China and ICARDA

Ties that Bind

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About ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of the 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to strengthening agricultural research in developing countries.

In the context of the challenges posed by the physical, social and economic environments of the dry areas, ICARDA's mission is to improve the welfare of people in the dry areas of the developing world by increasing the production and nutritional quality of food, while preserving and enhancing the resource base. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland and small-ruminant production; and the West Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices.

Much of ICARDA's research is carried out on a 948-hectare farm at its headquarters at Tel Hadya, about 35 km southwest of Aleppo. ICARDA also manages other sites in Syria and Lebanon, where it tests material under a variety of agroecological conditions. However, the full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa and elsewhere in the world.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.

A Thousand Million Hectares

CHINA has the world's largest population. Already over 669 million in 1961, it passed the billion mark in 1981. Today, it is about 1.2 billion; in other words it has doubled in 35 years. Although the rate of increase has slowed as China implements new strategies for population control, it continues to face the challenge of raising agricultural production in order to feed its people.

One of the approaches adopted by China to achieve increased agricultural production has been to expand the area under agriculture. Of 932 million ha of land area in China, only 36.8% was under agriculture in 1961; it reached 53.1% in 1994, with little scope left for any major future expansion. Increased cropping intensity has been another strategy adopted by China for increasing production; in several parts of China the current intensity of cropping exceeds 300%, much higher than almost anywhere else in the world. The third approach has been to increase productivity itself, and this will continue to remain the major thrust for the future.

China has had considerable success over the last 35 years 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, especially with regard to the improvement of barley, wheat, faba bean, lentil and chickpea. The Center has a world mandate for the improvement of barley, faba bean and lentil, and a regional mandate for wheat and chickpea.

Barley: More Yield from Less Land

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 tonnes, from 3.7 million to 3.5 million. This means that improved barley productivity has saved China over 2 million ha.

This growth in productivity started before ICARDA was even founded. But over the last 10 years, the Center has developed increasing collaboration with China on barley, working from its headquarters at Aleppo in Syria and through its joint program with Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), based in Mexico. 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; Shangha Grassland Institute of CAAS, Huhhot; Hubei Academy of Agricultural Science, Wuhan; and the Qinghai Academy of Agricultural Science, Xining.

Gobernadora *barley, released in China as* Zhenmai 1.

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 outyielded 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.

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.

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 on Barley Pays Off

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

One of ICARDA's senior barley breeders, Dr Hugo E. Vivar, based at CIMMYT, from where ICARDA's Latin America Program is conducted, stresses the importance of finding out exactly why *Gobernadora/Zhenmai 1* has this trait. He is now working with Oregon State University, USA, using new biotechnology tools to find out how scab-resistance is inherited. Thus, double-haploid plants are being used to analyze crosses between *Zhenmai 1* and a susceptible malting barley parent, to study the inheritance of scab resistance. When scientists establish the resistance or susceptibility of the double-haploid plants, ICARDA's collaborators at Oregon will conduct molecular-marker analyses to identify the genes that control scab resistance.

These international collaborations are making China a partner in a network for barley improvement which involves ICARDA, United States, and Mexican scientists. Part of the objective of the network is to identify new sources of resistance to head scab based on field screening in the United States, China, and Mexico. The resistant sources are further characterized by their toxin (DON) content in more specialized laboratories.

As mentioned earlier, 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.

Meanwhile, the ICARDA/CIMMYT Barley Program is undertaking a crossing program to combine different resistant sources of fusarium head scab and improve the level of resistance. Two years' data in Mexican screening trials using two Chinese lines, *Gobernadora/Humai-10* (early) and *Gobernadora/Humai-10* (dwarf), seem to confirm improvement of *Gobernadora's* original resistance level. So a sort of barley-breeding shuttle has developed; the network supplies China with genetic material, China improves it, it comes back, is improved further, and then goes back to China for yet more work! 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.

Other Chinese Successes with Barley

Besides *Zhenmai 1*, there have been other concrete achievements by Chinese barley scientists working with the ICARDA/CIMMYT Barley Program. These include:

Through cooperation with scientists of the Academy of Agricultural Science in the Sichuan Province, the cultivar *V-24* was identified for its adaptation in barley-producing areas. *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 has carried out a considerable amount of 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. Now, a large collection of hull-less barley from the ICARDA/CIMMYT Barley Program has been introduced 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 5 million ha are planted to winter cereals. Two of the lines, besides equaling the check in yield, proved resistant to Barley Yellow Mosaic Virus. 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.

Faba Bean: Markets, Systems and Challenges

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 indeed 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.

Faba bean has a long history in China, having been introduced during the West Han Dynasty, about 2000 years ago. But in ICARDA's home region, it goes back further, and is first mentioned in Sumerian cuneiform tablets dating from about 3500 years ago. Its exact center of origin has never been identified for certain, but it was somewhere in West Asia. This means that, 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. This has

Mr Hou Jia Peng (left) of the Germplasm Institute, Chinese Academy of Agricultural Sciences, and Ms Lang Li-juan (center) of the Zheijiang Academy of Agricultural Sciences, with an ICARDA researcher, select improved faba bean lines at ICARDA's main research station at Tel Hadya, near Aleppo, Syria.

helped ICARDA to make a worthwhile contribution to Chinese faba-bean improvement research.

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 tonnes were harvested from 1.7 million ha. However, these figures do not in themselves explain much, for 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. Chinese research indicates that faba bean's nitrogen-fixing qualities are of considerable importance for intensive production systems for raising cereal yields.

Faba bean intercropped with wheat, and relay-cropped with cotton in Zheijiang Province, China.

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.

"In order 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," wrote Professor Lang Li-juan, Senior Faba Bean Researcher from Zheijiang

Faba bean harvested for green seeds and pods in Hangzhou, China.

Academy of Agricultural Sciences (ZAAS), Hangzhou. She has herself led the way in Chinese cooperation with ICARDA and is now heading the China/Australia/ICARDA project on faba bean (see below).

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

An agreement of cooperation between China and ICARDA was signed in 1987. Left: Dr Mohamed A. Nour, Director General of ICARDA; right, Dr Liu Zhicheng, Vice-President, Chinese Academy of Agricultural Sciences.

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.

In 1994, faba bean line **H-14** ***was released as*** **Li Fang Chan Du** ***for the Zheijiang Province in China.***

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 outmanouver monogenic 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 tonnes 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 tonne per ha to about 3.54 tonnes. Despite this enormous achievement, China's growing population means that it must still import wheat. Imports of wheat and flour, about 4.7 million tonnes in 1961, grew to nearly 16 million tonnes in 1989. By 1994, these had dropped back to about half of that, but it is clear that the need to produce more persists.

Yang Chongli (left), an ex-ICARDA trainee, with his senior colleague, examines promising wheat lines at the ZAAS farm, Hangzhou, China.

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 like yellow rust, which is a serious menace in China. ICARDA and China have therefore been exchanging germplasm; China needs a broad spectrum of yellow-rust resistance sources. 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 looked promising for harsher environments, and three of the durum lines gave 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.

Collaboration in 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,

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

who was a visiting scientist at ICARDA, reported that the cultivation of ICARDA-developed kabuli chickpea lines FLIP 81-40C and FLIP 71WC has been increasing, following their release by the Qinghai Academy of Agriculture and Forestry. 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.

Collaboration in 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-

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

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.

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

Faba bean germplasm collection in China.

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).

Table 1. Germplasm provided by ICARDA to China 1990– 1996.

Crop/species	No. of samples
Aegilops	183
Barley	56
Bread wheat	16
Faba bean	372
Pea	21
Vicia sativa	43

Table 2. Germplasm of Chinese origin in ICARDA gene bank.

Crop/species	No. of accessions
Cereals	
Aegilops	20
Barley	3041
Wild *Hordeum*	47
Bread wheat	6
Durum wheat	33
Wild *Triticum*	2
Forage legumes	
Medicago	2
Onobrychis	1
Food legumes	
Faba bean	306
Faba bean pure lines (BPL)	342
Chickpea	21
Lentil	3
Pea	28

Networking and Publishing

Meanwhile, other forms of cooperation continue to be strengthened. In May 1989, ICARDA, in collaboration with CAAS, held the first *International Conference on Faba Bean* at Hangzhou. This took place at ZAAS, but representatives also attended from CAAS, the Zheijiang Provincial Science and Technology Commission (ZPSTC), and from institutes and universities in Nanjing, Qidong, Sichuan, Qinghai, Lingxia, Hubei, Shanghai, and Yunnan. Japan is an important market for Chinese faba bean, and Professor Kiyoshi Kogure attended from Kagawa University. Together, the participants exchanged experiences and set an agenda for future collaborative research.

Participants of the* First International Conference on Faba Bean, *jointly organized by ICARDA and the Chinese Academy of Agricultural Sciences and Zheijiang Academy of Agricultural Sciences at Hangzhou.

ICARDA also supported the production 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,

Participants of the Autumn-sown Faba Bean Research Network visit a field in Hangzhou, China.

Zheng Zhao-jie, Xu Ming-shi and Ying Han-qing. 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.

The Conference proceedings attracted the attention of Dr Harry Marcellos of the New South Wales Agricultural Research Center in Australia. With the help of ICARDA and the Australian Centre for International Agricultural Research (ACIAR), he drew up a proposal for supporting the Autumn-Sown Faba Bean Network further. The project started in 1995, with funding from ACIAR amounting to AUS$ 207,000 (about US$ 160,000) for a three-year period.

The project includes research on germplasm resources, and collection missions by a number of Chinese institutions in Yunnan, Gansu, and southern China. Improved germplasm from ICARDA is supplied to China and vice-versa as a part of the project. Germplasm will arrive every August and will be sown in Zheijiang. Subject to proving disease-free, selected lines will be multiplied at ZAAS and supplied for use in partner breeding programs. Germplasm will also be supplied to ICARDA from China according to need. For the new germplasm resources obtained, there will be evaluation of all phenological descriptors.

The project also includes breeding, leading to the development and distribution of superior new varieties. The partner provinces determine the breeding goal according to their individual circumstances and cropping systems (for example, Yunnan is breeding for cold tolerance). But typical goals include early maturity, large-seededness, protein content, and resistance to chocolate spot and ascochyta blight as well as improved yield. Other problems of biotic and abiotic stress and agronomic practices are also being addressed. It is hoped that benefits of this research will also flow to Australia.

In the meantime, ICARDA and the Centre for Legumes in Mediterranean Agriculture (CLIMA), and the New South Wales Department of Agriculture, Australia mounted a collection mission for faba-bean germplasm in the provinces of Yunnan and Sichuan in 1996. The mission was a cooperative venture with the Yunnan, Zheijiang and Sichuan Academies of Agricultural Sciences and the Chinese Academy of Agricultural Sciences. The mission resulted in 67 accessions of faba-bean landraces from remote areas of the two provinces.

As a further contribution to wheat genetic resources and breeding, the book *Biodiversity and Wheat Improvement*, published jointly by ICARDA and John Wiley, was translated into Chinese and published at the end of 1996 by CAAS in Beijing with ICARDA's support for the translation. According to Prof. Dong Yushen, the principal translator, the book has been of great value to all Chinese wheat scientists.

Human Resource Development

Since its collaboration started with China, ICARDA has been offering training opportunities to young Chinese researchers in several areas of vital importance. To date, the Center has trained over 41 Chinese researchers from various

Human resource development: Over 41 Chinese researchers have received training at ICARDA headquarters, Aleppo, Syria, during 1981-1997.

Table 3. Chinese scientists trained at/through ICARDA (1981–1997).

Organization/Institute	No. of participants
Chinese Academy of Agricultural Sciences	20
Hubei Academy of Agricultural Sciences	3
Jiangsu Academy of Agricultural Sciences	2
Qinghai Academy of Agricultural and Forestry Sciences	1
Shanghai Academy of Agricultural Sciences	1
Shandong Academy of Agricultural Sciences	1
Sichuan Academy of Agricultural Sciences	1
Yunnan Academy of Agricultural Sciences	1
Zheijiang Academy of Agricultural Sciences	6
Institute of Agricultural Sciences, Yancheng, Jiangsu	1
Lanzhou Institute of Animal Sciences	3
North Western Agricultural University, Yangling	1
Total	41

institutes (Table 3). In addition, five Chinese researchers have so far worked at ICARDA as Visiting Scientists. The appointment of a Chinese soil scientist, Dr Heping Zhang, as a scientific staff of ICARDA in September 1996 will help further strengthen cooperation.

The Future

Collaboration between ICARDA and China began in a small way in the early 1980s; it has mainly encompassed crop improvement research and training. This will continue to be strengthened, particularly through the exchange of germplasm and visits, and through joint collection missions. However, there are areas of great potential that have not been fully pursued; for example, in natural-resources conservation especially the control of desertification and management of water resources for improved efficiency at the farm level.

Recent studies indicate that desertification in China is moving at an alarming rate. For example, it is estimated that, in north China, 94.5 per cent of desertification is being caused by humans and 5.5 per cent by natural causes. ICARDA would like to share its experience and accumulated knowledge with China in the control of desertification.

The Center has developed and tested a multidisciplinary methodology for solving problems of dry-area crop and livestock production systems. The systems approach takes into account many interdependencies among biophysical, socioeconomic and policy dimensions. From the user perspective, ICARDA has developed and applied practical methods of incorporating the indigenous knowledge and perspective of farmers and pastoralists into technology development and transfer, thereby increasing the efficiency and effectiveness of agricultural research for the dry areas. Modern tools of remote-sensing and geographical information system are being used in developing research strategies for protecting natural resources and enhance their sustainable use. ICARDA, thus, has expertise in research approaches that span both high potential production environments and the more extensive marginal crop and rangeland areas that are under greater threat from degradation and non-sustainable exploitation. The Center looks forward to forging new linkages with China in these vital areas of research for sustainable agriculture.

ICARDA is eager to continue to work with China. Those thousand million hectares under agriculture are finite; the demands made upon them are not. But the Chinese are keenly aware of this, and have made enormous strides in the last 30 years. Together we can help harness science in the fight against hunger.