Ties That Bind

China and ICARDA

A productive partnership spanning three decades

ICARDA

Science for Better Livelihoods in Dry Areas

The International Center for Agricultural Research in the Dry Areas (ICARDA) is the global agricultural research center working with countries in the world's dry areas. It is the lead center for the global research initiative **CGIAR Research Program on Dryland Agricultural Production Systems**, launched in 2012 together with more than 60 partners in West Africa Sahel and the Dry Savannas, East and Southern Africa, North Africa and West Asia, Central Asia and the Caucasus and South Asia. *www.icarda.org http://drylandsystems.cgiar.org/*

Established in 1977,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 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 is a global partnership that unites organizations engaged in research for a food secure future. CGIAR research is dedicated to reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring more sustainable management of natural resources. It is carried out by the 15 centers who are members of the CGIAR Consortium in close collaboration with hundreds of partner organizations, including national and regional research institutes, civil society organizations, academia, and the private sector *www.cgiar.org*

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Overview

China and ICARDA: a productive partnership spanning three decades

ICARDA's collaboration with China has grown steadily since the early 1980s and now incorporates a wide range of activities – from capacity development to crop improvement and the exchange of germplasm. Focused on strategic crops, including wheat, barley and food legumes, the Center's research is helping Chinese partners to maintain food production against a backdrop of shifting climate patterns and increasing desertification.

The fruits of this research partnership can be seen in innovations in a number of areas where Chinese research centers and ICARDA have worked over the past three decades. For example, the faba bean variety Yandou 147, developed by Chinese crop breeders from ICARDA material, covers almost 30% of the faba bean area in Yunnan province – one of the world's largest faba bean production zones. And 75% of the barley area in Yunnan is sown to varieties originating from ICARDA material. They include Yundamai No. 2, which yielded 10.8 tons per hectare during the 2010 season – the highest ever recorded in China.

Milestones – the China-ICARDA scientific partnership

Early 1980s - Initial collaboration with Shanghai Academy of Agricultural Sciences on faba bean improvement.

1984 - China Joined CGIAR and CAAS & ICARDA started cooperation

1987 - Official cooperation agreement signed

2009 - Establishment of the Joint Center of Excellence for Dryland Agriculture, involving CAAS, ICARDA and ICRISAT.

2013 - Launching the Center for Dryland Agricultural Ecosystems involving Lanzhou University, ICARDA and University of Western Australia.

The early years – collaborative Faba bean research

Early activities in China were conducted through Mr. Xin Tao, a scientist from the Shanghai Academy of Agricultural Sciences, who studied faba bean improvement at ICARDA in the early 1980s and subsequently initiated the Center's partnership with the Chinese Academy of Agricultural Sciences (CAAS). Mr. Xin Tao also arranged ICARDA's first delegation to China which studied faba bean production and visited scientific research institutes such as CAAS and the Zhiejiang Academy of Agricultural Sciences (ZAAS).
The delegation led to ICARDA hosting regular visits and trainings for Chinese scientists at its headquarters in Aleppo. One prestigious guest was Prof. Lang Li-Juan, Head of the Faba Bean Program at ZAAS and CAAS, and China's national coordinator of faba bean production. A visiting scientist between October 1986 and August 1988, Prof. Lang Li-Juan developed high-yielding, disease-resistant faba beans which had an average 100-seed weight of 128.4g – over 12% more than large seeded Chinese checks. Other distinguished Chinese scientists included Dr. Gou Gua-Xue of the CAAS genebank who studied chickpea germplasm, and Dr. Lang who worked on legume pathology.
A subsequent formal country agreement was signed with CAAS in 1987 and led to the organization of an international conference on faba beans, hosted by ZAAS and CAAS. Proceedings of the First International Conference on Faba Beans, held in Hangzhou, was published jointly by ICARDA and Prof. Lang Li-Juan.

Expanding collaborative research to wheat and barley

Research activities eventually evolved to incorporate other crops such as wheat and barley. ICARDA supplied over 100 international barley nurseries to various Chinese scientific institutions, and introduced improved varieties that out-yielded local cultivars and demonstrated resistance to disease and other stresses. The improved variety Zhenmai 1, for example, was planted across 100,000 ha in Shanghai province and generated yields that were 20 – 25% higher than local varieties. Zhenmai 1 was also resistant to scab – a major disease in China which can lead to the production of toxins in seed, endangering human and animal health. In recent years, a strong partnership has developed with Prof. Yu Yuxiong and the Yunnan Academy of Agricultural Sciences (YAAS) – Yunnan is currently the second largest barley producing province in China.

In fact, 75% of the Province's barley fields are covered with ICARDA varieties. One variety in particular, Yundamai 2, broke China's yield record for barley in 2009, generating 10.8 t/ha. Also in 2009, ICARDA hosted a delegation of barley scientists from CAAS. The six-person delegation included Mr. Luo Bingwen, Vice President of CAAS, and Dr. Mei Xurong, Director General of the CAAS Institute of Environment and Sustainable Development. In 2011 the Tibet Agricultural Research Institute also extended an invitation to Dr. Flavio Capettini, ICARDA Barley Breeder, requesting further collaboration.

Cooperation to combat Yellow Rust in Wheat

In addition to barley, ICARDA has also exchanged wheat germplasm with China in a bid to build the country's resistance to yellow rust disease – a significant problem that threatens wheat production across the region. In the mid-1990s, ICARDA was sending 30 to 40 rust-resistant lines to China each year. Furthermore, since 1986, China has received over 76 bread wheat and 11 durum wheat nurseries from ICARDA. The improved bread and durum wheat lines demonstrated good adaptation to harsh environments and generated significantly higher yields than locally-cultivated varieties of wheat. Dengfeng 1, for example, which was released in 1995, was being cultivated on some 50,000 ha by 1997. The results of collaborative food legume research also produced excellent results. Working alongside Dr. Weibin Gu, of the Institute for Botany at the Chinese Academy of Sciences, ICARDA released several new lines of chickpea and lentil which demonstrated yield increases that were around 30% higher than local varieties. Released legume varieties have also demonstrated resistance to disease, and improved grasspea contained lower concentrations of the neurotoxin B-ODAP, a substance that can cause paralysis in humans. These low-toxin grasspea cultivars were subsequently supplied to the Gansu Grassland Ecological Research Institute and the Qinghai Academy of Agriculture and Forestry.

Helping smallholder farmers adapt to climate change in China and Central Asia

China - through the CAAS – has been an important player in a regional research initiative on climate change and agriculture, facilitated by ICARDA with the national agricultural research systems of Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, with the International food Policy

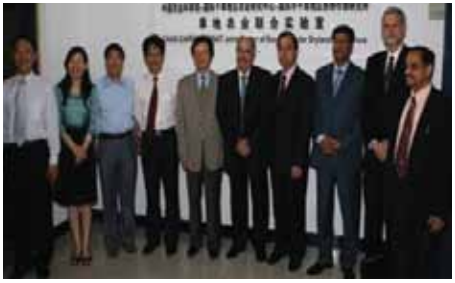
Research Institute (IFPRI). This three-year project, supported by the Asian Development Bank, has helped identify policy options to help smallholder farmers adapt to changing production conditions.
Research on how climate change affects farmers' livelihoods is crucial for decision making processes in every country. Project scientists used a combination of GIS mapping, crop modeling and socio-economic assessments to identify policies to strengthen climate change adaptation in dryland agriculture.
The initiative identified constraints that keep smallholder farmers from becoming more resilient in the face of climate change. There is a need for credit, access to water resources, infrastructure and facilities that allow them to produce efficiently as climate patterns change. The China component of the project was the down-scaling of CIS data, crop-modeling and adapting cost analysis in Ningxia Hui Autonomous Region.

Partnerships and Centers of Excellence

The Joint Center of Excellence for Dryland Agriculture

The Joint Center of Excellence for Dryland Agriculture, created in 2009 in an agreement between CAAS, ICARDA and ICRISAT. It acts as a knowledge hub for research cooperation and capacity building. The Center's research focuses on three important themes where innovations are needed to improve the livelihoods of smallholder farmers living in China's dry areas – crop Improvement, climate change, water and land productivity and watershed management and Livestock-Crop-Rangeland based production systems.

The Joint Center's activities include hosting internships and operate a training center; providing dynamic platforms for research and development; organizer important events to exchange in science and rural development issues; and to promoting cooperation.



Senior management of CAAS, ICARDA and ICRISAT at the launch of the Joint Center of Excellence for Dryland Agriculture in China.

China and ICARDA

In addition to this partnership, ICARDA has signed important agreements with other Chinese scientific and international institutions. These include a tripartite Memorandum of Understanding with the International Water Management Institute (IWMI) and the Chinese Academy of Science (NIGAE), for collaboration on land and water management in Jilin Province, and a further Tripartite Agreement with Lanzhou University and the University of Western Australia, which led to the establishment of the Center for Dryland Agricultural Ecosystems, which opened in May 2013. There have also been high-profile visits in recent years. In 2009, ICARDA's Director General, Mahmoud Solh, travelled to China for the planning of the Center for Dryland Agricultural Ecosystems, followed by visits to three Chinese research centers – the Institute of Crop Sciences, the Institute of Environment and Sustainable Development, and ZAAS. In 2010 ICARDA also hosted scientists from CAAS and ZAAS to discuss mutual areas of interest and formalize plans for collaborative project proposals. Further meetings were held with CAAS officials at regional symposiums – one at the Indian Council of Agricultural Research and another at the Bangladesh Agricultural Research Institute (BARI).

ICARDA's relationship with China, which spans over three decades, continues to strengthen and grow. Over the coming years, as the country adapts to a drier and hotter future, ICARDA scientists will continue to work alongside their Chinese counterparts to maintain and increase food production, strengthening food security for an ever burgeoning population.

Signing the proposal to create the Center for Dryland Agricultural Ecosystems. Prof. Fengmin Li (left) of Lanzhou University and Dr Mahmoud Solh, ICARDA Director General, 2011.

Center for Dryland Agricultural Ecosystems
China's Lanzhou University is working with other research centers to create a new research platform — the Center for Dryland Agricultural Ecosystems, which will develop new technologies for smallholder farmers in dry areas. Research will include drought-tolerant varieties, crop-livestock integration, water and land management, rangeland conservation and other areas. The partners include ICARDA, the University of Western Australia and the International Center for Research on Agroforestry. A proposal for establishment of the Center was signed between Lanzhou University and ICARDA. (see further article under Partnerships, Networking & Publishing section).

The China-ICARDA partnership – key milestones and achievements 1987 – 2012		
Date	**Agreements**	**Outcome**
1987	Formal agreement signed with Chinese Academy of Agricultural Sciences (CAAS)	First International Conference on Faba Beans
2008	Tripatite Agreement between Chinese Academy for Agricultural Sciences (CAAS), ICARDA, and ICRISAT	Establishment of Joint Center of Excellence for Dryland Agriculture
2009	Tripartite MOU between IWMI, Chinese Academy of Sciences (NIGAE), and ICARDA	Collaboration in land and water management in Jilin Province, China
2010	MOU between Zhejiang Academy of Agricultural Scienses (ZAAS) and ICARDA	Partnership on barley improvement
2012	Tripartite agreement between Lanzhou University, the University of Western Australia, and ICARDA	Establishment of the Center for Dryland Agricultural Ecosystem
Date	**Visits/Meetings**	**Outcome**
1982	ICARDA delegation to study faba bean production at the invitation of CAAS	Faba bean production and research studies in Shanghai, Nanking, Hangzhou, and Beijing
2009	ICARDA hosts delegation from CAAS	The six-person delegation included Mr Luo Bingwen, Vice-President of CAAS
Aug 2009	Visit to China by ICARDA and ICRISAT Directors General	Inauguration of the Joint Center of Excellence for Dryland Agriculture
Aug 2009	ICARDA Director General visits three research centers in China	ICARDA Director General visits three research centers in China
Dec 2009	Coordination meeting at the National Agricultural Science Complex (NASC), Indian Council of Agricultural Research (ICAR), New Delhi, India.	Regional Coordination Meeting of ICARDA, South Asia & China national agricultural research systems, with CAAS as Chinese partner.
Jan 2010	CAAS visit to ICARDA	Formalize plans for collaborative project proposals
Sep 2010	ZAAS visit to ICARDA	Establish cooperation in areas of mutual interest
2011	Invitation from Tibet Agricultural Research Institute extended to Dr. Flavio Capettini, ICARDA Barley Breeder	
Jan 2012	Coordination meeting at the Bangladesh Agricultural Research Institute (BARI)	Regional Coordination Meeting of ICARDA and South Asia and China national agricultural research systems, with CAAS as Chinese partner.
Date	**Academic-related**	**Outcome**
1986-1988	Visiting Professor	Prof. Lang Li-Juan develops high-yielding, disease-resistant faba beans at ICARDA HQ in Aleppo
2009	Ghuangzhou University	ICARDA Researcher, Dr. Michael Baum honored with the title of Guest Professor for three years at Ghuangzhou University
	Other activities	
	Release of Yundamai 2	Broke China's yield record for barley in 2009, generating 10.8 t/ha.

One Thousand Million Hectares

China has the world's largest population. Already over 669 million in 1961, it passed the billion mark in 1981. By 2011 it was 1.3 billion – more than doubling in 35 years.

Although the rate of population increase has slowed in recent years, the country faces the continued challenge of raising the potential of agricultural production to feed its people.

One strategy adopted by China to achieve this has been to expand the area under agriculture. Of 932 million hectares of land area in China, 36.8% was under agriculture in 1961; it reached 53.1% in 1994 and slightly more in 2011, with little scope left for any major future expansion (FAO).

A second strategy is to increase the cropping intensity. In several parts of the country the current intensity of cropping exceeds 300% -- higher than most other locations on the planet. A third food security strategy for China is to increase food productivity per unit of land – an approach that remains the major thrust for the future, as China is faced with a continually growing population and limited areas of cultivable land.

Over the past 35 years, china has been successful in increasing the productivity of many crops, including wheat and barley. Since the early 1980s, China and ICARDA have been research partners in this process, working closely on the improvement of barley, wheat, faba bean, lentil and chickpea. ICARDA has a global mandate for the improvement of barley, faba bean and lentil, and a regional mandate for wheat and chickpea.

Since the 1980s, the heads of ICARDA's barley research program have worked in collaboration with a range of Chinese research partners, to improve productivity and disease resistance of China's barley production. In the early 1980s, Dr. Enrique Rodriguez focused on food and feed quality and lysine; Dr. Hugo Vivar led efforts in Multiple disease resistance and yield (1984-2000). Recent program head, Dr. Flavio Capettini led research in multiple disease resistance, yield and malting, up to early 2013.

Barley: More Productivity from Less Land

Today, some 75% of the barley area in Yunnan is sown to varieties originating from ICARDA material developed by Chinese crop breeders. They include Yundamai No. 2, which yielded 10.8 tons per hectare during the 2010 season – the highest ever recorded in China.

The area planted to barley has dropped significantly in China since 1961, from about 3.5 million hectares to about 1.4 million in 1995. Yet barley output has dropped by only 200,000 tons, from 3.7 million to 3.5 million. This means that improved barley productivity has saved China over two million hectares.

Since 1986, ICARDA has supplied 109 international nurseries of barley to a variety of Chinese institutions, including: the Zheijiang Academy of Agricultural Science, Hangzhou; the Agricultural Science Research Institute for the Coastal Areas, Jiangsu; the Chinese Academy of Agricultural Science (CAAS), Beijing; Shanghai Academy of Agricultural Science; Shanghai Grassland Institute of CAAS, Huhhot; Hubei Academy of Agricultural Science, Wuhan; and the Qinghai Academy of Agricultural Science, Xining

This growth in productivity started before the China-ICARDA partnership. But over the last 10 years, the Center has developed increasing collaboration with China on barley hosted at Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), based in Mexico. ICARDA has the global mandate for Barley improvement. Since the 1980s, the heads of ICARDA's barley research program have worked in collaboration with a range of Chinese research partners, to improve productivity and disease resistance of China's barley production. In the early 1980s, Dr. Enrique Rodriguez focused on food and feed quality and lysine; Dr. Hugo Vivar led efforts in multiple disease resistance and yield (1984-2000). Recent program head, Dr. Flavio Capettini led research in multiple disease resistance, yield and malting, up to early 2013.

ICARDA's Regional Program on South Asia and China
The China- ICARDA partnership is put into action through ICARDA's South Asia and China regional program. The program covers Bangladesh, Bhutan, India and Nepal. It aims to build on strong synergies between ICARDA and the national agricultural research systems of China and India, for the benefit of the region for drylands agriculture in all countries of South Asia.

China and ICARDA

Collaboration between China and ICARDA on barley development yielded results in China as early as 1984, when the Institute of Agricultural Science in Coastal Areas in Jiangsu Province began to introduce barley lines from ICARDA. The Institute selected one of these, CT-16, a high-yielding feed-barley cultivar, from barley-yield trials for cold tolerance conducted in Yancheng District, an autumn-sowing barley area on the Yellow Sea coast.

It showed good adaptability, and out-yielded local varieties and checks by 10%. By 1990 it had been introduced and tested in other parts of China and, in the National Feed Barley Trial in Shanxi Province, *CT-16* gave the largest yield. It outperformed the check by nearly 18%—the check being Xigin-2, the most widely-grown cultivar in the Province. The scientists who reported on the development of *CT-16* were Drs Gong Qisheng, Lin Guoyu, Huang Ruding and Yin Jinlai, all from the Institute of Agricultural Science in Coastal Areas. They identified a number of good qualities in *CT-16* besides yield. These included responsiveness to high-input conditions; lodging resistance; cold resistance; net blotch, powdery mildew and rust resistance; and high tillering. The large number of spikes per unit area, they reported, was the basis for the high yield potential.

Gobernadora barley, released in China as Zhenmai 1.

CT-16, however, had two disadvantages: susceptibility to yellow mosaic virus and to fusarium head blight, or scab. The latter, in particular, is a serious problem in China, but the germplasm supplied to China by ICARDA has helped Chinese scientists find sources of resistance to this and other diseases. One of the most successful outputs of ICARDA-China collaboration occurred with a Mexican cultivar, *Gobernadora*—or, to give it its Chinese name, *Zhenmai 1*.

In 1995, farmers in Shanghai and three nearby provinces planted over 100,000 ha to the new variety and obtained 20–25% higher yields than from traditional varieties, representing millions of dollars of extra income. According to Professor Liu, who has spent many years researching scab-resistant varieties of small-grain cereals, there is another major benefit of *Zhenmai 1*. A large number of livestock can be fed on the extra barley grain, resulting in more meat for the market—and more manure, widely used in China as organic fertilizer.

The Yunnan barley team with ICARDA senior barley breeder, Dr. Flavio Capettini (2012).

Zhenmai 1 is resistant to scab, a major disease in the region, which leads to the production of toxin Deoxinivalenol, DON) in the seed and can affect human and animal health. It has been a serious problem in China's Yangtze Basin but is also common elsewhere in the country, affecting 7 million ha sown with wheat and barley in two-thirds of China's provinces. Between 1985 and 1995, however, Professor Liu Zongzhen, plant pathologist at the Shanghai Academy of Agriculture Sciences, identified a new source of scab resistance in *Zhenmai 1*. Besides scab resistance, it also has high resistance to Barley Yellow Mosaic Virus, another common problem. It is also resistant to lodging.

International collaboration: Oregon State University scientists screened promising barley lines for head scab resistance.

China and the International Barley Research Network

Former leader of the ICARDA Barley Program,the late, Dr Hugo E. Vivar stressed the importance of finding out exactly why the *Gobernadora/ Zhenmai 1* barley variety has scab resistance. While at Oregon State University, he used biotechnology tools to investigate how scab-resistance is inherited. This research used double-haploid plants to analyze crosses between *Zhenmai 1* and a susceptible malting barley parent, to study the inheritance of scab resistance.

In barley improvement, Chinese research centers and scientists have a long history of international collaboration, as partners in a network with ICARDA, United States, and Mexican scientists. This partnership has worked for two decades to identify new sources of resistance to head scab based on field screening in the United States, China, and Mexico. The resistant sources have been further characterized by their toxin (DON) content in more specialized laboratories. DON is known to cause human and animal-health problems. In lower-income areas, poverty could force people to eat toxin-contaminated grain, aggravating the problem caused by a deficient diet. Research aimed at solving the head-scab problem is vital for China and some Andean countries (Ecuador and southern Colombia), where barley is a staple food for poorer sections of society in fusarium-prone areas.

The ICARDA Barley Program for favourable conditions which was operated from CIMMYT headquarters in Mexico has pursued a crossing program to combine different resistant sources of fusarium head scab and improve the level of resistance. Data in Mexican screening trials using two Chinese lines, *Gobernadora/Humai-10* (early) and *Gobernadora/Humai-10* (dwarf) confirmed improvement of *Gobernadora's* original resistance level.

This partnership has resulted in a barley-breeding shuttle program. The network supplies China with genetic material, China improves it, it comes back, is improved further, then returns to China for yet more refining. In this way, China has, through ICARDA, joined a network through which a number of countries can share genetic resources to protect their barley crop.

Further Chinese Successes with Barley in Collaboration with ICARDA

In addition to *Zhenmai 1*, Chinese barley scientists working with the ICARDA Barley Program have achieved other successes. These include: identifying the cultivar *V-24* for its adaptation in barley producing areas – in cooperation with scientists of the Academy of Agricultural Science in the Sichuan Province. *V-24* was bred in India (*Karan 15*), identified as high yielding in Mexico, and distributed in the 8th International Barley Yield Trial (IBYT) in 1985/86. The cultivar *V-24* was planted on 40,000 ha in Sichuan Province, increasing yield by 20 to 25% over local cultivars, as reported by Professor Youchun Zou of the Sichuan Academy.

A cultivar, *Api/CM67//B1*, was released in the Southern Provinces. More recently, barley varieties Chuan-1 and Chuan-2 were released in Sichuan Province in 1996 and 1997, respectively. Bred from the ICARDA-CIMMYT material, these semi-dwarf varieties are resistant to diseases, and yield 8-9 t/ha.

ICARDA also did considerable research on hull-less barley, particularly in collaboration with the Ecuadorean national program, where the commercial cultivars *Shyri* and *Atahualpa* have been found to be resistant to head scab. Today large collection of hull-less barley from the ICARDA-CIMMYT Barley Program is in use in Tibet, where barley is used as a food crop.

Drs Sun Yuanmin and Guo Shaozheng of the Institute of Agricultural Modernization, Jiangsu Academy of Agricultural Sciences, conducted trials of 17 ICARDA barley lines in Nanjing in 1987/88. Nanjing is representative of the central and lower Yangtze valley, where five million ha are planted to winter cereals. In addition to increasing yields, two of the lines proved resistant to Barley Yellow MosaicVirus.

These lines have potential for high-yield production and were recommended for release. Drs Sun Yuanmin and Guo Shaozheng also tested a range of bread and durum wheat lines from ICARDA in the same set of trials.

A further success of China-ICARDA barley research cooperation is the barley variety Yundamai No. 2, developed from ICARDA material, which gave the highest yield ever recorded in China (10.8 t/ha).

Faba Bean: Markets, Systems and Challenges

The faba bean variety Yandou 147, developed by Chinese crop breeders from ICARDA material, covers almost 30% of the faba bean area in Yunnan province – one of the world's largest faba bean production zones.

Faba or broad bean (*Vicia faba L.*) is the fourth most important pulse crop in the world. It is the staple diet of many people in both Egypt and Sudan; and is important all over the Mediterranean world. But the world's largest producer of faba bean is in fact China; despite a reduction in the area in recent years, China still accounts for more than half the world's area for this crop. ICARDA has the global mandate for faba bean improvement.

Faba bean has a long history in China. It was introduced during the West Han Dynasty about 2000 years ago. But in West Asia the faba bean goes back further. It was first mentioned in Sumerian cuneiform tablets dating from about 3500 years ago.

In 1961, China produced 3.4 million tonnes of faba bean from about 3.6 million ha. From 1962, the peak year, production declined, although productivity rose; by 1995, around 2.1 million tons were harvested from 1.7 million ha. But these figures do not explain much. Faba bean in China is relay-cropped with cotton, which is planted before the faba bean is harvested, whereas with cereals the faba bean is planted as an intercrop.

Its center of origin is somewhere in West Asia. As with wheat, lentil and barley, ICARDA's headquarters is right in the middle of the region of crop origin, making it an ideal place for the collection and conservation of genetic material. Faba bean is an ICARDA mandate crop, with a crop improvement program that is now more than three decades old. Through this expertise, ICARDA has been able to make a significant contribution to China's faba-bean improvement research.

Chinese research indicates that faba bean's nitrogen-fixing qualities are of considerable importance for intensive production systems for raising cereal yields. The uses of faba bean are also diverse in China. Rich in protein, it is an important food crop in China, and the seeds are used in a number of traditional local dishes: bean-starch vermicelli or sheet jelly, pastries, and sauce. It is also eaten deep-fried, and the green pods are used as nutritious green vegetables. Export, particularly to Japan, is important.

The fresh stems and leaves are good livestock feed and, even after harvest, the mature stems, leaves and pod shells can still be used as animal feed. Professor Lang Li-juan, Senior Faba Bean Researcher from Zheijiang Academy of Agricultural Sciences (ZAAS), Hangzhou lead China's efforts to expand knowledge and research partnerships for research improving faba bean productivity in the country. She wrote that to improve the production of faba bean in China "…..we must learn techniques from the international research community and develop national research projects to tackle the major constraints." She led the way in Chinese cooperation with ICARDA and is subsequently was head of the China-Australia/ICARDA project on faba bean.

Update 2012-2013 – Faba bean and Chickpea breeding partnerships

Most recent developments in China-ICARDA research collaboration have identified one promising faba bean line and two chickpea lines are being considered for release by Chinese partners.

Between 2010 and 1012, some 76 ICARDA faba bean accessions that are drought tolerant and resistant to Ascochyta Blight, Chocolate Spot, and with low tannin levels were sent to Chinese partners. During a recent visit to China, the joint research team observed that faba bean and chickpea lines selected for early planting and high yield have adapted well to Chinese environments. During the discussions in early 2013, Chinese faba bean researchers requested materials for the coming season and special nurseries which for large seeds and disease resistance. Cold nurseries were requested to test in Qingdao province.

China and ICARDA

ICARDA-China cooperation on faba bean began in the early 1980s, when a faba-bean scientist from Shanghai Academy of Agricultural Sciences, Mr Xin Tao, came to ICARDA for a residential training course in faba bean improvement. In 1982, an ICARDA delegation, on the invitation of the Chinese Academy of Agricultural Sciences, visited China to see faba-bean production and research in Shanghai, Nanking, Hangzhou, and Beijing. In 1987, a formal country agreement was signed between the Chinese Academy of Agricultural Sciences and ICARDA, not just for faba bean, but also for other ICARDA mandate crops. Even before the agreement, Chinese scientists had started visiting ICARDA for joint research and training, and Prof. Lang Li-juan, herself was a visiting scientist at ICARDA between October 1986 and August 1988.

Her objectives at ICARDA were to develop lines with high, stable yield; with resistance to diseases; long pods; and large seeds. (The latter are important, as much of production is for human consumption and China exports a large part of it to Japan and other countries.) Among other things, she was also looking for a determinate growth habit to reduce lodging. Some faba-bean plants can grow to more than two meters in height, but this is not necessarily a good trait. It can cause lodging i.e., the plant bends over. Moreover, from the Chinese point of view, a tall plant interferes with the cotton with which it is relay-cropped or it shades the intercropped cereals.

Faba bean with a determinate growth habit suits this intensive cropping system. Lang Li-juan used ICARDA's new breeding lines to improve Chinese local varieties. In 1988, she selected 617 plants (including 198 of the determinate type) and took them with her when she returned to ZAAS. In the following seven years, large-seeded varieties were developed at ZAAS from this material; the 13 such lines gave an average 100-seed weight of 128.4 g, 12.1% more than the large-seeded local check. In 1994, the faba bean line *H-14* was released as *Li Fang Chan Du* for the Zheijiang Province. The material produced at ICARDA was also used to improve Chinese local varieties and produce 10 lines with independent vascular supply (IVS), identified by Chinese researchers as the answer to severe blossom and pod drop in Chinese faba bean.

These showed a considerable improvement in number of pods and seeds per plant, and potential yield, over the unimproved local check. ZAAS has also been using ICARDA material to incorporate resistance to chocolate-spot disease (*Botrytis fabae*), the most serious biotic constraint to faba-bean production in China. This is difficult, as resistance is polygenic—that is to say, it arises from a number of different genes—and is therefore harder to transfer. However, the resulting resistance is likely to last several seasons, whereas the pathogen may mutate and outmanoeuvr monoenic sources of resistance.

Given the havoc that chocolate spot can wreak on faba bean—it can cause very low yields, or wipe out the crop altogether—the work is well worthwhile. In trials in 1991/92, the lines produced by ZAAS from improving local cultivars with ICARDA material outperformed the local resistant check, increasing seed yield by up to 150%. ZAAS used similar techniques to produce lines for testing that had a determinate growth habit. The ICARDA material helped researchers to achieve yield increases of up to 193% in trials.

Thus, Lang Li-juan's work at ICARDA, and the subsequent developments at ZAAS in collaboration with Ling Xunyi, pathologist, demonstrated the potential of germplasm exchange between China and ICARDA. Germplasm exchange with China continues. Mr Hou Jia-Peng, Head of Food Legume Germplasm Unit of CAAS in Beijing, who was a visiting scientist at ICARDA, has contributed a lot to this collaboration. ICARDA has supplied a number of lines with disease-resistance and large seeds; 160 lines were supplied in 1996, the largest number ever.

Wheat: The Staff of Life

Nothing provides so dramatic an illustration of the power of agricultural development as the increase in wheat production and productivity in China. Between 1961 and 1995, production grew from about 14.3 million tons a year to 102.2 million. Moreover, this increase was achieved with only a slight increase in area harvested, since productivity increased from about 0.56 ton per ha to about 3.54 tons. Despite this enormous achievement, China's growing population means that it must still import wheat. Imports of wheat and flour, totaled some 4.7 million tons in 1961, peaked at 16 million tons in 1991, and dropped to around 3 million tons in 2011.

ICARDA has a regional mandate for the improvement of bread and durum wheat in the West Asia and North Africa (WANA) region, in collaboration with CIMMYT. It is producing wheat for low-input, low-rainfall areas, and is researching diseases, especially yellow rust, which is a serious menace to the country's wheat harvests. ICARDA and China have a long history of exchanging germplasm to develop the broad spectrum of rust-resistant whet that China needs. The ICARDA/CIMMYT breeding program has been sending a pool of about 30 to 40 rust-resistant lines per year to China. Since 1986, ICARDA has supplied 76 international nurseries of bread wheat, and 11 of durum wheat, to China.

Germplasm supplied to China was tested by Drs Sun Yuanmin and Guo Shaozheng in Nanjing at the same time that they tested ICARDA barley lines in 1987/88. There were also 25 bread wheat and 25 durum wheat lines from ICARDA (and a further 10 durum lines from CIMMYT). One bread wheat line is promising for harsher environments, and three of the durum lines give higher-than expected yields, leading the two scientists to realize the potential for durum in the Nanjing area (most wheat in China is bread wheat). A new variety from ICARDA germplasm was recently introduced in China. *Dongfeng 1* was selected from the CIMMYT/ ICARDA Spring Bread Wheat Project by Dr Henry Wang (former breeder at CAAS), during a visit to ICARDA in 1989. It was released for cultivation in the area of Licheng, China, in 1994/95. In 1996/97 the cultivar was grown on 50,000 ha and performed well under supplemental irrigation.

Chickpea and Lentil Improvement

Chickpea and lentil are grown in the North-West Province of Qinghai in China. In 1995, a total of 95,000 ha of lentil and 2,000 ha of chickpea were grown. Dr Gou Gao Qiu, who was a visiting scientist at ICARDA, reported that the cultivation of ICARDAdeveloped kabuli chickpea lines FLIP 81-40C and FLIP 71WC has been increasing, following their release by the Qinghai Academy of Agriculture and Forestry.

Former Head of Food Legume Genetic Resources of CAAS, Mr Hou Jia-Peng (right) examining improved kabuli chickpea material at ICARDA in 1984.

Several new lines of lentil with yield advantages of up to 30% over the local checks have been selected for further testing, as a follow-up to the release in 1989 of lentil line FLIP 87-53L.

Forage Legume Improvement

ICARDA's collaboration with China in grass pea (Lathyrus spp.) dates back to 1989. The emphasis has been on selection of lines with rela-tively low concentration of neurotoxin B-ODAP, which causes paralysis in humans. ICARDA-developed breeding lines of grass pea with low neurotoxin as well as vetch lines have been supplied to the Gansu Grassland Ecological Research Institute and Qinghai Academy of Agriculture and Forestry for use in their breeding program. This collaboration will continue to be strengthened.

Forging new linkages with China in forage legume research. Chinese trainees examine a low-neurotoxin line with an ICARDA researcher at the Center's research station near Aleppo, Syria.

Collection and Conservation of Genetic Resources

Collection and exchange of germplasm has been the backbone of collaboration between China and ICARDA in crop improvement. Several germplasm collection missions have been conducted by ICARDA in China, with colleagues from the Genetic Resources Institute of CAAS and other Chinese national programs, and valuable accessions collected. Germplasm collection and exchange has, however, covered a wide range of crop species (Tables 1 and 2). Dr. Peiguo Guo of Ghuanzhou University was employed at ICARDA from 2004 until Jan 2006 under the BMZ funded project "Exploration of Genetic Resources Collections at ICARDA for Adaptation to Climate Change: Identification and Utilization of Sources of Stress Tolerance". A number of publications resulted from this research collaboration (please see list under publications section).

Table 1. Germplasm provided by ICARDA to China (1984 – 2012)

Crop	No of accessions
Faba bean BPL	223
Aegilops	1133
Barley	602
Bread wheat	328
Primitive wheat	28
Wild Hordeum	140
Wheat hybrids	25
Wild Triticum	481
Forage and range	79
Pisum	31
Trifolium	1
Vicia	95
Faba bean	148
Lentil	70

Table 2. Germplasm of Chinese origin in ICARDA's genebank (1972-2009)

Crop	No of accessions
Aegilops	17
Barley	3054
Bread wheat	262
Durum wheat	60
Primitive wheat	7
Wild Hordeum	45
Wheat hybrids	3
Medicago annual	1
Forage and range	2
Pisum	142
Faba bean	571
Chickpea	33
Lentil	15

Partnerships, Networking and Publishing

China and ICARDA have produced a number of joint outputs, research products and publications as a result of their collaboration. These include:

- The first International Conference on Faba Bean at Hangzhou (1989).
- Co-authoring of two books: Faba Bean Production and Research in China, proceedings of the Conference; and Faba Bean in China: State-of the- Art Review (1993), by Lang Li-juan, Yu Zhao-hai, Zheng Zhao-jie, Xu Ming-shi and Ying Han-qing.

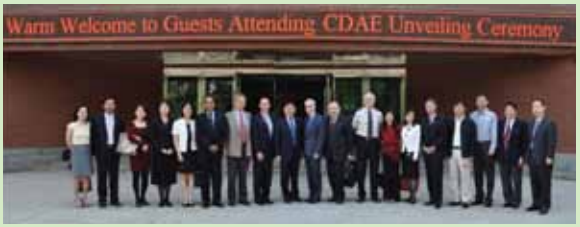
The 3rd Global Forum of Leaders for Agricultural Science and Technology was held in Harbin, China, in 2010. It attracted more than 500 participants from 39 countries, addressing the theme of 'Food security – the role of science and technology and international cooperation'. ICARDA Director General, Dr Mahmoud Solh, representing the Consortium of CGIAR Centers, delivered a keynote speech on the 'CGIAR's Agricultural Science and Development System'.

- As a follow-up of the recommendations of the First International Faba Bean Conference, ICARDA supported the operation of an Autumn-Sown Faba Bean Research Network for China, coordinated by Lang Li-juan. Scientists from five Provinces around Yangtse River, which produce most of autumn-sown faba bean in China, participated in this Network.
- Dr Peiguo Guo of Ghuanzhou University was employed at ICARDA from 2004 until Jan 2006 under the BMZ funded project "Exploration of Genetic Resources Collections at ICARDA for Adaptation to Climate Change: Identification and Utilization of Sources of Stress Tolerance". The following publications originated from that cooperation.

  ► Yanshi Xia, Zhengxiang Ning, Guihua Bai, Ronghua Li, Guijun Yan, Kadambot H.M Siddique, Michael Baum and Peiguo Guo (2013). Single nucleotide polymorphisms in HSP17.8 and their association with agronomic traits in barley. PlosOne, accepted

- ► Yanshi Xia, Zhengxiang Ning, Guihua Bai, Ronghua Li, Guijun Yan, Kadambot H.M Siddique, Michael Baum and Peiguo Guo (2012). Allelic variations within a light harvesting chlorophyll a/b-binding protein gene (Lhcb1) associated with agronomic traits in Barley. PlosOne.
- ► Guo P, M. Baum, S. Grando, S. Ceccarelli, G. Bai, R. Li, M. von Korff, R.K. Varshney, A. Graner, J. Valkoun (2009). Differentially expressed genes between drought-tolerant and drought-sensitive barley genotypes in response to drought stress during the reproductive stage. J. of Exp. Botany, 1-14. doi:10.1093/jxb/erp194. Guo P, M. Baum, R.K. Varshney, A. Graner, S. Grando, S. Ceccarelli (2008) . QTLs for chlorophyll and chlorophyll fluorescence parameters in barley under post-flowering drought. Euphytica 163:203–214.
- ► Guo P, BF Carver; R Li, AA Bernardo, M Baum, G Bai (2007) Transcriptional Analysis between Two Wheat Near-Isogenic Lines Contrasting in Aluminum (Al) Tolerance under Al Stress. MGG, 277:1-12.
- ► Li R, Guo P, Baum M, Grando S and Ceccarelli S (2006) Evaluation of chlorophyll content and fluorescence parameters as indicators of drought tolerance in barley. Agricultural Science in China 5:751-757
- ► Guo P, G.-H. Bai, R.-H. Li, G. Shaner, M. Baum (2006) Resistance gene analogs associated with Fusarium head blight resistance in wheat. Euphytica (2006) 151:251–261

- A special workshop, jointly organized by ICARDA and Tottori University, Japan, brought together scientists from China, Egypt, Japan, Tunisia and several international organizations (ICARDA, FAO, ICBA), and representatives of donor agencies. The meeting shared results from past Tottori-ICARDA research projects, and use these to plan future research on dryland agriculture. Presentations covered a range of areas, including biotechnology, environmental stresses (drought, heat, cold and salinity), and land and water management.



Opening of the Centre for Dryland Agricultural Ecosystems
The Centre for Dryland Agricultural Ecosystems at Lanzhou University, Lanzhou, Gansu province was inaugurated in May 2013. Present at the inauguration - representing the partner organizations - were Lanzhou university President Prof. Zhou Xuhong, Prof. Paul Johnson Vice-Chancellor and president of the University of Western Australia and Dr. Majd Jamal, Assistant Director General for Host Country Relations at ICARDA. The opening was attended by Professor Feng-Min Li coordinator of the Institute of Arid AgroEcology, staff from Lanzhou University, University of Western Australia, and representatives from the Provence of Gansu.

Capacity Development

Since its collaboration started with China, ICARDA has offered training opportunities to young Chinese researchers. In addition, five Chinese researchers have so far worked at ICARDA as Visiting Scientists.

TRAINING PARTICIPANTS FROM CHINA PARTICIPATING IN ICARDA TRAINING COURSES 1981-2012						
Year	Long-term course	Short-term courses	Individual Non-degree	Visiting Regional Scientist	Visiting Regional Scientist	Total
1981	1	-	-	-	-	1
1984	-	-	3	-	-	3
1985	2	-	-	-	-	2
1986	3	-	-	-	-	3
1987	3	-	-	-	-	3
1988	3	3	-	-	2	8
1989	3	-	-	-	1	4
1990	2	2	-	-	2	6
1991	-	-	1	1	-	2
1992	2	2	1	-	-	5
1993	1	-	-	-	-	1
1997	-	3	-	-	-	3
2001	-	1	-	-	-	1
2008	-	3	-	-	-	3
TOTAL	20	14	05	01	05	45

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