

The research partnership between ICARDA and the United States of America

USA-ICARDA

Ties that Bind



International Center for Agricultural Research
in the Dry Areas

ICARDA

ICARDA'S mission: To contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

Member of the CGIAR – a global research system: ICARDA is one of the 15 centers strategically located all over the world – the Consortium of on International Agricultural Research Centers, supported by the Consultative Group on International Agricultural Research (CGIAR, www.cgiar.org) and funded through contributions from the World Bank, UNDP, FAO, and IFAD, and more than 60 countries. The Consortium aims at generating international public goods and addressing the concerns of food security, poverty alleviation and conservation of natural resources.

ICARDA'S mandate: ICARDA has a global mandate for the improvement of barley, lentil and faba bean and serves the non-tropical dry areas for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa (CWANA) region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of the research outputs.

Governance: Between 1977 and 2007, the USA has contributed five members to the ICARDA Board of Trustees: Drs Robert Havener, 1977-1978; Lowell Hardin, 1980-1985; Carl Gotsch, 1986-1992; Ronnie Coffman, 1994-1999; Robert Havener, 1998-2003; and David Sammons, 2004-2009. Two US citizens currently serve on the Board: Ms Petal Somarsingh (2008-2011) and Dr. Susan Schram (2010 to date).

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The context of ICARDA's work in research for development

Since ICARDA's inception in 1977, the United States has been the single biggest donor to the center's research and capacity development programs.

The benefits of this significant investment by US partners are dramatically increased crop yields and thus enhanced food security, improved livelihoods for large numbers of farmers, and the large-scale capacity building of farmers and national institutions.

- More than 900 new varieties of barley, durum and bread wheat, lentil, faba bean, chickpea, and forage and pasture crops developed and disseminated
- Improved technologies for water and soil management
- Technology packages for integrated crop-livestock-rangeland systems
- Policy and institutional options to support smallholder agriculture
- Research programs and partnerships in more than 40 countries

A unique place in agricultural research

ICARDA's strategy is to work in close partnership with National Agricultural Research and Extension Systems (NARES) in the dry areas. The research program is put into action in close cooperation with them – leading to mutual learning and benefits for national researchers and institutions as well as ICARDA staff. ICARDA prides itself on being the international center that is probably the most closely linked to national partners and farming communities. It has worked with many of them on long-term joint programs over the past 33 years.

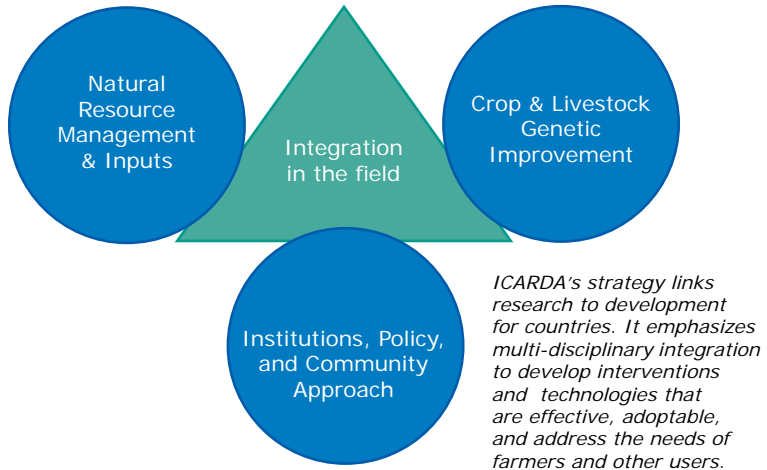
ICARDA's systems approach

As ICARDA has been closely involved in work in dry areas for three decades it has had the opportunity to work with national partners in scaling-up interventions and crop production.

In the past decade ICARDA has evolved from being a 'commodity' center focused on crop development, to becoming a center specialized in a systems approach to agricultural research *for* development.

In today's ICARDA strategy, crop development, livestock management, natural resource management and socio-economic research come together in a broad program focused on the *sustainable intensification and diversification of smallholder production systems*. This approach and thinking bring research as close as possible to the needs of rural communities – involving them in the research and development paradigm.

How ICARDA links research to development



A positive influence in conflict and post-conflict countries

ICARDA is also unique in its activities and contribution to the development of conflict and post-conflict countries. Current programs with Afghanistan, Iraq, Pakistan, Palestine and Yemen are focused on building the long-term capacity of the people, institutions and systems for agriculture and agricultural research in these countries.

As the Center has been working in these countries for many years, it is able to build long-term relationships, building the capacity of professionals at different levels of the agricultural and extension systems, and supporting the scaling-up of agricultural innovations – such as introduction of new crop varieties, seed multiplication and land and water management.

The United States and ICARDA

The United States and ICARDA have a long history of cooperation and partnership on agricultural research for development to benefit people in the world's dry areas.

Prior to the Center's establishment in 1977, the Ford Foundation provided funding for ICARDA's precursor, the Arid Lands Agricultural Development program, based in Lebanon. This program was the nucleus of what was to eventually become ICARDA. Since then, US support has been generous. The United States' contribution to ICARDA has been significant in terms of both financial and scientific support.

US development and research agencies fund the center's core scientific research and a range of special projects. An equally strong partnership is the scientific cooperation with dozens of American universities and advanced research centers – to the benefit of ICARDA's science program, the US scientists, and thousands of developing country researchers and agricultural extension partners.

United States investment: Since ICARDA's inception, the United States Government has been the largest donor to ICARDA, contributing USD 84 million to its core budget with total support exceeding USD 110 million. ICARDA has been closely cooperating with USAID on a number of major agricultural research and development projects, thus furthering USAID strategic activities within the region including in Afghanistan, Egypt, Iraq, Lebanon, Pakistan, the Palestinian Authority, Sudan and Yemen. ICARDA also partners with US universities and research institutes in joint projects supported by USAID. ICARDA also works with USDA in joint research and in implementing projects in North Africa (Morocco and Tunisia), East Africa (Ethiopia) and Central Asia.

Scientific partnerships with US research centers: The product of this investment is manifest in development of National Agricultural Research Systems. Ultimately we aim to reduce poverty and improve livelihoods. The knowledge we create is captured in publications of many types, much of it with our developing country partners; but a very large percentage comes from collaboration with colleagues from US institutions.

These partnerships are diverse and long-term. ICARDA values the relationships formed with US universities and with colleagues in USDA. There is tremendous synergy gained in these partnerships, owing to the comparative advantages each party brings to the cooperation. The following section describes some of the results achieved by these partnerships.

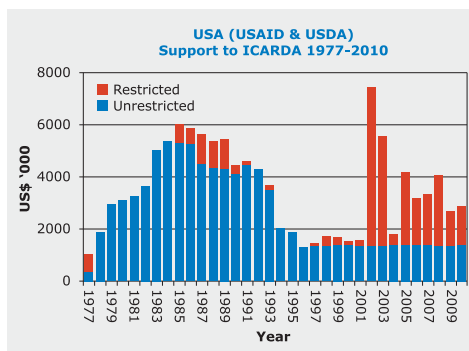
Improving food security and livelihoods in dry areas

USAID funding support to ICARDA – about \$ 34 million in the past 10 years – is of two kinds, ‘core’ and ‘targeted’. ‘Core’ funding supports the Center’s overall research programs, cutting across countries and scientific disciplines. Some core funds are earmarked for research to address particularly serious challenges such as developing water-efficient technologies for dry areas, or preventing the potential global spread of wheat rust diseases.

About 8% of core funds are allocated to linkage funds, designed to facilitate linkages between ICARDA and US researchers. ‘Targeted’ funds support additional research projects with specific goals; for example, overcoming a particular plant disease, or introducing new farming technologies in a particular region or country. Five such projects are ongoing, including a 3-year program in Ethiopia that began in 2011.

Contributions (US\$ '000)				
	Unrestricted	Restricted		Total
		USAID	USDA	
2000	1,382	105	43	1,530
2001	1,380	137	33	1,550
2002	1,380	5,799	231	7,410
2003	1,334	4,066	244	5,523
2004	1,380	1,552	282	1,773
2005	1,380	2,590	181	4,151
2006	1,380	1,495	268	3,143
2007	1,375	1,826	127	3,328
2008	1,380	2,573	82	4,035
2009	1,380	1,211	118	2,709
2010	1,380	1,330	136	2,846

USAID core funds also support ICARDA scientists based in 16 countries. These outreach scientists work closely with national research programs, farmer groups, NGOs, and other partners to ensure that new technologies move quickly from research stations to farmers’ fields. Outreach staff are located in seven regions: the Arabian Peninsula, Central Asia and the Caucasus, Nile Valley and sub-Saharan Africa, North Africa, West Asia, South Asia and China, and the Highland Network comprising Afghanistan, Iran, Pakistan and Turkey. ICARDA is also working with the Iraqi Ministry of Agriculture to establish an office in Baghdad.



This section is an overview of USAID-supported research implemented by ICARDA and its partners, with a few examples of the wide-ranging impacts on food security, livelihoods and farm income.

ICARDA's research portfolio

ICARDA's research portfolio is shaped by the challenges to smallholder agriculture in dry areas: low rainfall, frequent drought, high climatic variability, land degradation, widespread poverty, and others.

1. Biodiversity and crop improvement

USAID funds have helped improve food security and nutrition in developing countries worldwide, through research on a range of crops – barley, durum and bread wheat, lentil, faba bean, chickpea, and forage and pasture crops.

- Biodiversity conservation, in gene banks and in situ. Utilization of the global gene pool for crop breeding.
- High-yielding, disease- and pest-resistant crop varieties for farmers, new 'raw material' for plant breeders. New tools and methodologies for researchers and development organizations. Low-cost, environmentally friendly pest and disease management methods.
- Training and support for innovative ways to disseminate affordable, high-quality seed of improved varieties.

ICARDA and its partners have developed improved varieties of a range of crops, suitable for rain-fed agriculture in harsh and variable environments. The new varieties offer higher and more stable yields and higher tolerance/resistance to different

Current and recently completed ICARDA specific research projects supported by USAID

Some examples, 2001-2011

(Please note that this is an indicative list provided for general information, a completed list of targeted research project is available on request)

Water and Livelihoods Initiative (WLI) Regional Implementation Funds. *In progress*

Rapid Deployment of High Yielding and Rust Resistant Wheat Varieties for Achieving Food in Ethiopia. *In progress*

Accelerating seed multiplication to combat the threat of stem rust in wheat. *In progress*

Combating Dry land Degradation - Oasis. *In progress*

Global Rust Initiative. *In progress*

Food Security/Poverty Alleviation In Arid Agriculture Baluchistan- Pilot Project. *Completed*

Support to program of emergency seed relief in Tajikistan and Kyrgyzstan. *Completed*

Afghanistan - additional seed relief. *Completed*

Assisting Afghan farmers to restore food security. *Completed*

Ecologically-based Participatory and Collaborative IPM Research and Capacity Building Program in Central Asia. Completed

Afghanistan Water, Agriculture and Technology Transfer. *Completed*

Seed Potato Multiplication Procurement and Storage, Baharak. *Completed*

Molecular Genetics for Development of Durum Wheat Varieties Possessing High Yield Potential, Rust Resistance, Stress Tolerance and Improved Grain Quality. *Completed*

Development of High Yielding, Long Spike Bread Wheat Cultivars Possessing High Tiller Number, and Rust Resistance and heat Tolerance facilitated by Microsatellite DNA Markers. *Completed*

Leveraging an Integrated Expert System/Crop Modeling for farm Level Wheat Crop Management. *Completed*

Mining Wild Barley in the Fertile Crescent: A Genomics Approach for Exploiting Allelic Diversity for Disease Resistance in Barley. *Completed*

Rebuilding Agricultural Markets in Afghanistan Program Village-based Seed Enterprise Development. *Completed*

Demonstrating New Technologies in Farmers Fields. *Completed*

Introducing Protected Agriculture for cash crop production. *Completed*

Clean Seed Production, Multiplication and Marketing for increased potato production. *Completed*

Nangarhar Emergency Seed Wheat and Fertilizer Distribution. *Completed*



With its partners, ICARDA has developed improved crop varieties for rainfed agriculture in harsh and variable environments.

stresses (diseases, insect pests, drought, heat, cold, parasitic weeds). Some also offer large improvements in bread-making quality, nutritional value and other traits. More than 880 new varieties have been released for cultivation, generating benefits worth an estimated \$ 850 million per year.

Between 1977 (when ICARDA was established) and 1996, yields of durum wheat grew at 4.5%, 1.6%, 7.9% and 4% annually in Algeria, Morocco, Syria and Tunisia respectively.

Field trials in several countries showed significant increases in yield and profitability. The yield increases ranged from 30-100% in Algeria, 20-40% in Morocco, 10-25% in Syria, 5-20% in Tunisia, and 15-80% in Turkey. In specific cases, like the Hessian fly resistant varieties in Morocco, yields increased by over 300%.

These benefits have been measured through detailed impact assessments. For example:

- Improved dual-purpose barley gave a 32-43% internal rate of return in West Asia and North Africa, up to 70% in Morocco.
- Improved varieties significantly increased farmers' net returns: by 43% for wheat in Egypt; by 73% for chickpea in Sudan; and by 17%, 17% and 52% for lentil, chickpea and faba bean, respectively, in Ethiopia.

2. Better management of water and land resources

New technologies, developed with US funding, are helping farm communities use natural resources more efficiently, productively and sustainably.

- Rainwater harvesting, irrigation methods and other innovations for water-scarce environments. Integrated, watershed management methods. Technologies to exploit new and non-conventional resources including saline water and treated wastewater.
- Soil management and land use methods to fight land degradation and improve the ability of poor farmers to adapt to climate change.

Plant genetic resources - conserving biodiversity

The gene bank at ICARDA's headquarters holds more than 135,000 accessions, originating from more than 100 countries. About 22% of these accessions are wild species, either crop wild relatives or pasture and rangeland species. ICARDA's collection of primitive wheat genotypes (progenitors of modern wheat) represents 30% of the global total. The pasture and rangeland species in this collection includes at least 3,000 ecotypes of 570 species, collected from over 100 sites in a range of habitats: steppe, forest, cultivated area, and salt lakes. Each year, some 30,000 accessions are distributed to research centers worldwide, for use in plant breeding programs. New tools such as FIGS (Focused Identification of Germplasm Strategy) and molecular analysis are helping to identify novel genes that control traits such as drought or disease tolerance, to accelerate the development of new varieties from this germplasm. In 2008 new sources of resistance to four important pathogens – Sunn Pest, Ug99 race of stem rust, Russian wheat Aphid and Hessian fly – were discovered in wheat landrace material; while novel salt tolerance genes were discovered in the primitive wheat collection.

In addition to conservation in gene banks, ICARDA also promotes in situ conservation of biodiversity in different ways. Periodic eco-geographic surveys in the key agro-ecosystems in West Asia, Central Asia and North Africa – all important centers of diversity – help to monitor biodiversity status and give early warning of impending loss of habitat or species. Building on this information, protected areas and field gene banks are being established, and degraded areas rehabilitated with native species of shrubs and trees. Improved management methods, combining local knowledge with modern tools such as GIS analysis, are helping to protect natural habitats such as watersheds and rangelands. Community-led projects are helping to conserve wild species within the agricultural landscape, by promoting their sustainable use. For example, market opportunities are being developed for a number of medicinal and aromatic herbs. Crop diversity – landraces being cultivated by smallholder farmers – is also being preserved, through monitoring, training programs for farmers, and ex situ and in situ conservation.

Biodiversity conservation programs are community-driven, but research is a critical component. In degraded rangeland areas in Jordan and elsewhere, ICARDA and its partners have introduced mechanized methods for large-scale construction of water-harvesting micro-catchments where native species are being regenerated. They have also developed GIS-enabled databases that are helping to monitor soil and water resources and improve land use planning. In collaboration with US universities, a low-cost, non-destructive "digital vegetation charting technique" has been developed to monitor rangeland condition. Training programs are helping researchers in different countries use the technique to protect rangeland biodiversity.

To institutionalize conservation efforts, ICARDA works with national policy bodies to strengthen implementation of international conventions such as the International Treaty on Plant Genetic Resources for Food and Agriculture, through training, networking, development of genetic resources registers, and assistance with developing regional conservation strategies.

Rainwater harvesting – collecting runoff water during or after intensive rainfall, and channeling it to storage or to a cultivated area for more efficient use – is critical for farmers in dry areas. ICARDA has helped develop a suite of technologies to improve the design of water-harvesting systems, and use the collected water more effectively.

For example, GIS (Geographic Information System) analysis is being used to rapidly and accurately evaluate hundreds of alternative sites, to identify those most suitable for water harvesting – at a fraction of the time and cost needed for traditional surveys. A new method for rapid, mechanized construction of water-harvesting ‘micro-catchments’ has been developed, with the ability to build micro-catchments on up to 40 hectares per day, ideally suited for large-scale programs to rehabilitate degraded rangeland areas.

Another technology is supplemental irrigation – small quantities of water, applied at critical stages of crop growth or periods of stress. Supplemental irrigation ensures higher and more stable yields, reduces risk, and significantly increases water productivity (the amount of grain or biomass produced per liter of water).

For example, on-farm water productivity is 2.5 kg/m³ under supplemental irrigation, compared to 0.75 kg/m³ under full irrigation. Studies in several countries have demonstrated the yield gains. Wheat yields, for example, Syria, average wheat yield under rain fed conditions increased from 1.25 t/ha to 3 t/ha in Syria; from 4.6 to 5.8 t/ha in Morocco; and from 2.2 to 3.4 t/ha in Iran, with small amounts of supplemental irrigation.



New approaches to water and land management developed by ICARDA and partners with US funding, are helping farm communities use natural resources more efficiently.

ICARDA and its partners have developed and optimized supplemental irrigation packages for different crops and cropping systems in Ethiopia, Iran, Jordan, Lebanon, Pakistan, Morocco, Syria, Tunisia and Turkey. Countries in sub-Saharan Africa, including Burkina Faso and Niger, and others have launched their own programs based on ICARDA's model.

Protecting the world's wheat supplies

ICARDA is a central player in international (and US-funded) initiatives to protect global wheat supplies against epidemics of rust disease. Considerable progress has been made against the two most serious of these diseases, stem (black) rust and stripe (yellow) rust.

Ug99, a new race of stem rust, has spread from East Africa, where it was first reported in 1999, northwards within Africa, and into West Asia. New mutations of Ug99 are being reported; huge areas in South Asia, East Asia, and possibly parts of Europe and the US, are at risk. Varieties resistant to previous strains of wheat rust, but susceptible to Ug99, are grown on at least 40 million hectares in developing countries. However, progress has been encouraging. The Borlaug Global Rust Initiative has brought together more than 30 countries, with a huge pool of scientific skills. A global rust surveillance system has been put in place, and is being upgraded using new GIS- and web-based technologies. Ug99 movement is being monitored through the use of 'trap nurseries'. ICARDA and other partners are working on race pathotyping, to provide insights on the development of new races or strains of the fungus. More than 15,000 genotypes have been tested at rust 'hot spots' in Ethiopia and Kenya, and several new resistant varieties developed. Resistant durum and bread wheat varieties have been released in Ethiopia and Egypt; a number of promising genotypes are being field-tested to confirm resistance and adaptation to specific environments.

Epidemics of stripe (yellow) rust have increased sharply in the past 2 years, because of favorable weather conditions and breakdown of resistance in a widely used gene. North Africa, West Asia, Central Asia were all affected, because the main commercial wheat varieties are susceptible. Yellow rust management strategies have been developed, and are now being gradually put in place: fast-track introduction of resistant varieties, targeted fungicide sprays, and continuous monitoring of infected areas. To accelerate variety development, ICARDA used an innovative 'shuttle breeding' program in Syria and Ethiopia. Promising lines were then screened for resistance to different rust diseases in different environments – Egypt, Ethiopia, Kenya Lebanon, Sudan and Syria. A number of promising lines have been identified, with high yields, resistance to common diseases or insect pests, as well as resistance to both stem and yellow rust.

With support from the USAID Famine Fund, ICARDA and the International Wheat and Maize Improvement Center (CIMMYT) have launched a new program to combat stem rust in six food-insecure countries: Afghanistan, Bangladesh, Egypt, Ethiopia, Nepal and Pakistan. The program will accelerate testing and release of currently available resistant varieties; help promote already released varieties; and accelerate seed multiplication of both promising and released varieties. It will also accelerate dissemination by accelerated large-scale certified seed multiplication of certified seed (through linkages with public and private sector agencies), and targeted distribution of small packs of seed to small-scale farmers. In its first season, in Egypt alone, the program produced more than 350 tons of seed of two resistant varieties.

The Middle East Water and Livelihoods Initiative

The USAID-funded Middle East Water and Livelihood Initiative (WLI) was launched in 2010, to help improve rural livelihoods in the face of severe, and growing, water scarcity. It targets seven countries: Egypt, Iraq, Jordan, Lebanon, Palestine, Syria and Yemen. The WLI is led by ICARDA, and implemented jointly with national research programs, in the seven countries, the International Water Management Institute (IWMI), and nine universities – three in the Middle East (American University - Cairo, American University - Beirut, University of Jordan) and six in the US: Florida, Texas A&M, UC-Davis, UC-Riverside, Illinois (Urbana Champaign), and Utah State University.

Research focuses on the three main agro-ecosystems in the region: rainfed areas, irrigated systems and dry rangelands. It will be implemented at pilot “benchmark” sites in each agro-ecosystem, to ensure that results from these pilot sites can be quickly scaled out to far larger areas within each agro-ecosystem.

The WLI builds on current knowledge (available, proven technologies and research methods) and existing partnerships. This will reduce costs, increase efficiency and generate livelihood impacts much faster than conventional methods. The aim will be to develop, test and promote technology ‘packages’ that combine improved water and land management methods, new crops and crop varieties and other innovations, to create more profitable, diverse, sustainable crop-livestock systems. The first phase will focus on biophysical and socioeconomic characterization of benchmark sites, establishing baseline data, and identifying constraints and research targets. Capacity development – training programs for researchers, extension staff and communities – will be an integral component of work at all sites.

The involvement of US universities will provide a huge pool of scientific expertise, as well as training opportunities to train young researchers, from within and outside the Middle East. A number of project sub-components will be led by universities, and implemented by graduate students and their mentors.

3. More diverse, profitable farming systems

Research results are helping farmers diversify their farming systems and livelihoods, with new crop-livestock-rangeland technologies, sustainable intensification of traditional systems, and value-added crop and livestock products.

- Improved livestock productivity through better use of hardy native sheep and goat breeds, increased production of feed and fodder, better management of rangelands, and low-cost methods for animal nutrition and health care
- More intensive, market-oriented production systems for crops and livestock
- Conservation agriculture methods to reduce production costs and improve sustainability

ICARDA's livestock research focuses on sheep and goats, a major source of income for poor households in dry areas. The low-cost technologies developed and promoted, provide small-scale producers with stable, year-round supplies of feed and fodder.



With partners, ICARDA has developed integrated 'packages' combining feed/fodder production with health care and market-focused production.

These include forage legumes such as vetch (*Vicia sativa*), dual-purpose food legumes (e.g. chickpea, lentil) for both grain and fodder, and non-traditional resources such as spineless cactus (*Opuntia*), saltbush (*Atriplex*) and foliage and seeds from native trees and bushes. Alley cropping barley and Atriplex increased barley grain yield by 17% and barley straw yield by almost 100% compared to the traditional barley-fallow system.

The extra feed enabled owners to increase flock size and reduce feed costs by 33% on average. Surveys in Morocco showed adoption by almost 60% of smallholder farms, and 90-100% of holdings larger than 20 hectares. The internal rate of return (IRR) on Atriplex research has been estimated at 29%.

Another option is nutrient-rich feed blocks, produced from farm residues and agro-industrial by-products. Different 'recipes' have been developed, and can be selected depending on local prices of ingredients. Building on ICARDA's pilot projects, Iraq, Morocco, Tunisia and others have developed industrial-scale facilities to produce feed blocks.

Integrated 'packages' have been developed, combining feed/fodder production with animal nutrition, health care, and market-oriented production. For example, 'strategic supplementation', providing additional nutrients at critical growth stages, accelerate growth rates and improve animals' breeding performance. Preventive veterinary care, by community-based para-veterinarians, reduces diseases and mortality rates. Simple home-based processing methods can enable small-scale producers to produce high-value products such as cheese, yogurt and wool.

4. Understanding markets, strengthening policies and institutions

Socio-economics and policy research funded by USAID has provided new insights on poverty, livelihood strategies and gender roles in rural communities. The results are helping to inform policy development and create local institutions to support smallholder agriculture.

- Adoption and impact studies to measure changes in poverty, food security and incomes resulting from new agricultural technologies.
- Studies on patterns of technology dissemination, identifying what factors accelerate or hinder adoption, providing lessons for future research and development programs
- Identifying policy and institutional options to improve rural livelihoods, and create pathways out of poverty
- Characterization of agricultural livelihood strategies, and the social and cultural that shape them, to identify agriculture-based pathways out of poverty.

Market studies have helped identify research gaps, identify opportunities for investment opportunities, and help shape policy to enable small-scale farmers to benefit from potential markets. For example, dry areas often have a rich flora of medicinal and aromatic plants with considerable market potential. An ICARDA-led study in Egypt and Jordan provided the first comprehensive analysis of the complete commodity chain for four important herb species (chamomile, basil, oregano and sage), covering production, processing and trade, including price trends, margins, and institutional factors such as the role of cooperatives. Similar studies in North Africa explored market opportunities for dryland fruit and nut production, encouraging government agencies to build these into rural development programs.

The adoption and impact of water-saving technologies can be dramatically improved by policies to encourage efficient consumption. ICARDA economists have analyzed water use patterns in dry areas, on a range of crops, to help inform policy development. Over-irrigation of crops – a common problem throughout the developing world – is associated with technical, water-use, and cost inefficiencies. These studies have helped measure these inefficiencies and thus identify priorities for policy action.

Challenges in the dry areas

Over the past three decades, ICARDA has built longstanding partnerships with many countries. The focus of the research collaboration with each partner country varies according to the countries' priorities and the capacity of their national research programs.

Dry areas are today facing new and growing challenges. Dryland systems already face serious environmental constraints: persistent water scarcity, frequent droughts, climatic variability, land degradation and desertification – all of which will become more acute with climate change.

All predictions show that in the major dry areas of the world, climate change will result in lower rainfall, greater rainfall variability, and changes in temperatures and growing seasons, with serious implications for agricultural productivity, food security, and rural employment and livelihoods. The effect of changes in climate on the distribution of crop pests and diseases is already evident, threatening the region's staple food crops.

ICARDA's integrated systems approach – working together with national programs and farming communities in reference research sites – is being expanded to develop innovations that reduce risk, help farming communities adapt to climate change, and contribute to food security and employment. This system concentrates on improving water productivity through the more efficient use of rainfall and irrigation water; diversification and sustainable intensification of agricultural production systems; better linking farmers to markets; and building the institutional and policy support needed.

To this end, ICARDA, together with eight other CGIAR centers and the national programs of dryland countries, is leading the development of a global CGIAR Research Program (CRP) on *Integrated Agricultural Production Systems for the Poor and Vulnerable in Dry Areas*.

ICARDA worldwide

Opportunities and challenges for further cooperation with USAID

ICARDA's presence on the ground – in partnership with governments, in countries in West Asia and North Africa, Central Asia and the Caucasus, the Nile valley countries, South Asia and other dry areas provides an opportunity for the United States to invest in long-term national development by supporting agricultural research and capacity building in these countries.

This section provides examples of past successes in many different countries, supported by USAID and other donors. These technologies provide a foundation for future investment by the United States to increase productivity in rainfed agriculture in developing countries.

ICARDA has staff and offices in 16 countries, and works with partner organizations in more than 40 countries. Technologies developed in one country are often international public goods, that can be adapted to local conditions and used successfully in similar agro-ecosystems in other countries.

Afghanistan

USAID approached ICARDA in 2001 to organize a critical mass of scientists to assist in rebuilding Afghanistan's agricultural capacity, based on principles of scientific research. The work initially focused on providing emergency seed assistance but quickly developed into a long-term program of agricultural research for development. ICARDA is working with government agencies, international research centers, local NGOs and donors to help



ICARDA was called on to organize a critical mass of scientists to help rebuild Afghanistan's agricultural capacity.

rebuild the agricultural system. USAID has made significant investments, in emergency seed distribution (via ICARDA) and in longer-term support for research and development. ICARDA continues to contribute to USAID's efforts by partnering with US-led projects in the country.

As many as 19 new varieties of wheat, chickpea, lentil, barley and mungbean have been developed and released

in the past few years; five more will be released in 2011. These varieties give yields 30-70% higher than previously available ones, significantly improving food security and household nutrition. To speed up dissemination, 1100 demonstration plots have been established in 20 districts across four provinces.

Plots planted and managed by farmers showcase new varieties and improved management methods, provide training sites, and produce seed of the new varieties for further dissemination. More than 10,000 farmers have shared their knowledge at field days, interacting with scientists, extension staff and other farmers. Community-based seed production enterprises have been set up and are now self-sustaining. In the past four years they have produced more than 5000 tons of seed of improved varieties. New high-yielding potato varieties have been introduced in six provinces, increasing yields by 50 to 200%. A recent study estimated that new varieties could occupy as much as 55% of the country's potato area by 2010-11, if sufficient seed is available.

ICARDA has been instrumental in developing and introducing locally manufactured greenhouses for the production of high-value vegetables on small areas of marginal land. A demonstration and training site, now operated by the Ministry of Agriculture, was established. More than 400 greenhouses have been installed in farmers' fields. Research on developing alternative livelihoods has focused on increasing forage production, livestock productivity, and milk processing and marketing; cultivation, processing, and marketing of mint and other herbal and medicinal plants as a viable alternative livelihood.

The future priority in Afghanistan is to continue improving the productivity of staple food crops, and to diversify production and rural livelihoods through high-value, market- oriented crop and livestock products.

Bangladesh

In Bangladesh, ICARDA's research has focused on its global mandate crop, lentils. Three high-yielding lentil varieties (Barimasur 4, 5 and 6), developed from ICARDA-supplied germplasm, are grown on at least 110,000 hectares, producing 140,000 tons of highly nutritious grain. They are rich in protein and unusually high in zinc and iron content.

Together with the national Bangladesh Agricultural Research Institute (BARI), and other international centers, ICARDA is looking to expand the research to include other pulses (chickpea, mung bean and lathyrus, a strategic food crop of the very poor), combined with improved crop management practices and relay cropping in the rice-based cropping systems of Bangladesh.

Central Asia

In Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan, remote communities are using new technologies to increase fodder production; shrub plantations to rehabilitate degraded range areas; and rotational grazing systems to allow natural pastures to recover. Drainage water – which would otherwise be wasted – is being used to irrigate salt-tolerant native shrubs for fodder. New crop rotations in Uzbekistan, for example, have increased fodder production from 9.5 to 15.7 tons/hectare, in addition to producing 5.8 tons/hectare of maize grain.

Tajikistan

In Tajikistan, ICARDA has helped rural communities – and particularly women – produce handspun mohair yarn for export to boutique stores



Research supported peoples' capacity to produce handspun mohair yarn for export.

in the USA. Researchers addressed both production and processing of wool: establishing a 'breeding nucleus' to improve the genetic quality of village flocks; providing training on flock nutrition and management; and methods; providing women with training and simple equipment to increase quality and productivity; and creating linkages between goat producers, wool spinners' groups and export buyers.

The future focus will to continue to be on improving the productivity of water and combating salinization in irrigated systems, and improving the productivity of the extensive rangeland/livestock production systems, as well as assisting national programs to adjust agricultural and food production systems to their developing market economies.

China

In China, research has focused on ICARDA's mandate crops of barley and faba bean. Faba bean variety Yandou 147, developed from ICARDA material, covers almost one-third of faba bean area in Yunnan province – one of the world's largest faba bean production zones. Similarly, three-fourths of the barley area in Yunnan is sown to varieties originating from ICARDA material. They include Yundamai No. 2, which yielded 10.8 tons/hectare last year

– the highest ever recorded in China. ICARDA has joined with ICRISAT and the Chinese Academy of Agricultural Sciences to establish of a Joint Centre of Excellence for Dryland Agriculture – a platform for research for development and a training centre on technologies for dryland agriculture. The Center will benefit from China's scientific expertise in the development of dryland systems.

The Nile Valley countries

Egypt

The partnership with Egypt has focused on improvement of staple food crops (wheat and food legumes) in the regional Nile Valley Program; and research on improving cropping systems management, land and water resource management, livestock production and value chain analysis. For example, in a regional project on water management in benchmark sites for different agro-ecologies, Egypt hosts the principal benchmark site for irrigated systems. ICARDA and national researchers have developed a simple, low-cost alternative (raised-bed planting), to replace traditional (and inefficient) flood irrigation. This new system reduces water consumption by 30%, labor costs for land preparation, irrigation and weed control by 35%. Farmers' net income increased by 15%, net return per unit of water increased by 20%.

Future priority will be given to improving the wheat-based cropping system, including the promotion of conservation agriculture; improved water productivity and irrigation efficiency ; improved farm level management of shallow groundwater aquifers and salinization; integrated crop-livestock production systems; and linking smallholders with domestic and international markets (value chain approach).

Ethiopia

In Ethiopia, new lentil and chickpea varieties developed by ICARDA and national research centers have sparked a production revolution. Between 2001 and 2008, lentil yields increased by 37%, chickpea yields by 30%, and the country's total legume production by nearly two-thirds. Between 2005 and 2008, exports grew by more than 600%.

Highland farmers in Ethiopia are beginning to cash in on the huge potential offered by faba bean. New high-yielding, disease-resistant varieties have been developed, together with improved production methods. Production increased by 47% between 2001 and 2007. The next target is to expand faba bean cultivation in vertisol areas prone to waterlogging, which cover some 8 million hectares in the country. Traditional varieties are severely affected by excessive soil moisture and by root rot disease, which is common in waterlogged areas.

Ethiopia is a key partner in global efforts to combat the threat of the new strain of wheat stem rust disease, Ug99, with collaborative efforts to develop and rapidly multiply seed of resistant varieties.



In Ethiopia, new lentil and chickpea varieties developed by ICARDA and national research centers have sparked a production revolution – with dramatically increased yields.

ICARDA is working in the Amhara region since 2009, to test and promoting an integrated package of technologies for low-rainfall areas. This community-based approach includes testing of improved varieties and management practices with efficient and sustainable use of land and water. The project is testing and adapting methods for harvesting and using rainfall runoff to provide targeted irrigation during dry spells, for soil erosion control measures, and improved crop management

practices. The learning from this project will serve as a platform for developing and disseminating new technologies for similar ecologies in other countries. Ethiopia has a rich diversity of indigenous sheep breeds. Nine indigenous breeds have been identified through phenotypic and molecular characterization. A new project is helping to protect this unique gene pool.

Eritrea

A project on improving water productivity of cereals and food legumes in the Atbara River Basin of Eritrea, led by ICARDA, identified many improved cultivars and promising lines of barley, wheat, lentil, faba bean and chickpea. Several of these have been released and been integrated into the national program's seed increase system.

Adoption of these improved varieties will greatly increase yield and rainwater productivity. However for adoption to take place, there needs to be an increase of seeds, and Eritrea had no seed production or delivery. To address this problem, the project set up a pilot Village-Based Seed Enterprise for quality seed increase and delivery, and introduced the concept of using irrigation in the dry season for seed increase. These concepts have been adopted by a large development program for Eritrea. The ICRDA project devoted considerable resources to building the capacity of farmers, government extension staff and scientists from national system.

Sudan

In Sudan, wheat was traditionally grown in the north; however, the development of new high-yielding, heat-tolerant wheat varieties have allowed the crop to expanded southwards, where winter temperatures are higher, but land is more abundant and water is more easily supplied.

Twenty-six new varieties of wheat, faba bean, lentil and chickpea, developed jointly by the Agricultural Research Corporation and ICARDA, have been released, generating significant impacts on farm income and food security. For example, wheat farmers adopting the new technologies increased their net returns from US\$ 134 to 510 per hectare, on average. Collaborative studies established the basis for identification of plant viruses in Sudan, and developed resistant varieties as well as management practices for better control. Diagnostic kits, developed and distributed by ICARDA are enabling national centers to monitor virus diseases in crops and cropping systems. Information management capacity has been improved through training programs and a 'twinning agreement' with Egypt, coordinated by ICARDA. Socio-economists and GIS specialists worked together on the country's first comprehensive poverty mapping exercise; the results are being used to target research and development investments more accurately to the poorest and most vulnerable communities.

Faba bean, chickpea, and lentil are among the major sources of protein in the diets of the Sudanese. In cooperation with ICARDA, Sudan developed improved production "packages", for target farmer groups in specific locations.

In the future: A Sudan-ICARDA partnership developed priorities for future research for development programs. This was a joint effort with the Ministry of Science and Technology, the Ministry of Agriculture and the Coordination Council for the Southern States. Concepts were developed for projects on agro-ecological characterization and drought monitoring; strengthening the informal seed system; improving livestock performance; natural resource management; water harvesting; crop diversification and rural livelihoods; and capacity development. The ongoing conflicts in the country have made it difficult to raise donor support for the proposed research programs, while attention is still focused on emergency assistance.

The Middle East

Iraq

ICARDA has worked with Iraq since the Center was founded in 1977. Collaboration involved joint research at Iraqi research stations and in farmers' fields, plant genetic resource conservation and human capacity building. The number of accessions of Iraqi origin held in major gene banks outside Iraq is limited; the largest collections are at USDA (1,113 accessions) and at ICARDA (1,003 accessions). During the 1990s, the Iraqi national program sent its genetic resources collections to ICARDA to be held in the long-term storage. Its own gene bank at Abu Ghraib was subsequently destroyed.



Conservation agriculture is an important focus of the Iraq-ICARDA partnership.

Over the years ICARDA has distributed to breeding programs in Iraq a wide range of improved genetic material of barley, bread wheat and durum wheat, lentil, faba bean, chickpea and vetches. ICARDA continues to distribute germplasm from our gene bank to Iraq for use in crop improvement programs. Joint research on the use of supplementary irrigation of wheat revealed that in dry years supplementary irrigation during critical drought periods can increase wheat yields by up to 100%.

Iraq was one of eight countries that participated in a regional program on crop-livestock integration coordinated by ICARDA. The project developed a community approach to developing packages of 'best-bet' technical, institutional and policy options to support livestock production in dry areas. Considerable progress was made in the development of on-farm feed production and alternative feed sources and improved management of small ruminants. These community-based research sites could provide the platform for further up-scaling and out-scaling

More recently, research on conservation agriculture methods – combining zero tillage, early planting and crop rotations – is helping smallholder farmers increase yields, reduce production costs and improve soil quality. Adoption has grown from near-zero to 5,000 hectares in the past 5 years. Another project focuses on two of the country's key farming systems: rainfed wheat/legume systems in the north and irrigated date palm systems in central and southern Iraq. It is helping to promote environmentally

friendly methods to control diseases and insect pests, and more effective use of organic fertilizer. A project involving five government ministries and other partners is helping to fight soil and water salinity in the country's traditional breadbasket, the Tigris-Euphrates river basins.

ICARDA's strategy is to continue to support and strengthen the capacity of the national agricultural research and technology transfer systems to assist farmers in rebuilding their agricultural production capacity by improving crop production and cropping system management; strengthening seed production systems; improving on-farm water use efficiency in both rainfed and irrigated cropping systems; improving crop-rangeland- livestock production systems.

Syria

Syria is ICARDA's host country. Formerly a wheat importer, the country is now self-sufficient – and an exporter. Between 1991 and 2004 wheat production rose from 2.1 million to 4.5 million tons, with a combination of new high-yielding varieties, supplemental irrigation technology and supportive policies. Environmentally friendly methods to control Sunn pest, using entomopathogenic fungi, have replaced indiscriminate use of chemicals. The area sprayed by insecticides in Syria has dropped from 275,000 hectares in 2005 (mainly through aerial spraying) to less than 70,000 hectares in 2010 (80% through targeted ground application).

Arabian Peninsula

Gulf Cooperation Council (GCC) countries

In Qatar, Oman and other GCC countries, ICARDA has developed protected agriculture techniques for high-quality fruits and vegetables in greenhouses. Production packages have been developed, including alternative cooling methods, hydroponics or soil-less cultivation, and plant protection methods involving minimal use of pesticides. Packages bring substantial increases in yield (e.g. producers in Oman increased cucumber yields by 60%) and water productivity. For example, it requires 200 m³ of water to produce 1 ton of musk melon in soil in the open field. The same amount of water produces more than 15 tons under greenhouse hydroponics.

Major successes have also been achieved in date palm. Genetic diversity has been characterized through field and DNA studies; improved production methods have been tested and validated; control measures developed against major insect pests; and new market opportunities identified. Capacity development investments focused on genetic improvement (e.g. biotechnology tools) as well as postharvest handling and quality enhancement.



Oman is developing skills in hydroponic agriculture.

Elements of these technologies have been adapted in developing and transferring greenhouse production to other countries including Yemen, where low-cost protected agriculture methods are used by farmers to grow high-value greenhouse vegetables, generating large profits from small plots in marginal, water-deficient areas. Greenhouses are locally fabricated, inexpensive, and pay back the investment in two seasons. Using the technology, cucumber growers have reduced the use of agrochemicals by 80% with no loss of yield. Typical returns on investment (once the greenhouse is built) are 81% per year.

Yemen

One of the least developed countries in which ICARDA works, Yemen, faces major challenges. For millennia, farming has been adapted to the mountainous terrain based on well-developed terraced systems and spate irrigation from rainfall runoff from the mountains. However, these systems are collapsing. Low productivity, lack of employment and rural poverty is driving massive migration to urban areas. Once abandoned, the terrace systems rapidly disintegrate, causing widespread erosion and silting of watersheds.

Through a series of projects on Yemen's rainfed mountain agricultural systems, ICARDA has analyzed the constraints and generated baseline information that will be useful in developing improved and more productive technologies. A Rapid Impact Program, implemented by ICARDA, initiated efforts to strengthen on-farm adaptive research and revitalize on-station back-up research in various agro-climatic regions of the country.

Yemen's National Agricultural Research Strategy identifies commodity improvement and conservation of the limited land and water resources as major challenges facing the agricultural sector, and identifies the development of rainfed agriculture and crop/livestock integration as high priorities. To feed the rapidly growing population, increase rural employment and incomes, and reduce the rate of rural-to-urban migration, agricultural production will have to be increased. The improvement of rainfed agricultural productivity, in an environmentally sustainable manner, is key to sustainable economic development in Yemen.

North Africa

Libya

In Libya, ICARDA is helping to introduce GIS-based techniques for selecting and characterizing research sites with greater precision, and at lower cost. The Center is also providing technical support for large-scale national efforts to increase water productivity in agriculture, through rainwater harvesting and other means. New fodder varieties have been identified, including several genotypes (from within and outside North Africa) of oats, that yield more than 12 t/ha of dry matter; and several fodder legume genotypes that give high yields as well as sustainability benefits.

A study on livestock health, combining field surveys with laboratory analysis, provided data on animal diseases (relative importance and infection rates), parasites and in sheep and goats. The results are now being used to develop a national framework for animal health management strategies.

Morocco

In ICARDA's strategic partnership with Morocco, the Moroccan government funds joint research activities. As a result of this longstanding collaboration, ICARDA and its Moroccan partners have benefited from germplasm exchange; screening for pest and disease resistance; natural resources management and training. Together with other North African countries, Morocco has participated in regional projects, coordinated by ICARDA, on durum wheat improvement and adding value to durum wheat products; integration of crop-livestock production systems in low rainfall areas; on-farm water management; and mountain agriculture.

In a regional project on water management in benchmark sites for different agro-ecologies, Morocco hosts the principal benchmark site for rainfed systems, where research has focused on water harvesting. The technologies developed in Morocco can be adapted to local conditions and used successfully in similar agro-ecosystems in other countries.

Morocco's Cooperative Grants Program has supported a collaborative partnership with ICARDA to develop the capacity of Morocco's biotechnology research program. A scientist from ICARDA is posted in Morocco, and works together with scientists from the Institut national de la recherche agronomique (INRA). The grant program trained young researchers, students, junior level scientists and technicians. This joint raining effort between the national research system and ICARDA resulted in the adoption and application of biotechnology tools at INRA, in research that will benefit the entire region.

Tunisia

In Tunisia, collaborative research with the national program has focused on various areas: integrated crop-livestock production, water and soil management, socio-economics and policy, among others. Low-cost technologies have helped increase productivity and incomes among small-scale livestock producers in very dry areas. Opuntia (spineless cactus), a



Integrated crop-livestock production.

valuable energy source for animals, has been successfully introduced, and is now alley-cropped with barley, replacing the traditional barley-fallow system. The new system increased biomass yields by 57%: barley grain and straw yields remained the same or increased, while the cactus provided pads and fruits. Small-scale producers reduced their feed costs by 13%. Cactus was also used as a component of rangeland rehabilitation programs. Introduction of cactus in natural rangelands increased average herbaceous biomass yield from 3.3 t/ha to nearly 5 t/ha.

Future collaboration would focus on empowering rural communities through sustainable local development, based on crop-rangeland-livestock integration and diversification of production systems and income, essentially outscaling results achieved through earlier projects; as well as assisting rural communities to adapt to and cope with climate change in marginal and less developed areas.

South Asia

India

The India-ICARDA partnership focuses on strengthening synergies between ICARDA and the strong Indian national program, to generate technologies for regional benefit. In India, the narrow genetic base of lentil has been considerably broadened by the introduction of ICARDA germplasm, creating new opportunities to improve traits such as earliness, large seed size and resistance to *Stemphylium* blight. Two-thirds of the new lentil lines now being tested by national research centers contain genes from this germplasm.

Nepal

In Nepal, new lentil varieties developed jointly by ICARDA and the national research program now occupy about 68,000 hectares, producing an extra 55,000 tons of protein-rich grain each year. The total increase in national output is estimated at more than \$ 43 million. Improved malting barley genotypes have been identified targeted at relatively favorable environments.

Pakistan

In Pakistan, collaborative projects have focused mainly on Baluchistan province. ICARDA has led components of various US-funded programs, beginning with the Management of Agricultural Research and Technology (MART) project, 1985-1990. It introduced innovations such as saltbush cultivation for fodder, water harvesting and improved varieties of several crops; and helped build national capacity in livestock research, water management and rangeland conservation. Subsequent projects included



In Pakistan, collaborative projects have focused on diversified crop/livestock systems for food security.

rangeland monitoring and rehabilitation, dairy goat production, water management, and diversified crop-livestock systems. The 'Food security / poverty alleviation project' included a wide range of interventions: irrigation and water harvesting, high-yielding crop varieties, rangeland rehabilitation, livestock nutrition, veterinary care, and new income with cultivation of almond, pistachio and other high-value tree crops.

Research Partnerships with US universities

US universities provide high-level technical support for research projects, mentoring to developing-country scientists, and training and educational opportunities to project collaborators. Collaborative research programs with US universities include:

- Austin State University: Biotechnology tools to study insect pests
- Cornell University: Wheat rust diseases; livelihood options in Afghanistan
- Iowa State University: genebank management training for Central Asian countries
- Kansas State University: insect pest resistance and molecular biology
- Michigan State University: Phosphorus dynamics, pest management
- New Mexico State University: Adaptive research and technology transfer
- Ohio State University: carbon sequestration
- Oklahoma State University: training on crop estimation techniques in Central Asia
- Oregon State University: Animal grazing patterns, entomology, molecular mapping, molecular markers for disease resistance in barley
- Purdue University: GIS for watershed management, faculty and student exchange
- South Dakota State University: cereal-legume systems in the Caucasus
- Stephen Austin State University: cloning of insect pest enzymes
- Texas A&M University: Watershed modeling, capacity development and policy advisory services in Afghanistan
- Texas Tech University: Drought and heat tolerant barley
- University of California, Davis: Impact assessment, livestock/rangeland policy, property rights, market access for women, evolution of legume crops, water productivity, horticulture options
- University of California, Riverside: Salinity and drought stress
- University of Delaware: Web-based information systems
- University of Florida, Gainesville: forage systems
- University of Hawaii: capacity building for Iraqi researchers
- University of Massachusetts: Child nutrition
- University of St. Paul, Minnesota: disease resistance genes in wild barley
- University of Vermont: Biocontrol of insect pests
- University of Wisconsin: dairy sheep breeding, feeding systems, milk product quality
- Utah State University: Livestock and rangeland development in Central Asia
- Virginia Polytechnic: Impact assessment, poverty studies, livestock systems
- Washington State University: gene mapping in lentil, disease resistance breeding, molecular biology of insect pests, livelihood options in Afghanistan
- Yale University: Land use mapping, poverty and livelihoods analysis, impact analysis

Collaboration with the US Department of Agriculture

ICARDA has a number of long-standing programs with the USDA Agricultural Research Service (USDA/ARS):

- USDA/ARS: medicinal, herbal and aromatic plants in North Africa; wheat agronomy in Pakistan; cotton germplasm improvement, crop management and virus management in Pakistan
- USDA/ARS, Manhattan, Kansas: insect pest resistance and molecular biology
- USDA/ARS Cereal Rust Laboratory, Minnesota: pathotyping of stem rust
- USDA/ARS Stillwater, Oklahoma: screening and biotype characterization of insect pests
- USDA/ARS Forage and Range Research, Logan, Utah: livestock and rangeland development in Central Asia
- USDA/ARS Plant Stress and Water Conservation Laboratory, Lubbock, Texas: climatological analysis for agricultural decision-making
- USDA/ARS Grain Legume Genetics and Physiology Research, Pullman, Washington: genetic resources of food legumes, gene mapping in lentil
- USDA/ARS Western Regional Plant Introduction Station, Pullman, Washington: biodiversity conservation in Central Asia and the Caucasus

Collaboration with the private sector

- Busch Agricultural Resources Inc: development of barley germplasm with multiple disease resistance and enhanced malting quality.

About ICARDA and the CGIAR



ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa (CWANA) region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.



CGIAR

The Consultative Group on International Agricultural Research (CGIAR) is a strategic alliance of countries, international and regional organizations, and private foundations supporting 15 international agricultural Centers that work with national agricultural research systems and civil society organizations including the private sector. The alliance mobilizes agricultural science to reduce poverty, foster human well being, promote

agricultural growth and protect the environment. The CGIAR generates global public goods that are available to all.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR with a System Office in Washington, DC. A Science Council, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

Ties that Bind – ICARDA's programmes in partner countries

Titles available in this series:

- The United States and ICARDA
- SARC-NVRP Cool-Season Food Legume Program in Ethiopia
- Australia and ICARDA
- The Netherlands and ICARDA
- Japan and ICARDA (Eng, Jap)
- ICARDA and the Arab World (Eng, Ar)
- Morocco and ICARDA
- ICARDA: Serving the Highlands
- China and ICARDA
- Jordan and ICARDA
- Italy and ICARDA
- ICARDA in Central Asia and the Caucasus
- Germany and ICARDA
- Spain and ICARDA
- ICARDA and Syria (Ar)
- ICARDA and Ethiopia
- Sudan and ICARDA
- Libya and ICARDA
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