’s home country a viable one, as is stated in the International Conference on Population and Development (ICPD) Programme of Action. But this goal will not be easily realized. Efforts to enhance economic opportunity, to sustain and improve agricultural production and to provide health care and education are among the strategies proposed by the ICPD at Cairo. Equally important, however, are strategies to resolve political conflict, end human rights violations and promote good governance (Massey, 1990).

The economic, demographic and political trends influencing migration are likely to continue over the next few decades, given the time it will take to implement the strategies recommended in Cairo. The challenge for governments lies in formulating migration policies that take into account the economic constraints of receiving countries, the impact of migration on host societies, and its effects on countries of origin.

Demographic changes
Are the causes and consequences of demographic changes fundamentally local, national or global? There is much talk about the irrelevance of the nation state in an increasingly interdependent global economy. It has been found that the best way of measuring the strength of international linkages, and hence the extent of globalization, is in relation to those existing within nation states.

To the extent that international linkages, either on average or at the margin, are as strong as those within nations, then one could indeed argue that national boundaries were irrelevant for at least that linkage. Well, even then not quite irrelevant, since the nation state remains the main locus for establishing policies that create or discourage international factor mobility. In this sense, if densities were as tight internationally as within nation states, it would be because national governments either wish that to be the case or have decided to live with that reality. But that is getting ahead of the game in two ways: we have not yet established the extent of globalization, and policy issues will receive their own attention in due course. Here we want only to establish whatever broad considerations seem to apply across all types of international linkages (Williamson, 2001).

Demography and migration: Past, Present and Future
People have always tended to stay close to where they are born. It takes a strong push or pull to make them move, especially to far-away and unknown destinations. The migration-reducing effects of distance and of the unknown are offset and sometimes obliterated by the existence of
migration pathways, blazed by others from the same own family, town or region, providing welcoming arms and ready-made networks of family and friends at the far end. Migrants generally move from poorer and unstable to richer and more stable locations. Once migration is either chosen or forced, migrants tend to choose among alternative destinations based on the prospect of a better life, constrained by distance and risks. The major mass migrations a century ago were from Western Europe to the major immigrant receiving countries in the Americas and Oceania. The birth rate effect was large, suggesting that eventually almost half of excess births spilled over into emigration (Philip, 2004).

There is sharply increasing emigration from West Asia and North Africa. Five factors are most important here. First is demography, second is the change in immigration policies of the receiving countries, third is the declining costs of migration, fourth the increases in the education and incomes of the migrants, and fifth the gradual establishment of immigrant pathways from West Asia and North Africa into the main receiving regions: the New World, Western Europe, and the oil-producing Middle East.

Looking ahead, the seismic changes in migration patterns will combine with evolving demographic patterns to make immigration policies more selective in the receiving countries, while eventually reducing the demographic push from West Asia and increasing that from North Africa. Income-based incentives for individuals to migrate to higher income countries will remain very large, and there will continue to be large increases in the number of potential migrants with sufficient education, cash and connections to make migration feasible. Hence the scale of migration will become if anything more limited by the policies of immigrant-receiving countries.

People in poorer countries often report measures of life satisfaction as high as those in richer countries. Some economists have argued that this is paradoxical, and provides grounds for rejecting subjective measures of life satisfaction as indicators of well-being. There is ample cross-sectional evidence within and across countries showing that the most important sources of life satisfaction relate to the way life is lived, and much less to levels of GDP per capita. These non-material sources of life satisfaction are often higher, but not generally or necessarily so, in lower-income communities and countries (Kaufmann et al., 2003).

Thus it matters to individuals, families, and communities, whether and how global interdependence, and the consequences of demographic changes, affects trade, capital mobility, institutional reforms, and migration. Theoretical work has shown, as might be guessed, that if each of the linkages has various types of externalities, it is possible that there are several different equilibrium outcomes, some much less desirable for all concerned. For example, Baldwin and Venables (1994) paint two contrasting models of development in the transition economies. In their vicious circle path, skilled professionals move west because they do not expect to see technology and capital move fast enough in the reverse direction, while those in the west able to provide technology and investment to the transition economies do not do so because of the expectation that the best and the brightest have already emigrated, or are likely to do so. The virtuous circle path, by contrast, involves little emigration, lots of foreign investment and technology transfer, and rapidly rising incomes in the transition economies. It must be emphasized, even more than they do the importance of high quality of governance in increasing the likelihood that the virtuous path is feasible. In any event, their analysis of the transition economies has great relevance for the alternative ways in which global demographic and development imbalances are likely to be worked out over the current century (Kapur, 2001).

First, there is simply no way in which moving large fractions of the world’s population can solve the major problems in either the sending or the receiving regions. The fraction of the world’s
population already well-enough situated to be able to help the rest is simply too small for their help to take the form of large-scale intercontinental migration. Second, the critical shortages and gaps that can make life miserable relate to the structure of society, and the institutions by which it operates. These cannot be parachuted in from abroad, but there are nonetheless many ways in which international efforts from all segments of more favored societies can help plant and nurture the seeds. Third, broader measures of well-being depend far more on the quality of families, communities and institutions than on conventional measures of the economic standard of life (Helliwell, 2002 and 2003). Fourth, building life satisfaction requires individuals to feel engaged and efficacious, collaborating with others to produce a better life. These feelings of mutual engagement turn out to be of far more importance than the material consequences of their efforts. This may sound heretical to some economists, but it is so striking in the evidence that it needs to be given a more central role in the design of national and international policy agendas. Finally, studies on life satisfaction and suicide (Helliwell, 2004) show that migration is costly in more than economic terms and poses adjustment costs on both the sending and receiving communities. As the experience of the main immigrant-receiving countries has shown, immigration has been broadening and enriching, producing globe-spanning networks of value to individuals and to society as a whole. But expanded migration to a level that would materially alter demographic balances would be to strain the capacity of the receiving countries while draining much-needed human resources from the source countries. The above five points together suggest that, the most appropriate ways of dealing with global demographic transitions do not lie in large-scale international movements of either capital or labor, but in the sharing of ideas, of institutional know-how, of scientific advances, and of opportunities. If modern technology permits international collaboration of a far more sophisticated and mutually enriching sort than was possible even a decade or two ago, then this should be welcomed as part of the mix. Seen in this light, outsourcing is more a solution than a problem. By permitting virtual commuting between Bangalore and New York, it may well provide a highly effective means of exploiting demographic imbalances to mutual advantage. But successful societies will continue as always to pull themselves up by their own bootstraps, aided by as much international collaboration as populations are ready and willing to provide and receive. If large-scale factor movements are not likely to do much to mediate global demographic transitions in the coming decades, what might? To attempt an answer this question takes us beyond the scope of this paper. However, something needs to be offered in response to the policy challenges posed by increasing dependency ratios in the industrial countries. In keeping with the well-being focus that has been advocated here, the primary point to be made is that the well-being of both older and younger members of society depends much more on their active engagement than on their incomes. This suggests that the search should be on for policy options that support families, communities, and workplaces, increasing the extent to which each can contribute directly to the well-being of its members while also providing the services whose currently forecast costs are the focus of policy-making concern in Organization for Economic Co-operation and Development (OECD) countries (Obstfeld and Taylor, 2002).

**Biodiversity is a development issue**

Various surveys and research in recent years has shown that mixed farms and community forests, grazing areas, and water bodies provide individuals, households, and communities with more equitable and sustainable livelihood than production systems such as, mono-cropping and tree plantations that reduce biodiversity or rely on a relatively small range of exotic germplasm, as we
have observed in Sweida province of Syria (south of Damascus) where apple and grape vine cultivation has masked the wild-growing underlying cereal and legume crop diversity. This is because rural livelihoods involve not just the production of crops (which are sold or consumed) and the sale of family labor (on country farms and in the cities) but also a wide range of livelihood-enhancing activities that bring people in to constant with many interrelated natural and social resources.

Rural folks collect medicinal plants in common and private spaces in the local communities, as in the case of Jordan, to address health problems, use crop residues to feed their animals, exchange services with tradesmen and craftspeople in the community, collect forage from uncultivated lands and forests, do bee-keeping and so on. Value-added livelihoods of this nature rely heavily on the biodiversity available locally: in the fields, field boundaries, seed stores, farm cooperatives, and household kitchen gardens, etc. They also depend on the social and institutional relationships that regulate access to local biodiversity such as, gender relations, community membership, kinship, etc. Hence, the development of equitable and sustainable livelihoods in communities therefore needs to support and enhance both the biodiversity in the ecosystem and the social relationships that enable people to access and utilize the available biodiversity in the rural ecosystems.

Conclusion
A range of research topics have been surveyed and some new results added on the links between demographic changes and international movements of capital and population. What are the main conclusions? It remains true that the bulk of economic and social life takes place close to home, and that distance and national boundaries continue to provide an important part of the organizing framework for commercial, individual, family, and community activities. Thus both people and capital stay close to home, even after centuries of impressively strong, and historically variable, international connections. The oft-noted U-shape curve of declining and then increasing international intensities over the past century applies clearly to movements of goods and capital, while less so to migration, which is now determined much more by migration policies than by the number of willing migrants. If this is broadly the state of affairs, what are the implications for policy? The extent of international capital mobility is affected partly by policy decisions, but mainly by preferences and institutions unaffected by demographic changes.

Migration is a relatively rare event, but for many countries is determined by explicit policies. The evidence considered here suggests that large increases in migration are more likely to worsen rather than ease the problems posed by demographic transitions of all the projected types. This means that the policies needed to adapt to demographic changes will have a domestic focus. However, it was noted that offshore outsourcing might provide an example where new trade patterns were developing in a way that reflects and develops to mutual advantage the emerging patterns of skills, technologies and costs. It may thus provide some implicit demographic smoothing more efficiently, in both economic and human terms, than would be possible through large scale international population movements.

Throughout this paper it has been suggested that analyzing the consequences of demographic transitions in terms of well-being, as measured by individuals’ own assessments of life satisfaction, rather than just in terms of GDP per capita. This has two important implications for the structure of the argument. First, it changes the analysis of the costs and benefits, since the subjective well-being benefits of engaged families, communities and workplaces are far larger than those from higher incomes, especially when incomes have reached the levels of those in the
OECD countries. Second, it demands that policies be assessed in terms of their effects on how people live, work and participate in their communities. To illustrate this point, it has been suggested that a few ways in which demographic transitions could be eased, and even turned from problems into opportunities, by abandoning the notion of dependent population groups and instead seeking ways of giving individuals more scope, in both years and space, to engage with each other in mutual support. This could well lead both to greater engagement and lower costs. Recent research in well-being suggests that increased engagement is the more important of the two benefits, but so much the better to find policies that could do more with less.

References
The Agrobiodiversity Project Experience in the Development of Feed Blocks Technology in Sweida Province in Syria

A. D. Salman¹, A. Amri³, B. Mawlawi², and A. Saad²

¹. The State Board for Agricultural Research, Ministry of Agriculture, Baghdad, Iraq E-mail: alaasalman2006@yahoo.com
². General Commission of Scientific Agricultural Research (GCSAR), Douma, Syria
³. ICARDA, West Asia office, Amman, Jordan E-mail: a.amri@cgiar.org

Keywords: Rangelands, agrobiodiversity, overgrazing, conservation, feed blocks, Syria

Abstract
The prevailing animal farming systems in Sweida province in Syria is based on small ruminants which depend mainly on grazing native pasture and crop residues for considerable parts of the year. These feed resources contribute of about 85.7% of the total ruminant's diet which explain the low productivity of the herds in the Province. Also the persistence of this system will lead to serious deterioration of wide diversity of natural plants cover. One of the components of the regional Agrobiodiversity Project on “Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Syria and Palestinian Authority” is to develop low-cost technological packages for improving and alleviating pressure on rangelands. According to the inventory of locally available by-products at Sweida province, there are considerable amounts of agro-industrial by-products available which are mainly high moisture by-products (i.e., grape pomace, apple pomace, crude olive cake and yeast). But unfortunately these by-products have not been utilized in animal feeding. Feed blocks technology is the most efficient, practical and economical way of utilizing high moisture by-products as alternative feed supplements for ruminants. Therefore, the Agrobiodiversity Project team implemented new methodology in manufacturing feed blocks (equipment, formulation and manufacturing procedure) in Sweida Province in Syria. New equipment was developed in manufacturing feed blocks including the pan mixer and the mobile mechanical hydraulic press. Different new formulae of feed blocks were manufactured with different levels of grape pomace, apple pomace and olive cake and also different levels of wheat bran, urea, binders and salt. Inclusion of high moisture apple pomace and grape pomace, which are available in commercial quantity, gave excellent blocks regarding hardness and compactness. Formulation of these feed blocks was based on the inventory of locally agro-industrial by-products and small animals’ nutrient requirements during various stages of production cycle and production systems of small ruminants. Agrobiodiversity Project has developed this new methodology for the first time in the region and outside the region. Using feed blocks as alternative feed supplement can fill feed gap which exists between local supply of feed and small ruminants’ requirements in Sweida Province and will have significant impact in alleviating pressure on natural grazing resources, helping to combat degradation of rangelands and to prevent the loss of biodiversity from overgrazing.

Introduction
The main feature of animal farming systems in Sweida province located in the southern parts of Syria, is that the majority of small ruminants are raised under extensive production system. Small ruminants depend mainly on grazing native pasture and crop residues for considerable parts of the year (Abu Zanat, 2002). These feed resources contribute to about 85.7% of the total
ruminant's diet. In Sweida Province overgrazing by small ruminants and agricultural encroachment have serious impacts on plant cover, conservation of natural resources base and the environment (Salman, 2003). However, small ruminants play an important role in the livelihood of the households in the dry areas in the Sweida province. Animal’s products (lambs/kids and milk) are mainly for domestic consumption and the surplus is sold in local markets (Shomo et al., 2003). One of the components of the West Asia Dryland Agrobiodiversity Project (Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Syria and Palestinian Authority) sponsored by GEF and UNDP and coordinated at the regional level by ICARDA, is to develop low-cost technological options for promoting the in situ/on-farm conservation of local agrobiodiversity including that of rangelands and natural habitats including the rehabilitation through reseeding with native species, application of water harvesting, designing grazing management and finding alternatives feed resources. Therefore, the most appropriate technical option proposed by the project is the introduction of feed blocks technology. The experience of Iraqi national team of ICARDA's Mashreq/Maghreb Project indicted that feed blocks is a cost effective technology adapted to local conditions (Salman and Mamdouh, 2002). Also, by providing alternative cheap source of feed, feed blocks will relieve pressure on natural grazing resources, helping to combat degradation of rangelands and the loss of biodiversity from overgrazing. The Sweida Province is characterized with availability of considerable amount of agro-industrial by-products from the food industry. But, unfortunately these by-products have not been utilized in animal feeding (Salman, 2003).

**Inventory of locally available by-products at Sweida province**

According to survey conducted by the Syrian national team of Agrobiodiversity Project and field visits to processing plants, it is indicated that there are considerable amounts of agro-industrial by-products available in Sweida (Salman, 2003). These are mainly high moisture by-products (i.e., grape pomace, apple pomace, crude olive cake and yeast). The quantities of these by-products are presented in Table 2. There are also other by-products available in the Sweida, but their quantities have not been estimated such as burgle and starch making by-products.

<table>
<thead>
<tr>
<th>By-products+</th>
<th>Quantity (tons/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grape pomace</td>
<td>3000</td>
</tr>
<tr>
<td>Apple pomace</td>
<td>950</td>
</tr>
<tr>
<td>Olive cake</td>
<td>5550</td>
</tr>
<tr>
<td>Olive leaves collected in oil factory</td>
<td>750</td>
</tr>
<tr>
<td>Olive leaves and twigs</td>
<td>7000</td>
</tr>
<tr>
<td>Yeast</td>
<td>150</td>
</tr>
<tr>
<td>Grape juice residues ++</td>
<td>***</td>
</tr>
</tbody>
</table>

* + Fresh basis ++ Considerable amounts

Although considerable amounts of agro-industrial by-products are available in Sweida, but these by-products are not utilized in animal feeding. The main constrains behind that, was pointed out by animals owners’ through rapid questionnaire conducted by Syrian national of Agrobiodiversity Project on assessment of utilization of agricultural and agro-industrial by-products in Sweida and also in the two training workshop conducted during the mission. The main problems and difficulties in using agro-industrial by-products in animal feeding, are their continuous availability, their conservation and storage and the high costs of transportation (Salman, 2003). Also many animals’ owners’ mentioned that their main difficulties are the lack of knowledge of how to use these by-products in animals feeding.
Suggested strategy for by-products utilization

As indicated earlier, considerable amounts of high moisture by-products are available in commercial quantities in Sweida province, but these by-products are not efficiently utilized in animals feeding. Whereas, the experience within and outside the region has shown that many unconventional but locally available by-products can be used successfully as alternative feed supplement (Leng et al., 1991; Habib et al., 1991; Salman, 1996 and Hadjipanayiotou, 1997). Feed blocks manufactured from agro-industrial by-products proved to be excellent feed supplement and good management tool for improving ruminants’ productivity. The experience of Iraqi national team of ICARDA's Mashreq/Maghreb project has successfully identified the main points behind the success of feed blocks as alternative feed supplement for small ruminants in Iraq (Shideed and Salman 1997; Salman, 1997):

- A feed block is a cost-effective technology adapted to local conditions.
- Feed blocks manufactured from agro-industrial by-products can be used as a catalyst, strategic and substitution supplements for small ruminants raised under extensive, semi-intensive and intensive systems.
- It is the most practical and economical way of utilizing high moisture by-products (date pulp, grape pomace, apple pomace, tomato pomace, sugar beet pulp, brewer grain) because it conserves their nutritional value.
- Feed blocks can be made by making use of a wide variety of by-products, which are available locally.
- It is the most efficient and safe method of using urea as nitrogen supplement for ruminants because the blocks are consumed in frequent small meals, which makes the nutrients available continually.
- They optimize the use of conventional by-products (e.g., wheat bran, rice bran and cotton seed cake) in feeding larger flocks.
- Feed blocks can be used as carrier for rumen undegradable protein, trace elements and vitamins, pharmaceuticals (anthelmintic), energy and additives manipulating rumen fermentation.
- The methodology of feed-block making is simple and does not need sophisticated equipment.
- Farmers prefer to be given a readily usable package of technology.
- Feed block is easy in handling, transporting and does not disturb feeding practices of farmer.

Feed blocks manufacturing

The Iraqi methodology in formulation and manufacturing of feed blocks is considered as major development in the region and outside the region (Salman, 1996; Salman and Mamdouh, 2002). This methodology is simple and does not need sophisticated equipment to be imported from outside. The methodology widely adapted by private sector manufacturing plants in Iraq and many countries in the WANA region. Building on the Iraqi experience, the Agrobiodiversity team developed new methodology in manufacturing feed blocks (equipment, formulation and manufacturing procedure).

- Manufacturing equipment:

The new manufacturing equipment which was needed for large-scale production of feed blocks in Sweida province was developed by Agrobiodiversity project team. The equipment included a pan
mixer and a mobile mechanical hydraulic press. The new equipment was fabricated in Jordan by local artisans at very low cost. This equipment has been introduced to Syria for first time (Salman, 2004).

**Mixer**

Previous Syrian experience (Hadjipanayiotou *et al.*, 1993a) on feed blocks making suggested using concrete mixer in mixing the ingredients. But our experience in Iraq and other Mashreq/Maghreb project countries showed that using concrete mixer does not necessarily give homogeneous mixture due to different densities of ingredients (Salman, 1997). Heavy ingredients stick to the wall of mixer without falling off. This type is not of great significance for making good quality feed block, because it is just turning and mixing the ingredients. Therefore, we used pan mixer, which is similar to that used in tillers. This mixer gives excellent homogeneous mixture and is more efficient than any concrete mixer, particularly when working on formulae without any molasses. The pan mixer does not only mix the ingredients, but also beats and compresses the ingredients against the wall of the mixer. This smearing action results in better mixing of the ingredients, blocks of higher density, compactness and hardness. The mixer was manufactured locally in Iraq with different capacities (50 to 200kg) per patch. This mixer is available now in Iraq and Jordan and can be fabricated locally with reasonable price.

**The mobile mechanical hydraulic press**

For large-scale production of feed blocks, new methodology was developed by private sector manufacture plants in Iraq (Salman, 2004). This included mechanization of molding, pressing and demolding procedures instead of manual procedure. This was done through modification the cement blocks mechanical press to mobile mechanical press. Using this press could save manpower by 50 %. In Sweida Province new methodology has been developed made by modification the mobile mechanical press to mobile mechanical hydraulic press. This new press was designed to improve feed blocks compactness by applying more pressure. Six feed blocks can be pressed by the hydraulic press at each time. Using mechanical hydraulic press will facilitate the use of high levels of high moisture by-products and reduce levels of binders. The feed blocks produced by this methodology was of good quality with regard to hardness and compactness. Agrobiodiversity Project has developed this new methodology for the first time in the region and outside the region (Salman, 2004).

- **Feed blocks formulation**

  Based on agro-industrial by-products available in Sweida province, different new formulae of feed blocks were manufactured by the new equipment (Tables 3 and 4). These formulae were manufactured with different levels of grape pomace, apple pomace, olive cake and also different levels of wheat bran, urea, binders and salt. Inclusion of high moisture apple pomace and grape pomace, which are available in commercial quantity, gave excellent blocks regarding hardness and compactness. The apple pomace can be incorporated up to 60% of the feed blocks formula. The yeast from alcoholic factory used instead of water improved the feed blocks quality. The yeast seems to have binding quality; therefore it should be used in feed blocks making on sustainable manner. We would like to emphasis that this by-product is a product of high nutritional value (CP 50%) that is completely wasted through the city water facilities. The present way of discarding yeast by the factory will lead to severe environmental pollution in the future. The binders used in manufacturing feed blocks were quick lime, plaster of Paris and bentonite clay. Bentonite clay is not only a binder, but it can be also used as feed additive. Inclusion of bentonite clay in feed blocks making will reduce
the risk of urea toxicity, because it improves nitrogen utilization and decreases the rate of breakdown of urea into ammonia in the rumen (Al-Ani et al., 1998). The inclusion of high level of olive cake in feed blocks making will facilitate the use of low levels of binders (Salman, 2003).

Table 2: Formulae of ordinary feed blocks manufactured in Sweida Province

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>1 %</th>
<th>2 %</th>
<th>3 %</th>
<th>4 %</th>
<th>5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Grape pomace</td>
<td>34</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>17</td>
</tr>
<tr>
<td>Apple pomace</td>
<td>24</td>
<td>40</td>
<td>20</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Crude olive cake</td>
<td>22</td>
<td>20</td>
<td>30</td>
<td>30</td>
<td>36</td>
</tr>
<tr>
<td>Grape juice residue</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Quick lime (Cao)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Gypsum (Ca SO4)</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Salt</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Bentonite clay</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Yeast</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Minerals vitamins premix</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Feed blocks formulae, which can be used for large-scale production in Sweida province, are presented in Table 3. Formulation of these feed blocks was based on the inventory of locally agro-industrial by-products and small animals’ nutrient requirements during various stages of production cycle and production systems.
Table 3: Feed blocks formulae for large scale production in Sweida Province based on production cycle of animals and availability of by-products.

<table>
<thead>
<tr>
<th>Ingredients/Formula</th>
<th>Mating</th>
<th>Pregnancy</th>
<th>Lactation</th>
<th>Fattening</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3</td>
<td>4  5  6</td>
<td>7  8  9</td>
<td>10 11 12</td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td>5  5  5</td>
<td>4  4  4</td>
<td>4  4  4</td>
<td>4  5  5</td>
<td>4  5  5</td>
</tr>
<tr>
<td>Grape pomace</td>
<td>28 23 20</td>
<td>30 30 40</td>
<td>32 - 25</td>
<td>30 35 24</td>
<td></td>
</tr>
<tr>
<td>Apple pomace</td>
<td>- 15 18</td>
<td>26 26 24</td>
<td>25 55 25</td>
<td>22 24 24</td>
<td></td>
</tr>
<tr>
<td>Olive cake</td>
<td>25 20 20</td>
<td>20 20 -</td>
<td>- - 15</td>
<td>15 22 30</td>
<td></td>
</tr>
<tr>
<td>Wheat bran</td>
<td>15 10 10</td>
<td>5  5 15</td>
<td>15 15 9</td>
<td>15 - -</td>
<td></td>
</tr>
<tr>
<td>Cotton seed cake</td>
<td>7  7 7</td>
<td>- - 5</td>
<td>5  5 5</td>
<td>- - -</td>
<td></td>
</tr>
<tr>
<td>Quick lime</td>
<td>12 12 6</td>
<td>10 5 10</td>
<td>12 6 10</td>
<td>4 10 10</td>
<td></td>
</tr>
<tr>
<td>Bentonite clay</td>
<td>- - 6</td>
<td>- 5 -</td>
<td>- 6 -</td>
<td>4 - -</td>
<td></td>
</tr>
<tr>
<td>Gypsum</td>
<td>1 1 1</td>
<td>1 1 1</td>
<td>1 1 -</td>
<td>1 - -</td>
<td></td>
</tr>
<tr>
<td>Sodium sulfate</td>
<td>- - -</td>
<td>- - -</td>
<td>- 2 -</td>
<td>1 - -</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td>5 5 5</td>
<td>3 3 3</td>
<td>3 5 4</td>
<td>4 4 5</td>
<td></td>
</tr>
<tr>
<td>Min+ Vita premixes</td>
<td>2 2 2</td>
<td>1 1 1</td>
<td>1 1 -</td>
<td>1 1 -</td>
<td></td>
</tr>
</tbody>
</table>

How feed blocks fill feed gap in Sweida province

The prevailing animals farming systems in Sweida province in Syria is dominated by small ruminants which depend mainly on grazing native pasture and crop residues for considerable parts of the year. According to the data of Abu-Zanat (2002), the main feed resources available for ruminants in Sweida province and their contribution to the feeding calendar are 55.4 % natural pasture, 6.4 %, green fodder, 23.9 % cereal residues and 14.3 % concentrate feeds. This study is overestimating the quantities of feed resources available for small ruminants in the Sweida province. The contribution of rangelands for small ruminants’ feed resources is considerably high (55.4%). However, the general trend in the region (West Asia) is the declining of natural pasture contribution (<25%) to the total feed resources for small ruminants. According to Nordblom and Shomo (1993) the contribution of rangelands for small ruminants’ feed resources does not exceed 24%. Therefore, the realistic figures of annual feed resources available for small ruminants in Sweida region are presented in Table 4. The feed balance between nutrients requirements of small ruminants (Animal Unit) and the feed resources available is found to be negative -10%, -16% and -18% for dry matter (DM), metabolizable energy (ME) and crude protein (CP) respectively.

Table 4: The existing feeding system in the Sweida province in Syria.

<table>
<thead>
<tr>
<th>Feedstuff</th>
<th>The Existing feeding System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kg DM/Head/Year</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Rangelands</td>
<td>135</td>
</tr>
<tr>
<td>Cereal stubble</td>
<td>118</td>
</tr>
<tr>
<td>Green Fodder</td>
<td>60</td>
</tr>
<tr>
<td>Hand-fed straw</td>
<td>105</td>
</tr>
<tr>
<td>Hand-fed barley + wheat bran</td>
<td>134</td>
</tr>
<tr>
<td>Total</td>
<td>552</td>
</tr>
<tr>
<td>Nutrient Intake</td>
<td></td>
</tr>
<tr>
<td>ME (MJ/year)</td>
<td>4322</td>
</tr>
<tr>
<td>CP (Kg/year)</td>
<td>45</td>
</tr>
<tr>
<td>Feed Balance (%)</td>
<td>-16</td>
</tr>
<tr>
<td>ME</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td></td>
</tr>
</tbody>
</table>

Considerable amounts of agro-industrial by-products are available in Sweida province. But, unfortunately these by-products have not been utilized in livestock feeding. Opportunity in Sweida province exists to fill the gap between supply and the demand for feed resources through efficient
utilization of these by-products. The past experience indicated that feed blocks technology is the
most efficient, practical and economical way of utilization agro-industrial by-products as
alternative feed supplements for ruminants (Leng et al 1991, Habib et al 1991, Hadjipanayiotou et
al., 1993a and Salman, 1996). In Iraq new approaches of introduction of feed blocks to the sheep
production systems has been developed. Feed blocks manufactured from agro-industrial by-
products can be used as a catalyst, strategic and substitution supplements for small ruminants raised
under extensive, semi-intensive and intensive systems (Salman et al, 1998; Salman, 2004).
Two feeding strategies have been suggested to bridge feed gap existing between local supply of
feed and small ruminants requirements in Sweida province (Salman, 2004). The first feeding
strategy (Table 5) shows how feed blocks manufactured from agro-industrial by-products can fill
the gap between supply and the demand for existing feed resources available for small ruminants.

Table 5: The first feeding strategy for the small ruminants using feed blocks

<table>
<thead>
<tr>
<th>Foodstuff</th>
<th>Kg DM /head /year</th>
<th>Contribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rangelands</td>
<td>135</td>
<td>23</td>
</tr>
<tr>
<td>Cereal stubble</td>
<td>118</td>
<td>19</td>
</tr>
<tr>
<td>Green Fodder</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Hand-fed straw</td>
<td>105</td>
<td>17</td>
</tr>
<tr>
<td>Hand-fed barley + wheat bran</td>
<td>134</td>
<td>22</td>
</tr>
<tr>
<td><strong>Feed blocks</strong></td>
<td>55</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>607</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nutrient Intake</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ME (MJ/year)</td>
<td>5270</td>
<td></td>
</tr>
<tr>
<td>CP (Kg/year)</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Feed Balance (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME</td>
<td>+5</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>+6</td>
<td></td>
</tr>
</tbody>
</table>

The second feeding strategy (Table 6) shows how feed blocks can be used as alternative feed
supplement to replace 50% of costly concentrate feed (barley grain and wheat bran) and also fill
considerable part of the feed gap for the small ruminants. Both strategies will have significant
impact in alleviating pressure on natural grazing resources, helping to combat degradation of
rangelands and the loss of biodiversity from overgrazing.
Table 6: The second feeding strategy for the small ruminant

<table>
<thead>
<tr>
<th>Foodstuff</th>
<th>Kg DM /Head/Year</th>
<th>Contribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rangelands</td>
<td>135</td>
<td>23</td>
</tr>
<tr>
<td>Cereal stubble</td>
<td>118</td>
<td>19</td>
</tr>
<tr>
<td>Green Fodder</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Hand-fed straw</td>
<td>152</td>
<td>25</td>
</tr>
<tr>
<td>Hand-fed barley + wheat bran</td>
<td>67</td>
<td>11</td>
</tr>
<tr>
<td>Feed blocks</td>
<td>75</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>607</td>
<td>100</td>
</tr>
</tbody>
</table>

Nutrient Intake

| ME (MJ/year)                  | 5033             |
| CP (Kg/year)                  | 53               |
| Feed Balance (%)              |                  |
| ME                            | 0                |
| CP                            | 0                |

References


Salman, A. D. 2004. The Commencement of Large Scale Production and Dissemination of Feed Blocks in Sweida Province in Syria. Agrobiodiversity Project (Conservation and Sustainable Use of Dryland Agrobiodiversity in Jordan, Lebanon, Syria and Palestinian Authority) sponsored by GEF and UNDP and coordinated by ICARDA in collaboration with IPGRI and ACSAD.


SESSION NINE

ENABLING POLICIES AND LEGISLATIONS FOR THE
CONSERVATION OF AGROBIODIVERSITY, INCLUDING
NATIONAL STRATEGIES AND ASPECTS RELATED TO BENEFIT-
SHARING AND INTELLECTUAL PROPERTY RIGHTS
Enabling Policies and Legislations for Promoting the Conservation of
Dryland Agrobiodiversity in West Asia

M. Duwayri\textsuperscript{1} and A. Amri\textsuperscript{2}

\textsuperscript{1} Professor, University of Jordan, Amman, Jordan
\textsuperscript{2} Regional Coordinator, West Asia Regional Program, ICARDA, Amman, Jordan

Keywords: dryland agrobiodiversity, conservation, policy, legislation, West Asia.

Abstract
The dryland agrobiodiversity in West Asia region is of global importance which requires local, national, regional and international efforts for its conservation and sustainable use. Although most of countries in Central and West Asia and North Africa region (CWANA) have signed all international agreements and conventions related to genetic resources conservation and developed national strategies and action plans, the agrobiodiversity continue to be under severe threats. One of the prerequisites for successful and efficient conservation of the valuable genetic resources is to develop enabling policies and legislations to promote community-based \textit{in situ} conservation of local agrobiodiversity. The GEF-funded and ICARDA coordinated regional project on “conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria” developed a conceptual framework which was operationalized to develop harmonized national policies for the conservation of agrobiodiversity in the four countries. Among the preliminary impacts of the project, national agrobiodiversity units were established in the four countries and include both \textit{ex-situ} and \textit{in situ} conservation aspects, the swift shift to the use of native species in afforestation efforts and the introduction of biodiversity conservation in the education systems. The Ministers of Agriculture of four countries signed a memorandum of understanding for a regional alliance to conserve agrobiodiversity and ease the exchange and access to genetic resources. The importance of agrobiodiversity in CWANA region and the status of policies and legislations, and some recommendations for consideration in policy and legislation improvement are presented.

Introduction
Many people’s food and livelihood security depend on the sustained management of various natural resources including the biodiversity that is important for food and agriculture. Agricultural biodiversity, also known as agrobiodiversity encompasses the variety and variability of animals, plants and micro-organisms that are necessary for sustaining key functions of the agro-ecosystem, including its structure and processes for, and in support of, food production and food security (FAO, 1999a). Local knowledge can therefore be considered an integral part of agrobiodiversity, because it is the human activities that shapes and conserves this biodiversity. Many farmers, especially those in harsh environments where high-yield crop varieties and livestock improved breeds do not always express their potential, still rely on a wide range of landraces and wild species of crops and on local breeds of livestock which are the major components of traditional farming systems. This helps them maintain their livelihood in the face of un-even distribution and low rainfall and fluctuation in the price of cash crops, socio-political disruption and the difficulty to access to agro-chemicals inputs. Many underutilized or minor
crops and medicinal species grow side by side and their importance is often misjudged although these are crucial to household nutritional and health care strategies. There are several distinctive features of agrobiodiversity most of which are stressing the importance of human dimension for its in situ and on-farm conservation and sustainable use. Agrobiodiversity is actively managed by male and female farmers and most of its components would not survive without human interference and without the maintaining of related local knowledge. In addition, economically important agricultural systems are based on introduced crops and livestock, which creates a high degree of interdependence among the countries for the genetic resources most of which are exchanged through the existing collections conserved ex situ in national and international genebanks.

In addition to its contribution to sustaining agricultural production worldwide and the livelihoods of its custodians, agrobiodiversity contributes in different ways to ecosystem resilience and stability as adapted from Thrupp (1977):

- Increase productivity, food security, and economic returns
- Reduce the pressure of agriculture on fragile areas, forests and endangered species
- Make farming systems more stable, robust, and sustainable
- Contribute to sound pest and disease management
- Conserve soil and increase natural soil fertility and health
- Contribute to sustainable intensification
- Diversify products and income opportunities
- Reduce or spread risks to individuals and nations
- Help maximize effective use of resources and the environment
- Reduce dependency on external inputs
- Improve human nutrition and provide sources of medicines and vitamins, and
- Conserve ecosystem structure and stability of species diversity.

Locally varied food production systems are under threat, including the loss of related local knowledge and skills of women and men farmers. With this decline, agrobiodiversity is disappearing; the scale of the loss is extensive. With the disappearance of harvested species, varieties and breeds, a wide range of unharvested species also disappear. FAO (1996b) reported that Since early 1900s, some 75 percent of plant genetic diversity has been lost as farmers worldwide have left their multiple local varieties and landraces for genetically uniform, high-yielding varieties and 30 percent of livestock breeds are at risk of extinction. Today, 75 percent of the world’s food is generated from only 12 plants and five animal species.

There are many reasons for the loss of agrobiodiversity. Throughout the twentieth century the decline has accelerated, along with increased demands from a growing population and greater competition for natural resources. The principal underlying causes include:

1. The rapid expansion of industrial and “Green Revolution” agriculture: This includes intensive livestock production, industrial fisheries and aquaculture. Some production systems use genetically modified varieties and breeds. Moreover, relatively few crop varieties are cultivated in monocultures and a limited number of domesticated animal breeds, or fish, are reared or few aquatic species cultivated.

2. Globalization of the food system and marketing: The extension of patenting, and other intellectual property systems, to living organisms has led to the widespread cultivation and rearing of fewer varieties and breeds. This results in more uniform, less diverse, but more competitive global market. As a consequence there have been:
a. changes in farmers’ and consumers’ perceptions, preferences and living conditions;
b. marginalization of small-scale, diverse food production systems that conserve farmers’ varieties of crops and breeds of domestic animals;
c. reduced integration of livestock in arable production, which reduces the diversity of uses for which livestock are needed; and,
d. reduced use of ‘nurture’ fisheries techniques that conserve and develop aquatic biodiversity.

3. The main cause of the genetic erosion of crops—are reported by almost all countries—is the replacement of local varieties by improved or exotic varieties and species. Frequently, genetic erosion occurs as old varieties in farmer’s fields are replaced by newer. Gene and gene complexes, found in the many farmers’ varieties, are not contained in the modern. Often, the number of varieties is reduced when commercial varieties are introduced into traditional farming systems. While FAO (1996) states that some indicators of genetic erosion have been developed, few systematic studies of the genetic erosion of crop genetic diversity have been made. Furthermore, in the FAO Country Reports (1996) nearly all countries confirm genetic erosion is taking place and that it is a serious problem.

Importance of CWANA dryland agrobiodiversity
The CWANA region comprises 28 countries: 18 in West Asia, five in North Africa and five in Central Asia. It covers an area of about 19.5 million km² and has a total population of more than 578 million inhabitants. The region has very diverse topography, climate and soil. It covers the fertile valleys of the Tigris, Euphrates and Nile, the high mountains of the Atlas, Himalaya and Tien Shan, and the deserts of the Sahara, Arabia and Central Asia. Erratic and low rainfall, harsh and extensive deserts and limited water resources characterize the climate and the environment of much of the region. The forested area is very limited—less than 5 percent in most countries—but there is still very great plant biodiversity. Each country harbors thousands of plant species (9000 species are recorded in Turkey alone), of which many are endemic to the region.

The agricultural sector accounts for an overwhelming majority of the economic activity of many of the countries. However, few countries in the region are self-sufficient in major agricultural products, although some are significant world producers, e.g. Turkey is the world’s eighth largest wheat producer and sixth largest producer of barley and cotton, and Iran is the eighth largest producer of citrus (IFPRI 1995). Potential for expanding the area under agricultural production is limited in most countries.

The CWANA region covers three of Vavilov’s centres of origin of cultivated crops (near Eastern, Central Asian and Mediterranean centres). It is a centre of diversity for a number of globally important crop plants, including cereals (wheat, oat, barley and rye), food legumes (chickpea, lentil, pea and faba bean), vegetables (lettuce, turnip, cabbage, radish, onion, garlic, carrot, artichoke and mustard), fruit trees (fig, almond, apricot, pistachio, pomegranate, plum, pear, grape and olive), forage plants (alfalfa, berseem, vetch and medic), spices and condiments (cumin, fennel, mint and oregano) and hundreds of ornamental and medicinal plants.

Landraces of the crops originally domesticated in the region still grow there, particularly within the traditional farming systems still prevailing in the drylands and mountainous ecosystems. However, as agriculture develops, many landraces are being replaced by new high-yielding
varieties, particularly for major crops. Overgrazing and urbanization are destroying natural habitats and threatening the wild relatives of cultivated plants.

In CWANA region, government institutions, with some assistance from international and regional agricultural research centres, such as ICARDA (International Center for Agricultural Research in the Dry Areas), CIMMYT (International Maize and Wheat Improvement Center) and ACSAD (Arab Center for the Studies of Arid Zones and Dry Lands), carry out most breeding, as well as conservation and characterization of plant and animal genetic resources. This is particularly true for many food and feed crops that are unattractive to private companies, which tend to focus on major food crops and high-value crops such as maize, wheat, vegetables and medicinal and aromatic plants.

The informal seed sector is still dominant in most countries of the region. Farmers select, store and treat their own seed, although there is now increasing participation of private-sector companies in these activities.

Arable land is limited in most parts of the region owing to the presence of large desert and dry areas. Rainfed farming supports the cultivation of cereals and food and feed legumes, while irrigated agriculture is used for industrial crops such as cotton and sugar beet. Fruit trees and nuts are abundant and very diversified in both dryland and irrigated farming.

In most countries of the region, agriculture is still dominated by traditional farming systems, although intensification and commercial agriculture is expanding, especially in irrigated areas. Wheat and barley are the main annual rainfed crops although sorghum is important especially in the Arabian Peninsula, as are irrigated broad bean and cotton in Egypt. Food legumes—faba beans, chickpeas and lentils—are common in crop rotations and, where irrigation is possible, potatoes, summer crops (such as melons), oilseeds and sugar beet are gaining importance. Rainfed perennials include olive, almond, fig, pistachio and fodder trees.

Crop and livestock productivity is generally low in rainfed production systems. Combined with high population growth, especially in the Near East and North African countries, this is leading to increasing food deficits and, thus, increased reliance on imports. This is exerting tremendous pressure on most governments of the region to increase food production to maintain acceptable levels of food security.

Another major feature of the region is the emergence of the newly independent states in Central Asia. These countries are moving from highly centralized economies, the legacy of the Soviet era, towards market-driven economies. The on-going efforts to privatize large scale state farms have been beset by enormous problems that have contributed to a significant decline in crop productivity and food production. About one third of the population in these states is now living below the poverty line.

Although very diverse, the CWANA region has similarities that bring together countries as distant as Morocco and Uzbekistan. These similarities can be clearly seen in the presence of common gene pools, and cultural and historical backgrounds, but are also present in the types of problem that challenge the life of people across the whole region.

**Status of policies and legislations related to biological diversity conservation**

There many agreements and conventions developed to promote national, regional and international efforts for the conservation of agrobiodiversity among which:

1. International Plant Protection (1951); UPOV (1978); Patent Cooperation Treaty (1970); WIPO (1967);
2. UNESCO on means of prohibiting and preventing the illicit import, export and transfer of ownership of cultural property (1970);
4. Crucible group on Intellectual Property Rights (1993);
5. Trade related aspects on IPR (Trips);
6. Convention on Biological Diversity (CBD) and the Convention to Combat Desertification (UNCCD) launched during the World Summit in Rio de Janeiro in 1992 where the Agenda 21: Program of action for sustainable development and the declaration on Environment and Development and Statement of Forest Principles were also signed;
7. UN Commission on Human Rights and Subsidiary organs;

Some agreements are directly relevant to the conservation of plant genetic resources (International Treaty on PGRFA, International Plant Protection Convention, WTO-TRIPS agreement, UPOV (Plant Breeders’ Rights), Regional Agreements (e.g. Andean Pact), networks Agreements, FAO/CGIAR collections in trust, FAO/IPGRI genebanks standards, FAO Code of Conduct; and CGIAR policies on designated material).

The state of signature and ratification of these agreements and conventions is presented in the table 1. Only few countries did not ratify the binding agreements CBD and UNCCD. Fifteen countries have signed the ITPGR and Jordan and Syria were among the first countries to ratify the treaty and only Syria has drafted the national legislation for ITPGR with the help of FAO expertise.

The international agreements agree that existing Intellectual Property Rights did not protect knowledge, innovations and practices of local communities embodying traditional lifestyles and the complexity of developing consistent policies integrating all stakeholders concerns and of designing mechanisms for equitable benefit sharing. These new signed agreement and evolving agreements will affect a wide range of laws, policies and programs and a wide range of human activities at the national and regional levels and this will require to review all existing national legislations and policies, bust also for the countries in CWANA region to play a crucial role in presenting amendments during the review process of the international agreements.
<table>
<thead>
<tr>
<th>Agreements</th>
<th>No. countries</th>
<th>Years of ratification</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNCBD</td>
<td>21</td>
<td>1993-2001</td>
<td>ALG, BAH, EGY, JOR, LEB, LIB, MAUR, MOR, OMA, QAT, SAR, SUD, SYR, TUN, UAE, CYM, CYP, AFG, PAK, IRA, TUR</td>
</tr>
<tr>
<td>UNCCD</td>
<td>19</td>
<td>1995-1999</td>
<td>ALG, EGY, JOR, KWT, LIB, MAUR, MOR, OMA, QAT, SAR, SYR, TUN, UAE, YEM, CYP, AFG, PAK, IRA, TUR</td>
</tr>
<tr>
<td>CITES</td>
<td>14</td>
<td>1975-2001</td>
<td>ALG, EGY, JOR, MAUR, MOR, OMA, QAT, SAR, SUD, SYR, TUN, UAE, YEM, IRA, PAK, TUR, CYM</td>
</tr>
<tr>
<td>Wetlands</td>
<td>13</td>
<td>1977-2000</td>
<td>ALG, BAH, EGY, JOR, LEB, LIB, MAUR, MOR, SYR, TUN, IRA, PAK, TUR</td>
</tr>
<tr>
<td>Biosafety Protocol</td>
<td>9</td>
<td>2000-2002</td>
<td>ALG, EGY, JOR, MOR, TUN, IRA, TUR, CYP, PKA</td>
</tr>
<tr>
<td>UPOV</td>
<td>3 (3)</td>
<td>-</td>
<td>JOR, TUN, TUR (EGY, MOR, IRA)</td>
</tr>
<tr>
<td>WHC</td>
<td>17</td>
<td>-</td>
<td>ALG, BAH, EGY, IRAQ, JOR, LEB, LIB, MAUR, MOR, OMA, PAL, QAT, SAR, SUD, SYR, TUN, YEM</td>
</tr>
<tr>
<td>ITPGRFA</td>
<td>15</td>
<td>2001-2004</td>
<td>ALG, EGY, JOR, KUW, LEB, MAUP, MOR, OMA, SUD, SYR, TUN, UEA, IRA, CYM, TUR, CYM</td>
</tr>
</tbody>
</table>

() countries discussing the adhesion to the UPOV

All the countries drafted their national biodiversity strategies and action plans. But most of the biodiversity legislations did not give due importance to the agrobiodiversity. At the national level, all the countries have many laws and dispositions aiming at the protection of environment, natural resources and biodiversity, but these laws are not often enforced and the destruction of natural habitats and the loss of biodiversity are continuing at an alarming rate. Only few countries have sufficient plans for the protection of biodiversity in nature reserves and fewer have biosphere reserves. Most of these protected areas were not targeting the conservation of wild relatives of important crops and their centers of diversity. In situ conservation and mainly on-farm conservation of local agrobiodiversity is not well emphasized within the national strategies. For ex situ conservation, some countries have developed within their national research systems genebanks and activities for the conservation of plant genetic resources. Table 2 summarizes the activities and programs available within each country of WANA region for the conservation of plant genetic resources. More assessments of these activities and programs are needed to know better the reliability of the actions undertaken at the national level.
Table 2. Activities and programs related to plant genetic resources conservation

<table>
<thead>
<tr>
<th>Countries</th>
<th>FAO/PGR</th>
<th>NPGP</th>
<th>PBR</th>
<th>Quarantine</th>
<th>Seed Control</th>
<th>Gene bank</th>
<th>Nature Reserves</th>
<th>Biospheres Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>+</td>
<td>+</td>
<td>*</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>2</td>
</tr>
<tr>
<td>Jordan</td>
<td>+</td>
<td>+</td>
<td>*</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>1</td>
</tr>
<tr>
<td>Lebanon</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Libya</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>*</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Mauritania</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Morocco</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>2</td>
</tr>
<tr>
<td>Palestine</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Sudan</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Syria</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Tunisia</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>4</td>
</tr>
<tr>
<td>Bahrain</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Iraq</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Kuwait</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Oman</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Qatar</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>S. Arabia</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>UAE</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Yemen</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Cyprus</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pakistan</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Iran</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Turkey</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

FAO/PGR: Member of FAO/PGR commission; NPB: National Plant Breeding Program; PBR: Plant Breeding Rights

As shown in the table above, only few countries have operational genebanks and functional National Plant Genetic Programs which are at different stages of development and differ in the scope and organization. Very few national PGR programs have legal status and clear long term budget commitments. Additionally, diverse institutions are involved in the conservation of plant genetic resources with little or no effective coordination. Some clarifications are needed on the responsibilities among different ministries with regards to the implementation of projects related to international conventions. Very often, biodiversity conservation is not integrated in government policies dealing with sustainable rural development and poverty alleviation and incentives, research and extension efforts are mainly focusing on intensive agriculture. Limited role of NGOs and little involvement of local communities are focusing on the conservation of agrobiodiversity.

Activities and achievements of the West Asia Dryland Agrobiodiversity project

The projects established a thematic group of experts on policy and legislation which met twice a year during the third, fourth and fifth years of project implementation. The tasks executed at national level started with the review of existing policies and legislation related to biodiversity conservation and to agrobiodiversity in particular. A conceptual framework was designed by the experts to ensure the standardization and harmonization of the approach to develop technological, socio-economic, institutional and policy options at field, farm, community, national, regional and international levels. The process of policy development includes the following steps:

1. Situation analysis (decision-making environment);
2. Identify options (national & regional);
3. Testing options;
4. Mechanisms for implementation of options;
5. Development of the legal framework; and

Each national component has drafted the agrobiodiversity conservation strategy which was discussed with key stakeholders including farmers’ and herders’ communities, local and national NGOs and cooperatives, and representatives of different ministries. The strategies were proposed to respective government authorities for their consideration. During the implementation of the project, several actions were approved at the ministerial level among which:

1. A ministerial service order was sent to all Departments of Forestry to include at least 30% of indigenous wild fruit trees in the reforestation and afforestation programs. This order is now implemented in Syria, Jordan and Palestine where national forestry nurseries are multiplying large numbers of these species. In Lebanon, local and national NGOs, and developmental projects have developed nurseries multiplying the local species;
2. National Research Institutes in Jordan, Lebanon and Syria have upgraded their plant genetic programs to include both in situ and ex situ activities. In Jordan a new biodiversity unit is established at the Department of Forestry. In Palestine, biodiversity unit is created at the Ministry of Agriculture;
3. In Syria, the Ministry of environment is planning to establish a protected area targeting the conservation of wild relatives of fruit trees and wheat and barley at Sweida;
4. The project teams in collaboration with the Ministries of Education in the four countries have developed school curricula matrix, extra curricula activities and methodological guides for teachers which are now used in the education systems in Jordan, Syria and Palestine; This will contribute significantly to increasing awareness on the importance of preserving the environment and the biodiversity;
5. West Asia Dryland Agrobiodiversity Project culminated its activities with the organization of a ministerial meeting on 29 June 2005 to sign a Memorandum of Understanding to promote the conservation of agrobiodiversity and the exchange of genetic resources among the four countries. This MOU was signed by Their Excellencies the Ministers of Agriculture Dr. Yousef Kuraishi from Jordan, Prof. Dr. Trad Hamede from Lebanon, Dr. Walid Abed Rabboh from Palestine and Prof. Dr. Adel Safar from Syria, and by the DG of ICARDA Dr. Adel El-Beltagy as a witness. The Memorandum of Understanding, prepared by ICARDA is the first regional initiative in CWANA region aiming at creating a regional alliance for promoting the conservation of agrobiodiversity and the exchange of plant genetic resources. The published text of the MOU is published by ICARDA;
6. One major recommendation was repeated all workshops and in the First International Conference on community-based in situ conservation of dryland agrobiodiversity held at ICARDA during 18-22 April 2005 and is addressed to GEF to provide consequent support to the conservation of dryland agrobiodiversity and the diversity at the centers of origin and diversity.

The project organized several workshops which helped to share the lessons learned and to make necessary recommendations for the follow up of the efforts to sustain agrobiodiversity.
1. Recommendation of the ICARDA-Arab League workshop on “Implications of international agreements on the development of national policies and legislation related to biodiversity conservation”, Cairo, Egypt, 28-30 May 2002

- Establish an Arab strategy and policy for the conservation and sustainable use of biodiversity based on national strategies and develop mechanisms for its implementation and its financing;
- Creation an Arab network for the exchange of information, genetic resources and expertise and creation of an Arab integrated program for the conservation and sustainable use of genetic resources including the establishment of an Arab genebank for plant and animal genetic resources;
- Assign responsibility to a technical body of the Arab League to study and follow all international environment and biodiversity agreements and conventions in collaboration with the Arab, Regional and International organizations to ensure effective and active participation of the Arab region in the technical meetings and the Conference of Parties;
- Advise and ask the Arab countries to sign and ratify quickly the International Treaty for Plant Genetic Resources for Food and Agriculture;
- Conduct a comprehensive study on the state of biodiversity in the Arab world and an economic assessment in collaboration with the Arab, Regional and International organizations working in the region and the use of expertise in the region;
- Development of mechanisms for the access and exchange of genetic resources under bilateral agreements considering the benefits of training, exchange of information transfer of technologies, joint studies and publication and including a fixed duration short enough to allow for its continuous review and the calculation of economic benefits based on global benefits;
- Activate the role of Arab, Regional and International organizations and of research centers and universities in areas related to conservation and sustainable use of biodiversity and stress the importance of building strong collaboration among all national institutions;
- Benefit from traditional expertise and knowledge of local communities and document their property rights to ensure their role in sustaining the development;
- Stress the role of decision makers, different media and of local NGOs in increasing public awareness on the importance of supporting all efforts promoting the conservation and sustainable use of genetic resources and biodiversity especially the introduction of biodiversity conservation at all levels of education systems including graduate studies and the possibility of the creation of an Arab specialized institute on biodiversity;
- Development of a mechanism of coordination among all environment conventions related to biodiversity conservation for better use of available resources. The participation of biodiversity national focal persons to the meetings and activities of the committee of the desertification programme should be supported;
- The Arab League should organize a workshop to discuss the feasibility study of the creation of an Arab genebank in collaboration with the Arab, Regional and International organizations; and
- Organize a coordination meeting to study the training and capacity building needs of the Arab countries in the areas of conservation and sustainable use of agrobiodiversity.
2. Major recommendations of Policy thematic meeting (FAO-ICARDA and Agrobiodiversity project) 3-4 February 2005, Amman, Jordan

- The support and expertise of FAO in developing national ABS legislation is highly needed;
- Need to increase awareness especially of policy makers. This will require important capacity building efforts and to address high officials in the countries (Dr. Duwayri will make necessary contacts); and
- Need for regional networking to enhance harmonization among the countries and to include regional concerns in different conventions and agreements.


**General recommendations**

- Consistent with the decisions made by the CGRFA, the participants welcome the initiatives (monitoring the implementation of GPA; preparation of the second report on state of World’s PGR; the Global Crop Diversity Trust; and assessment of breeding and biotechnology capacities) and encourage the countries in West Asia to be fully involved in these efforts;
- Strengthen the attention and priority to be given to this region by all initiatives;
- Countries and the initiatives need to respond to national and regional priorities of research/development and allocate resources for conservation and sustainable use of PGR and develop mechanisms for equitable benefit sharing at national and regional levels;
- Need to enhance regional integration and networking.
- FAO to address letters to governments to confirm and/or nominate national focal points for PGR and seeds and encourage the countries to establish national PGR committee to include key stakeholders;
- There is a need for harmonization of PGR policies legislations and activities within and among countries (development of a model and a framework);
- Regional and international organizations involved in PGR activities should be full partners in the implementation of these initiatives;
- FAO, ICARDA, IPGRI, AARINENA, ACSAD, AODA, ICBA, are requested to assist the countries in the implementing the initiatives; and
- Financial support from bilateral and multilateral donors in order to be able to conduct these initiatives should be provided.

**Recommendations on monitoring the implementation of GPA**

- Need to mobilize resources to conduct the activity and FAO to take direct and active action in helping the countries in implementing the GPA monitoring;
- Need to include some countries from WANA region within the 2005 plan of work;
- Need to conduct national training workshops on the program developed for monitoring the implementation of GPA;
• Take advantage of existing databases and results of projects such as the WA dryland agrobiodiversity; and
• More emphasis is needed on the implementation of GPA.

**Recommendations on the preparation of the 2nd report on the State of World’s PGR**

• FAO should address letters to governments (Ministries of Agriculture or other institutions as specified by the countries) to facilitate the development of country PGR reports and the monitoring of the implementation of GPA;
• FAO’s technical assistance and its assistance in providing and mobilizing financial support to countries is highly needed to produce country reports;
• Include experience of projects such as West Asia dryland agrobiodiversity project within the case studies; and
• Countries are encouraged to provide feedback to FAO on the draft guidelines to prepare country reports before 31st March, 2005 (participants urged to provide their comments).

**Recommendations on Global Crop Diversity Trust**

• All WANA countries are encouraged to get involved in the development of the regional WANA strategy and relevant global crop strategies for the ex situ conservation of the Annex 1 Crops of the ITPGRFA and identify priorities guiding the allocation of funds from the GCDT;
• National, regional an international organizations/ collections will seek to develop an effective and efficient system for the conservation of the priority collections identified by the conservation strategy (specific role for the CG); and;
• AARINENA is requested to manage, in collaboration and with the technical assistance from regional and international organizations involved in PGRFA (ICARDA, IPGRI,….) the process for the development of the WANA conservation strategy and will ensure the inclusion of all WANA countries in the process.

**Assessment of breeding and biotechnology capacities**

• Countries should request to FAO to be part of the assessment of the breeding and biotechnology activities and in developing the national biosafety regulations and legislations;
• Collaborate with ICARDA and other institutions already involved in the evaluation of national breeding and biotechnology activities;
• Give attention to germplasm enhancement activities using PGR; and
• Seeds should be given due importance in the PGR conservation and sustainable use.

**Other important recommendations**

• Palestine should be an integral part of all the initiatives and efforts;
• Special assistance is requested for the conflict and post-conflict countries (Afghanistan and Iraq);
• Countries are encouraged to provide their comments on the drafted MTA;
• Need to design mechanisms for benefit sharing at national and regional levels and to harmonize the PGR (Access and Benefit Sharing) activities and legislations taking the advantage of the Syrian experience;
• Need to nominate names of 6 technical experts and 6 legal advisors to FAO Interim Committee for ITPGRFA (Contact group); and
• AARINENA, ICARDA and IPGRI and to be involved in the implementation of Global Crop Biodiversity Trust and the production of the second report on the state of World’s PGR.

**Initiative for Arab Genebank?**
- Need to conserve the genetic wealth continuously threatened.
- Need for concerted efforts for harmonization of action and for complementarity.
- Serve as safety collection.
- Reliable facilities and effective programs of conservation (training, database, expertise).

**Options Proposed (Based on Diversity of Environment and Ecosystem)**
- Creation of Arab Center for coordination and database on PGR;
- Creation of sub-regional genebanks; and
- Establishment of upgrading of national genebank.

**Institutional Arrangements**
- Sub-regional genebank will be composed of the existing genebanks or those to be created;
- The Arid Center for Coordination and Information will liaise between the sub-regional genebank; and;
- Each sub-regional genebank will have a Steering Committee composed of members of the countries which is responsible for developing its relevant policies.

**Policy reforms needed at the national level**
- Integrate biodiversity in government policies (education, research and extension efforts promoting biodiversity conservation and use);
- Develop models that will ensure close partnership between government and local communities in managing the genetic resources (devolution of authority on resources, co-management, joint decision making,…); and
- Take advantage of indigenous knowledge.

**National policies and legislations reforms**
- Development of agrobiodiversity strategies and action plans;
- Creation of national biodiversity committee or body and genetic resources committees;
- Rural development of biodiversity rich areas;
- Creation of a network of protected areas;
- Support of research on genetic resources and creation of genebanks;
- Regulation of access to and trade on rare species in addition to quarantine measures;
- Plant variety protection at national level;
- Public awareness actions; and
- Incentives and subsidies to farmers.
Requirements at the regional level

- Enhance sub-regional and regional coordination (promote exchange of germplasm, information and expertise; formulation of regional project proposals; coordinated efforts with international and regional institutions; creation of functional networks);
- Arab networking and coordination; and
- Concerted efforts to influence and benefit from the existing and future international agreements.

Major recommendation for International Centers

- International Centers involved in PGR conservation and utilization, natural resources management, sustaining livelihoods and poverty alleviation and combating desertification to give focus to all aspects promoting the agrobiodiversity conservation with emphasis on creation of enabling policy and legislation environments through:
  1. Development of expertise with needed resources to provide needed technical backstopping and training;
  2. Lead the international activities in the region for harmonization of legislations on biodiversity and PGRFA; and;
  3. Enhance networking and collaboration among NARSs.

Recommendations for global mechanisms and conventions

- Give more emphasis to agricultural biodiversity mainly in the main Centers of Diversity of globally important species;
- Speed up the processes of implementing the articles of the conventions and agreements mainly those related to Benefit Sharing as to reach the custodians of agrobiodiversity and local knowledge; and;
- Provide assistance to the developing countries for capacity building to enable them to adjust their legislations to the new treaties;

Recommendations at the national level

- Establishment of committees and bodies responsible for agrobiodiversity and PGR issues;
- Reforms of existing laws to include the duties and rights included in the ratified agreements;
- Contribute to channeling the benefits to local communities and farmers;
- Integrate more effectively biodiversity conservation and poverty reduction strategies within mainstream development policy and planning processes in order to contribute to the achievement of the MDGs. Given the multidimensional nature of biodiversity-poverty links, this entails a broad agenda for policy and institutional changes across many sectors and levels of action.
- Identify local win-win solutions – such as eco-agriculture, new markets for biodiversity-friendly products, and innovative financing mechanisms such as direct payments to farmers for maintaining ecosystem services – that simultaneously protect biodiversity and maintain critical ecosystem services while also reducing poverty;
- Strengthen global strategies and frameworks so that they adequately support country-led mechanisms to take advantage of such win-win solutions and to scale-up successful local-level processes;
• Assist developing countries in their efforts to set, measure, and achieve country-specific MDG targets linking environmental sustainability and poverty reduction;

• Encourage linkages between, and harmonization of, environmental targets, indicators and interventions developed within country-led MDG processes with mainstream national development frameworks and strategies, especially national poverty reduction strategies and the PRSP process;

• Engage with line ministries, including finance ministries and other agencies overseeing mainstream development planning, to address barriers to integrating environmental sustainability to national development and poverty reduction frameworks, strategies, and programmes;

• Create a more enabling policy and institutional environment for mainstreaming of biodiversity-poverty links through improved governance, including an expanded role for civil society in environmental management;

• Linking Biodiversity Conservation and Poverty Reduction to contribute to the achievements of the Millennium Development Goals;

• Reform trade-distorting policies that undermine the livelihoods of developing-country farmers, and build the capacity of poor farmers in developing countries to meet trade-related environmental standards that stimulate demand for biodiversity-friendly products commanding premium prices in world markets; and;

• Mobilize greater international support and to forge more effective partnerships for moving the poverty-environment agenda forward in a more integrated and focused manner than in the past.

References


Regional meeting to promote the implementation of the global plan of action for the conservation and sustainable use of plant genetic resources for food and agriculture in Central and West Asia and North Africa. Aleppo, Syrian Arab Republic 22nd to 25th June, 1998.

Thrupp, L.A. 1997. Linking biodiversity and agriculture: Challenges and opportunities for sustainable food security. World Resources Institute, USA.

Web sites
CIGAR web site: http://www.cgiar.org
Convention on Biological Diversity; http://www.biodiv.org/convention/articles.asp
http://www.cites.org/eng/disc/text.shtml
FAO Web site for Gender, Agrobiodiversity and Local Knowledge: www.fao.org/sd/links

International Undertaking on Plant Genetic Resources for Food and Agriculture. 1983.
http://www.fao.org/ag/cgrfa/IU.htm
UNCCD. http://www.unccd.int/
http://pubs.wri.org/pubs_content_text.cfm?ContentID=559
Trade related aspects on IPR (Trips). http://www.wto.org/english/tratop_e/trips_e/t_agm0_e.htm
UN Commission on Human Rights and Subsidiary organs
http://www.hri.ca/fortherecordcanada/vol_intro/UN_Guide.htm
UPOV (Plant Breeders’ Rights). http://www.upov.int/en/about/upov_system.htm
Empowering Pastoral Communities to Preserve Agrobiodiversity in the Eastern Ranges of Morocco

A. Herzeni

National Institute of Agricultural Research (INRA), P. O. Box 415, Rabat, Morocco

Keywords: Rangelands, biodiversity, conservation, pastoral communities, empowerment, devolution, Morocco.

Abstract
The High Plateaus of Eastern Morocco is the home of an important pastoral community and of rich plant and livestock diversity. The depletion of natural resources and of plant biodiversity in continuing despite the efforts to rehabilitate the rangelands. The present paper presents the state of the resource base and different arrangements for rehabilitation of rangelands. Devolution to Rural Communes and monitoring and support from government were proposed to empower local communities to contribute to the conservation of local agrobiodiversity.

Introduction
This paper is about the empowerment of pastoral communities of the High Plateaus of Eastern Morocco (HPEM). Empowerment is defined as the access of local communities to decision-making concerning all matters affecting their lives, especially matters pertaining to the management of natural resources. Although an end in itself, empowerment of local communities is precisely thought to be an effective means of ensuring sound natural resources management, including preservation of agrobiodiversity.

The HPEM expand between a line joining the towns of Taourirt and Jerada to the North, the eastern side of the Mid and High Atlases to the West, the Sahara to the South and the border with Algeria to the East. They cover more than 3 Million Hectares of arid steppes where rainfall rarely exceeds 200 mm per year.

The HPEM are home to about 8500 households distributed amongst an undetermined number of villages (duars), 33 fractions of tribe and 11 Rural Communes—the latest, modern and elective form of local government (Ministry of Agriculture 1996).

Over 75% of the households are in a way or another involved in shepherding. The area supports a population of over 1 million heads of sheep and goats, the former largely dominating and being themselves dominated by the breed called Beni Guil, after the name of a major tribe concentrated in the South of the area.

Duars, which used to be the basic shepherding unit, have become only nominal, since a great number of (small) shepherders have gone bankrupt and have settled in towns. Fractions of tribes have kept a role and even seen their role strengthened and renewed with the formation of shepherders cooperatives as we shall see, but, as we shall see too, there are signs that they may be coming, if not to an end, at any rate to a crucial moment when they have to choose between deeply reforming themselves, or accepting their own demise. The major stake in the competition between shepherders seems to be more and more control over Rural Communes.
This paper is not the output of a specific study. It draws from a number of research works that were done in the area during the last 15 years. The author participated to some of these works, but not to all of them.

The status of degradation of the vegetal cover and agrobiodiversity in HPEM
All evidence shows that HPEM have undergone through decades a very serious process of degradation of their vegetal cover and agrobiodiversity. A few decades ago still, the northern part of the area was covered with forests and wooden steppes. HPEM per se were home par excellence to species such as *Stipa tenacissima* and *Artemisia herba-alba*. The former species was so abundant that, besides being grazed by animals in times of feed gap bridging, it supplied for a prosperous local paper making industry.

Today, forests and wooden steppes of the North are hardly surviving. *Stippa tenacissima* and *Artemisia herba-alba* are rapidly disappearing. The area was known as being the “country of wind and *Artemisia*.” people say now that wind is still there, but not *Artemisia* anymore. Instead, poorer vegetation (*Anabasis aphyllum*, *Peganum harmala*, *Asphodelus microcarpus*) is taking over, when it does. In many spots, it is bare sand that has replaced the relatively rich pastures of past times (INRA-Oujda, 2004).

One way to realize the scope of degradation of the vegetal cover and agrobiodiversity of HPEM is to look at the rates of external feed dependency. Before, the rate was near zero. Today, it ranges from 25 % to 70 %, depending on the size of herds, the husbandry system used, the localisation in a South-North transect and, of course, the status of rainfall (IFAD 1996).

The causes of degradation
The causes of degradation of the vegetal cover and agrobiodiversity of HPEM are well documented and have become quite obvious. Besides recurrent droughts due to universal climatic changes, they are as follows:

- **Wood cutting:** This is a widespread practice due to the fact that households are as a general rule very poorly equipped, while winters may be very cold, cooking needs being of course permanent.

- **Overstocking and overgrazing:** Overgrazing is tangible in the area. It is due to overstocking, for which big sheepherders are the chief responsible, some of them owning herds exceeding 20,000 heads, but small sheepherders too may overstock, especially in the vicinity of water points. Overstocking itself may be explained by the following factors:
  - A stable, if not growing, demand for meat from cities,
  - A relative availability of money, thanks to migrants who send remittances to their parents to buy livestock,
  - Some kind of complacency from the State, which continues to subsidize feed, especially in times of drought,
  - A greater mobility of herds allowed by the use of trucks.

- **Cultivation:** This practice is another major cause of degradation. Some favorable spots used to be cultivated by sheepherders amidst their winter quarters. But now this practice is resorted to beyond any agronomic justification. It seems that the main motive behind it is “to be present when privatization occurs”, rumours about privatization spreading in effect episodically.
Now it must be stressed that none of these factors could have taken the proportions it has taken was not it for the decline of traditional organizations that used to protect range land from abusive appropriation, to regulate access to grazing areas and to arrange between tribes for large scale movements of herds.

**Brief history of the decline of traditional organisations**

One of the earlier decisions made by the authorities of the French Protectorate over Morocco was to submit collective land, and the tribal councils that oversaw it (the *jmaas*), to the tutelage of the Ministry of Interior. This decision took place as early as 1919. Its declared purposes were to protect collective land from the impingements of French settlers and of fast spreading urbanization, and to integrate eventually the *jmaas* in the territorial administration system. But none of these promises was fulfilled. Settlers invaded the plains of the Gharb, Tadla and Sais, in particular, and in 1941, with the arrival of new settlers, a French decree allowed for concessions over, and long term leases of, collective land. Although this decree was abrogated as soon as Morocco became independent, the erosion of collective land continued under new forms. As for integration in the territorial administration system, it was never even attempted. As a result, *jmaas* fell into marginality and their spokesmen, the *nuabs*, were at best co-opted by the Ministry of Interior as auxiliaries.

Others factors contributed to the decline of the *jmaas*, namely:

- **Demographic factors**: Emigration, in particular, made it more and more difficult to identify the very constituency of *jmaas*, the body of legitimate claimants to collective land and its use.
- **Economic factors**, such as degradation of natural resources, growth of new consumption needs, adoption of new production techniques, etc., all this leading to more competition and more social differentiation
- **Social and cultural factors**, including abandonment of traditional collective practices such as periodic redistribution of land, periodic endowment of youth with shares of access to natural resources, nomadism and even transhumance and, conversely, spread of individualistic behaviors such as appropriation of collective resources, sale of rights to third parties, etc.

For all these reasons, *jmaas* lost all autonomy. Their domain of competency did not stop shrinking as their natural resources base was drifting away. Their constituency became more and more opaque and plagued by inequality. Finally, Rural Communes captured whatever was left from their visibility and, needless to say, the tutelage of the Ministry of Interior over them is perduering.

**The mixed record of pastoral cooperatives**

May be not out of sympathy for *jmaas*, but certainly influenced by the general infatuation in international development circles with *participation* and participative approaches, and finally drawing the lesson from the less than satisfying result of decades of almost exclusively technical and bureaucratic efforts at stopping the degradation of ranges, authorities in charge operated a major shift in the beginning of the 1990s: they decided to create, at least in the HPEM, what they called “*ethnicity and kinship based cooperatives (EKC)*.” This time, the purpose was to guarantee the participation of the population to a wiser management of ranges, while re-dynamizing, and modernizing, traditional institutions, particularly at the level of fractions of tribes in this occurrence.
After over a decade of exercise, it is possible to outline the record of EKCs. Their main attainments may be summed up as follows:

- Jmaas were in effect re-dynamized to some extent,
- Officials found before themselves a new an interlocutor,
- Some plantations were established through the HPEM,
- Sheepherder’s representatives acquired some (modern) management skills,
- Sheepherders at large were initiated to democratic procedures.

These are the attainments. But, on the other hand, there are shortcomings, the more salient of which are the following:

- Although effective, the acquisition of managerial skills and democratic procedures was not sufficient,
- The extent of plantations stayed limited. Moreover, from the very beginning of the experience, authorities had been often misguided to select litigious areas for the establishment of plantations. Hence, conflicts about these areas continued, and many of them did not function as planned,
- Even plantations established in “safer” places were not always effectively protected,
- Cooperatives failed to cooperate among themselves.

As a result of these shortcomings, many cooperatives have simply collapsed, and some of those that formally survived are in reality mere figureheads for rich sheepherders--which is truly a shame, for the experience which had raised very high expectations, and has cost considerable efforts and amounts of money.

The HPEM at the crossroads

Today, all people who have an interest if not a stake in the future of the HPEM are confronted to three choices:

1. The “let go” choice: It means that cooperatives will die, that rich sheepherders will practically monopolize rangeland and that rangeland will ultimately be depleted;
2. The renewed tutelage choice: It may in effect be argued that after all a chance of autonomy was granted local communities, and that they failed to seize that chance, thus “deserving” to be kept under administrative control. A softer version of this choice would advocate the need of local communities for prolonged “technical assistance”
3. The “leap forward” choice: It implies acknowledging that the chance for autonomy given to local communities was never a full chance; that, true, some latitude for autonomous management was left to local communities, but that this generosity never extended to the issue of property. The point, though, is that without property there can be no real responsibility. The adoption of such an attitude would lead to proceeding in the rangelands of the HPEM to effective devolution of property, all the more readily since devolution would be here, in fact, mere restitution.

There is no doubt that the third choice is the only one conform to equity and the “spirit of the time.” However, demagoguery should be completely banned here. One cannot in effect blind themselves from recognizing that full devolution of property of rangelands to local communities is seriously obstructed by at least two major obstacles:

- One is that the very integrity of local communities is in jeopardy. Two phenomena in particular are undermining it: emigration and inequality. Emigration concerns now over 50 % of households (Tozy, 2004). A high proportion of these households count more than one migrant. And migrants are of course among the more dynamic and intelligent youth. As for
inequality, it has already been alluded to shepherders who own an incredible number of sheep, and to others who have gone bankrupt and live now in towns on precarious businesses. The latter are of course much more numerous than the former.

The second major obstacle before full devolution of property of rangeland to local communities is a question that has not been answered so far, and that is quite hard to answer:

To whom should devolution be made? Who best represents local communities? What may be remaining from old *jmaas*? Cooperatives that have survived? Or Rural Communes?

Unless these obstacles are lifted, speaking of empowerment of local communities, in the case of the HPEM at least, will be just superficial talk.

**The need for an emergency development plan**

Our contention, as far as the question of to whom make devolution is concerned, is that the best candidate is Rural Communes. Residence is in effect taking pre-eminence over ethnicity and kinship and even over economic occupation, partly at least because of the very reasons that are undermining communities (emigration, fall out of the business of shepherding, etc.). Besides, Rural Communes have become *de facto* the focus of local competition, and local competition has already favored the emergence of new leaders who could well be the prototypes of a new, young, educated, hopefully dedicated elite (Tozy, 2005). One cannot underscore the importance of leadership, when all other factors of development are not favorable.

Of course, when Rural Communes inherit the property of rangeland they will have to set rules for its sound, equitable and environment friendly exploitation. They will be able to treat with the population and with “foreigners” as well, either as individuals or groups, and for the latter either as traditional groups or modern organisations. Meanwhile, some party has to take care of the issues of poverty and degradation of the resource base of the HPEM. This party can be but the State. Only the State can undertake the promotion of economic alternatives, the development of education and health, the guaranteeing if not the provision of credit and other programs needed for an effective reduction of poverty. Only the State, too, can *impose* destocking and strict respect of protected areas that need to be multiplied. It may sound paradoxical, but this is the price to pay for eventual, hopefully not too far ahead, empowerment of local communities.
References
General Issues of Agrobiodiversity Conservation in Sustainable Economic Development

G. Edward Schuh

Keywords: Agrobiodiversity, economic development, sustainable development, policies.

Introduction

The setting for my remarks is a broad perspective on sustainable economic development. My colleague (Sandra Archibald) and I discussed this topic in relation to agriculture some years ago. That paper had been commissioned by the United Nation’s Food and Agriculture Organization (FAO), and was eventually published, together with other papers, in a book (1996).

Archibald and I took an approach to the sustainability issue that was significantly different than most people were taking at that time. We argued that contrary to the view prevailing at that time, sustainability involved more than environmental issues. To be specific, we argued that sustainable development referred to the capability for sustained increases in per capita income. From that perspective, a broad range of economic policies had to be considered as components of economic development policy. Those include aspects of monetary and fiscal policy so that savings rates were high and sustained, savings and investment policy, investments in human capital, and activities to preserve the environment.

The program of this conference is consistent with the Schuh/Archibald perspective. The conservation and sustainable use of dryland agrobiodiversity is not directly an environmental issue, although it has important implications for the environment. Instead, it deals directly with preserving the germplasm and other sources of animal and plant material that are critical to sustaining a flow of biological resources for agricultural development.

The organizers of the conference asked me to be sure to address aspects related to global and regional responsibilities for the promotion of the conservation of globally important biodiversity. That is what I will try to do. My perspective will range from macroeconomic policies to sustain a stable economic environment, to a discussion of the role of biological innovations in agricultural development, to more specific policies that can promote conservation and sustainability.

My general perspective is that biodiversity involves plant and animal genetic resources, livestock, insects, and soil organisms. To cover these various components of biodiversity in one contribution would be a major paper. To help narrow the focus I will dedicate most of my remarks to the issue of plant genetics and to the economic dimensions of policy – my professional comparative advantage. Many of my remarks will have more general application and implications, however.

The macroeconomic environment

Macroeconomic policies may sound rather far removed from the conservation of biodiversity. They are not, however. The conservation of biodiversity involves investments for the future. Unless an environment is created that encourages savings and investments at appropriate levels, little success can be expected with more narrowly focused policies.

The key policy issues in this case are national monetary and fiscal policies. The goal should be to have policies that result in a stable price level and that result in a balanced budget on, say, a three-year basis. Such policies, together with a system of flexible currency markets will result in
interest rates that will encourage savings and investments in rational configurations that will sustain economic growth into the future. Policies that depart from this standard will result in either negative real rates of interest, and thus dis-saving, or little incentive to invest for the future. Investing for the future is critical to investments that lead to the conservation of biodiversity.

My assignment was to be sure to cover regional and global issues. In effect, there are no regional issues on this particular issue of policy. However, there is a global issue. Although it is not likely to be something that receives a lot of discussion at this conference, there is a global dimension to stabilizing the global or international economy. That issue can usefully be mentioned in this context. Under present arrangements the United States is the central banker for a global economy that is on a dollar standard. To the extent that we do not have stable monetary and fiscal policies, we impose rather large shocks on other countries. The solution to this problem in my view is to establish a global central bank in the form of something like the International Monetary Fund and transfer the management of global economic policy to that organization. (See Schuh, 1986)

A second macroeconomic issue is the importance of proper trade and exchange rate policies. The problem is that many of the developing countries discriminate against their agricultural sector by protecting it, taxing it, and by overvaluing their currency. The result is to shift the domestic terms of trade against the agricultural sector, thus reducing the incentives to invest in agriculture. This lack of profitability makes it unlikely that farmers will make the investments to preserve biodiversity.

Another macroeconomic issue, largely because it involves national fiscal policy, is the need to sustain and increase the stock of human capital. This is a perspective that comes from the Schuh-Archiбалd framework. Human capital, whether in the form of education, health, knowledge, or production technology, has a tendency to depreciate in the same way that physical capital does, and to become obsolete as changes in the economy occur at an ever increasing rate. Sustaining the stock of human capital is an important macroeconomic issue.

The role of biodiversity in agricultural modernization and development

Probably the most widely accepted policy perspective for the modernization and development of agriculture is that articulated by Yujiro Hayami and Vernon W. Ruttan. Commonly known either as the induced technical change model or the induced institutional change model, this perspective argues that two main kinds of innovations drive the modernization process. One of these consists of biological innovations and has a major role to play in situations where land is scarce and there is a need to raise the productivity of that resource. The other class of innovations has to do with raising the productivity of labor, and is pertinent in labor scarce economies. At one time, mechanical innovations dominated this kind of innovation. Now, herbicides and related innovations play an ever-more-important role.

Two important insights pertinent to the title of my paper came from the Hayami-Ruttan perspective. The first is that biotechnology for agriculture tends to be location-specific, and needs to be adapted to local ecological and economic conditions. The implication is that agricultural research institutions to produce the new biological innovations must be “local” and committed to local regions or conditions. The second insight is that the biological innovations for the most part have to be produced by public institutions. The private sector has the incentive to produce mechanical innovations so it will tend to produce the mechanical innovations. With intellectual property rights it may be that more and more biological innovations will be produced by the private sector. However, that is not likely to eliminate the role for public programs or investments.
The policy implications of the Hayami-Ruttan perspective are that national policy makers, including at both the national and regional levels, need to invest in agricultural research to sustain new flows of biotechnology. The new flows of biotechnology constitute an important aspect of sustaining biodiversity. Some of the new knowledge will create new dimensions to that diversity. Other components may be useful in preserving what we already have. The latter becomes especially important in the case of vegetatively propagated crops, in which case bacteria and viruses constitute an important threat to preserving the genetic material.

At the regional and global levels, the international system has already responded to these needs in a remarkable way. The International Agricultural Research Institutes that make up the Consultative Group for International Agricultural Research (CGIAR) are strategically located in terms of ecological conditions. Moreover, most of them have undertaken efforts to preserve genetic diversity by creating gene banks for the commodities they specialize in. In addition, there is also an international center that has been given the responsibility of doing this for the world. The challenge this system faces is to sustain the financial support for it. Sustaining donor support has been a struggle, and not much creative thinking has gone into developing alternative sources of funding.

Finally, there is great potential for additional cooperation to preserve genetic material for those commodities that are not part of the international system. Collecting and preserving the plant material is a costly process. Two or more countries coming together in joint efforts should assist in reducing the cost to each one.

More narrow and localized policies

A number of dimensions of policy often take place at the local level but have devastating effects nationally or globally. I have been impressed in the past, for example, by policies in the Middle East region that led to substantial reductions in landraces and wild relatives of wheat that have great value in breeding programs elsewhere around the world. These landraces and wild species are not profitable to produce for individual farmers, but have great value to society as a whole. This may be a case in which in situ conservation is essential. In this case, the solution may be to just pay selected farmers to raise the crop each year and save the seeds. The obvious point is that public intervention is needed if the genetic material is to be raised.

Another issue of some significance is the destruction of forests and other virgin natural habitats that in turn wipe out important sources of biodiversity. One solution to this issue is the modernization of agriculture. One often forgets how important this process can be. One can gain the insight by thinking about what agriculture in the United States would be if there had been no increases in productivity. We would have been producing maize and other crops up the mountainsides of the Rocky Mountains and Appalachia. Instead, we have pulled more than a million acres out of production, thus adding to wilderness areas rather than reducing them.

Another basis for loss of plant genetic material is the subsidies that governments pay for the clearing of land. Such policies should be considered in the context of alternatives such as spending comparable resources to raise productivity so expansion on the extensive frontier is not needed.

A related policy is to allow grazing on public lands on which there is a diversity of plant material. Rules should be set to minimize the loss of plant material from such practices, or grazing should be prohibited outright if that should be the case.
Still another issue is the slow economic growth in many countries that causes labor to accumulate in rural areas rather than to migrate to urban centers. This accumulation is often the cause of labor pushing into fringe areas, with the destruction of biodiversity the consequence.

Rural development -- the expansion of non-farm activities in rural areas -- can help to alleviate such pressures. It is the human and financial costs of migration that contributes to the accumulation of resources in the rural sector. If jobs are created in rural areas, many of these costs will be reduced and labor will take employment close to where they live without pushing out on the frontier in search of remunerative activities.

Another micro issue in breeding programs is the issue of avoiding excessive specialization. Often there are significant gains from such specialization, but the danger is that when a disease or pest threat is posed, an entire crop can be wiped out. Although this is basically a case for preserving biodiversity, it is still an important issue on the policy side.

Finally, there is the issue of intellectual property rights. In many respects these are counterproductive in terms of conserving biodiversity. My concern is that such rights cause private companies to concentrate on a narrower range of crops and thus to reduce biodiversity in the process. Ironically, there is growing evidence that intellectual property rights are not needed for the private sector to invest in biological innovation. They basically grant monopolies in situations in which they are not justified.

**Concluding comments**

The issue I have not covered is finance. Many of the activities or initiatives I have discussed above involve public expenditures. Starting with the need to finance the CGIAR system, ranging down to the support of public research at the state level, and going through rural development and the enforcement of grazing and other laws, the demand for additional financial resources will grow as the demand for diversity grows. Aside from sorting out the various policy issues, the means to finance the various policy interventions will continue to grow.

Finally, I want to emphasize the importance of collaboration between economists and other social scientists with biological and natural scientists. Each has much to offer the other. We unfortunately tend to view each other as rivals rather than the more productive colleagues or complements. The challenging problems of biodiversity will not be solved by social scientists or biological scientists alone. The solutions will come only with collaboration.
References
Developing and Implementing Access and Benefit Sharing (ABS) Regulations in the Pacific Rim Region: Issues and Challenges

S. Carrizosa

Genetic Resources Conservation Program, University of California, Davis, CA 95616, USA. E-mail: scarrizosa@ucdavis.edu

Keywords: Biodiversity, conservation, benefit sharing, access, genetic recourse.

Abstract
The 1992 Convention on Biological Diversity (CBD) and the 2004 FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) recognized the sovereign rights of countries to control the use of their genetic resources. Since the CBD came into force, bilateral agreements have been the main vehicle to facilitate access under the few national access and benefit-sharing (ABS) policies that were developed to include the objectives and principles of the CBD. On the other hand, under the ITPGRFA, ABS goals will be achieved through a multilateral system of exchange of genetic resources. This access system is limited to some plant genetic resources for food and agriculture. Access to genetic resources for chemical, pharmaceutical, nonfood, and nonagricultural uses would still be negotiated bilaterally in accordance with national ABS policies and the CBD. To date only a limited number of countries have developed and implemented national ABS policies. Results of difficulty in implementation of these policies include the slowing of the flow of genetic resources between countries and reciprocal benefits. Given the importance of maintaining the flow of genetic resources, benefit sharing, and conservation, a large scale and comparative analysis of different national experiences is warranted.

To this end, four scholars at the Davis and Berkeley campuses of the University of California launched a study of ABS policies and their implementation among 41 countries on the Pacific Rim. The study began in January 2002 and concluded in July 2004. The key objectives were to describe the main components of the access and benefit-sharing policies, the processes of drafting these policies and the experience of implementation. The main purpose of this paper is twofold: 1) to provide a synthesis of the main results of the study, and 2) to describe some of the issues and challenges that have interfered with the development and implementation of ABS policies.

Introduction
The 1992 United Nations Convention on Biological Diversity (CBD) and the 2001 Food and Agriculture Organization of the United Nations (FAO) International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) recognized the sovereign rights of countries to control the use of their genetic resources. These two agreements also stressed that the authority to determine access to genetic resources rests with national governments and is subject to national policies. The objectives of the CBD are the conservation of biological diversity, its sustainable use, and the fair and equitable sharing of benefits derived from the use of genetic resources. Similarly, the objectives of the ITPGRFA are the conservation, sustainable use, and equitable sharing of the benefits derived from plant genetic resources for food and agriculture. This Treaty also stressed that these objectives shall be accomplished by linking this Treaty to the FAO and the CBD (FAO 2001).
The CBD, sometimes also called the “biotrade convention”, encouraged member countries to facilitate access to genetic resources and take measures to ensure the fair and equitable sharing of benefits derived from the use of these resources. The CBD emphasized that access to genetic resources should be on mutually agreed terms and subject to prior informed consent of the providing country. Since the CBD came into force, bilateral agreements have been the main vehicle to facilitate access under the few national access and benefit-sharing (ABS) policies that were developed to include the objectives and principles of the CBD. On the other hand, under the ITPGRFA, ABS goals will be achieved through a multilateral system of exchange of genetic resources. This access system is limited to all plant genetic resources for food and agriculture; access to genetic resources for chemical, pharmaceutical, nonfood, and nonagricultural uses would still be negotiated bilaterally in accordance with national ABS policies and the CBD. Initially, the exchange of germplasm of food and forage crops listed in an Annex and subject to modification will be regulated by this multilateral system (FAO 2001).

In 1992, the Convention on Biological Diversity (CBD) provided a mandate for countries to develop national access and benefit-sharing (ABS) policies. In the last 12 years, however, countries have been burdened by the development process of these policies, encountering multiple obstacles and problems. To date only a limited number of countries have developed and implemented ABS policies. Pacific Rim countries, such as the Philippines, Costa Rica, Colombia, Ecuador, and Peru, have been pioneers in the development of these policies. These nations have had difficulties and successes trying to design and implement ABS regulations and they offer valuable lessons to other biodiversity-rich countries that are still planning to develop these regulations. Results of difficulty in implementation of these policies include the slowing of the flow of genetic resources between countries and reciprocal benefits. These countries have also faced two contradictory issues in drafting national ABS policies to regulate access and exchange of genetic resources. First, restricting access is seen as a means to avoid domestic controversy and promote conservation by limiting overexploitation and by increasing the future value of genetic resources. On the other hand, providing access is necessary to generate a flow of benefits derived from biodiversity, including both commercial and scientific benefits. Given the importance of maintaining the flow of biological resources, benefit sharing, and conservation, a large scale and comparative analysis of different national experiences is warranted. To this end, four scholars at the Davis and Berkeley campuses of the University of California launched a study of ABS policies and their implementation among 41 countries on the Pacific Rim. The study began in January 2002 and concluded in July 2004 and it involved the participation of over 60 ABS experts from the Pacific Rim (Carrizosa et al. 2004). The key objectives were to describe the main components of the access and benefit-sharing policies, the processes of drafting these policies and the experience of implementation. This paper presents a brief synthesis of the main results of the study and it focuses on some of the issues and challenges that have interfered with the development and implementation of ABS policies.

**Main results**

The main results indicate that from the signing of the CBD until mid-2004, only nine Pacific Rim countries (22%) had developed some sort of national ABS regulation, 26 of them (63%) were working on their ABS frameworks, and 6 (15%) were not actively involved in a process working towards the development of ABS regulations.

Countries have selected a wide variety of policy options that address ABS issues (see Table 1). For example, while countries such as Mexico decided to incorporate ABS provisions into an
existing environmental law, other countries such as Costa Rica decided to develop a Law of Biodiversity that addresses not only ABS issues but also other objectives of the CBD. The following four main categories of policy options that address ABS goals were identified:

- Regional and national stand-alone ABS laws and policies (Andean Community of Nations, Malaysia, and the Philippines);
- Laws of biodiversity, sustainable development, or environment acts that include biodiversity conservation and sustainable use provisions and ABS guidelines usually designed to implement the CBD as a whole (Costa Rica, Cook Islands, Honduras, Indonesia, and Nicaragua);
- Existing environmental, sustainable development or ecological laws that have been amended to include ABS provisions (Australia and Mexico);
- ABS policies that may be developed further into more comprehensive ABS laws (El Salvador, Samoa, and Panama)

Access to agricultural genetic resources is covered by the scope of national ABS polices of Pacific Rim countries that we examined. As of July 2004 Australia, Colombia, Costa Rica, Ecuador, Malaysia, Nicaragua, Peru, and Thailand had signed or acceded to the FAO ITPGRFA. The USA also signed it, but there is little probability that the USA Congress will ratify it. In any case, the FAO ITPRFA entered into force on 29 June 2004 and present evidence indicates that these countries (except for the USA) will exclude the crops and forages listed in Annex 1 of the ITPGRFA from the scope of their national ABS laws and policies. The analysis of selected ABS policies revealed several issues and challenges that have interfered with the development and implementation of these policies.

ABS policy issues and challenges

More than any other natural resource policy, ABS policies have been the target of misconceptions, politics, and negative publicity. Biopiracy claims, poorly defined ownership rights over genetic resources, the patenting of life, the protection of traditional knowledge, and equity issues have thwarted access initiatives and have also contributed to the cancellation of bioprospecting projects in countries such as Mexico. Bioprospecting projects also remain the focus of fierce and intensive criticism by advocate groups that have great influence among indigenous organizations, government actors, and environmental groups worldwide.

The fact that most of these policies and projects will indulge or deprive specific stakeholders tends to mobilize them to shape the policies in their interests. Taking into account the importance of this debate we examined the following eight key issues (i.e., ownership, scope, access procedure, prior informed consent (PIC), benefit sharing and compensation mechanisms, intellectual property rights (IPRs) and the protection of traditional knowledge, in situ biodiversity conservation and sustainable use, and monitoring and enforcement) of selected national ABS policies. These are a few of the issues and challenges that can be identified from such analysis:

- The scope of most ABS policies covers nonhuman genetic, biological, and biochemical resources found in in situ and ex situ conditions. This broad scope has caused confusion among the users and providers of genetic resources about the type of activities that should be regulated by these policies. Since the main implication of Article 15(3) of the CBD is that ex situ genetic resources collected before the CBD entered into force are not covered by it, pre-CBD ex situ collections should not be covered by the scope of ABS policies. However, in practice, most ABS policies cover these collections.
Access to pre or post-CBD ex situ collections has not been clearly defined by the ABS polices analyzed in our study. Access procedures for ex situ genetic resources remain a gray area in all countries due to ownership issues. For now, it seems that applications for ex situ collections will be considered on their own merits with respect to a range of factors. These include the ownership of the material from which the ex situ accessions were obtained and the circumstances under which the material passed into the possession of the ex situ holder, including possible terms and conditions proposed by the holder (i.e., gene bank or botanical garden) of the ex situ genetic resources. For example, ex situ conservation centers such as the ones administered by FAO have adopted material transfer agreements as a standard practice to exchange genetic resources. Ownership of these collections is still controversial.

Monitoring bioprospecting activities is one of the most difficult, expensive, and resource consuming tasks. No Pacific Rim country has in place either a national or an international monitoring system. Once samples leave the country it is very difficult to follow their use and the exchange of information about them. Some countries might require bioprospectors to pay for monitoring and evaluation procedures or to purchase a compliance or ecological bond.

PIC should be obtained from both national authorities and the providers of genetic resources and traditional knowledge. According to ABS policies, PIC from the government can be obtained through collecting permits or access agreements and PIC from the providers of genetic resources or traditional knowledge local communities can be obtained through agreements or certificates that are usually the result of a consultation process. In any case, PIC procedures must be clearly outlined in a way that reduces time and transaction costs for bioprospectors and these procedures must also be simplified for noncommercial bioprospectors.

It is interesting to note that the Law of Biodiversity of Costa Rica initially excluded plants, animals, and gene sequences from patenting, however this exclusion was repealed years later by an amendment to the national patent law. This is just one example of the conflicting views about the patenting of life that we found in many Pacific Rim countries.

ABS policy development process: Complex policymaking and implementation scenarios
How do policymakers deal with the complexity of ABS issues? Motivations are as complicated and multiple as are the policy objectives. Some policymakers usually complain about the complexity of the issues and users they face. The inability to face this complexity may be responsible for the failure to uphold appropriate standards of equity, respect for traditional knowledge, and biodiversity conservation. In any case, few things are more difficult for policymakers to do than to pursue the development of ABS objectives in complex policymaking and implementation scenarios. The demands of interest groups, self-interest of specialized government and nongovernmental organizations, the complexity of the interactions within the system, and the possibility for unexpected and perverse side effects are ingredients certainly present in any policymaking and implementation processes carried out in countries such as Colombia, Australia, Malaysia and the Philippines. Furthermore, other countries have had to face social and economic crisis (Solomon Islands), severe shortages of trained personnel (Samoa, Cook Islands, Nicaragua), limited fiscal and technical capacity (Vietnam), fragile political relationships (Cook Islands), and weak institutions (Laos). In addition to these and other economic, political, or social conflicts, these and many other countries have had to address ABS policymaking and implementation processes in the context of different forms and levels of
centralized and decentralized government structures that influence and determine opportunities for success or failure.

In most if not all of the countries examined, ABS policymaking and implementation was often regarded as synonymous with centralized top-down initiatives and decision-making was usually monopolized by national governmental organizations. This is the heritage of government regimes (where the source of all power is usually found in the capital of the nation). Centralization of authority has been used in all societies as a way to improve both information flows and the ability to design and implement policies. A major and well-known problem of centralization is that technical expertise becomes increasingly scarce as one moves from the center to the periphery of a society and this is certainly the case in most of the countries examined in this report. This issue is compounded by the fact that ABS concepts are particularly complex and complexity implies the need for good information. The uneven quality of information among stakeholders influences the focus of attention.

Centralized expertise also fails to understand and respond to specific local conditions. In other words, the least powerful members of society may be exploited by local elites, they are literally invisible to centralized planners, and national elites always find ways of dominating policymaking. These least powerful members of society, particularly in developing countries, include unionized workers, bureaucracies, and farmer and indigenous communities. Another circumstance is that centralized agencies usually deal with local notables partly because the local elite simply is more articulate and informed than the mass of the population. Decentralization by itself, however, does not translate automatically into local people’s participation in the policymaking and implementation process of ABS. Decentralization also requires incentives such as strong local capacity and effective participation channels. Our findings indicate that village cooperatives, labor unions, peasant organizations, and NGOs have become increasingly important channels for the activism of indigenous, peasant, and university-educated people. These participatory scenarios facilitate the articulation of a valid counterpoint to centralized governmental input that enriches the debate and contributes to more balanced ABS policies. Besides, common sense dictates that locally originated proposals can be aggregated and shaped to ensure that they are compatible with top-down policymaking approaches such as the CBD requirements.

In addition, in every participatory process, it is important to be aware of subtleties of different stakeholders that are likely to determine the outcome of the development and implementation process of ABS policies. These include:

♦ Public authorities are not always responsive to public opinion. Especially when government organizations assume that they have sufficient technical capacity and expertise as illustrated by the development process of Decision 391.

♦ On most ABS issues most policymakers and other stakeholders do not have an opinion in the sense of having thought about the issue or having a consistent body of information about it. Instead most people are prepared to take a party line or position rather than invest time and effort analyzing a specific issue as exemplified by the development process of the Law of Biodiversity of Costa Rica.

**ABS policy implementation**

Implementation of ABS policies in the Pacific Rim region has been limited to a few cases. Between 1991 and mid-2004 most of the countries that have ABS policies invoked these frameworks to grant access to 22 bioprospecting projects. In the Philippines, only two out of 25
bioprospecting groups have been granted access to the country’s biological genetic resources. Some of the problems experienced by the Executive Order 247 were related to the scope of the law, the lengthy application procedure, prior informed consent issues, and biodiversity conservation issues. In 2001 the ABS policy of Samoa was invoked to negotiate a benefit-sharing agreement between the government of Samoa and the AIDS Research Alliance for the use of a compound derived from a local plant.

Implementation of Decision 391 in the Andean region has also been poor. In 1997 Colombia failed to negotiate a commercial access agreement under Decision 391 due to technical and political factors. Other access applications are on hold in Colombia until rules regarding the implementation of Decision 391 are clarified. Ecuador and Peru have also access applications on hold until national policies for Decision 391 are adopted. In Costa Rica, until now all access requests have been granted under the 1992 Wildlife Conservation Act and its 1997 regulation. Between 1991 and 2004, the National Biodiversity Institute and its partners in Costa Rica have implemented 15 bioprospecting projects. In Mexico, the Ecological Equilibrium Act granted access to three bioprospecting projects that were cancelled due to legal conflict and social protest. In the USA the Federal Technology Transfer Act and National Park Service (NPS) policy was invoked to facilitate ABS goals for the Diversa/National Park Service project that is currently suspended until the NPS completes an environmental impact study.

The Costa Rican experience indicates that chances of implementing effective national ABS policies are likely to increase in a decentralized context where the common denominator is strong local capacity and participatory mechanisms coupled with strong local government and nongovernment organizations. Furthermore, successful implementation of ABS policies will be facilitated when agreement and negotiation of projects take place between a minimum number of parties that share a common mission and with minimum intervention of bureaucracy and centralized government agencies. In contrast, as demonstrated by the Colombian experience an extensive and centralized bureaucratic process results in delays in the negotiation of projects that damage the morale and trust of implementers and recipients, thereby hampering successful implementation of ABS policy.

**Conclusion**

Only 22% of the countries analyzed in this study have developed some national ABS policy. This does not necessarily show that countries have been inefficient, but rather cautious and inexperienced. Before the CBD came into force, most, if not all, of these countries had a permit system to regulate the extraction and management of biological resources. The transition from these permit systems to more comprehensive ABS frameworks has proven to be difficult as many countries struggle to find the economic means to develop such frameworks, the technical expertise or the much-needed consensus about new and controversial issues raised by the CBD. The political framework for access to genetic resources that any country develops will only be as good as the process through which it is developed. To actually work once established, the political framework must have the broad support of all relevant sectors of government and society; fit within the country’s larger strategy for conserving and sustainably using biodiversity; and must be supported by decentralized institutional processes and capabilities sufficient to implement it. Building local capacity to improve policy development and implementation is a priority for all the countries reviewed in this study.

Finally, the 2002 Bonn Guidelines on ABS have provided guidance for the countries embarked on the development of ABS frameworks. However, governments and bioprospecting groups will
continue facing controversial issues such as the patenting of life, access to traditional knowledge, and the perception that benefit-sharing agreements are not equitable. These are also some of the key issues that must be carefully addressed in order to facilitate both the development of national ABS policies and future efforts to negotiate an international regime on ABS.

Table 1. Access and benefit sharing (ABS) policy status of Pacific Rim countries

<table>
<thead>
<tr>
<th>Country/Description of policy or reason why no policy exists</th>
<th>A. Countries with ABS laws and policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Colombia</td>
<td>As a member of the Andean Community, Colombia is subject to the 1996 Decision 391 on ABS, a regional law, and is currently working on a policy to facilitate implementation of Decision 391 at a national level.</td>
</tr>
<tr>
<td>2. Costa Rica</td>
<td>In 1998, Costa Rica enacted the Law of Biodiversity No. 7788. In late 1998, the Attorney General of the Republic challenged the law, which prevented its implementation. In December 2003, a “General Access Procedure” that will operate as the bylaw of the Law of Biodiversity was published. Before the development of this law, there were some provisions in the 1992 Law of Wildlife Conservation (and its 1997 regulation) regarding flora and fauna collection permits. There were also some bylaws dealing with research, specifically referring to national parks.</td>
</tr>
<tr>
<td>3. Ecuador</td>
<td>As a member of the Andean Community, Ecuador is subject to the 1996 Decision 391 on ABS, a regional law. In 1996, a law for the protection of biodiversity was passed by Congress. The law includes only one article that determines the State’s ownership of biological species as national and public goods. This article also states that the commercial exploitation of these species will be subject to special regulations issued by the President that will guarantee the rights of indigenous communities over their knowledge and genetic resources. Ecuador is also working on a draft regulation of Decision 391 that has been in the making since the ratification of Decision 391. A final draft was submitted in April 2001 to the Minister of the Environment. That draft received much criticism and was not approved by the Minister. There are also general provisions in the pending new draft National Law for the Conservation and Sustainable Use of Biodiversity debated by Congress in April 2002 and February 2003. The draft law is still under discussion among government officials (September 2004).</td>
</tr>
<tr>
<td>4. Mexico</td>
<td>Articles 87 and 87 BIS of the Ecological Equilibrium and Environmental Protection General Act (EEEPGA) regulate ABS issues in Mexico. This law incorporates the three main principles stated in the Convention on Biological Diversity (CBD): prior informed consent (PIC), mutually agreed terms, and benefit sharing. The EEEPGA is complemented by a norm (NOM-126-ECOL-2000) that facilitates a change of purpose from scientific (or noncommercial) to biotechnological (or commercial) uses. The 1999 Wildlife General Act (WGA) and the 2003 Sustainable Forestry Development Act (SFDGA) regulate the collection of wildlife and forest biological resources respectively. EEEPGA, WGA, and SFDGA set the principles but not the details that should regulate ABS initiatives. There are two ABS law proposals in the Federal Congress that purport to fill this gap: one submitted by Federal Senator Jorge Nordhausen (National Action Party, PAN), and another submitted by Federal Representative Alejandro Cruz Gutierrez (Institutional Revolutionary Party, PRI). So far Congress has not discussed these laws in the plenary.</td>
</tr>
<tr>
<td>5. Philippines</td>
<td>In 1995, the Philippines adopted the first ABS policy in the world, Executive Order 247 “Prescribing Guidelines and Establishing a Regulatory Framework for the Prospecting of Biological and Genetic Resources in the Philippines, their By-Products and Derivatives for Scientific and Commercial Purposes and for other Purposes.” In 2001, the Philippines enacted Republic Act No. 9147, also known as the Wildlife Resources and Conservation Act that addressed many of the criticisms made to the Executive Order 247. This Act includes only two clauses about bioprospecting issues but it modifies Executive Order 247 considerably. In July 2004, a final report of the draft Guidelines for Bioprospecting Activities in the Philippines was posted on the website of Secretary of the Department of Environment and Natural Resources (<a href="http://www.dem.gov.ph/article/view/2332/">http://www.dem.gov.ph/article/view/2332/</a>). If adopted, the guidelines would facilitate the implementation of the Wildlife Act and those provisions of EO 247 not repealed by the Wildlife Act. The Philippines has also been actively leading the development of the ASEAN Framework on Access to Biological and Genetic Resources that is scheduled to be adopted in 2004.</td>
</tr>
</tbody>
</table>
6. Peru
As a member of the Andean Community, Peru is subject to the 1996 Decision 391 on ABS, a regional law. Peru has a draft regulation for Decision 391 that is being reviewed by the National Environmental Council. The government is also developing a second regulation targeted to facilitate access to genetic resources found in indigenous land. In August 2002, Peru adopted Law No. 27811 for the protection of indigenous communities’ collective knowledge associated with biodiversity.

7. Samoa
In 2000, Samoa adopted the “Conditions for access to and benefit sharing of Samoa’s Biodiversity Resources” (CABSSBR) This is a regulation that is being implemented to facilitate access, while the country completes a draft bioprospecting regulation. However, further progress on this regulation is on hold until the Department of Lands, Surveys and Environment completes a review of the 1989 Lands, Surveys, and Environment Act. The draft bioprospecting regulation is expected to be appended to the Act.

8. Thailand
ABS is regulated by the following two laws and two regulations: The 1999 Plant Variety Protection Act, the 1999 Act on Protection and Promotion of Traditional Medicinal Intelligence Act, the 1999 Royal Forest Department Regulation on Forestry Studying and Research Conducting within Forested Areas, and the 1982 Regulation on the Permission of Foreign Researchers of the National Research Council of Thailand.

9. United States of America (USA)
The USA signed the CBD but it has not ratified it yet. Access to natural resources in the United States is ordinarily managed by the private or public owner of the resource. For example, access to genetic resources found in national parks is governed by the National Park Service (NPS) regulations. Since 1983, the NPS has issued permits to facilitate the collection of specimens, and Cooperative Research and Development Agreements (CRADAs) can be used to address benefit-sharing issues. A CRADA is defined by the Federal Technology Transfer Act of 1986 as “any agreement between one or more Federal laboratories and one or more non-Federal parties under which the Government, through its laboratories, provides personnel, services, facilities, equipment, or other resources with or without reimbursement (but not funds to non-Federal parties) and the non-Federal parties provide funds, personnel, services, facilities, equipment, or other resources toward the conduct of specified research or development efforts which are consistent with the mission of the laboratory.”

B. Countries working towards the development of ABS laws and policies

1. Australia
The draft Environment Protection and Biodiversity Conservation Amendment Regulations are expected to be enacted in 2005 and they will go under section 301 (Control of access to biological resources) of the 1999 Environment Protection and Biodiversity Conservation Act. These regulations will apply only to the “commonwealth area” of the country. The states and territories are also working on their own ABS regulations. For example, in mid-2004, Queensland passed a Biodiscovery Bill and Western Australia is currently discussing a licensing regime for terrestrial bioprospecting activities that will be included in a draft Biodiversity Conservation Act. In addition to this, in 2002 the Natural Resource Management Ministerial Council adopted a federal agreement on a “Nationally Consistent Approach For Access to and the Utilization of Australia’s Native Genetic and Biochemical Resources” to facilitate the development ABS regulations nationwide.

2. Cambodia
In 2002 Cambodia adopted a new Forestry Law. While this law is not specific about regulating ABS issues in relation to forest genetic resources, it regulates the commercial and non-commercial use of timber that is extracted from the all forests (natural and planted), including wild vegetation, wildlife products and services provided by the forest. Also, in 2002, the Ministry of Environment made public the country’s National Biodiversity Strategy and Action Plan. This document does not address the need to develop a comprehensive ABS policy, but it states as one of its goals to ensure the equitable sharing of benefits from the protection and sustainable use of biological resources. Furthermore, the strategy and action plan emphasizes that existing legislation concerning biodiversity conservation and sustainable use is currently under revision in Cambodia.

3. Canada
No official decision has been made as to whether Canada should have an ABS policy. However, this country has undertaken some background research on ABS issues and held preliminary discussions with the provinces, some aboriginal groups and stakeholders on ABS issues, especially with respect to the negotiation of the CBD Bonn Guidelines on ABS. The National Biodiversity Convention Office has been consulting aboriginal people on the Bonn
Guidelines in advance of the Bonn Guidelines being reviewed by the CBD Working Group on Article 8(j).

4. Chile
In late 2003, Chile concluded a proposal for a law to regulate access to agricultural genetic resources. This proposal was developed by the Ministry of Agriculture without the participation of all sectors of society and the government and it was discarded after much criticism. However, efforts to develop a new proposal continue within the Ministry. In December 2003, the National Commission of the Environment (CONAMA) published the National Biodiversity Strategy that was approved by CONAMA’s Ministerial Council. Subsequently, in mid-2004 the National Biodiversity Action Plan was initiated. It should be noted that the strategy emphasizes the need to develop legal instruments to regulate access to genetic resources and to ensure the fair participation in and equitable distribution of benefits derived from their use.

5. China
China, like many other countries, has policies that regulate access to genetic resources, but these policies lack benefit-sharing provisions. However, China’s 1997 National Report on Implementation of the Convention on Biological Diversity states that a priority action for the country is to draft a genetic resources policy or law that regulates prior informed consent principles, benefit-sharing issues, and intellectual property rights, among other issues. So, in late 2002, the State Council of China authorized the Environmental Protection Administration (SEPA) to coordinate all ABS-related issues to ensure the implementation of the CBD. Therefore, SEPA is currently leading a national project to inventory all genetic resources in China. This includes the participation of experts from many organizations and universities from the agriculture, forestry, fishery, and medical sectors. Also, SEPA is assembling a team to develop a comprehensive ABS policy or law.

6. Cook Islands
The country is currently working on a national ABS policy that will go under a proposed National Environmental Act. Central government ministries regulate national laws such as this act. The island councils of the different inhabited islands and the municipal councils for the capital island may adopt by-laws. These by-laws are managed under the Island Council.

7. El Salvador
In El Salvador there is no integral biodiversity law or strategy that regulates the use of and access to genetic, biological, and biochemical resources. The current legal framework for the regulation of access to genetic resources is partially covered by some laws. For example, Article 66 of the Environmental Law states that any access, research, manipulation, and use of biological diversity can only be carried out with a permit, license, or concession granted by the authority in charge of managing the resource in question. Every time this permit is granted relevant communities have to be consulted. In 2002, however the Environment Ministry developed policy guidelines, administrative procedures, and a capacity-building strategy on access to genetic and biochemical resources. This information is currently being reviewed by the Presidency and constitutes the foundation for a national policy on access to genetic and biochemical resources that must be adopted by the government in 2004 or 2005.

8. Fiji
There is no legal or administrative framework in place on ABS. There is a draft administrative paper that forms the basis of an unwritten understanding between all stakeholders on the issue of ABS. A national committee is also working on the development of an ABS policy. Committee members include scientists at the local University of the South Pacific and legal officers from the state law office.

9. Guatemala
The 1999 Action Plan of the National Strategy for the Conservation and Sustainable Use of Biodiversity states the need to develop a national ABS policy. However, no participatory process has been initiated yet. Guatemala is a signatory of the Central American draft protocol on “Access to genetic and biochemical resources, and their associated knowledge” but it has not been ratified yet by this nation.

10. Honduras
The country is currently working on a national law to regulate access and benefit-sharing issues. In 2001, the National Strategy on Biodiversity was adopted and one of its strategic themes was the ABS issue.

11. Indonesia
Indonesia is currently working on a law that is likely to be called Act on Genetic Resource Management. This act will include a government regulation on ABS issues. The government is also conducting an assessment of existing legal instruments that regulate ABS issues. Local officials estimate that ABS legislation will be concluded in 2004 or 2005.

12. Japan
The Japanese government initiated a survey to collect policies on ABS. Also, several ministries are involved in the
discussion about ABS issues; currently, discussion is at individual ministry levels. The government has also been
conducting studies on global issues and trends on ABS policies through research contracts or financial assistance with
think tanks. For example, the Japan Bioindustry Association (JBI) has been actively participating in the meetings of the
Conference of the Parties to the CBD. JBI has also conducted studies and seminars to help implement the CBD in Japan,
and in 2000 this organization published a policy statement that provided general and voluntary prior informed consent
and benefit sharing guidelines for its members.

13. Malaysia
The federal government is working on a national ABS bill that is likely to be adopted in 2005. However, states such as
Sabah and Sarawak already have the 2000 Sabah Biodiversity Enactment, the 1997 Sarawak Biodiversity Center
Ordinance and the 1998 Sarawak Biodiversity Regulations. The relationship between these policies that regulate ABS
issues and the new federal bill is uncertain.

14. Marshall Islands
In 2000, the National Biodiversity Strategy and Action Plan acknowledged the importance of regulating access to the
country’s genetic resources and ensuring that the benefits derived from the use of these resources are shared equitably.
Furthermore, the strategy calls for the development of IPR legislation that protects the rights of indigenous owners of
genetic resources and traditional knowledge and facilitates access to and benefit sharing of these resources and
knowledge under prior informed consent obligations. Plans to develop this legislation are in progress.

15. Micronesia
Micronesia finished its National Biodiversity Strategy and Action Plan in March 2002. It is expected that the
development of ABS legislation will follow from the needs identified through this collaborative process between the
National Government and the four states. The two national government departments that would be most involved in the
process of developing access legislation are the Department of Justice and the Department of Economic Affairs,
Sustainable Development Unit, National Biodiversity Strategy and Action Plan. Regional ABS model guidelines and
legislation have been developed with the assistance of a number of multilateral bodies (Secretariat of the Pacific
Community, WWF-South Pacific Programme, and the Foundation for International Environmental Law and
Development (FIELD) among them) that will assist in this effort. However, under the Micronesia’s Immigration law,
Title 50 of the Micronesian Code, researchers entering the country are required to declare the purpose of their visit. The
Department of Immigration then refers the request to the Division of Archives and Preservation. If acceptable to that
Division, the Department of Immigration issues an entry permit under the category “researcher’s permit” to the entrant.

16. New Zealand
The 2000 New Zealand Biodiversity Strategy addresses ABS goals and includes the following desired outcome for
2020: “There is an integrated policy for the management of all genetic material in New Zealand and for bioprospecting
activities, in accord with international commitments. There is appropriate domestic and international access to
indigenous genetic material, taking into account New Zealand’s sovereignty and rights to the benefits from its genetic
material, as well as rights and obligations under the Treaty of Waitangi.” In November 2002, the Ministry of Economic
Development published a discussion paper on bioprospecting. The paper invited the public to submit comments by the
end of February 2003. In May 2003 the Ministry posted a summary of the submissions on its website (http://www.med.govt.nz/ers/nat-res/bioprospecting/index.html). Further consultation will follow with stakeholders such as
the Maori people to examine key bioprospecting issues and a future national policy on ABS or bioprospecting will be
drafted taking into account this consultation process. However, future efforts to develop such a policy can be
complicated by a claim by a number of tribes (Iwi) of the Maori people to a tribunal. According to this claim the Maori
have exclusive ownership rights over both traditional knowledge and indigenous genetic resources under the Waitangi
Treaty of 1840 between the chiefs of most New Zealand Iwi at the time and the British Government (the Crown). This
claim was lodged in 1991, and it does not appear that it will be concluded in the near future.

17. Nicaragua
The government developed a proposal for a law of biodiversity that addresses ABS issues. The proposal should be sent
to Congress in 2004. Nicaragua’s draft law of biodiversity responds to the mandate (Article 70) of the 1996 General
Law of the Environment and Natural Resources No. 217.

18. Niue
The protection of traditional knowledge and ABS have been identified as priority issues in the National Biodiversity
Strategy and Action Plan. Therefore, funds were used to conduct a consultancy to assess capacity needs in Niue related
to this kind of work. Niue has experienced some access situations in the past year that suggest the urgent need for ABS
legislation. In the absence of this legislation, access applications have been handled on a contractual basis.
stakeholders are particularly interested about strategies to protect traditional knowledge. An Environment Bill was approved in 2003 and this will facilitate the insertion of ABS regulations and other regulations that protect traditional knowledge. ABS regulations may be modeled after the South Pacific Regional Environment Programme (SPREP) framework legislation on access and benefit sharing.

19. Panama

Panama is currently developing and modifying existing laws and policies to facilitate ABS goals. For example, draft Law No. 36, will create an Institute on Traditional Indigenous Medicine. This project includes ABS, intellectual property, and marketing provisions for products used in traditional indigenous medicine. Also, Panama is working on an ABS and indigenous knowledge policy that is likely to provide a course of action about how to implement existing and future ABS policies. The 1998 General Law of the Environment No. 41 (GLE) designates the National Authority for the Environment (ANAM) as the competent authority for the regulation, management, and control of the access to and use of biogenetic resources. ANAM shall also develop the legal instruments and economic mechanisms to this purpose. GLE clarifies that the holders of rights granted for the use of natural resources do not hold rights for the use of genetic resources contained in them.

20. Papua New Guinea (PNG)

The Department of Environment and Conservation is working closely with lawyers from the PNG Department of Justice and the Attorney General to develop a framework on ABS.

21. Republic of Korea

Comprehensive ABS provisions will be included into the 1991 National Environment Conservation Act No. 4492. This amendment is likely to be passed by the National Assembly in late 2004 or 2005. The 1994 amendment (Law No. 4783) of the act included one provision that facilitated access but it did not regulate benefit-sharing issues. Article 25.4 of the act applied only to foreigners and it regulated the use of domestic biological resources (excluding selected wild animals and plans) for commercial, medical or scientific use. This provision, however, was removed from the act by Law No. 5876 of 8 February 1999.

22. Russian Federation

An important problem for the country is the absence of coordinated measures towards conservation and sustainable utilization of biodiversity. In 1996, Russia started implementing the project of the Global Ecological Foundation Biodiversity Conservation. This project included three components: Strategy of Biodiversity Conservation (2001), Protected Natural Regions (2000), and Baikal Region (2003). The Supervisory Committee and Management Group, nominated for the project, have already begun preparing The National and Regional Strategy, and establishing ecological networks of protected areas (72 reserves and national parks). In mid-2001, the National Report of the Russian Federation on ABS was prepared for the Conference of the Parties of the CBD. The report states that prior to the development of an ABS policy it is necessary to establish a national coordination center for the problems related with access to genetic resources. Since 2003, the Department of Life and Earth Sciences of the Ministry of Industry, Science, and Technologies of the Russian Federation has been analyzing gaps, contradictions, and needs of existing national laws and policies that apply to ABS goals. Some of the challenges faced by policymakers include identifying land and genetic resources ownership rights and increasing awareness about ABS issues among local administrators, members of Parliament, policymakers, and the public in general.

23. Singapore

The country is currently formulating policy and guidelines that will regulate ABS issues. An ad hoc inter-agency committee is working on a strategy document on access to genetic resources. Member agencies of the committee include: the Intellectual Property Office of Singapore (Ministry of Law), Attorney-General’s Chambers, Ministry of National Development, Agri-food & Veterinary Authority of Singapore, Ministry of Trade and Industry, Economic Development Board, Trade Development Board, and National Science and Technology Board. The country does not have indigenous peoples engaged in traditional practices, therefore issues such as the protection of traditional knowledge are not being discussed by policymakers. Singapore has also been actively involved in the development of the ASEAN framework agreement on access to biological and genetic resources.

24. Solomon Islands

In the last few years, this country has experienced a period of social and economic crisis on the island of Guadalcanal. The shortage of economic resources caused by this situation and a weak governmental structure has delayed efforts to develop access and benefit-sharing policies. However, they are beginning to examine ABS issues with the assistance of SPREP and other organizations such as WWF South Pacific Programme that organized a workshop in May 2003. In the meantime, bioprospectors may apply for a research permit under the Research Act to the Ministry of Education and Training. The Ministry liaises with provinces and communities where research activity is to occur and a research committee decides whether to approve or reject the application. This decision takes into account the views of provincial
25. **Vanuatu**

After a national consultation process, the country is analyzing ABS policies that might be included in a draft of its Environment Act. Vanuatu, however, has a Cultural Research Policy that regulates consultation with local communities, chief’s councils, and women’s groups.

26. **Vietnam**

In 1995 Vietnam developed a National Action Plan on Biological Diversity that addresses ABS issues. In the last few years the government has been actively collecting examples of ABS laws and policies and it is planning to start working on national ABS legislation in 2004 or 2005.

C. **Countries not involved in any process leading to the development of ABS laws and policies**

1. **Kiribati**

   It is a high priority but the country lacks the funding needed to develop ABS policies. The National Biodiversity Strategy and Action Plan, however, may create momentum to begin the ABS development process. The plan was completed in February 2000 but it has not been tabled yet by the Cabinet for approval and endorsement.

2. **Laos**

   Lack of financial support and technical expertise has prevented this country from developing an ABS policy.

3. **Nauru**

   ABS is not a top priority, and there are budgetary constraints.

4. **Palau**

   Palau should start working on an ABS policy in 2004-2005, depending on funding and capacity availability. However, this country is currently working on a national biodiversity strategy and action plan.

5. **Tonga**

   This subject has not been raised with the government by the relevant government body, the Ministry of Labor, Commerce, and Industries. Tonga, however, is working on a national biodiversity strategy and action plan.

6. **Tuvalu**

   Tuvalu ratified the CBD in December 2002 and developing ABS regulations is not a top priority.

**References**


Introduction
Plant breeders rarely study roots or select directly for root characters, which may not be efficient. The first green revolution in bread wheat resulted from intercrossing five geographically diverse genotypes and selecting for shoot characters (Borlaug, 1968). They were Marroqui, from North Africa, Gabo from Australia, Mentana from Strampelli’s semi-dwarf breeding program in Italy, the dwarf Norin 10 from Korea and Japan, and Brevor from Vogel’s semi-dwarf program at Pullman, USA. The last three cultivars may have contained reduced-height (Rht) genes. Plants were selected in segregating generations that carried one or two Rht stem-dwarfing genes, namely \( \text{Rht1} \) or \( \text{Rht2} \), or both. The semi-dwarf stem habit, and thicker stems from Brevor, produced semi-dwarf culms, 55 to 90 cm tall, that allowed the culms to stand erect under high irrigation and fertilization, resulting in considerable gain in grain yield (Borlaug, 1968). Older wheat cultivars usually carried the recessive \( \text{rht} \) alleles that produced culms 90 to 120 cm tall, which lodged under high water and fertilizer input, thereby reducing economic grain yield. Many geneticists looked at the effect of Rht genes on above-ground plant characters, few observed their effect on below-ground characters. One exception was James Mac Key (1973), who studied the effects of Rht genes in isogenic lines of Swedish wheats. He observed that Rht genes are pleiotropic, and dwarfed not only the shoots, but also proportionally the roots. Although Mac Key (1978) reiterated his warning with regard to reduced root characters, few breeders paid attention (Gale and Youssefian, 1985). Green revolution wheats tend to have small root systems, relative to older landrace wheats (Ehdaie et al. 2003). No person made the connection that green revolution wheats, with small roots, may require large inputs of water and fertilizer for increased grain yield! Using up to eight isogenic combinations for homozygous \( \text{rht} \), \( \text{Rht1} \), \( \text{Rht2} \) and \( \text{Rht3} \) and hybrid combinations, in Brazilian cultivar ‘Maringa’ and early CIMMYT wheat ‘Nainari’, Ehdaie and Waines (1994) concluded there was an optimum stem height, between 80 – 100 cm, for maximum grain yield in each field grown cultivar. Similar results were obtained by Gent (1995). Neither group asked the now obvious question: Is there an optimum root length, biomass, etc. for maximum grain yield in these isogenic series of wheat?

CIMMYT “Veery” Wheats:
These wheats contain a rye/wheat chromosomal translocation. Chromosome arm 1RS of rye is translocated to the long arm of chromosome 1B of bread wheat, namely 1RS.1BL, which replaces chromosome 1B. In the southeast USA there is a variant translocation with 1RS.1AL in the cultivar ‘Amigo’. The translocation 1RS.1BL arose in Krasnador, Siberia, where breeders wished to transfer disease resistance from rye to bread wheat (Zeller and Hsam, 1984). Eventually, the disease resistance in these translocation lines broke down, but wheat with 1RS still maintained a 7% grain yield advantage, world wide, over wheat without it (Ramjaran et al. 1983). The yield advantage was attributed to improved ‘adaptation’ although the morphological...
or physiological basis of adaptation was not understood. That roots might play a part in adaptation in acid soils was suggested by the field studies of Manske and Vlek (2002), but they did not find root differences in better soil conditions. By use of near isogenic lines for the 1RS arm from ‘Kavkaz’ winter wheat (Lukaszewski, 1997), where the same 1RS arm was translocated onto three different chromosomes 1A, 1B, and 1D of ‘Pavon 76′ a spring semi-dwarf bread wheat from CIMMYT, Ehdaie et al. (2003) demonstrated presence of the 1RS arm coded for increased root biomass in sand cultures. The association of 1RS (Kavkas).1BL with increased root biomass was observed in tetraploid ‘Aconchi’ durum wheat (Triticum turgidum L.). Also, 1RS.1AL originated from ‘Amigo’ bread wheat conditioned increased root biomass in Pavon background, but not as much as 1RS.1AL from Kavkaz (Waines et al., 2004). Association between 1RS and increased root biomass in sand cultures may be a general trend in different wheat backgrounds.

The increase in root biomass associated with 1RS depended on which chromosome it was translocated to (i.e. position effect), with 1RS.1AL > 1RS.1DL > 1RS.1BL > Pavon in sand cultures. This suggests differential interaction of gene(s) on 1RS with gene(s) on 1AL, 1BL or 1DL. Near-isogenic 1RS.1AL line had 28% more root biomass than Pavon and took up more water (Ehdaie et al., 2003). In field studies, the 1RS.1AL isogenic line produced 35% more grain yield over Pavon spring wheat in irrigated plots. Similar results were obtained in winter wheat in irrigated plots in Colorado, where the 1RS.1AL (Amigo) translocation was associated with 23% increase in grain yield over its isogenic ‘Karl 92′ check (Owuoche et al., 2003). The 1RS effect of increasing root biomass and grain yield may be general in different wheat backgrounds. There was a positive correlation between root biomass in irrigated and non-irrigated sand cultures and grain yield in glasshouse studies. There was positive association between root biomass in glasshouse and grain yield increase in field studies under irrigation (Ehdaie and Waines, 2003). These results suggest the root system of Pavon is not large enough to allow optimum grain yield in irrigated field conditions. Pavon has a root system similar in size to other CIMMYT wheats, hence other CIMMYT wheats may also have root systems too small for maximum grain yield. Rarely has such a hypothesis been entertained or tested. We know the larger root system of Pavon 1RS.1AL takes up more water, and we presume more fertilizer, to contribute to increased grain yield. If we accept this working hypothesis, plant breeders should select root characters along with shoot characters and grain yield in wheat improvement programs.

**Cereal Root Systems**

An unwritten hypothesis of many wheat germplasm curators and breeders is that the root system is not important and can be ignored. This is in spite of the research of Hurd (1968) and Manske and Vlek, (2002). Our research indicates bread wheat landraces may have root systems two to three times larger than semi-dwarf green revolution cultivars, which vary between 2 and 3 g dry weight biomass in sand cultures. Similar results were obtained in barley (Hordeum vulgare L.) where 10 genotypes of landrace barley had larger root systems than 10 accessions of wild barley, which had larger roots than 10 modern cultivars (Grando and Ceccarelli, 1995). Human selection increased the size of the root system in landraces over wild races, perhaps to take up more water, nutrients and increase grain yield, and/or to out-compete weeds. Only in breeding programs during the last 150 years was there unconscious selection for smaller root systems as genes that reduced stem height were selected, which also allowed continued increase in grain yield under certain conditions. There is need of similar comparative root studies in other crop races. The Rht genes on homoeologous chromosome 4 in bread wheat reduce plant height and also the root
system. The Rht genes and alleles (there are at least 25 of them) appear to be very common in landrace and wild populations. A study of the occurrence and function of reduced height genes in wild grass populations as well as in landrace and modern cultivars is needed.

A Wheat Ideotype
The first ideotype proposed (Donald, 1968) said little about the root system. Bread wheat needs a semi-dwarf shoot system that does not lodge, that has high harvest index, along with a larger root system that is able to take up more water and nutrients to support increased numbers of fertile florets and developing grains. At first glance these two needs appear mutually exclusive, for a semi-dwarf shoot system based on Rht1 and Rht2 will also have semi-dwarf roots (Mac Key, 1973). While this may be so, we found in a F2 population of 32 from a cross between tall ‘Chinese Spring’ (rht1/rht1; rht2/rht2) and Yecora Rojo (Rht1/Rht1; Rht2/Rht2) a few plants that had short stem stature of Yecora Rojo and the large root system of Chinese Spring (Ehdaie and Waines, 1993). There is need for research to observe both root and shoot characteristics in segregating populations between very different parents. Other genetic systems of the parents may also affect root and shoot behavior.

‘Chinese Spring’ and other landrace wheats have another root characteristic that may be useful in rainfed sustainable systems. In sand cultures when drought stressed, the plant often reacts by increasing its root biomass, while many green revolution wheats either reduce their root biomass or show no reaction to drought (Ehdaie et al. 2001). We need to map the location of the gene(s) that condition Chinese Spring to increase its root system when stressed. We need to determine at what stage of plant development the stress is perceived to increase root growth.

The Rht reduced-height genes are located on homoeologous group 4 chromosomes in bread wheat. The gene(s) on the short arm of chromosome 1RS of rye appear to reverse the effect of Rht genes on the root system, and stimulate root growth, but not markedly alter the effect of Rht genes on stem height. Therefore 1RS may differentially affect root and shoot systems. The Rht genes are reported to be non-responsive to gibberellin (Gale and Gregory, 1977). A recent isolation of gibberellin metabolic pathway genes from barley and comparative mapping in wheat (Speilmeyer et al. 2004) does locate genes in the pathway for 2-oxidase enzyme on wheat arms 1AL, 1B and 1DL. These genes make GA1 and GA4, which are normally biologically active, inactive (conditioning small shoot and root). Presence of 1RS gene(s) may block genes for 2-oxidase enzyme and increase root growth without markedly affecting shoot growth.

Roots of the Next Green Revolution
Is the 35% increase in grain yield under irrigation obtained with Pavon isogenic 1RS.1AL line over Pavon in 1999 and 2000 at Moreno repeatable at other field locations in California, and in other Mediterranean climates? If so, this may mean the first green revolution is unfinished. By increasing the root systems of existing wheats, beyond 3.0 g dry weight in sand cultures, we may be able to significantly increase grain yield for irrigated and rainfed sustainable systems. Plant breeders might disregard the hypothesis that roots are not important. They should observe and select the whole plant, not only the easily observed above-ground parts. Breeders for the next green revolution should study cereal root characters, in conditions similar to what the plant experiences in a field, and select for larger root systems, as well as semi-dwarfed, thicker shoots, to achieve increased grain yield and sustainability. This may involve an experimental root-tube system up to 2 m depth for each plant, with four or more replications for each genotype. Roots are more morphologically variable than shoots, and may require more replications to obtain a
reliable estimate of the characteristics of genotypes. Such methods were devised in the past (Briggs and Shantz, 1914; Mac Key, 1973; Hurd and Spratt, 1975; Manske and Vlek, 2002), and may be refined.

**Methods to Increase Root Size**

Plant scientists working in sustainable agricultural systems for community based conservation and breeding programs also should observe roots and shoots. After 150 years of breeding it is surprising that half of the wheat plant is still not observed by crop scientists. The same criticism can be made for most crop plants. Engineers need to design standard equipment that will allow germplasm curators to easily characterize roots and shoots of an accession. We should know the genetic variation in root characters for plants in an accession, and among populations in our extensive germplasm holdings. This is required for wild races, landraces, modern cultivars and related species to be sure we have experimentally based knowledge of the range of morphological variation in wheat roots. No administrator in national or international research programs has thought root characters sufficiently important to demand funds be set aside to design equipment or to consistently carry out a survey. Perhaps, after the genomes of our crop plants have been sequenced, funds may be available for studies of plant roots and shoots. The experimental results with isogenic Veery wheat in California and Colorado, suggests that such a study would be worth while. Can we afford to neglect the possibility of a 20-40% increase in grain yield just because crop scientists have little interest in roots? Especially now the grain quality defects of Veery wheats have been overcome (Lukaszewski, 2000).

If such equipment becomes available, we need to think of ways to increase the root system of green revolution wheats by three or more fold. A recent model for winter cereals in the UK suggests the new ideotype should have roots 2 m deep, with many fine roots at depth, and less in the top 30 cm of soil profile (King et al. 2003). This would allow fine roots to efficiently mine the profile for water and nutrients. Do we know of bread or durum wheat genotypes that have such root characteristics? Rarely have wheat plants been observed so intensively at depth. Does rye, barley, goat-grass or other genera in the Triticeae, (*Agropyron* s.l.) have better roots than modern wheats? Translocations have been developed between rye, barley, goat-grass and *Agropyron* s.l. chromosomes, for pest and disease resistance, and the effect of these alien segments on root architecture should be assessed. All 14 chromosome arms of the rye genome should be systematically translocated into standard wheat such as Pavon, thereby creating a near isogenic series, to assess their effect on bread wheat. Rye is considered to have the largest root system of any temperate cereal (Starzycki, 1976) and the genome of a rye cultivar with desirable attributes should be investigated. The ideotype model for winter cereals (King et al., 2003) may provide an explanation of why field studies with isogenic Veery wheats in California and Colorado produced grain increases only in irrigated systems. The model predicts there will be twice as much yield increase with adequate water uptake than with increased fertilizer uptake. Synthetic species such as allopolyploids of durum wheat and *Aegilops tauschii*, that are new synthetic bread wheats (Mujeeb-Kazi et al., 1996), may have better root systems than green revolution cultivars, due to a larger root system from durum wheat or *Ae. tauschii*. CIMMYT has made several hundred synthetic bread wheats for pest, disease and above-ground components of yield studies. The roots of these wheats should be studied carefully. At present root characters are not factored into components of yield. Should they be? We suspect so. It may be possible to synthesize durum wheat from allopolyploids of *Ae. speltoides* (BB) and *Triticum urartu* (AA).
However, this F1 hybrid is not easy to make (Gill and Waines, 1978) and may need embryo rescue to secure synthetic species. Cereals with larger root systems may use available water and compete with weeds more efficiently, especially at times of the year when water is in excess. Larger roots may also take up and use fertilizer more efficiently. Only 30% of applied N is used by the wheat plant in developed countries (Raun and Johnson, 1999) and the unused 70% pollutes ground water and the atmosphere. Such squandering of energy resources is not acceptable.

Preservation of adaptive gene combinations and techniques
If the gene(s) on 1RS from Kavkaz and Amigo code for characters that impart a 7% grain yield increase, world-wide, in present-day wheats, and if these same genes code for a 20 – 35 % grain yield increase in isogenic experimental lines, then adaptive gene combinations on the 1RS arm of rye may be preserved in experimental wheats. Alternatively, there may be a heterotic effect as suggested by Owuoche et al. (2003). We need to understand and conserve interspecific and intergeneric euploid combinations in wheat. This may not be easy in future, since practicing cytogeneticists are a dying breed in universities and international research stations. Their expertise is in need of conservation! Administrators of plant research should avoid bandwagon mentality, where all the eggs for genetic manipulation are placed in a one-technique basket, and very few funds are made available for other techniques, which have a proven track record. While Verry wheats with 1RS.1BL arose by accident, the 1RS.1AL variant was the result of a deliberate breeding attempt. Both translocations were identified by cytogenetic techniques, and both promise grain yield increases in the future at relatively little cost. A second chromosomal construct that should be investigated is the wheat/wheat-grass 7D.7E translocation from *Agropyron elongatum* that was found to increase grain yield by 9% (Singh et al., 1998). The morphological basis of the yield increase is not understood.

Conclusions
Community based conservation and breeding programs should characterize and select for wheat root characteristics. There may be an economic advantage of further grain yield increase. Wheat plants with alien chromosome translocations, or synthetics made from different parental combinations also offer real advantage for the next green revolution. Germplasm curators, breeders and agronomists should work with all plant organs, not only easily observed above-ground parts.

References


Posters
Documentation of Indigenous Knowledge Related to Agro-biodiversity Conservation in Jordan

N. Abu-Shriha

Noor Al-Hussein Foundation (NHF) E.Mail: abushriha@mail.com

Keywords: Agrobiodiversity, local knowledge, conservation, uses, Jordan

Abstract
The Convention on Biological Diversity recognised the urgent need to conserve and sustain the use of biodiversity and the central role of local comunities in conserving local biodiversity and local knowledge including the traditional practices. This international recognition has promoted and motivated national governments to design strategies and action plans for achieving these goals. This study was conducted to document indigenous knowledge of local farmers for conserving and sustainably using local agrobiodiversity focusing on landraces and wild relatives of economically important plant species in Jordan.

A survey was conducted in Irbid, Zarqa, Mafraq, Amman, Ma'an, Madaba, Karak, Aqaba, Balq'a, and Tafiela governorates in Jordan and it focused on documentation of changes in landuse, practices for preventing degradation of natural resources and the local uses of landraces and wild species. The results showed that a large number of landraces of wheat, barley, olive, fig and onion are still widely grown by farmers but there is a concern for sustaining their cultivation following recurrent droughts and switching to modern agriculture which favors monocultures and the use of improved varieties and introduced species. The traditional practices to prevent soil erosion and to sustain land productivity are documented. The diverse uses of wild relatives and species as medicinal, herbs, fiber, for handcrafts, food and feed were also documented.

Introduction
In the semi-arid and arid regions, the traditional knowledge and traditional agriculture farming systems including the Hema system for community management of grazing have in the past contributed to the conservation and sustainable use of local agrobiodiversity in Jordan. But, in recent year, the replacement of the traditional farming systems by modern agriculture and the vanishing of community grazing systems are threatening the local agrobiodiversity and its associated local knowledge. Preserving landraces and wild relatives and the traditional agricultural practices are targeted by many international and national efforts and conventions. The Convention on Biological Diversity (CBD) signed by 185 countries and parties and the International Treaty on Plant Genetic Resources entered into force in 2004 and signed by Jordan are stressing the need to conserve dryland agrobiodiversity and the species of global importance. Jordan lies within the Fertile Crescent mega-center of diversity and its rich flora includes many species directly related to today’s mostly widely grown crops such as wheat and barley. This local agrobiodiversity is endangered.

This study aims to document the indigenous knowledge and uses of local agrobiodiversity in Jordan and traditional practices which contributed to its conservation.
Methodology
A participatory approach was used to document local knowledge and traditional agricultural practices. A total of 240 farmers were selected over 22 areas of Jordan on the basis of their involvement and their good knowledge of agricultural activities (Table 1). Women were also included in the surveyed sample. The process started with the selection of areas and contacts with local communities. Then the questionnaire was designed and pre-tested before conducting the full survey in the 22 areas.

Table 1: Farmers profile characterization.

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Farmers</th>
<th>Age range</th>
<th>Education</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>North (9 rural areas)</td>
<td>90</td>
<td>35-80</td>
<td>Illiterate or Elementary</td>
<td>Farmers Retired Army</td>
</tr>
<tr>
<td>Middle (6 rural areas)</td>
<td>60</td>
<td>40-75</td>
<td>Illiterate or Elementary, High School</td>
<td>Farmers Retired Army Education</td>
</tr>
<tr>
<td>South (7 rural areas)</td>
<td>70</td>
<td>45-80</td>
<td>Illiterate or Elementary</td>
<td>Farmers Retired Army Trade</td>
</tr>
</tbody>
</table>

Results
The surveyed persons identified two major farming systems, cropping-based system and livestock-based system. The main characteristics of these systems are presented in Table 2. Mixed systems were not reported although some farmers are practicing it. The cropping-based systems are mainly located in the high elevation and high rainfall areas while the livestock-based system is predominant in the arid and Badia regions.

Table 2: Main characteristics of the farming systems identified by surveyed persons.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Predominant habitat</th>
<th>Main land occupation</th>
<th>Land farming</th>
<th>Predominant Land tenure</th>
<th>Agriculture activities</th>
<th>Shared resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropping-based group</td>
<td>Cultivated arable land</td>
<td>Cropped land</td>
<td>Rainfed</td>
<td>Individual ownership</td>
<td>Cropping</td>
<td>Rangeland and water</td>
</tr>
<tr>
<td>Livestock based group</td>
<td>Rangelands</td>
<td>Grazed areas</td>
<td>Fully irrigated</td>
<td>Open communal lands</td>
<td>Livestock</td>
<td>Rangeland and water</td>
</tr>
</tbody>
</table>

The information collected on the status of landraces and wild relatives is shown in Table 3. Landraces of barley, olive and fig are still widely used and the threats are low. For wild *Triticum*
species, they are distributed in patches and highly threatened, the Aegilops were not recognized by the surveyed people and the wild barley is still widely distributed.

Table 3: Assessment of distribution and degree of threats to landraces and wild relatives of some species based on feedback from surveyed persons.

<table>
<thead>
<tr>
<th>Species</th>
<th>Distribution (1)</th>
<th>Degree of threats (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild Triticum</td>
<td>Patchy</td>
<td>High</td>
</tr>
<tr>
<td>Aegilops spp</td>
<td>Not recognized</td>
<td>High</td>
</tr>
<tr>
<td>Wheat landraces</td>
<td>Still used</td>
<td>Medium</td>
</tr>
<tr>
<td>Wild barley</td>
<td>Widely distributed</td>
<td>Medium</td>
</tr>
<tr>
<td>Barley landraces</td>
<td>Widely</td>
<td>Low</td>
</tr>
<tr>
<td>Olive local varieties</td>
<td>Still used</td>
<td>None</td>
</tr>
<tr>
<td>Fig local varieties</td>
<td>Still used</td>
<td>Low</td>
</tr>
</tbody>
</table>

Regarding uses of different species known by the surveyed persons, most of them are used as food, feed and medicine. Uses in beverages, timber, crafts, fiber and ornamental were also cited for few number of species.

Table 4: Documentation of indigenous knowledge on different uses of native and wild species

<table>
<thead>
<tr>
<th>Uses</th>
<th>List of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td><em>Quercus spp.</em>, Garden Rocket, <em>Ashillea spp.</em>, Sneeze wort, Palestine Vetch,</td>
</tr>
<tr>
<td></td>
<td><em>Cynara spp.</em>, <em>Ononis spp.</em>, Wave-Leaved Fleabane, <em>Portulaca spp.</em>, Silvery</td>
</tr>
<tr>
<td></td>
<td>Whitlow wort, Silvery Whitlow wort, Musk Dead nettle, <em>Lepidium spp.</em>, <em>Crocus</em></td>
</tr>
<tr>
<td></td>
<td><em>aleppicus</em>, Thyme, <em>Colchicum spp.</em>, <em>Cyclamen</em>, <em>Long-Stamened Garlic</em>,</td>
</tr>
<tr>
<td></td>
<td><em>Carlina spp.</em>, <em>Beta Vulgaris</em>, <em>Crocus spp.</em>, <em>Foeniculum spp.</em>, <em>Thlaspi</em></td>
</tr>
<tr>
<td></td>
<td><em>spp.</em>, <em>Stippa spp.</em>, <em>Calotropis procera</em>, <em>Alhagi spp.</em>, Thumble Thistle,</td>
</tr>
<tr>
<td></td>
<td><em>Silene spp.</em>, <em>Boletus badius</em>, <em>Raphanus spp.</em>, <em>Glancium spp.</em>, <em>Common Giant</em></td>
</tr>
<tr>
<td></td>
<td><em>Fennel</em>, <em>Salvia spp.</em>, <em>Echium spp.</em>, <em>Fenugreek (Ghee)</em>, Pale Centaury,</td>
</tr>
<tr>
<td></td>
<td><em>Nepeta spp.</em>, <em>Prosopis spp.</em></td>
</tr>
<tr>
<td>Medecine</td>
<td><em>Ashillea spp.</em>, Sneeze wort, Ciliate Love. Wild Rue, <em>Melilotus spp.</em>, <em>Malva</em></td>
</tr>
<tr>
<td></td>
<td><em>spp.</em>, <em>Ononis spp.</em>, <em>Papaver spp.</em>, Silvery Whitlow wort, Silvery Whitlow wort*</td>
</tr>
<tr>
<td></td>
<td><em>Thlaspi spp.</em>, <em>Stippa spp.</em>, Honey suckle, <em>Calotropis procera</em>, Thumble</td>
</tr>
<tr>
<td></td>
<td>Thistle, Dwarf chicory, Common Asphodel, <em>Sinapis spp.</em>, <em>Raphanus spp.</em>,</td>
</tr>
<tr>
<td></td>
<td><em>Common Caper</em>, <em>Varthemia spp.</em>, Squirtling Cucumber, Field Eryngo, Neltle,</td>
</tr>
<tr>
<td></td>
<td><em>Sternbergia spp.</em>, <em>Cynodon spp.</em>, <em>Nepeta spp.</em>, <em>Shrubby Restharrow</em>,</td>
</tr>
<tr>
<td></td>
<td><em>Prosopis spp.</em></td>
</tr>
<tr>
<td>Feed</td>
<td><em>Quercus spp.</em>, <em>Veronica spp.</em>, Ciliate Love, Rose Dock, <em>Malva spp.</em>, <em>Cynara</em></td>
</tr>
<tr>
<td></td>
<td><em>spp.</em>, Egyptain Hartwort, Wave-Leaved Fleabane, Rough Hawkbit, White Broom,</td>
</tr>
<tr>
<td></td>
<td><em>Crocus aleppicus</em>, <em>Cyclamen</em>, <em>Artemisia spp.</em>, <em>Noaea spp.</em>, <em>Clammy Inula</em>,*</td>
</tr>
<tr>
<td></td>
<td>Bramble, Black berry, African Fleabane, Field Eryngo, <em>Sternbergia spp.</em>, Pale</td>
</tr>
<tr>
<td></td>
<td>Centaury, Shrubby Restharrow</td>
</tr>
<tr>
<td>Beverage</td>
<td><em>Ashillea spp.</em>, Musk Dead nettle, Thyme, <em>Foeniculum spp.</em>, <em>Thlaspi spp.</em>,</td>
</tr>
<tr>
<td></td>
<td><em>Prosopis spp.</em></td>
</tr>
<tr>
<td>Timber</td>
<td><em>Quercus spp.</em>, Oleander, White Broom, <em>Artemisia spp.</em>, <em>Stippa spp.</em>, <em>Shrubby</em></td>
</tr>
<tr>
<td></td>
<td>Restharrow</td>
</tr>
<tr>
<td>Fiber</td>
<td><em>Imperata spp.</em>, Rocket</td>
</tr>
</tbody>
</table>

597
The surveyed persons listed several practices used to prevent land degradation and depletion of natural resources (Table 5).

Table 5: Traditional practices for preventing land degradation

<table>
<thead>
<tr>
<th>Natural resource managed</th>
<th>Purpose of the practices</th>
<th>Traditional practices</th>
</tr>
</thead>
</table>
| Soil management         | To maintain soil fertility | - Surface tillage with traditional tillage tool (*Mehrath Baladi*) and not with disc plow instrument.  
- Good tillage: plowing the soil two times per year  
- Using animal manure.  
- Planting one year legumes and the second vegetables.  
- Grazing one year and fallow the second year.  
- Animal manure fermentation sites.  
|                         | To minimize soil erosion | - Digging drainage rows in the ground for water drainage.  
- Making tillage strips and animal grazing in summer.  
- Planting plain areas and leaving rocky areas for animal grazing.  
|                         | To improve soil moisture | - Using animal manure.  
- Tillage by using traditional Mehrath to open the soil surface to receive the first winter rainfall showers.  
- Summer tillage by local Mehrath.  
|                         | To improve infiltration of rain water | - Digging wells for collecting of water.  
- Putting stones to facilitate water harvesting.  
- Building ponds and dams from soil and stones.  
| Water management        | To reduce evaporation | - Tillage of the upper surface of the soil by traditional *Mehrath* or chisel plow in November and December.  
- Tillage opposite to the slope of land.  
- Tillage by using traditional methods *Mehrath* with animals (*Al Fadan*).  |
| **To improve water use efficiency** | - Building water irrigation canals.  
- Digging soil ponds and water collection marshy. 
- Planting crops according to their water requirements needs. 
- Making water reservoirs from soil and stones. |
| **Water harvesting practices** | - *Shiggag*(3) tillage opposite to the ground slope. 
- Building (stone and soil) ponds and dams. 
- Digging soil ponds and water collection marshy. 
- Planting crops according to their water requirements needs. 
- Making water reservoirs from soil and stones. 
- Digging wells and making stone terraces to collect water. |
| **Irrigation practices?** | - Digging in the soil to make soil irrigation canals.  
- Building ciment irrigation canals. 
- Surface irrigation by digging irrigation rows opposite to the ground slope and collecting the excess of irrigated water in big cannals and soil ponds. |
| **Runoff control measures** | - Dividing the land into quarterly portions every ten rows together. 
- Building stone terraces with dimensions (3 X 1 meters). |
| **Watershed management practices?** | - Planting crops according to their water requirements needs. 
- Replanting crops that grow well in the area and can withstand high temperatures and shortage of water. 
- Introducing wild species in home gardens. |
| **Tillage** | **Tillage practices?** | - Tillage 2-3 times at the same time opposite in direction. 
- Fallow tillage one time/year. 
- Tillage by *Al Fadan* (by using animals) 
- Using traditional *Al Mehrath*, Chisel and *Al Fadan*. 
- Not using disc plow for tillage. |
| Grazing | Grazing practices? | - *Mashad Saifey* planting the land in summer and leaving it for grazing in winter.
- *Mashad Shatawi* planting the land in winter and leaving it for grazing in summer.
- Planting the plain lands and leaving the rocky and mountain lands for grazing. |
|----------|------------------|---|
| Rotations | Rotations | - Planting one year wheat and the other year barley.
- Summer planting and winter planting (planting wheat in winter and lentil in summer or planting half of the land wheat and the other half barley).
- Planting one year legumes and the other year cereals.
- Planting in winter wheat or barley and leaving the land in the second year without planting (fallow). |

**Conclusions and recommendations**
- On-farm conservation and of landraces and agriculture practices within rural communities are clearly important part for promoting in-situ conservation of plant genetic resources and traditional practices;
- Farmers were proud of the interest attached by researchers for their germplasm and their knowledge and they realized the need for documenting this valuable germplasm, practices, uses and associated knowledge;
- Farmer participation is increasingly recognized as a vital aspect for conducting research and ways for empowering local communities need to be developed; Farmers should be involved in the assessment of biodiversity loss, land degradation and desertification;
- Adapting of certain traditional agricultural practices need to be done in collaboration with researchers;
- The inputs from women in this study was highly rewarding;
- Need to consider supports and incentives to the custodians in any projects aiming at conserving agrobiodiversity and there is a need to find appropriate mechanisms for equitable sharing of benefits arising from the use of local germplasm and knowledge.
Assessment of Genetic Diversity of *Pistacia atlantica* Desf. (*Anacardiaceae*) from Syria by AFLP Analysis.

K. Chabane¹, T.O.M. Bazun² & I. Basha³

¹ International Center for Agricultural Research in the Dry Areas (ICARDA)  
² International Plant Genetic Resources Institute-Central and West Asia and North Africa Regional Office (IPGRI-CWANA)  
³ Aleppo University, Aleppo, Syria

**Keywords:** Pistachio, genetic diversity, AFLP markers

**Abstract**

Pistachio (*Pistacia vera* L.) and four others *Pistacia* wild species are found in West Asia region where they hold comparative advantage over other fruit trees in view of its adaptation to harsh conditions, income generation opportunities and benefits for the ecosystem. Syria ranks fourth main producer of pistachio nuts in the world, where a great diversity of local landraces and cultivars exist. Currently, the identification and characterization of *Pistacia* landraces relies on a small number of morphological traits mainly of fruit, which are complex and are greatly affected by the environment. This work was carried out with two hundred-twelve trees collected from fifteen sub-regions in Syria, to shed more light on Syrian *Pistacia atlantica* diversity. The investigation was carried out with a country-wide ecogeographic survey, sampling of genetic resources. Molecular evaluation using Amplified Fragment Length Polymorphism (AFLP) technique was also carried out. This paper shows that AFLP is an efficient tool for landraces discrimination and estimating genetic relationships in *Pistacia atlantica*.

**Introduction**

The genus *Pistacia* (*Anacardiaceae*) comprises 11 species of dioeciously trees grouped based on morphology and shrubs into four sections (Zohary, 1952). Geographically, the largest concentration of *Pistacia* species is found in West Asia with six species, and in the Mediterranean basin with four species. The main characteristic used for pistachio species identification is leaf morphology, especially leaf shape, number of leaflets and size. Syria is considered as a center of origin of some wild *Pistacia* species. Viz. *P. atlantica*, *P. palaestina*, *P. khinjuk*, and *P. terebinthus* (Post 1932; Khalife 1958, Mouterde 1966; Hadj brahim et al. 1998). The species *Pistacia atlantica* desf. belongs to the primary gene pool of the cultivated species *P. vera* as it can be used in crosses and as root stocks to adapt better to biotic and abiotic stresses. The objectives of this study were to screen and select combination of primer pairs for the generation of AFLP markers and to assess the current situation of genetic diversity of the wild *Pistacia atlantica* in Syria.

**Material and methods**

Two hundred and twelve samples of *P. atlantica* consisting of vegetative material from 10-15 plants were collected from 15 regions in Syria. The selected primers were 5’ end labeled with fluorescent tag. AFLP sizing have been made on an ABI 377 using GS-500 size standard. Polymorphism Information content (PIC) was calculated. Genetic similarity was estimated using
Phylip software. Popgene software has been used to analyze single and group-populations statistics.

**Results and discussion**

AFLP appears to be effective for the differentiation between the population trees of *P. atlantica* (figure 1).

![Dendogram](image_url)

**Figure 1.** Dendogram based on the relationship among 15 groups of *P. atlantica* based on Nei’s genetic distance

The populations of *P. atlantica* from the Northeast and South of Syria are the most diverse. Our results shown that it is possible to correlate the degree of similarity through AFLP analysis with the geographical origin and climatic conditions (figure 2) and with certain morphological characters like shape leaflets of *P. atlantica*. This result may help in the sampling and the collection of the genetic variability and in designing plans for *in situ* conservation of the pistachio germplasm. This method can target the populations with good adaptation to harsh conditions and can help in selecting diverse populations to be used in afforestation efforts.
Figure 2. Unrooted phylogenetic tree reported AFLP-based genetic relationship among
*P. atlantica* regions.

**References**


Post, G., 1932. The Flora of Syria, Palestine and Sinaï. American Press, Beirut,
Application of Biochemical and PCR-based Molecular Markers to the Characterization of Syrian Pear (*Pyrus syriaca* Boiss) Genotypes

B. M. Muzher

*General Commission for Scientific and Agricultural Research, Sweida Center, Syria*

**Keywords**: genetic diversity, *Pyrus syriaca*, PCR techniques, conservation

**Abstract**

Wild pear species (*Pyrus syriaca* Boiss.) is widely spread in West Asia region, which is believed to be its center of diversity. The genetic variability and relationships among seven pear genotypes were studied using two isozyme markers (peroxidase and esterase) and 32 RAPD primers, 14 SSR primer pairs, and 10 AFLP primer combinations. Peroxidase showed a high level of polymorphism between the seven pear genotypes (90%), while esterase revealed monomorphic bands. The level of polymorphism for all genotypes as revealed by RAPD, SSR and AFLP was 81.47%, 93.6%, and 92.5%, respectively. RAPD, SSR, and AFLP revealed genetic differences among the seven pear genotypes, using Jaccard coefficient. The highest similarity was between WT1 and WT3 (62%), Meskawi and WT3 (65%), and 54% between Abu-Satel and WT2 when using RAPD, SSR, and AFLP, respectively. The combined genetic relationship as revealed by RAPD, SSR, and AFLP was the highest between Abu-Satel and WT2 (52%), while the lowest similarity was between Meskawi and Likonte (29.4%). The dendrograms derived from different techniques discriminate between Likonte and the Syrian pear genotypes. Both RAPD and SSR clusters revealed genetic similarity between Romi and Likonte, while AFLP clustered Likonte genotype in a separate cluster. RAPD, SSR, and AFLP techniques characterized the seven pear genotypes by a large number of unique markers, which revealed 67, 20, and 223 unique markers, respectively. Likonte genotype was characterized by the highest number of unique markers (70), followed by Romi which has 50 unique markers, while Abu-Satel has the lowest number of unique markers (31). SSR technique revealed the highest expected heterozygosity (0.263), while AFLP technique revealed the highest multiplex ratio (136.2), effective multiplex ratio (1362) and marker index (207.04) compared with RAPD and SSR marker types. The highest correlation was between RAPD and AFLP marker types (0.945).

**Introduction**

The genus *Pyrus* belongs to the subfamily Pomoedeae of the Rosaceae. The basic chromosome number of *Pyrus* is *x*=17. *Pyrus syriaca* Boiss. is widely distributed in Lebanon, Palestine, Turkey, Iraq, Jordan and Syria. In Syria, several wild pear genotypes occur in different environmental regions from the semi-arid to the humid areas.

Traditional methods for plant cultivar identification rely on morphological and agronomic characteristics, which some are affected by environmental variations and are time-demanding. Several molecular techniques are proposed as additional tools for characterization and identification of varieties including protein, isozymes and PCR techniques. DNA markers are a tool of choice used to measure the genetic relationships of closely related species or genotypes. Also, DNA markers can provide useful information on individual identity, genealogy, and on degrees of relatedness between genotypes. It also provides information on how genetic variation is distributed within different populations. Random amplified polymorphic DNA (RAPD) is a
DNA molecular technique resulting from the PCR amplification of genomic DNA segments recognized by random primers - usually 10 mers of arbitrary nucleotide sequence. RAPD markers have been used for cultivar identification in several woody tree species including pear cultivars. Simple sequence repeats (SSRs, also called Microsatellites) are based on PCR amplification using a unique pair of primers flanking the SSRs. SSRs consist of tandemly repeated nucleotide units from 1-5 nt long. Amplified fragment length polymorphism (AFLP) technique is based on the selective amplification of a subset of genomic restriction fragments using PCR. This study uses isozymes and DNA based markers to assess the genetic diversity and identification of forms of wild pears found in Sweida region, south of Syria.

Materials and Methods
The main objectives of the study were to:
- Estimate the genetic variability among seven Pyrus genotypes;
- Assess the genetic relationship between these genotypes based on the genetic distances obtained from Isozyme and DNA molecular marker data;
- Identify the different Pyrus genotypes by unique DNA markers;
- Evaluate the efficiency of different PCR-based markers that are used in analyzing the pear genome.

Genotypes used: seven pear genotypes were used in this study: 1-Mestkawi, 2-WT1, 3-Abu-Satel, 4-WT2, 5-WT3, 6-Romi from Syria and 7-Lecontei from Egypt.

Isozymes analysis: For isozymes analysis, extraction was performed using the youngest green leaves from two weeks old grafted pear. Analysis was performed using PAGE according to the method described by Chevreau et al. (1997). Two enzymes were analyzed, viz. Peroxidase (PRX) and Esterase (EST).

Genomic DNA extraction and purification: Extraction of total DNA was performed using CTAB protocol according to the Doyle and Doyle (1993) method. DNA concentration was determined depending on visual method.
- Random amplified polymorphic DNA (RAPD): a set of 32 random 10-mer primers was used in the detection of polymorphism among the seven pear genotypes. The amplification products were resolved by electrophoresis in a 1.4% agarose gel containing ethidium bromide.
- Direct amplification of Simple Sequence Repeats (SSR): thirteen SSR primer- pairs derived from apple genome were used, in addition, one SSR primer pair was designed by a repeat-enriched pear genomic library. The products of the microsatellite-based PCR were detected by electrophoresis on 2% agarose gel.
- Amplification Fragment Length Polymorphism (AFLP): ten primer combinations between EcoRI primer plus three 3\textdagger extension bases and Msel primer plus three 3\textdagger extension were used to selectively amplify the DNA fragments. AFLP products were detected by polyacrylamide denaturing sequencing gel.

Results and discussion
All techniques revealed genetic differences among the genotypes evaluated. Based on the results in tables below, it can be concluded that:
- Biochemical markers: peroxidase were able to differentiate between the seven pears genotypes, while esterase could not distinguish between them;
DNA marker techniques represent an efficient tool for estimating the genetic variability and the genetic relationship among closely related genotypes;

DNA marker techniques revealed that the genotype “Romi” does not belong to the Syrian genotypes grouping;

The different DNA marker techniques could be complimentary to each other due to the mechanism of detecting polymorphism, genome coverage and application for each marker type.

The fingerprints of each genotype with specific markers of the Syrian pear genotypes are very useful for germplasm management, breeding programs, and protection of breeders’ rights.

Table 1: Peroxidase polymorphism of pear genotypes

<table>
<thead>
<tr>
<th>Band No</th>
<th>R.M</th>
<th>Meskawi</th>
<th>WT1</th>
<th>Abu-Satel</th>
<th>WT2</th>
<th>WT3</th>
<th>Romi</th>
<th>Lecontei</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.5</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>3.3</td>
<td>+</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.5</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>3.7</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>3.9</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4.2</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4.5</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4.7</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2: Esterase polymorphism of pear genotypes

<table>
<thead>
<tr>
<th>Band No</th>
<th>R.M</th>
<th>Meskawi</th>
<th>WT1</th>
<th>Abu-Satel</th>
<th>WT2</th>
<th>WT3</th>
<th>Romi</th>
<th>Lecontei</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>8.7</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
### Table 3: Polymorphism detected using RAPD markers for pear genotypes

<table>
<thead>
<tr>
<th>Primer</th>
<th>Total # of amplicons</th>
<th>Polymorphic amplicons</th>
<th>Polymorphism %</th>
<th>Primer</th>
<th>Total # of amplicons</th>
<th>Polymorphic amplicons</th>
<th>Polymorphism %</th>
</tr>
</thead>
<tbody>
<tr>
<td>p23</td>
<td>5</td>
<td>4</td>
<td>80</td>
<td>p43</td>
<td>7</td>
<td>6</td>
<td>85.7</td>
</tr>
<tr>
<td>p25</td>
<td>8</td>
<td>7</td>
<td>87.5</td>
<td>OPA01</td>
<td>9</td>
<td>5</td>
<td>55.5</td>
</tr>
<tr>
<td>p27</td>
<td>12</td>
<td>8</td>
<td>66.67</td>
<td>OPA02</td>
<td>10</td>
<td>8</td>
<td>80</td>
</tr>
<tr>
<td>p29</td>
<td>8</td>
<td>7</td>
<td>87.5</td>
<td>OPA03</td>
<td>7</td>
<td>3</td>
<td>42.85</td>
</tr>
<tr>
<td>p30</td>
<td>7</td>
<td>7</td>
<td>100</td>
<td>OPA04</td>
<td>10</td>
<td>9</td>
<td>90</td>
</tr>
<tr>
<td>p31</td>
<td>13</td>
<td>11</td>
<td>84.6</td>
<td>OPA05</td>
<td>14</td>
<td>12</td>
<td>85.7</td>
</tr>
<tr>
<td>p32</td>
<td>12</td>
<td>10</td>
<td>83.33</td>
<td>OPA06</td>
<td>8</td>
<td>6</td>
<td>75</td>
</tr>
<tr>
<td>p33</td>
<td>10</td>
<td>9</td>
<td>90</td>
<td>OPA07</td>
<td>7</td>
<td>5</td>
<td>71.43</td>
</tr>
<tr>
<td>p34</td>
<td>12</td>
<td>10</td>
<td>83.33</td>
<td>OPA08</td>
<td>7</td>
<td>5</td>
<td>71.43</td>
</tr>
<tr>
<td>p35</td>
<td>13</td>
<td>11</td>
<td>84.6</td>
<td>OPA09</td>
<td>11</td>
<td>10</td>
<td>91</td>
</tr>
<tr>
<td>p36</td>
<td>10</td>
<td>7</td>
<td>70</td>
<td>OPA10</td>
<td>8</td>
<td>6</td>
<td>75</td>
</tr>
<tr>
<td>p37</td>
<td>11</td>
<td>10</td>
<td>91</td>
<td>OPA11</td>
<td>13</td>
<td>12</td>
<td>92.3</td>
</tr>
<tr>
<td>p39</td>
<td>7</td>
<td>6</td>
<td>85.7</td>
<td>OPA12</td>
<td>8</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>p40</td>
<td>8</td>
<td>7</td>
<td>87.5</td>
<td>OPA13</td>
<td>9</td>
<td>7</td>
<td>77.77</td>
</tr>
<tr>
<td>p41</td>
<td>5</td>
<td>5</td>
<td>100</td>
<td>OPA14</td>
<td>7</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>p42</td>
<td>6</td>
<td>3</td>
<td>50</td>
<td>OPA15</td>
<td>4</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>81.5 (79)</td>
</tr>
</tbody>
</table>

### Table 4: Polymorphism detected using Simple Sequence Repeats (SSRs) on pear genotypes

<table>
<thead>
<tr>
<th>Primers</th>
<th>Total allelic forms</th>
<th>Polymorphic alleles</th>
<th>% Polymorphism</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH02B10</td>
<td>4</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>CH01F02</td>
<td>4</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>CH01G12</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CH01H01</td>
<td>3</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>CH02D12</td>
<td>4</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>CH01E12</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>CH01F09</td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>CH02B03b</td>
<td>6</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>CH02B12</td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>CH01H02</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CH01E01</td>
<td>4</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>23g4</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>02bl</td>
<td>2</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>BN</td>
<td>3</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>47 (45)</td>
<td>44 (42)</td>
<td>93.6 (93.3)</td>
</tr>
</tbody>
</table>

### Table 5: Polymorphism detected by AFLP markers on pear genotypes

<table>
<thead>
<tr>
<th>Primer combination</th>
<th>Total # of amplicons</th>
<th># polymorphic amplicons</th>
<th>% Polymorphism</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-AAC/M-CAA</td>
<td>139</td>
<td>136</td>
<td>97.84</td>
</tr>
<tr>
<td>E-AAG/M-CAC</td>
<td>170</td>
<td>168</td>
<td>98.82</td>
</tr>
<tr>
<td>E-AAC/M-CAG</td>
<td>124</td>
<td>120</td>
<td>96.7</td>
</tr>
<tr>
<td>E-AAC/M-CTA</td>
<td>132</td>
<td>122</td>
<td>92.4</td>
</tr>
<tr>
<td>E-AAG/M-CTC</td>
<td>162</td>
<td>160</td>
<td>98.8</td>
</tr>
<tr>
<td>E-AAG/M-CTG</td>
<td>105</td>
<td>102</td>
<td>97.1</td>
</tr>
<tr>
<td>E-ACA/M-CAT</td>
<td>171</td>
<td>147</td>
<td>86</td>
</tr>
<tr>
<td>E-ACA/M-CAA</td>
<td>195</td>
<td>179</td>
<td>91.8</td>
</tr>
<tr>
<td>E-ACG/M-CTA</td>
<td>134</td>
<td>115</td>
<td>85.82</td>
</tr>
<tr>
<td>E-ACG/M-CTT</td>
<td>141</td>
<td>113</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>1473 (1407)</td>
<td>1362 (1254)</td>
<td>92.5 (87.7)</td>
</tr>
<tr>
<td>Average</td>
<td>147.3 (140.7)</td>
<td>136.2 (125.4)</td>
<td></td>
</tr>
</tbody>
</table>
Utilization of Forest Biodiversity: Rewards of *Ceratonia siliqua* L. for *Apis mellifera* (Honey bee)

M. Syouf and N. Haddad

*National Center for Agricultural Research & Technology Transfer (NCARTT), Ministry of Agriculture, Jordan; P.O. Box 639 Baqa’ (19381) Jordan. Email: syoufmaha@yahoo.com*

**Abstract**

Plant community of *Ceratonia siliqua* L. at Wasfi Al-Tal forest reserve was investigated during the period of 26th September to 23rd December 2004 to assess the utilization of *Ceratonia siliqua* L (Carob) by *Apis mellifera* (Honey bee). Nectar Production rate was measured by emptying flowers, covering them for 24 hours with nylon mesh bags, and then sampling their nectar contents. The *Ceratonia siliqua* L. plant showed good nectar volume and concentration and there was important honey bee visits for pollen and nectar. Male trees were higher than the female ones regarding nectar volume and concentration. The means of nectar volume were 17.4 and 4.25 and the respective mean nectar concentrations were 63.97 and 29.25 for male and female, respectively.

**Introduction**

*Ceratonia siliqua* L. (Carob tree), a member of the Papilionaceae family, is considered as one of the important native tree species, underutilized and neglected crops in the Mediterranean region (Batlle and Tous, 1997). The Carob is a dioecious species with some hermaphroditic forms; thus male, female and hermaphrodite flowers are generally borne on different trees. The flowers are initially bisexual, but usually one sex is suppressed during late development of the flowers (Tucker 1992). The carob pods have traditionally been used as animal and human food and recently it is used mainly for gum extraction (Louca and Papas 1973). Carob powder consists of 46% sugars, 7% protein and small amounts of numerous minerals and vitamins (Whiteside 1981). Carob pulp was among the first horticultural crops used for the production of industrial alcohol by fermentation in several Mediterranean countries (Merwin 1981). In Jordan Carob syrup is a popular drink obtained by extracting carob kibbles with water. Furthermore, sugar solutions extracted from carob pods are used as substrate for culturing fungi such as *Aspergillus niger* and *Fusarium moniliforme*. (Imrie 1973). The tree is also used as an ornamental tree and windbreaker and has also usesl in pharmaceutical and cosmetic industries (NAS, 1979; Esbenshade and Wilson 1986, Batlle and Tous, 1997). In this research the nectar concentration, volume, and bee visits were studied to assess the utilization of Jordanian *Ceratonia siliqua* as a honey bee forage plant.

**Materials and methods**

Plant community of *Ceratonia siliqua* at Wasfi Al-Tal Forest reserve was investigated during 26th September to 23rd December 2004. The latitude, longitude and elevation of the site was assessed using a Garmin 12X Geographical Positioning System(GPS) instrument. A total of 10 male and 10 female trees were marked and flower phenology was studied according to a task on which the following data were taken:
- Plant volume was measured by a meter taking the maximum plant height, diameter of tow cross section of the whole tree.
- Plant distribution this was assessed by measuring distance in meter between randomly chosen pairs.
- Flower parameters: number of florets per raceme and their length and width.
- Bee visits: a total of 140 flowers was monitored at 10 o'clock in the early morning for 10 minutes.
- Nectar production rate was measured by emptying 20 flowers per male and female trees, covering them for 24 hours with nylon mesh bags, and then sampling their nectar contents by calibers using 1μl micro pipettes. Hand held-pocket refract meters (Japanese made ATAGO N1 0~ 45 and 40~ 80%) was used to measure nectar concentration. sampling were taken over two successive days at least. Nectar yield was determined by the amount of nectar available to honey bees. The value of the species as a food source for honey bee is estimated on the basis of its volume and nectar concentration.

**Results and Discussion**

Population of *Ceratonia siliqua* was studied at Wasfi Al Tal Forest at Baqa’a site (32 08 47.9N and 35 51 00.6E with elevation of 597.5 m). The mean of maximum height for the male and female trees were found to be 6.1m±2.5 and 4.1m±1.5 respectively. The volume of male trees was larger than that of female trees as indicated by the maximum average of the two cross diameters and maximum plant height (Tables 1 and 2).

Table 1: Maximum plant height and mean of the cross diameter of male *Ceratonia siliqua* trees.

<table>
<thead>
<tr>
<th>Plant no.</th>
<th>height (m)</th>
<th>d1(m)</th>
<th>d2(m)</th>
<th>(d1+d2)/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>4.4</td>
<td>2.1</td>
<td>3.25</td>
</tr>
<tr>
<td>2</td>
<td>4.5</td>
<td>3.1</td>
<td>2.2</td>
<td>2.65</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>6.5</td>
<td>5.8</td>
<td>6.15</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>2.6</td>
<td>2.1</td>
<td>2.35</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>2.5</td>
<td>3.9</td>
<td>3.2</td>
</tr>
<tr>
<td>6</td>
<td>7.5</td>
<td>3.7</td>
<td>4</td>
<td>3.85</td>
</tr>
<tr>
<td>7</td>
<td>3.5</td>
<td>3</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>4.1</td>
<td>5.4</td>
<td>4.75</td>
</tr>
<tr>
<td>9</td>
<td>9.5</td>
<td>4.4</td>
<td>3.4</td>
<td>3.9</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>3.4</td>
<td>6</td>
<td>4.7</td>
</tr>
<tr>
<td>mean</td>
<td>6.1</td>
<td>3.77</td>
<td>3.83</td>
<td>3.8</td>
</tr>
<tr>
<td>std</td>
<td>2.5</td>
<td>1.2</td>
<td>1.5</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Table 2: Maximum plant height and mean of the cross diameter of female *Ceratonia siliqua* trees.

<table>
<thead>
<tr>
<th>plant no.</th>
<th>height (m)</th>
<th>d1(m)</th>
<th>d2(m)</th>
<th>(d1+d2)/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>2.85</td>
<td>3.6</td>
<td>3.2</td>
</tr>
<tr>
<td>2</td>
<td>6.5</td>
<td>4.0</td>
<td>4.4</td>
<td>3.2</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
<td>3.0</td>
<td>2.8</td>
<td>2.9</td>
</tr>
<tr>
<td>4</td>
<td>4.0</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td>5</td>
<td>3.5</td>
<td>4.3</td>
<td>3.2</td>
<td>3.8</td>
</tr>
<tr>
<td>6</td>
<td>2.5</td>
<td>3.7</td>
<td>2.9</td>
<td>3.3</td>
</tr>
<tr>
<td>7</td>
<td>2.5</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>8</td>
<td>5.0</td>
<td>4.5</td>
<td>4.4</td>
<td>4.5</td>
</tr>
<tr>
<td>9</td>
<td>3.0</td>
<td>3.2</td>
<td>4.2</td>
<td>3.7</td>
</tr>
<tr>
<td>10</td>
<td>6.3</td>
<td>3.3</td>
<td>4.6</td>
<td>3.9</td>
</tr>
<tr>
<td>mean</td>
<td>4.2</td>
<td>3.5</td>
<td>3.7</td>
<td>3.5</td>
</tr>
<tr>
<td>std</td>
<td>1.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Plant distribution was assessed by measuring the distance between randomly chosen pairs. The mean distance was found to be 8m±3.6 (Tables 3 and 4). This distribution fits well within the recommended range of tree distribution in the afforestation and plantation (Batlle and Tous, 1997)

Table 3: Plant distribution of *Ceratonia siliqua* trees.

<table>
<thead>
<tr>
<th>Plant number</th>
<th>Distance (m)</th>
<th>Plant number</th>
<th>Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.2</td>
<td>11</td>
<td>7.6</td>
</tr>
<tr>
<td>2</td>
<td>6.6</td>
<td>12</td>
<td>15.9</td>
</tr>
<tr>
<td>3</td>
<td>12.7</td>
<td>13</td>
<td>10.7</td>
</tr>
<tr>
<td>4</td>
<td>13.2</td>
<td>14</td>
<td>9.2</td>
</tr>
<tr>
<td>5</td>
<td>5.3</td>
<td>15</td>
<td>5.5</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>16</td>
<td>7.6</td>
</tr>
<tr>
<td>7</td>
<td>7.8</td>
<td>17</td>
<td>9.7</td>
</tr>
<tr>
<td>8</td>
<td>6.2</td>
<td>18</td>
<td>13.4</td>
</tr>
<tr>
<td>9</td>
<td>8.3</td>
<td>19</td>
<td>4.9</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>20</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Mean total sd 8.1 3.6

Florets number, length and width of male trees were found to be higher than the female ones as shown in Tables 4 and 5, respectively.
Table 4: Number of florets, length and width of inflorescence of *Ceratonia siliqua* male trees.

<table>
<thead>
<tr>
<th>Inflorescence No.</th>
<th>no. of florets per inflorescence</th>
<th>Length (cm)</th>
<th>Width (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57</td>
<td>7.4</td>
<td>1.2</td>
</tr>
<tr>
<td>2</td>
<td>59</td>
<td>7.6</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>57</td>
<td>12</td>
<td>1.5</td>
</tr>
<tr>
<td>4</td>
<td>45</td>
<td>8.4</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>77</td>
<td>9.6</td>
<td>1.8</td>
</tr>
<tr>
<td>6</td>
<td>57</td>
<td>8.6</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>47</td>
<td>7.5</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>52</td>
<td>7</td>
<td>1.9</td>
</tr>
<tr>
<td>9</td>
<td>80</td>
<td>6.6</td>
<td>1.5</td>
</tr>
<tr>
<td>10</td>
<td>42</td>
<td>7.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Mean</td>
<td>57.3</td>
<td>8.19</td>
<td>1.54</td>
</tr>
<tr>
<td>Std</td>
<td>12.6</td>
<td>1.6</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 5: Number of florets, length and width of inflorescence of *Ceratonia siliqua* female trees.

<table>
<thead>
<tr>
<th>Inflorescence No.</th>
<th>no. of florets per inflorescence</th>
<th>Length (cm)</th>
<th>Width (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>67</td>
<td>6</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>48</td>
<td>5.6</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>41</td>
<td>5.5</td>
<td>1.5</td>
</tr>
<tr>
<td>4</td>
<td>74</td>
<td>6.5</td>
<td>1.6</td>
</tr>
<tr>
<td>5</td>
<td>72</td>
<td>5.5</td>
<td>1.5</td>
</tr>
<tr>
<td>6</td>
<td>75</td>
<td>5.5</td>
<td>1.5</td>
</tr>
<tr>
<td>7</td>
<td>75</td>
<td>6.5</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>74</td>
<td>6.5</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>62</td>
<td>6.6</td>
<td>1.9</td>
</tr>
<tr>
<td>10</td>
<td>61</td>
<td>4.5</td>
<td>1</td>
</tr>
<tr>
<td>Mean</td>
<td>64.9</td>
<td>5.87</td>
<td>1.39</td>
</tr>
<tr>
<td>Std</td>
<td>12.0</td>
<td>0.7</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Ortiz *et al.* 1996 found that pollen transport from staminate to pistillate flowers is affected by insects, mainly bees. In this research *Ceratonia siliqua* L. plant showed good results regarding the nectar volume and concentration for honey bees, as assessed by bee visitation. Male trees showed higher nectar volume and concentration than femal trees. The mean nectar volume was 17.4±97 for male tree whereas, for the female it was only 4.25±4.9. The nectar concentration was 63.97±10.19 for the male tree and only 29.25±34 for female tree (Figures 1 and 2). Ortiz *et al.* 1996 indicated that flowers of all three sexes (male, female and hermaphrodite) were found to secrete nectar which attract insects in general. Monitoring the honey collecting both nectar and pollen from *Ceratonia siliqua* L. trees was done in the field. Every 10 minutes, two honey bees, 10 flies and 7 wasps visited each flower on average.
Conclusion

Plant community of *Ceratonia siliqua* L. at Wasfi Al-Tal forest reserve was investigated during 26 September to 23 December 2004 to assess the utilization of *Ceratonia siliqua* L (Carob) for *Apis mellifera* (Honey bee). Nectar Production rate was measured by emptying flowers, covering them for 24 hours with nylon mesh bags, and then sampling their nectar contents. The *Ceratonia siliqua* L. plant showed good results regarding the nectar volume and concentration and there was good honey bee visitation for pollen and nectar. Male trees were higher than the female ones regarding nectar volume and concentration, the mean volume for male trees was 17.4±97sd whereas, for the female ones it was only 4.25±4.9sd. The mean volume for the nectar concentration for male trees was 63.97±10.19sd whereas, for the female ones it was only 29.25±34 sd. These results indicated that this plant is a good source for honey bee feeding, since it blooms during a time of the year where very scarce plant bloom during this part of the year where very few other plants are blooming.

![Figure 1: Nectar volume and concentration for male trees covered for 24 hours](image-url)
Fig 2: Nectar concentration and volume for male *Ceratonia siliqua* trees

References
Highlights of Major Achievements of the West Asia Dryland Agrobiodiversity Conservation Project

A.Amri, M. Ajlouni, R. Assi, Y. Sbeih A.Saad, W. Khoury and A. Khnifes

1 Regional Project Coordinator, the International Center for Agricultural Research in the Dry Areas (ICARDA), Amman-Jordan, e-mail: a.amri@cgiar.org
2,3,4,5 Respectively, National Project Coordinators in Jordan, Lebanon, Palestine and Syria

Keywords: Agrobiodiversity, drylands, West Asia, project achievements

Abstract
West Asia mega-center of diversity holds genetic resources and associated local knowledge of global importance which require concerted efforts at local, national, regional and international levels for its conservation to sustain agricultural development worldwide while improving the livelihoods of the major custodians of local agrobiodiversity. The GEF-funded, ICARDA-coordinated regional project on “conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria, contributed to the development of a holistic approach for promoting the community-driven in situ/on-farm the conservation of landraces and wild relatives of cereals, food and feed legumes and fruit trees originating from West Asia. The project assessed the status of local agrobiodiversity in two target areas per country and identified major threats to landraces and natural habitats. It has demonstrated in collaboration with local communities, National Research and Production Institutions, local NGOs and private sector examples of technological, adding-value and alternative sources of income options for efficient in situ/on-farm conservation of local agrobiodiversity. The project has led to institutional arrangements, recommended policy options to empower local communities and allowed a significant capacity building at local, national and regional levels and a significant increase in public awareness including the introduction of biodiversity conservation within the education systems in the four countries. These options are included in the community development plans and natural habitats management plans developed in concertation with major stakeholders and proposed to government authorities. The project contributed also to the development of scientific basis for effective community-driven in situ/on-farm conservation and assembled valuable databases (socio-economic, eco-geographic, botanic, GIS/RS, etc.) in addition to fieldguides and software to ease the identification of species and monitoring local agrobiodiversity. The project succeeded in introducing important policy recommendations including the shift to the use of wild fruit trees in afforestation efforts and the signing of Memorandum of Understanding between the Ministers of Agriculture of the four countries for a regional alliance to conserve local agrobiodiversity and promote the exchange of plant genetic resources.

Introduction
Dryland agrobiodiversity, better known for its high within species diversity and endemism and for its inherent traits for adaptation to harsh and adverse conditions (heat, drought) continue to constitute the basis for the livelihood of rural populations living in the dry areas (CBD, 1992). The agrobiodiversity in the drylands of the West Asia is of special significance since it encompasses the diversity of plant species of global importance such as wheat, barley, lentil, many forage (Lathyrus, Medicago, Trifolium, Vicia)and fruit tree (Ficus, Olea, Pistachia,
Prunus, etc.) species (Frankel, 1978; Hawkes, 1983, Harlan, 1992). The landraces of these species continue to form the basis of the traditional farming systems still prevailing in the dryland and mountainous areas. The wild relatives are found in fragmented habitats where their abundance and frequency are affected by various threats. West Asia is also known for its richness in vegetables and in medicinal, aromatic and herbal plant species in addition to a significant richness in local breeds of sheep, goats and cows. These genetic resources have been used extensively in breeding programs locally and at the international level and hold valuable gene pools for future genetic improvements (ICARDA, 2004).

The convention of Biological Diversity (CBD) and Agenda 21 have emphasized the need to develop work on *in-situ* conservation that is considered as the fundamental requirement for the conservation of biological diversity within their ecosystems and natural habitats (CBD, 1992). *In situ* conservation is recently advocated to complement *ex situ* conservation efforts through allowing the evolution of populations under natural and users selection (Maxted *et al*., 1997d). As exclusive reserves are not always appropriate and accepted by local communities, the sustainable use of biodiversity by local communities is advocated for long-term preservation of local knowledge. Additionally, *in situ* conservation can make a direct contribution to the wellbeing of farmers and communities as the local populations are directly available to them. The development and the implementation of this type of conservation require an active participation and the development of appropriate measures which will combine conservation, sustainable use and improvement of the livelihoods of rural communities. The *in situ* approach will require activities such as:

- Increasing public awareness at the local, national, regional and international levels on the importance of biodiversity for future generations and on the shared responsibility of preserving this universal heritage.
- Development of technological packages for improving the productivity of local genetic resources while preserving the diversity (participatory breeding, low cost soil and water management techniques, seed quality improvement,…).
- Increasing the demand for the products derived from the local genetic resources through processing and by advocating them as organic farming products.
- Development of legal and policy options that will recognize the efforts of farmers in preserving the biodiversity.
- Understanding the human and environmental factors affecting the genetic diversity and determining sound scientific basis for *in situ* conservation.

ICARDA is conserving *ex situ* more than 133,000 accessions of cereals, legumes and forages in its genebank and assisting more than 12 countries in CWANA region to establish operational national genebanks (ICARDA, 2004). Through the adoption of integrated natural resources management and participatory approaches, ICARDA is contributing to *in situ* conservation of local agrobiodiversity through promoting the use of native species. It has initiated research trials since 1995 in three sites in Syria to study the dynamics of wild relatives of cereals and legumes population using restoration management. The West Asia dryland agrobiodiversity has allowed ICARDA to contribute to the development of community-driven *in situ* conservation approaches. This contribution describe the approach and the main achievements of the project.

**West Asia dryland agrobiodiversity project**
The Global Environment Facility (GEF) has financed through the United Nations Development Programme (UNDP) a six-year project on “the conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, Palestine Authority and Syria”. ICARDA is implementing and executing the regional component of the project and providing technical backstopping and training in cooperation with IPGRI (International Plant Genetic Resources Institute, now Bioversity International) and ACSAD (Arab Center of Studies of Arid zones and Dry Areas). The National Center for Agricultural Research and Technology Transfer (NCARTT) in Jordan, The Lebanese Agricultural research Institute (LARI) in Lebanon, The Ministry of Agriculture and the UNDP/Programme of Assistance to Palestinian People in the Palestinian Authority, and the General Commission for Scientific and Agricultural Research (GCSAR) in Syria, were leading the implementation of the respective national project components. The project was conducted in two sites in each of the four countries (Ajloun and Muwaqqar in Jordan, Baalbak and Aarsal in Lebanon, Hebron and Jenin in Palestine, and Al-Haffeh and Sweida in Syria) covering complementary ecosystems and farming systems prevalent in West Asia and North Africa region (WANA). It has targeted *in situ/on-farm* conservation of landraces and wild relatives of 16 target genera including wheat, barley, lentil, chickpea, pea, vetch, *lathyrus*, medics, clovers, fruit trees (almonds, plum, apricot, pistachio, cherry, pear, olive, fig) and *Allium*.

Universities, the Ministries of Agriculture, Ministries of Environment, Education and Tourism, local and international NGOs, and local communities and farmers and herders cooperatives are major partners in the implementation of project activities. International expertise from advanced institution was also used for key aspects. The project aimed at achieving the following outputs:

- Better understanding of the status and threats to local agrobiodiversity;
- Promoting alternative landuse practices at project sites to conserve and sustain the use agro-biodiversity;
- Technical backstopping, capacity building and training in all aspects related to *in situ* and on-farm conservation;
- Investigation and transfer of add-value technologies and alternative sources of income options;
- Increasing public awareness on the importance and benefits of conserving dryland agrobiodiversity;
- Modify existing legislation and land use rights where necessary and in the national interest to promote the conservation and sustainable use of agrobiodiversity;
- Enhancing regional integration and collaboration through networking and coordination;
- Monitor the impacts of project activities for lessons learned and adaptive project management.

The following chart summarizes the elements of the holistic approach developed by the project to promote community-driven *in situ/on-farm* conservation of agrobiodiversity. The strategy calls for more participatory research on low-cost technological packages for increasing the productivity of landraces and natural habitats, the introduction of income generating activities and benefit sharing mechanisms for improving the livelihoods of the custodians of agrobiodiversity of global importance. In-kind incentives and subsidies are included mainly in launching business oriented activities and to support the management plans implementation, respectively.
Major project achievements
Different evaluation missions acknowledged the achievements of most project outputs and of indications of preliminary impacts. The project achievements are summarized below for each project output.

1. Better knowledge of status and threats of local agrobiodiversity
Socio-economic and farming surveys were conducted in 2000 and 2004 in 26 project sites (communities) in the eight target areas. The survey in 2000 is considered as a baseline and the survey in 2004 was designed to provide information of the impacts of the project on the livelihoods of local communities in addition to assessing the trends in on-farm conservation. Eco-geographic and botanic surveys were conducted in 73 monitoring areas selected within the remaining biodiversity rich natural habitats for one to 4 years. GIS/RS tools were used to assess and monitor changes in land uses, to develop biodiversity indices and to perform environment similarity analysis over CWANA region. The main results are:

- Landraces of barley, lentil and fig are still exclusively used by farmers in all target areas, but their acreages are decreasing due to replacement by plantation of fruit trees. For olive, grape, cherry and almond the use of landraces is still predominant, but some improved varieties are taking acreage. For bread and durum wheats, landraces are replaced to a great extent by improved varieties in Palestine. Only few landraces of apple, plum and apricot are still used by farmers.
• For wild relatives, the fragmentation and destruction of natural habitats for urbanization and agricultural encroachment, the over-grazing and deforestation and the quarries have affected seriously the densities and frequencies of wild species. In Palestine and parts of Lebanon, wild relatives of wheat and lentils have disappeared in the locations where they have been previously reported.

• The GIS/RS showed that natural habitats in most of the target areas have been converted over the past 20 years to other landuses such as plantation of fruit trees as in Sweida and Aarsal or by quarries as seen in Aarsal and Hebron and by occupation measures as in the West Bank.

• Community development plans and natural habitats management plans were introduced including technological, economic, institutional and policy options to promote the conservation and sustainable use of local agrobiodiversity.

• The project developed a software for the eco-geographic/botanic surveys and two fieldguides for *Medicago* and *Lathyrus* to ease the taxonomic identification of species of these genera.

• These surveys allowed also to collect local germplasm of landraces and wild relatives used to enrich ICARDA and national genebanks. Field genebanks for landraces of fig, grape and almond were established in Lebanon and for olive in Jordan. A total of 17 areas for potential *in situ* conservation of wild relatives of target species were spotted. Four *in situ* conservation simulated sites were established in Jordan and two in Syria.

• Local knowledge survey on the use of wild relatives and medicinal plants was also conducted in Lebanon, Jordan and Palestine.

2. *Promoting alternative landuse and appropriate technological packages*

The project demonstrated in various project sites low-cost technologies for increasing the productivity of landraces and natural habitats. Among the technologies with significant gains:

• Seed cleaning and treatment against seed transmitted diseases at community levels have showed significant gains in grain and straw yields of cereals and legumes ranging from 5 to 78%. The project provided seed cleaning and treatment machines for local communities in all the target areas to enhance informal seed production system. As a consequence in Palestine, more than 78 tons of good quality grains of durum wheat and legumes were provided in two years to collaborating farmers which contributed to regain acreage by landraces of field crops. When low rates of fertilizers and herbicides are used, significant gains were achieved in farmers’ fields for wheat and barley landraces.

• Variety verification trials showed in all environments that landraces of barley and wheat are performing as good and sometimes better than improved varieties under harsh conditions. Through farmers participatory selection, new multilines with better grain yields were derived from landraces of barley, wheat and lentil showing the possibilities for significant grain yield gains with less reduction of genetic base of landraces.

• For fruit trees, water harvesting and integrated crop/pest management techniques showed possibilities for improvement of both fruit productivity and quality of landraces.

• The feeding calendar and flocks mobility surveys undertaken by the project showed that the rangelands are contributing between 25 to 45% to small ruminants feed needs. For management of biodiversity in rangelands, plantation of shrubs and of native range species combined with water harvesting techniques showed possibilities for
rehabilitation of highly degraded rangelands. More than 150-300 ha were used as pilot sites for demonstrating these packages and for initiating grazing management options. The project introduced feed blocks using residues from fruit trees and other by-products available in the regions to contribute to take pressure off natural vegetation during critical periods. More efforts are also needed in livestock management including culling and health improvement measures.

- For wild relatives of fruit trees, plantation of native species was done through reforestation efforts along with water harvesting techniques. The Departments of Forestry in the four countries issued a service order to use native species in the afforestation programs. The project allowed the planting of more than 575,000 seedlings of target species in target areas.

3. Capacity building and technical backstopping

More than 83 national and 11 regional training courses and workshops were organized by the project, which have benefited a total of 4700 persons including 1480 women. The beneficiaries include farmers, herders, extension agents, researchers, teachers and education specialists, forestry staff and members of NGOs and the training covered various aspects of in situ conservation approaches, integrated natural resources management, food processing, rangeland and livestock management and technological packages. In addition, 38 persons were supported for BS, MSc and PhD studies in the four countries. Some of these students are now active in research on conservation of agrobiodiversity. The project provided technical backstopping for implementing project activities in different countries, mainly in the areas of monitoring agrobiodiversity, taxonomy, GIS/RS, fruit trees, rangeland management, policies and legislation, socio-economic data analysis, food processing and alternative sources of income.

4. Investigation and promotion of adding value and alternative sources of income

The project focused on training of local communities and mainly women on various techniques for adding value to local produce through processing and on introduction of additional income generating activities. Technical backstopping was provided for the establishment of cooperatives and individual businesses. The most successful activities are:

- Production and marketing for the first time of jams, compotes and syrup products from wild plum, arbutus and other wild fruit trees.
- Better packaging and libeling of local produces (jams, syrups, burghul, frikeh, …) by local cooperatives.
- Establishment of local cooperatives, two in Lebanon, two in Jordan and three in Palestine for processing and marketing local products from agrobiodiversity. Funds were obtained from donors such as YMCA to acquire needed equipments and building in Lebanon.
- Introduction of special cheese “Shinglish” to Palestine and Jordan after a training in Syria. More than 80 women are trained in Palestine.
- Training was also provided in apiculture and honey production in the four countries and mushroom production was introduced in Jordan.
- Eco-tourism was introduced in Ham-Maaraboun villages in Lebanon where links were established between local communities and eco-tour operators and more than 12 groups of tourists have already visited the sites in two years.
• A study was conducted in Lebanon on packaging and labeling of herbal plants and their acceptance by consumers, cafes and shops. The results were encouraging.
• For enhancing the marketability of local products, the project components organized six agrobiodiversity fairs and participated in more than 9 national agricultural fairs where collaborating cooperatives were able to show and sell their local products. The project succeeded in establishing agrobiodiversity shop in Syria and a weekend summer market in Jordan close to historic sites for selling local products. Links were also created between women cooperatives and shops and super markets for selling local products.
• Some farmers and women established special nurseries for multiplying and selling landraces of fruit trees.

5. Increasing public awareness
One of the major contributions of the project is its success to increasing the awareness of farmers, local communities, school students, decision makers and general public. Several awareness supports were used.
• Newsletters and websites were developed by the regional and Lebanese components;
• More than 56 reports and 70 posters were produced on the importance of targeted species in addition to photos for screen savers;
• Organization of public awareness workshops attended directly by more than 12,000 persons in the four countries. In Syria, rural theater was very efficient in this regard;
• Use of mass media (TV, radio and newspapers) and production of one regional and four national documentary films and several TV spots broadcasted by many channels.
• The project was successful in introducing biodiversity conservation in the education systems in the four countries. Curriculum and methodological guides were developed by all national components and already implemented at primary schools in Syria and Palestine. Many extra-curricula activities were introduced in schools including the establishment of school gardens, participation to reforestation efforts, documentation of parental knowledge, wall newsletter and organization of painting contests. The regional component organized a regional painting contest in the four countries for school children 8-14 years old and more than 1600 paintings were selected among which the best four per country were awarded. At the university level, in situ conservation was introduced in plant genetic courses in Jordan and Palestine and a Masters’ Program is initiated at the Jordan University for Science and Technology on management of natural habitats and conservation of biodiversity.

6. Modification of policies and legislations
The project has also worked towards the development of policies and legislation options to empower local communities and ensure the domestication of the international agreements (the Convention of Biological Diversity, the International Treaty for Plant Genetic Resources for Food and Agriculture,...) within national policies.
• A conceptual framework was developed by experts during the thematic workshops which helped in developing policy recommendations.
• The four countries were able to draft national policies for conserving local agrobiodiversity which are proposed to governments for consideration.
Following the recommendation of the policy workshop organized by the project at the Arab League headquarters in Cairo, the four countries were among the first signatories of the International Treaty on Plant Genetic Resources (ITPGRFA). Syria, with the help of FAO has already drafted the PGR access legislation. FAO and ICARDA expressed their keen interest to assist nationals in drafting their PGR access legislations.

7. Enhancing regional integration
ICARDA through the dryland agrobiodiversity project has contributed to enhancing multi-institutional and regional collaborations through:

- Involvement of universities, NGOs, other ministries and international experts in the implementation of project activities;
- Four thematic groups were established which helped in the standardization of methodologies and in harmonization of the implements of the activities and the reporting.
- Participation to national steering committee meetings and organization of annual regional technical and planning and annual steering committee meetings attended by representatives of national implementing institutions, GEF and UNDP country representatives and scientists from ICARDA, IPGRI and ACSAD.
- The project organized several traveling workshops to exchange visits among the project components and for the project teams to visit other agrobiodiversity projects in WANA region.
- The project teams shared their experiences and results in more than 56 workshops and conferences. More than 146 reports were produced and 42 scientific papers were published in different journals and conference proceedings. In April 2005, ICARDA organized the first international conference on promoting community-based in situ/on farm conservation of agrobiodiversity attended by 157 participants from 27 countries.
- The expertise built within the project is actually helping the nationals and in many other countries in developing project proposals targeting the conservation of local agrobiodiversity.
- At the closing meeting of the project, ICARDA witnessed the signing by Their Excellencies the Ministers of Agriculture in Jordan, Lebanon, the Palestinian Authority and Syria a Memorandum of Understanding for a regional alliance for conservation of agrobiodiversity and for facilitating the exchange of germplasm among the four countries.
- ICARDA in collaboration with Wageningen International and the Generation Challenge Program launched from Iran an international training program including the ex situ and in situ conservation of agrobiodiversity attended by participants from sub-Saharan, Asia, CWANA countries and Iran.

Conclusions and lessons learned
This project is among the first few initiatives financed by GEF to promote the conservation of dryland agrobiodiversity of global significance. All national, regional and international institutions and communities who contributed to the implementation of the project, the evaluation teams and the participants to the conferences and workshops organized by the project have acknowledged the efforts and achievements of the project in developing a sound strategy for promoting in situ/on farm conservation of agrobiodiversity including the efforts for increasing
public awareness. Many recommendations and lessons were derived and will be helpful in planning and implementing future projects.

- GEF should continue and increase its support and funding to projects targeting the conservation of dryland agrobiodiversity mainly to safeguard genetic resources of global importance. This support could include the establishment of protected areas and natural reserves in the areas of primary and secondary centers of diversity of major crops.

- Building strategies and approaches for community-based *in situ* on-farm conservation of agrobiodiversity should be considered as a long-term research program requiring continued and sustained efforts. The West Asia dryland agrobiodiversity project could have benefited from another phase to implement the numerous exit strategies developed at the end of the project.

- *In situ* on-farm conservation of agrobiodiversity will require actions for improving the livelihoods of the main custodians of local agrobiodiversity including adding value and alternative sources of income along with the funding mechanism for equitable benefit sharing.

- Strengthening regional and international collaboration is a prerequisite for effective conservation of agrobiodiversity of global significance through sharing of expertise and harmonization of conservation actions between neighboring countries. This type of collaboration will overcome the limited expertise in areas such as taxonomic identification of species, policy and legislation development and participatory approaches.

- Need for national institutions to develop mechanisms and actions for sustaining the activities and approaches initiated by outside funded projects, including some initial in-kind incentives and subsidies for the implementation of community development and natural habitats management plans.

- Thematic groups were very instrumental in standardization of methodologies and in harmonizing the implementation of activities. International and lead experts played a key role in these groups and in developing approaches.

**References**


Impact of Land Reclamation on Local Agrobiodiversity in Sweida Region of Syria

A. Khnifes and A. Amri

1 General Commission for Scientific and Agricultural Research, Syria (GCSAR)
2 International Center for Agricultural Research in the Dry Areas (ICARDA)

Abstract
Most of the lands in the southern part of Syria are rocky with limited agricultural investment. Sweida region is located within a volcanic area and is characterized by rich plant diversity with more than 650 species including the wild relatives of wheat, barley and of many fruit trees and forage species. Farmers’ initiatives and government subsidies to reclaim new agricultural lands from natural habitats started as far back as the 1950s but gathered pace during the last 20 years. This study documents the effects of land reclamation on local agrobiodiversity in natural habitats through a survey of 50 farmers from three sites in this region.

The results reveal that land reclamation has allowed the plantations of large areas by introduced apples at the expense of field crops, grapes, fallow and natural habitats. This situation has resulted in a significant decrease in livestock populations and activities. Farmers are requesting more reclamation of agricultural land from the remaining natural habitats that, if not efficiently monitored, will cause serious losses to local agrobiodiversity and fragment the natural habitats.

Introduction
Syria is located within the West Asia mega-center of diversity where number of field crops and fruit trees now grown over the world and contributing significantly to its food security, were domesticated over the past 10,000 years (Harlan, 1992). The flora of Syria was studies by many taxonomists and the first surveys were undertaken by Post (1933) and Mouterde (1970). Sweida region and Jabal Al-Arab site are of special importance since they harbour a rich plant biodiversity including the wild relatives of cereals, feed legumes and many fruit trees (Chikhali, 1999). This region is known to harbor the richest flora in Syria including the continuous use of landraces of barley, durum wheat, and chickpea in the cropped lands.

Sweida is located in the southern part of Syria and the lands are rocky in nature having limited investments in agriculture and the adoption of new technologies for a long time. The Syrian government as well as farmers returning from work abroad with considerable savings have started reclaiming the lands and clearing the rocks for new plantations mainly of fruit trees. Furthermore, government subsidies helped in changing the land-use patterns in Sweida region.

The West Asia dryland agrobiodiversity, aimed at promoting the in situ conservation and sustainable use of landraces and wild relative of species of global importance, has conducted this study to assess the effects of land reclamation and conversion on local agrobiodiversity. This contribution reports the main findings of this work.

Methodology
A survey was conducted with the participation of 50 farmers in all at five project sites in the Sweida region (Rashida, Al-Mushanaf, Sahwat Blata, Kanawate) and one at the Bosra site,
located in the western part to assess the cropping patterns and land-uses for the years 1970, 1980, 1990 and 2003. The survey was designed to take into consideration the effects of land reclamation on the existing crops, the introduced species, and on natural habitats. Livestock changes and its impact were also assessed over the same period before and after land reclamation. Secondary data on the government policy for land reclamation was reviewed. Farmers’ opinions on land reclamation were also collected. The data were analyzed and results are presented comparing the situation before and after land reclamation.

Results and Discussion
The secondary data showed that the areas had been reclaimed from the original rocky habitat areas in each of the villages surveyed. The total area reclaimed in the entire Sweida region from 1986 to 2002 is 4236 hectares, one third of which was done on natural forest habitats and the remaining was caused by the changed use of land from landrace cultivation of field crops to fruit tree plantations. In the six villages, the total reclaimed land is 1137 ha out of which 60 % is converted to fruit tree plantations from natural habitats that were originally either forests or rangelands (Table 1). The highest claimed acreages are located in the plains and valleys and the lowest are in the very dry areas of Al-Mushanaf.

Table 1: Total area (ha) reclaimed from cultivated areas and natural habitats in six villages from 1986 to 2002

<table>
<thead>
<tr>
<th>Project sites</th>
<th>Area claimed from cultivated fields</th>
<th>Area claimed from natural habitats</th>
<th>% reclaimed from natural habitats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rashida</td>
<td>131</td>
<td>89</td>
<td>40</td>
</tr>
<tr>
<td>Al-Mushanaf</td>
<td>35</td>
<td>16</td>
<td>31</td>
</tr>
<tr>
<td>Sahwat Blata</td>
<td>13</td>
<td>135</td>
<td>91</td>
</tr>
<tr>
<td>Kanawat</td>
<td>147</td>
<td>120</td>
<td>64</td>
</tr>
<tr>
<td>Sahwat AlKhodr</td>
<td>62</td>
<td>30</td>
<td>44</td>
</tr>
<tr>
<td>Bosra</td>
<td>290</td>
<td>69</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>678</td>
<td>459</td>
<td>60</td>
</tr>
</tbody>
</table>

The changes in cropping patterns showed that the average farm size has increased by 129 % on an average, with new lands brought into cultivation favoring mainly introduced species of apples, olives and almonds, as well as a significant increase in chickpea acreage (Table 2). The fallow has been completely abandoned.

Table 2: Changes in average acreages of crops and fallow per farm before and after land reclamation in six villages in Sweida region from 1986 to 2002

<table>
<thead>
<tr>
<th>Crops</th>
<th>Before reclamation</th>
<th>After land reclamation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acreage (Ha)</td>
<td>%</td>
</tr>
<tr>
<td>Cereal</td>
<td>2.4</td>
<td>43</td>
</tr>
<tr>
<td>Fallow</td>
<td>1.7</td>
<td>31</td>
</tr>
<tr>
<td>Grape</td>
<td>1.2</td>
<td>22</td>
</tr>
<tr>
<td>Olive</td>
<td>0.2</td>
<td>4</td>
</tr>
<tr>
<td>Chickpea</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Apple</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Almond</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The reclamation of lands from natural habitats and the elimination of areas, with field crops and fruit tree plantations, from grazing have contributed to a significant decrease in livestock in the villages except at the driest site of Al-Mushanaf (Table 3). The livestock was completely eliminated at Kanawat village and reduced to by two thirds at Bosra villages.

Table 3: Changes in livestock in four villages (Average number per household) in Sweida before and after land reclamation

<table>
<thead>
<tr>
<th>Project sites</th>
<th>Sheep</th>
<th>Goats</th>
<th>Cows</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
</tr>
<tr>
<td>Rashida</td>
<td>90</td>
<td>70</td>
<td>18</td>
</tr>
<tr>
<td>Mushanaf</td>
<td>25</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>Kanawat</td>
<td>108</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Bosra</td>
<td>150</td>
<td>51</td>
<td>0</td>
</tr>
</tbody>
</table>

This land-use and farming patterns changes have contributed to significant increase in farm incomes, with an increase in income from crop production and a decrease from livestock production (Table 4). There was also an increase of 7% in off-farm income.

Table 4: Effects of land reclamation on farm income (in percent) as a result of land reclamation

<table>
<thead>
<tr>
<th>Source of income</th>
<th>After reclamation</th>
<th>Before reclamation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant production</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>Animal production</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>Off-farm</td>
<td>48</td>
<td>55</td>
</tr>
</tbody>
</table>

**Conclusion**

This study has shown that there have been significant effects impacting agrobiodiversity brought on by the land reclamation processes. This development has resulted surely in an improvement of the farm-income with the introduction of fruit tree plantations in the region. However, it has affected negatively the acreages of landraces and the biodiversity in natural habitats due to conversion of land-use. The land reclamation for plantation of fruit trees has extended to areas where farmers have not enjoyed important economic returns but have secured the ownership of land from natural habitats. Farmers are still applying for government support to reclaim even more land from the original habitats and this could cause serious losses to the remaining natural plant diversity. It is the conclusion of this study, that the reclamation of land should be based on suitable land-use maps to be established taking into consideration the safeguarding of the remaining agrobiodiversity. The decrease of livestock in some areas could impact positively the preservation of wild relatives of herbaceous species if they could be limited to field borders.
References
Jabal El-Arab: An Important Centre for Biodiversity in South East Syria

C. Mwaffak and A. Amri

P.O.Box 5793 Damascus-Syria; E-mail: mchikh@scs-net.org

Keywords: Plant biodiversity, threats, Sweida, Syria

Abstract
Jabal Al-Arab, located in the southern part of Syria has a diverse climate which is reflected in four types of vegetation, Irano-Mediterranean, Eu-Mediterranean, Irano-Turanian and hygrophitic vegetation. More than 512 higher plant species were recorded including many wild relatives of fruit trees, field crops and many forage legumes. The area has one of the largest population of *Triticum dicoccoides* species giving it along with other species a biodiversity hot spot of global importance. Land reclamation for agricultural and urbanization purposes along with wood collection in forest areas and grazing in the eastern part are the major threats to local agrobiodiversity. Plans should be designed to promote the *in situ* conservation of this biodiversity rich area.

Location and climate
Jabal El-Arab is located in the southern end part of Syria near the border with Jordan, bounding between latitudes of 36° 15’ N and 37° 00’ N and longitudes of 32° 07’ E and 33° 10’E. The climate of Jabal El-Arab is very closely linked with its topography. Four specific factors are responsible for the spatial distribution of rain: Altitude, shading effect of the western slopes compared to the eastern slopes, effect of the Tiberias-Hermon gap, the humid Mediterranean air flow within this gap to reach Jabal El-Arab and the effect of humid air of Khamasin cyclone at the beginning of the spring. (March-April).

The average annual rainfall amounts to 220 mm in the northern and southern parts of the study area and highest rainfall occurs at the western slopes of the mountain in the Ein El-Arab station (538.6 mm at, 1510 m). The coldest month is January where lowest mean annual temperature (2.5°C in Ein El Arab) while hottest month is July (23.4°C in Shahba). Monthly mean minimum temperature varies from -1.5°C (Ein El-Arab) in January increasing gradually until August (17.6°C in Shahba). Monthly mean maximum temperature varies from 5.8°C (Ein El-Arab) in January increasing to 30.9°C (Sweida) in August. Frost occurs in about 4 months of the year from January to April during this period temperature may drop to −14°C. Emberger aridity index (Q) lies between 40 and 66 and the average of minimum temperature (m) during the coldest month varies between −1.5°C in Ein El-Arab and 3.1°C in Sweida which indicates a semi-arid bioclimate with a cool Mediterranean variety.
Flora and Vegetation
Jabal Al-Arab is located within the West Asia Mega-center of diversity where number of species of global importance have originated and domesticated (Harlan, 1992). The first surveys of the flora of this location was done by Post (1933) and Mouterd (1970) which reported the high plant species richness of this location. Five hundred twelve species species belonging to 234 genera and 51 families were collected and. the most dominated families are Fabaceae (113 species), Poaceae (74 species) and Asteracea (44 species). Forty-one species are listed as new records for the study area which are belonging to 14 families and 33 genera. The leading two families are Poaceae and Fabaceae with 11 and 10 species respectively (Chikhali, 2000).

The vegetation of Jabal El-Arab could be sub-divided into four main types:
1. North-western zone: The vegetation is an Irano-Mediterranean type. The most dominant trees species are Pistacia atlantica and Amygdalus korschinskii, which form a rich association with very numerous herbaceous and shrub species (Ononis spp., Vicia sp., Astragalus sp., Capparis spinosa ...)
2. Central zone: The main vegetation of this massif is a Quercus calliprinos-Crataegus azarolus forest-like stands (Eu-Mediterranean) with a lot of tree species on the low altitudinal belt (Pyrus syriaca, Amygdalus spp., Pistacia atlantica ...). The higher area of this zone forms a sub-alpine tragacanthic plant formation with Astragalus bethleheimiticus.
3. South-eastern and southern zone: The vegetation of this zone is an Irano-Turanian type and the main three vegetation types are Artemisia herba-alba-Poa sinaica, Artemisia herba-alba Achillea fragrantissima and Salsola vermiculata-Haloxylon articulatum associations.
4. Hygrophitic vegetation comprises of Typha australis-Butomus umbellatus association fragments, with Mentha aquatica, Vitex anagus-castus, Ranunculus spp. and others.

Genetic Resources
No more than 12 tree species are growing in Jabal El-Arab and the most dominate species being: Pistacia atlantica, Crataegus sinaica, Pyrus syriaca and Quercus calliprinos. The first three species are valued as native parents that could be used as rootstocks in agriculture. Pistacia atlantica is one of the most important tree species which characterizes the arid or semi-arid climatic conditions, occupying areas transitional between the Mediterranean and the Saharo-Sindian territories.

Crataegus is represented in Syria by three species. Those are C. monogyna Jacq., C. azarolus L. and C. sinaica Boiss., where the first two species are widely distributed in the old world, and the last grows only in two countries, Syria and Egypt.

Pyrus syriaca is occurring in the maquis of the Mediterranean mountains, in the steppe-forest of the Mediterranean-Irano-Turanian borderlands and also in the Kurdo-Zagrosian ranges. The geographical distribution of the species is limited to the Mediterranean area in Syria, Lebanon, Turkey, Jordan and Palestine.

Fabaceae forms the largest family of Jabal El-Arab’s flora with 18 genera and 113 species distributed over the area. Thirty percent of the species are Mediterranean, 15% are Irano-
Turanian, 18% are biregional (Mediterranean, Irano-Turanian). Twenty-four species of *Astragalus*, 14 species of *Vicia*, 28 annual species of *Trifolium*, 11 annual species of *Lathyrus*, 8 annual species of *Medicago* and 6 species of each *Ononis* and *Trigonella*.

The region is well known for its richness in wild relatives of cereals mainly of wheat and barley. Seven *Aegilops* species and large population of *Triticum dicoccoides* are found in this region. *Hordeum spontaneum* and *H. bulbosum* are widely spread in the region. Six wild *Allium* species were identified in the region.

**Main threats to biodiversity**

The large number of plant species and the richness in the wild relatives of fruit trees and field crop species with global importance make this area one of the most important centre of diversity and part of the hot spot where species are subject to rapid degradation. Earlier surveys have reported more than 760 plant species (Mousterd, 197). The main threats to natural habitats are the extensive encroachment of fruit tree plantations, principally apples and cherries at high altitudes, intensive grazing in the eastern part and the urbanization due to expansion of villages. The total cultivated area in fruit trees has increased up to 25% in the past 5 years. Average grazing intensity is moderate and the forage supply varies greatly from year to year, since rainfall is extremely unreliable. Woody vegetation is threatened by the demand for firewood within the dry and forest-like area of Jabal El Arab. Due to the growth rate of the population in Syria (3.3% per year), the housing, infrastructure needs and human demands are increasing in high rate annually. Non-ecological aspects of the development projects and activities have led to the reclamation of the most biodiversity rich areas through government subsidized, the reclamation of the removal of rocks and land led to remove the natural vegetation.

There is one natural reserve established on the edges of Jabal El Arab but the protection is not reinforced. The government has forbidden grazing in most parts of the area since 1999. The West Asia Dryland Agrobiodiversity project worked in Sweida and advised the government and the international community to protect this area which is of global importance since it has the largest population of *T. dicoccoides* remaining in the region. The Ministry of Environment is planning to establish a protected area over 2500 ha at Al-Lajat which is to the extreme west and drier areas and highly degraded by overgrazing. It has been advised to reforest the area degraded using native fruit trees species found in the region and to make plans for promoting the in situ conservation of this valuable local agrobiodiversity. Many of the wild fruit tree species are considered as underutilized species (Padulosi, 1999; Padulosi et al. 1999). These species hold promises and opportunities for cultivation, utilization and marketing which will contribute to the improvement of the livelihoods of local communities within the overall community-based strategy for in situ conservation of local agrobiodiversity.

**References**


Preliminary Characterization of Cultivated Cherries (Prunus avium L.) in Lebanon Using Morphological Traits and Molecular Markers

L. Chalak¹, A. Chehade¹, A. Elbitar¹, P. Cosson², A. Zanetto² and E. Dirlewanger²

¹Lebanese Agricultural Research Institute, P.O. Box 287 Zahle, Lebanon. Email: lchalak@lari.gov.lb
²Institut National de la Recherche Agronomique, UREFV, B.P. 81, F-33883 Villenave d’Ornon, France. Email: dirlewan@bordeaux.inra.fr

Keywords: Cherry, Prunus avium, genetic diversity, morphological characterization, AFLP markers

Abstract
This study undertook a preliminary characterization of 16 clones of cultivated cherry distributed in different zones of Lebanon at an altitude ranging from 800 to 1400 m above sea level. Each clone was described using 13 traits involving flowering and maturity dates and morphological characteristics of leaves and fruits.

Principal component analysis revealed that nut volume, petiole and leaf lengths and fruit diameter had a higher contribution to the total variation. The DNA analysis was performed with four Amplified Fragment Length Polymorphisms (AFLP) primer combinations leading to cluster the clones into different groups.

Introduction
Cherry (Prunus avium L.) is a species well adapted to the environmental conditions of Lebanon, especially at high altitudes that permits it to satisfy its cold requirements. The cherry accessions have not yet been inventoried in Lebanon and the authentic names of the local varieties are unknown. Old accessions were named by the nurseries on the basis of the name of the introducer or, if local, by the farmer in relation to a precise trait of the fruit. Other denominations seem to be an Arabic translation of the original name of the accession. This study reports, for the first time, an inventory of different accessions of cherries cultivated in Lebanon. Morphological, physiological and molecular (AFLP) characterizations were performed in order to evaluate the relationship among the varieties.

Materials and Methods
Sixteen accessions of cherry grown in three sites located in the principal zones of cherry production in Lebanon were characterized. Thirteen traits were studied according to cherry descriptors previously developed by the International Plant Genetic Resources Institute (IPGRI) (Schmidt et al., 1985), involving flowering and maturity dates as well as morphological characteristics of leaves and fruits. Principal Component Analysis (PCA) was performed in order to validate the quantitative traits used in this study. DNA extraction was performed using young leaves as described by William et al. (1990). Four primer pairs of Amplified Fragment Length Polymorphisms (AFLP) were selected from eight previously tested in cherry by Tavaud et al. (2000). The relationships among accessions were analyzed with the SIMQUAL procedure of NTSYS P.C. 2.0 (Rohlf, 1997) computer program package that computes similarity coefficient for both genetic and monogenic qualitative data. Distances were calculated according to Jaccard
Trees were produced by clustering the data with the unweighted pair-group method (UPGMA).

Results and Discussion

Nouwari, Nouwari-ferawni, Yabani and Zahri accessions were considered early in flowering (15 March), nine accessions were classified intermediate (1 April) whereas, Aswad murr, Banni kasir and Banni tawil bloomed late (15 April). The maturity date was early (5 May) for the accessions of Nouwari, Abiad, Aswad ukrani, and Moukahal ukrani, intermediate (from 20 May to 1 June) for the accessions of Banni and Ferawni and late for the accessions of Aswad murr, Kalbeltair, Kawskozah and Soukari. In general, leaf shape was lanceolate with a crenate margin except for Karaz hamoud (acid cherry) which presented an oviform leaf shape. Fruit shapes varied between cordate, round and reniform with the color ranging between red-black, red-dark, red, red-yellow, red-bright and pink (data not shown).

PCA revealed that the first three components explained 81% of the total variation. The first component accounted for 39% of the variation due mainly to the measurable quantitative traits of leaf, fruit and nut. The second component, contributing to 24% of the variation, particularly included the peduncle length. The third component explaining 18% is related mainly to the maturity date (Table 1).

Table 1. Traits validation studied (nine traits), using the three Principal Component Analysis of 16 cherry accessions cultivated in Lebanon.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Components</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Leaf length</td>
<td>0.76</td>
<td>-0.48</td>
<td>0.25</td>
</tr>
<tr>
<td>Leaf width</td>
<td>0.73</td>
<td>-0.60</td>
<td>-0.12</td>
</tr>
<tr>
<td>Petiole Length</td>
<td>0.77</td>
<td>-0.27</td>
<td>-0.33</td>
</tr>
<tr>
<td>Fruit weight</td>
<td>0.70</td>
<td>0.57</td>
<td>0.34</td>
</tr>
<tr>
<td>Fruit diameter</td>
<td>0.74</td>
<td>0.54</td>
<td>0.30</td>
</tr>
<tr>
<td>Peduncle length</td>
<td>0.09</td>
<td>-0.81</td>
<td>0.43</td>
</tr>
<tr>
<td>Flowering date</td>
<td>0.29</td>
<td>0.39</td>
<td>-0.45</td>
</tr>
<tr>
<td>Maturity date</td>
<td>0.12</td>
<td>-0.16</td>
<td>-0.92</td>
</tr>
<tr>
<td>Stone volume</td>
<td>0.84</td>
<td>0.22</td>
<td>-0.11</td>
</tr>
<tr>
<td>Percentage of total variation</td>
<td>0.39</td>
<td>0.24</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Molecular study was conducted for eight accessions only, since the others had a bad DNA quality. The four primers tested gave polymorphism and revealed 81 alleles, 17 of which were polymorphic with a size ranged from 92 to 390 bp. The percentage of polymorphism varied between 17.4% for the EcoRI+AAC/MseI+CG and 40% for the EcoRI+AGA/MseI+CA, whereas the discrimination power ranged between 0.4 for EcoRI+AGA/MseI+CA and 0.87 for EcoRI+AGG/MseI+CG which gave eight polymorphic bands. These results confirmed that the discrimination power is not related to the percentage of polymorphism (Tessier et al., 1999). Also these four primers previously developed for cultivated French cherry (Tavaud et al., 2000) permitted to discriminate the eight studied accessions of cherry cultivated in Lebanon with a similar discrimination power (0.93) (Bouty, 1999).

The dendogram based on AFLP showed five groups at 0.1 Jaccard distance (Fig. 1). The two accessions Itali and Kawskozah with intermediate flowering dates were different from the others.
and presented nine alleles in common with the four primers. The second group included Soukari and Ferawi tawil with intermediate flowering dates and sharing 11 similar alleles for the studied primers. The third group included Nouwari and Yabani accessions with early flowering dates and intermediate nuts and having ten alleles in common. The remaining two groups were constituted of one accession each.

![Dendogram](image)

**Fig. 1.** Dendogram constructed with eight cherry accessions cultivated in Lebanon, using four AFLP primers, SimQual program, Jaccard distance and UPGMA clustering.

**Conclusion**

For the first time, cherry accessions were listed and characterized in Lebanon. Interesting results were obtained by using morphological traits and AFLP markers showing an important diversity in the cherry Lebanese germplasm. However AFLP markers are dominant and give part of the information which needs to be completed with use of co-dominant markers such as microsatellites.

**Acknowledgments**

The authors are grateful to the CEDRE French-Lebanese program n°99 LEB F59/L59 for their financial support. They also thank the UNDP Agrobiodiversity project LEB 97/G34 for their contribution in collecting the material.

**References**


Tavaud, M., E. Bouty, A. Zanetto and E. Dirlewanger. 2000. Molecular characterization and
diversity evaluation in French cherry varieties. Plant and animal Genome VII, San Diego:
17-21.
Tessier, C., J. David, P. This, J.M. Boursiquot and A. Charrier. 1999. Optimization of the choice
of molecular markers of varietal identification in Vitis vinifera L. Theor Appl Genet 98:
171-177.
Williams, J.G.K., A.R. Kubelik, K.J. Livak, J.A. Rafalski and S.V. Tingey. 1990. DNA
polymorphisms amplified by arbitrary primers are useful as genetic markers. Nucleic Acids
Genetic diversity in Tunisian date-palm collections mediated by ISSR and SSR markers


1 Laboratoire de Génétique Moléculaire, Immunologie & Biotechnologie, Faculté des Sciences de Tunis, Campus Universitaire 2092 El Manar Tunis, Tunisie. Email: szehdi@yahoo.fr
2 Laboratoire de Génétique Moléculaire, Immunologie & Biotechnologie, Faculté des Sciences de Tunis, Campus Universitaire 2092, El-Manar Tunis, Tunisie. Email: rhoumasoumaya@yahoo.fr
3 Faculté des Sciences et Techniques, Université de Nouakchott, B.P. 5026, Mauritanie. Email: boukhary@univ-nkc.mr
4 Laboratoire de Génétique Moléculaire, Immunologie & Biotechnologie, Faculté des Sciences de Tunis, Campus Universitaire 2092 El Manar Tunis, Tunisie. Email: helasakka@yahoo.fr
5 IRD (Institut de Recherche pour le Développement), UMR DGPC/DYNADIV, 911 Avenue Agropolis BP 64501, 34394 Montpellier cedex 5, France
6 Laboratoire de Génétique Moléculaire, Immunologie & Biotechnologie, Faculté des Sciences de Tunis, Campus Universitaire 2092 El Manar Tunis, Tunisie. Email: Mohamed.marrakchi@fst.rnu.tn
7 IPGRI, Centre de Recherches Phoénicicoles, 2260 Degache, Tunisie. Email: a.rhouma@cgiar.org
8 Laboratoire de Génétique Moléculaire, Immunologie & Biotechnologie, Faculté des Sciences de Tunis, Campus Universitaire 2092 El Manar Tunis, Tunisie. Email: trifimokhtar@yahoo.fr

Keywords: Date palm, genetic diversity, molecular markers, SSR, ISSR

Abstract
Date palm, (Phoenix dactylifera L) a long-lived dioecious monocotyledon species, constitutes the main factor of oases environmental and economic stability in Tunisia as well as in several tropical countries. Moreover, recent investigations have evidenced a large diversity within Tunisian date-palm groves since more than 250 cultivars have been identified. However, this increased phylogenetic resource has been seriously threatened by a severe genetic erosion due to the predominant plantation of Deglet Nour elite variety. Hence, elaboration of a strategy aiming at the genetic diversity’s evaluation and the preservation of this important germplasm is imperative. For this purpose, Inter Simple Sequence Repeats (ISSR) and of the Simple Sequence Repeats (SSR) markers were uses to survey the polymorphisms in Tunisian date-palms. ISSR results provided evidence of a large genetic diversity and strongly supported the date-palms’ Mesopotamian domestication origin. The SSR data concur with previous analyses of Tunisian germplasm using other molecular markers. This contribution reports on the usefulness of molecular markers methods to examine the genetic diversity and to fingerprint the local date palms accessions.

Introduction
In Tunisia as in several tropical countries, oasis agricultural systems consist of date palm groves. Date-palm, (Phoenix dactylifera L) a long-lived dioecious monocotyledon (2n=36), constitutes the major factor of oases environmental and economic stability. Moreover, recent investigations have evidenced a large diversity within Tunisian date-palm groves since more than 250 cultivars have been identified (Rhouma, 1994). However, for several decades these phylogenetic resources have been seriously threatened either by diverse pests and diseases such as the brittle leaves and the...
bayoud diseases or by the increasing plantation of the elite cultivar Deglet Nour in the new plantations (Rhouma, 1995). Hence, it is imperative to elaborate a strategy aimed at the evaluation of the genetic diversity and the preservation of this important germplasm. For this purpose, many studies have been reported and described the use of morphological traits, and isozyme makers to identify the Tunisian date palm varieties (Rhouma 1994, Ould Mohamed Salem et al. 2001). Furthermore, results based on molecular markers such as Restriction Fragment Length Polymorphisms (RFLPs) and Random Amplified Polymorphic DNA (RAPD) have been developed to molecularly characterize date palm genotypes (Cornicquel and Mercier 1994, Ben Abdallah et al. 2000, Trifi et al. 2000, Trifi 2001, Sakka et al. 2004). These studies have proved the sustainability of the evidenced markers for the date palm varietal identification. The present study reports the results of using of the ISSR and the SSR markers to survey polymorphisms and genetic diversity within Tunisian date palms.

Materials and methods

Plant material
A set of 34 accessions (28 varieties and 6 male ecotypes) were collected from three different oases (Tozeur, Gabès and Kébili), and chosen for their good fruit quality and/or for their predominance in the main plantation areas located in the south of Tunisia. Detailed varieties’ fruit quality is summarized in table 1 (Rhouma, 1995). Two foreign varieties called Zehdi and Ghars Mettig, recently introduced from Iraq and Algeria respectively, were also included in the study. The plant material collected consists of young leaves issued from adult trees randomly sampled in date palm groves.

<table>
<thead>
<tr>
<th>Accession¹</th>
<th>Region</th>
<th>Origin</th>
<th>Maturity</th>
<th>Fruit characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deglet Nour</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>October</td>
<td>Excellent</td>
</tr>
<tr>
<td>Boufagous</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>October</td>
<td>Good</td>
</tr>
<tr>
<td>Ftimi (aka Alligue)</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>October</td>
<td>Very good</td>
</tr>
<tr>
<td>Kenta</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>October</td>
<td>Very good</td>
</tr>
<tr>
<td>Kintichi</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>October</td>
<td>Good</td>
</tr>
<tr>
<td>Deglet Bey (aka Menakher)</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>October</td>
<td>Excellent</td>
</tr>
<tr>
<td>Ghars Mettig</td>
<td>Tozeur</td>
<td>Algeria</td>
<td>September</td>
<td>Very good</td>
</tr>
<tr>
<td>Zehdi</td>
<td>Tozeur</td>
<td>Iraq</td>
<td>October</td>
<td>Good</td>
</tr>
<tr>
<td>Arichti (aka Rochdi)</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Good</td>
</tr>
<tr>
<td>Khou Ftimi</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>October</td>
<td>Good</td>
</tr>
<tr>
<td>Horra</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>Okhet Degla</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>T124*</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>T138*</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>T158*</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>T169*</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>DF1*</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>DG9*</td>
<td>Tozeur</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
</tbody>
</table>
DNA preparation
Total cellular DNA was extracted from frozen young leaves using DNAeasy Plant Mini Kit (Qiagen S.A., Courtaboeuf, France) according to manufacturer’s protocol. After purification, DNA concentrations were determined using a GeneQuant spectrometer (Amersham Pharmacia Biotech, France) and quality was checked on agarose minigel electrophoresis according to Sambrook et al. (1989).

Primers and ISSR assay
A total of 12 primers were tested to amplify DNA banding patterns using the varieties’ total cellular DNA. These are as followed: (AGG)$_6$, (TGGGA)$_5$, (ACTG)$_4$, (GACA)$_4$, (GACAC)$_4$, (AG)$_{10}$, (AG)$_{10}$G, (AG)$_{10}$C, (AG)$_{10}$T, (CT)$_{10}$A, (CT)$_{10}$G and (CT)$_{10}$. PCR reaction mixture (25 µl) is composed of: 20-30 ng of total cellular DNA (1 µl), 60 pg of primer (1 µl), 2.5 µl of Taq DNA polymerase reaction buffer, 1.5 unit of Taq DNA polymerase (QBIOgene, France) and 200 µM of each dNTP (DNA polymerization mix, Amersham-Pharmacia, France). Each reaction mixture was overlaid with 25 µl of mineral oil to avoid evaporation during PCR cycling. Amplifications were performed in a DNA amplification thermocycler (Crocodile III, QBIOgene, France). The apparatus was programmed to execute the following conditions: a denaturation step of 5 min at 94°C followed by 35 cycles each one is composed of 30 seconds at 94°C, 90 seconds at the primer’s specific melting temperature (Tm), and 90 seconds at 72°C. A final extension step of 5 min was run at the end of the last PCR cycle. Controls containing the reaction mixture without any DNA were included during each experiment.

PCR reactions were electrophorezed on 1.4 % agarose gels in 0.5 × TBE buffer by loading 20µl of the reaction mixture into prepared wells. Gels were run during 3 h at 50 mA, stained with ethidium bromide (0.5 µg ml$^{-1}$) according to Sambrook et al., (1989) and ISSR banding patterns visualized using a UV transilluminator.

Microsatellites amplification

<table>
<thead>
<tr>
<th>Variety</th>
<th>Location</th>
<th>Country</th>
<th>Month</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharroubi</td>
<td>Tozeu</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>Angou</td>
<td>Tozeu</td>
<td>Tunisia</td>
<td>November</td>
<td>Rather good</td>
</tr>
<tr>
<td>Besser Hlou</td>
<td>Tozeu</td>
<td>Tunisia</td>
<td>October</td>
<td>Good</td>
</tr>
<tr>
<td>Rhaimya</td>
<td>Tozeu</td>
<td>Tunisia</td>
<td>September</td>
<td>Good</td>
</tr>
<tr>
<td>Bidh Hmam</td>
<td>Tozeu</td>
<td>Tunisia</td>
<td>September</td>
<td>Very good</td>
</tr>
<tr>
<td>Gasbi</td>
<td>Tozeu</td>
<td>Tunisia</td>
<td>August</td>
<td>Rather good</td>
</tr>
<tr>
<td>Lemsi</td>
<td>Gabès</td>
<td>Tunisia</td>
<td>September</td>
<td>Good</td>
</tr>
<tr>
<td>Bouhattem</td>
<td>Gabès</td>
<td>Tunisia</td>
<td>October</td>
<td>Medium</td>
</tr>
<tr>
<td>Smiti</td>
<td>Gabès</td>
<td>Tunisia</td>
<td>October</td>
<td>Rather good</td>
</tr>
<tr>
<td>Dengi</td>
<td>Gabès</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
<tr>
<td>Aguiwa</td>
<td>Gabès</td>
<td>Tunisia</td>
<td>October</td>
<td>Rather good</td>
</tr>
<tr>
<td>Kechdou Ahmar</td>
<td>Kébili</td>
<td>Tunisia</td>
<td>October</td>
<td>Medium</td>
</tr>
<tr>
<td>Fhal Ksebba</td>
<td>Kébili</td>
<td>Tunisia</td>
<td>October</td>
<td>Rather good</td>
</tr>
<tr>
<td>Rakli</td>
<td>Kébili</td>
<td>Tunisia</td>
<td>November</td>
<td>Medium</td>
</tr>
<tr>
<td>Fermla</td>
<td>Kébili</td>
<td>Tunisia</td>
<td>September</td>
<td>Rather good</td>
</tr>
</tbody>
</table>
A total of 16 date-palms specific primer pairs developed by Billotte et al. (2004) were used. PCR reactions were performed in a total reaction mixture of 10 µl containing: 20 - 30 ng of total cellular DNA (1µl) as template, 1.5 µM of MgCl₂, 1 x PCR buffer (Promega Corp. Madison, USA), 0.2 mM of dNTP PCR mix (Promega), 0.625 U of Taq DNA polymerase (Promega) and, 0.2 µM of primers and using reverse primer 5’ end labelled with a fluorescent M13 tail. Amplifications were performed in a Biometra Thermocycler (Biometra GmbH, Goettingen, Germany) with the following conditions: a denaturation step of 5 min at 95 ºC followed by 35 cycles of 30 seconds at 95 ºC, 1 min at 52 ºC and 1 min at 72 ºC, and a final extension step at 72 ºC for 7 min. A negative control, with the reaction mixture excluding DNA, was also included in each experiment.

**SSR genotyping**
SSRs were screened on Li-Cor IR² automated DNA sequencer (Li-Cor, Lincoln, NE, USA) by loading 0.2 µl of PCR product diluted 10 x in loading buffer, on 6.5 % polyacrylamide gel. Automatic genotyping and allele size scoring were performed by the SAGA-GT™ software (Li-Cor, Lincoln, NE, USA).

**ISSR data analysis**
Data were transformed into a binary matrix where the presence of the generated band is scored as 1 and its absence as 0. A genetic distance matrix was estimated from the data matrix by using the Genedist (version 3.572c) program based on the formula of Nei and Li (1979). The genetic distance matrix was then analysed with the Neighbour program to produce a dendrogram using the Unweighted Pair Group Method with the Arithmetic Averaging Algorithm (UPGMA) cluster analysis (Sneath). The TreeView program was used to draw the between and among accessions’ dendrogram. Appropriate programs in PHYLIP (Phylogeny Inference Package, version 3.5c) and TreeView (Win32, version1.5.2) were used to carry out all these analyses (Felsenstein, 1993).

**SSR data analysis**
The samples were subdivided into three geographical groups of cultivars. Estimates of total genetic diversity were conducted on all individuals. In order to compute ordinations and hierarchical classifications, we calculated the shared allele distance: DAS (Chakraborty and Jin 1993) using Populations 1.2.28 Software (Langella 2002). This genetic distance is known to be appropriate for recently diverged populations (Goldstein and Pollock 1997). The distance matrix obtained was used as input file for Populations 1.2.28 Software (Langella 2002), to construct the dendrogram using the Neighbor-Joining (NJ) algorithm.

**Results and discussion**

**ISSR primers resolving power**
Among the 12 primers screened for their ability to generate consistently amplified banding patterns and to assess polymorphisms in the tested varieties, only 7 have revealed polymorphic with unambiguously scorable bands: (AGG)₆, (AG)₁₀G, (AG)₁₀C, (AG)₁₀T, (CT)₁₀A, (CT)₁₀G and (CT)₁₀T. A smear or no amplified products were generated using the remaining oligonucleotides.
Using the primers that generated multiple banding profiles, 7 to 11 with a mean of 9.57 polymorphic DNA bands were amplified in a ranging size from 200-2500 bp. A minimum of 7 and a maximum of 11 DNA fragments were obtained using (CT)₁₀A and (AG)₁₀C respectively.
All the other primers have generated an intermediate number of polymorphic DNA bands suggesting that the ISSR procedure constitutes an alternative approach suitable for the date-palm DNA diversity characterization. This is strongly supported by the large number of polymorphic DNA bands (i.e.: a total of 67 out of 95) produced which is higher than those observed in other cultivated crops such as grapevine where 35 polymorphic bands were generated among closely related germplasm in presence of 12 ISSR primers (Moreno et al. 1998).

**Genetic polymorphism**

The binary data matrix was computed to estimate the genetic distances between accessions. These are ranged from 0.23 to 0.98 with a mean of 0.54 suggesting a high degree of genetic diversity at the DNA level. The smallest distance value of 0.23 was observed between DF1 and T169, indicating that these accessions are the most similar. The maximum distance value (0.98) is scored between Besser Hlou and Deglet Nour, Angou and Kenta, Bouhattam, and Deglet bey, Lemsi and Zehdi, Lemsi and Khou Ftimi, Lemsi and Horra, Lemsi and T138 Lemsi and T158, Denga and Horra, Gasbi and T138, and Gasbi and T158. This result suggests that the mentioned varieties are characterized by great divergence. The genetic distance matrix was analysed with the Neighbour program using the UPGMA algorithm in order to cluster the accessions according to their genetic similarity and to draw the relationships between the tested accessions. The resulting dendrogram displays the genetic divergence described above (Figure 1). Two major clusters (labelled a and b) could be identified and supported a varietal clustering made independently of the trees’ sex and the ecotypes’ geographic origin. This interpretation is well illustrated in the case of the cluster a that includes either varieties or male accessions. Furthermore, the cluster b is composed of varieties originated from different prospected date palm oases.
Fig. 1: NJ dendrogram of 34 Tunisian date-palm accessions constructed with Nei & Li genetic distance based on ISSR markers (The scale indicates the relative genetic distance. Accessions originated from Tozeur, Gabès and Kébili oases are labelled (●), (♦) and (■) respectively)

**Genetic diversity analysis using SSR**
The 14 primer pairs used to generate expected SSR banding patterns in Tunisian data palms, are successfully established for the genotypes of the 34 accessions. The SSR profiles exhibited more than three different alleles per locus, with homozygous and heterozygous individuals clearly identifiable. A total of 96 alleles with a mean of 6.85 alleles per locus were scored. The number of alleles per locus varied from 3 (mPdCIR35) to 10 (mPdCIR78).
A derived NJ dendrogram based on Das genetic distance, exhibited three main clusters each one is composed of males as well as cultivars (Fig. 2). In addition, the observed clustering topology showed that groupings of accessions are made independently either from their geographic origin or the sex of trees.

Fig. 2: NJ dendrogram of 34 Tunisian date-palm accessions constructed with Das genetic distance based on 96 microsatellite alleles (The scale indicates the relative genetic distance. Accessions originated from Tozeur, Gabès and Kébili oases are labelled (●), (●) and (■) respectively)
This study portrays the molecular characterization of a large number of Tunisian date palm ecotypes with the help of ISSR and SSR markers. Among the ISSR tested primers seven were discarded since they produced weak or no banding patterns. At least the two following hypotheses could be put forwarded to explain these primers’ particularity: (i) the appropriate complementary microsatellite sequences are infrequent in the date palm’s genome; (ii) the corresponding microsatellite sites are distantly located in date palm DNA in such a way that no amplification occurred. On the other hand, the generated ISSR markers have permitted to explore the DNA polymorphism in the collection analysed. These results concur with those using RAPD technique in date palms varieties from Moroccan, Tunisian and Iraqi collections (Ben Abdallah et al. 2000, Trifi 2001, Sedra et al. 1998). These authors assumed that the studied accessions are clustered independently to their geographic origin and suggested a narrow genetic diversity in this crop. It is worth noting that both analyses have generated a dendrogram topology which agree with those based on morphometric criteria particularly related to the fruit parameters (Rhouma, 1994). This is well exemplified in the case of Boufaggous and Deglet Bey varieties characterized by nearly similar dates (large size). In addition, accessions’ groupings are not well defined either according to their geographical origin or the sex of tree since the introduced varieties and the male ecotypes did not significantly diverge from the autochthonous female accessions. Consequently, we may assume that our data strongly supported the ancient date-palm’s Mesopotamian (fertile crescent) domestication origin (Wrigley 1995).

SSR Data exhibited evidence of the utility of this technology to enlarge the number of markers suitable for evidencing molecular polymorphisms in this crop. As a result, a large number of SSR alleles have been revealed with a mean of 6.85 per locus and permitted to detect a relatively high degree of genetic variability in this crop. In fact, the scored values of diversity are higher at the intra-groups level than at the inter-groups level. Similar results have been reported in Moroccan, Algerian and Tunisian date palm cultivars using isozyme markers (Torres and Tisserat 1980, Bennaceur et al. 1991, Fakir 1992, Ould Mohamed Salem et al. 2001). These results are also comparable to those reported in other long-lived cultivated species such as olive (Ouazzani et al. 1995) and fig (Salhi-Hannachi et al. 2004). Taking into account our present data together with prior isozyme information (Ould Mohamed Salem et al. 2001) the genetic diversity seems to be high in Tunisian date palms. This could be attributed to the dioecious nature of this crop. Tozeur group showed significant deficit of heterozygocity. However, the two other remaining groups (Gabès and Kébili) showed non deviation from Hardy Weinberg equilibrium. This result can be explained by the stronger selection operated in Tozeur oasis compared to Kébili and Gabès oases.

In addition, analysis of the genetic diversity structure has exhibited spatial organisation of accessions typically continuous and independent from both the geographic origin or the sex of trees. Using RAPD markers, similar results have been reported in date palms (Sedra et al. 1998, Trifi et al. 2000). These authors have suggested a common genetic basis among date palms genotypes in spite of their distinctiveness by morphometric parameters, particularly those related to the fruit traits. Hence, our data suggest the existence of an ancestral date palm population and are in agreement with the unique Mesopotamian domestication origin of this crop (Wrigley 1995).
References
palmier dattier (Phoenix dactylifera L.) par l’amplification aléatoire d’ADN (RAPD). 

palm (Phoenix dactylifera L.) from Algeria revealed by enzyme markers. Plant Breeding 
107: 56-69.

microsatellite markers for the date palm (Phoenix dactylifera L.): characterization, utility
across the genus Phoenix and in other palm genera. Molecular Ecology Notes 4: 256-258.

statistical considerations of determining relatedness and population distances. In: DNA
fingerprinting: State of the Science, Chakraborty, R., J. T. Epplen, and A. J. Jeffreys,
Birkhäuser Verlag, p. 153-175.

Cornicquel, B. and L. Mercier. 1994. Date-palm (Phoenix dactylifera L.) cultivar identification
by RFLP & RAPD. Plant Science 101, 163 - 172.

Analyse du polymorphisme enzymatique et protéique. Thèse de Doctorat de l’Université
Paris VI, France, 118 p.

Felsenstein, J. 1993. PHYLIP (Phylogeny Interference Package), version 3.5c. Distributed by the
author, Department of genetics, University of Washington, Seattle, Washington, USA.


Langella, O., Populations 1. 2. 28 Software. CNRS. UPR9034. France.

Moreno, S., J. P. Martin and J. M. Ortiz. 1998. Inter-simple sequence PCR for characterization of
closely related grapevine germplasm. Euphytica 101: 117-125

Nei, M. and W.H. Li. 1979. Mathematical models for studying genetic variation in terms of
restriction endonucleases. Proc Natl Acad Sc USA 76, 5269-5273

Ouazzani., N., R. Lumaret, and P. Villemar. 1995. Apport du polymorphisme alloenzymatique à


Rhouma, A. 1994. Le palmier dattier en Tunisie. I: le patrimoine génétique. ARABESQUE,
Tunis, Tunisie, 127 p.

Génétique. Séminaire « Ressources Génétiques et développement durable » Tunis 13 - 14
Octobre 1995. UTAP- SSNT- ATMS


Genetic Characterization of Date palm Varieties Using RAPD Markers

I. Rawashdeh¹ and A. Amri²

¹ Genetic Resource Unit, National Center for Agricultural Research and Technology Transfer (NCARTT), P.O. Box 639, Baq’a, Jordan. E-mail: irawashdeh2002@yahoo.com.
² International Center for Agriculture Research in the dry areas (ICARDA), West Asia office, Amman. E-mail: icarda-jordan@cgiar.org

Keywords: Date palm, genetic resources, genetic diversity, primers, RAPD technique,

Abstract
Randomly amplified polymorphic DNA markers technique was used to characterize five date palm varieties, Tabarzal, Zagloul, Mekfazy, Barhee and Nabt Saif. Thirty primers were polymorphic and the seven highly polymorphic ones were used to differentiate among the five date palm varieties. A consensus method was used for clustering the five date palm varieties into groups. Zagloul and Mekfazy formed the first group while the others three varieties form each a separate group. Some bands were unique for the studied cultivars. Based on the results, all varieties were different based on RAPD showing that this technique could be used efficiently to study the genetic diversity in date palm and to help in identification of varieties.

Introduction
The date palm (Phoenix dactylifera L.) is a dioecious species belonging to the Palmaceae family. It is largely grown in the oasis areas in West Asia and North Africa where it constitutes the basis for the livelihood of the local communities (Al Ugaydy, 2000). Iraq and Morocco are known to have the largest genetic diversity (Dr. Jirbi, personal communication) and many varieties of good quality originating from Morocco (Madjhool) and Tunisia (Deglet Nour) are grown in United States and many other countries. Many other varieties are exchanged between the countries among them Tabarzal, Zagloul, Mekfazy, Barhee and Nabt Saif. In Jordan, most of the widely grown varieties have been characterized morphologically, but there are still problems in providing plantlets of the desired cultivars to farmers from the nurseries. Therefore, the use of DNA markers will provide a powerful tool to certify the identity of the cultivars at the seedling stage through variety fingerprinting. Random Amplified Polymorphic DNA (RAPD) markers are generated with single primers of arbitrary nucleotide sequence amplified by the Polymerase Chain Reaction (PCR) (Williams et al., 1990).
This work aims at the determination of a set of RAPD primers that can be used to discriminate among date palm varieties used in Jordan.

Materials and Methods
Plant material: Five varieties of date palm (Tabarzal, Zagloul, Mekfazy, Barhee and Nabt Saif) widely grown in Jordan were used for this study. The plants were grown at the experiment stations of Al-Karamah and Al-Safi in the Jordan Valley.
DNA extraction: The soft inner leaves of the inner core offshoots were collected and cut with sterilized scissors into small pieces, grounded in liquid nitrogen to a fine powder and stored in tubes in a freezer at -20°C. The Wizard method (Promega, USA) was used to extract total DNA with some minor modifications such as including the addition of 0.79% of 2-Mercaptoethanol to
the Nuclei lysis step. Freezing tissue (50 mg) was mixed with 0.6 ml of Nuclei lysis solution. The homogenate was then incubated at 65°C for 30 minutes, then mixed with 0.2 ml protein precipitate and centrifuged at 14,000 rpm. Nucleic acids were precipitated using isopropanol and centrifuged at 14,000 rpm. The pellet was dissolved in TE buffer (10 mM ,pH 7.4), 1mM EDTA (pH 8.0), RNase was added at this step and incubated at 37°C for 30 minutes, then stored in a freezer at (–20°C) until used for polymerase chain reaction. The concentration of extracted DNA was measured by luminometer TD-20/20 DNA (Sunnyvate, CA). The DNA is then diluted to 1:9 with TE buffer.

**PCR amplification:** PCR amplification was performed as described by Williams *et al.* (1990) with 10-mer oligonucleotides from Kits synthesized by Operon Technologies (Almeda, Calif.) (Table 1). The reaction mixture was as described by Shah *et al.* (1994), with minor modifications such as the addition of 1.5µl of MgCl2, 29-36µg/µl primer and an increased annealing temperature of 36°C. The reaction mixture (25µl) contained 50 mM KCl, 10 mM Tris-HCl (pH 9.0 at 25°C), 1.5 mM MgCl2 and 0.1%Triton® X-100, 100 µM of primers, 40 ng of genomic DNA and 2.5 U of Taq polymerase (Promega). Amplification was carried out in a thermocycler (MJ Research model PCT-100), one cycle of 1 min at 94°C followed by 44 cycles, each consisting of a denaturation step of 1min at 94°C, followed by an annealing step of 1min at 36°C and an extension step of 2 min at 72°C. The last cycle was followed by further extension step of 5 min at 72°C to ensure that the primer extension reaction was completed. Thirty-seven oligonucleotide primers were used and primer amplification was repeated four times to confirm the results (Table 1).

**Data analysis:** RAPD bands were scored using 1 (present) and 0 (absent) for all markers and for all varieties studied. Specific or unique bands were identified for each cultivar (Table 3). Jaccards (1908) coefficient of similarity, Nei’s genetic distance and the unweighed pair group method with arithmetic average (UPGMA) tree were performed using NTSYS-PC 2.0 software (Exeter Software, East Setauket, N.Y.).

Table 1: Primers with arbitrary sequence tested for their effectiveness in RAPD analysis

<table>
<thead>
<tr>
<th>Primer name</th>
<th>Primer sequence 5’ to 3’</th>
<th>Total No. of bands per primer</th>
<th>*Varieties with amplification</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPA05</td>
<td>AGGGGTCTTGG</td>
<td>13</td>
<td>1,3</td>
</tr>
<tr>
<td>OPA07</td>
<td>GAAACGGGTTG</td>
<td>17</td>
<td>1,2,3,5</td>
</tr>
<tr>
<td>OPA13</td>
<td>CAGCACCCAC</td>
<td>25</td>
<td>1,2,3,4</td>
</tr>
<tr>
<td>OPA14</td>
<td>TCTGTGCTTGG</td>
<td>17</td>
<td>3,4,5</td>
</tr>
<tr>
<td>OPB15</td>
<td>GGAGGTTGTT</td>
<td>20</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>OPB16</td>
<td>TTTGCCCGGA</td>
<td>17</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>OPB19</td>
<td>ACCCCGAAG</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>OPC03</td>
<td>GGGGGTCTTT</td>
<td>26</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>OPC07</td>
<td>GTCCCGACGA</td>
<td>35</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>OPC10</td>
<td>TGCTCGGTTG</td>
<td>29</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>OPC14</td>
<td>TGGTGCTTGG</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OPC18</td>
<td>TGAGTGGGTG</td>
<td>21</td>
<td>1,2,3,4</td>
</tr>
<tr>
<td>OPD04</td>
<td>TCTGGTGAGG</td>
<td>19</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>OPD07</td>
<td>TTGGCCCGGG</td>
<td>21</td>
<td>1,2,3,4,5</td>
</tr>
<tr>
<td>OPD15</td>
<td>CATCCGTGCT</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OPE01</td>
<td>CCCAAGGTCGCC</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OPE02</td>
<td>GGTGCCCGAA</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Results and Discussion

Out of the thirty-seven primers used, seven failed to produce any amplified fragments. Four primers (OPA05, OPB19, OPF18 and OPM10) produced only few fragments for one or two varieties which did not help in discriminating among the varieties (Table 1).

The remaining 26 primers yielded a total of 625 fragments many of them monomorphic between the varieties. The primers could be grouped into twelve different groups according to their ability to differentiate among the varieties used in this study. The first group of the primers (OPB15, OPB16, OPC03, OPC07, OPC10, OPD04, OPD07, OPF10, OPM01, OPZ07, OPZ09 and OPZ15) showed polymorphism for all varieties (Table 1) and seven of these primers resulted in clear and distinct patterns allowing to differentiate among the five tested varieties (Table 2, Figures 1 to 2). These ones were used for cluster analysis. Three of the seven primers (OPC07, OPM01 and OPZ10) showed polymorphism for 4 to 10 bands. The size of amplified fragments ranged from 250 bp to more than 2000 bp. Fragments with molecular weights higher than 2000 bp were not measured due to inconsistency.

Table 2. Number of amplified fragments for each variety for the most polymorphic primers

<table>
<thead>
<tr>
<th>Primer name</th>
<th>Tabarzal</th>
<th>Zagloul</th>
<th>Mekfazy</th>
<th>Barhee</th>
<th>Nabt Saif</th>
<th>G+C%</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPB15</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>60%+0%</td>
</tr>
<tr>
<td>OPC03</td>
<td>2</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>50%+10%</td>
</tr>
<tr>
<td>OPC07</td>
<td>7</td>
<td>4</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>30%+40%</td>
</tr>
<tr>
<td>OPC10</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>50%+10%</td>
</tr>
<tr>
<td>OPM01</td>
<td>7</td>
<td>7</td>
<td>10</td>
<td>9</td>
<td>7</td>
<td>50%+10%</td>
</tr>
<tr>
<td>OPZ07</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>40%+30%</td>
</tr>
<tr>
<td>OPZ10</td>
<td>5</td>
<td>7</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>10%+50%</td>
</tr>
</tbody>
</table>
Fig. 1. PCR-RAPD patterns (on 1.4% agarose gel) of date palm varieties produced by primers OPC10, OPC07 and OPC03. lane 1: Nabt Saif; lane 2: Barhee; lane 3: Mekfazy; lane 4: Zagloul; lane 5: Tabarzal. M: 1kb ladder (promega).

Table 3. Diagnostic fragments and their molecular weight for different date palm varieties

<table>
<thead>
<tr>
<th>Specific bands for primers</th>
<th>Cultivar identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPB15. 750</td>
<td>Mekfazy</td>
</tr>
<tr>
<td>OPB15. 500</td>
<td>Barhee, Nabt Saif</td>
</tr>
<tr>
<td>OP03. 676</td>
<td>Barhee</td>
</tr>
<tr>
<td>OPC07. 501</td>
<td>Mekfazy</td>
</tr>
<tr>
<td>OPC07. 437</td>
<td>Nabt Saif</td>
</tr>
<tr>
<td>OPC10. 584</td>
<td>Barhee</td>
</tr>
<tr>
<td>OPC10. 324</td>
<td>Tabarzal</td>
</tr>
<tr>
<td>OPM01. 750</td>
<td>Barhee</td>
</tr>
<tr>
<td>OPM01. 437</td>
<td>Nabt Saif</td>
</tr>
<tr>
<td>OPM01. 323</td>
<td>Barhee</td>
</tr>
<tr>
<td>OPZ10. 501</td>
<td>Nabt Saif</td>
</tr>
<tr>
<td>OPZ10. 437</td>
<td>Barhee</td>
</tr>
</tbody>
</table>

The second group of primers was composed of OPA13, OPC18, OPM15, OPN12, OPN14 and OPN16 showing amplification for the four varieties Tabarzal, Zagloul, Mekfazy and Barhee only. The remaining groups amplify fragments in 3-4 varieties. The polymorphic primers allowed the identification of all varieties studied and around twelve fragments appear to be specific and could be used in identification of each cultivar (Table 3). Most of these fragments belong to different primers. Barhee variety had 5 specific fragments with 5 primers, 3 for Nabt Saif and 2 for Mekfazy. The similarity among the cultivars is assessed and the consensus dendrogram (Fig. 2) showed groups: Zaghloul and Mekfazy the in the first group while the others formed each a separate group.
The results of this study showed clear and high yields of amplified DNA fragments that can be attributed to increasing in the concentration of magnesium confirming the results reported by many authors (Hoelzel and Green, 1994; Rychik et al., 1990 and Bullitta, 1995). RAPD method, which is an easier technique compared to the other DNA molecular techniques and needs small amounts of DNA, appears to be a powerful technique for the analysis of genetic diversity of date palm germplasm. Many oligonucleotide primers are available from this study for future genetic diversity analysis of date palm and for identification of available varieties and seven of them showed high number of bands and have discriminated among the five varieties. Apparently, the oligonucleotide primers with high percent of the C+G showed high amplification and polymorphism or with GTT, GTC, GGG, CCA and CCG are giving highly conserved amplified DNA fragments. This could help in developing simple sequence repeats primers (SSR) which can be used in studying genetic diversity of date palm germplasm. All the five varieties studied were genetically different using morphological characteristics of the fruits (color and form of the fruit, unpublished data). In fact, most of the date palm varieties grown in Jordan can be distinguished at production stage using morphologic and taste characteristics or through the origin analysis (country of introduction). The RAPD technique and other DNA molecular techniques are useful to differentiate among varieties that can not be discriminated by the morphology, but most importantly to study the genetic diversity of unnamed genotypes issued from recombination of genes among different varieties and to insure the growers about the authenticity of the varieties delivered by private and government nurseries multiplying the most suited varieties.

This study has also assigned specific bands to each of the five cultivars but the specificity of these bands can only be confirmed after testing of large number of date palm varieties grown in Jordan and elsewhere. In conclusion, this paper has provided an efficient procedure that can be used routinely to identify date palm varieties. This procedure can also be used to study the genetic diversity of ornamental palms that are difficult to classify according to their morphological traits and geographical origin.
References

Al Ugaydy, H. 2000. Date palm: science, agricultural techniques and processing. (Arabic book from Zahran Dar Al-Nashr, Jordan) 721 pp


Potentials for *In vitro & In vivo* Propagation of Local Varieties of Almond (*Prunus amygdalus* Batsch)

N. Saker and L. Chalak

*Lebanese Agricultural Research Institute, Tal Amara, P.O.Box 287 Zahlé, Lebanon,*

**Keywords:** *Prunus amygdalus*, *In vitro*, *In vivo* propagation

**Abstract**

This study is a part of a comprehensive program for the conservation and sustainable use of dryland agrobiodiversity. Concerned with the improvement and production of local almond varieties, this study was initiated at the Lebanese Agriculture Research Institute. Seven local varieties of almond: Awja, Metwi, Halwani double kernel, Half-Khachabi, Khachabi, Biadi and Italia were used. Almond propagation at different stages under *in vitro* and *in vivo* conditions were studied. For *in vitro* propagation, the starter explants were buds and meristems of the current year’s branches. Two cultural media, (a) mineral formula of Murashige and Skoog, and that of (b) Quoirin *et al.* were tested for bud and meristem resumption (revival) and multiplication. Both the media appeared favourable at the first stage of culture initiation, leading to revival rates between 9.1 and 67.3%, but none of the two media was found satisfactory for stem proliferation. The shoot multiplication coefficient did not exceed 3, even in the better cases. Rooting was successful for Half-Khachabi, with a rate of 56.25%, as a result of treatment involving an induction phase of four hours in the dark with an AIA solution (100 mg/l), followed by the transfer of plants to the Murashige and Skoog medium, half diluted and deprived of growth regulators. Of the seven varieties studied, only Half-Khachabi responded well to rooting and multiplication. In *in vivo* propagation, lignified cuttings were recalcitrant and rate of rooting was negligible. The study emphasized the need for developing adequate cell culture technique for almond propagation so that stable long-term propagation of certified plants can be achieved.

**Introduction**

Almond (*Prunus dulcis* L.) is one of the most important cultivated fruit trees in Lebanon. Its fruits are consumed fresh, partially dried or as dried and/or roasted kernels. It is also used in the food industry various purposes. The Lebanese production of almonds is estimated at 23,000 tons per year of fresh fruits (FAO, 2003). However, imports of dried kernels are necessary to cover the national demand. Cultivated orchards are mostly planted with local clones grafted onto seedlings. Recently established commercial orchards have been planted with a limited number of exotic? varieties leading to a reduced genetic diversity. Characterization of local varieties has been initiated (Talhouk *et al.*, 2000) but the exercise is yet incomplete. Several methods may be used to analyze the genetic diversity and to identify the varieties. The traditional methods relied on phenotypic traits that can be measured only at plant maturity. Molecular markers offer an attractive alternative and/or complement to identification based on phenotypic characters and can be used at any stage of maturity (Manubens *et al.*, 1999). More recently, microsatellites or simple sequences repeats of DNA (SSRs), with a polymorphism based
on different numbers of a repeated motif at a given locus became markers of choice in diversity analysis and cultivar identification of different plants (Rafalski et al., 1996). Several microsatellite markers have already been reported in peach (Testolini et al., 2000; Dirlewanger et al., 2002). It has also been demonstrated that most of them were transportable within Prunus species (Dirlewanger et al., 2002).

Almond clones growing in Lebanon have not been yet inventoried, and the identity of the varieties remains unknown. Characterization of the genetic diversity of cultivated almonds in Lebanon was undertaken using morphological characters and microsatellites markers and described in this paper.

**Materials and methods**

**Plant Material**

Field surveys were conducted in 2002-2003 to collect different clones of cultivated almond in twelve stands distributed in the four principal growth areas of almond in Lebanon (Beka’a, the North, Mount Lebanon, and the South) (Table 1). At these locations, the altitude varied from 134 m to 976 meters, latitude between 33°30.789 and 34°48.646, and longitude from 35°24.932 to 36°06.097. The minimal winter temperature ranged from 0.3°C to 9.5°C, and the annual rainfall from 560 mm to 1170 mm (Plassard, 1981).

Prospective orchards were chosen depending on their size (minimum of 10 almond trees per orchard), their sanitary state, and the quality of cultural practices. A total of 36 clones of almond were collected (Table 1). For morphological characterization of each clone, samples of 15 mature fruits and 15 leaves were collected from a single tree. For molecular analysis, young leaves were collected for DNA extraction.

**Table 1.** Geographic and climatic characteristics of the 12 stands studied.

<table>
<thead>
<tr>
<th>Stands (Region)</th>
<th>Altitude (m)**</th>
<th>Latitude (°/N)**</th>
<th>Longitude (°/E)**</th>
<th>Rainfall (mm)*</th>
<th>Minimal winter temperature (°C) *</th>
<th>Clones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idbel (North)</td>
<td>394</td>
<td>34°31.778</td>
<td>36°06.097</td>
<td>783</td>
<td>8.7</td>
<td>Awja 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bandouk awja</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Itali 1 Halawani double</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Khachabi 7</td>
</tr>
<tr>
<td>Jdeir Aamar (North)</td>
<td>142</td>
<td>34°27.620</td>
<td>35°55.551</td>
<td>920</td>
<td>7</td>
<td>Itali 2 Halawani</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Khachabi</td>
</tr>
<tr>
<td>Btaboura (North)</td>
<td>323</td>
<td>34°16.441</td>
<td>35°46.003</td>
<td>1120</td>
<td>9.2</td>
<td>Oum oumar Halawani 4</td>
</tr>
<tr>
<td>Jdabra (North)</td>
<td>388</td>
<td>34°14.581</td>
<td>35°41.472</td>
<td>1010</td>
<td>9.2</td>
<td>Awja 4 Nahali Halawani males Halawani mwabbar</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Khachabi tawil Khachabi 6</td>
</tr>
<tr>
<td>Fghale (Mount Lebanon)</td>
<td>227</td>
<td>34°12.361</td>
<td>35°39.804</td>
<td>1120</td>
<td>9.2</td>
<td>Khachabi 1 Khachabi 3 Khachabi 4</td>
</tr>
</tbody>
</table>
### Morphological Descriptors

Characterization of leaves and fruits was based on almond descriptors previously developed by the International Plant Genetic Resources Institute (IPGRI) (Gulcan, 1985). Thirteen qualitative and 16 quantitative traits were used in this study.

### Molecular Characterization

DNA extraction was performed according to the method described by Shaghai-Maroof et al. (1984). Six primer pairs of microsatellites CT or AG enriched library were used based on their good results for amplification, simple locus, and high discrimination power on peach (Testolini et al., 2000, Dirlewanger et al., 2002).

Microsatellite amplifications were performed in a total volume of 15 µl with PCR buffer (10 mM Tris-HCl, 50 mM KCl, 1.5 mM Mg²⁺), 200 µM of each dNTP, 0.2 µM of each primer, 0.4 U of Taq DNA polymerase and 10 ng of almond genomic DNA. The amplification program consisted of 2 min at 94°C, 35 cycles of 45 s at 94°C, 45 s at 57°C and 45 s at 72°C, followed by a 10min extension at 72°C. Five µl of the PCR products were separated on a 2% agarose gel stained with ethidium bromide to check the PCR amplification and determine the size of the amplified fragments.

The PCR products were denatured by the addition of 7 to 30 µl of 95% formamide/dye solution, heated for 5 min at 94°C and then chilled on ice. An amount of 1.5 to 2 µl of the denatured preparation was loaded in 6% polyacrylamide sequencing gels containing 7.5 M urea in 1x TBE-buffer (90 mM Tris, 90 mM boric acid, 2 mM EDTA). Gels were run for 2 h at 80 W and then silver-stained according to the protocol described by Cho et al. (1996). Allele sizes were established by direct comparison with the 10 bp ladder-DNA sizing markers (Gibco BRL).
Data analysis

For qualitative traits, scores were attributed according to IPGRI almond descriptors (Gulcan, 1985). For each quantitative trait, mean and standard deviation were calculated. Principal Component Analysis (PCA) were performed on 23 quantitative traits. To assess the information given by microsatellite markers, the following parameters were calculated: number of alleles per locus, percentage of observed heterozygosity (Ho), expected heterozygosity (He=1-Σp², where p' is the frequency of the ith allele) and the power of discrimination (PD=1-Σg², where g is the frequency of the ith genotype) (Kloosterman et al., 1993). The presence of an allele was scored as 0.5 for heterozygous individuals, 1 for homozygous individuals and 0 when the allele was not present. Genetic relationships among the 36 almond clones were analyzed with the SIMGEND procedure of NTSYS P.C. 2.0 package (Rohlf, 1997) that computes similarity coefficient for genetic data. Genetic distances were calculated according to Rogers (1972). Trees were produced by clustering the data with the unweighted pair-group method (UPGMA) with SAHN–clustering and tree programs of NTSYS.

Results

Pomologic characterization

Qualitative traits

The flowering and maturity dates were determined in comparison with the clones denominated Awja that were always the earliest in flowering and maturity in all the stands studied across different environmental conditions. Bandouk awja clone was considered early in flowering (20-28 February) and in maturity (first of August), the eight Halawani clones and Melkani, Itali, Oum oumar, and Abou soumeh clones were intermediate in flowering (1-8 March) and early in maturity, thirteen Khachabi clones were intermediate in flowering and late in maturity (30 August), the two clones Demi-khachabi and Metwi were considered intermediate in flowering and maturity (15 August). Finally, Nahali, Istanbouli and Biadi were considered late in flowering (9-15 March) and early in maturity, thirteen Khachabi clones were intermediate in flowering and late in maturity (30 August), the two clones Demi-khachabi and Metwi were considered intermediate in flowering and maturity (15 August). Finally, Nahali, Istanbouli and Biadi were considered late in flowering (9-15 March) and early in maturity (data not shown). All the clones, except Istanbouli (which has pink flowers), have white flowers. Most of the clones have lanceolate leaf with serrated? margin. Leaf apices present an acuminate, acute or subacute shape. Nuts shapes are either cordate, ovate, oblong or extremely narrow. The majority of the clones presented an elliptic kernel shape (data not presented here). Concerning the fruit traits, the shell was not retained on the outer side of the nut, except for two clones of Khachabi. The outer shell varied between sparsely, intermediate, and densely pored. The majority of the clones presented a mucron at the base of the nut. For the shell softness, clones were classified into 5 categories: 4 clones with extremely hard shell, 12 clones with a hard shell, 5 clones with intermediate shell, 5 clones with intermediate to soft shell and 10 clones with soft shell. All the extremely hard and hard shell clones presented a non-opening suture (excellent seal), whereas the majority of intermediate to soft shell showed an opening suture. The kernels varied between slightly wrinkled, intermediate and wrinkled (data not shown).

Quantitative traits

Leaf length ranged from 4.2 cm to 11 cm and leaf width from 1.5 cm to 4 cm. The Awja 2 clone presented the biggest leaf (45.27 cm²) while Khachabi 7 clone had the smallest (6.46 cm²). Petiole length ranged from 0.8 to 2.9 (data not presented here).
The clone Khachabi 5 was distinguished by the biggest nut (25.35 cm$^3$, 9.41 g) and kernel (4.05 cm$^3$, 1.94 g), while Khachabi 4 presented the smallest nut (3.6 cm$^3$, 1.39 g) and kernel (1.06 cm$^3$, 0.48 g). The breaking yield varied between 20.51 (Khachabi 5) and 72.57 (Halawani double). Among 36 clones studied, only 16 clones presented nuts with only one kernel, whereas the others had double kernels with a percentage ranging from 6.67 to 86.67 (Table 2).
Table 2. Nut and kernel quantitative traits for the 36 almond clones. Means  standard deviation of 15 repetitions per clone.
Clones

Abou soumegh
Awja 1
Awja 2
Awja 3
Awja 4
Bandouk awja
Biadi
Demi khachabi
Halawani 1
Halawani 2
Halawani 3
Halawani 4
Halawani 5
Halawani double
Halawani males
Halawani mwabbar
Istanbouli
Itali 1
Itali 2
Khachabi
Khachabi 1
Khachabi 10
Khachabi 2
Khachabi 3
Khachabi 4
Khachabi 5
Khachabi 6
Khachabi 7
Khachabi 8
Khachabi 9
Khachabi kabir
Khachabi tawil
Melkani
Metwi
Nahali
Oum oumar

Nut weight
(g)

Nut length
(cm)

Nut width
(cm)

Nut
thickness
(cm)

Nut volume
(cm3)

Kernel
weight
(g)

Kernel
length
(cm)

Kernel
width
(cm)

Kernel
thickness
(cm)

Kernel
volume
(cm3)

Breaking
yield

% of
double
kernel

1.62 ± 0.44
5.31± 1.76
7.82 ± 1.80
4.13 ± 0.89
2.60 ± 0.54
2.56 ± 0.61
2.95 ± 0.41
2.60 ± 0.36
2.41 ± 0.52
2.97 ± 0.42
2.10 ± 0.62
1.66 ± 0.32
2.62 ± 0.35
2.11± 0.42
2.02 ± 0.30
1.73 ± 0.22
2.75 ± 0.43
2.25 ± 0.25
2.91 ± 0.58
4.40 ± 0.78
2.39 ± 0.36
2.70 ± 0.62
2.82 ± 0.52
1.49 ± 0.26
1.39 ± 0.32
9.41 ± 1.57
6.38 ± 1.18
3.46 ± 0.47
4.56 ± 1.08
3.41 ± 0.54
6.30 ± 1.00
4.96 ± 0.51
2.09 ± 0.28
2.61 ± 0.30
2.03 ± 0.51
1.78 ± 0.16

2.78 ± 0.19
4.88 ± 0.44
4.74 ± 0.59
6.08 ± 0.43
3.56 ± 0.23
3.32 ± 0.29
3.63 ± 0.28
3.49 ± 0.16
3.07± 0.25
3.43 ± 0.19
2.37 ± 0.20
2.47 ± 0.14
3.94 ± 0.36
3.03 ± 0.13
2.84 ± 0.16
2.47 ± 0.12
3.46 ± 0.23
3.20 ± 0.17
3.45 ± 0.24
2.72 ± 0.20
2.55 ± 0.16
2.97 ± 0.21
2.47 ± 0.13
1.92 ± 0.09
2.35 ± 0.18
3.95 ± 0.20
3.28 ± 0.14
3.30 ± 0.16
3.23 ± 0.26
3.07 ± 0.18
3.38 ± 0.19
4.15± 0.17
3.35 ± 0.18
3.47± 0.19
2.52 ± 0.17
2.71 ± 0.14

1.86 ± 0.12
2.49 ± 0.25
2.54 ± 0.21
2.31± 0.31
2.27 ± 0.13
2.03 ± 0.23
2.34± 0.16
2.29 ± 0.20
2.10 ± 0.16
2.34 ±0.10
1.75 ± 0.14
1.75 ± 0.12
2.36 ± 0.27
2.03 ±0.10
1.88 ±0.11
1.90 ± 0.10
2.33 ± 0.32
2.16 ± 0.09
2.12 ± 0.41
2.08 ± 0.11
1.67 ± 0.14
1.80 ± 0.13
1.88 ± 0.10
1.49 ± 0.08
1.36 ± 0.12
3.12 ± 0.22
2.40 ± 0.12
2.31 ± 0.10
2.11 ± 0.17
1.88 ± 0.12
2.50 ± 0.17
2.27 ± 0.10
1.92 ± 0.14
2.27 ± 0.20
1.93 ± 0.24
2.36 ± 0.10

1.35 ± 0.15
1.78 ± 0.19
1.93 ± 0.17
1.62 ± 0.19
1.38 ± 0.13
1.34 ± 0.15
1.51 ± 0.12
1.59± 0.13
1.48 ± 0.13
1.53 ± 0.13
1.31 ± 0.14
1.37 ± 0.16
1.29 ± 0.09
1.44 ± 0.17
1.38 ± 0.10
1.46 ± 0.10
1.59 ± 0.14
1.23 ± 0.05
1.37 ± 0.11
1.60 ± 0.06
1.35 ± 0.06
1.51 ± 0.14
1.72 ± 0.15
1.29 ± 0.10
1.12 ± 0.26
2.05 ± 0.12
1.82 ± 0.23
1.50 ± 0.10
1.55 ± 0.12
1.40 ± 0.09
1.83 ± 0.19
1.55 ± 0.07
1.37 ± 0.05
1.61± 0.15
1.52 ± 0.16
1.40 ± 0.06

7.04 ± 1.81
21.79 ± 5.36
23.38 ± 5.80
22.86 ± 5.63
11.24 ± 2.33
9.09 ± 2.78
12.90 ± 2.59
12.78 ± 2.44
9.60 ± 2.19
12.36 ± 1.39
5.48 ± 1.48
5.95 ± 1.22
12.07 ± 2.01
8.89 ± 1.65
7.44 ± 1.08
6.86 ± 1.09
12.88 ± 2.93
8.57 ± 0.99
10.12 ± 2.83
9.11± 1.50
5.79 ± 1.01
8.16 ± 1.91
8.04 ± 1.51
3.69 ± 0.62
3.60 ± 1.21
25.35 ± 4.01
14.44 ± 2.60
11.50 ± 1.51
10.63 ± 2.45
8.13 ± 1.44
15.55 ± 3.23
14.67 ± 1.59
8.90 ± 1.32
12.73 ± 2.63
7.44 ± 1.46
8.97 ± 0.96

0.96 ± 0.09
1.48 ± 0.37
1.76 ± 0.40
0.92 ± 0.32
1.18 ± 0.14
1.38 ± 0.16
0.92 ± 0.14
1.12 ± 0.15
1.33 ± 0.25
1.18 ± 0.17
1.19 ± 0.23
0.68 ± 0.08
1.44 ± 0.18
1.00 ± 0.15
1.23 ± 0.11
1.00 ± 0.10
1.48 ± 0.22
1.58 ± 0.20
1.77 ± 0.21
1.20 ± 0.16
0.65 ± 0.08
1.13 ± 0.29
0.72 ± 0.17
0.47 ± 0.07
0.48 ± 0.09
1.94 ± 0.40
1.48 ± 0.20
1.10 ± 0.18
1.02 ± 0.21
0.86 ± 0.11
1.49 ± 0.18
1.19 ± 0.10
0.89 ± 0.12
1.15 ± 0.14
0.90 ± 0.27
1.11 ± 0.14

2.13 ± 0.11
3.37 ± 0.18
3.25± 0.26
3.13 ± 0.32
2.54 ± 0.19
2.45 ± 0.15
2.38 ± 0.18
2.47 ± 0.14
2.34 ± 0.16
2.53 ± 0.21
1.89 ± 0.14
1.95 ± 0.16
2.82 ± 0.11
2.22 ± 0.21
2.22 ± 0.23
1.92 ± 0.08
2.35 ± 0.1
2.49 ± 0.13
2.66 ± 0.20
2.02 ± 0.14
1.81 ± 0.12
2.26 ± 0.21
1.80 ± 0.15
1.45 ± 0.10
1.66 ± 0.13
2.74 ± 0.19
2.60 ± 0.11
2.44 ± 0.11
2.28 ± 0.19
2.14 ± 0.11
2.48 ± 0.17
2.92 ± 0.11
2.39 ± 0.13
2.43 ± 0.15
1.85 ± 0.15
2.15 ± 0.10

1.22 ± 0.07
1.38 ± 0.14
1.39 ± 0.23
1.19 ± 0.18
1.35 ± 0.12
1.33 ± 0.08
1.31 ± 0.1
1.33 ± 0.10
1.35 ± 0.09
1.36 ± 0.14
1.21 ± 0.07
1.16 ± 0.16
1.51 ± 0.16
1.26 ± 0.11
1.33 ± 0.08
1.25 ± 0.05
1.39 ± 0.11
1.42 ± 0.10
1.58 ± 0.11
1.30 ± 0.07
1.00 ± 0.13
1.06 ± 0.10
1.11 ± 0.08
1.05 ± 0.22
0.85 ± 0.06
1.80 ± 0.11
1.40 ± 0.09
1.39 ± 0.11
1.22 ± 0.20
1.14 ± 0.07
1.40 ± 0.19
1.31 ± 0.04
1.13 ± 0.07
1.33 ± 0.10
1.17 ± 0.11
1.50 ± 0.10

0.82 ± 0.07
0.67 ± 0.14
0.87 ± 0.19
0.58 ± 0.16
0.70 ± 0.15
0.90 ± 0.06
0.57 ± 0.04
0.64 ± 0.06
1.23 ± 0.26
0.85 ± 0.12
1.03 ± 0.09
0.74 ± 0.06
0.69 ± 0.08
0.84 ± 0.08
0.95 ± 0.10
0.86 ± 0.09
0.89 ± 0.05
0.91 ± 0.03
0.85 ± 0.0
0.91 ± 0.06
0.74 ± 0.04
0.88 ± 0.16
0.80 ± 0.09
0.80 ± 0.17
0.75 ± 0.05
0.82 ± 0.09
0.82 ± 0.11
0.69 ± 0.06
0.83 ± 0.10
0.75 ± 0.06
0.91 ± 0.09
0.65 ± 0.04
0.71 ± 0.06
0.66 ± 0.06
0.83 ± 0.17
0.93 ± 0.07

2.13 ± 0.32
3.13 ± 0.85
3.95 ± 0.83
2.15 ± 0.72
2.42 ± 0.57
2.95 ± 0.32
1.77 ± 0.31
2.10 ± 0.35
3.90 ± 1.07
2.92 ± 0.60
2.35 ± 0.48
1.67 ± 0.32
2.94 ± 0.63
2.35 ± 0.44
2.79 ± 0.41
2.07 ± 0.21
2.89 ± 0.44
3.20 ± 0.42
3.58 ± 0.59
2.38 ± 0.35
1.35 ± 0.30
2.11 ± 0.68
1.61± 0.38
1.23 ± 0.56
1.06 ± 0.19
4.05 ± 0.65
2.98 ± 0.41
2.35 ± 0.35
2.30 ± 0.54
1.84 ± 0.25
3.20 ± 0.49
2.49 ± 0.22
1.91± 0.29
2.12 ± 0.25
1.80 ± 0.61
2.97 ± 0.42

66.1
31.64
23.1
21.9
55.48
62.05
31
43.33
65.67
65.89
58.42
67.88
55.34
72.57
66.24
60.61
53.71
69.92
63.92
27.81
27.3
42.11
28.06
35.41
36.45
20.51
26.66
34.32
27.74
26.7
28.22
24.04
42.73
44.29
49.65
62.12

13.33
6.67
0
0.15
26.67
20
0
0
13.33
86.67
0
80
0
66.67
13.33
6.67
0
0
6.67
0
0
0
13.33
20
6.67
0
20
13.33
33.33
6.67
26.67
0
0
0
20
0

656


Table 3. Principal Component Analysis of 36 almond clones with 23 quantitative morphological traits.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Nut volume</td>
<td>-0.90</td>
</tr>
<tr>
<td>Width volume</td>
<td>-0.88</td>
</tr>
<tr>
<td>Kernel length</td>
<td>-0.87</td>
</tr>
<tr>
<td>Kernel weight</td>
<td>-0.84</td>
</tr>
<tr>
<td>Nut weight</td>
<td>-0.83</td>
</tr>
<tr>
<td>Kernel volume</td>
<td>-0.81</td>
</tr>
<tr>
<td>Nut length</td>
<td>-0.76</td>
</tr>
<tr>
<td>Kernel width</td>
<td>-0.75</td>
</tr>
<tr>
<td>Nut thickness</td>
<td>-0.74</td>
</tr>
<tr>
<td>Leaf area</td>
<td>-0.54</td>
</tr>
<tr>
<td>Leaf width</td>
<td>-0.52</td>
</tr>
<tr>
<td>Leaf length</td>
<td>-0.51</td>
</tr>
<tr>
<td>Marking of outer shell</td>
<td>-0.50</td>
</tr>
<tr>
<td>Flowering date</td>
<td>0.40</td>
</tr>
<tr>
<td>Shrivelning of kernel</td>
<td>-0.34</td>
</tr>
<tr>
<td>Clingstone</td>
<td>0.34</td>
</tr>
<tr>
<td>Breaking yield</td>
<td>0.26</td>
</tr>
<tr>
<td>Petiole length</td>
<td>-0.13</td>
</tr>
<tr>
<td>Maturity date</td>
<td>0.12</td>
</tr>
<tr>
<td>Suture of the shell</td>
<td>0.12</td>
</tr>
<tr>
<td>% double of kernel</td>
<td>0.10</td>
</tr>
<tr>
<td>Kernel thickness</td>
<td>0.03</td>
</tr>
<tr>
<td>Mucron</td>
<td>-0.02</td>
</tr>
<tr>
<td>Percentage of total variation</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Table 4. Alleles number, molecular weight, observed heterozygosity (Ho), expected heterozygosity (He), discrimination power (Dp) of 6 microsatellites.

<table>
<thead>
<tr>
<th>SSR name</th>
<th>Repeat motif</th>
<th>Nb. of alleles</th>
<th>Molecular weight</th>
<th>Ho</th>
<th>He</th>
<th>Dp</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPPCT 001</td>
<td>(GA)$_3$(AG)</td>
<td>15</td>
<td>103-151</td>
<td>0.66</td>
<td>0.83</td>
<td>0.92</td>
</tr>
<tr>
<td>BPPCT 007</td>
<td>(AG)$_2$(CG)$_2$(AG)</td>
<td>12</td>
<td>129-162</td>
<td>0.89</td>
<td>0.87</td>
<td>0.93</td>
</tr>
<tr>
<td>BPPCT 025</td>
<td>(GA)$_3$</td>
<td>16</td>
<td>157-201</td>
<td>0.94</td>
<td>0.88</td>
<td>0.94</td>
</tr>
<tr>
<td>BPPCT 026</td>
<td>(AG)$_3$(GG)(AG)</td>
<td>11</td>
<td>137-161</td>
<td>0.89</td>
<td>0.79</td>
<td>0.85</td>
</tr>
<tr>
<td>BPPCT028</td>
<td>(TC)$_3$(CT)</td>
<td>10</td>
<td>160-190</td>
<td>0.91</td>
<td>0.84</td>
<td>0.9</td>
</tr>
<tr>
<td>UDP 98408</td>
<td>(CT)$_3$(TG)</td>
<td>11</td>
<td>99-129</td>
<td>0.54</td>
<td>0.78</td>
<td>0.87</td>
</tr>
<tr>
<td>Mean</td>
<td>12.5</td>
<td>0.80</td>
<td>0.83</td>
<td>0.90</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Traits validation

PCA revealed that the first three components explained 62% of the total variation, based on 23 quantitative traits (Table 3). The first component accounted 33% of the variation mainly due to the measurable quantitative traits of nut and kernel (expected kernel thickness). The second component, contributing to 19% of the variation, particularly including the breaking yield trait. The third component accounted 10% of the variation only. Leaf traits can be eliminated due to their poor contribution to the total variation. These results are in agreement with the study of Lansari et al. (1994) who found that nut and kernel traits are the most important variables contributing to the diversity found among the almonds selected in Morocco.
Molecular Characterization

The six SSRs tested were polymorphic and revealed 75 alleles with an average of 12.5 alleles per primer and a size ranging from 99 to 190 bp (Table 4). The most frequent alleles were found in Awja and Bandouk awja with BPPCT001, BPPCT025, BPPCT026, BPPCT028 and UDP98408. Rare alleles were found in Khachabi 6 clone with BPPCT025 and BPPCT026 primers. The expected heterozygosity (He) ranged from 0.78 to 0.88 (mean 0.83). The observed heterozygosity was lower than the expected one with an average of 0.8. The six primers used in this study had a discrimination power higher than 0.85. Thus, the six primer pairs of microsatellites previously reported for their efficiency in studying peach cultivars in Italy (Testolin et al., 2000) and in France (Dirlewanger et al., 2002), proved to be suitable for almonds as well.

Distance values between clones ranged from 0.615 observed in the pairwise comparison between Khachabi 10 and Awja clones to 0.000 between Awja 1 and Awja 2; Awja 4 and Bandouk awja; Itali 1, Itali 2 and Halawani 5; Halawani 2, Halawani males and Halawani 4; Istanbouli, Demi Khachabi and Metwi. Some of these clones (Demi Khachabi and Metwi; Itali 1 and Itali 2) were not distinguishable neither for the genetic markers nor for the pomologic traits. Such proximities in both genetic analysis and agronomic traits suggest synonymies. The smallest distance between clones (0.214) was found between Halawani double and Halawani 2, Halawani males and Halawani 4.

The dendrogram based on microsatellites data revealed four main groups (Fig. 1). The largest group included 20 clones presenting one allele in common with BPPCT026 primer as well as a shell not retained to the outer of the nut. A second group included Khachabi 10 and three of the four Awja clones analyzed, showing one allele in common with BPPCT001 primer. These clones were clearly distinguished by the non-opening suture. In a third group, the clones of Nahali, Khachabi, Halawani 1 and Halawani 3 presented one allele in common with BPPCT007 primer as well as a lanceolate leaf shape. The last group included Melkani and Halawani mwabbar clones besides six clones of Khachabi, sharing one allele with BPPCT026 primer and intermediate flowering dates. Among the 75 polymorphic alleles observed with the six SSRs used, none was found to be unique to any group of the almond clones studied.
Figure 1. Dendogram constructed from single-locus SSR, using SimGen program, Rogers distance modified by Wright, and UPGMA clustering with the 36 almond clones.

Conclusions

Almond clones cultivated in Lebanon were characterized for the first time. Some of them, such as Khachabi, probably derived from seeds could be native, others such as Italy clones that presented similar traits with varieties cultivated elsewhere in the world (Cavaliere) might have been introduced from France or Italy. An important diversity was observed among the clones, precisely for the flowering and maturity dates and the morphological fruit characteristics. The nut and kernel quantitative traits, appeared to be the most important parameters in terms of their contribution to the total variability between clones.

A good proportion of microsatellite markers already used to characterize peach diversity in Europe (Testolin et al., 2000; Dirlewanger et al., 2002) proved to be useful for other Prunus species and efficient in determining genetic distances between almond clones. Additional primers should be tested in order to identify the different accessions of almond. Such information would be useful to avoid duplications or mislabeling of the genotypes. This could also help in diversification strategy by introducing new and improved varieties for world market, and keeping the local varieties, adapted to the tastes of Lebanese consumers (fresh fruits) and the climatic conditions, for the local market. In fact, the ability to offer a larger number of varieties would be an asset for Lebanese almonds in both the national and the international markets.

The almond clones listed in this study should be placed in a specific collection in order to preserve the Lebanese genetic resources and subsequently to evaluate their agronomic potential (autofertility, yield, organoleptic quality and diseases resistance). They constitute a potential wealth of genetic diversity that can be used for the improvement of this species in Lebanon and elsewhere.

Acknowledgements
The authors are grateful to the CEDRE French-Lebanese program for their financial support and to the GEF-UNDP Agrobiodiversity project for their contribution in collecting the material.
References


Exploration of molecular genetic diversity in Tunisian *Hedysarum* species

N. Trifi-Farah, H. Chennaoui, S. Marghalii, and M. Marrakchi

*Laboratoire de Génétique Moléculaire, Immunologie et Biotechnologie, Faculté des Sciences de Tunis. Campus Universitaire, 2092 El- Manar, Tunis, Tunisie. Email: neila.trifi@fst.rnu.tn*

**Keywords:** genetic diversity, phylogeny, AFLP, RFLP, ISSR, Hedysarum, Tunisia

**Abstract**

Molecular techniques such as restriction fragment length polymorphism (rDNA-RFLP), inter-simple sequence repeats (ISSR) and amplified fragment length polymorphism (AFLP) have been employed to obtain a deeper insight in *Hedysarum* genus diversity. Results showed high degree of polymorphism, these concerns either in intra- or inter-specific levels. Attempts were made in this approach to assess the extent of variability at the DNA level occurring with the domestication process. In addition, considerable variability has been detected in the case of populations that are characterised by a maximum phenotypic diversity. Hence, we may assume that some of the revealed molecular markers are strongly correlated with important agronomic traits. These markers allowed to gather information about the phylogenetic relationships among the included species and can molecularly assist the selection within the improvement programmes.

**Introduction**

Around the Western Mediterranean basin, the genus *Hedysarum* (Fabaceae) includes endemic species (2n=2x=16) that constitute diversified phylogenetic species able to perform an important role in crop production increase (Baatout 1995; Trifi-Farah *et al.* 2002). The main advantages of this germplasm are its high nutritive value and its relatively good soil protection and enrichissement. Among The Mediterranean species, *H. coronarium* is one of the most important forage, silage making and seed production commonly cultivated mainly in Spain, Italy and North Africa (Boussaid *et al.* 1995; Trifi-Farah *et al.* 2002).

The Tunisian pastoral areas are currently highly degraded due to over-grazing. Due to agricultural encroachment, the rangelands remain mainly in the dry areas where severe droughts are contributing to further to the loss of species diversity. Among crops that are reliable to promote pastoral zones, *Hedysarum* genus (Fabaceae) is an important genetic resource contributing to pastoral production particularly in semi-arid areas. The knowledge of the genetic population structure of wild species related to cultivated types would be very useful in developing an efficient selection and breeding program.

Therefore, the conservation of *Hedysarum* species is of particular importance for pasture sustainability. Five species are inspected throughout Tunisia. *H. coronarium* L., *H. carnosum* Desf. and *H. pallidum* Desf. are predominantly allogamous; *H. spinosissimum* L. shared opposite mating system which mostly allogamous in the subspecies *H. capitatum* Desf. and mostly autogamous in the subspecies *H. euspinosissimum* Briq.

In Tunisia, these species constitute an important germplasm adapted in the semi-temperate and arid areas (Boussaid *et al.* 1995; Trifi-Farah *et al.* 2002). The Tunisian Dorsal has been shown to separate the semi-temperate ecological domain of *H. coronarium*, *H. spinosissimum ssp capitatum*, *H. pallidum* to the north and the arid ecological domain of *H. carnosum*, *H. spinosissimum ssp spinosissimum* to the south.

Introduction of several cultivars (Grimaldi, Scaravatti, Sparacia,...) mainly from Italy has failed due to their poor performance for silage, and to the lost of their characteristics under
Tunisian environments. This crop concerns the north of Tunisia near spontaneous populations of *H. coronarium* (Trifi-Farah *et al.* 2002). The aim of this study is to characterize spontaneous populations in comparison to cultivated forms by the use of molecular techniques, such as restriction fragment length polymorphism (rDNA-RFLP), inter-simple sequence repeats (ISSR) and amplified fragment length polymorphism (AFLP) in order to study the range of genetic variation in this crop and the wild species for their use in crop improvement.

**Materials and methods**

**Plant material**
The analysis was carried out on five populations of species representing the genus *Hedysarum*. The seed collection originated from a range of habitats to maximize geographical coverage (Table 1). Ten seeds that constitute each population were used to assess intra- and inter-specific variation levels.

**DNA extraction**
After seed’s germination, total cellular DNA was extracted according to the procedure described by Dellaporta *et al.* (1983). After purification, DNA concentrations were determined using a Gene-Quant spectrometer (Amersham, Pharmacia, France) and its integrity was proved after agarose minigel electrophoresis according to Sambrook *et al.* (1989).

**RFLP procedure**
DNA was digested with *Hpa*II, *Alu*I, *Sma*I and *Bgl* enzymes. A fragment of 1.6Kb corresponding to the intergenic spacer was used as homologous rDNA probe for southern hybridization (Southern 1975). Prehybridization and hybridization were performed in 5×SSC, 5× Denhardt, 0.5× SDS, 45% Formamide at 42°C overnight with random prime labelled probe (Sambrook *et al.* 1989).

**ISSR amplification**
A total of 10 appropriate primers complementary to simple sequence repeats (ISSR) were tested to amplify DNA using total cellular DNAs as template. These primers, listed in table 1, consisted of four single primers as described by Gupta *et al.* (1994) and six 3’ anchored ones which are arbitrarily chosen. PCR amplification was carried out, performed and the amplified DNA was loaded and then visualized according to Ghariani *et al.* (2003).

**AFLP technology**
AFLP markers were generated using eight primer combinations of *Eco*RI and *Mse*I primers from AFLP Analysis System (Life Technologies, Inc) as described by Vos *et al.* (1995).

**Data analysis**
Molecular markers (RFLP bands, amplified products) were scored as present (1) or absent (0) to form a binary matrix. This latter was computed with the Gendist program (PHYLIP 3.5) (Felsenstein 1995) using the Nei and Li (1979) formula to generate the genetic distance matrix exploited by the Neighbour program in order to define relationships between the populations studied. The obtained treefiles were then submitted to the TreeView (Win32 1.5.2) software to map phylogenetic diagrams based on the Unweighted Pair Group Method with the Arithmetic Averaging (UPGMA).

**Results**
**Inter-specific analysis**

Using all the generated markers by RFLP, AFLP and ISSR techniques (142), a between species genetic distance matrix is summarized in table 1. The obtained average distance ranging from 0.467 to 0.878 with a mean of 0.694 expresses a wide genetic diversity among the tested species. The smallest distance value of 0.462 is observed between *H. coronarium* and *H. carnosum* which seem to be the most similar species. Also, the maximum distance value is observed between *H. coronarium* and *H. pallidum* suggesting their divergence. In addition, results showed that, in spite of their classification as subspecies, both *H. capitatum* and *H. spinosissimum* showed an important genetic distance value of 0.813 currently observed between a given species and any other one. The molecular discrimination between the subspecies of *H. spinosissimum* is supported by morphological and isoenzymatic analysis (Trifi-Farah *et al.* 1989; Baatout *et al.* 1990; Trifi-Farah and Marrakchi 2001).

**Table 1:** Genetic distances matrix between the five *Hedysarum* species.

<table>
<thead>
<tr>
<th></th>
<th><em>H. coronarium</em></th>
<th><em>H. carnosum</em></th>
<th><em>H. capitatum</em></th>
<th><em>H. spinosissimum</em></th>
<th><em>H. pallidum</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>H. coronarium</em></td>
<td>0.4672</td>
<td></td>
<td>0.8615</td>
<td>0.6383</td>
<td>0.8783</td>
</tr>
<tr>
<td><em>H. carnosum</em></td>
<td>0.8615</td>
<td>0.6931</td>
<td></td>
<td>0.4785</td>
<td>0.8615</td>
</tr>
<tr>
<td><em>H. capitatum</em></td>
<td>0.6931</td>
<td>0.4785</td>
<td>0.8127</td>
<td></td>
<td>0.7217</td>
</tr>
<tr>
<td><em>H. spinosissimum</em></td>
<td>0.8127</td>
<td>0.8615</td>
<td>0.7217</td>
<td>0.5250</td>
<td></td>
</tr>
</tbody>
</table>

The genetic distance matrix was analyzed with the Neighbor-joining algorithm to cluster the data and to elucidate relationships among the *Hedysarum* species. The resulting phenogram illustrates their tree branching (Fig. 1). Two clusters involving species characterized by similarities between their DNA have been identified. The first one is composed of *H. coronarium* and *H. carnosum*. A second one regroups *H. pallidum* and *H. spinosissimum*. In addition, the third branch constituted with *H. capitatum* as monophyletic cluster has been detected. The species’ groupings suggest a nuclear lineage of the diploid species of the western Mediterranean basin.
H. coronarium inter-populations diversity

Considering the tested H. coronarium populations, a total of 287 polymorphic markers were generated by RFLP, AFLP and ISSR procedures, displaying a great genetic diversity. The use of such markers allowed the gathering of information about the inter-populations variation in H. coronarium species. A genetic distance matrix based on molecular markers was estimated according to Nei and Li’s (1979) formula. The genetic distances varied from 0.116 (Tunis) and (El Haouaria) to 0.277 (El Haouaria) and Zit with a mean of 0.209 suggesting a wide range of variation (Table 2). Relatively high genetic distances were recorded between all spontaneous populations and the cultivars. Noteworthy that both wild and cultivated forms are located in limited areas. Consequently, gene flow may occur between these forms according to allogamous mating system. This observation supports strongly particular molecular characteristics of cultivar related to distinctive agronomic trait. Moreover, the highest genetic distance is observed between Zit and El Haouaria populations which are distinguished by an opposite geotropism: El Haouaria with plagiotropic tendency and Zit presenting orthotropic form. Thus morphologic trait seems to be strongly correlated to the molecular polymorphism generated by several RFLP, AFLP and ISSR markers.

<table>
<thead>
<tr>
<th>Table 2 : Genetic distances matrix between the analyzed H. coronarium accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivar</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Mateur</td>
</tr>
<tr>
<td>Tunis</td>
</tr>
<tr>
<td>El Haouaria</td>
</tr>
</tbody>
</table>

Fig. 1. Dendrogram of five Hedysarum species constructed from Nei and Li’s genetic distance matrix clustered with UPGMA
The matrix was then computed by the Neighbor program to produce Treefile using the Neighbor joining method. The resultant phylogram constructed with the TreeView program is represented in Fig. 2. The clustering analysis supports the distinctiveness of three mains groups. The first one is composed of Tunis, El Haouaria and Bizerte. A second one regroups populations from Mateur and Zit. The third branch identifies cultivar as a monophyletic group. So far, it has been assumed that both populations of Tunis and El Haouaria are closely clustered with Bizerte; A tendency of clustering to follow the architectural form of plants is significantly illustrated in the phylogram. This is well exemplified in the case of Tunis, El Haouaria and Bizerte populations with plagiotropic form which are separated from Mateur and Zit populations with orthotropic architecture suggesting a strong correlation between molecular markers and this morphological trait. In spite of genetic exchanges that may occur between both forms due to the mating system in _H. coronarium_, the obtained results expressed the molecular discrimination of cultivated form since its introduction in Tunisia.

**Discussion**

In the present study, we have examined the genetic diversity in _Hedysarum_ genus with the help of RFLP, AFLP and ISSR techniques. As result, data provide evidence of genetic polymorphism either at the intra-specific or the inter-specific level. Similar results have been reported with morphological variability and isoenzymes polymorphism (Figier et al. 1977; Trifi-Farah et al. 1989).

Taking advantage of the wide variation of molecular markers, the phylogenetic relationships among species of the complex _Hedysarum_ was investigated. The species’ groupings of the diploid species of the western Mediterranean basin evidenced the nuclear lineage between the implicated species. Our data exhibit evidence of the molecular discrimination between the subspecies of _H. spinosissimum_ and agree with results issued from morphological and isoenzymatic analysis (Trifi-Farah et al. 1989; Baatout et al. 1990; Baatout et al. 1991; Baatout 1995). Regarding the predominantly selfing of _H. spinosissimum_ ssp _spinosissimum_ and the mostly outcrossing of _H. spinosissimum_ ssp _capitatum_, it could be postulated that these subspecies constitute very distinct taxonomic entities.

Starting from a set of _H. coronarium_ populations characterized by a maximum of phenotypic variability, a high degree of genetic variation was detected. In addition, a tendency of clustering to follow the architectural form of plants is significantly exhibited. The UPGMA tree strongly supported an opposition of “El Haouria, Tunis, Bizerte” and “Mateur, Zit” populations. These results concur with data based on morphological studies since these populations are characterized by an opposite geotropism. RFLP, AFLP and ISSR procedures provided several molecular markers correlated with the plants’ geotropism. In addition, and based on their distinctiveness by agronomic characters, cultivated species populations or cultivars are molecularly different from wild populations in spite of the mating system in _H. coronarium_. Since its introduction in Tunisia, these sympatric forms may develop genetic exchanges. However, cultivars’ selection has been rigorously made for their agronomic traits (particularly morphological traits) which has been maintained them.

**References**


Felsenstein, J. 1995. PHYLIP (Phylogeny Interference Package), version 3.57c. Distributed by the author, Department of genetics, University of Washington, Seattle, Washington, USA.


Demonstrating the Effect of Reseeding with Native Legumes and Fertilizer Application on Rangeland Rehabilitation in Nabha

R. Assi¹, N. Chamoun¹, M. Monzer¹, S. Bsat¹, and A. Nassar²

¹ Agrobiodiversity Project – Lebanon Agricultural Research Institute, LARI, Tel Amara, Lebanon
² International Center for Agricultural Research in the Dry Areas – Terbol Station

Keywords: Native species, phosphorous fertilizer, range rehabilitation, Lebanon

Abstract
The misuse of rangeland is a common practice in Lebanon, especially in the dryland areas of the Baalbeck Caza, resulting in the genetic erosion of important native forage species and the degradation of the vegetation cover affecting negatively the livelihood of the local communities. One of the outputs of the GEF/UNDP Project on “Conservation and sustainable Use of Dryland Agrobiodiversity in the Near East” is to promote alternative land-use practices for the conservation and sustainable use of agrobiodiversity. Rangeland management and rehabilitation is one of the activities carried out by the project to achieve this output. One of the project sites includes the village of Nabha and its surroundings, with around 80 % of land (2,500 hectares) considered as open access rangelands in the absence of local grazing management. A demonstration plot was selected to show the effect of reseeding with native legumes and the application of P2O5 using contour lines water harvesting on rangeland rehabilitation. The plot was divided into 4 sections: One was treated with 30 Kg/ha of P2O5 application; the second was reseeded with a mixture of native legumes at a rate of 12 Kg/ha with P2O5 application; the third was reseeded with the same rate of the native mixture but without P2O5 application and the fourth was left untreated as control. The results of this study indicated that the average total vegetation dry matter in treatments where reseeding was applied were much higher compared to the other treatments with no significant effect of P2O5 application on legumes and grasses productivity. This indicates that reseeding with native species within the contour lines should be a major option for the rehabilitation of the degraded rangeland in Nabha which should be accompanied by the establishment of local grazing management scheme.

Introduction
The misuse of rangelands is common in Lebanon, especially in the dryland areas of the Baalbeck Caza, resulting in the genetic erosion of important native forage species and the degradation of the vegetation cover and land affecting negatively the livelihood of the local communities. One of the outputs of the GEF/UNDP Project on “Conservation and sustainable Use of Dryland Agrobiodiversity in the Near East” is to promote alternative land-use practices for the conservation and sustainable use of agrobiodiversity. Rangeland management and rehabilitation is one of the activities carried out by the project to achieve this output. The project is implemented in three sites in the Bekaa valley, Baalbeck Caza. One of the project sites includes the village of Nabha and its surroundings with around 80 % of land (2,500 hectares) considered as rangelands. Around 4,000 heads of sheep and goats belong to herders in this area. The rangelands are considered open access lands for the Nabha flocks in the absence of local grazing arrangements.

Materials and Methods
After several meetings with the local herders in the project site of Nabha, a demonstration plot (25 ha) was selected to show the impact of controlled grazing (deferred rotational grazing) versus uncontrolled grazing (the current grazing practices). A subplot (4 ha) was selected to conduct an experiment on the effects of reseeding with native legumes and the application of P$_2$O$_5$ on rangeland rehabilitation. The area was then divided into 4 sections with 4 different treatments (1 ha each) as follows:

- **T1**: P$_2$O$_5$ (Super Phosphate) application at a rate of 30 Kg/ha without reseeding of native species.
- **T2**: Reseeding with a mixture of native forage legumes (provided by ICARDA station in Terbol) at a rate of 12 Kg/ha. The mixture was composed of six *Trifolium* sp. (*resupinatum, lappaceum, tomentosum, pilulare, purpureum, haussknechti*), two *Trigonella* sp. (*mesopotamica and astroites*), two *Astragalus* sp., and *Medicago radiata*. In addition, P$_2$O$_5$ was applied at a rate of 30 Kg/ha.
- **T3**: Reseeding with the same rate and composition of the native legumes mixture without P$_2$O$_5$ application.
- **T4**: Control (no fertilization and no reseeding).

![Sampling method](Image)

**Figure 1.** Sampling method used for estimation of dry matter, with spots showing the quadrates (samples) along transects in treatments T1, T2, T3 and T4.

Upon the flowering stage of most legumes species, samples were taken from each treatment to estimate the dry matter yield as follows: Two diagonal transects for each treatment in X form were taken as illustrated in Figure 1. Then, five quadrates (25 cm$^2$ each) were selected along each transect for the sampling with 30m equidistance between quadrates. Ten samples were taken from each treatment. Each sample was subdivided into three components: Grasses, legumes and others (all other species). All samples were dried in the oven at 75°C for 24 hours. Afterwards, weighing of the dry matter was undertaken for all components of all samples.
Results and Discussion
Studies undertaken in Lebanon indicated that annual grasses dominate rangelands with low density of legume species due to overgrazing (El-Hassan, M.I., 1995). Seed collection of native legumes, seed increase and reseeding of degraded rangeland is an option to significantly improve pasture productivity (Hamadeh, S. 2002). The results of this study, which are shown in figure 2, indicate that the average total dry matter weights for treatments where reseeding was applied (T2 and T3) were much higher compared to the other treatments (T1 and T4). P2O5 application did not affect legumes and grasses productivity in contrast to other species. Therefore, reseeding should be a major option for the rehabilitation of degraded rangeland in Nabha to re-establish the vegetative cover, diversify its composition and reverse the decline in pasture productivity, accompanied by the establishment of local grazing management scheme with full involvement of local communities.

![Figure 2: Average dry matter weights for the different treatments (g/unit area; unit area = 0.0625 m²)](image)

Acknowledgment
The authors would like to thank GEF-UNDP for their financial support, ICARDA for technical assistance and for providing seeds of native species and the Lebanese Agriculture Research Institute for the in-kind contribution and technical assistance as well as the local communities for their cooperation and contribution.

References
Contribution to the Elaboration of an On-Farm Conservation Strategy for Barley Landraces in Morocco

K. Rhrib¹, A. Amri², F. Nassif³ and F. Gaboun¹

¹ Institut National de la Recherche Agronomique (INRA), Rabat, Morocco. Email: rhrib@awamia.inra.org.ma / ² International Centre for Agricultural Research in the Dry Areas (ICARDA), P.O. Box 950764, Amman, Jordan. Email: a.amri@cgiar.org ³ Institut National de la Recherche Agronomique (INRA), Settat, Morocco. Email: fnassif@menara.ma

Keywords: barley, landraces, genetic diversity, adding value, in situ conservation,

Abstract

Barley landraces are still widely cultivated and highly appreciated by farmers in mountainous and dryland areas. They are known for their adaptative characteristics to biotic and abiotic stresses, as well as for their good grain and straw qualities. This work aims to enhance the knowledge for the promotion of in situ conservation, as the most appropriate way to better maintain and preserve the local germplasm of barley in Tanant and Taounate sites. Two types of studies were carried out which were 1) the diversity assessment of barley local populations from Tanant and Taounate sites and 2) the investigation of adding-value techniques applied to increase the productivity of barley landraces. Thirty-nine barley landraces collected from Tanant and Taounate villages were subject to an agro-morphological characterization at the experiment station and at on-farm. The results of statistical analysis showed the existence of a high variability between and within barley landraces from both sites for the majority of pertinent traits except for the thousand kernel weight and spike length in Taounate site. The cluster analysis gathered the local populations into five distinctive groups according to specific agro-morphological criteria. The improvement of seed lots quality through cleaning and treatment as well as chemical weeding is tested as techniques a low cost agronomic package in order to improve productivity of barley landraces in farmers’ fields. The results of the two years trials conducted on-farm and in the experiment station revealed the significant effect of seed treatment and chemical weeding on barley landraces productivity. The yield gain in certain cases reached 50%. The seed cleaning effect was not significant and confirmed the results of the test of farmers’ seed lots quality which was good for all tested populations. The results of yield potential evaluation of some of these populations in experiment station in comparison with two improved varieties (Igrane and Laannoceur) revealed an important yield potential of barley landraces but remain lower in comparison with the two checks. They also showed the ability of this material to produce more in-term of grain and straw, when the conditions are favorable (seed treatment, chemical weeding, irrigation, diseases treatment). The results of yield potential evaluation carried out “on- farm” revealed that all the landraces showed a superiority of yields in comparison with the improved varieties. Based on these results, some elements for promoting in situ conservation of barley landraces in Tanant and Taounate sites are proposed.

Introduction

Morocco presents a great diversity of environments and farming systems and subsequently is an important niche for more than 4500 plant species among which 14% are endemic (FAO, 1993). Morocco is well known as a center of diversity for many economic important species including barley (Baum, 1977; Baum and Feddak, 1985; Buirchell and Cowling, 1989; Bounejmate, 1992). Barley is the most widely grown crop in Morocco. The five-year
average (1996-2000) indicates 2.2 million hectares of barley cultivated annually which represents 41% of the total cereal area (Nassif et al, 2003). Barley is grown by the quasi-majority of farmers regardless of farm size. Most importantly, barley is produced across all agro-ecological zones of the country with typical barley producing areas located under the most fragile and marginal conditions of the arid and semi-arid and mountainous areas characterized by high intra and inter-annual climatic variability. Because of its adaptation to harsh conditions and multiple uses as feed and food, barley is definitely one of the few crops that are highly appreciated by Moroccan farmers. Over 20 new barley varieties have been developed by the National Agricultural Research Institute (INRA) since 1973 (Amri, 1994 Memoire ingenieur en chef). However, landraces are still grown in more than 75% of total barley area. Certified seeds are used in 1% of annual barley area compared to 13 and 20% respectively for durum wheat and bread wheat.

Because of its desired genetic characteristics, the local germplasm of cereals, especially in the case of barley, has been widely used in national and international breeding programs. In fact, some barley varieties developed by INRA-Morocco were used by Australians to improve nematodes resistance, and are well known for their forage production ability (Rhrib et al, 1995). Furthermore, a recent study showed that local populations of barley harbor an important genetic variability between and within populations (Rhrib, 1996; Rhrib et al, 2002). Most of barley landraces are highly resistant to yello and leaf rusts (Amri, 1994). However, the diversity of these resources is more and more threatened by the abandoning of farming with successive droughts experienced lately and the gradual adoption of newly released homogenous varieties. This genetic erosion reached even marginal areas. Thus, the need to conserve these resources and the urgency of their preservation were recognized at international and national levels and by many organizations and programs. Whereas the collect and the preservation of plant genetic resources in genebanks (ex situ conservation) allowed a sampling of restricted part of genetic diversity, the in situ conservation in farmers’ fields offers a new approach for conserving larger genetic base and to ensure the preservation of evolutionary and adaptation processes and the diversity embodied in the crop and prevailing agro-ecosystems. It allows local communities to preserve related local knowledge. This later approach is recently promoted by many organizations and projects over the world and for many species (Altieri and Merrick, 1987; Oldfield and Alcorn, 1987; Brush, 1991; IPGRI, 1993; Bouch et al, 1994; Li and Wu, 1996; Demissie and Bjornstad, 1996; Bellon et al, 1997; Iwanaga, 1997, Amri 2005). In situ conservation of the landraces is recently presented as a better way for conservation and should be complementary to the on-going efforts of conservation in gene banks.

This research was part of the project on “Strengthening the scientific basis of in situ conservation of agricultural biodiversity on-farm: Morocco’s component” in cooperation between INRA, IAV-Hassan II and IPGRI. This paper is based on two major research activities conducted over three years in Tanant and Taounate sites of Morocco. These are the diversity analysis of barley landraces of both sites and the contribution to on-farm adding value of barley landraces in the same sites through the increase of their productivity.

Materials and methods

The activities conducted were: a) socioeconomic studies, essentially surveys of the farming systems in the sites conducted by multidisciplinary teams b) on-farm and on-station trials for agro-morphological characterization of barley landraces in Tanant and Taounate sites in order to determine the existing genetic variability between and within these populations on-farm, c) a trial to evaluate the yield potential of local populations of barley, d) trials of the effects of
seed cleaning, treatment and chemical weeding on productivity of barley landraces and e) grain quality analysis of barley landraces at the INRA food technology laboratory. The collections of barley local populations were conducted in 1998-1999 and 1999-2000 season after choosing the two project sites for barley (figure 1).

Figure 1: Collecting sites of barley landraces in Morocco

These sites were the Chaynou village in Thar souk rural community, Taounate province, and Bouhrazen village in Tanant rural community, Azilal province. While both Tanant and Taounate sites represent mountain areas, Tanant site is semi-arid (350 mm average rainfall) and Taounate site is relatively humid (600 mm rainfall). The most important common feature of both sites is the important place devoted to barley in the prevailing cropping systems. Survey samples consisted of 43 farmers from the Bouhrazen village (Tanant site) which represented the third of the total number of farmers in that village. In Chaynou village (Taounate site), all the 54 village farmers were surveyed. The survey questionnaire was designed and validated by the in situ conservation project multidisciplinary team with emphasis on the target crop and on-farm conservation aspects such as barley crop management, farmer knowledge and use of barley improved varieties, farmers’ perceptions of barley landraces, desired crop characteristics, seed sources and seed management. All the field work was conducted by a multi-disciplinary team which comprised among others a barley geneticist and a sociologist (Nassif and Mahdi, 2002).

For the agro-morphological characterization, 30 head-rows from each of 39 barley landraces collected from Tanant and Taounate sites (how many for Tanant and how many for Taounate) respectively were planted at Merchouch research station during the 1998-99, 1999-00 and 2000-01 cropping seasons. Characters measured included plant growth habit (erected, semi-erected, semi-prostrate and prostrate), tillering capacity, plant vigor (very high, high, intermediate, low and very low), plant height (cm), resistance to major diseases, spike traits (spike length and shape, awn color and length, kernel size (cm) and seed color (brown, white...
and yellow) and fertility characteristics (number of grains/spike and thousand kernel weight). Descriptive statistical analysis (means and coefficient of variation), frequency distribution, analysis of variance and variance decomposition for each trait and multivariate analysis (CPA, Hierarchical analysis) were performed using SAS statistical package. Only the most pertinent characters will be emphasized in the results.

An additional trial was conducted at Merchouch research station during the 2000-01 cropping season to evaluate the yield potential of four barley landraces collected from Tanant and four collected from Taounate in comparison with two improved varieties (Laanoceur and Igrane). The experimental design was a randomized complete block design (RCBD) with three replications. Measured traits included days to heading, days to maturity, plant height, grain and straw yields. Analyses of variance as well as mean comparison were performed.

For the effects of seed cleaning and treatment and chemical weeding, four kilos of seed samples of five barley landraces were collected from Taounate farmers’ seed lots and four from Tanant farmers’ seed lots. During the 1998-99 cropping season seed samples were divided into four lots (cleaned/treated, cleaned/non-treated, non-cleaned/treated and non-cleaned/non treated) and returned back to each of the respective farmers who supplied the seed. During the 1999-00 cropping season, collected seed samples were divided into four treatments: treated/weeded, treated/not weeded, not treated/weeded and not treated/not weeded and planted back at each of farmers who supplied the seed, using randomized complete block designs (RCBD) with three replications. Characters measured included yield and yield components. The fungi treatment to control seed born diseases was made by using Vitavax with a dose of cc/kg of seeds. The chemical weeding was applied at 3-4 leaf stage, using first Grandstar against dicotyledones (12 g/ha) and Illoxan against wild avena (1 l/ha) after a week. In conjunction with these trials, about 100 grains from each seed sample were subjected to germination and purity tests.

With respect to the analysis of grain quality, grain lots (200-300g) of barley local populations were collected from Tanant and Taounate farmers. These lots were analyzed at the INRA laboratory of food technology in order to determine the grain quality of collected populations. Measured traits included hectolitre weight, protein rate, and yield after husking.

Results and discussion

The results of socioeconomic surveys confirmed the important place of barley within the farming systems. On average, barley is grown on about two thirds of Bouhrazen farms and 44% in Chaynou farms. Another important finding is the fact that barley landraces were used by 100% of surveyed farmers in both villages. All surveyed farmers from Bouhrazen as well as from Chaynou recognized using the local variety of barley that is generally called “beldi”. Farmers often use many criteria to differentiate the landraces. For them, these criteria are numerous and often repetitive. But, they can be gathered into criteria related to performance, color, food quality and grain and straw yields. For example, barley landraces from Tanant site is distinguished by clear grain color (white – yellow), long grain, high stems, long spike, tasty flour, and good straw yield. Farmers from the two sites are unanimous about the reasons of the utilization of these barley landraces. These reasons include the heritage, their availability, their production within the villages, their adaptation to prevailing harsh conditions of the two sites, their straw yields and their good quality for human food and animal feed. The results of the agro-morphological characterization of barley landraces on station revealed that most barley populations collected from Tanant and Taounate sites were characterized by
yellow awns, white kernels, dense spikes, moderately erected plant growth habit, and a high plant vigor (Figures 2 to 6).

Figures 2-6: Frequencies distribution of barley landraces collected from Tanant and Taounate sites for some agro-morphological traits

The results of variance decomposition using the variance components estimation procedure for each site revealed a high genetic variability between and within populations for the majority of measured variables (Tables 1 and 2). This indicates the existence of a strong heterogeneity among studied barley landraces. The same results were found by Rhrib (1996) on barley landraces collected from 5 different regions of Morocco and by Jaradat (1991) on Jordanian durum wheat landraces. PCA and cluster analysis allowed distinguishing five different groups or units characterized by specific agro-morphological traits (Table 3). Similar results were found by Brown (1999) on barley where he has identified 9 groups based on the dissimilarity of morphological and developmental traits. The table 4 showed the power of agro-morphological characters as discriminatory variables of groups obtained by hierarchical analysis. In fact, the grain color is the most discriminating trait of the five groups. In contrast, awn color, spike length, thousand kernel weight and the number of grains/spike are the least discriminating traits of the same groups. While awn length and plant height, possess an intermediate discriminating power.
Table 1: Signification of differences between barley local populations for the measured characters:

<table>
<thead>
<tr>
<th>Traits</th>
<th>F test value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant vigor</td>
<td>9.83</td>
<td>0.0001</td>
</tr>
<tr>
<td>Plant height</td>
<td>8.93</td>
<td>0.0001</td>
</tr>
<tr>
<td>Plant stand</td>
<td>2.44</td>
<td>0.0001</td>
</tr>
<tr>
<td>Spike characters:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Awn length</td>
<td>10.38</td>
<td>0.0001</td>
</tr>
<tr>
<td>- Spike density</td>
<td>10.03</td>
<td>0.0001</td>
</tr>
<tr>
<td>- Awn color</td>
<td>8.43</td>
<td>0.0001</td>
</tr>
<tr>
<td>- Spike length</td>
<td>2.38</td>
<td>0.0001</td>
</tr>
<tr>
<td>Grain color</td>
<td>8.77</td>
<td>0.0001</td>
</tr>
<tr>
<td>Fertility characters:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1000 grains weight</td>
<td>13.43</td>
<td>0.0001</td>
</tr>
<tr>
<td>- Number of grains/spike</td>
<td>5.18</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Table 2: Structure of genetic diversity of barley local populations in Tanant and Taounate

<table>
<thead>
<tr>
<th>Site</th>
<th>Tanant</th>
<th>Taounate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters</td>
<td>F test value Differences between populations</td>
<td>F test value Differences within populations</td>
</tr>
<tr>
<td>Spike characters:</td>
<td>**</td>
<td>***</td>
</tr>
<tr>
<td>- Spike length</td>
<td>**</td>
<td>***</td>
</tr>
<tr>
<td>- Spike density</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>- Awn color</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>- Awn length</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Grain color</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Fertility characters:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Number of grains/spike</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1000 grains weight</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at 0.05      *** Significant at 0.01
Table 3: Groups of barley populations defined using hierarchical analysis for all characters

<table>
<thead>
<tr>
<th>Groups/units</th>
<th>Populations</th>
<th>Characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>GR1</td>
<td>1,3,8,9,10,11,12 et 14</td>
<td>Yellow grains, dense spikes, high awn length and number of grains per spike and a plant height exceeding 121 cm</td>
</tr>
<tr>
<td>GR2</td>
<td>2,5,7 et 15</td>
<td>Brown grains and awns, prostrate plant growth habit and a high 1000 grains weight and spike length</td>
</tr>
<tr>
<td>GR3</td>
<td>6,62 et 63,64,59,61</td>
<td>High vigor and semi prostrate plant growth habit, white and yellow awns</td>
</tr>
<tr>
<td>GR4</td>
<td>13,49,4,53 et 65</td>
<td>White awns, very high plant vigour and semi erected growth habit</td>
</tr>
<tr>
<td>GR5</td>
<td>44,47,48,50 54,56 et 57</td>
<td>Lax and intermediate spikes</td>
</tr>
</tbody>
</table>

Table 4: Classification of characters according to their discriminative degree of units based on F test

<table>
<thead>
<tr>
<th>Variables</th>
<th>F</th>
<th>Pr &gt;F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain color</td>
<td>93.50</td>
<td>0.25%</td>
</tr>
<tr>
<td>Awn length (cm)</td>
<td>10.08</td>
<td>0.1%</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>7.22</td>
<td>0.06%</td>
</tr>
<tr>
<td>1000 grains weight (g)</td>
<td>4.23</td>
<td>0.95%</td>
</tr>
<tr>
<td>Number of grains/spike</td>
<td>4.51</td>
<td>0.71%</td>
</tr>
<tr>
<td>Spike length (cm)</td>
<td>3.6</td>
<td>1.89%</td>
</tr>
<tr>
<td>Awn color</td>
<td>0.695</td>
<td>60.20%</td>
</tr>
</tbody>
</table>
Concerning the yield potential evaluation trial, the variance analysis results for each site revealed significant differences between populations for the studied traits except for the straw yield in Tanant and Taounate sites and for plant height in Tanant (Table 5). When compared to improved varieties (Igrane and Laanoceur), landraces had higher straw yields (Table 6). Straw yields varied between 3805 kg/ha for Laanoceur and 5366 kg/ha for the local population from Tanant. However, grain yields of Laanoceur and Igrane out-yielded all local populations at both sites. Grain yields of landraces varied between 1579 and 2452 kg/ha.

Table 5: Analysis of variance of date to heading, date to maturity, plant height, grain and straw yields of barley landraces in Tanant and Taounate sites

<table>
<thead>
<tr>
<th>Site/variables</th>
<th>Day to heading</th>
<th>Day to maturity</th>
<th>Height (cm)</th>
<th>Grain yield (kg/ha)</th>
<th>Straw yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taounate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fobs</td>
<td>30.82***</td>
<td>79.61***</td>
<td>ns</td>
<td>3.87*</td>
<td>ns</td>
</tr>
<tr>
<td>VC</td>
<td>2.29</td>
<td>0.9</td>
<td>4.32</td>
<td>16.48</td>
<td>11.19</td>
</tr>
<tr>
<td>Mean</td>
<td>101.5</td>
<td>150.33</td>
<td>96.66</td>
<td>2201</td>
<td>4933</td>
</tr>
<tr>
<td>Tanant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fobs</td>
<td>17.30***</td>
<td>16.29***</td>
<td>4.75**</td>
<td>9.28***</td>
<td>ns</td>
</tr>
<tr>
<td>VC</td>
<td>1.97</td>
<td>1.03</td>
<td>5.49</td>
<td>1104</td>
<td>1441</td>
</tr>
<tr>
<td>Mean</td>
<td>94.05</td>
<td>144.72</td>
<td>101.94</td>
<td>2620</td>
<td>4361</td>
</tr>
</tbody>
</table>

Table 6: Multiple comparison of day to heading, day to maturity, plant height, grain and straw yields for barley landraces and two improved barley varieties in Tanant and Taounate sites

<table>
<thead>
<tr>
<th>Barley landraces/Traits</th>
<th>Day to heading</th>
<th>Day to maturity</th>
<th>Plant height (cm)</th>
<th>Grain yield (kg/ha)</th>
<th>Straw yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tanant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>95</td>
<td>146.66</td>
<td>101.66</td>
<td>2448</td>
<td>5366</td>
</tr>
<tr>
<td>2</td>
<td>97.33</td>
<td>146.33</td>
<td>96.66</td>
<td>2155</td>
<td>4918</td>
</tr>
<tr>
<td>3</td>
<td>98.33</td>
<td>148</td>
<td>113.33</td>
<td>2452</td>
<td>4918</td>
</tr>
<tr>
<td>4</td>
<td>96.66</td>
<td>147</td>
<td>108.33</td>
<td>2113</td>
<td>4773</td>
</tr>
<tr>
<td></td>
<td>Taounate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>103.33</td>
<td>153</td>
<td>96.66</td>
<td>2392</td>
<td>4421</td>
</tr>
<tr>
<td>6</td>
<td>111</td>
<td>159.66</td>
<td>96.66</td>
<td>1749</td>
<td>4901</td>
</tr>
<tr>
<td>7</td>
<td>104.66</td>
<td>154.33</td>
<td>98.33</td>
<td>2055</td>
<td>4490</td>
</tr>
<tr>
<td>8</td>
<td>108</td>
<td>155.33</td>
<td>95</td>
<td>1579</td>
<td>4301</td>
</tr>
<tr>
<td>Igrane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laanoceur</td>
<td>87.66</td>
<td>137</td>
<td>91.66</td>
<td>2642</td>
<td>4246</td>
</tr>
<tr>
<td></td>
<td>94.33</td>
<td>143.66</td>
<td>101.66</td>
<td>2787</td>
<td>3805</td>
</tr>
</tbody>
</table>
The on-farm seed cleaning and treatment trial during 1998-99 cropping season did not show significant positive effects on grain yield. This confirmed the good quality of farmers’ seed lots as indicated by germination and purity tests. In fact, the germination tests revealed high germination rates and good purity of seeds of all tested populations. Germination rates varied between 89 and 99% with an average of 96% and purity rates varied between 87.0% and 98.9% with an average of 95.9%. However, the on-farm trial during the 1999-00 season on the effect of seed treatment and herbicide use on yields revealed that these technologies increased yields significantly. In fact, the variance analysis results for the grain yield revealed the existence of a highly significant differences between the four treatments which are treated and weeded lot (TW), treated and non weeded lot (TNW), non treated and weeded lot (NTW) and non treated and non weeded lot (NTNW) (Table 7). The fungi treatment of seeds and the chemical weeding allowed an important gain in the grain yield by almost 50% for the majority of barley landraces in both Tanant and Taounate sites (Table 8). The results revealed that the mean grain yield of barley landraces in Taounate site was higher than the one of landraces from Tanant site regardless the type of the treatment applied. The seed cleaning and treatment is promoted through the demonstration of small machines for mechanical seed treatment and cleaning. A dozen units of these machines were bought with distributed to farmers in order to establish farmers and community based informal seed production at both Tanant and Taounate sites.

With respect to grain quality of barley landraces, hectolitre weight of barley populations of both Tanant and Taounate sites was found to be close to that of the improved varieties Laanoceur and Igrane (Rhrib, 2000). Moreover, Taounate landraces had higher weight than the checks and reached 64.9%. Protein level of Tanant barley landraces was higher than that of Taounate landraces and outweighted that of the new varieties. One of the barley landraces from Tanant reached a protein content of 15.2%. Yield after husking was high for all landraces of both sites and exceeded 72.35%. It’s clear that most barley landraces have interesting quantity and quality characteristics which explain why farmers appreciate them and still continue to use them exclusively.

Table 7: Analysis of Variance of the effects of the four treatments on grain yield of local populations of barley in the two sites Tanant and Taounate.

<table>
<thead>
<tr>
<th>Sites</th>
<th>F-value and significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanant</td>
<td>5.20**</td>
</tr>
<tr>
<td>Taounat</td>
<td>17.84***</td>
</tr>
</tbody>
</table>

** Significant at 5%  *** Significant at 1%

Table 8: Mean grain yields (kg/ha) of barley populations by site and by treatment

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Tanant site</th>
<th>Taounate site</th>
</tr>
</thead>
</table>
### Conclusion

Morocco is considered among the most important reservoirs of barley landraces. Not only is barley the most cultivated cereal but barley landraces remain widely produced and maintained based on an informal seed system by which farmers produce their own seeds. Consequently, barley landraces are maintained and modeled from generation to generation under combined effect of different natural and human selection pressures. In fact, farmers modify progressively genetic structure of landraces by selecting plants with preferred traits. With time, these landraces acquire adaptive traits that are specific to their cultivation areas. Finally, farmers become guarantors of the conservation of this diversity.

The *in situ* conservation of landraces is a dynamic and participative approach that takes advantage of farmers and their local knowledge and allows a continued evolution and a development of useful germplasm. The establishment of scientific basis for the *in situ* conservation of barley landraces requires the understanding of the processes and the mechanisms of maintenance and on farm management of genetic diversity under the effect of traditional practices of farmers. Socioeconomic description of Tanant and Taounate sites through surveys allowed to assess the reasons behind farmers’ low adoption of barley improved varieties. The studies results confirmed the adaptation embodied in landraces and that adaptation was one of the reasons behind farmers’ use and maintenance of local populations. The analysis of two years agro-morphological characterization data, revealed an important genetic variability between and within landraces for the majority of measured traits. The cluster analysis identified groups or units of landraces characterized by specific agro-morphological traits.

The third part of this study aimed to identify ways or adding value techniques which can enhance productivity of barley landraces on-farm. The first concerned the evaluation of yield potential of barley landraces in Tanant and Taounate sites in comparison with two improved varieties (Igrane and Laanoceur). The second focused on the evaluation of the effects of seed cleaning and treatment and chemical weeding on the productivity of these landraces. The evaluation of yield potential of barley landraces in experiment station demonstrated that there are still possibilities to improve the yield of these landraces. The latter had better straw yields and less grain yields the improved checks. However, landraces performed better and exceeded the checks on-farm. The analysis of the results also revealed the importance of seed treatment and the chemical weeding on grain yield of barley landraces. The chemical weeding has not a significant effect because the manual weeding form barley fields in Tanant and Taounate sites is more perceived as a grass collecting for animal feeding than a cleaning operation of the field. The results of the analysis of grain quality confirmed why farmers from Tanant and Taounate sites still use and highly appreciate barley landraces rather than improved varieties.

### Recommendations

Conscious of the importance of existing genetic variability between and within barley landraces and of their potentialities to produce more through the identification of simple adding value means, future directions should be oriented to formulate development actions as
an integral part of an in situ conservation strategy. These actions should include the following:

- Establish an effective informal seed production system which will be under local communities’ responsibility and integrated in already existing cooperatives systems. This will be supported by the existing local development associations which could contribute to their management. These means will allow to add value to barley landraces via the improvement of their productivity and conservation;

- Involve farmers in the management of their local resources and find ways to maintain a sustainable balance between conservation and seed production. In fact, this balance includes the implication of farmers by helping them to maintain this rich diversity between local populations and to improve their productivity;

- Strengthen the utilization of biochemical and molecular markers to analyze the existing genetic diversity and quantify its extent. This work will contribute to set up identification criteria of units already found by agro-morphological characterization without the environment effect.

- Explore the genetic variability and the potentialities of production within barley landraces in barley breeding programs. Three strategies could be identified: 1) the development of high yield pure lines from landraces after testing their stability in different environments 2) the use of pure lines extracted from barley landraces which are superior for the yield and for other traits (quality, diseases resistance,..) as parental material in crosses in order to introduce desirable characters in adapted genetic background; and 3) the development of mixtures or multi-lines established from a variable number of pure lines characterized for many agronomic and stability traits.

- To conclude, the livelihoods of the custodians of this valuable genetic resources should be tackled through improvement of the productivity of landraces, the increase of their marketability and the investigation of alternative sources of income. Maintaining genes of this rich material in breeding programs or through in situ conservation program is a moral obligation towards all the farmers who maintained them for many years and the benefit sharing recognized by the international conventions and agreements on biodiversity and genetic resources should help in rural development efforts in the biodiversity rich areas in the world.

References


Spring barley is sown in the Central Valley and surrounding foothills of California in November and early December similar to many environments in North Africa and the drylands of the Middle East. Historically California barleys were considered “Coast” types of Egyptian origin as opposed to “Manchurian” type barleys. Fifty years ago about one million acres were sown to barley but today the acreage has declined for several reasons including competition from wheat, low commodity prices, increased production costs, and other factors. The sown spring barley area is now down to about 100,000 acres. As a result of declining acreage, barley is now a specialty crop occupying several end-use niches to which the barley breeding program has adapted. The breeding goals include the following: (1) short statured (semidwarf) six-rowed feed barley, (2) naked grained (hulless) barley for human consumption (3) early heading barley for low rainfall areas, (4) hooded, intermediate stature barley for forage production, (5) six- and two-rowed malting barleys for the brewing industry, and (6) feed barley for long daylengths environments. The barley breeding program is located at the University of California at Davis (UCD) and has a minimal budget with all breeding work done by a single scientist who is funded only by extramural sources.

Short-statured, six-rowed feed barley. The six-rowed feed barley improvement program has been core breeding component for several decades. The semidwarf plant type predominates but major defects still exist and improvements in grain yield and yield stability over years can still be made. Even though the sdw gene is used lodging is still a problem in the higher rainfall environments. With the use of the sdw gene lodging has become less of a problem but plant stature needs to be reduced about another five to seven centimeters to eliminate the lodging problem. The other area of improvement involves breeding for disease resistance. Barley stripe rust has become a new, major disease in the last decade and race surveys indicate that there are pathotypes capable of overcoming all the known genes conferring resistance. Scald and net blotch continue to be important diseases in northern part (Sacramento Valley) of the Central Valley, which has abundant rainfall. Barley yellow dwarf virus is present every year but losses have been prevented for decades now by the use of the yd2 gene. A new effort is being made to eliminate modest grain yield losses resulting from “cereal yellow dwarf virus” (CYDV) by using the resistance found in the ICARDA/CIMMYT lines “Bella Union” and 23 IBYT 7, which was derived from “Egypt4/Teran78//P.Sto/Quina”(1). Powdery mildew has become a minor disease and leaf rust appears too late in the growing season to cause yield losses. Yield losses because of Russian wheat aphid can be avoided in most growing areas by the use of appropriate planting dates but some spring barley plantings can destroyed. With the decline in sown acreage, barley diseases appear to have also declined in importance, but the threat of a stripe rust epidemic is a clear and present danger to the remaining barley acreage. The ICARDA /CIMMYT barley breeding program has become the primary source of germplasm for the California six-rowed feed barley improvement program primarily because the diseases common in the Yaqui Valley of northern Mexico are shared in common with California. This conclusion is supported by the observation that over the years barley lines selected near Ciudad Obregon have been demonstrated to have excellent disease resistance in California whereas material coming from more distant breeding programs do not.
Naked grained, hulless barley. The hulless lines coming from the ICARDA/CIMMYT barley improvement program have been an important germplasm resource for the California breeding program. Commercialization of the first six-rowed, hulless barley seems likely. The advanced line UC 1134, derived from the cross CMB91A-1192-AL/UC 960, produces a high grain yield with good threshability. The grain beta-glucan content is almost seven percent. High beta-glucan soluble fiber content is desirable for a heart healthy diet in order to decrease cholesterol in the blood stream. Hulless barely is likely to become increasingly important in the future as an alternative to oats from for human consumption and as a result this breeding goal has taken on increased importance.

Early heading time. Annually we have evaluated the ICARDA/CIMMYT early maturity lines at Davis. The $ea_k$ gene originating from “Kinai” or the “Bonus” mutants as well as the $ea_{sp}$ gene from “Super Precoz” predominate in the ICARDA/CIMMYT early maturing materials. The other two $ea$ genes, originally called $ea$, from China, and $ea_7$, first identified at Davis, conferring early heading were not fully exploited by the ICARDA/CIMMYT program, but both produce heading times similar to $ea_k$ and $ea_{sp}$ genes at Davis. At least two of the $ea$ genes conferring extreme earliness have dominant enhancers ($En$), which cause an even earlier heading time, but both the $En-ea$ and $en-ea$ genotypes have proven too early for our environment(3). However when the $sdw$ gene, which confers a semidwarf character and delays heading 3 to 5 days was added, the phenotype appeared much more productive. Barley which heads too early is subject to frost damage if heading occurs much before March 15 and biomass is usually very low. Furthermore the major part of plant growth occurs when scald is extremely important, while later heading plants grow out of this period producing clean penultimate and flag leaves. The first cycle of breeding produced interesting lines but they still lodged too much and produced seed lacking in sufficient plumpness. A second breeding cycle seeks to correct these deficiencies. A second genetic subsystem also confers extreme earliness and was evaluated at Davis. The genes in this subsystem are traced back to “Olli”. With early November emergence plants would begin jointing in December or early January and when colder days continued the plants would rosette at the apex and lodge at crown level producing a maladapted phenotype (the arrested internode elongation phenotype with rosetted leaves) which was unsuitable for the Central Valley(3). Early maturing barleys with the $en-ea-sdw$ genotype should be useful for marginal rainfall areas in the southern part of the Central Valley (San Joaquin Valley), where frost damage is not a problem.

Hooded barley for forage. A forage barley from the UCD barley breeding program has not yet been commercialized. One of the major impediments has been the lack of plumpness associated with the use of hoods rather than traditional awns. The first cycle of breeding focused on the use of “Hooded Atlas” as a parent. A second cycle of breeding will use the Oregon St. Univ. barley “Sara/Tango” crossed to UCD hooded lines selected for plumpness. “Sara” was selected from ICARDA/CIMMYT material by Pat Hayes, who crossed it to “Tango”.

Feed barley for long daylengths. The Klamath Basin on the California-Oregon border has an environment which differs from that of the Central Valley. Whereas barley is sown in November to mid-December in the Central Valley, barley is planted in mid-April through early May in the Klamath Basin. At a much higher altitude (1500m) with high radiant energy and a short growing season which ends in late August to early September, the Klamath Basin produces extremely high grain yields on organic soils with a shallow water table. Barleys bred for the Central Valley generally perform poorly in this environment where spring barleys from Idaho and Minnesota do quite well. The breeding plan for this environment was
to cross high grain yielding barleys adapted to southern Idaho and northern Utah with more
disease resistant semidwarf material from the program at Davis

Barley with malting quality. Prior to World War II, California exported six-rowed barley to
England for malting. That market was destroyed by the war. Two decades later a modest
breeding effort was made to introduce mid-western malting quality into the “Atlas” barley
background for the California environment but the effort was short lived and not sustained.
In the United States malting barley production is concentrated mostly in North Dakota,
Montana, Idaho, and Washington. Canadian provinces adjacent to these states are also major
producers of malting barley. Unfortunately malting barleys from these growing areas are
poorly adapted to Central Valley growing conditions. Closer to California the malting barley
breeding program at Oregon State University focuses on winter malting barley improvement.
This source of malting germplasm is being exploited because many of the diseases occurring
in California are also common in Oregon. The current strategy is to identify
ICARDA/CIMMYT parents having near malting quality combined with good adaptation to
Central Valley growing conditions and cross these lines with the best available lines from the
northern states or provinces. Both two-rowed and six-rowed barleys are being exploited. Each
set of ICARDA/CIMMYT lines is evaluated at Davis for two or three years for agronomic
appearance. Subsequently a small number of selections are sent to the USDA Malt
Laboratory in Madison, Wisconsin. Based on their results the majority of the selections are
discarded with only a small number of lines being used as parents. To date the best two-
rowed selections have been the following: 28IBON107, 29IBON20, and 30IBON299. These
three lines plus “Orca” from Oregon St. Univ. combine the adaptation, disease resistance and
near malting qualities that are required of good parents. The ICARDA/CIMMYT line
“Madre Selva” is being used as a parent for resistance to CYDV transmitted by the aphid
Rhopalosiphum padi. No six-rowed parents with near malting quality have been identified.
One six-rowed barley with near-malting quality from the cross to “Stander” to “UC960” is
used as a parent. But generally six-rowed California feed barleys are poor parents for malting
purposes in that they are too low in alpha- and beta-amylase activity, soluble protein, soluble/
total protein ratio, diastatic power and are far too high in wort beta-glucan. Six-rowed malting
barleys from Mexican breeding programs might provide a good source of germplasm and
remain to be evaluated in the Central Valley.

International usefulness: Barleys bred in California should be adapted to warmer
environments in the Mediterranean region including, southern Spain and southern France,
North Africa and parts of the Middle East including Egypt, Israel, Palestine, Jordan, and
Saudi Arabia(2).

References
Capettini, F., H. Vivar, L. Gilchrist, and M. Henry, 2001 Building up multiple disease
resistance in barley. CIMMYT Wheat Symposium, Poster On-line.
Gallagher, L.W. and K.M. Soliman, 1988 Classification of global environments and cultivars
Gallagher, L.W. and L. BelMoktar, 2001 Inheritance of heading time in spring barley
Small ruminant production on range and stress lands in Pakistan

A. Iqbal1*, M.A. Mirza2 and M.J. Hayat1

1 Department of Livestock Management, University of Agriculture, Faisalabad, Pakistan
E-mail: dr.arshad_iqbal@hotmail.com
2 Institute of Animal Nutrition & Feed Technology, University of Agriculture, Faisalabad, Pakistan.

Keywords: Small ruminants, rangelands, agro-ecological zones, production systems, Pakistan

Abstract
Pakistan has 87.98 million hectares (MH) land, of which 59.3% is wasteland and depleted rangeland with poor vegetation. The population of sheep and goat is estimated at 24.7 and 54.7 million respectively. Lack of water resources limits viable agricultural activity in these rangelands which support approximately 80-90% small ruminants and meet their 60% feed requirements. There is a heavy pressure on these rangelands from grazing animals. Out of the total land area, 68 MH land receives annual rainfall less than 300 mm, 6.3 MH is saline and unfit for crop production. Lack of water resources, and in some areas souring day temperature limit vegetative growth of most plants except some grazable trees, shrubs and grasses which can singly or with other feedstuff meet the maintenance requirements of sheep and goats. In developing countries like Pakistan, the challenge of hunger elimination and food security can be achieved through extensive use of these resources.

Introduction
Pakistan has 87.98 MH land, of which 59.3% is wasteland and depleted rangeland with poor vegetation. Its 68 MH land lies in fragile region receiving annual rainfall of less than 300 mm, 15.5 MH affected by water logging, 6.3 MH affected by salinity and unfit for crop production. Pakistan supports 79.4 million small ruminants (Anonymous, 2004). They are mainly raised for mutton production. The milk produced by them has a negligible share (Iqbal et al. 2003). Small ruminants contribute 42% of the total meat produced in the country (Afzal et al. 2003). Traditional Muslim festival (Eid al-Adha) is the major single event when a remarkable number of first-rate young male animals of trendy local goat and sheep breeds like Beetal, Kamori, and Kajli are directly bought by families for thanks giving and sacrificial purpose.

As small ruminants are maintained by traditional pastoralist families and landless farmers, they are obviously on meagre feed resources and hence their productivity is not optimal. Rapid increase in human population had driven agriculture towards intensification consequently; the grazing civilization is fast disappearing from irrigated areas. Besides the grazing areas are gradually being denuded due to overgrazing and soil degradation resulting from salinity, sodicity and water-logging (Gill et al. 1995).

Balochistan province has the biggest chunk of rangelands (Table 1) with very poor vegetation. The stocking density is lowest in these rangelands because annual rainfalls are extremely low and summer temperatures are oppressively high. Small ruminants are the predominant group of livestock in these areas. Improvement in agricultural farming in these areas could change the status of principle feed resources available for small ruminants.

Table 1: Distribution of range lands in Pakistan

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Area</th>
<th>Range Area</th>
<th>Percentage of</th>
</tr>
</thead>
</table>
This article gives a detailed account of the agro-ecological zones of Pakistan. It briefly describes common breeds of small ruminants and traditional production systems employed in various areas of Pakistan. It also describes how population pressure has affected the natural feed resources and how rangelands are under intense grazing pressure and how consistent efforts to improve these rangelands had paid off in last many years.

1. Agro-Ecological Zones of Pakistan
Pakistan has diversified area with respect to agro-ecological zones. It has immensely high peaks (K2- the 2nd highest in the world) and at the same time areas which are at sea level. Pakistan could be divided into six agro-ecological zones: subtropical dry, tropical moist, subtropical moist, temperate moist, temperate dry and alpine or cool highlands (Quraishi et al. 1993). Various agro-ecological zones are shown in Fig 1. These zones vary in climate, rainfall, altitude, topography and density of human population.
1.1. Subtropical dry (Arid) zone
This zone covers 43% of the country’s area. It receives 0-250 mm of rainfall annually. Excessively dry and hot weather with little and erratic rains prevent cropping during most part of the years. Some hardy grazable perennial grasses like Dhaman (Table 2) and scattered shrubs like Phulai and Wan, Jand and trees like Kikar (Table 3) can successfully be grown and maintained in this area.
Table 2: List of local natural grasses and conditions that favour their growth

<table>
<thead>
<tr>
<th>Grasses (local name)</th>
<th>Favouring Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hurricane grass (Palwan)</strong></td>
<td>Sub tropical sub-humid to humid ecological zones with 500-1300 mm rainfall. Drought tolerant can grow on moderately acidic to slightly alkaline.</td>
</tr>
<tr>
<td><strong>Cenchrus ciliaris (Dhaman)</strong></td>
<td>Arid, semi arid and tropical areas. Rainfall 350-800 mm. Prefer sandy loam soils. Also adoptable to harder and heavy textured scrub soils.</td>
</tr>
<tr>
<td><strong>Chloris gayan (Rhode grass)</strong></td>
<td>Annual rainfall requirement is 600-1200 mm. Wide adoptability to light to heavy textured sandy loam soils but prefers fertile soils.</td>
</tr>
<tr>
<td><strong>Cynodon dactylon (Khabbal or Bermuda grass)</strong></td>
<td>Prefers heavy soil than light soil. Withstands flooding and grow well both in acidic and alkaline soils.</td>
</tr>
<tr>
<td><strong>Elephant (Pennisetum purpureum)</strong></td>
<td>Suitable for Pothowar Plateau where rainfall exceeds 500 mm. Grows best on deep soils of moderate to fairly heavy texture. Tolerates short drought t but does not withstand water logging.</td>
</tr>
<tr>
<td>Grazable trees/bushes (local name)</td>
<td>Favoring Conditions</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Leucaena leucocephala (Ipil-Ipil)</strong></td>
<td>Extensively planted in scrub ranges in Punjab and under dry conditions in Sindh. It requires considerable rainfall (600-1700 mm). It can survive high temperature (45°C) and grows well in neutral to slightly alkaline soils (pH upto 8) and frost tender.</td>
</tr>
<tr>
<td><strong>Prosopis cineraria (Jand-Kandi)</strong></td>
<td>It grows in wide range of soils with sufficient sub-soil moisture. It is both drought and salt tolerant. Tolerates pH as high as 9.8.</td>
</tr>
<tr>
<td><strong>Acacia nilotica (Kikar)</strong></td>
<td>Its maximum shade temperature, maximum (40-50°C) and minimum (-1-15°C) of its habitat and mean rainfall 400-800 mm. It is salt tolerant but does not tolerate water logging.</td>
</tr>
<tr>
<td><strong>Acacia Senegal (Khor)</strong></td>
<td>Grows under sub-desert conditions where rainfall is as low as 200 mm but prefers 300-450 mm. It can survive the most adverse conditions. Considered ideal for reclamation of refractory sites and shifting sand dunes.</td>
</tr>
<tr>
<td><strong>Bauhinia variegata (Kachnar)</strong></td>
<td>Annual rainfall requirement is 500-250 mm with extreme temperature (maximum 40-47°C) and minimum below zero. It grows on a wide variety of soils; from gravelly soils on mountain slopes to sandy loam soils in the valleys and plains.</td>
</tr>
<tr>
<td><strong>Olea ferruginea (Kau)</strong></td>
<td>It grows at altitudes between 500-2000 m with annual rainfall of about 500-1200 mm and prefers limestone rocky soils. Best grows on deep soils with sufficient moisture supply.</td>
</tr>
<tr>
<td><strong>Morus alba (Mulberry)</strong></td>
<td>It is shade tolerant and fast growing species, usually planted as a under storey in plantations.</td>
</tr>
<tr>
<td><strong>Acacia modesta (Phulai)</strong></td>
<td>It can tolerate very high temperature (50°C). Can grow in infertile, dry, shallow soils and eroded low hilly areas.</td>
</tr>
<tr>
<td><strong>Triticum aestivum (Wan)</strong></td>
<td>It is highly drought tolerant/resistant and can grow in saline areas. It withstands extreme temperatures and can survive with little rainfall (180 mm). It performs well on medium and fine textured soils such as sandy loam and sandy clay loams.</td>
</tr>
</tbody>
</table>

Muzaffargarh, Layyah, Bhakkar and Cholistan make up the arid zone in Punjab. This area comprises of shifting sand dunes and is un-suitable for crop production due to modest rain (100-250 mm annual) and soaring temperature (>50°C) in summer. The farmers in this area get good crop of chickpeas from preserved moisture, the productivity of which however depends on timely spell of rainfall. The land for this crop has to be carefully prepared by uprooting all kinds of grasses and shrubs from the surface which discourage small ruminants production. A project of ‘Greater Thal Canal’ is under consideration by the Government of Pakistan for many years. This canal if constructed will change the features of the area.
Major part of Balochistan comprises of extensive plains, highlands and mountains. Lack of water resources limits viable agricultural activity. As a result, 95% of 35 million hectare is sparingly vegetative wasteland. Upper and lower highlands support about 76% of the province’s livestock. Open rangelands are expanding as the common rangelands undergo degradation and abandoned by their users (Buzdar et al. 1989). Most of the crops are grown in the irrigated areas of Nasirabad and Jaffarabad and the rainfed areas of Kachhi and Sibbi plains. At present, Balochistan province has 20 million livestock which are 6-7 times more than the carrying capacity (Khalifa, 2004) of its already over-stressed ranges. Opportunities for other classes of livestock in this area are limited. As a result, the number of small ruminants is increasing. Their performance is, however, influenced by climatic variability. Existing techniques could be however be improved to sustain small ruminants productivity.

In Punjab province, most agricultural lands are irrigated by network of canals that emerge from a number of rivers. Sindh province forms the lower basin of river Indus. It covers an area of 14.09 million hectares of which 2.39 million ha is sown and 1.32 million ha area is under forest (Jenejo, 1993). Small ruminant production in these areas is mostly integrated with crop production. Seeded fodders like lucerne (*Medicago sativa*), sorghum (*Sorghum bicolor*), jantar (*Sesbania aculeate*) and tree branches form the mainstay of the small ruminant feeding. A great number of agro-industrial crop residues like mustard cake, cottonseed cake, sunflower meal, wheat bran, rice polishings and cane molasses are also available for supplemental feeding or specialized fattening program.

1.2. Subtropical moist zone
It covers 3% of the Pakistan’s total area. This zone consists of forest (mangrove) and derived savannahs.

1.3. Subtropical moist zone
This area covers 10% of Pakistan which includes Quetta and Qalat valleys. This zone receives 1000 to 1500 mm of rain annually which sustains plants for 180 to 270 plant growing days. Food and cash crops are grown, including maize, fruits, vegetables, millet, groundnut, and cowpeas.

1.4. Temperate dry
This area covers 25% of Pakistan. It includes northern NWFP, north western Balochistan and Kashmir.

1.5. Temperate moist:
The temperate moist zone receives more than 1000 mm of rainfall annually which sustains plants for 270-365 plant growing days. The zone occupies 3% of Pakistan, mostly in northern NWFP, Kashmir and northern Punjab including districts of Jhelum, Chakwal, Rawalpindi and Attock. The annual rain fall substantially support the growth of natural vegetation. Farmers grow millet, sorghum, groundnut, maize and cowpeas. This area has plenty of opportunities for the development of small ruminants.

1.6. Alpine (Cool Highlands)
Alpine or the cool highlands zone includes areas above 1500 m altitude that have a mean daily temperature of less than 20°C. This zone represents 6% of the total area of Pakistan, most of which lies in NWFP and Kashmir. The soils are deep fertile. The zone receives rainfall (1000 mm annually) and there are two growing seasons. The cool highlands are a high potential area for crop-livestock integration.

2. Breeds of sheep and goat
Indus valley is home to the finest breeds of goats. Most popular breeds are Beetal, Barbari, Chapar, Damani, Daira Din Panah (DDP), Hairy goat, Kaghani, Kamori, Nachi, Pak. Angora (Crossbred), and Teddy. The area also abounds in sheep wealth, un-exploited and undervalued. There are two categories of sheep breeds in Pakistan. Thin tail breeds are Cholistani, Damani, Kachhi, Kajli, Kooka, Lohi, Thali, Kaghani, Kail, Hisssardale, Baghdale whereas fat tail breeds are Balkhi, Bibrik, Harnai, Hasht Nagri, Salt Range, Waziri, Baluchi, and Michni.

3. Population Pressure and Natural Resources

In pure arid areas of Punjab and Balochistan where there is little or no cropping activity, low human population, small ruminants are kept in little flocks. These flocks travel long distances year-round looking for forage along specific routes. The animals are kept on scrub and desert vegetation feeding. Landed farmers with big flocks heavily rely on seeded fodders in irrigated areas. Erratic rains promote migration of livestock owners within the province as well as across the province. Sindh province frequently faces such migration from Balochistan. Opportunities for other classes of livestock in this area are limited. In canal-irrigated area, cash crops get the maximum preference of the farms who can afford moderate to high agricultural inputs. Crops-livestock systems dominate the area. Seeded fodders for small ruminants are, in general, considered uneconomical. A recent survey in the Punjab, Pakistan (Teufel et al. 1998) has demonstrated that those households that have little or no land, and no regular substantial off-farm income and thus exclusively rely on small ruminants for subsistence are economically viable/successful.

In areas where farmers follow traditional methods, inputs are scarce and markets are poorly developed, the crop–livestock systems has proved to be economically sustainable as continuous cropping leads to a decline in fertility and hence the need to introduce animals into the system to provide farm yard manure. Since pasture and fallow are no longer options for feeding livestock, crop residues start to play a more important role.

Where human population is fast increasing, it has driven agriculture towards intensification. The cropping has intensified in canal-irrigated areas of Punjab and Sindh where farmers can afford more agricultural inputs. In these areas mechanization is rapidly replacing human labour in traction, harvesting and post-harvesting haulage and storage of commodities. There has also been improvement in marketing. Small ruminants production is on the decline in such areas. Specialized market-oriented livestock production/fattening is practiced in peri-urban areas, keeping in view the demand of urban dwellers. This activity is more evident on the eve of traditional Muslim Eid al-Adha (Eid-qurban). There have been a growing number of urban-based entrepreneurs from traditional non-farming communities who are now involved in raising these animals around cities. They practice modern husbandry techniques and the animals are fattening on concentrates replacing crop residues.

4. Major production systems in Pakistan

Small ruminants are mostly owned by the small or landless farmers having less than two hectare of land. The flocks are usually grazed on ranges, roadsides or canal banks. Livestock production systems in Pakistan can be distinguished mainly through three production factors, land, labour and capital. The traditional livestock production systems are:

4.1. Nomadic
Nomads keep on moving in search of water and grazing pastures all year round. This system is prevalent in southern Balochistan, Cholistan, Thal (Punjab) and Tharparker (Sindh). The flocks owned by nomads are dominated by cattle, sheep, goats and camels. Flock size ranges from 60 to 300.

4.2. Transhumant (Migratory)
This migration is prompted by shortage of feed and temperature fluctuations. It is characterized by the movement of flocks from upland to lowland during early winter and from lowland to upland during early summer. The size of flock is 50 to 150. Mortality rate during migration is high as the small ruminants have to travel long distances. This system is prevalent in all provinces viz. Punjab (Cholistan, Bahawalpur), NWFP (Dera Ismail Khan, Malakand, Hazara), Sindh (Kohistan and Thar), Sibbi division of Balochistan and throughout Azad Kashmir and northern areas.

4.3. Sedentary
It can be found in irrigated areas of central Punjab, upland Balochistan, Indus valley and southern NWFP. Flock size is dependant on socio-ecological conditions of farmers, which ranges from 15 to 30. Flocks graze on scrublands of towns whole day long and brought back in the evenings. With the introduction of tube wells irrigation (mid 1970s), there has been a steady increase in the number of livestock owners becoming sedentary near irrigated lands where they grow cash crops. Fattening of lambs/kids (stall feeding) is commonly practiced just before marketing their produce.

4.4. Household/ Peri-urban
Small units of about five animals are raised under this system and mostly found in peri-urban areas of cities. They are kept confined in houses and fed on scraps and weeds. Mostly animals are reared for meeting their domestic needs and occasionally sold for this purpose.

5. Productivity of small ruminants
Some of the local sheep (Kajli) and goat breeds (Beetal, DDP) have unbelievably high potential for meat and superior body weights. They can not, however, thrive in rangelands with poor vegetation. Some of the smaller and hardy breeds have adapted to the range conditions and can still manifest reasonable growth in scrub lands, ranges and stress lands where feed resources are extremely limited. A local sheep breed weighing from 31-40 kg demonstrated a daily growth rate of 153-172 g/day in irrigated areas. When similar animals were transferred to rangelands, the growth rate drastically dropped to less than 60 g/ day (unpublished data of Animal Nutrition Centre, Rakh Dera Chahl, Lahore). The average daily growth rate of other local breed Teddy (goat) and Thalli (sheep) under range conditions were also observed to be very poor (Wahid et al. 1992). This is because over-grazing has brought down the productivity of rangelands to as little as 15-40% of their potential. Three consecutive years of drought (2002-2004) in Balochistan, parts of Sindh and Cholistan (Punjab) reduced the livestock number, in some districts up to 80% of their 1999 estimates.

6. Opportunities and future outlook
Small ruminants in Pakistan seem to have great genetic make up but in the absence of organized national herd improvement programme, genetic upgrading in local breeds over the years has been negligible. There is a need to establish an appropriate
recording system for small ruminants. The data should be handled by a central data processing unit operating under the government. All future breeding in sheep and goat should be devised on the basis of the estimates of genetic parameters obtained from the data bank. Also the gene pool of national sheep and goat should be preserved through cryo-preservation in each province.

Inconsistent policies of the both federal and provincial public departments with regard to the small ruminant development are the single major cause of under-development of small ruminants especially in rangelands. The scenario gets worst when departmental policies are abruptly changed. Pro-veterinary elements dominate policy making who ought to give way to improving the productivity of sheep and goat through planned breeding, feeding, housing and management. Link among researchers, extension workers and farmers should be strengthened. Administrative control of mutton marketing in cities must immediately be abolished. Processing facilities for mutton should be encouraged which will ultimately improve the marketing.

Both contagious and non-contagious diseases in small ruminants are rampant. Professional help is required to eradicate major contagious and non-contagious diseases from small ruminants. Brucellosis, enterotoxaemia, and ovine postural dermatitis need urgent attention. Long term strategy should be formulated to eradicate internal and external parasites.

**Conclusion**

A sustained small ruminant development in Pakistan is intimately linked to a sound rangeland development programme. Introduction of newer varieties of fodders/grasses that can thrive under harsh rangeland environment of poor annual precipitation and soaring heat is required to meet challenges of feed scarcity during crunch periods like drought. There is a need to preserve rain water and to harvest underground water resources. In areas with brackish underground water, planting of salt bush like *Atriplex* could potentially improve the status of small ruminant feeding in degraded soils. Careful selection and planned breeding coupled with improved feeding have good prospects for small ruminant flock upgradation.

**References**


Morphological characterization of nine Syrian olive (*Olea europaea* L.) cultivars

Malek Abdeen¹, Ashraf Tubeileh², Anwar al-Ibrahem¹, and Francis Turkelboom²

¹ General Commission for Scientific Agricultural Research, Olive Research Department, Idleb, Syria
² International Center for Agricultural Research in the Dry Areas, ICARDA, P.O. Box 5466, Aleppo, Syria

Keywords: Olive, landraces, conservation, diversity, fruit weight, dry areas.

Abstract

Syria has a rich variety of olive (*Olea europaea* L.) germplasm that has not been yet fully explored and exploited. In efforts to conserve this rich germplasm, a few olive germplasm collection sites were established across the country. In this paper, we report partial results on the research done to characterize nine different olive cultivars originating from different parts of the country. Some of these cultivars are important and wide-spread while others are less known. This work was carried out under rainfed conditions in Kafr Yahmool, near Idleb in northwestern Syria. The most important criteria related to tree and drupes are presented. Our results show the high diversity in olive germplasm in Syria, which provides growers with a large choice of varieties suitable for different olive uses and different environments.

Introduction

Syria has a rich olive germplasm including more than seventy varieties grown in different parts of the country (Nseir et al., 1985), and this number is likely to increase if the abundant landraces resources are evaluated (Tubeileh et al., 2004). In the meanwhile, local cultivars are not satisfactorily studied yet (Belaj et al., 2003). In his document, Zaghloul (2000) has provided a description of some 50 indigenous olive varieties available in germplasm collection sites in Syria. However, there is still much to be done in order to characterize these varieties and their adaptation to diverse climatic conditions. This paper contributes to the efforts to determine the morphological and productive characteristics of local olive cultivars in Syria in order to identify the most promising ones for dry farming.

Materials and methods

This study was carried out during 2002 under rainfed conditions at the olive germplasm collection in Kafr Yahmool, Idleb governorate in northwestern Syria. The 20-year average annual precipitation in the study area amounts to 493 mm and the annual rainfall for the 2001/2002 season reached 512 mm. Average maximum temperature for the hottest month (August) is 34.7°C and average minimum temperature for the coldest month (January) is 2.6°C. Soil was plowed four times every year (once in winter after fruit harvest, once in spring, and twice in summer) using a cultivator. Composted animal manure was added at a rate of 20 kg per tree every two years.

As shown in table 1, the studied nine cultivars originated from different geographical areas. Five of these cultivars rank among the seven most important cultivars in the country but the rest (‘Abbadi abu-Ghabra’, ‘Homeisi’, ‘Manaqiri’, and ‘Shami...
modaabal’) are much less known. Most of these varieties are usually grown under rainfed conditions, except those originating from Damascus and Palmyra, which are grown under irrigation due to low annual rainfall (less than 200 mm) in their natural habitats.

With regard to the alternate bearing cycle of olive, the 2002 year was a bearing year for the sampled trees. The study was conducted on two-three average-size trees of each cultivar, planted in 1986. This number of replicates was imposed by the number of trees available of each cultivar. Dates of major stages related to production (flowering, fruit-set, and different fruit ripening stages) were monitored and the length of the maturation stage (between fruit-set and final color) was determined during one season. Fruits were picked when they attained their final color although table cultivars used for green pickling are usually picked earlier. Fruit weight and pulp/pit ratio were determined at harvest.

**Results and discussion**

**Tree characteristics**

All the studied cultivars showed good vigor and adaptation to the local rainfed conditions although they originate from different geo-climatic areas (Table 1). Most of the cultivars have an erect growth pattern and dense foliage.
Table 1: Tree and drupe characteristics of the studied cultivars

<table>
<thead>
<tr>
<th></th>
<th>Abbadi abu-Ghabra</th>
<th>Shami modaabal</th>
<th>Jlot</th>
<th>Homeisi</th>
<th>Manaqiri</th>
<th>Qaisi</th>
<th>Khodeiri</th>
<th>Zeiti</th>
<th>Sorani</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of origin and occurrence</td>
<td>Palmyra</td>
<td>Palmyra</td>
<td>Damascus</td>
<td>Idleb</td>
<td>Tartous</td>
<td>Aleppo</td>
<td>Tartous</td>
<td>Aleppo</td>
<td>Idleb</td>
</tr>
<tr>
<td>Fruit end-use</td>
<td>Table</td>
<td>Table</td>
<td>Table</td>
<td>Table and oil</td>
<td>Table and oil</td>
<td>Table and oil</td>
<td>Oil and table</td>
<td>Oil</td>
<td>Oil and table</td>
</tr>
<tr>
<td>Tree growth pattern</td>
<td>Erect</td>
<td>Erect</td>
<td>Erect</td>
<td>Spreading</td>
<td>Spreading</td>
<td>Erect</td>
<td>Erect</td>
<td>Drooping</td>
<td>Spreading</td>
</tr>
<tr>
<td>Foliage density</td>
<td>Dense</td>
<td>Dense</td>
<td>Dense</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Dense</td>
<td>Dense</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Fruit shape</td>
<td>Ovoid</td>
<td>Spherical</td>
<td>Elongated</td>
<td>Spherical</td>
<td>Spherical</td>
<td>Spherical-ovoid</td>
<td>Ovoid</td>
<td>Spherical</td>
<td>Ovoid</td>
</tr>
<tr>
<td>Fruit symmetry</td>
<td>Symmetrical</td>
<td>Symmetrical</td>
<td>Slightly asymmetrical</td>
<td>Asymmetrical</td>
<td>Slightly asymmetrical</td>
<td>Symmetrical</td>
<td>Slightly asymmetrical</td>
<td>Symmetrical</td>
<td>Asymmetrical</td>
</tr>
<tr>
<td>Fruit top</td>
<td>Almost round</td>
<td>Round</td>
<td>Round</td>
<td>Round</td>
<td>Round</td>
<td>Almost round</td>
<td>Pointed</td>
<td>Round</td>
<td>Pointed</td>
</tr>
<tr>
<td>Fruit lenticels frequency</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Lenticels size</td>
<td>Large</td>
<td>Small</td>
<td>Large</td>
<td>Small</td>
<td>Large</td>
<td>Large</td>
<td>Large</td>
<td>Small</td>
<td>Small</td>
</tr>
<tr>
<td>Coloration starting position</td>
<td>Top</td>
<td>Thoroughly</td>
<td>Top</td>
<td>Top</td>
<td>Top</td>
<td>Bottom</td>
<td>Thoroughly</td>
<td>Top</td>
<td>Thoroughly</td>
</tr>
<tr>
<td>Final fruit color</td>
<td>Black</td>
<td>Dark purple</td>
<td>Dark purple</td>
<td>Purple</td>
<td>Black</td>
<td>Dark purple</td>
<td>Black</td>
<td>Dark purple</td>
<td>Dark purple</td>
</tr>
<tr>
<td>Maturation time</td>
<td>Late September</td>
<td>Early October</td>
<td>Mid November</td>
<td>Early November</td>
<td>Mid October</td>
<td>Mid-late October</td>
<td>Mid November</td>
<td>Mid-late November</td>
<td>Mid-late November</td>
</tr>
<tr>
<td>Length of maturation period (until final color)</td>
<td>107</td>
<td>125</td>
<td>165</td>
<td>153</td>
<td>146</td>
<td>153</td>
<td>167</td>
<td>164</td>
<td>168</td>
</tr>
</tbody>
</table>
**Fruit characteristics**
Flowering occurred in the third week of May and did not vary from one cultivar to another, while pit hardening started in the third week of June for all cultivars. The maturation period differed greatly among cultivars and was longer for oil cultivars. ‘Abbadi abu-Ghabra’ was the earliest to ripe, with maturation period of 107 days, and ‘Sorani’ the latest with maturation period of 168 days (Table 1). Cultivars showed big differences in all the criteria related to fruit shape, fruit symmetry, and lenticels occurrence and size. Table cultivars tended to be symmetrical and to have a round fruit top. Fruit weight varied considerably among the studied cultivars and was in the following descending order: ‘Abbadi abu-Ghabra’, ‘Shami-modaabal’, ‘Qaisi’, ‘Jlot’, ‘Homeisi’, ‘Sorani’, ‘Khodeiri’, ‘Zeiti’, and ‘Manaqiri’ (Fig. 1). Pulp/pit ratio was also higher for table cultivars and followed the descending order: ‘Shami-modaabal’, ‘Abbadi abu-Ghabra’, ‘Homeisi’, ‘Qaisi’, ‘Jlot’, ‘Sorani’, ‘Manaqiri’, ‘Khodeiri’, and ‘Zeiti’ (Fig. 1).

![Fig 1. Fruit fresh weight and pulp pit ratio for the studied cultivars.](image)

The values of fruit weight and pulp/pit ratio that we observed for ‘Sorani’, ‘Zeiti’ and ‘Qaisi’ are in the range reported in the literature (Nseir et al., 1985; Tubeileh et al., 2004). However, our values for ‘Jlot’ are slightly lower than those observed by Nseir et al. (1985) for 10-year old trees. This might be due to the higher tree production in our case or to seasonal effects. For the other cultivars, our values are close to the indicative values given by Zaghlouleh (2000).

**Conclusions**
Our results demonstrate the morphological differences among olive cultivars in Syria. The cultivars originating from Aleppo, Palmyra, and Damascus were well adapted and productive under the edapho-climatic conditions prevailing in Idleb. This study contributed to the description of local cultivars, which can help in increasing the public awareness about the genetic diversity in olive germplasm in Syria. Some of these cultivars still need to be screened to assess their productivity, oil content, and fruit quality for pickling. Since olive production is expanding to marginal dry areas, studying these cultivars under various environments would be another important challenge for the future of olive sector in Syria.

**References**


Diagnostic of plant parasitic nematodes using molecular biotechnology

S. K.Ibrahim

Faculty of Agriculture, The Lebanese University, UNESCO Area, Beirut, Lebanon. E-mail: sibrahim58@yahoo.com

Key words: Biotechnology, nematodes, PCN, Globodera pallida, G. rostochiensis, PCR.

Abstract
The plant parasitic nematodes are economically important pests worldwide including in Lebanon. The use of molecular biology techniques confirmed the recent discovery of the potato cyst nematode (PCN) *Globodera rostochiensis* in Lebanon and assessed its distribution throughout the country. All 204 soil samples collected from 38 different locations were infested with PCN with 76.1% of the samples having a density of less than 10 eggs/g soil. The PCR results confirmed the presence of the potato cyst nematode *G. rostochiensis*. The current paper also demonstrated the usefulness of the biotechnology tools in the field of nematology.

Introduction
Nematodes, or eelworms, are present in virtually all soil types. They attack a wide range of economically important crops of horticultural, agricultural and forest systems. Their worldwide annual losses are estimated at approximately US$100 billion, caused mainly by root-knot nematodes (*Meloidogyne*) (RKN) and cyst nematodes (*Heterodera* and *Globodera*) (CN). The potato cyst nematodes (PCN) *Globodera pallida* and *G. rostochiensis* are economically important pests that are distributed worldwide. The estimated annual yield loss that they cause to potato production in the European Community is valued at 300 million €. In the United Kingdom alone, annual yield loss caused by PCN is estimated to £15-56 million.

Approximately 21% of Lebanese land is in an arable rotation and the potato crop, grown in 14,000 hectares and yielding 265,000 tons of tubers, is the most important vegetable grown. In a small survey conducted in 1997, soil samples were collected from different potato fields in the interior Bekaa Plain and examined for nematode infestations. Extracted PCN were identified as *G. rostochiensis* (Ibrahim *et al.*, 2000). In order to find out how widespread these nematodes were in the Lebanon and establish from where they originated, a survey on a larger scale was conducted.

Materials and methods
The current study seeks to establish protocols under which significant savings in the cost of nematicides (and the associated environmental risks) could be made, and under which crop losses due to nematodes infestations could be estimated using of biotechnology techniques.

Field soil sampling
Two hundred and four soil samples were collected from 82 fields from 38 different locations (Fig.1).
**Cyst extraction, detection and estimation of cyst contents**

The soil samples were air-dried and cysts were extracted using a modified container based on the Fenwick can technique (Fenwick, 1940). The number of cysts and their content were estimated by standard methods (Southey, 1970).

**Species identification**

**DNA Extraction**

DNA was extracted as described by Ibrahim et al., (2001).

**PCR Amplification and agarose gel electrophoresis**

The PCR amplification was used as described by Mulholland et al., (1996) and (Ibrahim et al., 1997)

**Results and discussion**

Results from this survey confirmed the presence of the potato cyst nematode *G. rostochiensis* in Lebanon and demonstrated its distribution throughout the country (Table.1). All 204 soil samples collected from 38 different locations were infested with PCN. Of the samples tested 72.5% contained live eggs. The population density ranged between 0.18-4.1 cyst/g soil and 0.13 -15.5 eggs/g soil. Of the infestation found, 76.1% had a population density of less than 10 eggs/g soil (Fig.1). The PCR data confirmed the presence of the potato cyst nematode *G. rostochiensis* (Fig.2). The three set PCR primers readily identified field samples in a single PCR reaction. However, the origin of this infestation remains unknown.
Table 1. Percent of fields infested with eggs of *Globodera rostochiensis* in different regions of Lebanon

<table>
<thead>
<tr>
<th>Regions</th>
<th>Number of locations</th>
<th>Number of samples tested</th>
<th>Number of samples containing cysts</th>
<th>Number of samples containing eggs</th>
<th>% samples containing eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>North-Lebanon</td>
<td>10</td>
<td>66</td>
<td>66</td>
<td>52</td>
<td>78.8</td>
</tr>
<tr>
<td>Bekaa-Valley</td>
<td>19</td>
<td>101</td>
<td>101</td>
<td>75</td>
<td>74.3</td>
</tr>
<tr>
<td>Mount-Lebanon</td>
<td>7</td>
<td>22</td>
<td>22</td>
<td>12</td>
<td>54.5</td>
</tr>
<tr>
<td>South-Lebanon</td>
<td>2</td>
<td>15</td>
<td>15</td>
<td>9</td>
<td>60.0</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>204</td>
<td>204</td>
<td>148</td>
<td>72.5</td>
</tr>
</tbody>
</table>

*Globodera* sp. cysts (100%) were found in all samples tested by standard detection methods. This figure is significantly higher than 17% of the last survey (Ibrahim *et al*., 2000), indicating a significant increase in distribution. The previous survey was concentrated in a small area (Riakk), while the current one covers almost all potatoes cultivated areas throughout the country. Recent survey (484 field samples) carried out in England and Wales revealed that 64% of samples were infested with PCN (Minnis, *et al*., 2000). This survey demonstrated that all soil samples tested (204) contained PCN cysts, however, only 72.5% of these samples contained live eggs. This may indicate the wide distribution of PCN throughout the country. Although, there was no significant difference found between different regions, the north Lebanon showed the highest level of cysts containing live eggs (39%) in comparison to the Bekaa Valley (17%) and south of Lebanon (19%). The difference of infestation levels among the areas could be due to several factors, such as cultural practices, absence of crop rotation, use of susceptible cultivars, different soil types and chemical application.

As potato production has become more specialized with fewer growers, it has been concentrated on a smaller area of land leading reduction in rotations, which have led to the build-up of PCN infestations. Discussions with growers included in the survey indicated that they were unaware of the presence of nematodes and they repeated potato production on the same field may have contributed to accumulation of high levels of PCN and thus resulting in yield loss. In addition, the sugar beet production has become very restricted or even absent; forcing the growers to shift to potato production. Potato production has been carried out all over the Bekaa plain, Akkar, Marjouyoun as well as in certain localities in Mount Lebanon without crop rotation. This may explain the build–up of PCN infestation. Also, there are other factors that may contribute to this large distribution of PCN in Lebanon, such as the use of susceptible varieties, contamination of equipment, uncertified cultivars or seeds, soil type, irrigation methods and absence of quarantine.

The species identification by PCR found only *G. rostochiensis* present in the soil samples tested. The PCR data are also in agreement with an earlier report (Ibrahim *et al*., 2000) confirming the presence of *G. rostochiensis* in Lebanon. The origin of *G. rostochiensis* detected in Lebanon is not known. However, it may have been introduced on potato seed tubers imported from Europe. The distribution of *G. pallida* and *G. rostochiensis* is worldwide and they rarely occur as separate species but more often as a mixture species in one field. The current study found only *G. rostochiensis* present in the soil samples tested. However, the absence of *G. pallida*, cannot be ruled out as only a small proportion of potato growing land in the Lebanon has been sampled and, in fields that have been infested relatively recently containing unevenly distributed populations, the probability of detecting cysts in a soil sample is low (Haydock & Evans, 1998). In the contrary, a recent survey
carried out in England and Wales revealed that *G. pallida* was the dominant species in the field samples tested. The PCR results indicated that 66% of field samples contained pure *G. pallida*, 8% contained pure *G. rostochiensis* and 26% contained mixtures of the two species (Ibrahim *et al.*, 2001).

**Conclusion**
Growers and farmers are not aware of the cyst nematodes infestations in their potato field and efforts for increasing their awareness and for transferring appropriate control packages are needed. Growers should be routinely soil sampling and should use resistant varieties, use of rotations combined with application of nematicides.

**Acknowledgement**
This work was funded by the Lebanese National Council for Scientific Research.

**References**

**Conservation and Adding-value to Phytogenetic Resources of the Southeast Oases of Morocco: a Botanical Garden of the Aromatic and Medicinal Plants**
Keywords: Medicinal aromatic plants, conservation, adding value, botanic garden, Oasis, Morocco

Abstract

Introduction
The Tafilalet region which contains the most important oases of the south-east of Morocco constitutes the northern border of the Sahara. It is situated in border of the Saharan domain. The hard climate of the region is characterized by low rainfall and high evapo-transpiration with violent hot winds, a weak pluviometry, a strong evaporation and violent winds. Its flora is varied and constituted of 1000 species or sub-species belonging to sixty botanic families, some of which are endemic to presaharian and Saharian zones.

The Tafilalet region conceals of a particular, rich and varied flora which is especially known by the uniformity of Saharan types. This flora belongs to about sixty botanical families and contains thousand of species and variety; an important number of which is common or endemic in presaharan and Saharan zones (Ozenda, on 1983 and 1991; Rejdali, on 1999, El Rhaffari and al, on 2000 and El Rhaffari, on 2001). No more than 44% of the species are valued traditionally as aromatic and medicinal plants by the local communities in the area. These natural resources represent an important patrimony with high added value.

Due to different very ingenious systems for water harvesting using flood waters and of irrigation, the diversion of the flood waters and the harnessing of the subterranean waters, this region knew a settlement and a very ancient agricultural activity. The different populations who became established in this zone developed the oasis agriculture system centred on date palm combined with cereals, forages and fruit trees. This system has been maintained over centuries through a rich local knowledge based on communal integrated natural resources management. The sustainability of this systems has been realized only by the symbiosis between the main factors which are: the man, the plants, the water and the soil. At present this system is seriously affected by the successive droughts and the disintegration of traditional on of several aridity cycles. This is aggravated by unsuitable human management and agricultural strategy.

Agriculture systems. Agriculture cannot sustain the livelihoods of rural communities in these systems and the improvement of their income is not capable any more of meeting the need of the population more diversification of the cropping systems through the introduction of medicinal and aromatic plant species, tolerant to drought and salinity and with good adding-value, and through off farm income generating activities. The introduction of new agricultural speculation, like medicinal and aromatic plants, which has for characteristics a weak water requirement, a resistance to the salinity and a high added value would allow. This approach will contribute to maintain the agrobiodiversity and the local knowledge of the oasis systems, better to protect the ancient agricultural perimeters and the valuation of new perimeters.
In this work we present our program of research and for development aiming at contributing to the conservation of phytogenic resources in this region of the southeast oases of Morocco (Figure 1). It focuses on the establishment and management of a botanical garden of the aromatic and medicinal plants, a high added-value agrobiodiversity. It’s a result of about ten years of studies on the ethnobotany, inventory, cartography, phytochemistry, ethnopharmacology, taming and attempt of culture of the plants and their resistance to the abiotic stress in the area (El Rhaffari, 2001 and 2002; El Rhaffari et al., 2003; Alem et Amri, 2005; Alem et al., 2002). This work is a contribution to the protection and collection of germplasms and individuals medicinal and aromatic plants. We relate various stages of implementation of the botanical garden of this natural resources of the oases of the southeast of Morocco.

**Methodology**

This work started 10 years ago, and embraced studies on ethnobotany, inventory, cartography, phytochemistry, ethnopharmacology, taming and research on cultivation and domestication of some species and the characterization of their resistance to the abiotic stress in the area (El Rhaffari, 2001, Rhaffari, 2002; El Rhaffari et al., 2003; Alem et Amri, 2005; Alem et al., 2002). This work has also allowed the collection of germplasm in the region.

This contribution reports on activities for the conservation of genetic resources of medicinal and aromatic species of the oasis through the establishment of a botanical garden. This work started 10 years ago, and embraced studies on ethnobotany, inventory, cartography, phytochemistry, ethnopharmacology, taming and research on cultivation and domestication of some species and the characterization of their resistance to the abiotic stress in the area. This work has also allowed the collection of germplasm in the region.

A garden of 500 m² was created to host the plantation of medicinal and aromatic species collected and selected. A herbarium and a nursery for multiplication of the selected species are also established with the botanic garden. The species included in the botanic garden are selected on the basis of: large distribution, endemism, rarity, overexploitation, low water requirement, salinity tolerance and added-value potential (Table 1). Seeds and cutting were collected from farms for cultivated species and from natural habitats for wild species and used in the plantation.

Table 1: List of medicinal and aromatic plants species included in the botanical garden

<table>
<thead>
<tr>
<th>Plants</th>
<th>Criterion of choice</th>
<th>Cultural technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Big Distribution</td>
<td>Endemism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Origin</td>
</tr>
<tr>
<td></td>
<td>Rarity</td>
<td>Over-exploitation</td>
</tr>
<tr>
<td><strong>Weld Wild species</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Achillea leptophylla</em></td>
<td>Mediterranean</td>
<td></td>
</tr>
<tr>
<td><em>Anethum graveolens</em></td>
<td>Saharan</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing</td>
<td></td>
</tr>
<tr>
<td><em>Artemisia herba alba</em></td>
<td>North Africa</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing, division of bundle</td>
<td></td>
</tr>
<tr>
<td><em>Baboniun graveolens</em></td>
<td>Common South of Morocco</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing,</td>
<td></td>
</tr>
<tr>
<td><em>Capparis spinosa</em></td>
<td>Mediterranean</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing, cutting</td>
<td></td>
</tr>
<tr>
<td><em>Cotula cinera</em></td>
<td>Common South of Morocco</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing, division of bundle</td>
<td></td>
</tr>
<tr>
<td><em>Lavandula multifida</em></td>
<td>North Africa</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing, cutting</td>
<td></td>
</tr>
<tr>
<td><em>Ormenis africana</em></td>
<td>North Africa</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing, division of bundle</td>
<td></td>
</tr>
<tr>
<td><em>Ormenis eriolepis</em></td>
<td>South of Morocco</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing, Cutting</td>
<td></td>
</tr>
<tr>
<td><em>Rosmarinus officinalis</em></td>
<td>Mediterranean</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Sowing</td>
<td></td>
</tr>
</tbody>
</table>
The objectives of the this activity were achieved by the establishment of the botanical garden allowing the first initiative undertaken by the Faculty of Science and Technology to contribute to ex-situ conservation of medicinal and aromatic species of the Oasis ecosystem. More than 30 species are actually multiplied and conserved in the botanic garden (Table 1). This initiative will also contribute to supply germplasm for interested farmers and will be used for educational purpose on various aspects related to identification, domestication and multiplication of medicinal and aromatic species along with studies of genetic diversity using morphologic and molecular parameters. This is the first efforts for conservation of medicinal and aromatic species in oasis region and comes as a support to the efforts of the Agricultural Research Institute in Morocco (INRA) which is undertaken the collection of medicinal, herbal and aromatic species in other regions of the country. This botanical garden will serve as the source of germplasm to provide seeds and cuttings for interested farmers and for the rehabilitation of degraded natural The material to be generated by this botanical garden can be used in the rehabilitation of degraded systems. More research will be undertaken on investigation of add-value technologies to contribute to in situ and on-farm conservation of local agrobiodiversity with full participation of local communities.

1. Implementation of the botanical garden
The garden was sized in the beginning on a surface about 500m² where the collected species were planted for various studies and for seed increase. The species were chosen on the basis of wide distribution, endemism, rarity and threatened, over-exploitation, tolerance to salinity and drought and on the basis of the potential for adding-value It contains premises for the conservation of germoplasme, the herbarium, a nursery, and plots of land for plant collection. The works of the ground were made in autumn; the number of plots of land is a function of the number of plants.

2. Garden plantation
The plantation of the garden has follows following schedule:
   a. Choice of plants
      In the beginning, more than an about twenty plants were chosen according to the following criteria: big distribution, endemic, rarity, over-exploitation, weak water requirement, salinity tolerance and added value (Table 1). This garden was used to produce seeds and cuttings for the propagation of these species in farmers’ fields.
   b. Germoplasme collection
      Seeds were collected at the end of the flowering period on the land. The collection of seeds was made according to a schedule in advance established according to the biologic cycle of wild plants.
   c. Plants preparation and cultivation

<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
<th>Propagation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvia verbenaca var clandestina</td>
<td>Mediterranean</td>
<td>Sowing</td>
</tr>
<tr>
<td>Santolina rosmarinifolia</td>
<td>Mediterranean</td>
<td>Sowing, division of bundle</td>
</tr>
<tr>
<td>Teucrium polium</td>
<td>Mediterranean</td>
<td>Sowing, division of bundle</td>
</tr>
<tr>
<td>Thymus satureioides</td>
<td>South of Morocco</td>
<td>Sowing, cutting</td>
</tr>
<tr>
<td>Thymus wilddenowii</td>
<td>Morocco</td>
<td>Sowing, cutting</td>
</tr>
<tr>
<td>Warionia saharae</td>
<td>Morocco</td>
<td>Sowing, cutting</td>
</tr>
<tr>
<td>Cultivated species</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvia officinalis</td>
<td>Morocco</td>
<td>Sowing</td>
</tr>
<tr>
<td>Salvia argentea</td>
<td>Morocco</td>
<td>Sowing</td>
</tr>
<tr>
<td>Salvia sclarea</td>
<td></td>
<td>Sowing</td>
</tr>
<tr>
<td>Thymus vulgaris</td>
<td>Morocco</td>
<td>Sowing, cutting</td>
</tr>
<tr>
<td>Vetiveria zizanoïde</td>
<td>Madagascar</td>
<td>Division of bundle,</td>
</tr>
</tbody>
</table>
Plants are prepared and transplanted according the biologic cycle of species, by sowing, cutting, layering and division of bundle. The zones of distribution of wild plants are known and in advance listed.

Results and discussion
In total 30 species of medicinal and aromatic values were collected and planted in the botanical garden established for the conservation and propagation of these species. This is the first efforts for conservation of medicinal and aromatic species in oasis region (Table 1). The Agricultural Research Institute in Morocco (INRA) has collected medicinal. Herbal and aromatic species in other regions of the country. The idea and objective are to establish a bridge between the natural sites and the botanical garden, place of collection and conservation of the aromatic and medicinal plants. The results expected by this work were reached. It was a question of making a success of a collection of germplasms and individuals of medicinal and aromatic plants. Indeed around thirty seeds and plantations of this natural resources were listed and collected. This botanical garden will serve as the sources of germplasm for future studies on characterization of germplasm, research on domestication and cultivation packages, and to provide seeds and cuttings for interested farmers and for the rehabilitation of degraded natural habitats. This botanical garden has numerous consequences for the region: it’s the first and the only experience of ex-situ conservation of biodiversity of flora in the area. This will contribute to the transfer of technology of culture, conservation of the biodiversity by culture and use; it’s a laboratory of forming, search and attempts for the scientists in valuation and conservation of the biodiversity of flora of the southeast oases of Morocco. It can play, in the medium term, the role of place of production of medicinal and aromatic plants in order to contribute to the rehabilitation of ecosystems and the improvement of the income of the population of oases. It is also a place of acclimatization of new sorts of plants with added value. Future research will also tackle the investigation of adding-value options through identification of active chemical compounds along with packing and libelling of local products for better marketability and better return to local communities.

In addition, this work has allowed the University of Science and Technology at Errachidia to develop expertise and education supporting activities on medicinal and aromatic species of the desert and oasis ecosystems. In this way this botanical garden can have scientific, socio-economic, ecological, landscaped and ecological tourism consequences for the region and its population within the framework of a participative approach.

References


Bio-geographic Survey of Northern Areas of Pakistan for Minor Fruits and Medicinal Plants

Zahoor Ahmad

Programme Leader, Plant Genetic Resources Programme, National Agricultural Research Centre, Islamabad

Keywords: minor fruit tree, medicinal plants, survey, Pakistan

Abstract

The Northern Areas of Pakistan comprising mainly of high mountain ranges of Himalayas, Hindu-Kush and Karakoram are considered dry areas receiving an annual average rainfall of 160 mm. Due to great altitudinal variations and climate, this region is rich in genetic diversity and is holding more than 250 endemic species. A bio-geographic survey of areas was conducted for minor fruits and medicinal plants which revealed that nine species of pome fruits, eight species of stone fruits, six species of tree nuts, ten species small fruits, four species of grapes and eight species of other fruit trees are growing either as wild or cultivated. Most of these species are growing on extremely dry slopes. Approximately 1000 species of medicinal plants are growing in the area and some of the species like Picrorrhiza kurroa, Podophyllum hexandrum, Dioscorea deltoida, Paeonia emodi, Rheum emodi and Sassurea costus are highly vulnerable due to over exploitation.

Introduction

The Northern Areas of Pakistan comprises of mountain ranges of Himalayas, Hindukush and Karakoram. These areas lie between 34°-0’ to 36°-50’ north latitude and 71°-12’ to 75°-0’ east longitude. Although high altitude mountains are the major source of water in the form of snow that is used for agriculture in the country and conserved in the dams, but most of the mountains are barren, dry with characteristic xerophytic vegetation. As consequence of the isolation of many arid, dry and remote valleys in the rugged mountain area and the longer period of time people have lived there, not only have many diverse human cultures evolved, but many plant species have been exploited for food and primary health care. Additionally, the ancient trade route from China to Western Asia and Europe passed through region resulting in the introduction of many horticultural and medicinal plant species. Great variation in altitude, rainfall and climate has given rise to a corresponding diversity in wild flora and fauna. This region supports over 100 species of manuals, about 500 species of birds and over 50 species of reptiles beside approximately 6000 species of higher plants (Malik 2002). The mountain populations largely depend on agriculture including fruits for food, medicinal flora for health care and other natural resources for the livelihood. During the recent years, the resource base has deteriorated due to many biotic and abiotic pressures. The biotic pressures include population pressure, over-exploitation, poor management policies while abiotic pressures are from drought, decline in soil fertility etc. Among crops, wheat (Triticum aestivum), barley (Hordeum vulgare), Maize (Zea mays), Foxtail millet (Setaria italica), Common millet (Panicum miliaceum), barnyard millet (Echinochloa frunantacea), oat (Avena sativa), Amranthus, buckwheat (Fagopurum spp.) are cultivated mainly depending upon the altitude (Bhatti, 1998). The major fruit species cultivated include apples, apricots, peaches, plums, cherry and walnut. Besides these, there are number of other minor or under-utilized species and wild relatives of many other fruit
species. Regarding medicinal plants, the Flora of Northern Areas comprises of about 2000 higher plants with approximately 250 endemic species (Flora of Pakistan). The medicinal plants which are almost wild provide an important income particularly to dwellers or nomads. As a result of over-exploitation, degradation, fragmentation, ignorance, and climate change, many plant species like *Saussurea lappa*, *Podophyllum hexandrum*, *Dioscorea deltioda*, *Rheum emodi*, *Valeriana wallichii*, *Colchicum lutem* and *Fumeria parvisfolia* and few in other area becoming scarce and rare. This paper mainly describes the extent of diversity in minor fruits and medicinal plant species.

**Pome fruit diversity**

The minor pome fruit species growing in the region are listed in Table-1. They include *Pyrus pashia*, *Malus domestica*, *Cydonia oblonga*, *Sorbus lanata*, *S. tianshanica*, *Cotoneaster lindleyi*, and *C. nummularia*. *Pyrus pashia* (Wild pear) occurs at elevations between 750 and 2,500m together with *Pistacia chinesis* and *Diospyros lotus*. The fruits of wild pear are one to two cm long and brown with conspicuous white raised lenticels. After harvesting, the fruit is stored and allowed to soften and turn dark brown to make it edible. The domestic apple (*Malus domestica*) is planted widely and produces small to medium-sized early maturing fruits. *Cydonia ablonga* (quince) is not distributed widely in the region and the type of fruit found in the area is bitter. People use the fruit cooked, boiled and preserved in sugar, and for medicinal purposes. *Sorbus* (*Sorbus lanata*) occurs at elevations from 2,000 to 3,600m. The associated species include *Abies pindrow*, *Picea smithiana*, *Cedus deodara*, *Pinus wallichii*, and *Juglans regia*. The fruit is round, 2-4 cm in diameter, and orange with a heavy red blush flesh. The soft fruit is edible and sweet. The fruit can be kept for one month after harvesting. *Cotoneaster* (*C. songarica*) is known locally as Cochina in Kohistan, Shinjuli in Kaghan, Gooni in Chital, and Singiary in Pushtoo. It is common in cultivated areas of Balochistan, the Kurram Valley, Chitral, Swat, Astore, Gilgit, Hazara, the Murree hills, and Kashmir at elevations of from 925-2,800m. Trees are propagated by seeds or suckers. The mature fruit hangs on the tree for several months. As well as being grown for its fruit, *C. songarica* is also used as root stock for quince and apple. Local knowledge suggests that the root stock is resistant to root rot. The Cotoneaster genus is represented in the region by *C. affinis*, *C. integerrima*, *C. lindleyi*, and *C. nummularia*. *C. affinis* is found associated with *Pinus gerardiana*, *Cedrus deodara*, *Ulmus*, and *Pyrus pashia* at altitudes of from 1,100-3,000m, whereas *C. integerrima* is found at altitude of from 1,200-4,000m. All four cotoneaster species have ornamental value and the fruits are edible.

**Stone fruit diversity:**

Stone fruits in the Pakistan mountains are represented by 12 species, excluding almonds (Table-1). These include four wild and naturally occurring species of cherry (*Prunus cerasioides*, *P. jacquemontii*, *P. prostrata*, and *P. cornuta*). Seven species of *Prunus* apart from sweet cherry (*Prunus avium*), which is a recent introduction, have been introduced into this area at different times in human history. *Prunus cerasioides* is very rare because the region lies at its western limit of distribution. Its distribution (up 800m) indicates that it has low chilling requirements and is resistant to stone fruit diseases. It produces small, acid fruit and may be useful as a rootstock. *Prunus jacquemontii* is distributed widely from Balochistan to Chitral, Gilgit, and Kaghan at elevations of between 1,250 and 3,700m. Although this species is exposed to heavy grazing, it is still quite common in the wild. It produces juicy, tart edible fruits. Besides having ornamental value, it could usefully be explored as a dwarfing root stock for cherries. *Prunus prostrata* is a spreading shrub and...
subjected to heavy grazing. The fruits are very small and inedible. It is found on open, rocky, dry, and sunny slopes. It may be a valuable ornamental because of its flowers and the nature or its occurrence. The Himalayan bird cherry (*P. cornuta*) is common in moist, temperate regions at elevations of from 2,100-3,700m associated with *Pinus, Abies, Juglans,* and *Quercus* species. Although frequently lopped, it is found in the Kaghan valley because the fruit area edible. It has good compatibility as a root stock for sweet cherry. *Prunus cerasus* (Pie cherry) and *P. mahaleb* (Mahaleb cherry) are introductions in this area, most probably brought in by the British as a root stock for sweet cherry or as ornamentals. Both these species are rare. *Prunus tomentosa* (Korean cherry) is cultivated for both ornamentation and for its edible fruits. *Prunus cerasifera* (myrobalan mirabello plum) is distributed widely throughout northern Pakistan at altitudes of from 500-2,300m. It is called alucha everywhere. The fruits are edible, 2-2.5 cm in diameter, and available in the market from May to mid-July. Other species of stone fruit such as *Prunus salicina* (Japanese plum), *Prunus persica* (peach), and *Prunus armeniaca* (apricot) are considered as the major fruit trees in this area.

Table 1: Minor fruit crop resources of the Pakistan mountains

<table>
<thead>
<tr>
<th>Latin Name</th>
<th>English Name</th>
<th>Local Names</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pome fruits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pyrus pashia</em></td>
<td>Wild pear</td>
<td>Batanji, Tanchi khapa</td>
</tr>
<tr>
<td><em>Malus domestica</em></td>
<td>Domestic apple</td>
<td>Chottla, Shird</td>
</tr>
<tr>
<td><em>Cydonia oblonga</em></td>
<td>Quince</td>
<td>Behi, Chator, Charoll</td>
</tr>
<tr>
<td><em>Sorbus lanata</em></td>
<td>Sorbus</td>
<td>Tameez</td>
</tr>
<tr>
<td><em>Sorbus tianshanica, Sorbus</em></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td><em>Cotoneaster affinis,</em></td>
<td>Cotoneaster</td>
<td>Bedour, Kabeshoo</td>
</tr>
<tr>
<td><em>Cotoneaster intergerrima</em></td>
<td>Cotoneaster</td>
<td>-</td>
</tr>
<tr>
<td><em>Cotoneaster nummularia</em></td>
<td>Cotoneaster</td>
<td>-</td>
</tr>
<tr>
<td><strong>Stone fruits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Prunus cerasioides,</em></td>
<td>Wild cherry, Carmine cherry</td>
<td>-</td>
</tr>
<tr>
<td><em>Prunus jacquemontii</em></td>
<td>-</td>
<td>Jikh, Mabheen</td>
</tr>
<tr>
<td><em>Prunus prospirata</em></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>Prunus cornuta</em></td>
<td>Himalayan bird cherry</td>
<td>Burris, Parrt</td>
</tr>
<tr>
<td><em>Prunus cerasus</em></td>
<td>Pie cherry, tart or sour cherry</td>
<td>-</td>
</tr>
<tr>
<td><em>Prunus mahaleb</em></td>
<td>St.Liuce cherry, Mahaleb cherry</td>
<td>-</td>
</tr>
<tr>
<td><em>Prunus tomentosa</em></td>
<td>Manchu downy, Korean cherry</td>
<td>Shogun, Shugun</td>
</tr>
<tr>
<td><em>Prunus cerasifera</em></td>
<td>Myrobalan plum, Cherry plum</td>
<td>Alucha</td>
</tr>
<tr>
<td><strong>Other fruit tree species</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Diospyros lotus</em></td>
<td>Date plum</td>
<td>Amlok</td>
</tr>
</tbody>
</table>

712
<table>
<thead>
<tr>
<th><strong>Ficus carica</strong></th>
<th>Fig</th>
<th>Anjir</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ficus palmate</strong></td>
<td>Wild fig</td>
<td>Jangli anjir</td>
</tr>
<tr>
<td><strong>Morus alba</strong></td>
<td>White mulberry</td>
<td>Toot</td>
</tr>
<tr>
<td><strong>Morus nigra</strong></td>
<td>Black mulberry</td>
<td>Shahtoot</td>
</tr>
<tr>
<td><strong>Morus serrata</strong></td>
<td>-</td>
<td>Toot</td>
</tr>
<tr>
<td><strong>Olea ferruginea</strong></td>
<td>Indian olive</td>
<td>Kao</td>
</tr>
<tr>
<td><strong>Zizyphus spp.</strong></td>
<td>Jujube</td>
<td>Ber, anab, Markhanay, Singli</td>
</tr>
</tbody>
</table>

**Tree nuts**

<table>
<thead>
<tr>
<th><strong>Corlus jacquemontii</strong></th>
<th>Hazalnut</th>
<th>Mazeer, Jangli badam</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pistacia atlantic</strong></td>
<td>Wild pistachio</td>
<td>Toke</td>
</tr>
<tr>
<td><strong>Pistacia chinesis</strong></td>
<td>Wild pistachio</td>
<td>Shinala, Kangar</td>
</tr>
<tr>
<td><strong>Pistacia khinjuk</strong></td>
<td>Wild pistachio</td>
<td>Saveen, Khakaon</td>
</tr>
<tr>
<td><strong>Prunus bucharica</strong></td>
<td>Wild almond</td>
<td>Jangli badam</td>
</tr>
<tr>
<td><strong>Prunus kurmanica</strong></td>
<td>Wild almond</td>
<td>Jangli badam</td>
</tr>
</tbody>
</table>
### Small fruits

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Alternate Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duchesnea indica</td>
<td>Indian strawberry</td>
<td>-</td>
</tr>
<tr>
<td>Fragaria nubicola</td>
<td>Wild strawberry</td>
<td>Magaroos</td>
</tr>
<tr>
<td>Ribes alpestre</td>
<td>Asian gooseberry</td>
<td>-</td>
</tr>
<tr>
<td>Ribes orientale</td>
<td>Wild currant</td>
<td>-</td>
</tr>
<tr>
<td>Rubus anatolicus</td>
<td>Wild blackberry</td>
<td>Kanachi, Kanwara</td>
</tr>
<tr>
<td>Rubus ellipticus</td>
<td>Golden raspberry</td>
<td>Guracha</td>
</tr>
<tr>
<td>Rubus hoffmeisterianus</td>
<td>Wild raspberry</td>
<td>Rumu</td>
</tr>
<tr>
<td>Rubus iritons</td>
<td>Wild red raspberry</td>
<td>Rutuch</td>
</tr>
<tr>
<td>Rubus macilentus</td>
<td>Wild yellow raspberry</td>
<td>-</td>
</tr>
<tr>
<td>Rubus niveus</td>
<td>Black raspberry, Mysore raspberry</td>
<td>Buganray, Bukaran</td>
</tr>
</tbody>
</table>

### Grapes and related species

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Alternate Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampelopsis vitifolia</td>
<td>Crow’s grape</td>
<td>Kawali yatch, Grabuch</td>
</tr>
<tr>
<td>Vitis jacquemontii</td>
<td>Wild grape</td>
<td>Gidar kwar (jackal grape)</td>
</tr>
<tr>
<td>Vitis parvifolia.</td>
<td>-</td>
<td>Kali dhak</td>
</tr>
<tr>
<td>Vitis vinifera</td>
<td>Wine grape</td>
<td>Angoor</td>
</tr>
</tbody>
</table>

### Tree nuts

Walnuts and almonds are cultivated tree nuts of economic importance to local communities. In addition to these, three species of *Pistacia*, two species of wild almond, and the hazelnut *Corylus jacquemontii* all grow in this area. Three wild species of *Pistacia* (*P. atlantic*, *P. chinesis*, and *P. khinjuk*) grow on dry rocks, in rock clefts, and in places inaccessible to people. *Pistacia chinesis* is mostly found in graveyards together with wild olives. The two species of wild almond are *Prunus bucharica* and *P. kurminica* (Almond). *Prunus bucharica* is very rare, *P. kurmanica* grows in the Kurram Valley and in Chitral on dry slopes. Because these species have small trees and are found in areas where there is extreme drought, they may be valuable as root stock for cultivated almonds. Filberts or hazelnuts (*Corylus jacquemontii*) are found in the moist forests of the Kalam valley, but trees are rare. The nuts are collected by local people and sometimes sold in the local market.
Diversity and importance of other fruit tree species

Other minor fruits species occurring in the northern mountain area of Pakistan are listed in Table 1. These species have significant economic importance to local people, either for income or as food. Two species of mulberry (Morus) are found widely distributed in the area and both fresh and dried fruits are consumed by the local people. *Diospyros lotus* (Date plum) is cultivated widely by villagers in the hills at altitudes of between 750 to 2,100m. Small fruits are dried and sold in the market and seedlings are also used as root stock for *D. kaki* cultivars. The wild fig, *Ficus palmate*, is also common in hilly areas. These trees produce small fruits that are edible. This species also has good attributes as a root stock of commercial figs.

Among the small fruits, there are two wild species of strawberry, three species of gooseberry, one species of blackberry, and five species of raspberry native to the area. However, the diversity of these species is threatened by overgrazing.

Diversity of grapes and their wild relatives

There are three wild grape species in the area: *Ampelopsis vitifolia*, *Vitis jacaquemontii*, and *Vitis parvifolia*. *Ampelopsis vitifolia* is found in Chitral, Swat, Kohistan, Hazara, and Muzaffarabad at elevations of from 900 to 2,400m growing either in moist gullies or in regions with substantial rainfall. *Vitis jacaquemontii* is found in Swat, Hazara, and Azad Kashmir at elevations of between 600 and 2,400m. The vines are vigorous and climb up trees or hand over river banks. The fruits are black and juicy with tough skins and two to three seeds per berry. The fruits are edible and available in the local markets. *Vitis parvifolia* is found growing in gullies in Swat, Hazara, and Azad Kashmir. The fruits are not edible but the vines are used as fodder.

Diversity of medicinal plants

Most of the floristic surveys conducted in Pakistan indicate that at least 1000 species of medicinal plants occurs in northern parts of Pakistan (Ikram & Fazal, 1978). Of these species 500 are known for their active constituents from research conducted in Pakistan or elsewhere (Williams and Ahmad, 1999), and around 400 species are known to have entered in herbal markets. Most of the medicinal plants used in commercial quantities are found in three ecological regions of northern mountains (Rafiq, 1998) which are as follows:

- **Alpine and high altitude areas**: The medicinal plants growing mainly in this zone are slow growing perennial species which require several years for vegetative growth and reproduction. The important species of this zone are *Podophyllum hexandrum*, *Saussurea costus*, *Picrorrhiza kurroa*, *Aconitum heterophyllum* and *Corydalis* spp. Because of their slow growth and over collection, most of these species are classified as endangered or vulnerable.

- **Temperate forests**: The common medicinal plants of this area are *Atropa acuminate*, *Angelica glauca*, *Paeonia emodi*, *Geranium wallichianum*, *Artemisia* spp., *Glycyrrhiza glabra* and *Ephedra* spp. Due to 50% decrease in forest area during the last 100 years, the medicinal plants growing in this zone has decreased drastically.

- **Sub-tropical foothill forests**: Himalayan foothill forests spread over an area of 1.702 mha are rich in floral diversity. The important medicinal plant species of commercial importance are *Terminalia* spp., *Mallotus philippensis*, *Phyllanthus emblica* and *Butea monspera*. 
Management concerns

Genetic vulnerability in minor fruit species and their wild relatives is pronounced in the Pakistan mountains because of population pressure and the cultivation of commercial cultivars of major fruit species. Woody species are diminishing because they are cut for timber and fuel. Small shrubs and climbers are being grazed. Species with inedible fruit are under threat of extinction. Horticultural Development Programmes by various public sector organizations and NGOs are also causing genetic erosion by introducing exotic cultivars. Some of the indigenous species such as Sorbus, lanata, Cydonia oblonga, Prunus prostrate and Prunus mahaleb are much more common in areas with rainfed farming than in areas where there is irrigation. At present, the habitat loss, degradation, fragmentation, resource over exploitation, ignorance and development pressures are causing a serious loss to biodiversity including medicinal plants. Further, the demand for medicinal plants by industry and for export is soaring. For meeting both local and export demands, cultivation of selected species of medicinal plants is the only alternative for economic and ecological rehabilitation of local communities and ecosystems. The breeding of selected plant species to obtain higher and better quality will substantially play role in poverty alleviation and conservation of resources.

References


Introduction of Biodiversity Conservation in the Education Systems in West Asia Countries

A.Amri¹, M. Ajlouni², R. Assi³, Y. Sbeih⁴, A. Saad⁵, W. Khoury³ and A. Khnifes⁵

¹ Regional Project Coordinator, the International Center for Agricultural Research in the Dry Areas (ICARDA), Amman-Jordan, e-mail: a.amri@cgiar.org
², ³, ⁴, ⁵ Respectively, National Project Coordinators in Jordan, Lebanon, Palestine and Syria

Keywords: Biodiversity, conservation, education, schools, universities, extra-curricula

Abstract
Increasing general public awareness can contribute substantially to the conservation of local biodiversity and the education systems can play a crucial role in this regard. The West Asia dryland agrobiodiversity, in close collaboration with the Ministries of Education has succeeded in introducing agrobiodiversity conservation within the curricula and extra-curricula activities of schools and universities in Jordan, Lebanon, the Palestinian Authority and Syria. School syllabus, teachers’ methodological and scientific guides were produced and various extra-curricula activities were undertaken for this purpose.

Introduction
Local biodiversity in the mega-centers of diversity is under serious threats most of which are directly linked to anthropogenic factors and its conservation and sustainable use will require adoption of holistic approach targeting the empowerment and improvement of livelihoods of the custodians of local agrobiodiversity and the increased awareness of key stakeholders and general public on the benefits and values of conserving the environment and biodiversity. The GEF funded project on “conservation and sustainable use of dryland agrobiodiversity in West Asia” aimed at promoting community-based in situ and on-farm conservation of landraces and wild relatives of species of global importance using a holistic approach including technological, economic and policy options in addition to capacity building and public awareness activities. This project is coordinated by the International Center for Agricultural Research in the Dry Areas and implemented in the drylands of Jordan, Lebanon, Palestine and Syria during the period of 1999-2005. This contribution presents the activities undertaken to introduce biodiversity conservation in the education system.

Methodologies and achievements
A thematic group formed of education specialists from the Ministers of Education and biodiversity specialists organized several meetings and discussed the approaches and the curricula and extra-curricula activities. It has been agreed to include biodiversity conservation related aspects within the existing school syllabus and be an integral part of different courses. The curriculum matrices were developed to include different concepts and activities within the grades and types of courses. The school books are reviewed and enriched with biodiversity concepts, definitions and examples from the region which are included in the scientific guide and in the standardized teachers’ methodological guide. Training courses were provided by the project teams to teachers and education specialists and to students at schools in targeted areas.
Several extra-curricula activities were undertaken mainly with schools in target areas which include: visits to biodiversity rich areas and assessment of status and threats of local biodiversity, participation to farm activities, establishment of school gardens, participation to afforestation efforts and to forest cleaning, creation of environment and biodiversity clubs and wall newsletters, documentation of parental knowledge, school theater, and painting contests, etc. A regional painting contest was organized where 8 to 13 years old children has envisioned their understanding and perception of the values and status of local agrobiodiversity.

The project helped also in developing a Masters program on biodiversity conservation and natural resources management at Jordan University for Science and Technology in Jordan and at Al-Qods University in Palestine where the Regional Coordinator and National Coordinators are lecturing. Training on conservation of agrobiodiversity was given annually to newly graduated students in Palestine and Lebanon.

The project has succeeded in launching the process and has developed collaboration between the Ministries of Education and Agriculture to ensure the sustainability of the efforts.
Experience of the Syrian Ministry of Agriculture in Using Native Wild Fruit Tree Species in the Afforestation Efforts

A. Daoud¹ and A. Amri²

¹ Former Director General of the Forestry Directorate, Ministry of Agriculture and Agrarian Reform
² International Centre for Agricultural Research in the Dry Areas, ICARDA, Amman, Jordan

Keywords: wild fruit trees, afforestation, conservation, Syria,

Abstract
Syria is located within the center of diversity for many fruit trees and field crops, and many wild relatives of these species are found within the remaining forests and natural habitats. The Ministry of Agriculture and Agrarian Reform has undertaken since early 1970s’ intensive afforestation efforts with an average 2700 ha planted annually. Pines, wild pistachio and eucalyptus are predominately used with little attention to the conservation of the genetic base of the native species. The collaboration with the dryland agrobiodiversity project stressed the importance of using native species of all fruit trees and other wild neglected species in the afforestation programs over the country and the importance of sampling the seed sources for nurseries based on better sampling of populations diversity.

The Ministry of Agriculture and Agrarian Reform issued a directive to the departments of forests at the governorate to reserve at least 30% of the planned forest areas to wild relatives of fruit trees such as wild pistachio, wild almond, wild pear, crateagus, and others.

Introduction
Syria is located within the West Asia mega-center of diversity where number of field crops and fruit trees now grown over the world and contributing significantly to its food security, were domesticated over the past 10,000 years (Harlan, 1992). The flora of Syria was studies by many taxonomists and the first surveys were undertaken by Post (1933) and Mouterde (1970). Syria’s flora accounts more than 3700 higher plant species reflecting the diversity of eco-geographic variation ranging from Desert areas to High Elevation Mediterranean types of environments. This part of the world includes Centers of diversity for many fruit tree species and their wild relatives including Pyrus, Prunus, Amygdalus, and Pistachia species. The natural habitats and forest areas are suffering from alarming degradation due to the overuse of the resources, their reclamation for urbanization and for agricultural encroachment.

Natural forest represents 232,000 ha in Syria and since 1953 high attention is reserved to afforestation efforts. Form that date till 1970, an average of 2700 hectares are planted every year reaching more than 5000 ha in 1970. Since then, more efforts have led to reforestation of 12,000 ha and multiplication of 15 million seedlings annually. A total of 250,000 ha are reforested but only 7-10% with native species mainly wild pistachio species, but the majority belong to Pinus and Eucalyptus species. The West Asia Dryland Agrobiodiversity has collaborated with the Forestry Directorate to promote the use of wild fruit tree species native to the region in the reforestation efforts. This contribution will highlight the progress made in this regard.

Distribution of wild fruit trees in the forest ecosystems
The following map shows the different types of forests in Syria.

Traditional knowledge on the use of wild fruit trees
Farmers are using wild fruit trees for different purposes including medicinal, food and feed. Farmers are aware of the importance of these species as rootstocks for grafting the cultivated species and they always keep some of these wild species in the borders of their orchards for this purpose when reclaiming the land from natural habitats. These species can play an important role in the improving the livelihoods of local communities. Many of these species are underutilized and efforts should be undertaken to promote their use and the marketing of their products (Padulosi, 1999; Padulosi et al., 1999). These uses along with eco-tourism could help in the overall strategy for promoting the in situ conservation of this valuable local agrobiodiversity.

New strategy of afforestation
Increased awareness of the importance of using native species in the rehabilitation of degraded ecosystems have increased recently through interaction with the agrobiodiversity project which focuses on promoting the in situ conservation of landraces and wild relatives of fruit trees and field crops along with rangeland legumes species. The adaptation of these species is a good attribute for their success under harsh conditions and for reducing the costs of handling new plantations during establishment phases. These plantations will contribute significantly to reducing the trends of land degradation and desertification experienced in the dry areas. Weber et al. (1986) have recommended the use of adaptive native species of the rehabilitation of degraded natural habitats and for afforestation.

In 2003, a strategic plan was established including the assessment of non cultivated government lands and the degraded forest ecosystems to develop plans for afforestation for each region. Use and choice of drought resistant species, mainly native ones, was privileged for new reforestation efforts along with the introduction of water harvesting techniques were advocated by the West Asia dryland agrobiodiversity project. The five years plan projects to reserve 30% of reforested areas for the plantation of species targeted by the project such as
those belonging to *Amygdalus, Prunus, Pyrus, Crateagus, Pistachia, Rhus, Ficus* and *Olea* genera. This share will be increased through the years.

The government nurseries play an important role in multiplying the seedlings of forest species and target species. Most of the reforested areas are planted to Pinus and Eucalyptus and even for the areas planted to native species, most of the seedlings are tracing back to restricted genetic base which could make them vulnerable to pests and diseases. From 1999 to 2003, the number of seedling of targeted species multiplied by government nurseries have dropped to a half (Table 1).

Table 1: Number of seedlings (in 1000’s) multiplied in the Forest Department nurseries in Syria during 1999-2003 period.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pistachia sp</em></td>
<td>2585</td>
<td>2260</td>
<td>2960</td>
<td>1445</td>
</tr>
<tr>
<td><em>Pyrus syriaca</em></td>
<td>195</td>
<td>5</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><em>Amygdalus sp</em></td>
<td>650</td>
<td>30</td>
<td>130</td>
<td>275</td>
</tr>
<tr>
<td><em>Prunus Mahaleb</em></td>
<td>70</td>
<td>10</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,030</strong></td>
<td><strong>2,304</strong></td>
<td><strong>3,130</strong></td>
<td><strong>1,575</strong></td>
</tr>
</tbody>
</table>

The agrobiodiversity project has helped in increasing the seedlings of many target species in the government forestry nurseries in Lattakia and Sweida where 125,000 seedlings and grafts are multiplied and used to reforest areas and school gardens in the two regions. The Ministry of Agriculture and Agrarian reform issued orders to forest services to include native shrub and tree species in more than 30% of the afforestation annual plans. The agrobiodiversity project introduced the best sampling methodology for collecting seeds of these native species to be multiplied in the nurseries and preserve most of the existing genetic diversity.

The project has provided training on eco-geographic/botanic surveys and management techniques and plans for promoting *in situ* conservation of local agrobiodiversity under forest ecosystems to more than 35 Forestry Department staff. The sampling of diversity was emphasized in collecting the seeds for nurseries to avoid genetic vulnerability when seeds are collected from few trees.

**Conclusion**

This joint effort will contribute significantly in the promotion of conservation of local biodiversity mainly the wild relative of globally significant fruit crops, the sustaining of ecological functions and the conservation of other species which grow under natural habitats to be rehabilitated. Community-based management plans need to be developed to ensure sustainability of use of the forest resources. The project has made recommendations for the creation of natural reserve in Sweida region to preserve the remaining wild fruit tree species and the progenitors of wheat and barley and many other herbaceous and shrub species.

**References**


Conservation and Sustainable Use of Dryland Agrobiodiversity in Lebanon: Highlights of Project Impacts and Achievements

R. Assi1, W. Khouri1, A. Amri2, M. Monzer1, S. Bsat1, N. Chamoun1, D. Dahrouj1, and M. Yazbeck1

1 Dryland Agrobiodiversity Project, Lebanon Agriculture Research Institute – Lebanon
2 International Center for Agricultural Research in the Dry Areas, Amman, Jordan. E-mail: a.amri@cgiar.org

Keywords: Drylands, agrobiodiversity, conservation, achievements, Lebanon

Abstract
The project on “Conservation and Sustainable Use of Dryland Agrobiodiversity in Lebanon” is a component of the regional project including Jordan, Lebanon, the Palestinian Authority and Syria. The project aims at promoting in-situ and on-farm conservation of landraces and wild relatives of important field crops, forage legumes and fruit trees species originating in the region through direct participation of the local farming and rural communities.

The project in Lebanon is active in the drylands of the Baalbeck Caza, Bekaa Valley, in three main sites, namely Ham/Maaraboun, Aarsal, and Nabha. It is funded by the Global Environment Facility (GEF), managed by the United Nations Development Programme (UNDP), nationally executed by the Lebanese Agricultural Research Institute (LARI), and regionally coordinated by the International Center for Agricultural Research in the Dry Areas (ICARDA).

This paper highlights the major impacts and achievements of the project activities executed with the participation of key stakeholders to demonstrate technological, institutional, add-value and alternative sources of income, and policy options, needed to promote the conservation and sustainable use of local agrobiodiversity. Capacity building and public awareness are also tackled by the project. This project has allowed the knowledge of the state of local agrobiodiversity and the major factors of its degradation, and has already led to institutional changes at research, education and development levels which will contribute to the safeguarding of the valuable agrobiodiversity.

Project aim and strategy
The project on “Conservation and Sustainable Use of Dryland Agrobiodiversity in Lebanon” is a component of the regional project including Jordan, the Palestinian Authority and Syria. The project aims at promoting in-situ and on-farm conservation of landraces and wild relatives of important field crops, forage legumes and fruit trees species originating in the region through the direct participation of the local farming and rural communities. The project in Lebanon is active in the drylands of the Baalbeck Caza, Bekaa valley, in three main sites, namely Ham/Maaraboun, Aarsal, and Nabha. It is funded by the Global Environment Facility (GEF), managed by the United Nations Development Programme (UNDP), nationally executed by the Lebanese Agriculture Research Institute (LARI), and regionally coordinated by the International Center for Agricultural Research in the Dry Areas (ICARDA).

To reach the overall objective of the project, numerous activities involving major stakeholders were undertaken to demonstrate technological and policy options, to promote alternative sources of income, and to increase capacity building and public awareness in areas related to agrobiodiversity conservation and sustainable use.
Major impacts of the project
- Establishment of a local seed cleaning/treatment unit in Aarsal and distribution of more than 10 tons of quality seeds of landraces of cereals and legumes to local farmers in the target area.
- Support the establishment of two agro-food processing centers for the benefit of local women
- Groupings in Ham/Maaraboun.
- Creation of new agricultural cooperatives in the target area.
- Establishment of a community local nursery focusing on the multiplication of wild species and local varieties of fruit trees in Aarsal. The nursery produces 6000-10,000 seedlings every year.
- Advocate the introduction of native targeted wild fruit trees species in the national reforestation Programme by the Minstry of Environment decision. Many projects are actually using native species in the afforestation efforts.
- Development of policy options that promote sustainable agrobiodiversity conservation and sustainable management of natural resources based on the socio-economic, ecological and institutional analysis of factors affecting agrobiodiversity. The drafted policy and legislation recommendations are presented to government for consideration.
- Development and proposition of a scheme to introduce biodiversity concepts in the national education curricula.
- Support the establishment of a local fattening unit aiming at reducing the pressure of overgrazing on rangeland.

Status of local agrobiodiversity and major threats
The project conducted socio-economic, eco-geographic, indigenous knowledge and eco-botanical surveys in the project sites of Aarsal, Ham, Maaraboun and Nabha. The results showed that these areas are experiencing rapid loss in agrobiodiversity. Few landraces are still used by local farmers namely those of wheat, barley, grapes, figs, lentil, and chickpea. While the major factor affecting the use of local varieties of fruit trees is their replacement with improved varieties, the major factor reducing the area of field crops landraces is the introduction and expansion of improved varieties of fruit trees. With respect to wild relatives, land reclamation, overgrazing, deforestation, quarries and drought are the major factors of degradation. GIS tools were also used (land cover maps in the project sites for 1962 and 2000), allowing some analysis of how agrobiodiversity and land use have changed over the past decades.

Technological options
- Several demonstration sites were established to show the effect of water harvesting, reseeding with native legumes and protection on rangeland rehabilitation. Aarsal community participated in the management of grazing and large area was used to demonstrate the technological options in Nabha.
- A survey was conducted on animal grazing and feeding calendars in the target area. The project, in collaboration with other programmes, supported the Herders Cooperative of Aarsal to establish a fattening unit aiming at reducing the pressure on rangeland.
- Support was provided to conduct research studies on field crops landraces yield improvement which showed the possibility of selecting lines and multilines from the original populations of wheat and barley which can give higher yields.
- A nursery was established with a local NGO (Aarsal Rural Development Association) producing around 10,000 seedlings/plantlets per year of targeted wild and local varieties of fruit trees.
- Field gene banks for figs and grapes local varieties were created at the Lebanese Agriculture Research Institute where more than 70 landraces are actually conserved.
- Management plans were drafted for two selected sites rich in diversity of targeted species.
- Reforestation site was established in Aarsal and planted with 3,000 seedlings of targeted wild fruit trees species.
- The project demonstrated the effect of seed treatment and cleaning on yield of landraces and established a local seed cleaning unit in Aarsal, which distributed more than 10 tons of cleaned landraces seeds of cereals and legumes to more than 70 farmers in the target area.

Add-value and alternative sources of income
- The project supported and promoted eco/rural tourism activities in Ham/Maaraboun project site. Six tours with three private eco-tour operators were initiated in the area (150 participants). This activity has allowed members of the communities to benefit financially from providing local dishes, hiking, and other agricultural activities.
- A study was conducted on the status of honey production in the project target area and several trainings were conducted on improving apiculture techniques.
- The project supported the local women groupings in the area of agro-food processing; several trainings were provided. An agrobiodiversity fair was organized. YMCA, through USAID fund, established two agro-food processing centers in Nabha and Ham/Maaraboun with the cost of equipment being co-shared with the project (more than 50 women benefiting from this initiative). The center in Ham is operational.
- The project identified medicinal and aromatic plants in the target area and, in collaboration with ICARDA station in Terbol, collected seeds of plants with medicinal potential. Plant characterization and seed increase were carried out. A local women’s cooperative in Aarsal was supported by the project to locally cultivate those plant species.

Capacity building
Four graduate (MSc.) and eight undergraduate (BSc.) students from national universities were financially supported by the project to conduct their research studies in areas related to agrobiodiversity conservation. Several trainings and workshops were conducted for local communities and researchers in areas related to project activities (benefiting 831 persons including 200 women). These included trainings on integrated pest management, organic farming, orchard management practices, water harvesting techniques, GIS applications for management of agrobiodiversity, quality seed production, proper and safe use of pesticides, soil and water resources management, plant taxonomy, management of NGOs, land tenure and natural resources management, improved apiculture techniques, agro-food processing, in situ conservation, importance of indigenous plant genetic resources in sustainable agriculture, establishment and management of fruit trees nurseries, pasture and pasture nursery management. In addition, the project supported researchers and farmers to attend many trainings provided at the regional level.

Public awareness
- The Project developed a national documentary film on agrobiodiversity and broadcasted two TV spots on several national TV stations.
- Many interviews/reports were broadcasted/published on national TV (10), Radio (5) stations and newspapers (9) about the project.
- Three posters and eight leaflets on agrobiodiversity, the project sites, and the project activities were produced; in addition to 30 posters intended for exhibitions.
- A national website was developed (www.lari.gov.lb/agrobio) which contains studies and reports on all project activities.
- Seven issues of a national project newsletter were produced (English, Arabic and French).
- Calendars with the theme of “Wild Fruits of Lebanon” were distributed, as well as hats and other public awareness materials.
- Several presentations (16) were conducted at national schools/universities.
- Six training sessions were provided to teachers from local schools on concepts and teaching methodologies related to biodiversity conservation.
- A painting contest on agrobiodiversity for students between 10-14 years old was launched in 12 local schools in the project target area with the participation of 150 students.
- The project participated in several fairs/exhibitions (10) and organized one in the target area for local NGOs which allowed 23 NGOS to present their local products.
- The Curriculum guide, which includes the biodiversity concepts to be included at all levels of education system within the contents of different courses was produced and presented to the National Educational Center for Research and Development for consideration.

Policy and legislation recommendations

The Project reviewed the national legislation related to biodiversity and management of natural resources in Lebanon. Also, the project did a study that proposes the mechanism for the national domestication of international conventions and agreements related to the conservation and sustainable use of agrobiodiversity. In addition, the project prepared a study for the establishment of a national plant genetic resources (PGR) programme in Lebanon. The objective of this PGR programme is to regulate the conservation and exchange of the national plant genetic resources by setting the scientific, administrative, institutional and legal framework for this sector, in the light of the international and regional relevant agreements and conventions that were ratified by Lebanon. The project formulated policy options at the farm-household, community and national levels that promote sustainable agrobiodiversity conservation and sustainable management of natural resources. These options were based on the socio-economic, ecological and institutional analysis of factors affecting agrobiodiversity.

Acknowledgment

The authors would like to thank GEF-UNDP for their financial support, ICARDA for their technical backstopping and the Lebanese Agriculture Research Institute for the in-kind contribution and technical assistance as well as the local communities for their cooperation and contribution.
Conservation and Sustainable Use of Dryland Agro-biodiversity in the Palestinian Authority - Highlights of project impacts and achievements

Y. Sbeih¹ and A. Amri²

¹National Project Manager, Palestinian Authority, UNDP/PAPP, Ministry of Agriculture, Ramallah, Palestine.
²International Center for Agricultural Research in the Dry Areas (ICARDA), West Asia Regional Office, Amman, Jordan

Project aim and strategy
The agrobiodiversity project promotes the in situ and on-farm conservation of landraces and wild relatives of field crops, forage legume and fruit trees species that have their origin in West Asia. A holistic strategy involving major stakeholders and based on testing and demonstrating technological, institutional and policy options was adopted. Add-value and alternative sources of income options along with capacity building and increasing public awareness were also among the main activities of the project. The project’s field activities are conducted involving two communities in each of Jenin and Hebron districts.

Major impacts of the project
- The informal seed production system was initiated and institutionalized in collaboration with three grassroots associations and contributed towards regaining importance and interest in landraces. Durum wheat acreage has increased substantially at the project sites as a consequence;
- The Ministry of Agriculture of the Palestinian Authority has created a Department of Agrobiodiversity in the new structure and the Forestry Department has adopted the use of native fruit tree species in their reforestation programs. The project has distributed more than 10,000 seedlings of wild fruit trees used in these reforestation efforts;
- A qualified multidisciplinary team is actually working at the Ministry of Agriculture to sustain project goals;
- Two nurseries were created and another was supported by the project and all three focus on multiplying fruit tree landraces and wild relatives with a capacity to produce 50,000 seedlings annually.
- Policy and legislation options are developed and proposed to the Government for consideration;
- The introduction of the study biodiversity conservation in the education system has been adopted by the Ministry of Education.

Status of local agrobiodiversity and major threats
Socio-economic and eco-geographic surveys showed that most of barley, lentil, olive, fig and almonds grown in the target areas are mainly landraces while wheat, apple, apricot, plum, cherry and onion are mostly improved or introduced varieties. The main factors affecting genetic erosion in the areas of landraces are the replacement by improved varieties and introduced species. In case of wild relatives, overgrazing and land reclamation for urbanization and agricultural purposes, in addition to quarrying activities in Sair and the effects of occupation are the main factors of land degradation. The project has developed a
1/20,000 soil map for project sites and compiled valuable information on land uses and species distribution using GIS/RS tools.

**Technological options**
- The project demonstrated the positive effects of seed treatment and cleaning, and has initiated a community-based informal seed production and distribution system. More than 79 tons of seeds were distributed which benefited more than 425 farmers.
- The project developed an integrated approach for the rehabilitation of degraded rangelands through the plantation of fodder shrubs within water harvesting structures, the introduction of alley cropping and of feed block technology using crop residues. A feed block unit was provided to the Dahriya livestock cooperative. More than 60 ha of rangelands were used to demonstrate the rangeland improvement and management options;
- The benefits of water harvesting techniques on fruit trees was demonstrated on a large scale at Sair and Tayassir;
- Two field genebanks for fruit tree landraces (fig, stone fruits, pistachio, Ceratonia, etc.) were created at Beit Qad experiment station and at Tayassir with the collaboration of a local NGO;
- Management plans were drafted for two above-mentioned selected areas.

**Add-value and alternative sources of income**
- This project focused on the investigation and training of local communities, mainly women, on options for adding value to local agrobiodiversity and for opportunities to improve and diversify the sources of income for the custodians of the agrobiodiversity.
- Practical training workshops were organized benefiting more than 370 persons including 225 women. The training covered diverse areas such as, food processing, nursery management, cultivation of medicinal and/or herbal plants, dairy production, and apiculture;
- A processing unit for production of jams, syrup and pickling was provided and it is operated by the local women center in Sair;
- More than 50 beehives were distributed to 80 women and first production averaging 8 kg per hive were sold at local market. Actually each woman has two beehives and more than 12 women have joined in this activity;
- More than 556,000 seedlings of medicinal plants were distributed to 2245 women all over the West Bank for their home gardens. This has made the households self sufficient in medicinal plants and the surplus is sold at local market;
- Dairy production unit was provided to Deir Abu Deif women center to produce mainly “Shinglish” cheese. The collaborating women have received training on “Shinglish” cheese-making in Syria;
- The project has succeeded in mobilizing additional funds that were used to acquire other sources of extra income such as, sheep, goats, cows, chicken, and pigeons;
- Agrobiodiversity fairs were organized to generate publicity and allow the marketing of local products and these were highly successful;

**Capacity building**
• Three MSc students supported by the project completed their degree studies; Four Ministry of Agriculture (MoA) staff and two students are working towards MSc degree at local Universities. Three MoA staff are studying for Diploma at the Lattakia Forestry and Rangland Institute in Syria;
• MSc degree training in biodiversity conservation has been initiated at Al-Quds University with the support and collaboration of the agrobiodiversity project;
• More than 30 participants attended regional training courses covering all aspects of in situ conservation and integrated natural resources management;
• A total of 17 training courses and workshops were organized at the national level and have benefited 1524 persons, including 878 women.

Public awareness
• Project strategy and objectives were explained directly to more than 700 persons during field days;
• Two documentary films were produced and broadcast over at least three local TV channels as well as the national satellite TV network;
• Intensive use of mass media including 12 episodes on agrobiodiversity related issues, more than 20 interviews by local radio and TV stations, and several articles in newspapers;
• Organization of three agrobiodiversity fairs;
• A total of 8 posters, 12 leaflets, and 6 issues of newsletter were produced;
• Environmental clubs were created at 8 schools at the project sites which are active in creating school gardens, wall newsletter, reforestation, etc;
• Training of more than 80 school teachers and education specialists on agrobiodiversity conservation concepts;
• Organizing painting contests for school children;
• Distribution of calendars, T-shirts, field caps, etc.

Other major achievements
• National policy, legislation options and recommendations were developed;
• Curriculum and teaching methodological guides were produced in collaboration with the Ministry of Education;
• More than 10 partners (institutions, NGOs, and universities, …) have collaborated in the implementation of project activities, and have adopted the project strategy and approach in their agenda;
• The United Nations Development Program/Program of Assistance to the Palesstinian People (UNDP/PAPP) has supported many activities towards the promotion of the preservation and sustainable use of local agrobiodiversity;
• The project is actually working on the development of exit strategies such as, the management plans for biodiversity rich areas, sustainable livelihoods for the custodians of agrobiodiversity, community development plans and the role of gender in the conservation of agrobiodiversity.
Highlights of major achievements of the dryland agrobiodiversity project in Syria

A. Saad¹ and A. Amri²

¹General Commission for Scientific and Agricultural Research, Damascus, Syria
²International Center for Agricultural Research in the Dry Areas, Amman, Jordan

Project strategy and objectives
The West Asia Dryland Agrobiodiversity aims at promoting multiple stakeholders involvement in the conservation and sustainable use of landraces and wild relatives of species of global importance originating from the West Asia Mega-center of diversity. The project investigated the status of local agrobiodiversity, the technological packages to enhance its productivity and quality, options for adding value and alternative sources of income and the policy recommendations, capacity building and public awareness actions. Field activities are conducted in 10 communities at Sweida and Al-Haffeh regions.

Project preliminary impacts
The project, although initiated in 1999 has already led to significant impacts that are consolidated by clear commitment from government institutions to sustain the project goals and out-scaling them to other regions in the country. There is a significant shift to the use of wild fruit tree native species in the afforestation efforts where instructions were given to include 15-30 % of project target species in the multiplication plans and actually more than 3.5 million seedlings are produced annually. The project has produced 150,000 seedlings and grafting of fruit trees distributed to farmers in the target areas. The project in collaboration with the Ministry of Education has succeeded in introducing biodiversity issues in the school curricula and already 10th grade students are learning about agrobiodiversity. Another institutional change is the creation of national agrobiodiversity program at the GCSAR to include both in situ and ex situ conservation aspects.

Status of agrobiodiversity and its major threats
Eco-geographic and socio-economic surveys conducted respectively in 29 monitoring areas and 10 project sites has shown that barley, lentil, chickpea figs and most of the durum wheat are exclusively represented by landraces. But their acreage is reduced by the extension of the plantations of fruit trees mainly apples in Sweida and cherries, citrus and olive trees at Al-Haffeh. The Plant diversity in natural habitats is characterized by high species richness including the wild relatives of wheat, barley, fruit trees and large numbers of forage species. Their abundance and distribution are highly affected by the land reclamation and fragmentation of natural habitats. The remaining areas rich in biodiversity are spotted and their management plans are being developed.

Technological options
The project has demonstrated low cost-technologies to improve the productivity and quality of landraces through seed quality improvement, integrated pest management and establishment of private nurseries producing landraces of fruit trees. For the rangeland, the project has been able to initiate community-driven rehabilitation and management actions for the rehabilitation of more than 300 ha in two sites. Water harvesting, plantation of shrubs, reseeding with native species and introduction of feed block technology are among the tested options.
Add-value and alternative sources of income options
The project provided training especially to women on divers areas related to food processing, dairy production and honey production. Jam from Zyziphus was introduced by the project at Al-Haffeh where an agrobiodiversity shop was created jointly between the project, the private sector and the local Women Union focusing on selling local products of agrobiodiversity. Four private nurseries were supported by the project specialized in multiplying local varieties and wild relatives of fruit trees and medicinal plants.

Capacity building and increasing public awareness
Two PhDs and 5 Masters were supported by the project and will ensure the continuity of project activities. Thirty nine training courses were provided to farmers, extension agents, forestry staff and young researchers on all aspects of in situ conservation totaling 546 beneficiaries. More than 20 field days and workshops were organized with the participation of 1806 persons including 823 women. For the public awareness activities, more than 2150 persons have directly participated to events explaining project objectives, goals and strategies. Additionally, use of mass media, the production of documentary film, leaflets, posters and reports and the distribution of T-shirts, caps and calendars have helped in spreading the project aims to larger audiences. Of major importance, the introduction of biodiversity in education system needs to be put at the credit of the project.

Policy and Legislation reforms
Recommendations were made to the parliament to enforce actions conducive to agrobiodiversity conservation. The preliminary impacts on reforestation highlights the change brought by the project. The Ministry of Environment is actually working to develop a natural reserve in Sweida to preserve the remaining diversity of wild relatives of field crops and fruit trees.

Other achievements
- Creation of two field genebanks for landraces of fruit trees;
- Collection and conservation ex situ of 280 accessions of Triticum, Aegilops and Hordeum species and 466 accession of landraces and wild relatives of legumes collected from the two target areas;
- Selection of 4 sites for in situ conservation and their management plans are being developed;
- More than 125 teachers and education specialists and 200 students were trained on agrobiodiversity importance and conservation methods;

Three seed cleaning units and one feed block units were provided to local communities as in kind incentives to promote the conservation and add-value actions of local agrobiodiversity.
Phenotypic Diversity of Agronomic and Morphological Traits of Durum Wheat (*Triticum turgidum* L. *durum* group) Landraces from Jordan

N. K. Rawashdeh¹, N. I. Haddad², M. M. Al-Ajlouni³ and M. A. Turk⁴

¹ National Center for Agricultural Research and Technology Transfer (NCARTT), Amman, Jordan.
² Department of Horticulture and Crop Science, Faculty of Agriculture, University of Jordan, Amman, Jordan.
³ Ago-biodiversity Conservation Project, Amman, Jordan.
⁴ Plant production Department, Jordan University of Science and Technology, Irbid, Jordan.

Keywords: Genetic diversity, durum wheat, landraces, Jordan

Abstract
Durum wheat landrace genotypes are disappearing from the main wheat producing areas in Jordan because of the increasing and rapid use of uniform cultivars and the serious reduction in the wheat cultivated area. This study was conducted to evaluate genetic diversity in durum wheat landraces in Jordan, and to identify desirable agronomic traits associated with them to be utilized by breeders. Wheat landraces were collected from two target areas: Ajloun and Karak. The collected accessions were evaluated under rainfed conditions using an augmented design with five blocks and four repeated check cultivars. Data were collected on 14 morphological and agronomic traits. Phenotypic diversity index (*H’*) was estimated, and the relationship among collected accessions for the measured parameters was studied using cluster analysis and dendrogram similarity matrix. Results revealed that landraces possessed high levels of variability for biological yield, fertile tillers per plant, number of seeds per spike, seed weight per spike and weight of 1000 seeds. These landraces are considered as a reservoir for desirable genes that plant breeders need to exploit and utilize in their wheat improvement programs. They need to be conserved using both *ex situ* and *in situ* methods.

Introduction
The geographic and climatic regions of Jordan are very diverse considering the size of the country. Also farmers’ agricultural practices differ from area to area. Differences in elevation, length of growing season, rainfall, sowing dates, and traditional cultural practices, may have resulted in the development of very diverse durum wheat landraces. This could possibly also have led to the evolution of gene combinations resulting in traits adapted to the diverse environmental conditions.

Durum wheat landrace genotypes are rapidly disappearing from the main wheat producing areas in Jordan. This is due to the introduction of new "high yielding" cultivars which have replaced original landraces. Also, there is considerable reduction in the area under wheat cultivation. Hence, the genetic base is expected to narrow down and this in turn limits the genetic improvement of this crop.

Therefore the objectives of the study are: to evaluate genetic diversity in durum wheat landraces in Jordan and to identify desirable agronomic traits associated with them, in order to broaden the germplasm pool that could be utilized in the improvement of crop productivity and stability.

Materials and Methods
Wheat landraces were collected from two target areas: Ajloun in the north and Karak in the south. A total of 398 single spikes were collected during June and July 2001; 197 single spikes from seven villages in Ajloun, and 201 single spikes from five villages in Karak. The
collected spikes were threshed and grown at the Maru Agricultural Experimental Station during the 2001/2002 growing season. The station represents the wheat growing areas in Jordan and received 459 mm of rain during the experimental season when the test was conducted. Augmented design with five blocks was used with four repeated check cultivars randomly arranged in each block. The check cultivars were “ACSAD 65”, “Sham 1”, “Hurani” and “Jubeiha”. Data were collected on 14 morphological and agronomic traits).

Results
  **Yield and other traits**
  The analysis of variance for the characters under investigation revealed the presence of wide range of variability among wheat landraces for most of the studied traits. Biological yield, grain yield and harvest index: Accessions collected from Ajloun showed high variability for biological yield as compared to those collected from Karak and to the improved cultivars. Their biological yields ranged from 9.2 to 66.3 g with a mean 33.68 g. The CV exceeded the CV of accessions collected from Karak and the improved cultivars by 8%. Variation in grain yield was slightly different from that of biological yield, where the improved varieties have higher standard deviation and CV values over the landraces but the means are about equal. The CV for the improved cultivars exceeded the CV in Ajloun accessions by 3.5% and in Karak accessions by 7.8%. Variation in harvest index followed the same trend that was observed with grain yield, where the improved varieties harvest index was higher than the accessions from Ajloun by 9% and of those of Karak by 6% with a substantially greater CV. Landraces showed superiority over the improved check cultivars for fertile tillers per plant, number of seeds per main spike, seed weight per main spike, thousand kernel weight, days to heading and days to maturity, grain filling period, plant height, and flag leaf area. The improved cultivars were superior for, main spike length and awn length.

**Phenotypic Diversity Indices (H’)**
Variation or polymorphism was common in varying degrees for most traits, indicating a wide variability among Jordanian landraces. Estimates of (H’) for individual traits are presented in (Table 3). These estimates ranged from 0.43 for spike length to 0.80 for grain yield with an over all mean of 0.63. Most traits showed a relatively high (H’) > 0.60) levels of polymorphism. However, those with values exceeding 0.75 are: biological yield, grain yield, fertile tillers per plant and awn length.

**Cluster analysis**
The dendrogram of 12 villages mean of landraces and four improved cultivars resulted in two main clusters. The first cluster had five sub-clusters: The first sub-cluster contained accessions from Qaser and Mazar, Alouseh and Mu’tah villages, all of these villages are from Karak area, with dissimilarity values ranging from 0.03 to 0.05; the second sub-cluster has Hurani, Raba, Soug and Wadi Ajloun with dissimilarity values ranging from 0.06 to 0.0.09; the third sub-cluster has Fakreh standing alone and differ from the others; the fourth sub-cluster contain accessions from Sakneh and Srabeese and the fifth sub cluster has Koufranjeh standing alone in a separate position. The second main clusters consist of three sub-clusters; the two improved cultivars ACSAD 65 and Sham 1 were very close to each other and to the improved cultivar Jubeiha, whereas accessions from Sefsafeh have a very distinct position from the other accessions and from the improved cultivars.

**Discussion**
In spite of the limited area of durum wheat cultivated with landraces, and the small number of fields available to the present study, considerable variation for most important agro-morphological traits are still to be found.

It is clear from the results that the accessions collected from Ajloun areas have a large level of variability as compared to the variability of the accessions collected from Karak areas. This is rather expected due to the diverse agro-ecologies found in Ajloun as compared to those found in Karak area; Ajloun is a mountainous area with very rough topography and relatively high annual rainfall, which vary significantly between locations.

Grain yield of landraces showed considerable variability which was close to the improved cultivars. However, biological yield of landraces have higher mean values than the improved varieties. This is rather logical, because the improved cultivars have been selected for their high grain yield potential and they are generally of semi-dwarf types. In contrast to that, landraces are selected by farmers in Jordan based on both grain and straw yield potential, because of the importance of straw as animal feed. Furthermore, landraces have taller plants which contribute to high biological yield and as a result more straw production. These results are comparable to those reported by Jaradat (1991) which indicated that considerable variation in landrace grain yield is still present in landraces and high yielding pure lines or multi-lines can be extracted from these landraces.

The result showed that the accessions collected from Ajloun governorate tend to be late in heading and in maturity comparatively to those collected from Karak. This might be due to the high climatic variability that exists in the mountainous areas. The cool weather in Ajloun is expected to affect the adaptation of the local landraces, and as a result, types with delayed heading and delayed maturity will be maintained and selected by farmers. On the other hand, the early types are more common in the accessions collected from Karak, which is a result of the dry and hot weather of the area. Jaradat (1991) reported wide variation among Jordan landraces and areas of origin for these characters. Days to heading and maturity were found to have the highest direct effect on grain yield of Iranian wheat landraces as reported by Ehdaie and Waines (1989).

The results showed that landraces from the same collection site tend to cluster together in the same main cluster (Fig. 2). This indicates their adaptation to the environmental conditions of their areas. “Hurani” is grouped with the landraces, because this cultivar is originally a selection from a Jordanian landrace. However, the other three improved cultivars were closer to each others and very distinct from the all the landraces except for those collected from Sefsafeh village in Ajloun governorate. These later cultivars are probably improved varities adopted by farmers of this region, and therefore, they are similar in many of the agro-morphological traits. Accessions from Sefsafeh seem to have traits distinct from the other landraces and thus need to be considered further in future evaluations.

**Conclusion**

Jordanian durum wheat landraces still exhibit wide degree of variability for most agronomic traits. These landraces are considered as a reservoir for desirable genes that plant breeders need to exploit and utilize in their wheat improvement programs. The promising accessions with highly desirable traits must be conserved in a comprehensive program using both ex situ and in situ conservation approaches. The genetic manipulation of landraces could help select new high yielding multilines which will allow farmers to continue use the landraces and promote then their on-farm conservation.

**Acknowledgement**
We thank the GEF funded West Asia Dryland Ago-biodiversity Conservation Project at the National Center for Agricultural Research and Technology Transfer (NCARTT), Amman, Jordan for financing this research.

References
Ehdaie B., and J.G. Waines, 1989: Genetic variation, heritability and path-analysis in landraces of bread wheat from southwestern Iran, Euphytica. 41, 183-190
Potential Association of Phenolic and Peroxydase Activities to Salt Tolerance Assessed in Two Barley Cultivars ACSAD 1230 and Arig 8

Eleuch L.1, Rezgui S.1, Slim-Amara H.1, Daaloul A.1, EL Hassni M.2 and EL Hadrami I2

1 Laboratoire de génétique et amélioration des plantes, Département d’Agronomie et Biotechnologies Végétales, Institut National Agronomique de Tunis. 43 Avenue Charles Nicolle 1082 Tunis, Cité Mahrajène. Tunisie e-mail: lilia.eleuch@voila.fr
2 Laboratoire de Physiologie Végétale, Équipe Biotechnologies et Physiologie Végétales, Faculté des Sciences Semlalia, BP 2390, 40001, Marrakech, Maroc.

Keywords: Barley, phenolic compounds, peroxydase, salt stress, salt tolerance

Abstract
Salt tolerance was assessed on two barley cultivars Acsad 1230 and Arig 8 originated from ACSAD and Morocco respectively using 0, 70, and 140 mM of NaCl. Phenolic compounds and peroxydase activity were determined at Z2.1 and Z4.5 of Zadock’s scale using third leaves and flag leaves after four and twenty weeks growth periods. These measurements were also carried out on the root system for both growth periods. Results indicated that Acsad 1230 is less sensitive to salt stress than Arig 8. Increased accumulation of soluble phenolic compounds and higher peroxydase activity were observed in the former cultivar treated with 140 mM of NaCl. These Phenolic compounds increased by 30% while peroxydase activity increase ranged from 50% to 239% at Z2.1 and Z4.5 respectively in Acsad 1230. However, phenolic compounds were not affected by greater salt treatment, whereas an increase of 159% of peroxydase activity was observed in Arig 8 at Z4.5 growth stage only. These results suggest that genetic variability for salt tolerance could be associated with phenolic compounds and peroxydase activity. The magnitude of expression of these compounds may be considered as valuable tool to select for salt stress.

Introduction
Genetic variability for salt tolerance is a prerequisite to discriminate among field crop cultivars and to increasing productivity in salt affected areas. Several mechanisms are involved in salt tolerance and induce irreversible physiological disorders (Lachaal 1998). Identifying potential mechanisms of salt tolerance within plant species is a research priority to efficiently select for tolerant cultivars that can withstand increased concentration of NaCl in the nutrient medium. The widespread distribution pattern of peroxidases within vegetative parts would suggest that these enzymes are involved in several physiological processes such as lignin synthesis (Sasumu et al. 2001) and other abiotic and biotic stresses (Aoued et al. 2000). The high catalytic activity of peroxidasen was found to regulate several plant growth processes (Gasper et al. 1991; Dougall 1992a). Peroxidase and phenolic compounds were both considered as potential indicators of plant salt stress reaction.

Material and methods
Vegetal material
Two barley cultivars, Acsad1230 and Arig 8, were grown in a pot and treated with 0, 70, and 140 mM of NaCl. Alternate washing irrigation was used after each salt treatment application. At Z2.1 and Z4.5 Zadock’s growth scale corresponding to four weeks and twenty weeks of
post sowing growth periods, third leaves and flag leaves as well as root were sampled and dried (lyophilised).

**Analysis of phenolic compounds**

Lyophilised vegetal material of 50mg was ground in cool temperature using 1,5 ml of MeOH (80 %) (El Hadrami *et al*. 1997). The aliquot was then agitated for 5 mins at 4°C. The mixture was subsequently centrifuged at 7000 g x 3 mins and the supernatant was recovered and conserved at -20°C. The residue was fixed with 2 ml of NaOH and placed at 100°C x 2h to extract non soluble phenolic compound. After incubation the extracts were acidified to PH 2 with HCL 2N. Ethyl acetate was then used to extract phenolic compounds and evaporated under dry conditions. Soluble phenolic compounds evaluation was determined using Folin Ciocalteu’s reactif (El Hadrami *et al*. 1997). Optic density recorded at 760 nm and phenolic compounds rates was expressed as mg of chlorogenic acid per g DM.

**Extraction and analyses of peroxydase activity**

Peroxydase extraction was carried out using a buffer of Tris-maléate (0,1 M, pH 6,5) enriched with Triton X-100 (0,1 g/l). Peroxydasic activity was measured using spectrophotometry at 470 nm and using gaïacol as substrate (Ridge et Osborne, 1970). 100 à 200 μl of the enzymatic extract (200 mg MS/ 2 ml) was added to 2ml reaction mixture of 0,1 M de Tris-maléate (pH 6.5) and 25 mM gaiacol solution. Reaction was initiated using 10 μl of H2O2 (10%) and data recorded during 3 min. Results are expressed as ΔDO min-1 mg-1 DM.

**Results**

**Effect of salt stress on the phenolic compounds**

At 70 mM NaCl treatment, both cultivars Acsad 1230 and Arig 8 exhibited comparable rates of phenolic compounds in the leaves to those noted for the control. However, phenolic compounds accumulations rates discriminate between both cultivars treated with 140 mM of NaCl (Figure 1a and 1c). Stable rates of soluble phenolics compounds were noted in Acsad 1230 and reduced rates were observed in Arig 8 (-22%). At 70 mM, the phenolics compounds were not affected by NaCl treatment measured in the root. However, using 140 mM NaCl at 3-4 leaves growth stage, a more pronounced phenolic compounds effect was noted in Acsad 1230 (+39,%) than in Arig 8 (+ 31%) (Figure 1b and 1d).

Slight increase of bounded phenolic compounds in the leaves have been found in Acsad 1230 at Z2.1 growth stage when 70 mM NaCl was applied, whereas these compounds were not affected in Arig 8 cultivar as compared to check treatment. At Z4.5 growth stage reduced phenolic compounds was detected in Acsad 1230 with no noticeable variation in Arig 8. However, a pronounced reduction of 50% of these compounds was found in Arig 8 at Z2.1 growth stage treated with 140mM. At Z4.5 growth stage, results indicated a lack of significant of NaCl treatment on bounded phenolic compounds for both cultivars (Figure 2a and 2c).

Using roots bounded phenolic compounds have increased by 20% in Acsad 1230 and reduced by 44% in Arig8 treated with 70 mM NaCl at Z2.1 growth stage. At Z4.5 growth stage, bounded phenolic compounds were more pronounced in Acsad 1230. The application of 140 mM NaCl, increased the accumulation of bounded phenolic compounds (+141,88%) in Acsad 1230 and reduced it in Arig 8 at Z4.5 (Figure 2b and 2d).

**Effect of salt stress on peroxydase activity**

738
Stable peroxydase activity in both leaves and roots was noted at Z2.1 growth stage for either salt application (70 and 140 mM) in cultivar Arig 8. Inversely, in Acsad 1230 treated with 140mM peroxydase activity increase of 50% and 60% was observed for both 3rd leaf and roots respectively (Figure 3a and 3b).

A positive association of peroxydase activity with increased levels of salt treatment at Z4.5 growth stage for both cultivars was found. However, higher rates of peroxydase activity were depicted in Acsad 1230 and reached 88% and 239% for 70 and 140 mM respectively. Lower peroxydase activity rates of 68% and 160% were noted in Arig 8 for both salt treatments respectively. Induced peroxydase activity of 163% and 90% in the root system in Acsad 1230 was noted for 70mM and 140mM respectively as compared to Arig 8 (Figure 3c and 3d).

**Discussion**

Positive peroxydase activity response to salt treatment was noted in Acsad 1230 while no significant metabolic effect was noted for Arig8. The lack of peroxydase activity response in this latter cultivar could be attributed to an enzymatic inhibition. Gosset et al. (1994a) concluded that salt susceptible cultivars are characterized by a significant reduction of peroxydase activity. Peroxidases were found to be involved in salt tolerance in Acsad 1230 barley cultivar and contribute to strengthening cell walls of the leaves and roots. This process could regulate the absorption of toxic ions and the detoxification as well as the protection of cells from toxic oxygen species that are induced by salt stress (Aoued 1997). It has been recognized that peroxidases are involved in H2O2 decomposition that initiates toxic oxygen production. These radicals are implicated in lipid peroxidation, denatured proteins and DNA (Penel and Castillo 1991; Rennenberg and Polle 1994), that favours a cellular decompartmentation and could be accentuated cellular damage. Several investigations demonstrated the implication of these enzymes in the lignification, defence mechanism against invading pathogens, salt tolerance and senescence (Baaziz 1990; Susumu and al. 2001). Increased peroxidase activity under salt stress could result in either the synthesis of isoperoxidase or the activation of existing peroxidase. (Seigel 1993; Gosset et al.1994a). Results of bounded and soluble phenols indicated an increase of these compounds in Acsad 1230 treated with greater salt application. However, in Arig 8 these compounds decreased or remained unchanged under salt stress.

**Conclusion**

Physiological and biochemical related traits suggested that Arig 8 is susceptible to salt stress, whereas Acsad 1230 was found to be tolerant to this stress. Increased levels of phenolic compounds and peroxydase activity are conditioning factors of the expression of salt tolerance in Acsad 1230.

**References**


Wheat Genetic Resources in Lebanon

S. Khairallah1*, and J. Breidi1

Plant Breeding Department, Lebanese Agricultural Research Institute (LARI), Tal Amara, Rayak, P.O. Box: 287-Zahle, Lebanon. Email: skhairallah@hotmail.com, jobreidy@hotmail.com

Keywords: Wheat, genetic resources, conservation, Lebanon

Introduction

The total number of species of economic value is difficult to estimate. About 6000 species are known to be used in agriculture, forestry, fruit, local food, industry, medicine and others. But this number could be reduced to 1000-2000 species and of these, 100-200 are of major importance, with 15 species providing the world's food crops such as rice, wheat, corn, sorghum, barley, sugar cane, sugar beet, potato, sweet potato, cassava, beans, soya beans, peanut, coconut and banana (Heywood 1993).

Lebanon is a small country (10,452 km²) composed of coastal, montaneous and plain areas. The distance from North to South is 190 km with a maximum width of 75 km. That area is located under latitude North of 33 to 34.5°, with a longitude East of 35 to 36.5°. The change in the geographic location allows Lebanon to have a large diversity of species due to a difference in weather conditions found in locations with low and high rainfall, variable temperature, moist and dry areas, allowing the growth of many cultivated and wild species from sea level to 2500 m elevation.

The Lebanese flora is very rich. It harbors an estimated 2600 wild species, more than England, France and Switzerland that are 22, 53 and 4 times bigger in size than Lebanon, respectively (Nehme 1980). The Lebanese flora includes different kinds of species classified according to their economic value, edibility, medicinal, industrial, and chemical usage. Moreover, they are sources of genee for many cultivated crops such as wheat, barley, lettuce, carrot, almond, pear and many others.

Wheat genetic resources

Wheat constitutes the main food crop for the Lebanese population. It provides about 40% of the total food calories. It is grown in areas as low as sea level up to 1500 m of elevation, under irrigated and rainfed conditions. The most commercial and consumed grown species are *Triticum aestivum* or bread wheat, and *Triticum durum* or durum wheat. Bread wheat is widely grown in areas of Akkar and South of Lebanon, but mainly in the Beqa'a plain. It is used by wheat mills to produce flour to make bread. Part of the grain production enters also in Bourghol production (Parboiled wheat), especially the red grain varieties, that are very well appreciated by the majority of consumers. Durum wheat or macaroni wheat is locally grown, but not as much as bread wheat. The main production is used for macaroni, Bourghol and some sweet preparations.

The genetic resources of wheat can be divided into two groups:

The first group covers the traditional varieties that were known in the past and that are still grown in limited area of the arid and semi-arid zones. Those are bread and durum landraces that are not well adaptable to the high rainfall and irrigated areas. Therefore, they are susceptible to lodging and to rust diseases and they do not have high yield potential. But despite all that, they have the proper genes to produce a good grain quality and are resistance to cold weather (Abi Antoun and Khairallah 1998).
Salamouni red grain is a well known bread wheat variety used bourghol production and has an improved taste when included in the preparation of some Lebanese food where bourghol constitutes the main ingredient. A part also of Salamouni red grain is used in local bakery. Salamouni white grain is also cultivated locally, but the whole yield goes to flour production for bread making. Haurani is a very old variety durum wheat variety adapted to medium rainfall areas where it gives a medium yield and resist lodging. Its genetic makeup provides good grain quality with high content in carotene making it well appreciated by consumers of bourghol as well as by local Lebanese bread industry for its good taste and yellow color that is not found in other wheat varieties. Beqaii, originated from Beqa'a plain, is another durum variety still grown in the Beqa'a and some part of the South Lebanon. This variety is adapted more to semi-arid regions and is susceptible to lodging and rust diseases under high rainfall environments. It has a good grain quality and is very well known and appreciated for bourghol making due to the grain red color and hardness. The price of one kilogram either of seed or bourghol is the highest in the local market among other wheat varieties. All the formerly mentioned varieties were introduced as parental material in National breeding program. Beqaii variety taking the largest part of this program with the introduction of the red grain genes to create new grain varieties with high grain yield and resistance to lodging and to diseases.

The second group includes the wild wheat and relatives of wheat. Longtime ago, and precisely since the 16th century, botanists were attracted by the Middle-East and were mainly interested by the Lebanese flora which was considered as an important genetic resource for many cultivated crops. Many expeditions were made by European scientists to study the Lebanese flora and to collect some herbarium specimen. The most important work was by G. Post in 1896, and P. Mouterde in 1966, who studied their collected herbarium and edited books on that subject. Wild wheat species and their relatives were intensively studied and P. Mouterde described many Triticum and Aegilops species starting with their classification, description and geographic distribution. Mouterde also reported the presence of two Triticum species known as Triticum dicocoïdes and Triticum thaoudar as well as 11 Aegilops species (Mouterde, 1966).

Between 1993 and 1994 a collaboration program was established between the Lebanese Agricultural Research Institute (LARI) and the International Center for Agricultural Research in the Dry Areas (ICARDA) collect and study the wild wheat species and their relatives in Lebanon. The expeditions covered the Beqa'a Valley from North to South in addition to Western Beka'a. The wild wheat species found in different locations were: Triticum dicocoïdes, Triticum urartu and Triticum boeoticum. The wild relatives of wheat found in either large or small populations that are located in narrow and limited locations and that were collected in the Beqa'a are: Aegilops ovata, Aegilops columnaris, Aegilops biuncialis, Aegilops triuncialis, Aegilops cylindrica, Aegilops caudata, Aegilops searsii, Aegilops vavilovii and Aegilops peregrina. Tables 1 and 2 indicate the locations of the wild wheat species and wild wheat relatives in Lebanon (Abi Antoun, 1996)

**Conclusion**

All the wild wheat species constitute a very important gene pool for wheat breeding program. Some of them have genes for leaf and stem rust resistance; others have genes for cold resistance that can be transferred to susceptible wheat varieties. More collection mission are needed to save the remaining population of wild species of Triticum and Aegilops. Otherwise, many species will disappear as it happened with one Triticum species that disappeared from the locations where it was found between 1993 and 1994.

Table 1- Wild wheat species (Triticum) found in Lebanon
<table>
<thead>
<tr>
<th>Species</th>
<th>Reference</th>
<th>Year</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Triticum thaoudar or</em></td>
<td>Paul Mouterde</td>
<td>1965</td>
<td>Kfarkuok, El Kala'a Ba'albeck</td>
</tr>
<tr>
<td><em>T.urartu</em></td>
<td>Dr. G. Post</td>
<td>1928</td>
<td>Deir el Ahmar, I'a't</td>
</tr>
<tr>
<td><em>Triticum dicoccoides</em></td>
<td>Paul Mouterde</td>
<td>1965</td>
<td>Bouarej, Wadi el Arayech</td>
</tr>
<tr>
<td></td>
<td>Dr. G. Post</td>
<td>1928</td>
<td>Wadi el Karm, Rachaya, Kfarkouk</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Karaoun, Yanta, Bakka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Ai'ta el Fakhar, Ai'ha, Kfarmechki, Ai'n Ata,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ai'n Horchi, Kaoukaba, Rachaya</td>
</tr>
<tr>
<td><em>Triticum urartu</em></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Rachaya, I'a't</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Ai'nata, Yammouneh</td>
</tr>
<tr>
<td><em>Triticum boeoticum</em></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Ai'ta el Fakhar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Yanta, Ai'nata</td>
</tr>
</tbody>
</table>
Table 2- Wild wheat relatives species (Aegilops) found in Lebanon

<table>
<thead>
<tr>
<th>Species</th>
<th>Reference</th>
<th>Year</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aegilops ovata</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Ba'albeck, Beyrouth</td>
</tr>
<tr>
<td></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Hazmieh, Barouk</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Mkalles, Bhamdoun</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Tawmat niha, Jabal el Kneisseh, Hasroun, Ta'anayel, Zahle, Ba'albeck</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Aïnata, Rachaya, Jeb Jannine, Talia, Aïn Ata, Aïn Horchi,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Kaoukaba</td>
</tr>
<tr>
<td><em>Aegilops triaristata</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Bhamdoun</td>
</tr>
<tr>
<td><em>Aegilops columnaris</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Rachaya, Ka'a el Rim</td>
</tr>
<tr>
<td></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Ia'at, Jeb Janine</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Deir el Ahmar</td>
</tr>
<tr>
<td><em>Aegilops biunicialis</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Chekka, Kfarchima</td>
</tr>
<tr>
<td></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Mrouj, Rayfoun, Hasroun</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Talia, Aïn Ata</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Aïn Horchi, Kaoukaba, Rachaya, Kfarnechki</td>
</tr>
<tr>
<td><em>Aegilops triunicialis</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Beyrouth</td>
</tr>
<tr>
<td></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Rachaya, Deir el Ahmar</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Ia'at, Rachaya, Kaoukaba</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Jeb Jannine</td>
</tr>
<tr>
<td><em>Aegilops kotschyi</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Tripoli</td>
</tr>
<tr>
<td>subsp. Eu-variabilis</td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Dekwaneh, Kfarchima, Chekka, Bhamdoun</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Dhour choueir, Ka'a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td></td>
</tr>
<tr>
<td><em>Aegilops multiaristata</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Beyrouth, Kattin</td>
</tr>
<tr>
<td><em>Aegilops intermedia</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Sidon, Abayh</td>
</tr>
<tr>
<td><em>Aegilops peregrina</em></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Tyr, Saida, Beyrouth, Tripoli, Wadi Chahrou</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Talia, Aïn Ata, Aïn Horchi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&amp;1994</td>
<td></td>
</tr>
<tr>
<td><em>Aegilops brachyatera</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Jabal Abtadir</td>
</tr>
<tr>
<td><em>Aegilops cylindrica</em></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Marjhin, Fnaïdek</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Aïnata</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&amp;1994</td>
<td></td>
</tr>
<tr>
<td><em>Aegilops caudata</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Aïnata</td>
</tr>
<tr>
<td></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Aïnata</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Deir el Ahmar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Ia'at, Al Safra (Ba'albeck)</td>
</tr>
<tr>
<td><em>Aegilops comosa</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Al Masna'a</td>
</tr>
<tr>
<td><em>Aegilops squarrosa</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Al Masna'a</td>
</tr>
<tr>
<td><em>Aegilops crassa</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Mountains</td>
</tr>
<tr>
<td><em>Aegilops speltoïdes</em></td>
<td>Dr. G. Post</td>
<td>1896</td>
<td>Tripoli</td>
</tr>
<tr>
<td></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Saida, Damour, Nahr Beyrouth, Nahr el Kalb, Chekka, Tripoli, Bsatmera,</td>
</tr>
<tr>
<td></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Beit Meri</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&amp;1994</td>
<td></td>
</tr>
<tr>
<td><em>Aegilops longissima</em></td>
<td>Paul Mouterde</td>
<td>1950</td>
<td>Beyrouth, Khalde</td>
</tr>
<tr>
<td><em>Aegilops searsii</em></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Talia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&amp;1994</td>
<td></td>
</tr>
<tr>
<td><em>Aegilops vavilovii</em></td>
<td>ICARDA-LARI</td>
<td>1993</td>
<td>Ia'at, Yammouneh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1994</td>
<td>Al Safra (Ba'albeck)</td>
</tr>
</tbody>
</table>

References


أبي أتطون ميشال. 1996. الأصول الوراثية للحبوب ودورها في تربية النبات. من وقائع الندوة الوطنية العلمية الأولى حول الأصول الوراثية النباتية في لبنان. 29 نيسان 1995، مصلحة الأبحاث العلمية الزراعية، تل عمار، لبنان.
On-farm Improvement of Some Palestinian Local Vegetable Varieties in a Participatory Approach

T. Hijawi¹ and A. Saleh²

¹ Technical Director, Arab Agronomist Association (AAA), Palestinian Agricultural Relief Committee (PARC), P.O.BOX 25128- Shufat- Jerusalem
² Department of Life Sciences, Faculty of Science and Technology, Al-Quds University, Abu Deis, P.O.Box 20002, Jerusalem

Introduction
The importance of local seed varieties of vegetables in Palestine

Due to natural aridity and limitations enforced by Israel on Palestinian water use, rain-fed (dryland) agriculture predominates on more than 90% of cultivated lands. Cultivation stretches over the highlands and semi-coastal areas of the West Bank and involves, fully or partially, 70% of the population. Traditional vegetable production remains a major income generating activity of these areas. Local vegetables are cultivated on some 80,000 dunums (8000 ha) and about 12,000 farming families with some 120,000 family members earn a living from this activity each year. Specific varieties that cater to the local needs are used by these farmers.

Agricultural vegetable production takes place within the traditional dryland crop rotation system, where cereals (wheat or barley) and leguminous crops are rotated with summer vegetable crops in order to maintain the soil’s fertility and to generate the main cash income from agriculture. Important dryland vegetables cultivated include diverse kinds of local squashes, eggplants, faqoos (wild cucumber), onions, tomatoes, okras, beans and cauliflowers. Since 85% of cereal fields are rotated with summer local vegetables on a triennial basis, the cultivation of these drought resistant varieties is related to a total area of 350,000 dunums and directly involves some 32,000 farming families.

Horticultural vegetable production takes place in the more fertile valleys using water from springs, cisterns, or wells for supplementary irrigation. Here, winter rainfed vegetables such as, local lettuce, turnip, radish, garlic, green onion, faba beans, cabbage, etc. are rotated with irrigated summer vegetables such as local types of squashes, eggplants, tomatoes, hot peppers, runner beans and Jews mellow.

The above activity is undertaken with the aim of preserving the diversity of local landraces, and ensuring better efficiency and sustainable use of resources, and thus preventing the enviromental damages brought about by the excessive use of pesticides and fertilizers. This research project contributes to the preservation of the environmentally-safe traditional agricultural practices that ultimately will contribute towards the development of organic farming in Palestine.

Methodology and project implementation approach
1. Conducting on-farm and participatory crop improvement

   Farmers are involved in the process of restoring the characteristics of landraces that were affected by the gene flow from introduced improved varieties. Mass selection with progeny testing was used on the original populations and in a few cases crosses followed by selection based on progeny testing was adopted. The selection criteria were based on landrace ideotypes and on resistance to diseases and pests. The selection and yield trials are conducted in farmers’ fields with the participation of a large number of farmers including their families, and extension workers.
2. Development of seed supply system
   - Establishing on-farm seed production on a small scale in order to ensure quality and supply for occasional seed regeneration. Positive and negative mass selection methods were used with the full participation of farmers who received training on seed increase and field inspection techniques.
   - Complementary activities were conducted at the experiment stations, when required, in order to manage risks of on-farm seed production.

3. Seed distribution
   - Promoting seeds produced by the farmers themselves thus ensuring isolated seeding and quality seed crop management.
   - Establishing simple facilities for seed testing, adequate storage, and seed packaging.

4. Information and knowledge dissemination
   Workshops and on-job training were arranged for the farmers and extensions workers and leaflets and field-guides were developed and distributed.

   The research, design, management and time-frame for implementation followed a regional and “modular” concept, that would allow a gradual expansion of geographic coverage and widen the beneficiaries base and enlarge the coverage of local crops under development.

   The research was implemented with a group of selected farmers, seed development workers and extension workers which participated in all the phases of project planning, implementation, and evaluation.

   The indicators of success of the project were developed and these include availability of good quality seeds, development of varieties with desirable characteristics, and increased higher adoption rate and market competitiveness.

Highlights of achievements
   - Overall achievements
     1. Since the year 2000, the project has successfully been implemented in Northern Central and Southern West Bank for 27 local varieties selected from the 35 most important local varieties used in Palestine. Important gains were achieved for many squashes and fakoos (faqoos?) landraces with different types and colors (faqoos baladi white, faqoos sahouri short type, faqoos baladi green), red gumbos?, water melon, melon, green gumbos?, eggplant (red short, eggplants tall Bateery), hot pepper baladi long, pepper, beans, wild cucumbers, okra, tomatoes, local cauliflower, turnip, cucumber, lubia and runner beans crops. These selected types are highly adapted to their niches and appreciated by farmers. They are helping to generate additional substantial incomes to farmers. The approach has been actually extended to three other varieties.
     2. More than 600 farmers tried out and evaluated the selected varieties and were satisfied with the results, especially in case for eggplants, squashes, faqoos, okra, cucumbers and tomato. There is now a high demand from farmers to provide them with good quality seeds of these varieties.

   Farmers’ evaluation of the performance of these varieties has led to the generation of a net increase of $50 to300 in income per dunum (1000 m²) due to improved crop quality and yields. For more information see the attached annexes showing the success of the program in different districts of the West bank.
3. On-farm seed production was also developed for the 27 selected varieties in their original areas of cultivation. Farmers produce seeds under a voluntary field inspection and seed growing control system provided by the research team from the project, which can guarantee the seed quality and purity. The seeds and seedlings thus distribution benefited 500 to 800 families.

4. Because small amounts of seeds were distributed initially, farmers are highly motivated to save their own seeds and subsequently provide seeds to their neighboring farmers which has led to the rapid adoption and spread of the varieties developed. Annually, the estimated additional area planted to these varieties exceeds 300 hectares, benefiting more than 600 families and generating additional income totalling about $50,000 to 200,000 dollars.

- Achievements per crop

**GREEN BALADI SQUASH**
This local squash is favored for its taste and sweetness and this variety is extensively cultivated in Ram Allah - Jerusalem - Bethlehem, Jenin, Tulkarem and Hebron regions, both under dry-land and irrigated condition and as summer vegetable (cultivated area: up to 20,000 dunum). The variety has a trailing plant habit and tolerates well drought and poor soil conditions. Long vines produce a few green, shiny, and characteristically striped blochy fruit. The sweet and creamy flesh has exceptional cooking quality. This variety is economically one of the most important vegetable crops in Southern West Bank and successfully competes with the introduced hybrid varieties due to high local market demand and selling price, and cheap traditional techniques of production. Nevertheless, there have been serious problems which need to be addressed, such as:

(a) Complete loss of the unique identity of the local variety as its characteristics have been mixed up with features of introduced hybrid varieties and, (b) Sensitivity to virus diseases. Relevant to the complexity of needs, different breeding programs were conducted with the aim of:

- Restoring original features of Baladi squash (trailing plant - green fruits) and then to select for higher yield. Breeding method used was positive mass selection.
- Producing a new bush type of Baladi squash, giving an intensive higher yield. Breeding method: initial crosses made with a more productive white fruit – dwarf plant variety, which produced dwarf plant having intensive fruit-set, but yielding the favored Green Baladi fruits. And then, in the following generations, single plant selections were performed with progeny testing methods in order to stabilize these desirable green fruit – dwarf plant features. The breeding process involved winter selections in Jericho and summer progeny tests in the Uplands.

1. **New Bush Type of Green Baladi Squash: B 20**
This new variety produces up to six fold more vegetables than the original one. It grows as a bush variety giving an early and good yield and after that shows semi-trailing characteristics, but still setting fruit at each nodes. On the other hand the original variety gives fruits after the tenth leaf. Long, 60 days harvest times. Excellent yield and economic performance both under irrigated and rain fed conditions:

- **Hilly dry-land conditions:** 1000 – 1500 kg/dunum, sowing: March-April.
- **Hilly irrigated conditions:** 1800 – 2200 kg/dunum, depending on growing conditions and calendar; with very late sowing and harvest in October: 900 kg/dunum.
- **Jericho area:** 800 - 1500 kg/dunum, sowing September.

Average income: 3 NIS/kg production, while standard hybrid varieties only 1.5 NIS/kg.
This generates an extra income of $500-800/dunum in comparison with the original trailing variety. Recommendation: needs a well-structured and fertile soil. High amount of organic...
manure is required for soil preparation (7-10 m³ per dunum). and especially for dry-land cultivation timely spring planting and a well-prepared soil is essential. Under these conditions, the new variety is prolific and tolerates excessive heat - drought conditions even better than the original local variety. Planting in highly calcareous white soils should be avoided. Over-watering and overuse of urea has an adverse effect, such as inducing fruit rot and tendency towards a lighter green fruit color. The variety also has good prospects for crop diversification in Jericho.

**Weakness of the variety:** (a) Still sensitive to virus diseases, but easily escapes when practices allow a vigorous initial growth. (b) 1-2 % off-type plants: with white fruits, (c) occurrence of ‘Baladi’ type, but lighter green fruit color (if irrigated cultivation up to 20 %), but that has no influence on the marketability.

**Seed supply development of B 20 variety:** There is a huge demand from farmers that at present stage the research project is unable to meet through its ‘commercially’ produced seed supply of only 20 kg. Therefore, the research project is attempting to satisfy the highest number of farmers by providing them with seed samples and extension advice for seed saving measures. Progress has been made in improving the efficiency of seed production in the hilly areas. Annually, the project target is to assist in the production of 60 kg seeds of commercial quality in addition to the basic-seed maintenance activities. 

Seed production technique: negative mass selection
Basic seed maintenance: single plant selection with progeny testing method

**Project Impact:** Since 1997 this new variety is very popular among farmers in Central and Southern West Bank and is cultivated on several hundred dunoms. The vegetable produced abounds in the markets.

2. **New Bush Type of Green Baladi Squash: H 19**
Similar to the B20 type, the H 19 gives an early and good yield, but with less vigor to renew itself on semi-trailing vines at the end of season, therefore there is a shorter harvest period: 30 days (as in commercial varieties).

**Hilly irrigated performance:** 1600 kg – 1800 kg/25 days harvest, with spring-summer sowing.
Income generation: average 3.5 NIS/kg produce
In comparative trial with hybrids, the H 19 Baladi variety showed a lower rate of occurrence of powdery mildew and virus symptoms and over 25 days of harvest generated a 45% higher income, while its yield were only 13 % less.

**Recommended** for irrigated cultivation, for farmers who wish a short, but good harvest period, in order to realize different land use and growing cycles in a year. However, it needs a well-structured and fertile soil and the use of large amount of organic manure. Not recommended for planting in white chalky soils.

**Seed supply development of H 19 variety:**
The project aims to produce an annual seed amount of 20 kg besides basic seed maintenance activities. Actually, the research project distributes seed samples to farmers and provides advice for seed saving activities.

3. **Improved Trailing Baladi Squash**
The aim was to restore the true green fruit-trailing plant’s ‘Baladi’ characteristics of the deteriorated rain-fed variety and then to select for better yield was successfully attained. At present, the purity of the variety is 98% and delivers a stable dryland performance. The variety sustains itself on poorer soil and drought conditions of the South West Bank.

**Dry-land productivity in Hebron region:** it is 500 - 700 kg/dunum, with planting distance: 2 x 2 m.
**Recommendation:** this variety is still the best adapted to dryland hilly agriculture using the ‘usual’ amounts of organic manure for soil preparation. The variety is most particularly recommended to those farmers who wish to cover a large area with squash, have no access to large amount of organic manure, and have the labor force to harvest only dryland related yields.

The established quality seed production (20kg) meets the local demand for occasional seed renewal. Seed production uses negative mass selection technique.

**Impact:** Since 1997, the improved variety is known and widely cultivated in Hebron region (a few hundreds dunum).

Income: 2-4 NIS/kg produce. Generates an extra income of up to $100/dunum, as compared to the initial quality of the same variety in 1994.

**TRAILING ROUND SQUASH (Qar’a)**

This local variety, cultivated only in Jerusalem-Bethlehem-Hebron areas, is a kind of pumpkin whose fruits are harvested when small and are favored for stuffing. Economically and ecologically it is an important rainfed crop (cultivated area up to 2000 dunums), as it tolerates well both drought and fragile soils of Southern West Bank. Only uniformly light green and round fruits are appreciated in markets and sold at a high price. The aim was to purify the strongly deteriorated plant material (only 20-40% of the yield was with market desired characteristics) was successfully attained.

Breeding method was: positive mass selection

Seed production uses: negative mass selection method.

**Improved Trailing Round Squash (Qar’a)**

At present, the unwanted yellow color is eliminated and fruits are predominantly round without protuberant apex. (about 90% of the yield). The variety gives a stable rain-fed performance.

**Rain-fed productivity in Hebron region:** 400 - 600 kg/dunum, with planting distance 2x2 m

With complementary irrigation: up to 900 kg/dunum.

Income generation: 2-4 NIS/kg produce

The variety is recommended for hilly dryland agriculture, under the same conditions as the trailing green squash and also for crop diversification in irrigated and Jericho areas (can also adapt to alkaline-salty soil). Seed production schema was introduced on limited scale (2 dunum) to ensure seeds for renewal.

**WILD CUCUMBERS (Faqoos)**

In 1998, wild cucumber or faqoos became the most widely cultivated dryland vegetable crop in Palestine (some 20,000 dunum), because it generates a good income, while tolerating drought conditions. Wild cucumber is favored in the same manner as field cucumber: fresh or pickled. But, the plant habit, foliage and flowering characteristic shows great similarity with local melon crop (Faqoos is the ancestor and the actual ‘wild’ relative of melon).

In the past there were two distinct variety: the favored for its sweetness “Sahuri”, in Southern West Bank and the more productive “Baladi”, nowadays favored mainly in Northern West Bank. The ‘Sahuri’ type itself had distinct local strains: the Long type (in Hebron) and the Short type (in Ramallah-Beit Sahur areas). The ‘Baladi’ type had distinct strains of white and green fruit color. A natural cross took place between all these landraces mixing the Sahuri whitish and blocky fruit characteristics with Baladi green and thin fruit’s characteristics as well as the other distinctly ribbed, hairy and tendency towards bitterness characteristics.
The initial aim, to restore the Sahuri brands, eliminate bitterness and increase the yield, was successfully achieved. And, recently the project extended its crop development activities to northern provinces involving White Baladi and Green Baladi varieties.

Breeding technique: positive mass selection and single plant selection with progeny testing
Seed production uses: negative mass selection method.

1. **Improved Sahuri Wild Cucumber - Long Hebron’s Type**

Now, no bitterness occurs and this important variety performs up to three times better than before. Variety purity is 99%, having whitish, sweet and predominantly straight fruits. The fruit shape is characteristically ‘Sahuri’ with ten vertical ribs; 20-22 cm long and 2.5-3 cm wide.

**Excellent dry-land yield:** 700 - 1200 kg / dunum with planting distance 1.5 x 2 m in Hebron region.

**Irrigated performance in Jericho:** 1000-1500 kg/dunum, with sowing in October. Fuzarium infected field should be avoided. Farmers income: 2-4 NIS/kg produce
Generates an extra income: up to 150 $ / dunum, as compared to the initial quality of variety in 1994.

**Recommended** for traditional dry-land farming in Hebron region and for crop diversification in Jericho area.

**Seed production development:** there is a high demand from farmers that the project is finally able to meet from its quality seed supply source. In general, the quality seed production model of the wild cucumber face no economic constraints (good seed yield and seed price).

**Impact:** since 1997: the improved variety is popular and widely cultivated in Hebron region on several hundreds of dunum.

**Next issue:** increasing Fusarium wilt tolerance. Up to 1997, no Fusarium soil born disease and virus sensitivity occurred in faqoos fields over the West Bank. Since, both diseases became rampant in most of fields. There is a necessity to produce tolerance selected seed supply and to promote crop rotation.

2. **Improved Sahuri Wild Cucumber – Short Type (Ramallah-Beit Sahur)**

Now, this type is pure in essential Sahuri white features: bear short (10-12 cm) and wide (2.5-3 cm) blochy fruits with sweet taste. Some bitterness can occur only with late sowing.

Prolific, if timely rain-fed sowing is done and good soil preparation is made.

Actually, this variety is being introduced for large-scale farmer’s trials and evaluation. The variety is recommended for dry-land cultivation in Ramallah, Jerusalem and Bethlehem districts.

**Seed production:** quality seed is produced on limited scale, but meeting needs at present development stage.
Next issue: Improving Fusarium tolerance.

3. **Baladi Wild Cucumber – White Type (under development since 1999 - present)**

This type is favored and cultivated in Salfit-Tulkerim area, bearing long (20-25 cm) and thin fruits with whitish color and rough skin. The purity of landrace has been fairly well preserved in Der Ballout area. Therefore, directly seed production schema was introduced by the project, where all off-type plants (10 %); and Fusarium and virus infected plants (40 %) were removed from the field before seeding.
Next issue: further development of the landrace, with seeds produced to be used for promotion and distribution, as well as field evaluations, since the quality of the variety is good.

4. **Baladi Wild Cucumber – Green Type (under development since 1999 - present)**

Green types are widely favored in Jenin, Tobas, Tulkerim, and Nablous areas. No well-preserved plant material was found. The Green Baladi should yield straight, long 20-25 cm and thin fruits with rough skin and grass-green color and sweet taste. But only 30% of the plants displayed all these features in the fields. Therefore, selections are aimed at four localities to restore the identity of the completely diluted variety and to eliminate bitterness in taste.

We obtained an initially improved plant material, where 70% is already homogenous for the desired characteristics.

Next issue: further breeding will continue, but produced seed will be promoted for distribution, since our source is already better than any other in the country.

**LOCAL EGGPLANTS - TALL BATTEERY**

Well-favored in Jerusalem-Bethlehem markets, the Tall Battery sweet variety with elongated fruit and attractive color comes from Bethlehem region. It became economically the most important crop in some fertile valleys of Bethlehem-Ramallah regions where spring water abounds. Despite its economic competitiveness (local demand and selling prices up to three times higher), the cultivated area has decreased during the last 15 years. The main reason for this is: (a) the appearance of Rhizoctonia soil born disease (wilting and then drying of branches or the whole plant) destroying 70-80% of plants and yield, (b) high occurrence of plants with white fruit color and curved shape, and (c) showing other off-type features in plant habit and fruit color.

The aim to restore the original features of the variety and to increase its Rhizoctonia tolerance was successfully achieved.

Breeding technique: positive mass selection was used amongst the progeny of 10 single selected plants as parents.

1. **Improved Tall Battery Eggplant at Ein Sinia: improved for Ramallah region**

Excellent purity and homogeneity, no off-type occurs. Plants are very tall and bear long (20-25 cm), predominantly straight fruits with a bulbous extremity and having an attractive bright reddish fruit color overlaid with gray vertical strips. The white flesh is sweet, tender and has exceptional cooking quality.

The variety has a well-expressed Rhizoctonia tolerance: (a) in all cases no early dumping-off occurs, (b) strong infection is observed only on 12% of the plant population at the end of July and this rate of occurrence does not evolve on medium infected fields, And (c) on heavily infected fields (with no crop rotation for several years) light symptoms evolve to heavy infestation on 30-40% of the plant population up to October.

**Productivity:** (3) - 6 Tons / dunum / season. The variety has a very high income-generating potential, if cultivated in deep and nourished soil with intensive irrigation and where eggplants (or tomatoes) are not planted in the same plot for a minimum of 4 years.

Farmer’s income: 3-6 NIS/kg produce
Generates an extra income: 500 - 1000 $ / dunum, as compared to the initial quality of variety in 1994.
**Tolerance selected seed supply**, produced at Ein Sinia, meets the needs, and the research project is able to reach all Tall Battery growers.

2. **Tolerance selected Tall Battery Eggplant in Wa’di Fukeen: for Bethlehem region**

   Since 1997, Tall Battery plant materials from different origins were evaluated in Wa’di Fukeen in order to develop a Rhizoctonia tolerant variety for this heavily infected site. It was observed that the variety improved at Ein Sinia (Ramallah region) displayed a better initial tolerance on medium-infected fields: no early dumping-off or wilting symptoms occurred up to July, while the comparative local plant material was depressed. Therefore, the improved at Ein Sinia Tall Battery has been further selected to reinforce its site-specific Rhizoctonia tolerance to Wa’di Fukeen.

   **Impact:** this tolerance selected seed stock and the 20,000 seedling distributed are under evaluation in large-scale trials on farmers’ fields. Very recent results are encouraging and improvement similar to Ein Sinia’s level is expected.

   **Seed supply:** tolerance selected seed production is established in Wadi Fukeen meeting the needs of all Tall Battery growers.

**SMALL TYPES OF EGGPLANTS**

1. **New Small Battery Eggplant: (variety for stuffing and pickling purpose)**

   This new variety was selected from a heterogeneous Tall Battery plant material for its wide-spread growth, intensive fruit-set even under heat stress, and less sensitivity to powdery mildew as compared to the tall variety. It bears small (10 cm), mini Battery fruits with a bulbous extremity and has a distinct bright reddish color overlaid with gray strips. The white flesh is tender. Initially, the research project developed this new variety for Southern Upland agriculture as it needs less irrigation water then the tall one.

   **Breeding technique:** positive mass selection was used amongst the progeny of 5 single selected plants as parents.

   **Project impact:** since 1998 the cultivation of this variety expands well into the Jordan Valley and the Northern provinces. The reason: as it is a small vegetable for stuffing, this new type has a advantage over the more prolific, but thin type of small battery (from seeds supplied by Israel), that is widely cultivated in the Northern provinces only for pickling purpose and has a less attractive pale color.

   **Performance:** (2) - 4 tons/dunum/season, performs well in nourished soil  
   Farmer’s income: 1-3 NIS/kg produce  
   Weakness: some variability in fruit width that had no effect on marketability.

   **Seed supply:** despite some weakness the variety is expanding as some nurseries promote the variety and save seeds. However, further improvement and basic seed maintenance is still needed and is being carried out by the project.

2. **New Small Red Eggplant: (variety for stuffing or pickling purpose)**

   This variety has a more vigorous wide-spread growth, bears small (10 cm) bulbous fruits, slightly flatted, and with two ribs on both sides. The skin has a glossy deep-red color. A similar variety is known in Northern West Bank as ‘Naboulsi’, but our new type was selected in the same manner as the small battery, and for similar purpose. Now, the new variety is expanding well in the Jordan Valley.

   **Productivity:** 2-4 tons/dunum/season, performs well on nourished soils.  
   Farmer’s income: 1-3 NIS/kg produce
Weakness of the variety: in poor or cool conditions, tendency to whitish spots at fruit apex. **Seed supply:** the variety expands, as being promoted by some nurseries, but the needed basic seed maintenance and production is done by the project.

**RUNNER BEAN**

Runner beans are favored and cultivated all over the West Bank on small, irrigated parcels (0.2-0.5 dunum) since they generate a high income for farmers. The main issue was to reduce the variability of the local variety cultivated in Ramallah region and to increase its earliness.

**Improved Runner Bean**

The aim to improve the earliness of the local variety combined with a good yield performance was successfully achieved. Now the variety gives an early and intensive yield over one month and then the productivity decreases. This variety produces wide long type green pods, much favored in the markets in the Central West Bank. At maturity seeds have a beige color. **Performance:** 2 tons/dunum/30 days harvest, if cultivated in fertile soil with intensive irrigation. Recommended for timely spring sowing in irrigated, fertile valleys in Ramallah–Bethlehem regions. **Weakness:** up to 3% off-type plants detected. **Farmer’s income:** 3-6 NIS/kg produce. **General note:** for controlling bacterial infections (yellowing of leaves) that create damage in many fields in the West Bank, simple organic means of spraying (copper-oxy-chloride) should be applied before the flowering stage, especially when seeds are saved by farmers themselves (it is a seed-borne disease).

**LUBIA BEANS**

Lubia beans is a widely favored local crop all over the West Bank and Gaza Strip. Ecologically and economically it is an important dryland summer vegetable, since it generates a good income, while can stand drought and poor soil conditions. Lubia is a self-pollinating crop; therefore it has not been subject to variety dilution process. But, there is a lack of easily available seed supply from reliable sources and in adequate packing and amounts.

**Lubia beans: ‘Black Eye’**

This white seeded type with ‘black eye’ has been introduced for quality seed production program in Hebron region since 1998. Seed production was needed in order to satisfy demand from women groups for home gardening. Limited amount of seed was produced on one dunum to serve this purpose and for promoting the farmer’s own seed saving. **Seed supply development:** the research project produces limited seed stock (20 kg), which is devoted to disseminate the variety through farmer's trials and promoting seed saving activities. Next issues: further selection to eliminate off-type plants and production of quality seeds in Jenin region.
RAINFED LOCAL OKRAS

Okra is a widely favored and cultivated vegetable in Palestine as summer dry-land crop (cultivated area up to 15000 dunums) or with complementary irrigation. Mainly ‘green pod’-more productive types, and ‘reddish pod’ - more tasty types are distinguished within the population. However, each growing area has its own variety with distinctive features as to pod shape and spiny-ness. Varieties also differ in plant habit: tall vigorous plants or less tall plants cultivated in rows. A natural cross took place between all these landraces, leading to a loss of distinctness of many local types.

In Hebron the okra has narrow, elongated fruits (which shed seeds when fully ripen) while the more productive Ramallah strain has short, wide and more spiny fruits (retaining seeds after full ripening). The initial aim was to reduce the variability and to improve the yield of both strains, since they have to sustain the very poor dry-land conditions of Uplands.

1. **Okras - for Southern dry-land agriculture**

Good results were obtained with the Hebron type by selecting for increased tendency to branch and bear fruits more compactly on every branch. A limited amount of improved seed amount was distributed and returned to farmers up to 1998. Since in view of the fact that consumers demand is changing, the seed production of a different type from Beit Ula (Hebron region) was promoted by the Women’s Unit. The established small-scale seed production serves distribution purpose in order to support home gardening issues.

Next issue: this year (2005?) development was extended to northern areas involving green and reddish types.

Actually, the project maintains the following land-races:

2. **Improved type of Hebron Green Okra**
3. **Selected Beit Ula’s type of Green Okra (Hebron Region)**
4. **Selected Reddish type of Okra in Maitheloon (Jenin region)**
5. **Selected Green type of Okra in Der Ballout (Salfit region)**

Hebron region: yield of an okra crop, Hebron’s type of Green Okra in 1997 displaying mixed variety characteristics.

**DRYLAND TOMATOES**

Rain-fed tomato was the most widely cultivated vegetable crop in the West Bank. But, in the nineteen nineties its cultivated area decreased to about 15,000 dunums due to the quick development of plastic-house production in concentrated areas. And, in rainfed fields too, landraces were replaced by Israeli improved hybrid varieties. These hybrid varieties out-performed the landraces, but only in selected years with good winter rainfall. And, field survey data of past 20 years clearly shows that there has been no increase in average productivity on rainfed fields. Therefore, the project aim was to prevent the loss of the last remaining landraces of this crop, by improving competitiveness and promoting their greater use.

Breeding technique: tomato is a self-pollinating crop, therefore the best performing single plants were selected and tested as pure lines.

**Improved Hebron's Type of Tomato**
This local strain is cultivated in Hebron region and favored for its juicy flesh with subacid flavor. Plants have an upright growth, with small leaves, and very large irregular fruits. The main reason for this variety losing competitiveness has been: very low yield (7-10 fruits per plant), deteriorated unattractive fruit shape (unclosed pericarp) and short shelf life. As a response to selection work the improved variety set double the number of fruits per plant with a more attractive fruits. Participating farmers were all satisfied with this amelioration. However, they evaluated its potential as not competitive in comparison with Israeli hybrids.

Rainfed yield: 500 kg/dunum, with planting density of Hebron region: 250 plants/dunum
Seed supply: despite of its weakness in the general market, farmers for domestic or local demand are still cultivating the variety and our seed supply to them satisfies that demand.

1. **Improved ‘Jiljilaweh’ Tomato**

This local strain is known the in Ramallah region. Plants show a broad-spreading growth and the vines have thin and long internodes. The aim was to improve the average productivity of the crop, since some plants produced 40-50 fruits, whereas others only 10–20 while some vigorous plants were sterile. As a response to selection work carried out, plants now set 30-50 medium-sized, round, firm and very attractive tomatoes with long shelflife. Impact: currently, the variety is being promoted for farmer and home garden trials. And after further selection seed supply will be able to satisfy demands at the current development stage.

2. **‘Marmand’ type of Tomato**

This type of tomato, widely favored in the past, yields tasty and meaty giant fruits that are up to half kg per piece, with very small seed cavities inside setting only a few seeds. Weak seed setting and the lack of quality seed were probably the cause of sudden genetic erosion of this type.

3. **Pure line # 2520**

Origin of line: an early producing heterogeneous rainfed plant material that is found in the Jenin region that has been designated as ‘local’ and reproduced as such. The new line that was selected from this origin and now stabilized has a vigorous but compact plant habit that produces a concentrated set of high yield on determinate vines. Round and firm fruits are medium-sized with a good taste. Despite the good yield, the line is not recommended for market-oriented production. This is because when picking, the calyx detaches from the fruit. Therefore, the line is maintained for its prospects as a home garden vegetable and for food processing purposes.

**HOT PEPPER**

With its attractive long, straight and bright green fruits the aim was to improve the productivity of the hot pepper and reduce the variability of the local variety cultivated mainly in the Jordan Valley. Breeding method: single plant selections and positive mass selection method. Seed production: use of positive mass selection method.
1. **Improved Baladi Hot Pepper – Long type**
   Breeding work eliminated the variability in fruit shape and plant habit and the average fruit number per plant was increased. The improved variety is now homogenous and prolific in the region. The very attractive and market favored long fruits (12–15 cm) with a broad width of (2.5-3 cm wide) are continuously set on tall, strong, and upright plants. Plants continue to grow and yield fruits up to the onset of winter.
   **Impact**: actually, the improved variety is at the stage of farmer’s evaluation in Ramallah, Jericho and Tulkerim areas and has successfully proven its competitiveness both in the case of indoor as well as outdoor cultivation. The variety in outdoor cultivation outperformed the comparative Israeli hybrid variety.
   **Next issue**: seed supply development and promoting the variety for large-scale use.

2. **Improved Baladi Hot Pepper**
   Very similar to Long Baladi type above, continues to grow up to winter and is prolific. It was selected from the same origin, but fruits are less elongated (8-11 cm). The variety in outdoor organic farming outperformed the Israeli hybrid variety and was more resistant to diseases. Actually this variety is promoted basically for home gardening and the produced seed satisfies this demand.

**RAINFED CUCUMBER (under development since 1999 - present)**

During the last decade greenhouse cucumbers and irrigated outdoor varieties replaced the ‘Green Baladi’ and ‘White Baladi’ dryland types. But greenhouse production does not satisfy local demand for pickling cucumbers; and therefore, pickling produce obtains a high selling price than the salad type. This is where the renewed farmer’s interest for dryland cultivation of green type of cucumbers comes in. But the adaptation to these conditions of the local seed has been lost. Therefore, the project has aimed at finding germplasm from the Green Local type, and evaluating and improving its potential and to develop adequate seed supply.

**Initially Improved Field Cucumber – Green Type:**
Initial evaluation of collected germplasm: the variety sustains drought and poor dry-land conditions, while giving a consistent rain-fed yield, estimated at 300-500 kg/dunum. The homogeneity of the variety has been well-preserved and plants produce deep green, straight, and thin fruits with excellent crispiness and flavor.
Seed production schema was directly introduced in order to increase seed stock. Selection was aimed at eliminating some off-type plants with different fruit shape (5%) and to produce seeds from continuously prolific plants.
**Next issue**: promoting the produced seed and obtaining enough seed amount for large-scale trials in rainfed regions.

**RAINFED FIELD MELON (under development since 1999 - present)**

Also during the last decade, dryland cultivation of local melon – once famous in Jenin region - declined to a few hundred dunoms. The main raison was due to the unfair competition of cheaper irrigated produce from Israel. Nevertheless, there is a renewed interest in the more tasty rainfed local types. Therefore, the project has started to aim at increasing competitiveness of local crop and to develop quality seed supply for farmers.
1. **Initially Selected Baladi Melon**
This variety is cultivated in Maitheloon area. Trailing vines yield a few oval types of very sweet and flavored fruits, up to 2 kg per fruit. The deep green rind changes to deep orange when mature.
Initial selection has aimed at eliminating plants bearing ‘wild cucumber like’ elongated fruits (up to 30 % of the produce) and seed was produced from plants with desired characteristics. Actually this plant material is being evaluated in comparison with other local seed sources.
Next issue: further improvement of the landrace

**RAINFED CAULIFLOWER**
This vegetable is very favored for its very large and tasty head. The winter maturing variety is widely cultivated as a summer dryland crop (planted in May). Economically it is an important crop mainly in Southern West Bank and successfully competes with the introduced early maturing varieties due to consumers preference for the local type. High selling prices (up to 12 NIS/head) are obtained and the added advantage is the fact that the variety tolerates poor dryland conditions of the Southern provinces.
The quality of the variety has been well preserved by a few knowledgeable old farmers but the generation of these farmers and the seed procurement from reliable sources is unfortunately disappearing.
Therefore, the project targets the preservation of the valuable seed growing indigenous knowledge, and develops quality seed production from reliable sources. These seeds will be promoted amongst local nurseries and individual farmers who ask for them.
Quality seed production schema was introduced which allowed flowering and seeding only those with early maturing and perfect plants. These seeds are promoted amongst local nurseries and individual farmers.

**TURNIP**
This vegetable is favored in southern area. The flat, local type has been well-preserved by some farmers. However the rate of early bolting (developing flower stem and flowering instead of root development) is high and there is some variability in root form.
Quality seed production scheme was introduced, allowing for flowering and seeding only of the early maturing and plants with perfect roots.

**References:**
The Status of Organic Agriculture in Palestine

Judeh J. and T. Hijawi

Palestinian Agricultural Relief Committees (PARC), Palestine
E-mail: Judeh@pal-arc.org, thameen@pal-arc.org

Introduction

The agricultural sector has been the backbone of the Palestinian economy traditionally. In the late sixties the agricultural sector contributed 37% to the GDP. This contribution declined in the eighties to 18%, and this trend continued, to reach 7% in 2001. Despite the poor contribution of the agricultural sector to the GDP and the domination of small familial units in the sector, it absorbs more than 29% of employment. Many factors have contributed directly to the decrease of the agricultural sector's contribution to GDP among these are the Israeli strategy of land expropriation for settlements, its control of water resources, the difficulty in marketing of agricultural products and the absorption of agricultural labour by the work in Israel. But, agriculture has gained importance with the recent closures. The agricultural sector still plays an important role in providing 90% of white meat, 91% of vegetables, 61% of milk, 35% of red meat and 35% of cereals for domestic consumption. The most important agricultural exports are olives, olive oil, vegetables, fruits and flowers. The contribution of agricultural exports accounts for 23% of total Palestinian commodity exports. The agricultural sector has been severely affected by the occupation. There have been many problems and obstacles encountered by the farmers in the agricultural practices and marketing in addition to difficulties for farmers to reach their fields. According to the Ministry of Agriculture, the total direct losses in the agricultural sector from September 29 2000 to September 30 2002 reached more than 750 millions US$. The problems that the agricultural sector suffers from can be summarized as follows: Israeli closure, scarcity of water resources, lack of access to markets and the restrictive trade regime, the extremely high protective tariffs on agricultural raw materials, inadequate domestic policies for securing food supplies, land confiscation and restrictions, weak agricultural institutions, market constraints, lack of infrastructure and lack of planning and coordination. Organic farming is promoted to increase the marketability of local products and increase the net profit to farmers.

Marketing of organic products in Palestine

Marketing of olive oil

Olive is the major crop in the cultivated areas of the West Bank, constituting up to 25% of the gross agricultural income. According to the statistics of 2002, olive trees cover about 881,000 dunums with a total production of about 153,000 tons of olives. Moreover, there is an increase in the olive-cultivated area with an annual average of 2000 – 3000 dunums (MOA 2001; PCBS 2002, PFU 2003). Most of the mountainous areas in the West Bank are not suited for any other agricultural activity except the growing of olive trees. Olive tree is native to the region, surviving and thriving on the rocky soil and rainfed areas prevailing in the West Bank. That is a major advantage especially in light of the severe water scarcity in the region. The olive trees also reduce soil erosion during the rainy season by providing cover for parched soils, lessening the impact of raindrops on fragile soils, and therefore one of the leading defenders against desertification. Olive production provides the bulk of income for about 71,000 farmers’ families distributed over the different governorates of the West Bank.
Most of the olive production (up to 95%) is used for the extraction of olive oil, and the rest is used for olive pickles. The supply of olive oil reached 35,800 tons in October 2002, of which 4,000 tons were stored from previous years. The average total local consumption is about 12,500 tons per year, and the surplus reached 23,300 tons (PFU 2003). This amount, in case well produced and marketed, would have provided about US$ 70-90 million to a large number of mostly marginalized olive growers’ families.

The farmers face many obstacles in the production process in addition to the Israeli occupation. Marketing strategies of organic and non-organic products in Palestine are still traditional and suffer from the internal and external constraints imposed by the Israelis. The continuous closure and siege imposed on the Palestinian territories narrowed the local market for agricultural products and this created the need for opening up new markets for these products. The most traditional marketing channels used to distribute the agricultural products for local market are the following: Central markets, semi-central markets, wholesalers and retailers, agricultural cooperatives and direct customers. A very important character of the exports is that 95.2% of the exports are to the Israeli market, and the exports to the international markets are negligible due to many constraints including the absence of a body that can focus on finding marketing channels abroad. Now, Al Reef Company is playing this role but is faced with constraints caused by the occupation.

The marketing of olive oil is done in local markets which account for 12,500 tons. The Arab markets of neighboring countries and Gulf States are recently importing around 8000–10,000 tons per year. However, the export to these countries has significantly decreased in the past years to reach only 2500 tons at present. Attempts were undertaken to open new international markets for olive oil. The Norwegian government signed a contract with the Cooperative Union in the late eighties to buy 6000 tons of olive oil with fair prices. The local cooperatives then started buying oil from the local market on behalf of the Cooperatives Union, which was the official party to implement the deal. The export process however, faced obstacles after the delivery of the first shipment, since the specifications of the olive oil were lower than the required standards. It is worth mentioning that further attempts were made to open new markets for olive oil in Europe. The quantity exported in 2001 and 2002 reached 50 tons. The Israeli market imports between 1000 to 1500 tons annually. However, the quantities exported to Israel had declined in the past two years of Intifada to reach only 700 tons in 2002. The quantities of organic products marketed are shown in Table 1.

Table 1: Estimated quantities of agricultural products marketed during 2003-04 season.

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Quantity/ Kg</th>
<th>Area of Production</th>
<th>Area of Marketing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>40,000</td>
<td>Jenin</td>
<td>Local</td>
</tr>
<tr>
<td>Olive oil</td>
<td>30,000</td>
<td>Jenin</td>
<td>Local and International</td>
</tr>
<tr>
<td>Vegetables</td>
<td>20,000</td>
<td>Hebron</td>
<td>Local</td>
</tr>
<tr>
<td>Fruits</td>
<td>30,000</td>
<td>Hebron</td>
<td>Local</td>
</tr>
<tr>
<td>Vegetables</td>
<td>25,000</td>
<td>Jericho</td>
<td>Local</td>
</tr>
<tr>
<td>Date Palm</td>
<td>25,000</td>
<td>Jericho</td>
<td>Local and International</td>
</tr>
</tbody>
</table>

In order to increase the marketability of agricultural products, efforts are undertaken to fit to the quality standards required by international market and to produce organic and biological products.

Local marketing at Hebron
The Palestinian Agricultural Relieve Committees (PARC) have chosen 10 farmers in 1997 and trained them on organic farming, seed production and integrated pest and crop managements. Moreover the farmers also got advise and supervision on a weekly basis from the extension staff. In 2001, PARC started to market organic products in Hebron two days a week and this activity is still on-going but affected by the prevailing political situation. Farmers are selling mainly organic vegetables and fruits in this market.

Local marketing in Jenin

The dryland farming system is widespread in Palestine. The inputs and the outputs in such kind of agriculture are reduced comparatively to intensive agriculture. Farmers with the help of PARC started to use the compost and the alternatives for the chemicals and to use quality seeds of local varieties. The produce of these farms was organic but no certificate is delivered as the body to certify these products is not yet established in Palestine. These products are gaining importance as a lot of consumers start buying the products with higher prices. This stimulated demand has encouraged farmers in Jenin to grow more of organic vegetables, olive oil, and wheat.

Local marketing in Jericho

This market started in 2002 in Jericho with the help of PARC. The extension agents have helped in advertising the organic products through contacting consumers and distributing leaflets and brochures. The farmers started to sell their products labeled organic close to their farms with 10% price premium. The consumers started ordering organic products from confirmed farmers through phone calls, but the supply is limited over the year. In case of excess in production, PARC help farmers to market their products in Ramallah. The main products marketed at Jericho are medicinal and herbal plants, dates and vegetables.

Inspection and Certification

Until 2003, no institution is available for the inspection and certification of organic farming and its products. PARC, with funds from the Italian Ministry of Foreign Affairs, started to promote organic farming including the objective to establish a certification and inspection body. PARC team was trained in the Center of Organic Agriculture in Egypt (COAE), and PARC got the permission to officially use of the logo of this Center until they develop their own. A committee was created by PARC and the Ministry of Agriculture to work on the development of international standards to apply to Palestinian organic farming products, according to the European Commission and the IFOAM requirements.

Products, marketing and consumers.

Through the Project “Introduction of organic farming in Palestine” we are providing the following:

- Implement several information campaigns for the consumers, through brochures and TV advertising, in order to promote the purchase of organic farming production.
- Involved “key elements” of the Palestinian society (social, political and economic) in supporting organic farming.
- Organising and equip three market/shops for organic farming, in order to sell the production and spread the knowledge about it. These shops (about 200 square meters each) will be rented in Nablus, Bethlehem and Ramallah.
Actions to encourage farmers to apply sustainable agricultural techniques and marketing of safe agricultural products

Despite the difficult circumstances that the agricultural extension program faced due to the continuously imposed closure throughout the year, the extension workers were able to conduct a number of field visits to 50 farmers using safe agricultural techniques. 50 demonstrations were conducted about the use of compost, colored traps, and organic pesticides available in the market. The organic farming and IPM demonstrations were implemented in 2,000 dunums of land; it is worth noting that farmers were not successful in marketing their product in a specialized shop, so they had to market them in local marketing centers and shops. The program was able to raise the administrative and leadership skills of 50 farmers.

It is important to note that the number of field visits decreased in comparison to the year 2001, the fact that 2,553 visits to 1,516 farmers were conducted while only 908 visits were conducted in 2002. The cause of this decrease in number of visits was due to the increased time and cost to reach the desired destinations. As for the organic farming and IPM demonstrations they also decreased in comparison to the previous year, which included 38 organic farming and 75 IPM demonstrations in 2001 and 29 organic farming and 60 IPM demonstrations in 2002. The individual field visits were substituted with workshops and training courses, because they are able to accommodate a bigger number of trainers and are more effective for exchange of experience and knowledge.

Status of organic agriculture in Palestine

The activities are carried by PARC in the field of organic agriculture are

1. Realisation of Training courses for agricultural extensionists on organic farming techniques and methodology.
2. Realisation of Training courses for “key” farmers.
3. Establishment of a Committee of producers (100 members).
5. Certification for organic farming products based on international standards.
7. Re-conversion of 100 farms to organic farming.
8. Realisation of a research on sustainable agriculture in the Arab world.

Description of activities

1. Training courses for agricultural extensionists on organic farming.
Three training courses held one per year for a total of 60 agronomists and agricultural extensionists. The courses centred on a theoretic and on the job training program, concerning land re-conversion and organic farming production. The courses will take place in the pilot farms at Jenin, Jericho and Gaza. At the end of each course, there is an examination and a certificate of “Organic Farming Extensionist” awarded.
Beneficiaries of the training courses agronomists and extensionists of PARC or other NGOs, or other interested farmers associations

2. Realisation of Training courses for “key” farmers.
These training courses (15 in total) take place on a six-month period base, three each six months for five times. Each course will take place every two months. Each course will be attended by 30 people (men and Women), for a total of 3000 people. The program mostly realised in the pilot farms. Each course last one week
3. Establishment of a Committee of producers.
A Committee of producers (100 members, one third of the beneficiaries of the “key farmers” training course) were established.

4. Implementation of three pilot farms for training courses and “on the job” training.
Three organic farming pilot farms implemented and used as location for training courses. The farms located in Jericho, Jenin and Gaza and equipped. Land will be rent for ten years by farmers and the farms “productive centers”, with nurseries and greenhouses. In addition, farms will be stations for biological struggle against parasites and for research on natural fertilizing methods, such as compost and others.

5. Opening of three shops for organic farming products.
Three shops for the promotion and selling of organic farming products coming from pilot farms and reconverted farms will be opened. The shops (+/-200 square meters) will be rented in Nablus, Bethlehem and Ramallah and equipped with the necessary furniture and equipment.

6. Certification for organic farming products based on international standards.
The project will implement a Committee (composed by PARC and the Ministry of Agriculture) in order to fix the international standards to apply to Palestinian organic farming products, according to the European Commission and the IFOAM standards, in order to allow their export.

7. Establishment of a Supporting Committee for the introduction of organic farming.
A Supporting Committee, composed by 1500 people, established. The Committee spread and promote organic farming as an added value for environment protection and people health. In addition, the Committee act as promoter for new laws connected at the organic farming production.

8. Re-conversion of 100 farms to organic farming.
The project applied the realisation of 100 organic farming productive units (farms), re-converted from traditional farming.

9. Realization of a research on sustainable agriculture in the Arab world
A research for the analysis and the evaluation of the recent training programs on extension activities in organic farming realized, together with a research on organic farming and technical development in the sector.

Case study: The Project “Introduction of organic farming in Palestine”

Beneficiaries
This project involved several sectors of the Palestinian society: producers, to improve the “competition” on the market; traders, to offer a new kind of products; consumers, as regards their health. But the most important beneficiary was the agricultural “world”, in order to assure to farmers, choosing organic farming, a best income generation.
The project mostly located in pluvial areas, because in these areas is concentrated the majority of poor farmers, owing to the scarce productivity of land, the difficulties in obtaining credits and the lack of resources to be invested in inputs for agriculture. The second priority will be the Gaza and Jericho regions, where small-scale producers are concentrated.
Organic farming will improve soil fertility and renewable resources, through absence of chemical inputs.

Special attentions were devoted to women, who encouraged cultivating domestic orchards, in order to improve food quality and to assure an income generation. Training organised in groups, 20 people each, and 50% will be women. The selection of beneficiaries based on economic and social criteria, following PARC experience in the last years: first of all, the ownership of the land (with priority to farmers who base their income generation on farming). This project was discussed with farmers’ representatives, following the PARC Strategic plan on Agriculture (1998/2001), and answering to several consumers “point out” about food quality in Palestine.

**Overall Objective**

Overall objective of the Project is the introduction in Palestine of the production of organic farming products, obtained through the improvement, development and organisation of organic farming techniques in the area. In addition, the Project aims to “open” the local and international market of this kind of products. The Project will promote a close link with Italian “structures” involved in organic farming production and trade. An added value of the project will be the “struggle” against rural unemployment, soil erosion, and desertification.

**Immediate Objectives**

The process following these immediate objectives:
- to protect and improve soil fertility in the long term;
- to implement renewable farming systems based on local resources;
- to promote the creation of Farmers Associations of organic farming;
- to promote the breeding of local races;
- to preserve genetic variation in the farming system;
- to “open” an organic farming products market, domestic and international.
- to promote the adoption of a regulation on organic farming in the country.
- To build a body for inspection and certification of the organic farms.

**Implementation of the Project**

**Methodologies**

The Project implement an integrated structure in order to deal with every subject related to organic farming, from land re-conversion to production and trade:

**a) Implementation of three pilot farms (where training courses will be located).**

The Project foresees the implementation of three pilot stations (farms) of organic farming, to be used as location for the training courses (on the job training). The stations will be in Jericho, Jenin and Gaza. Land will be the contribution of farmers to the Project (for a period of ten years), together with the needed water for irrigation. The farms will be equipped with nurseries and greenhouses. In the farms, in addition to the training courses, compost production will be implemented.

**b) Extensionists and “key” farmers (women and men) training; follow up and selection of the trained for local upgrading.**

Workshops and training courses implemented as follows:

Organisation and implementation of two different trainings: one for the extensionists (agronomists) and one for “key” farmers (women and men), on the following subjects:
- Soil preparation for the re-conversion of farms to organic farming;
Production of compost and other natural fertilizers;
Choice of the best seeds;
Research and specification of plant diseases in Palestine;
Preparation of natural remedies;
Biologic “fight”;
Re-conversion of breeding techniques.

As regards the beneficiaries, farmers, PARC extensionists, other NGOs extensionists and farmers association members, were selected for the courses. The project cooperates with Research Centres and Institutions based in countries where the organic farming is still developed. Experts will assure consulting on product preservation, packaging, and marketing, definition of the standards for product certification, environmental protection, and re-conversion to organic farming.

c) Definition of a Statute and a Mission for the Organic Farming Producers Committee.
The Project foresees the creation of an Organic Farming Producers Committee in order to improve the spread and the knowledge of this farming system. This Association (100 members at least) will define a “mission” and a working program. The Committee will also supply the necessary services for the certification of organic farming production. During the period of re-conversion from traditional farming to organic farming, farmers lose their income; so the project foresees to support them through “in cash” subsidies (100 farmers, with 5 dunums of land each. The subsidy is Lit. 260.000 For each dunum, for a total of Lit. 130.000.000).

d) Standards of certification for organic farming and social legislation.
The Project create a Committee (composed by PARC and the Ministry of Agriculture), in order to assess the international standards to be applied to Palestinian production, following the European Union and the IFOAM standards. This allow the marketing (export) of products. Once settled the standards, a Certification Committee will manage the official certification of the organic farming production.

e) Products marketing and consumers.
The Project provides the following:
- Implement several information campaigns for the consumers, through brochures and TV advertising, in order to promote the purchase of organic farming production.
- Involved “key elements” of the Palestinian society (social, political and economic) in supporting organic farming.
- Organising and equip three market/shops for organic farming, in order to sell the production and spread the knowledge about it. These shops (about 200 square meters each) will be rented in Nablus, Bethlehem and Ramallah.

f) Institutional support.
A supporting Committee (1.500 people and 20 farmers associations and NGOs) will be created. The Committee will play an essential role in convincing farmers and consumers of the importance of organic farming. In addition the committee will “lobby” for the issuing of regulations on organic farming and production marketing.

Conclusion:
The above-mentioned program encouraged farmers to use sustainable environmental techniques; the number of farmers using these techniques reached 550 farmers cultivating
2,000 dunum of land. Twenty new applications were also introduced to the program. In addition to the above, 14 farmer leaders were trained in organic farming techniques.

Current and Expected results:
- 3 training courses (one each year) implemented and 60 extensionists, (PARC and others NGO’s) trained.
- 15 training courses (3 each six months) implemented. 300 farmers, men and women, trained.
- A farmers Committee (minimum 100 farmers) installed.
- Three pilot farms (Jenin, Jericho and Gaza, with a minimum extension of 1.5 ha. Each) installed and operating.
- Three shops (+/- 200 m²) in Ramallah, Bethlehem and Nablus financed by the selling of products opened and functioning; domestic and international trade of organic farming products operating.
- Quality certification for products (international standards).
- A Supporting Committee for the introduction of organic farming established.
- 100 farms reconverted to organic farming.
- A research on sustainable agriculture in the Arab world implemented; publication of the research; one seminary to spread the result of the project realised.
- Labelling of olive oil
Plant Genetic Resources Conservation and Utilization at INRA-Morocco: Where Do We Stand?

H. Ouabbou

INRA, CRRA-SETTAT, B.P. 589, Settat 26000, Morocco. Email: ouabbou@yahoo.com

Keywords: Plant genetic resources, conservation, INRA, Morocco

Abstract

Introduction
Located along the Atlantic Ocean and the Mediterranean Sea, with the Rif Mountains in the North, the Atlas Mountains running north to south, and the Sahara Desert east and south of the Atlas Mountains, Morocco harbours a unique array of agro ecosystems. Forty distinct ecosystems have been identified in continental Morocco. A large number of these consists of forests, woodlands, and grasslands. Bioclimatically, the following natural regions are found in Morocco: Sahara and (hot and dry) regions in the south of the country with its ephemeral vegetation, hyper-humid and humid (cold and moist) regions in the mountainous areas and sub-humid and semi-arid regions in the plateaus and plains. These contrasts of environment coupled with the location and history of the country engender an exceptionally rich biological diversity of both fauna and flora. There are 4979 accepted taxa in the Moroccan flora, of these 1282 are recognized as subspecies. This significant number of vascular plants gives Morocco a privileged position amongst the countries bordering the Mediterranean Sea, after Turkey, Italy, Greece and Spain (Sauvage, 1975; Ibn Tatou and Fennane, 1989; and Benabid, 2000).

There are nine important families with over 100 species each containing almost 60% of the flora. These families are in order of importance: Asteraceae (600 species), Fabaceae (470 species), Poaceae (350 species), Caryophyllaceae (240 species), Lamiaceae (225 species), Cruciferae (Brassicaceae) (240 species), Apiaceae (170 species), Scrophulariaceae (145 species), Liliaceae (110 species).

Other families are also important, but are represented with only 50 to 60 species each. These families are as follow: The Boraginaceae, Chenopodiaceae, Cistaceae, Cyperaceae and Ranunculaceae. Some families contain less than five species (i.e., Oxalidaceae), and others are monotypic (i.e., Berberidaceae, Coriariaceae, Adoxaceae and Droseraceae). The genus Silene is by far the richest in the Moroccan flora with more than 70 species, followed by the genera Centaurea, Ononis, Teucrum, Euphorbia, Trifolium and Linaria where the number of species varies between 40 and 50, then the genera Orobanche, Juncus, Helianthemum, Erodium, Ranunculus, Lotus, Vicia and Carex each containing 30 to 35 species.

Besides this native flora, there is a multitude of exotic species introduced for their economic value such as Pinus species, Ornamentals such as Hibiscus species, as well as several adventives and ruderals. It is important to note that the Saharian provinces are still underexplored. Further exploration could reveal more unique species.

Since Vavilov’s elaboration of location of genetic diversity and depiction of centres of origin on a map, and because of the importance of Morocco as a center of diversity as stated above, germplasm collecting missions have been undertaken since the beginning of the 20th century. The expeditions were conducted, however, as a response to foreign plant breeding programs. Since the early 1980s, collecting activities have been mainly conducted by national institutions in collaboration with International Agricultural Research Centers (IARCs) such as
the International Plant Genetic Resources Institute (IPGRI), the International Center for Agricultural Research in the Dry Areas (ICARDA) and institutions and universities from developed countries, i.e., USA, UK, Canada, France, Australia, etc. This collected material was evaluated and used in breeding which has led to commercial varieties release by different national and international research programs throughout the world. Some of the collected material was used to isolate interesting genes, which when introduced into breeding lines, have served to improve the quality of other cultivars. A remarkable example concerns local ecotypes of forages from Morocco that have been used at an international level to produce commercial cultivars in countries with a large sheep industry.

There is a growing concern by the Government of Morocco to address environmental and agro biodiversity issues and to develop a better understanding of natural resources and biodiversity conservation of the country. In 1993 a Ministry of Environment was established with a mandate for defining strategies and policies and for coordinating and managing the environment sector including nature conservation. In 1994, the Ministry of Environment formulated a National Strategy for Environmental Protection and Sustainable Development (NSEPSD). This document contains some general recommendations concerning conservation of biodiversity.

A National Biodiversity and Desertification Committee (NBCD) was established under the auspices of the Ministry of Environment to be specifically responsible for the follow-up of the CBD and related conventions. It is a multisectorial and multidisciplinary committee consisting of representatives of major concerned sectors, particularly all relevant Ministries, academic and research institutions, including representatives from the National Institute for Agronomic Research (INRA), given its important role in the management and the conservation of plant genetic resources.

In order to protect its valuable genetic material, and to ensure its royalties on the use of the locally collected material that has been used for variety release, Morocco has been a signatory to many conventions dealing with the use of plant genetic resources among which, the Convention on Biological Diversity (CBD) that was signed in 1992 and ratified in 1995, and the International Treaty of Plant Genetic Resources for Food and Agriculture that was signed by Morocco in 2002.

Plant breeding at INRA has been and is still considered the main axis of agricultural research for improvement of crop productivity. Plant breeding programs are based on: (1) local germplasm, such as pasture and forages, fruit trees and date palm germplasm, (2) exclusively on introduced germplasm, mainly for horticultural crops (vegetables and fruit trees, i.e., apple and plum, and (3) hybridization between the local and the introduced germplasm, as in the case of cereals, oil crops. The plant breeding efforts undertaken mainly by INRA, using both the local and the introduced germplasm, have contributed to the release of an array of cultivars of different species, which are economically and socially important to the country (wheat, barley, food legumes, forages, date palm, fruit trees etc.).

### 1. Plant genetic resources maintained by INRA

The total genetic resources that INRA has at its disposal are maintained as *ex situ* collections represented by field and seed gene banks:

#### 1.1. Field gene banks

About 26 species of vegetatively propagated crops and fruit trees are maintained by INRA in field gene banks (Table 1).

**Table 1. Field gene banks maintained by INRA**

<table>
<thead>
<tr>
<th>Crops</th>
<th>Number</th>
</tr>
</thead>
</table>

768
<table>
<thead>
<tr>
<th>Species</th>
<th>Varieties</th>
<th>Clones/Genotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar cane</td>
<td>1</td>
<td>133</td>
</tr>
<tr>
<td>Fruit trees</td>
<td>11</td>
<td>701</td>
</tr>
<tr>
<td>Olive trees</td>
<td>1</td>
<td>400</td>
</tr>
<tr>
<td>Citrus trees</td>
<td>12</td>
<td>250</td>
</tr>
<tr>
<td>Date palm</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>26</strong></td>
<td><strong>1526</strong></td>
</tr>
</tbody>
</table>

1.1.1. Date-palm collection
This collection is maintained mainly at INRA-Zagora research experimental station. It is represented by a collection of 673 date-palm trees resistant to “Bayoud” (*Fusarium*) namely black Bousthammi, white Bousthammi, Iklane, Boufeggouss or Moussa, Tadmamt, and Sayer layalat; a variety collection of 460 date-palm trees susceptible to Bayoud which are Jihel, Ahardane, Aguellid; a clone collection of 1486 date-palm trees which are thought to be resistant to Bayoud and having good dates quality; a collection of 3064 date-palm trees issued from crosses, and a Collection of 32 cultivars of date-palm trees of which 28 are local varieties and four were introduced from Tunisia and Iraq. One clone, “Najda” was selected for its good performance and will be registered in the official national catalogue. A great effort has been made by INRA to select resistant genotypes of date palm to the “Bayoud” disease (*Fusarium oxysporum*).

1.1.2. Fruit trees collection
Conservation activity of fruit trees has been implemented by INRA since 1950s. This effort allowed INRA to assemble thousands of varieties and clones in different research experimental stations around the country, especially at Ain Taoujdate, Ménara, Tassaout, and Annoceur. The main collection is maintained at Aïn Taoujdate in Meknes region. Around 75% of this collection is made of introduced varieties and 25% are local clones.

1.1.3. Olive tree collection
The INRA-Marrakech experimental station holds a collection of several olive varieties introduced from all the Mediterranean countries, a centre of diversity for olives. About 120 varieties were introduced in 1927, 1954, and other 9 varieties were introduced in 1987 namely Leccino, Picholine Languedoc, Sourani, Arbequine, Ayvalik, Branquitta, Manzanille and Carolea. In addition to Ménara-Marrakech, the second collection of olive trees is maintained at Ain Taoujdate-Meknès. In collaboration with IPGRI, 274 varieties were introduced lately and are maintained at Tassaout research experimental station. This collection represents the core of the global collection that will reach in the future more than 1000 accessions.

1.1.4. Citrus tree collection
The citrus trees collection of 964 genotypes is represented by 12 species and 250 varieties and is maintained at four INRA’s experimental stations. Two collections are maintained at El Menzeh and Allal Tazi stations (Gharb region) and are of 632 and 81 genotypes, respectively. A third collection of 149 genotypes is conserved at Afourer experimental station (Tadla region) and the fourth collection of 102 genotypes is held at Melk Zhar station (Souss region).

1.2. Seed gene banks
For seed collections, more than 16,000 accessions are maintained in storage facilities at different INRA regional research centers (Table 2) mainly under medium term storage conditions. These accessions are at risk (Birouk *et al.*, 1996; Mellas, 1997).
Table 2: Seed maintained by INRA genebanks

<table>
<thead>
<tr>
<th>Crops</th>
<th>Species</th>
<th>INRA Registered Varieties</th>
<th>Number Populations and other varieties</th>
<th>Total accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter grown Cereals</td>
<td>4</td>
<td>84</td>
<td>4800</td>
<td>4884</td>
</tr>
<tr>
<td>Spring grown Cereals</td>
<td>3</td>
<td>38</td>
<td>1123</td>
<td>1161</td>
</tr>
<tr>
<td>Forages</td>
<td>270</td>
<td>27</td>
<td>8130</td>
<td>8157</td>
</tr>
<tr>
<td>Textiles</td>
<td>3</td>
<td>104</td>
<td>-</td>
<td>104</td>
</tr>
<tr>
<td>Oil crops</td>
<td>4</td>
<td>36</td>
<td>52</td>
<td>88</td>
</tr>
<tr>
<td>Food legumes</td>
<td>6</td>
<td>18</td>
<td>2134</td>
<td>2152</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>293</strong></td>
<td><strong>209</strong></td>
<td><strong>16239</strong></td>
<td><strong>16448</strong></td>
</tr>
</tbody>
</table>

1.2.1. The INRA genebank at Settat

Following the adhesion of Morocco to the FAO Plant Genetic Resources Undertaking and the adoption of the Global Plan of Action on Plant Genetic Resources (PGR), INRA-Morocco has recently established an appropriate facility at Settat Regional Research Center for medium and long-term conservation that can serve as a national center for conservation and utilization of plant genetic resources. A duplicate of all the genetic material held by different conservation units of INRA’s research programs will be transferred to the national genebank of Settat together with its related passport data in order to centralize the seed material and the database. The genebank has a storage capacity of more than 65,000 accessions.

The major objectives of the National Center for Conservation and Utilization of Genetic Resources are as follows:

- Collection, conservation, characterization, evaluation, and enrichment of plant genetic resources of cultivated, pastoral, medicinal and aromatic plant species, and their wild relatives,
- Rational utilization of local and introduced plant genetic resources by encouraging the utilization and access to its information to breeders,
- Contribute towards curbing genetic erosion and public awareness,
- Participation of the Centre in the international network to contribute to the international efforts aiming at the conservation and the rational utilization of the biodiversity for a sustainable development,
- Documentation of Genebank collections by developing a centrally managed information system,
- Application of Genetic Markers to identify, characterize, evaluate and assess the collected material,
- Repatriate Moroccan accessions available at International centers and Universities around the world.

One of the priorities of the genebank is the development of a single centrally managed documentation and information system because of its vital role in helping increased access and better management and utilization of plants through assembly, exchange and in terms of useful information to users.

Two data management and information system were developed at INRA genebank in collaboration with ICARDA and IPGRI.

The first database developed at INRA is based on a model of genebank database used at Genetic Resources Unit of ICARDA. The ICARDA database scheme was modified according
to needs of Moroccan genebank. The system contains three types of data, viz.: (1) passport
data that provides the identity of the accession, (2) evaluation and characterization data that
describes the phenotype of the accession, and (3) the management data that identify the
storage location, the amount and quality of seeds, etc. The system also allows users to create
tables, build the query of all fields in the database, and create labels for distribution and
storage.

The other system that was developed by IPGRI, and was modified in accordance to the needs
of the Moroccan genebank, is less data dependent and more integrated system for managing
genetic resources in a way that it: (1) provides information on collecting sites, including
interactive GIS maps, taxonomy, echo-geographic surveys, collected simples, (2) monitor
accessions in the genebank, and (3) most importantly, and in order to maximize both
operation and management efficiency, a bare-code technology was incorporated into the
system along with a remote and mobile technology to make use of PDA palm unit for digital
survey forms.

1.2.2. *Ex-situ conservation of genetic resources at INRA genebank*
The number of accessions held actually in the cold store in Settat genebank is more than 11,000 accessions of different species (261), including cereals, forages, food legumes, cotton, melon etc. and their wild relatives (Table 3). These accessions were transferred from different INRA research units or repatriated from International Institutions and Universities all around the world. Five genera held in the genebank represent more than 65% of the total accessions, namely, *Hordeum, Triticum, Medicago, Vicia,* and *Trifolium*. The genus *Hordeum* accounts for more than 32% of total accessions available in the cold stores.

<table>
<thead>
<tr>
<th>GENUS</th>
<th>Species within genus</th>
<th>Accessions</th>
<th>GENUS</th>
<th>Species within genus</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aegilops</em></td>
<td>7</td>
<td>83</td>
<td><em>Lens</em></td>
<td>1</td>
<td>359</td>
</tr>
<tr>
<td><em>Agropyron</em></td>
<td>1</td>
<td>2</td>
<td><em>Linum</em></td>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td><em>Agrostis</em></td>
<td>1</td>
<td>3</td>
<td><em>Lolium</em></td>
<td>4</td>
<td>46</td>
</tr>
<tr>
<td><em>Allium</em></td>
<td>1</td>
<td>1</td>
<td><em>Lotus</em></td>
<td>16</td>
<td>63</td>
</tr>
<tr>
<td><em>Anthyllis</em></td>
<td>1</td>
<td>36</td>
<td><em>Lupinus</em></td>
<td>7</td>
<td>301</td>
</tr>
<tr>
<td><em>Arrhenatherum</em></td>
<td>1</td>
<td>1</td>
<td><em>Lycopersicon</em></td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td><em>Astragalus</em></td>
<td>9</td>
<td>139</td>
<td><em>Medicago</em></td>
<td>34</td>
<td>1183</td>
</tr>
<tr>
<td><em>Avena</em></td>
<td>8</td>
<td>156</td>
<td><em>Melica</em></td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td><em>Biserrula</em></td>
<td>1</td>
<td>18</td>
<td><em>Melilotus</em></td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td><em>Brachypodium</em></td>
<td>2</td>
<td>4</td>
<td><em>Onobrychis</em></td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td><em>Brassica</em></td>
<td>2</td>
<td>2</td>
<td><em>Ononis</em></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Briza</em></td>
<td>2</td>
<td>3</td>
<td><em>Ornithopus</em></td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td><em>Bromus</em></td>
<td>5</td>
<td>5</td>
<td><em>Oryza</em></td>
<td>2</td>
<td>327</td>
</tr>
<tr>
<td><em>Carthamus</em></td>
<td>1</td>
<td>14</td>
<td><em>Panicum</em></td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><em>Cicer</em></td>
<td>2</td>
<td>281</td>
<td><em>Phalaris</em></td>
<td>8</td>
<td>68</td>
</tr>
<tr>
<td><em>Coronilla</em></td>
<td>1</td>
<td>37</td>
<td><em>Phaseolus</em></td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td><em>Cucumis</em></td>
<td>1</td>
<td>606</td>
<td><em>Phleum</em></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Dactylis</em></td>
<td>3</td>
<td>120</td>
<td><em>Piptatherum</em></td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td><em>Dasypyrum</em></td>
<td>1</td>
<td>1</td>
<td><em>Pisum</em></td>
<td>1</td>
<td>69</td>
</tr>
<tr>
<td><em>Elytrigia</em></td>
<td>2</td>
<td>3</td>
<td><em>Poa</em></td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
2. Future challenges ahead
Despite significant progress for conserving plants, much remains to be accomplished. The objective of the genebank will be to continue to seek and collect new germplasm acquisitions, but in the near future its activities should shift from rescuing disappearing germplasm to its active use in plant improvement. Without active use, potentially valuable germplasm remains unexploited, and genebanks become a museum. Efficient germplasm use requires active interaction among a multidisciplinary team of scientists, including genebank curators, plant biologists, and breeders.

Efficient evaluation of the collection is a prerequisite for the successful exploitation of conserved germplasm. Recent progress in molecular biology offers a powerful tool to tackle the problem. The development and use of these techniques will complement agromorphological characterization used up to now in the genebank.

A further challenge ahead in the conservation of plant genetic resources in Settat genebank, particularly the conservation of species that are sterile and stored as clones, as well as species that are highly heterozygous. The approach to conservation for all of these problematic species is the field genebank, but this method of conservation cannot provide secure, long-term conservation due to inherent risks involved. The genebank will pursue one of its strategic objectives by developing and applying cryopreservation protocols to germplasm collections for long-term preservation. This collection will serve as a back up in the event the material maintained is destroyed in the field due to biotic or abiotic stresses, or removed due to maintenance costs.
References


Small ruminant production on range and stress lands in Pakistan

A. Iqbal1*, M.A. Mirza2 and M.J. Hayat1

1 Department of Livestock Management, University of Agriculture, Faisalabad, Pakistan
E-mail: drarshad_iqbal@hotmail.com
2 Institute of Animal Nutrition & Feed Technology, University of Agriculture, Faisalabad, Pakistan.

Keywords: Small ruminants, rangelands, agro-ecological zones, production systems, Pakistan

Abstract
Pakistan has 87.98 million hectares (MH) land, of which 59.3% is wasteland and depleted rangeland with poor vegetation. The population of sheep and goat is estimated at 24.7 and 54.7 million respectively. Lack of water resources limits viable agricultural activity in these rangelands which support approximately 80-90% small ruminants and meet their 60% feed requirements. There is a heavy pressure on these rangelands from grazing animals. Out of the total land area, 68 MH land receives annual rainfall less than 300 mm, 6.3 MH is saline and unfit for crop production. Lack of water resources, and in some areas souring day temperature limit vegetative growth of most plants except some grazable trees, shrubs and grasses which can singly or with other feedstuff meet the maintenance requirements of sheep and goats. In developing countries like Pakistan, the challenge of hunger elimination and food security can be achieved through extensive use of these resources.

Introduction
Pakistan has 87.98 MH land, of which 59.3% is wasteland and depleted rangeland with poor vegetation. Its 68 MH land lies in fragile region receiving annual rainfall of less than 300 mm, 15.5 MH affected by water logging, 6.3 MH affected by salinity and unfit for crop production. Pakistan supports 79.4 million small ruminants (Anonymous, 2004). They are mainly raised for mutton production. The milk produced by them has a negligible share (Iqbal et al. 2003). Small ruminants contribute 42% of the total meat produced in the country (Afzal et al. 2003). Traditional Muslim festival (Eid al-Adha) is the major single event when a remarkable number of first-rate young male animals of trendy local goat and sheep breeds like Beetal, Kamori, and Kajli are directly bought by families for thanks giving and sacrificial purpose.

As small ruminants are maintained by traditional pastoralist families and landless farmers, they are obviously on meagre feed resources and hence their productivity is not optimal. Rapid increase in human population had driven agriculture towards intensification consequently; the grazing civilization is fast disappearing from irrigated areas. Besides the grazing areas are gradually being denuded due to overgrazing and soil degradation resulting from salinity, sodicity and water-logging (Gill et al. 1995).

Balochistan province has the biggest chunk of rangelands (Table 1) with very poor vegetation. The stocking density is lowest in these rangelands because annual rainfalls are extremely low and summer temperatures are oppressively high. Small ruminants are the predominant group of livestock in these areas. Improvement in agricultural farming in these areas could change the status of principle feed resources available for small ruminants.

This article gives a detailed account of the agro-ecological zones of Pakistan. It briefly describes common breeds of small ruminants and traditional production systems employed in various areas of Pakistan. It also describes how population pressure has affected the natural
feed resources and how rangelands are under intense grazing pressure and how consistent efforts to improve these rangelands had paid off in last many years.

1. Agro-Ecological Zones of Pakistan
Pakistan has diversified area with respect to agro-ecological zones. It has immensely high peaks (K2- the 2nd highest in the world) and at the same time areas which are at sea level. Pakistan could be divided into six agro-ecological zones: subtropical dry, tropical moist, subtropical moist, temperate moist, temperate dry and alpine or cool highlands (Quraishi et al. 1993). Various agro-ecological zones are shown in Fig 1. These zones vary in climate, rainfall, altitude, topography and density of human population.

1.1. Subtropical dry (Arid) zone
This zone covers 43% of the country’s area. It receives 0-250 mm of rainfall annually. Excessively dry and hot weather with little and erratic rains prevent cropping during most part of the years. Some hardy grazable perennial grasses like Dhaman (Table 2) and scattered shrubs like Phulai and Wan, Jand and trees like Kikar (Table 3) can successfully be grown and maintained in this area.

Muzaffargarh, Layyah, Bhakkar and Cholistan make up the arid zone in Punjab. This area comprises of shifting sand dunes and is un-suitable for crop production due to modest rain (100-250 mm annual) and soaring temperature (>50°C) in summer. The farmers in this area get good crop of chickpeas from preserved moisture, the productivity of which however depends on timely spell of rainfall. The land for this crop has to be carefully prepared by uprooting all kinds of grasses and shrubs from the surface which discourage small ruminants production. A project of ‘Greater Thal Canal’ is under consideration by the Government of Pakistan for many years. This canal if constructed will change the features of the area.

Major part of Balochistan comprises of extensive plains, highlands and mountains. Lack of water resources limits viable agricultural activity. As a result, 95% of 35 million hectare is sparingly vegetative wasteland. Upper and lower highlands support about 76% of the province’s livestock. Open rangelands are expanding as the common rangelands undergo degradation and abandoned by their users (Buzdar et al. 1989). Most of the crops are grown in the irrigated areas of Nasirabad and Jaffarabad and the rainfed areas of Kachhi and Sibbi plains.

At present, Balochistan province has 20 million livestock which are 6-7 times more than the carrying capacity (Khalifa, 2004) of its already over-stressed ranges. Opportunities for other classes of livestock in this area are limited. As a result, the number of small ruminants is increasing. Their performance is, however, influenced by climatic variability. Existing techniques could be however be improved to sustain small ruminants productivity.

In Punjab province, most agricultural lands are irrigated by network of canals that emerge from a number of rivers. Sindh province forms the lower basin of river Indus. It covers an area of 14.09 million hectares of which 2.39 million ha is sown and 1.32 million ha area is under forest (Jenejo, 1993). Small ruminant production in these areas is mostly integrated with crop production. Seeded fodders like lucerne (Madicago sativa), sorghum (Sorghum bicolor), jantart (Sesbania aculeate) and tree branches form the mainstay of the small ruminant feeding. A great number of agro-industrial crop residues like mustard cake, cottonseed cake, sunflower meal, wheat bran, rice polishings and cane molasses are also available for supplemental feeding or specialized fattening program.

1.2. Subtropical moist zone
It covers 3% of the Pakistan’s total area. This zone consists of forest (mangrove) and derived savannahs.
1.3. Subtropical moist zone
This area covers 10% of Pakistan which includes Quetta and Qalat valleys. This zone receives 1000 to 1500 mm of rain annually which sustains plants for 180 to 270 plant growing days. Food and cash crops are grown, including maize, fruits, vegetables, millet, groundnut, and cowpeas.

1.4. Temperate dry
This area covers 25% of Pakistan. It includes northern NWFP, north western Balochistan and Kashmir.

1.5. Temperate moist:
The temperate moist zone receives more than 1000 mm of rainfall annually which sustains plants for 270-365 plant growing days. The zone occupies 3% of Pakistan, mostly in northern NWFP, Kashmir and northern Punjab including districts of Jhelum, Chakwal, Rawalpindi and Attock. The annual rain fall substantially support the growth of natural vegetation. Farmers grow millet, sorghum, groundnut, maize and cowpeas. This area has plenty of opportunities for the development of small ruminants.

1.6. Alpine (Cool Highlands)
Alpine or the cool highlands zone includes areas above 1500 m altitude that have a mean daily temperature of less than 20°C. This zone represents 6% of the total area of Pakistan, most of which lies in NWFP and Kashmir. The soils are deep fertile. The zone receives rainfall (1000 mm annually) and there are two growing seasons. The cool highlands are a high potential area for crop-livestock integration.

2. Breeds of sheep and goat
Indus valley is home to the finest breeds of goats. Most popular breeds are Beetal, Barbari, Chapar, Damani, Daira Din Panah (DDP), Hairy goat, Kaghani, Kamori, Nachi, Pak. Angora (Crossbred), and Teddy. The area also abounds in sheep wealth, un-exploited and undervalued. There are two categories of sheep breeds in Pakistan. Thin tail breeds are Cholistani, Damani, Kachhi, Kajli, Kooka, Lohi, Thali, Kaghani, Kail, Hisssardale, Baghdale whereas fat tail breeds are Balkhi, Bibrik, Harnai, Hasht Nagri, Salt Range, Waziri, Baluchi, and Michni.

3. Population Pressure and Natural Resources
In pure arid areas of Punjab and Balochistan where there is little or no cropping activity, low human population, small ruminants are kept in little flocks. These flocks travel long distances year-round looking for forage along specific routes. The animals are kept on scrub and desert vegetation feeding. Landed farmers with big flocks heavily rely on seeded fodders in irrigated areas. Erratic rains promote migration of livestock owners within the province as well as across the province. Sindh province frequently faces such migration from Balochistan. Opportunities for other classes of livestock in this area are limited. In canal-irrigated area, cash crops get the maximum preference of the farms who can afford moderate to high agricultural inputs. Crops-livestock systems dominate the area. Seeded fodders for small ruminants are, in general, considered uneconomical. A recent survey in the Punjab, Pakistan (Teufel et al. 1998) has demonstrated that those households that have little or no land, and no regular substantial off-farm income and thus exclusively rely on small ruminants for subsistence are economically viable/successful.
In areas where farmers follow traditional methods, inputs are scarce and markets are poorly developed, the crop–livestock systems has proved to be economically sustainable as continuous cropping leads to a decline in fertility and hence the need to introduce animals into the system to provide farm yard manure. Since pasture and fallow are no longer options for feeding livestock, crop residues start to play a more important role.

Where human population is fast increasing, it has driven agriculture towards intensification. The cropping has intensified in canal-irrigated areas of Punjab and Sindh where farmers can afford more agricultural inputs. In these areas mechanization is rapidly replacing human labour in traction, harvesting and post-harvesting haulage and storage of commodities. There has also been improvement in marketing. Small ruminants production is on the decline in such areas. Specialized market-oriented livestock production/fattening is practiced in peri-urban areas, keeping in view the demand of urban dwellers. This activity is more evident on the eve of traditional Muslim Eid al-Adha (Eid-qurban). There have been a growing number of urban-based entrepreneurs from traditional non-farming communities who are now involved in raising these animals around cities. They practice modern husbandry techniques and the animals are fattening on concentrates replacing crop residues.

4. Major production systems in Pakistan
Small ruminants are mostly owned by the small or landless farmers having less than two hectare of land. The flocks are usually grazed on ranges, roadsides or canal banks. Livestock production systems in Pakistan can be distinguished mainly through three production factors, land, labour and capital. The traditional livestock production systems are:

4.1. Nomadic
Nomads keep on moving in search of water and grazing pastures all year round. This system is prevalent in southern Balochistan, Cholistan, Thal (Punjab) and Tharparker (Sindh). The flocks owned by nomads are dominated by cattle, sheep, goats and camels. Flock size ranges from 60 to 300.

4.2. Transhumant (Migratory)
This migration is prompted by shortage of feed and temperature fluctuations. It is characterized by the movement of flocks from upland to lowland during early winter and from lowland to upland during early summer. The size of flock is 50 to 150. Mortality rate during migration is high as the small ruminants have to travel long distances. This system is prevalent in all provinces viz. Punjab (Cholistan, Bahawalpur), NWFP (Dera Ismail Khan, Malakand, Hazara), Sindh (Kohistan and Thar), Sibbi division of Balochistan and throughout Azad Kashmir and northern areas.

4.3. Sedentary
It can be found in irrigated areas of central Punjab, upland Balochistan, Indus valley and southern NWFP. Flock size is dependant on socio-ecological conditions of farmers, which ranges from 15 to 30. Flocks graze on scrublands of towns whole day long and brought back in the evenings. With the introduction of tube wells irrigation (mid 1970s), there has been a steady increase in the number of livestock owners becoming sedentary near irrigated lands where they grow cash crops. Fattening of lambs /kids (stall feeding) is commonly practiced just before marketing their produce.

4.4. Household/ Peri-urban
Small units of about five animals are raised under this system and mostly found in peri-urban areas of cities. They are kept confined in houses and fed on scraps and weeds. Mostly animals are reared for meeting their domestic needs and occasionally sold for this purpose.

5. Productivity of small ruminants
Some of the local sheep (Kajli) and goat breeds (Beetal, DDP) have unbelievably high potential for meat and superior body weights. They can not, however, thrive in rangelands with poor vegetation. Some of the smaller and hardy breeds have adapted to the range conditions and can still manifest reasonable growth in scrub lands, ranges and stress lands where feed resources are extremely limited. A local sheep breed weighing from 31-40 kg demonstrated a daily growth rate of 153-172 g/day in irrigated areas. When similar animals were transferred to rangelands, the growth rate drastically dropped to less than 60 g/day (unpublished data of Animal Nutrition Centre, Rakh Dera Chahl, Lahore). The average daily growth rate of other local breed Teddy (goat) and Thalli (sheep) under range conditions were also observed to be very poor (Wahid et al. 1992). This is because over-grazing has brought down the productivity of rangelands to as little as 15-40% of their potential. Three consecutive years of drought (2002-2004) in Balochistan, parts of Sindh and Cholistan (Punjab) reduced the livestock number, in some districts up to 80% of their 1999 estimates.

6. Opportunities and future outlook
Small ruminants in Pakistan seem to have great genetic make up but in the absence of organized national herd improvement programme, genetic upgrading in local breeds over the years has been negligible. There is a need to establish an appropriate recording system for small ruminants. The data should be handled by a central data processing unit operating under the government. All future breeding in sheep and goat should be devised on the basis of the estimates of genetic parameters obtained from the data bank. Also the gene pool of national sheep and goat should be preserved through cryo-preservation in each province. Inconsistent policies of the both federal and provincial public departments with regard to the small ruminant development are the single major cause of under-development of small ruminants especially in rangelands. The scenario gets worst when departmental policies are abruptly changed. Pro-veterinary elements dominate policy making who ought to give way to improving the productivity of sheep and goat through planned breeding, feeding, housing and management. Link among researchers, extension workers and farmers should be strengthened. Administrative control of mutton marketing in cities must immediately be abolished. Processing facilities for mutton should be encouraged which will ultimately improve the marketing.

Both contagious and non-contagious diseases in small ruminants are rampant. Professional help is required to eradicate major contagious and non-contagious diseases from small ruminants. Brucellosis, enterotoxaemia, and ovine postural dermatitis need urgent attention. Long term strategy should be formulated to eradicate internal and external parasites.

Conclusion
A sustained small ruminant development in Pakistan is intimately linked to a sound rangeland development programme. Introduction of newer varieties of fodders/grasses that can thrive under harsh rangeland environment of poor annual precipitation and soaring heat is required to meet challenges of feed scarcity during crunch periods like drought. There is a need to preserve rain water and to harvest underground water resources. In areas with brackish underground water, planting of salt bush like *Atriplex* could potentially improve the status of small ruminant feeding in degraded soils. Careful selection and planned breeding coupled with improved feeding have good prospects for small ruminant flock upgradation.
References
Pakistan.
of Pakistan, Islamabad.
Balochistan. A socio-economic perspective. MART/AZRI. Report No. 5. Arid Zone
Research Institute (AZRI), Quetta, Pakistan
Junejo, B.M. 1993. Goat breeding and development in Sindh province of Pakistan. Pages 68-
71. Goat Production in SAARC Countries. Proceedings of the International Seminar on
Goat Production. (M. Afzal and R.H. Usmani, eds.) 22-24 April 2003, Islamabad,
Pakistan.
of Atriplex on crude fibre utilization and blood biochemistry of Teddy goats. Pakistan
Iqbal, M.A., M.A. Mirza and M.E. Babar. 2003. Genetic potential for milk yield in different
Proceedings of the International Seminar on Goat Production. (M. Afzal and R.H.
Forestry, Range Management and Wildlife. University of Agriculture, Faisalabad,
Pakistan.
Teufel, N., K. Ketttnner and C. Gall. 1998. Contribution of goat husbandry to household
behaviour of Teddy goats versus Thalli sheep. Asian-Australasian Journal of Animal
Figure 1. Agro-ecological zones and land use in Pakistan
<table>
<thead>
<tr>
<th>Region</th>
<th>Total Area (MH)</th>
<th>Range Area (MH)</th>
<th>Percentage of Total Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punjab</td>
<td>20.63</td>
<td>8.20</td>
<td>40</td>
</tr>
<tr>
<td>Sindh</td>
<td>14.09</td>
<td>7.80</td>
<td>55</td>
</tr>
<tr>
<td>NWFP</td>
<td>10.17</td>
<td>6.10</td>
<td>60</td>
</tr>
<tr>
<td>Balochistan</td>
<td>34.72</td>
<td>27.40</td>
<td>79</td>
</tr>
<tr>
<td>Northern Areas</td>
<td>7.04</td>
<td>2.10</td>
<td>30</td>
</tr>
<tr>
<td>AJK</td>
<td>1.33</td>
<td>0.60</td>
<td>45</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>87.98</strong></td>
<td><strong>52.20</strong></td>
<td><strong>59.30</strong></td>
</tr>
</tbody>
</table>

AJK = Azad Jammu and Kashmir  
NWFP = North-Western Frontier Province  
Source: Quraishi et al. 1993
Table 2: List of local natural grasses and conditions that favour their growth

<table>
<thead>
<tr>
<th>Grasses (local name)</th>
<th>Favouring Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hurricane grass</strong> (Palwan)</td>
<td>Sub tropical sub-humid to humid ecological zones with 500-1300 mm rainfall. Drought tolerant can grow on moderately acidic to slightly alkaline.</td>
</tr>
<tr>
<td><strong>Cenchrus ciliaris</strong> (Dhaman)</td>
<td>Arid, semi arid and tropical areas. Rainfall 350-800 mm. Prefer sandy loam soils. Also adoptable to harder and heavy textured scrub soils.</td>
</tr>
<tr>
<td><strong>Chloris gayan</strong> (Rhode grass)</td>
<td>Annual rainfall requirement is 600-1200 mm. Wide adoptability to light to heavy textured sandy loam soils but prefers fertile soils.</td>
</tr>
<tr>
<td><strong>Cynodon dactylon</strong> (Khabbal or Bermuda grass)</td>
<td>Prefers heavy soil than light soil. Withstands flooding and grow well both in acidic and alkaline soils.</td>
</tr>
<tr>
<td><strong>Elephant</strong> (Pennisetum purpureum)</td>
<td>Suitable for Pothowar Plateau where rainfall exceeds 500 mm. Grows best on deep soils of moderate to fairly heavy texture. Tolerates short drought t but does not withstand water logging.</td>
</tr>
</tbody>
</table>
### Table 3: List of local grazable trees/bushes and conditions that favour their growth

<table>
<thead>
<tr>
<th>Grazable trees/bushes (local name)</th>
<th>Favoring Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Leucaena leucocephala</em> (Ipil-Ipil)</td>
<td>Extensively planted in scrub ranges in Punjab and under dry conditions in Sindh. It requires considerable rainfall (600-1700 mm). It can survive high temperature (45°C) and grows well in neutral to slightly alkaline soils (pH upto 8) and frost tender.</td>
</tr>
<tr>
<td><em>Prosopis cineraria</em> (Jand-Kandi)</td>
<td>It grows in wide range of soils with sufficient sub-soil moisture. It is both drought and salt tolerant. Tolerates pH as high as 9.8.</td>
</tr>
<tr>
<td><em>Acacia nilotica</em> (Kikar)</td>
<td>Its maximum shade temperature, maximum (40-50°C) and minimum (-1-15°C) of its habitat and mean rainfall 400-800 mm. It is salt tolerant but does not tolerate water logging.</td>
</tr>
<tr>
<td><em>Acacia Senegal</em> (Khor)</td>
<td>Grows under sub-desert conditions where rainfall is as low as 200 mm but prefers 300-450 mm. It can survive the most adverse conditions. Considered ideal for reclamation of refractory sites and shifting sand dunes.</td>
</tr>
<tr>
<td><em>Bauhinia variegata</em> (Kachnar)</td>
<td>Annual rainfall requirement is 500-250 mm with extreme temperature (maximum 40-47°C) and minimum below zero. It grows on a wide variety of soils; from gravelly soils on mountain slopes to sandy loam soils in the valleys and plains.</td>
</tr>
<tr>
<td><em>Olea ferruginea</em> (Kau)</td>
<td>It grows at altitudes between 500-2000 m with annual rainfall of about 500-1200 mm and prefers limestone rocky soils. Best grows on deep soils with sufficient moisture supply.</td>
</tr>
<tr>
<td><em>Morus alba</em> (Mulberry)</td>
<td>It is shade tolerant and fast growing species, usually planted as a under storey in plantations.</td>
</tr>
<tr>
<td><em>Acacia modesta</em> (Phulai)</td>
<td>It can tolerate very high temperature (50°C). Can grow in infertile, dry, shallow soils and eroded low hilly areas.</td>
</tr>
<tr>
<td><em>Triticum aestivum</em> (Wan)</td>
<td>It is highly drought tolerant/resistant and can grow in saline areas. It withstands extreme temperatures and can survive with little rainfall (180 mm). It performs well on medium and fine textured soils such as sandy loam and sandy clay loams.</td>
</tr>
</tbody>
</table>
INDEX

A

Abdeen, M.
Abed Rabboh, W.
Abed, N.
Abi Antoun, M.
Abo Omar, J.
Abo Safat, M.
Abourrouh, M.
Abu Amrieih, M.
Abu-Irmaileh, B.
Abu-Zanat, M.
Ajlouni, M.
Akl, M.
Al Faiz, C.
Alali, F.
Al-Atawneh, N.
Al-Ayyash, S.
Al-Eisawi, D.
Alexanian, S.
Al-Ibrahim, A.
Al-Juhari, N.
Al-Kayed, N.
Al-Khateeb, S.
Allahham, S.
Al-Nasser, A.
Al-Said, H.
Al-Tabini, R.
Al-Zein, M.
Amara, H.
Amri, A.
Aouelouafa
Aouragh, E.
Arslan, S.
Assi, A.
Assi, R.
Awad, L.
Ayad, G.

B

Baalbaki, R.
Bahrouni, H.
Barake, R.
Bari, A.
Batal, M.
Bazun, T.
Belarhzal, R.
Belguedj, M.
Beloued, A.
Belqadi, L.
Ben Abdallah, M.
Benaouda, H.
Benbrahim, N.
Bendaanoun
Benyaich, M.
Birouk, A.
Bouizgaren, A.
Boujnah, M.
Boulouha, B.
Bourayou, K.
Bsat, S.

C

Carrizosa, S.
Chabane, K.
Chalak, L.
Chamoun, N.
Chatti, K.
Chehabeddine, H.
Chehade, A.
Chennaoui, H.
Chikhali, M.
Christophe Pintaud, J.
Chukhina, I.
Cosson, P.
Csizmadia, G.

D

Daaloul, A.
Daaloul, O.
Dahrouj, D.
Damania, A.
Dauod, A.
De-Pauw, E.
Dirlewanger, E.
Duwayri, M.

E

Eagleton, N.
Ebrahim, E.

785
El Ouafi, I.
El Bouhssini, M.
El Haddoury, J.
El Hadrami, I.
El Hassni, M.
El Mzouri, E.
Elbitar, A.
Eleuch, L.
El-Hajj, S.
El-Saliby, I.
Erskine, W.

F

Fanissi, D.
Moutaouakil, E.
Farah-Trifi, N.
Furman, B.

G

Ghaouti, L.
Ghazale, B.
Gill, B.
Giuliani, A.
Gonzalez-Andujar, J.
Grando, S.
Gyovali, A.

H

Haddad, N.
Hajjar, S.
Hajj-Hassan, N.
Hamza, M.
Hasasneh, H.
Hawamdeh, I.
Herzenni, A.
Hijawi, T.
Hilal, J.
Hilal, C.
Hmama, H.
Holly, L.
Houmymid, M.
Hrimat, N.
Hunter, E.

I
Ibrahim Basha, B.
Ibrahim, S.
Isaac, J.
Issolah, R.
Izyajen, A.

J

Jana, S.
Jarvis, D.
Jilal, A.
Lhaloui, S.

K

Kadri, A.
Kanaan, S.
Kaseh, T.
Khalaf, G.
Khnifis, A.
Khoury, A.
Khoury, C.
Khoury, W.
Konopka, J.
Korichi, M.

M

Maataoui, F.
Malhotra, R.
Mansouri, T.
Már, I.
Marghalai, S.
Marrakchi, M.
Mars, M.
Martin, A.
Martini, M.
Mawlawi, B.
Maxted, N.
Mazid, A.
Mcheik, M.
Mikhael, G.
Mneyer, D.
Monzer, M.
Musselman, L.
Muzher, B.

N
Nachit, M.
Nasr, N.
Nassar, A.
Nassif, F.
Neffati, M.
Noaman, M.
Noun, J.
Nsarellah, N.

O
Odah, M.
Ojeil, C.
Omar, G.
Omar, S.
Oran, S.
Ouabbou, H.
Oukabli, A.
Ould Mohamed Salem, A.
Ouled Belgacem, A.

P
Padulosi, S.
Peacock, J.
Porceddu, E.

Q
Qrunfleh, M.
Qualset, C.

R
Rajaram, S.
Rawashdeh, I.
Rawashdeh, N.
Raymond, R.
Rezgui, S.
Rhouma, A.
Rhouma, S.
Rhrib, K.
Rishmawi, K.
Rizk, H.

S

Saad, A.
Saad, S.
Saddoud, O.
Sadiki, M.
Saidi, N.
Saidi, S.
Saifan, S.
Saker, N.
Sakka, H.
Saleh, A.
Salih-Hannachi, A.
Salkini, A.
Salman, A.
Sampson, T.
Sarker, A.
Sbeih, Y.
Sfeir, R.
Shatnawi, R.
Shehadeh, A.
Shehadeh, Y.
Shibli, R.
Shideed, K.
Siakoui, L.
Smekalova, T.
Subaih, W.
Syouf, M.

T

Taghouti, M.
Taibi, M.
Taleb, M.
Talhouk, S.
Tennakoon, K.
Thami-Alami, I.
Thomas, T.
Traboulssi, A.
Trifi, M.
Tubeileh, A.
Turk, M.
Turkelboom, F.

V
Valkoun, J.

W
Wajhani, Y.

Y
Yazbik, M.
Younes, A.

Z
Zaman, S.
Zanetto, A.
Zehdi-Azouzi, S.
Zirari, A.
Zurayk, R.
Table of Content

No  Title
1.  Foreword
2.  Preface

Session One

Understand the Status and Current Trends of On-Farm/In-Situ Dryland Agrobiodiversity for Designing Conservation and Sustainable Use Strategies

3.  The Current Status of On-farm and In situ Conservation of Dryland Agrobiodiversity and Strategies for their Future Conservation and Sustainable Use

4.  Status and Threats to Crop Wild Relatives in Selected Natural Habitats in West Asia Region

5.  Assessing the Impact of Agrobiodiversity Conservation on Rural Livelihoods in the Dry Areas

6.  Agrobiodiversity in Algeria: Status and Perspectives

7.  Indicators and Estimators of Agrobiodiversity: A Review


9.  The Fodder Legumes in Algeria: Distribution, Endemism and Utilization

10.  On-farm Conservation of Barley Genetic Resources in Morocco

Session Two

Documentation and Characterization of Agrobiodiversity Using New Tools

12. Using GIS Model to Identify the Predictive Potential Suitable Sites of Wild Wheat Relatives in the Palestinian Authority

13. Managing wheat genetic resources for today, tomorrow, and forever


15. Using a Geographic Information System and Remote Sensing to Delineate Agro-Ecological Zones in the West Bank

16. Application of Biochemical and PCR-based Molecular Markers to the Characterization of Syrian Pear (Pyrus syriaca Boiss) Genotypes

17. Comparative analysis of date palm cultivars identification using isozymes and molecular methods

18. Conservation of Tunisian fig (Ficus carica L.) Germplasm Mediated by Molecular Genetic Diversity Studies

19. Study of Genetic Diversity of Local and Wild Syrian Wheat Using Molecular Markers Techniques

20. Variation in Quantitative Attributes of Aegilops Species under Water Stress

21. Phenotypic diversity of peach (Prunus persica L.) clones cultivated in Lebanon

22. In Situ Conservation and Sustainable Use of Lathyrus Plant Genetic Resources


Session Three
Use of Genetic Resources in Crop Improvement
25. Plant Genetic Resources in Crop Improvement: Case of Cereals

26. Salient Results of Wild Relatives Use in Wheat Breeding Program in Morocco

27. Morphological Evidence for Introgression in Jordanian Wild Emmer wheat (*Triticum dicoccoides* (Körn. ex Assch. & Graebner.) Schweinf)

28. Comparison of Genetic Variability for Root Rot Tolerance in Durum Wheat Crosses Involving Wild Relatives

29. Exploitation of Lentil Genetic Resources

30. Genetic Diversity of Durum Landraces and their Potential for Use in Breeding

**Session Four**

*Technological And Management Options of Agrobiodiversity within Natural and Semi-Natural Habitats Including Rangelands, Forests and Protected Areas*

31. Management of Natural Habitats for *In Situ* Conservation of Wild Relatives of Crop Plants

32. Biodiversity Conservation in Rangelands through the Utilization of the Indigenous Forages of Kuwait

33. Processes of Community Involvement for Promoting the Conservation of Rangelands Agrobiodiversity

34. Main Aspects of the Development of Plant Genetic Resources: *In Situ* Conservation Strategy for Russia

35. *In Situ* and *Ex situ* Conservation and Monitoring of Biodiversity in Arid and Desert Regions of Tunisia

36. Wadi Sair Genetic Reserve Management Plan

37. Biodiversity Management of Forage, Pasture, Medicinal and Aromatic
Species and Micro-organisms

38. Promotion of Caper Production in the Northern Bekaa valley of Lebanon

**Session Five**

*Technological and Management Options for Managing Agrobiodiversity Inside Farmers’ Fields*

40. The Relevance of On-farm Conservation of Landraces in Ecologically Sensitive Areas Under Low Input Conditions

41. Technological Options for Promoting On-Farm Conservation of Landraces of Cereals and Legumes Grown in West Asia Region

42. On-farm Improvement of Some Palestinian Local Vegetable Varieties in a Participatory Approach

43. Planning, with stakeholders the management of genetic resources of date palm in the oases in the Maghreb

44. *In Vitro* Conservation of Plant Genetic Resources

45. Use of Participatory Plant Breeding to Promote On-farm Conservation of Landraces of Durum Wheat

46. Development of Community-based Informal Seed Production System for Promoting the Conservation of Durum Wheat Landraces in Palestine

47. Farmers’ Welfare Improvement through Participatory Barley Breeding

48. Gender Role in the Conservation and Sustainable Use of Agrobiodiversity in West Asia

**Session six**

*Added-value and alternative sources of income for the improvement of the livelihoods of the local custodians of agrobiodiversity*

49. Enhancing the Value Chain for Markets for Traditional Producers of (neglected and underutilized) Aromatic, Vegetable and Fruit Species in
the Near East: A Pilot Study in Syria

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.</td>
<td>Promoting Lebanese Olive Oil from Local Varieties and Value-added to Wild Oregano Populations in Lebanon</td>
</tr>
<tr>
<td>51.</td>
<td>Current Activities on Conservation and Sustainable Use of Underutilized Plant Resources</td>
</tr>
<tr>
<td>52.</td>
<td>Local Community Participation at Anaqeed Al Khair Project</td>
</tr>
<tr>
<td>53.</td>
<td>The Relevance of Durum Wheat Landraces to the Quality of On Farm End Products and Consumers’ Preference in Tunisia</td>
</tr>
<tr>
<td>54.</td>
<td>Reclaimed Water Reuse in Jordan – The Bedouin Experience in Wadi Mousa</td>
</tr>
<tr>
<td>55.</td>
<td>Assessing the Potential Uses of Wild Fruit Trees in Northern Drylands of the Beqa’ a, Lebanon</td>
</tr>
<tr>
<td>56.</td>
<td>Antimicrobila Activity of some Medicinal Plants Collected in Lebanon</td>
</tr>
<tr>
<td>57.</td>
<td>Wild Species with Medicinal Uses in Aarsal, Nabha, Ham and Maaraboun: Indigenous Knowledge and Plant Characteristics</td>
</tr>
</tbody>
</table>

**Session seven**

*Public awareness actions for promoting agrobiodiversity conservation*

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>58.</td>
<td>Public Awareness: A Toll for Promoting the Conservation of Agricultural Biodiversity</td>
</tr>
<tr>
<td>59.</td>
<td><strong>Session eight</strong></td>
</tr>
<tr>
<td></td>
<td><em>Other benefits and values of local agrobiodiversity</em></td>
</tr>
<tr>
<td>60.</td>
<td>Cultural and Religious Keystone Species: The Need to Re-sacralize Nature</td>
</tr>
<tr>
<td>61.</td>
<td>Social and Economic Challenges in Conservation of Agrobiodiversity</td>
</tr>
<tr>
<td>62.</td>
<td>The Agrobiodiversity Project Experience in the Development of Feed Blocks Technology in Sweida Province in Syria</td>
</tr>
</tbody>
</table>
Session Nine

63. Enabling Policies and Legislations for Promoting the Conservation of Dryland Agrobiodiversity in West Asia

64. Empowering Pastoral Communities to Preserve Agrobiodiversity in the Eastern Ranges of Morocco

65. Project Actions to Enhance Community Participation in Agrobiodiversity Conservation

66. General Issues of Agrobiodiversity Conservation in Sustainable Economic Development

67. Developing and Implementing Access and Benefit Sharing (ABS) Regulations in the Pacific Rim Region: Issues and Challenges

68. Posters

69. Index