

# Japan's

## Investment in CIMMYT: Results in 2000

The Government of Japan and CIMMYT recognize the urgency of devising better strategies for food, income, and environmental security in the developing world. Japan supports four CIMMYT research projects directed at reversing environmental problems, hunger, and poverty. The projects cover a wide range of activities, from breeding at the molecular level to disease surveillance across the developing world. They include research on genetic resources, on improved seed, and on environmentally sound farming practices. The latest results from each project are summarized here. We are pleased to report that these four projects are yielding positive impacts, and we are grateful for the financial support that has made them possible.



Official Development  
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# CIMMYT®

International Maize and Wheat Improvement Center



# CIMMYT Global Project 1

## Conservation and Management of Genetic Resources

**Contact: Dr. Suketoshi Taba, Principal  
Scientist, Maize Program.**

This project conserves valuable genetic resources and helps researchers use them to benefit farmers. Genetic resources are natural resources that provide "insurance" against many threats to farmers' crops, thereby contributing to food security and helping to alleviate hunger and poverty.

**Genetic Resource Conservation** The CIMMYT maize germplasm bank was the first facility ever to systematically collect and preserve the seed of tropical maize varieties. It is the world's largest collection of tropical maize landraces. The bank conserves nearly 20,000 samples of maize landraces, improved varieties, near relatives of maize, and special genetic stocks. This seed represents 70% of the maize collections in germplasm banks throughout the Americas and twice as many as there were at CIMMYT in 1990. Researchers continually obtain and grow

seed, store it properly under CIMMYT's computerized inventory system, and perform other key curatorial duties. More than 1,300 new collections entered the CIMMYT maize germplasm bank in 2000.

**Saving Landraces.** Through the Latin American Maize Evaluation Project (LAMP), phase II, CIMMYT researchers evaluated maize landrace collections from national germplasm banks and backed them up at CIMMYT and NSSL. To complete collections of native races still sown in Latin America and to promote their conservation on-farm, they worked with Mexican researchers, farmers in Oaxaca and Chihuahua in Mexico, and CIMMYT social scientists to evaluate native varieties and improve them for traits that farmers value. In addition to the immediate benefits for farmers, this work improved our understanding of farmers' needs and how to foster on-farm conservation at other locations.

**Access to Seed and Diversity.** In 2000 we shipped more than 1,700 seed samples to researchers worldwide. To help researchers access useful diversity in our

seed stores, we continued to form subsets of major CIMMYT maize collections. Each subset contains only one-fifth of the seed samples in the major collection but, through agronomic evaluation and sophisticated statistical analyses, embodies nearly all the original genetic variation. Information on these subsets is available through the CIMMYT germplasm database and, in the case of the subset of Latin American collections evaluated under LAMP phase I, on a CD distributed worldwide.

**Pre-breeding: Insuring Diversity in Tomorrow's Varieties.** Subsets of Caribbean, Brazilian, Tuxpeño (an important landrace), and highland maize enrich CIMMYT breeding stocks. Seed from subsets is crossed with elite CIMMYT inbred lines that are known to produce good hybrids. Information from this research is used to form special collections that are improved according to ecological adaptation, grain color, and maturity, among other traits. These collections or "gene pools" are very useful for CIMMYT breeders and partners throughout the world.

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\* Most CIMMYT seed collections are back-ups of samples held in other banks in Latin America, as recommended in the Global Plan of Action of the Convention on Biological Diversity. Back-up collections of many CIMMYT bank accessions are also held for safety in long-term storage at the National Seed Storage Laboratory (NSSL) of the United States Department of Agriculture.



# CIMMYT Global Project 6

## Increasing Wheat Productivity and Sustainability in Stressed Environments: Biotic Stress

**Contact: Dr. Ravi P. Singh, Principal Scientist,  
Wheat Program.**

This project gives farmers another kind of "insurance" against hunger and poverty: wheat seed that naturally resists diseases ("biotic stresses"). Disease epidemics are especially devastating to small-scale farmers and poor consumers. For example, rust diseases destroy approximately 20 million tons of wheat annually (slightly more than Australia's total wheat production).

**Worldwide Disease Monitoring.** Wheat disease epidemics that start in one area could be very serious for the rest of the world. CIMMYT monitors important and emerging wheat diseases worldwide (something that no national organization

can do alone) to help give early warning of epidemics. As part of this work:

- A nursery for monitoring rust pathogens was grown at key locations in six regions (the Indian Subcontinent, China, Eastern and Southern Africa, West Asia/North Africa, Central Asia, and South America).
- A new race of the stem rust pathogen carrying virulence for resistance genes *Sr31* and *Sr38* was detected in Uganda. Timely detection allowed countries throughout the world to be alerted early.
- Spot blotch is a major problem in the eastern plains of India, but its importance is on the rise in the northwest, a very important wheat growing area. In Nepal, spot blotch and tan spot were found in 81% and 29%, respectively, of samples collected in 23 districts.

### **Synthetic Wheats to Fight Disease.**

Synthetic wheats are bred at CIMMYT through a special process that incorporates valuable genetic traits—including disease resistance—from wild species related to wheat. Synthetics can be crossed with “normal” wheat to transfer those valuable traits. Wheats developed by CIMMYT show genetic resistance to six or seven diseases at the same time, plus tolerance to such problems as waterlogging and drought. In 2000, more than 16 synthetics generated at CIMMYT showed *Fusarium* head scab resistance. The best ones have excellent levels of all four types of resistance. New wheats

developed from synthetics had high levels of resistance to diseases caused by *Septoria* species. Crosses of bread wheat and synthetics were evaluated at Poza Rica, Mexico, where *Helminthosporium* disease is very strong, and lines with good agronomic features and resistance were identified. About 55 new synthetics were identified with immunity to Karnal bunt, and 11 resistant wheats were developed from them. Another set of synthetic-derived wheats showed good resistance to crown rot and common root rot in greenhouse tests.

### **Four Types of *Fusarium* Resistance in One Wheat.**

Improved bread wheats with all four types of resistance to head scab were identified, giving breeders an unusual and very powerful means of fighting this disease, which affects wheat, barley, and maize worldwide. Global estimates of disease loss are unavailable, but head scab has caused several billion dollars in losses in the US in the last five years, and epidemics in China can result in losses of up to 2.5 million tons of grain. Fungicides provide inadequate protection against the disease and are not environmentally sustainable. The new resistance is derived from Chinese and South American sources.

**Disease Mapping.** This activity is linked to research undertaken in the “Biotechnology and Genetic Engineering” project, described on the next page.

# CIMMYT Frontier Project 3



## Biotechnology and Genetic Engineering to Improve Maize and Wheat for Developing Countries

**Contact: Dr. David Hoisington, Director, Applied  
Biotechnology Center.**

Japan's contributions to this project focus mainly on enhanced disease resistance, which benefits farmers in the ways described previously. One additional and potentially very important contribution, however, has been in drought resistance—an issue of life and death importance for subsistence farmers in many marginal agricultural regions.

**Disease Resistance.** JIRCAS geneticist Dr. Kazuhiro Suenaga, an adjunct scientist at CIMMYT since 1998, mapped genes from a Japanese wheat that provide resistance to *Fusarium* head scab. Mapping these genes is an important step toward creating varieties with greater resistance

to this devastating disease. Dr. Suenaga identified three quantitative trait loci (QTLs) which together account for roughly 30–40% of the scab resistance. By targeting specific gaps in his map construction, he hopes to account for 60–70%. Similar wheat/*Fusarium* mapping is being done for a Chinese variety (by a JIRCAS colleague in Japan) and a Brazilian variety (by CIMMYT). By comparing maps from these varieties, researchers can determine whether resistance comes from the same or different genes. This knowledge is valuable: if the sources are the same, there may be little to gain, in terms of scab resistance, from crossing these varieties. If the sources are different, the genes could be combined to create resistance that lasts for a long time and works in many environments.

Dr. Suenaga's work produced additional findings that proved extremely helpful to CIMMYT research on wheat rusts. The linked *Lr34* and *Yr18* genes confer durable resistance to rust and have been useful to CIMMYT breeders for decades.

Unfortunately, when breeding for this gene, scientists could not use cutting-edge technologies because they lacked a good molecular marker for *Lr34*. In 2000, while working on scab, Dr. Suenaga discovered just such a marker for leaf and yellow rust resistance. Additional screening confirmed the marker's efficacy, representing a

modest but important advance in using molecular genetics to develop disease resistant wheat.

**Drought Resistance.** A high-level workshop, sponsored by the Rockefeller Foundation and held at CIMMYT-Mexico, brought researchers from around the world and across grain commodities together to investigate how biotechnology could promote the development of drought resistant cereals. Last October, JIRCAS, through its geneticist Kazuko Yamaguchi-Shinozaki, took this effort from the discussion level to the applied level by supplying CIMMYT with the DREB gene, which has been shown to increase tolerance to drought, salt loading, and freezing in *Arabidopsis* and some other plants.

CIMMYT scientists successfully inserted the gene into wheat, and first-generation plants will be grown out by May 2001. The next generation of these plants will be tested in a growth chamber for tolerance to drought and cold temperatures. JIRCAS will soon send a similar DREB gene from rice, which scientists believe may provide even higher levels of tolerance. While it is not clear whether transferring the DREB gene to wheat actually confers drought tolerance and cold hardiness, should it prove successful, the impact will be significant for farmers.



# CIMMYT Regional Project 3

## Sustainable Wheat Production Systems in the Indo-Gangetic Plains and China

**Contact: Dr. Peter R. Hobbs, Principal Scientist,  
Natural Resources Group.**

This project develops and disseminates more efficient, productive, and sustainable technologies for wheat farming. This project has a strong emphasis on practices to sustain natural resources. It features close collaboration with the Rice-Wheat Consortium (RWC) for the Indo-Gangetic Plains, a CGIAR eco-regional initiative for which CIMMYT is the convening center.

**Sowing the Seeds of Productivity.** In parts of South Asia, farmers grow wheat varieties dating back to the 1960s; in other areas, large zones are covered with a single variety. These practices make the crop vulnerable to pests and diseases. Replacing older varieties with newer, better yielding, stress tolerant varieties and diversifying varietal coverage are basic objectives of CIMMYT's regional trials. In 2000, Asian research partners planted 15 sets of the 4<sup>th</sup> Eastern Gangetic Plains

Screening Nursery and 12 of the 2<sup>nd</sup> Eastern Gangetic Plains Yield Trial. More than 600 promising wheats were selected from these nurseries, and seed was distributed to breeding programs. Nepal's Wheat Research Program was particularly active, making 150 new crosses among Nepalese and CIMMYT wheats and preparing F<sub>5</sub> progeny with outstanding traits (e.g., disease resistance, heat tolerance, and bold, white grain) for inclusion in regional nurseries. Finally, varietal diversification received a strong push through nurseries distributed from CIMMYT headquarters in Mexico.

In another effort to fight wheat diseases, CIMMYT staff have developed and distributed a *Helminthosporium* resistance nursery for South Asia and organized and monitored a regional survey to assess the virulence of rust pathogens.

To encourage rapid adoption of new varieties, farmers (men and women) worked with researchers in India, Nepal, and Pakistan to select promising varieties and obtain seed of the ones they liked. One line, selected at Varanasi, India, performed particularly well under reduced tillage, a resource-conserving practice promoted in the region (see below). Finally, regional scientists, extension workers, and other partners received training in farmer participatory approaches to speed adoption and improve the relevance of research.

**Plowing Less, Profiting More, Preserving Resources.** South Asia's rice-wheat rotation provides food and livelihoods for hundreds of millions, many of whom are among the poorest of the poor. Yet yields in this cropping system appear to be

leveling off, and irrigation water is being depleted at alarming rates. The RWC (of which CIMMYT is a member) is successfully promoting reduced tillage practices that save 75% or more fuel, result in higher yields, require half the herbicide and at least 10% less water, and greatly increase fertilizer-use efficiency

National research organizations report that farmers used the new methods on 8,000 hectares in India and 5,000 hectares in Pakistan in 2000, and adoption is expanding rapidly. In addition to increasing food security and incomes, widespread use of reduced tillage will curtail greenhouse gas emissions and provide habitats for beneficial insects. Finally, raised bed planting systems that improve the efficiency of resource use—especially water—were successfully introduced to farmers in Pakistan, India, and China.

**Focus on China.** China is the world's foremost wheat producer and consumer, with nearly 30 million hectares harvested, providing food for 700 million inhabitants. Population growth and reductions in arable land make increased productivity the main objective for wheat research in China. CIMMYT has contributed in many ways, especially through wheat breeding. In 2000, five wheat nurseries containing elite experimental varieties were distributed to more than 60 of the country's institutes. Chinese agencies released several new varieties descended from CIMMYT wheats, including Ningmai 10 (SHA 7/PRL's'//VEE6), Attila, and AGA/4#Horks. Ten advanced lines showed outstanding performance in various provinces.

Grain quality has become a crucial factor for wheat in China. CIMMYT provides technical support to Chinese researchers through training and by testing wheat samples, among other activities. In 2000, five good quality wheat varieties (Zhongyou 9507, Jinan 17, Longmai 26, Ningchun 4, and Liaocchun 10) descended from CIMMYT wheats were sown on some 1.5 million hectares.

CIMMYT has also promoted production practices to conserve resources as well as improve yields. One such practice, planting on raised soil beds, showed great advantages for both wheat and maize in wheat-maize rotations.

**CIMMYT® ([www.cimmyt.org](http://www.cimmyt.org)) is an internationally funded, non-profit scientific research and training organization. Headquartered in Mexico, the Center works with agricultural research institutions worldwide to improve the productivity, profitability, and sustainability of maize and wheat systems for poor farmers in developing countries. It is one of 16 food and environmental organization known at the Future Harvest Centers ([www.futureharvest.org](http://www.futureharvest.org)). The centers, located around the world, conduct research in partnership with farmers, scientists, and policymakers to help alleviate poverty and increase food security while protecting natural resources. They are principally funded through the nearly 60 countries, private foundations, and regional and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR) ([www.cgiar.org](http://www.cgiar.org)). Financial support for CIMMYT's research agenda also comes from many other sources, including foundations, development banks, and public and private agencies.**

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# CIMMYT worldwide

## Our Mission

CIMMYT is an international, non-profit, agricultural research and training center dedicated to helping the poor in low-income countries. We help alleviate poverty by increasing the profitability, productivity, and sustainability of maize and wheat farming systems.

## Focus

Work concentrates on maize and wheat, two crops vitally important to food security. These crops provide about one-fourth of the total food calories consumed in low-income countries, are critical staples for poor people, and are an important source of income for poor farmers.

## Partners

Our researchers work with colleagues in national agricultural research programs, universities, and other centers of excellence around the world; in the donor community; and in extension and non-governmental organizations.

## Activities

- Development and worldwide distribution of higher yielding maize and wheat with built-in genetic resistance to important diseases, insects, and other yield-reducing stresses.
- Conservation and distribution of maize and wheat genetic resources.
- Strategic research on natural resource management in maize and wheat-based cropping systems.
- Development of new knowledge about maize and wheat.
- Development of more effective research methods.
- Training of many kinds.
- Consulting on technical issues.

