Innovation for Development

CIMMYT

Annual Report 2002-2003

A Message from the Director General

Last year my message described how diversity was essential to CIMMYT's research and integral to its character as an organization. I concluded by discussing our plans to develop a mission and strategy that would build on that diversity and strengthen CIMMYT's contribution to sustainable development.

A new mission for renewed impact

In the intervening year, CIMMYT has consulted extensively with a broad base of stakeholders to determine how CIMMYT, with the mandate to work with two of the world's most important crops, can best contribute to sustainable development. The consensus was that CIMMYT should build on its networks and knowledge to serve the poor as stated in its proposed new mission:

CIMMYT acts as a catalyst and leader in a global maize and wheat innovation network that serves the poor in developing countries. Drawing on strong science and effective partnerships, we create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources.

This report, "Innovation for Development," gives an idea of what a "global maize and wheat innovation network" can mean in practice and in people's lives. It describes the ways that partners create and share knowledge and science-based solutions that people can use to move out of poverty and towards environmental sustainability.

The first section, "Innovation for local food security," describes strategies that enable poor communities in Africa, Asia, and Latin America to achieve food security. Some strategies start with soil nutrient management, others begin with plant breeding, and still others rely on selecting and delivering improved seed—but all take advantage of the unique contributions of many partners. Usually they build on years of prior research and much local knowledge. These stories show that a "one-size-fits-all" approach cannot promote development. There is no substitute for careful attention to local needs, and there is no impact without successful communication.

The second section of this report, "Innovation for human and environmental health," looks at the integral role of food systems in delivering health and nutrition and conserving natural resources. It describes how CIMMYT links partners working on different aspects of two major health problems (arsenic poisoning and rickets). Through a broad research consortium in Asia, CIMMYT is also increasing the potential for vital food systems to be resource-conserving systems. With our partners, we have developed resource-conserving technologies that are flexible and profitable enough for some of the world's poorest sharecroppers, who have little incentive to improve the land under their care, to conserve the agricultural resource base.

The final section of this report, "Innovation to adapt to change," shows how we work with poor people to seize new opportunities and resolve problems that arrive with change. For example, we train farmers in Bangladesh to grow maize—a "new" crop that is rapidly growing in demand throughout Asia. We study traditional seed sharing networks in Mexico to determine how rural emigration and the potential loss of incentives for traditional maize production will affect seed sharing and genetic diversity. By partnering with advanced research

institutes and the private sector, we are learning how to help plants—and by extension, producers—cope with future droughts or climate change.

New ways of working

We do not merely recommend that others adapt to change: CIMMYT is doing the same. Although the range of CIMMYT's products and services will not change dramatically over the coming years—we will still develop improved maize and wheat seed and production practices, for example—we will make major changes in how we orient our research, how we work with others, and how we structure our research program. The details are available in our forthcoming strategic plan (*Seeds of Innovation*, CIMMYT, 2003), but we can summarize some essential points here.

As indicated in our new mission, poor people and their livelihood strategies are at the heart of our research program. Through a broad and growing set of partnerships and networks, we will:

- Reinforce research in locations where poverty is deepest and most widespread
- Take an integrated, interdisciplinary approach to understanding local needs and developing a spectrum of options for local circumstances
- Set priorities through regular consultation with partners
- Focus on solutions tailored specifically to the needs of small-scale farmers
- Give careful attention to the full cycle of innovation and the sharing and use of knowledge across scientific, institutional, and national boundaries
- Stay attuned and responsive to the needs of poor people and promote the impact of all partners' efforts to foster sustainable human development

CIMMYT's research—and its organizational structure—will be based on projects that emphasize global and eco-regional priorities. The projects reflect CIMMYT's commitment to being as integrative as possible in its research, considering the different natural, economic, and cultural factors that determine where and how maize and wheat are grown.

A commitment to the future

The stories in this report offer a glimpse, in microcosm, of the new CIMMYT. They show that results depend on the collaboration of many people and organizations. They also show that CIMMYT and its partners do not simply lay the groundwork for solutions to the problems of the future. They reveal how field and laboratory research come to fruition in the lives of the poor.

We are providing solutions that people can use *now*—not when the next round of trade negotiations ends, when the civil war is over, or when the private sector decides it is time to enter a new market. Now is when people have to pay school fees, buy seed, obtain medical treatment, decide whether to abandon their village in search of wage employment, or bury a family member who has died of HIV/AIDS or malnutrition. Although we have spent much time over the past year in planning for tomorrow, this report shows that we have not interrupted our efforts to help people today and every day. In the coming year, as the "new CIMMYT" takes shape, this important work will continue to empower more people to transform their lives for the better.

Dr. Masa Iwanaga
Director General

Contents

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Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
BARI	Bangladesh Agricultural Research Institue
BRRI	Bangladesh Rice Research Institute
Bt	*Bacillus thuringiensis*
CIAT	International Center for Tropical Agriculture
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CSO	Civil society organization
GIS	Geographic information system
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Center for Research in the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IPGRI	International Plant Genetic Resources Institute
IRRI	International Rice Research Institute
NARC	Nepal Agricultural Research Council
OPV	Open-pollinated variety
QPM	Quality protein maize
RWC	Rice-Wheat Consortium for the Indo-Gangetic Plains
SADC	Southern African Development Community
t	Metric tons
USAID	United States Agency for International Development

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FUTURE HARVEST CIMMYT is a Future Harvest Center of the CGIAR (www.cgiar.org). Future Harvest® is a not-for-profit organization that catalyzes action for a world with less poverty, a healthier global population, well-nourished children, and a better environment (see www.futureharvest.org).

Innovation for Local Food Security

Will hunger become a lasting feature of their future?

Reducing the Footprint of Famine on African Soil

CIMMYT cannot conjure the rains or alter the macro-economic forces that are battering African nations, but its staff are mobilizing partnerships, knowledge, and other resources to restore the future to farm families despite famine and depleted fields.

A single mother in Mbingwa Village, some 100 kilometers northwest of Malawi's capital, Lilongwe, Agness Pungulani cannot produce enough on her half hectare of farmland to feed herself and her children. "My children are not healthy," she says. "Our problems are a lack of food, fertilizer, and sources of income." She sells her labor when she can find fieldwork, but she must weed the equivalent of a 140-meter row in a field, for example, to purchase a single kilogram of maize at the normal market price of 10 kwacha (about US$ 0.11).

During the 2002 hungry season, markets were devoid of grain, local traders were selling maize at 25 kwacha per kilogram or more, and little fieldwork was available. When the food stocks disappeared, Pungulani and many others foraged, drank tea from wild occra leaves in place of evening meals, and pounded banana tree roots into a crude flour approximating their preferred maize staple, *nsima*. The head of a neighboring household, which also fared badly, says, "This flour tastes sour, but we eat it because we have no choice."

The hungry season normally arrives during January-February in this part of Malawi, but lately families have run out of grain as early as September and must survive until the March harvests. World Vision and other CSOs are distributing foodstuffs to needy villagers like Pungulani, but others have starved. Similar levels of hunger have been common in Zimbabwe of late, and will probably worsen before the end of 2003. An entire generation of children is suffering the debilitating physical and social effects of chronic hunger. Will famine become a lasting feature of their future?

Empty soils, stomachs, and pockets

Most of the region's inhabitants live in rural areas, farm for a living, and eat large amounts of maize when they can get it. Poor soils, drought, conflict, malnutrition, and disease—particularly malaria and HIV/AIDS—are daily hardships. But of all their troubles, the one farmers mention most is a lack of fertilizer for depleted soils.

"In Zimbabwe, for example, people used to apply lots of fertilizer and cattle manure, but they've suffered many droughts and lost cattle," says Shephard Siziba, CIMMYT research associate and economist from the University of Zimbabwe. He has surveyed farmers in Malawi, Mozambique, Zambia, and Zimbabwe to understand the economics of soil fertility issues. "Subsidies have been removed. Traders pay the least they can for harvests and sell the grain back at premium prices during the hungry season. Farmers cannot afford fertilizer. Soils are becoming more acidic, less fertile. What farmers really need is help in leveraging their meager soil and water resources."

From dialogue to development

Siziba, his CIMMYT colleagues, and the partners mentioned above are helping farmers find new ways to care for and get more out of their soils through an organization known as Soil Fert Net.

The network fosters communication and teamwork among hundreds of researchers and institutions—ministries of agriculture, extension agencies, universities—nationally and internationally. "Soil Fert Net helps avoid duplication of effort and keeps the focus on the real-world concerns of small-scale farmers," says Stephen Waddington, network coordinator and CIMMYT regional agronomist. "Soil scientists and agronomists, extensionists, CSOs, anthropologists, economists, and policymakers all take part." Soil Fert Net also links with a complementary project to help smallholders cope with agricultural risk (see "Risk Management in Maize Systems," p. 5).

Among Soil Fert Net's accomplishments are "best bet" options for improving soil fertility, technical input for agricultural policy decisions, improved fertilizer use recommendations, training for private input dealers, and support for thousands of smallholder farmers to test and adopt new practices they might otherwise never have tried.

Knowledge to nurture soils

Inhabitants of Chihota Communal Area have the good fortune to live only 50-80 kilometers from Zimbabwe's capital, Harare. They sell tomatoes, onions, peas, greens, and other produce to Harare markets, growing it on carefully tended and fertilized plots known as or "dambo" or "vlei" land, normally adjacent to rivers. In contrast, on their acidic, sandy, upland plots, they sow a range of maize hybrids, typically obtaining very low yields. In 1999, with support from Soil Fert Net, extension staff of the Zimbabwe Agricultural Research and Extension Agency (AGRITEX) helped hundreds of farmers to test liming—a chemical treatment that reduces soil acidity—as well as green manures and rotations of various crops in maize fields.

About Soil Fert Net

The network's formal name is the Soil Fertility Management and Policy Network for Maize-based Farming Systems in Southern Africa. With technical support and coordination from CIMMYT, Soil Fert Net conducts targeted research and extension activities, fosters regional partnerships, and advocates appropriate policies to help farmers in Malawi, Mozambique, Zambia, and Zimbabwe. Soil Fert Net was established in 1994 with Rockefeller Foundation support.

Several hundred local farmers have picked up the improved soil management practices, and many continue to experiment. Mary Munemo grew maize for three seasons on a field to which she had applied lime in 1999 and noticed a big yield improvement. "It's difficult and expensive to get lime and sometimes the quantities are not enough for everyone," says Munemo, but now she and her peers have begun pooling resources to purchase inputs in bulk.

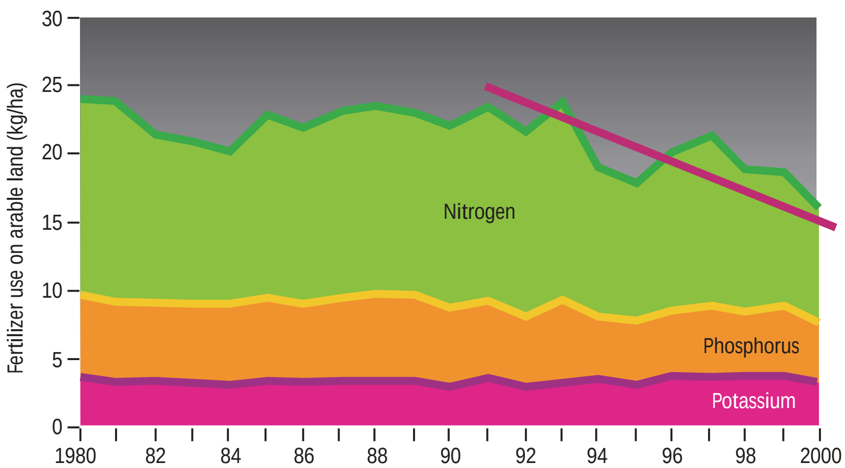
Venancio Gotami, an AGRITEX supervisor who has worked in the district since 1989, says Soil Fert Net empowers farmers to experiment with more complex, knowledge-based practices. "The value of the land has even gone up," says Gotami, "because farmers see the benefits of maize production using the new practices."

In Mozambique, Soil Fert Net participants are helping the country's recently established maize research program to conduct a widespread program of on-farm trials involving intercrops of maize and grain legumes and rotations of maize and cassava. These practices maintain soil fertility and provide food.

Long-term land care

Farmers in southern Africa need multiple coping strategies, if they are to build up resources for the future. "Even with the use of fertility management practices, maize farming in southern Africa is basically extractive," says Waddington.

Convincing farmers to diversify might help, according to Siziba. "In Manica Province, Mozambique, for example, 50-60% of the area is devoted to maize, but there's also sorghum, millet, legumes, cassava, and fruits," he notes. "In Zimbabwe, where people sow 80% of their land to maize, there's nothing to eat when the crop fails."



Fertilizer use continues to fall in Africa.

Conservation agriculture also holds promise. It includes practices that reduce tillage and recycle crop residues to save labor, enrich the soil, and capture and retain moisture. In May 2003, representatives from CIMMYT, Malawi, Tanzania, Zambia, Zimbabwe, the African Conservation Tillage Network, the University of Hohenheim, the Regional Land Management Unit based in Kenya, German Technical Cooperation (GTZ), and Sasakawa Global 2000 met to design a conservation agriculture project for eastern and southern Africa.

In June, Soil Fert Net members and representatives from the International Center for Tropical Agriculture (CIAT), World Forestry Center, and International Crops Research Intitute for the Semi-Arid Tropics (ICRISAT) met with John Lynam, associate director of the Rockefeller Foundation Food Security Program, with special responsibility for soil fertility. A major outcome was an undertaking to develop a consortium on soil fertility research and development to enhance food security in southern Africa. "The idea is to broaden participation, bringing more resources to bear on these important problems, and to coordinate and focus everyone's efforts," says Waddington.

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Risk Management in Maize Systems

As a complement to Soil Fert Net, CIMMYT coordinates the Risk Management Project. The project combines crop modeling and products from Soil Fert Net to help farmers at three locations in Malawi and Zimbabwe that typify the region's drought-prone conditions.

"Erratic rainfall makes maize yields swing like a yo-yo," explains CIMMYT research affiliate Zondai Shamudzarira, who coordinates Risk Management work with about 80 farmers in 4 villages in Zimbabwe. "Over the last 20 years, maize harvests in sub-Saharan Africa have ranged from 15 to 28 million tons. Over the same period, the region's population has increased by 200 million."

To help farmers deal with high risk and evaluate new practices, the project uses a model to simulate the performance of different practices across many seasons, gauging the extent and frequency of losses in bad seasons. Farmers help assess model results and develop rules of thumb on the conditions (land type, soil type, farmer category) under which a particular strategy is most attractive. The same approach is used to study topics such as the residual effects of legumes, or the best time during the crop season to work legume residues back into the soil.

Says Dowa Moses, chairman of a farmer group in Chikato Village, Zimuto Communal Area, with whom the project began working in 1999: "When CIMMYT came, they offered something new, bringing farmers together to test the use of legumes that regenerate soils. We have serious problems with soil fertility, so we accepted."

Moses had sown a series of project trials on a plot that had been abandoned since 1983 because of its poor fertility. He was pleased with the results of the trials, and said he would like to intercrop maize with soybean, pigeonpea, or *Crotalaria grahamianan* in the future.

One promising topic of research is the targeted use of small amounts of fertilizer. "We are working on this with farmers in Maranda Village, Zimbabwe, and Kamphenga, Malawi," says Shamudzarira. "In a year of good rains, you apply a little more fertilizer. If the rains are bad, you stop applying it, a simple sort of response-farming strategy that is nearly always cost-effective."

Shamudzarira and his associates share findings with CSOs, Soil Fert Net members, and others who are promoting improved soil fertility management practices.

Why Seed Matters:
Hunger Grows in a Land of Hybrids

In southern Africa, many farmers plant hybrid maize. So why are they hungrier than ever?

In southern Africa, declining soil fertility, climate risks like drought, and a lack of cattle manure or chemical fertilizer mean that once-productive hybrids are now sown in exceptionally harsh settings. Most farmers save seed from their harvests to sow the following year, even though the yield will be lower.

From the second generation onward, hybrid maize becomes genetically mixed. After several seasons, it generally yields less than a good open-pollinated variety (OPV). A good OPV can give better value than even first-generation hybrids in tough environments—say, where yields average 1.5 tons per hectare or less, as typically occurs on small farms in southern Africa. Farmers who plant OPV seed saved from a previous harvest sacrifice less in yield than is the case for hybrids.

Farmers have been asking for more appropriate varieties, and government agencies and CSOs are promoting OPVs. Meanwhile, breeders have found a way to develop hardier varieties. This new "stress-tolerant" maize yields well in years of good rains but can also produce enough grain for household needs in dry years. Most important, it uses no more water or soil nutrients than other varieties.

Tough handling turns out hardy strains

Maize breeders once selected varieties based chiefly on their performance in optimal environments—with adequate water and more than enough fertilizer. Now they also grow their experimental varieties under controlled drought and in poor soils to identify plants that are superior anywhere, anytime.

In 1996 the Southern African Drought and Low Soil Fertility Project (SADLF) brought this "stress breeding" approach to the region and helped hundreds of scientists and technicians to use it. (A joint effort between CIMMYT and national research programs, SADLF is funded by the Swiss Agency for Development and Cooperation and the Rockefeller Foundation.) Stress-tolerant OPVs from this work have been released in Malawi, Mozambique, South Africa, Tanzania, and Zimbabwe, and they are also used in Angola and Zambia.

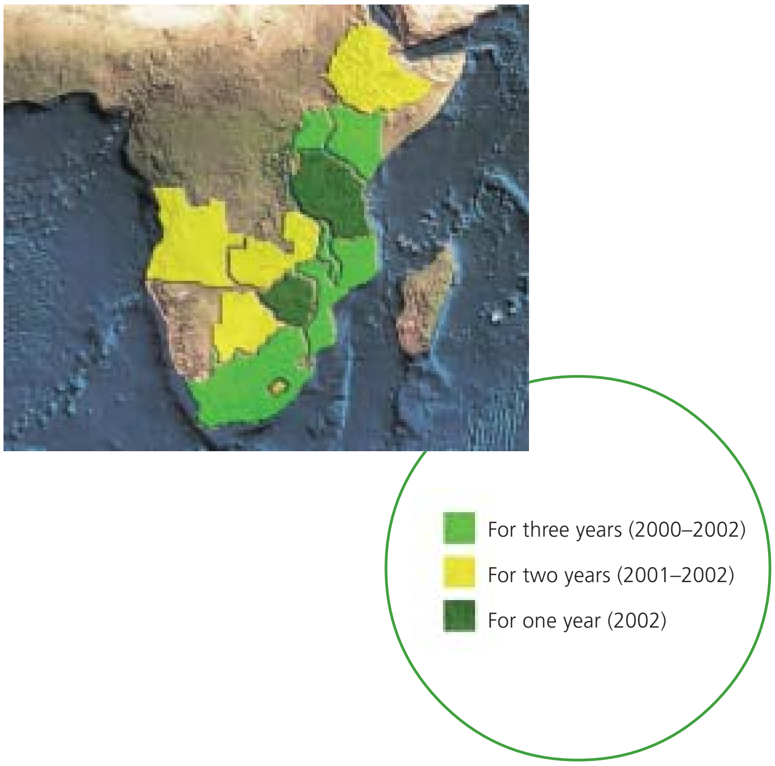
In trials from Ethiopia to South Africa, one OPV from this effort (ZM521) produced an average 34% more grain than popular improved varieties. A new generation of SADLF maize is 15% more productive than ZM521 or its sister varieties. The SADLF varieties are currently grown on more than 100,000 hectares region-wide, and their coverage is expanding.

More than seed is needed

Useful maize seed that sits on a researcher's shelf is of little help to humanity. "To verify the performance of the best varieties under farmers' conditions and make the seed available quickly, we devised a cost-effective, farmer-centered approach known popularly as 'mother-baby trials,'" says Mick Mwala, senior lecturer at the University of Zambia and CIMMYT research affiliate. Mwala has been helping partners to implement the trials since 2000 (see next page).

"CIMMYT is fostering the establishment of the trials widely in the region," says Mwala. "We're talking 150 mother trials region-wide, with more than 800 baby trials!"

Mother-baby trials implemented in eastern and southern Africa.



Karsto Kwazira and Xavier Mhike from AGRITEX are coordinating mother-baby trials in Zimbabwe. "Our own coordinating unit includes representatives from several CSOs as well as from extension, and there are regional representatives for local implementation," says Mhike. "This is the first time information is shared like this among national programs, Ministries of Agriculture, CSOs, and private companies. Previously everyone worked somewhat in isolation. Now there is complementarity, with a heightened awareness about the farmer."

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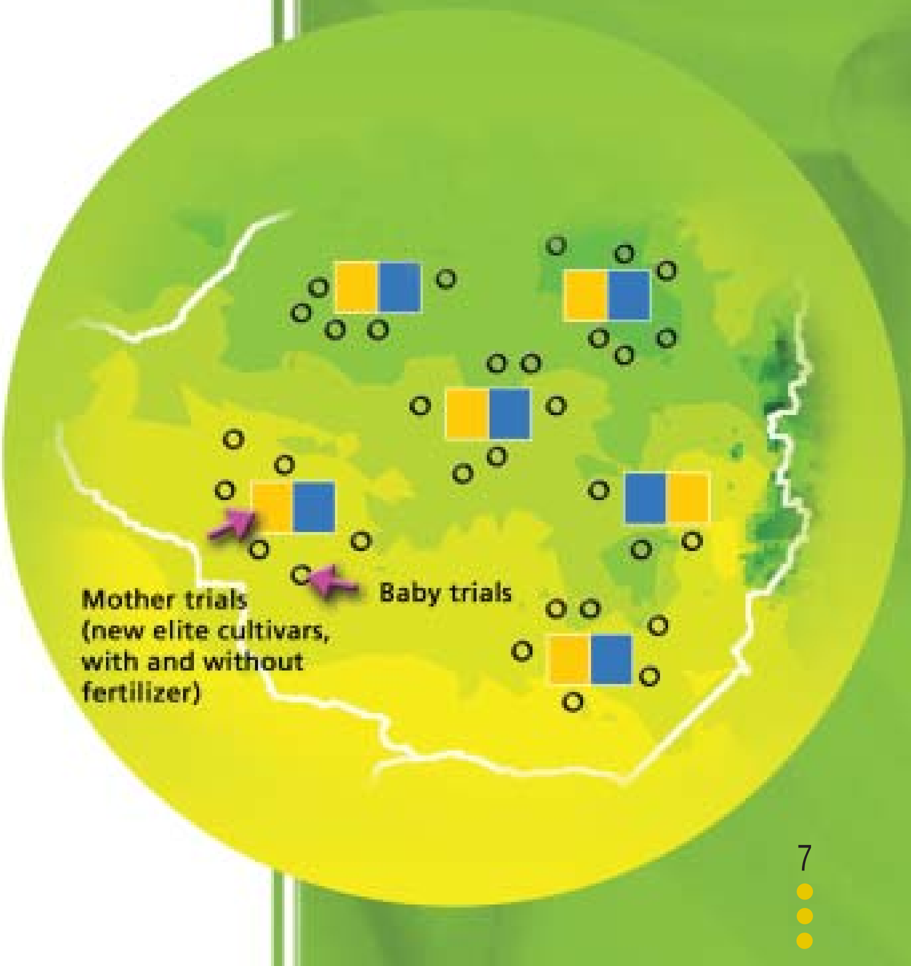
How do mother-baby trials work?

Mother-baby trials are a farmer-participatory method for testing and evaluating varieties under farmers' conditions. The trials are managed by researchers as well as farmers. The "mother" trial may involve as many as 12 varieties sown under varied researcher-designed treatments. The mother trial is located close to the community and is handled by schools, colleges, CSOs, or extension agencies. The "babies" are satellite subsets of the mother, comprising maybe 4-6 varieties in the fields of participating farmers under their management.

Researchers and farmers assess the trials, and the data are collected, analyzed, and distributed among multiple stakeholders. For example, some of the trials have links to community-based seed production schemes, some provide feedback on varieties to seed companies, and all of them spread results and seed to partner organizations.

Trials are currently grown throughout eastern and southern Africa.



Producing the Seeds of Change in Nepal—One Community at a Time

How can an insignificant handful of people hope to improve prospects in Nepal's mid-hills region, where armed insurrection compounds the suffering imposed by poverty, hunger, and isolation?

In Balefi, a tiny hamlet alongside the road in Sindhupalchok District, Nepal, the Hill Maize Research Project (HMRP), in collaboration with a local farmers' association, helps six farmers produce maize seed. The harvest should be good.

"I estimate that they'll produce four or five tons of quality maize seed," speculates Neeranjan Rajbhandari, CIMMYT adjunct scientist with the HMRP. "The average yield in this area is about one ton per hectare."

The project provided the farmers with source seed, plus training in seed production techniques, storage, and marketing. "We're counting on getting 50 to 100% more money for our seed than we get for maize grain," says one producer. "Other farmers want to buy our seed because it will produce up to three times more than their current varieties."

Nearly 80% of Nepal's maize is grown in the mid-hills (see map), where more than 10 million people depend on the crop for food, income, and animal feed. Shortages are chronic.

The HMRP ensures that there is sufficient seed of new maize varieties for farmers to replace old improved or local varieties, which yield very little. Community-based seed production accelerates seed replacement, disseminates new technologies, improves household food security, and raises incomes.

Tuki lights the way

Just a few kilometers up the road is one of many farmers' groups called Tuki associations (*tuki* means "oil lamp" or "leader" in Nepal). These associations, established with funding from the Swiss Agency for Development and Cooperation, seek to improve farmers' yields and their welfare, a goal that meshes with CIMMYT's mission.

Tuki has a network of farmers involved in producing maize seed. (Where there are no networks, the HMRP starts producers' groups.) Ten years old, this particular Tuki association spans 30 village units and has a leader in each. Of the leaders, 35% are women. This excellent network extends to areas that can be reached only on foot.

Tuki not only provides farmers with seed but buys their production, which is usually 200-300% above the average maize yield in this region. It pays a premium (double what farmers would normally get) for excellent quality. The fact that Tuki buys the seed just after harvest is a great advantage: the money flows in, and farmers do not have to look for markets or risk storing the seed and having insects eat it. Because the sustainability of seed production depends on successful marketing, the HMRP is careful to coordinate production and avoid creating a glut that would affect the premium paid to producers.

Seed producers sow three CIMMYT-derived maize varieties: a Rampur composite, Arun 2, and Manakamana 1. Other activities to improve maize production, including the use of soil-conserving practices, have been initiated in 6 villages with 84 farmers. Tuki provides extensive community support in many other ways, such as teaching women to read, write, and keep accounts and instructing them about which crops to sow off-season to make higher profits. An educational program ensures that all children go to school. Tuki also operates a savings and loan association.

Braving the insurgency

Kabre Village in Dolkha District is the site of Kabre Experiment Station, which was destroyed not long ago by insurgents. "We have some trials there again," comments Salendra Thapa, technical assistant assigned to Kabre, "but most of my time is spent interacting directly with farmers at the station's outreach sites, providing training in many things, including maize seed production." The HMRP has supported and collaborated on all maize-related activities in the area for four years.

Farmers' holdings are small: 72% are less than one hectare. Women do most of the farming. Few men are left in these communities. In the village of Kiratichap, 10 women produce maize seed on 1.4 hectares. The quality of the seed is so good that the extension agents use their field as a demonstration plot and buy the seed to distribute to other producers.

"We never had enough to eat until we started producing seed," recalls Debaki Karki, leader of the women's group. "Our maize harvests were so small that the grain provided enough food for only three or four months. Then Mr. Thapa came and taught us to produce seed. We started harvesting three tons of seed per hectare, and the difference was like night and day!" Soon the women were doing so well that they initiated a savings and loan service for their group.

The number of people involved in seed production is rising steadily. "When other farmers see seed producers increasing their yields and earning a lot of money, they are very interested in joining," says B.N. Adhikari, technical officer at Kabre. With support from the HMRP, he and Thapa constantly form new groups in the extensive area they cover. They have not let the destruction of their base station discourage them, nor are they letting fear of the insurgents keep them from reaching out to farmers.

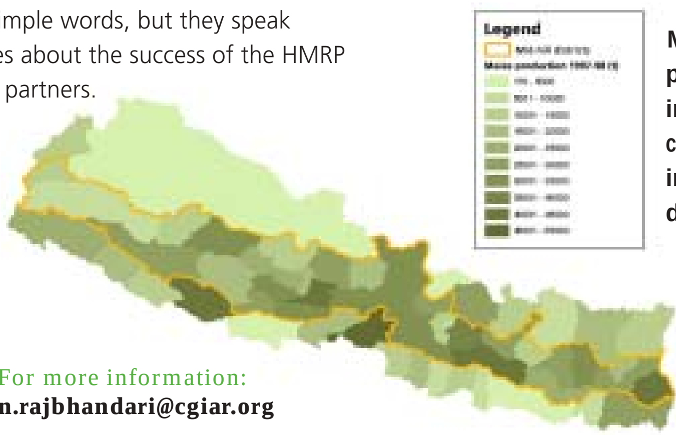
"Mr. Thapa is like a member of our family," points out Durga Devi Karki, a group member who is the head of her household. "He didn't leave us when things got rough."

The income from seed sales has improved the lives of the women and their families. Any leftover grain (only the best is used as seed) goes to the household, and the maize stover is fed to the livestock. Better-fed animals produce more milk, and the women sell the surplus on the local market. The additional income is spent on their children's schooling, clothes, and shoes, as well as on food and other household expenses.

"Just three of the women in our group read and write. The rest can barely sign our names, but we're sending our children—girls and boys—to school. They are even learning English!" Durga Devi says. Simple words, but they speak volumes about the success of the HMRP and its partners.

About the Hill Maize Research Project

Two-thirds of the maize produced in the hills of Nepal is consumed directly by farmers who nonetheless experience food shortages. It is imperative to increase production without placing undue stress on the environment. The Hill Maize Research Project (HMRP), a collaboration of CIMMYT and the Nepal Agricultural Research Council (NARC), is funded by the Swiss Agency for Development and Cooperation. Now in its second five-year phase, the HMRP supports all maize-related research in the hills of Nepal through five NARC agricultural research stations. It provides resource-conserving practices and more productive maize varieties suited to farmers' circumstances in these fragile hill environments. The project also facilitates, organizes, and provides training to local researchers.



Maize production in Nepal is concentrated in the mid-hill districts.

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Afghanistan Update

Wheat and maize occupy 80% of the area sown to annual crops in Afghanistan. How has CIMMYT responded to the desperate need to reinvigorate Afghan agriculture?

Wheat is the number one staple crop in Afghanistan. Maize is number three in importance and the number one summer crop. One of CIMMYT's main objectives in Afghanistan is to make improved, high-quality seed of both crops available to farmers, along with appropriate crop management technologies. Given the many challenges of working in Afghanistan, CIMMYT focuses on community-based approaches in which farmers help identify the varieties and crop management practices that will be most helpful.

To date, CIMMYT has responded to Afghanistan's most urgent needs by:

- Distributing 300 tons of quality seed of locally adapted wheat variety MH-97 to 9,000 farmers in 4 provinces of Afghanistan in time for 2002 fall planting.
- Producing 2.5 tons of breeder's and foundation maize seed and delivering them for planting by Afghan farmers in the 2003 season.
- Planting 35 wheat variety trials at 6 sites, and 24 maize trials at 8 sites, to identify additional materials that are well suited to farmers' needs.
- Training Afghan researchers in-country and at CIMMYT in Mexico. Already 15 researchers have attended courses in Mexico, and more training is planned.

CIMMYT has responded quickly to Afghanistan's needs for seed of locally adapted wheat and maize varieties because it has collaborated with Afghan researchers for over three decades (even during the war, thanks to the Swedish Committee for Afghanistan).

Most wheat varieties grown in Afghanistan are of CIMMYT origin. Several hundred CIMMYT wheat and maize nurseries have been evaluated in different parts of Afghanistan in the past 30 years. Duplicates of these nurseries have also been tested in the region (e.g., Pakistan, Tajikistan, and Iran) and in other parts of the world. This testing has identified wheats with high yield potential and improved disease resistance that are well adapted to Afghanistan. In maize, results of trials conducted in Afghanistan have been analyzed and promising cultivars selected from several populations.

"The maize which was brought by CIMMYT and implemented by Kunduz Rehabilitation Agency is doing wonders."

–Ghulam m Aqtash,
Executive Director, KRA

CIMMYT activities in Afghanistan are made possible by the Future Harvest Consortium to Rebuild Agriculture in Afghanistan (funded by the US Agency for International Development and coordinated by the International Center for Agricultural Research in the Dry Areas, ICARDA) and a separate initiative funded by AusAID and the Australian Centre for International Agricultural Research. We particularly appreciate the valuable cooperation and help of many CSOs and development organizations operating in the country, including the UN's Food and Agriculture Organization (FAO), International Fertilizer Development Center (IFDC)-USAID, ACTED (a French CSO), the Aga Khan Development Network, and the Improved Seed Enterprise. Also essential is the collaboration of the Agricultural Research Institute of Afghanistan and the Afghan Ministry of Agriculture.

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Seed Delivery Systems for Africa's Smallholders

"The farmer's dilemma is simple. There may be only one seed supplier nearby, and the farmer finds only a single variety or hybrid on the shelf, and there's no information about its qualities or how best to grow it. So how can she be sure that, by spending her limited cash on this seed, it will yield enough to feed her family?"

The dilemma for this farmer—as described by CIMMYT maize physiologist Marianne Bänziger—may be simple, but solving the problem is not. CIMMYT adjunct scientist Peter Setimela is working with myriad partners in southern Africa to establish sustainable systems for delivering appropriate seed to small-scale farmers.

"My job is somewhat improvisational," says Setimela. "I'm looking for ways for CIMMYT to make a difference by capitalizing on its science, its knowledge of the problems, and its awareness of stakeholders' diverse needs and concerns. Several countries and CSOs are working on seed production. We're also linking with seed companies to see how much seed they process, and what type. Sometimes there's enough seed, but distribution is inadequate."

A recent visit to Malawi took Setimela to the office of Jeff H. Luhanga, deputy director of the Department of Agricultural Research and Technical Services of the Ministry of Agriculture. "With government assistance, 1,500 farmers have ventured into seed production," says Luhanga, "and the government and CSOs have helped farmers to form associations that address issues of seed production, marketing, and linkages to seed companies."

Farmers also urgently need accurate information about seed. Setimela and Bänziger have developed and distributed a guide to the open-pollinated maize varieties (OPVs) available in Africa. The guide (see next page) helps people choose the best variety for their particular circumstances and provides contact information for seed suppliers.

"We also work with extension to train farmers to produce seed of OPVs, as well as to come up with seed production systems that work," says Setimela. "The crux is marketing! If small-scale farmers are linked to a seed company, they know the company will package and sell the seed."

Marketing through the private sector

In Malawi, Setimela also visited the Lilongwe office of Seed-Co, Ltd., which is producing well over 2,000 tons of seed of drought-tolerant varieties for sale in Malawi in 2003. The varieties were developed through the Southern African Drought and Low Soil Fertility Project (SADLF), described on p. 6.

"We're propagating three of their OPVs—ZM421, 521, and 621—which are quite good," says John Lungu, the Seed-Co production manager. This seed promises to be a reasonably-priced, key input for many maize farmers, as well as a welcome source of income for others. Lungu reckons that some 130 farmers—many of them smallholders—produce OPV seed for Seed-Co.

The CSO connection

Most of Seed-Co's OPV seed is being produced for CSOs involved in community seed production schemes throughout Malawi. One example is the work of World Vision International in the Chitera Area Development Program, about 20 kilometers from Blantyre in southern Malawi. Setimela traveled to Chitera with World Vision officer Walter Mwachande.

Chitera has a population density of nearly 450 persons per square kilometer, meaning that the average farm household of about five members must gain its food and livelihood from less than half a hectare of land. According to Mwachande, the area has always been food insecure, so work has aimed at raising yields. In four years of trials with hybrids as well as OPVs, the outstanding performer has been ZM521. "ZM521 outyielded all others, and farmers like its other qualities—early maturity, poundability, good flour quality, high yields, taste, resistance to head smut, and superior drought tolerance," says Mwachande.

World Vision International has worked in Chitera for 12 years and administers the Europan Union-funded Agricultural Production and Investment Program. The program provides inputs and "loans" about 20 tons of seed to 2,000 farmers. The farmers pay for the seed, which is enough to sow about half a hectare, with earnings from their harvest. World Vision charges 40 kwacha (about US$ 0.48) per kilogram of seed—about three times the market price for grain and just enough to cover costs.

World Vision procured seed last year from Zimbabwe, but this year they want to produce it locally. The farmers have produced seed of other crops but are just learning the complexities of producing high-quality maize seed. CIMMYT and the Chitedze Research Station are providing the foundation seed for future community seed production efforts. World Vision is furnishing some training and linking to organizations that can provide training in accounting and marketing.

Regionalizing seed production and marketing

A new CIMMYT study sponsored by the Rockefeller Foundation is taking a much closer look at seed marketing incentives to foster the spread of improved seed among southern Africa's poorest farmers. Augustine Langyintuo, the CIMMYT economist

conducting the study, explains that some of the technical, economic, and institutional constraints that prevent poor households from acquiring commercial maize seed are well known but not always well documented. By gathering detailed information about the organization and performance of seed production and distribution systems, the study should help seed company officials and/or policymakers to identify bottlenecks in seed supply and enable them to implement reforms.

CIMMYT and others are already exploring the possibility of approaching seed delivery from a regional perspective. In April 2003, CIMMYT, ICRISAT, and other stakeholders from the public and private sector took part in discussions led by the Seed Security Network of SADC on the regional harmonization of seed laws. CIMMYT geographic information system (GIS) tools, together with information from SADC trials, were used to show the advantages of exploiting new varieties across eco-regions rather than within national borders. CIMMYT and ICRISAT scientists also helped develop a working model that was used for discussion.

"CIMMYT is not just about finding a good variety, distributing it to solve one problem or set of problems, and then going on to the next variety," says Bänziger. "We look at each and every part of the system and see where we can make a difference."

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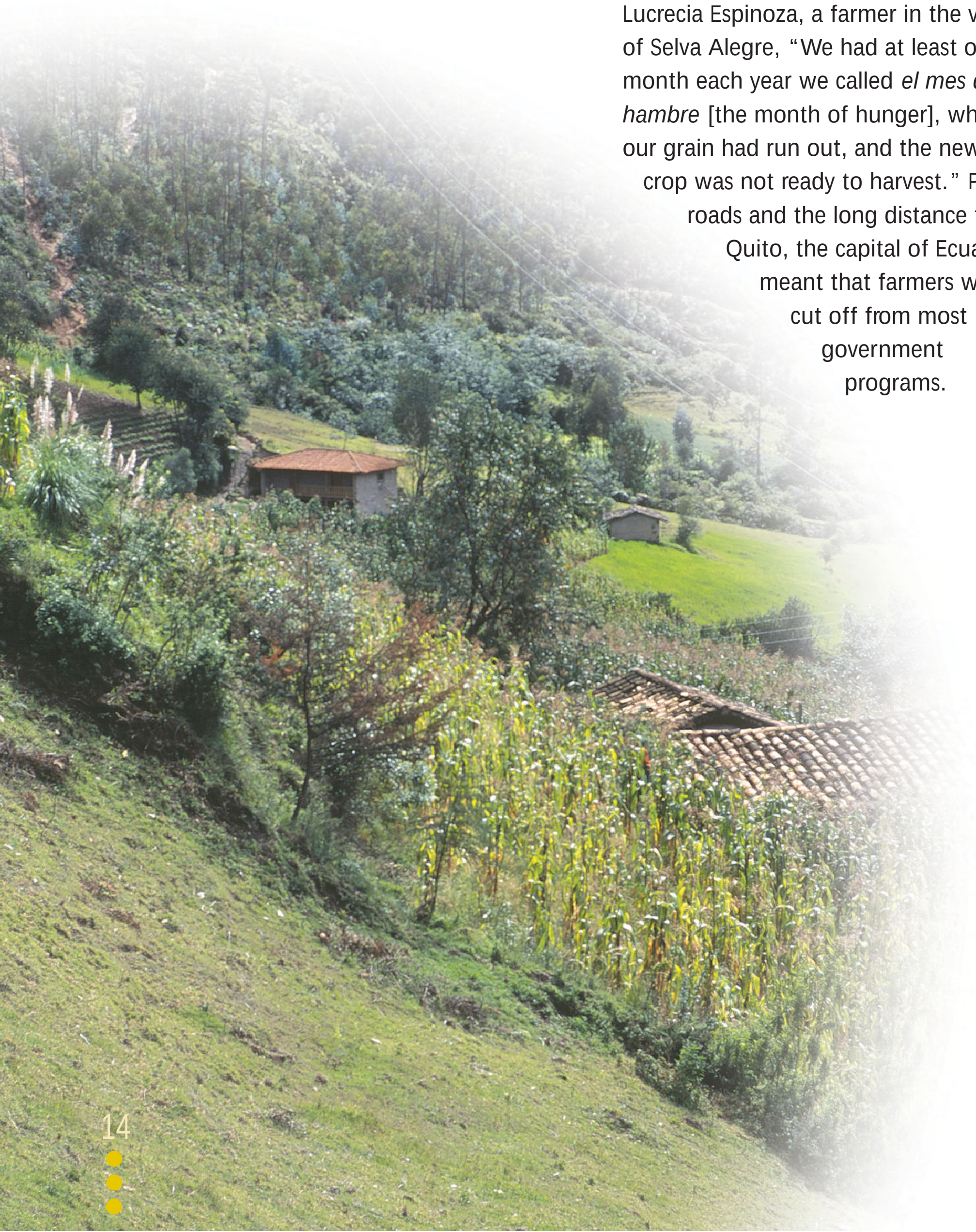
Innovation in Saraguro: Low Investment, High Impact

The Saraguro Indians have literally won an uphill battle for food security, thanks to a few key innovators.

Scattered over the Andes in southern Ecuador, between 2,000 and 3,500 meters above sea level, lie the communities of the Saraguro Indians. The Saraguro have subsisted in this area since the Incas brought them from neighboring Bolivia, more than five centuries ago.

At first glance, the slopes look impossibly steep to farm, but green fields and the occasional grazing cow or sheep are everywhere, as if glued to the mountainsides by a giant hand. Though beautiful, these peaks and valleys are covered by thin soil that once produced very little. Such low production put families at risk every year. Recalls Doña Lucrecia Espinoza, a farmer in the village of Selva Alegre, "We had at least one month each year we called *el mes del hambre* [the month of hunger], when our grain had run out, and the new crop was not ready to harvest." Poor roads and the long distance from Quito, the capital of Ecuador, meant that farmers were cut off from most government programs.



The road starts with just one farmer

In 1995, improved agricultural technology started trickling into Saraguro through a modest project aimed at helping farmers to try new varieties of barley, one of their main food crops. The two new varieties, called Shyri and Atahualpa, were developed by Ecuador's National Institute of Agricultural and Livestock Research (Instituto Nacional de Investigación Agropecuaria, or INIAP) and the ICARDA/CIMMYT Barley Breeding Program for Latin America, under the leadership of Hugo Vivar, based at CIMMYT. The new varieties resisted diseases and potentially could yield much more than farmers' current varieties.

The work in Saraguro is a collaboration between CIMMYT and INIAP, which assigned breeders Jorge Coronel (see p. 16) and Oswaldo Chicaiza (who led the effort for several years) to the project. Coronel asked the local priest to announce at Sunday Mass that researchers were looking for farmers to plant improved varieties. Just one farmer, Abel Gualán, agreed to try the new barley. Gualán took a sack of seed, plus some fertilizer, and sowed his crop. "A few months later he harvested eight times more grain than his neighbors," relates Coronel.

Next year, a number of farmers were eager to try the new seed. Coronel proposed a deal: they could have a sack of seed and a little fertilizer—on credit. Most farmers had never been considered eligible for credit, and they were wary. Coronel explained that they were not to repay the loan in cash but with the harvested grain. Thirteen farmers accepted. None had any trouble repaying the loan.

Nine years later, the project helps more than 3,000 farmers in 17 communities. Average barley yields in these communities (2.8 tons per hectare) are the second highest in South America, after those of Chile (3.5 tons per hectare), where resources are much more plentiful. The Saraguro have enough to eat all year, and most farmers have a surplus to sell. Comments Doña Lucrecia, "Nowadays if people don't have maize, barley, wheat flour, and potatoes to eat, it's because they're just plain lazy."

Expanding choices for farmers

Now that they do not have to worry about food security, individual communities have started tackling other problems. The people of Selva Alegre recently pooled their resources to dig small reservoirs high in the mountains, where they store water from streams and rain. They hooked up several kilometers of plastic pipe to bring the water down to their fields. The new system allows them to sow two crops per year. Their next goal is to provide all 36 households in Selva Alegre with running water. The inhabitants of Seucer, the driest environment in the area, carved a reservoir from the rock at the top of a hill, but they have not raised enough funds to buy the three kilometers of pipe they need to fill the reservoir and channel the water to their fields.

The project has also raised awareness about conserving and improving the soil. Concerned farmers have begun rotating barley, maize, wheat, triticale, or potatoes with beans, peas, and other nitrogen-fixing species. Local leaders such as Don Lucho García of Selva Alegre are trying zero tillage. Vivar and Coronel are promoting the formation of natural terraces with earth-anchoring grasses to keep soil from washing away.

The Saraguro are increasingly interested in new options. In response to their request for improved versions of other crops, INIAP selected and released Cotacachi, a high-yielding wheat introduced from CIMMYT and well adapted to the high, harsh environment of Saraguro. Farmers are also sowing an improved potato variety from the International Potato Center (CIP). The variety is resistant to potato late blight, a serious disease in the area.

The women of Selva Alegre are improving family nutrition by diversifying the vegetable crops they grow in their household plots, and they have learned to prepare a wider range of foods from barley and maize through training from INIAP.

The secret of success

"The success in Saraguro is the result of a combination of factors: the farmers themselves, the local leaders, the project coordinator, and the technology," points out Vivar. "The fact that the loans were payable in kind, not cash, was essential. In the past nine years, economic conditions in Ecuador have fluctuated widely—even the currency changed, from the sucre to the dollar—but none of this affected farmers' ability to repay their loans."

Village teamwork underpins the project. In each village, one farmer distributes seed and encourages others to try new crops and practices. These well-respected men and women set an example of hard work, collaboration, and openness to new ideas.

A man had ridden all night from his remote village for some of the barley seed that could be gotten just on the strength of one's signature.

Doña Carmen Sanmartín is the community leader in La Papaya, where she lives with her husband and their nine children. Tall and wiry, she is indefatigable at home and in the field. She was among the first to plant a new maize variety introduced from Bolivia. Called quality protein maize, or QPM, it could improve protein intake—particularly of children and farm animals.

Patricio Ordoñez, from San Pablo de Tenta, began helping with the project some years ago. Not long ago he was roused from bed early one morning by a man who had ridden on horseback all night from his remote village. He had come for some of the barley seed that could be gotten on the strength of one's signature. Ordoñez gave this complete stranger some seed and fertilizer on credit, which contrasts with the usual response in a place where people do not even listen to you unless you "know someone." Honoring this confidence, project participants have an excellent record of repaying their loans.

A highly productive investment

The project's achievements were made on a shoe-string budget: starting with virtually nothing (in cash) the first year, it now has a budget of US$ 20,000 annually. Supporters have included Oregon State University, Colorado State University, CIMMYT, ICARDA, Field Crop Development Centre/Alberta, Canada, Spain's Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, and PREDUZA (a CSO funded by the Netherlands). Operating on such a low budget has been possible because of low local costs and the efficiency with which the project is managed. Nevertheless, the lack of funds prevents the project from moving into similar poverty-stricken areas.

A major concern is what will happen after the project draws to a close. Vivar and Coronel are trying to set up cooperatives, for example, to produce and sell seed or to raise livestock for the local market. In this and other ways, they hope the Saraguro will maintain their new-found food security for a long time to come.

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Jorge Coronel: Committed to the Community

Jorge Coronel, the INIAP agriculturalist who is the mainstay of the project, is totally committed to the people of Saraguro. His role goes far beyond technology transfer: he knows everyone and has become an integral part of the community. He provides a whole range of services. Every weekend, when he returns to his family in Biblián, near the city of Cuenca, he takes a long list of things not locally available—from farm tools to medications—which people have asked him to purchase.

Since there is no hospital or ambulance in the small villages and the project's pick-up is one of the few vehicles in the area, Coronel also rushes people to the hospital in the town of Saraguro when there is an emergency. When someone dies, he usually fetches the coffin. Every day as he makes his way from village to village, people are waiting along the road for a ride. It's not unusual to see the pick-up overflowing with men, women, small children, farm animals, dogs, and even small farm machines and motorcycles.

Coronel spent six months at CIMMYT in Mexico in 1991. He credits the CIMMYT way of working for the things he has achieved in Saraguro: "People who have been to CIMMYT generally have one thing in common: their dedication and willingness to do whatever it takes to get the job done."

Innovation for Human and Environmental Health

Giving sharecroppers incentives to use resource-conserving practices

Conservation a Necessity, Not a Luxury, for Poorest Farmers

Environmentally sensitive agriculture is often viewed as a luxury even by wealthy farmers and nations, but in eastern India, some of the world's poorest farm households regard it as an absolute necessity.

The roads are more potholes than macadam. The dusty shanty shops lining the roads are thinly stocked with necessities: matches, laundry soap, cigarettes (sold singly). In nearby fields, people toil barefoot, without even a pair of plastic sandals. One can physically feel the poverty that stifles India's state of Bihar, and unfortunately that feeling is supported by official statistics.

In April 2003, India's president expressed his anguish at the results of a study from the Rajeev Gandhi Institute of Contemporary Studies and the Confederation of Indian Industry, which ranked Indian states from "A" to "E" in their economic progress and development. Bihar was the only state in all of India to "earn" an "E" rating.

"Bihar is where CIMMYT needs to be"

"Bihar is exactly where we want to be, where CIMMYT needs to be," says Raj Gupta, CIMMYT researcher and regional facilitator of the Rice-Wheat Consortium (RWC) of the Indo-Gangetic Plains.

Gupta and the RWC promote resource-conserving technologies (RCTs) and crop diversification in rice-wheat areas of Bangladesh, India, Nepal, and Pakistan. The RCTs, as the name implies, are technology packages (tillage, crop management, and other agronomic practices) that conserve soil and water and reduce fuel and labor requirements (detailed in CIMMYT's last two Annual Reports).

"There is a misconception that RCTs such as zero tillage and bed planting only benefit large-scale farmers in high production areas such as the Punjab," says Gupta. "This is far from the truth. If you want to see impact on people's livelihoods, come to Bihar, come to eastern Uttar Pradesh."

Diversification with conservation

At a five-acre farm in the village of Pilkhi, Bihar, a slightly built man with an entourage of old and young family members approaches and identifies himself as Mr. Mehato. Gupta explains that this small farm exemplifies the goals and general approaches of the RWC: providing farmers with management options employing RCTs, taking a farmer participatory approach to research, diversifying the cropping system, and assembling a committed project team.

Mehato and agronomist Mruthyunjaya Kumar of Rajendra Agricultural University view a plot in which maize and *boro* (winter) rice are planted on beds. Mehato was encouraged that the rice was doing fairly well in the scheme suggested by Kumar, and was more than pleased that the maize, Shaktiman, a CIMMYT-derived quality protein maize (QPM) hybrid, did well during the coldest winter in 50 years, when his neighbors' maize failed.

Following these winter crops, monsoon rice will be planted, then potatoes on beds and maize in the furrows. After the potatoes are harvested, the soil is mounded around the maize and boro rice is planted again. "The analysis is still underway," says Gupta, "and this may not be the most efficient rotation, but we are moving toward diversifying the cropping system, and we are doing it hand-in-hand with farmers."

Uttar Pradesh: Even sharecroppers benefit

Mehato's holdings may seem modest to outsiders, but they are grand compared to those of Keshoram, who farms one acre (less than half of a hectare), and of sharecroppers Rameshwar Singh and his wife Parameshwari Devi, all from eastern Uttar Pradesh.

Keshoram has planted zero-till rice and wheat for the past year. He had to take the risk of planting the rice directly rather than transplanting it. His neighbors mocked him. Even the RWC team was concerned because of shortcomings with the zero-till planter and the uneven nature of the field. Weeds—a big challenge of zero tillage for poor farmers, who have little money for herbicides—were handled by Keshoram the old-fashioned way. He weeded his field manually. In the end, his persistence paid dividends in the form of abundant rice and wheat yields.

Zero tillage allows farmers to plant wheat earlier than usual because they can avoid the multiple stages of land preparation entailed by conventional tillage. With wheat, each day of delay in planting past the optimal time results in a 1–1.5% loss in yield. "On Keshoram's acre that would work out to one ton lost over the season," says Gupta, "given that planting delays of 20 to 30 days are common under conventional tillage."

Sharecropper Rameshwar Singh and his wife (pictured on p. 17) adopted zero tillage to gain that early planting advantage. Singh maintains that he harvested at least 800 kilograms more wheat from his single acre. While Gupta notes that this is not a scientific finding, he adds that Singh also saved on costs because less custom land preparation had to be done—only a single tractor pass with zero tillage, as opposed to 3–6 passes for wheat and 3–8 passes for rice under conventional tillage.

When farmers crop such small areas, it is not the size of the farm that counts, but the number of farmers who use resource-conserving technologies. Local researchers estimate that in Bihar about 1,700 farmers now use the technology; in Eastern Uttar Pradesh, about 2,800.

Farmer Mehato (left) and agronomist Kumar assess rice and maize planted on beds. They want to diversify Mehato's range of crops and use practices that conserve resources, especially water. The maize, a quality protein variety, survived the coldest winter in 50 years.

A service industry for small-scale farmers

Some might think that fewer tractor passes would be an ominous trend for custom equipment operators, disposing them to oppose zero tillage and bed planting. This may be the case for some operators, but clearly not all. Manoj Kumar runs the custom agricultural service that worked Singh's acre, and he was the first in his area to purchase a zero-tillage seed drill after experimenting with a drill loaned to him by the RWC. He says it is true that he makes less money per farmer, but he provides service to many more farmers, and he can do their work faster.

Kumar also farms. This past year he grew rice on raised beds, which reduced fuel costs and water use. He believes that as local farmers see the bed technology for themselves, they may bypass zero tillage and go directly to bed planting.

This would not surprise Gupta, who takes obvious pleasure in working directly with farmers as they experiment, sometimes successfully, sometimes less so, with the diverse components of zero tillage and raised bed planting. There are few places where he would rather see the economic and environmental benefits of his work than in this long-suffering region of India.

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Arsenic and Agriculture: Coping with the "Largest Mass Poisoning in History"

Can efforts to untangle sources of contamination in the food chain counteract the "largest mass poisoning in history"?

Hashem Mondal had not been feeling well. A rickshaw puller in rural Bangladesh, he noticed that on sunny days he tired easily, and his skin became itchy and prickly. That was about a year and a half ago. Shortly afterward, his skin became mottled with dark brown patches, and lesions festered on the palms of his hands and soles of his feet. It was more than an inconvenience. A rickshaw puller's livelihood (US $2 on a good day) is earned through his feet and hands.

Unbeknownst to Mondal, he had joined tens of millions of Bangladeshis as another victim of arsenicosis—arsenic poisoning—in what the World Health Organization (WHO) has called the "largest mass poisoning of a population in history." In a poignant and bizarre tale, this health threat arose from a humanitarian effort in the 1970s to bring clean drinking water to Bangladesh and curb deadly water-borne diseases such as typhoid, dysentery, and diarrhea. Thousands of tubewells were drilled throughout the country. The incidence of water-borne diseases decreased dramatically. What was not foreseen was that the nation's shallow aquifers would become increasingly contaminated with arsenic. Arsenic was part of the silt deposited throughout the lowland basin of Bangladesh and West Bengal in India as the Himalayas eroded. As large amounts of irrigation water were pumped over the land in the winter, the arsenic was released into the water for drinking and agriculture.

The maximum level of arsenic in water viewed as safe by the WHO is 10 parts per billion (ppb); the official Bangladeshi threshold is 50 ppb in drinking water. In rural Bangladesh, many wells pump water with arsenic concentrations exceeding 500 ppb. The well Mondal fetched his water from later tested at 400 ppb, and his early symptoms of arsenicocis are typical. Longer exposure often results in cancer. It is estimated that arsenic in drinking water will cause as many as 270,000 cancer deaths in Bangladesh in coming years. There may also be effects related to diabetes, vascular diseases, and reproduction. The poor cannot afford the bottled water, meat, or even lentils that could counteract the toxin's effects.

Arsenic: Flowing through the food chain?

Not surprisingly, arsenic has become a top priority of the government and of aid organizations. Until recently, research and remediation focused almost exclusively on drinking water. Key links between arsenic and agriculture, specifically irrigated land and crops, had been largely overlooked.

"Arsenic in irrigation water poses a potential threat to soils and crops, the food chain generally, and consequently to human health," says CIMMYT agronomist Craig Meisner. "On average, a Bangladeshi adult drinks about 4 to 5 liters of water a day and consumes about 450 grams of rice. Assuming 200 ppb arsenic in the drinking water and about 0.5 milligrams per kilogram in rice grain, the total daily intake of arsenic would be around 1.2 milligrams, which may not be safe." ▶

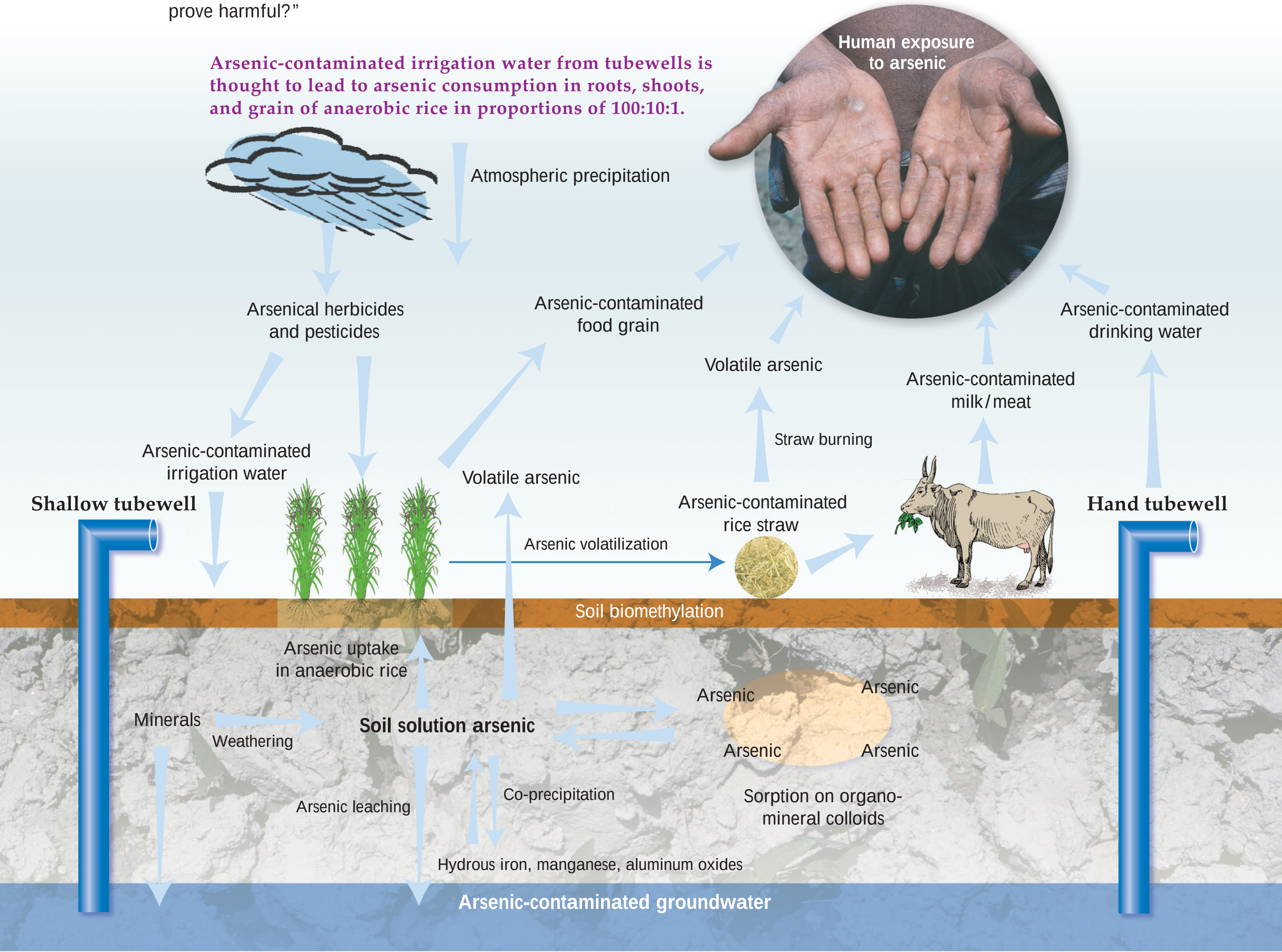
The lesions on Hashem Mondal's hands are from arsenic poisoning. They make his work as a rickshaw puller unbearably painful.

The problem as it relates to the food chain and human health is multifaceted (see figure). According to CIMMYT affiliate scientist G.M. Panaullah, "There are questions about how much arsenic is actually absorbed by the plant, and then how much of that is taken into the grain and straw under diverse conditions and farm management systems. Then, does arsenic in the grain actually pose a health hazard, and if so, at what levels and under what conditions? Consider also that the straw is fed to animals and burned as fuel. Will people be affected by drinking the milk or eating the meat of those animals? Will the smoke from a straw-fueled fire prove harmful?"

Much more information and knowledge are needed. "At this point," Panaullah says, "we do not want to alarm people about circumstances that ultimately may not prove to be hazardous. On the other hand, it's critical that we determine what is happening in the fields and the food chain, and start formulating responses."

> "Mainly, we are grateful that someone is trying to help"

CIMMYT, together with the Bangladesh Agricultural Research Institute (BARI), the Bangladesh Rice Research Institute (BRRI), the Bangladesh Institute of Nuclear Agriculture (BINA), the Bangladesh Agricultural University, and Cornell and Texas A&M Universities, is tackling these issues through a USAID-funded project. The project will assess arsenic contamination in irrigation water and soils, study the effects of arsenic on crop yield and grain and straw composition and quality, and develop mitigation technologies for safe agriculture and food. To accomplish this, the project provided rigorous training for Bangladeshi scientists and research technicians at the US universities. The project is also sponsoring PhD programs for four Bangladeshi students.



Arsenic-contaminated irrigation water from tubewells is thought to lead to arsenic consumption in roots, shoots, and grain of anaerobic rice in proportions of 100:10:1.

During 2002 and early 2003, a preliminary assessment was conducted at 450 shallow tubewell sites in five representative areas in eastern, central, and western Bangladesh. Irrigation water, soil samples, and grain and straw samples were collected from all sites and analyzed by the recently trained Bangladeshi team, with results confirmed in the US university labs.

The farm of Yusuf Ali Sarker in Faridpur was typical of the research sites. The farmer works with officials of the Department of Agricultural Extension and BINA scientists to set up sampling regimes for testing irrigation water at different distances from the well, boring soil samples at different field sites, and collecting grain and straw at different distances from the wellhead and from different varieties of rice. The project team regularly visits the site and monitors data collection.

Ali Sarker has little if any formal education, but he fully realizes the magnitude of the situation. "When the government began testing the tubewells five or six years ago, I became aware of the problem," he says. "The well where I get my drinking water tested red [the designation for a dangerous well—in this case, 181 ppb or 18 times the WHO acceptable limit], but what can I do? I'm poor and no man can live without water. So I'm working with the scientists and extension workers to see what we can do. Mainly, we are grateful that someone is trying to help."

Early results

The project has already made useful discoveries, while confirming that the path from water to soil to crops to food is complex. Rice grain and straw analyses revealed unusually high levels of arsenic in grain (0.8–1.0 mg/kg) at a few sites, but more generally the range was 0.2–0.4 mg/kg. Panaullah says that a general rule of thumb emerged that arsenic concentrations were on the order of 1:10:100, grain:straw:root. Notably for farming systems research, in some soils, rice grown under anaerobic conditions had arsenic levels 10-20 times greater than wheat, which is grown under aerobic conditions. It is anticipated that similar ratios will be found between rice and crops such as maize and potatoes.

Water and soil arsenic concentrations do not always correlate well with each other, however, and individually they do not always correlate to high arsenic concentrations in plants. High and low arsenic concentrations in *both* irrigation water and soil consistently result in plants with high and low arsenic concentrations, respectively. But the scientists report that "there is a large middle ground where the picture is muddled." Mineralogy, soil texture, or factors related to irrigation, such as flow rate and distance from the wellhead, may play a role. These are some of the possibilities investigated at the farms of Ali Sarker and others.

Following data collection and analysis, says Meisner, the project will issue a risk assessment. "It will tell farmers that if they have a well with this level of arsenic and their crop is this or that distance from the wellhead, here is what the impact will be." Depending on the research conclusions, substituting maize, wheat, or other crops for *boro* rice (irrigated winter rice), or accelerating the adoption of water-conserving technologies such as zero tillage and bed planting, might be an important response to the problem.

Even at this early stage, Panaullah, Meisner, and the project team feel that they can make a positive impact on the health and livelihoods of Bangladeshis. The rickshaw puller's illness was recognized in a chance encounter with project staff who directed him to a doctor and have followed up with him since then. His strength is returning and the painful lesions receding. "It is gratifying to see he's getting better," Panaullah comments. "Now just imagine if we can do that for millions more."

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By sampling soil, water, grain, and straw, researchers learn how arsenic enters the food chain.

Farmers' Future Rests on "Permanent" Beds

Many Asian farmers are under strong pressure to reduce costs and further intensify and diversify production—but are they stretching agriculture to the breaking point? "Permanent" bed planting helps farmers achieve their goals without depleting soil and water.

"Ken Sayre left India disappointed in March 2000 and said he would not come back until a lot more was happening with bed planting," recalls Raj Gupta, regional facilitator of the Rice-Wheat Consortium. He then cheerily notes that Sayre, head of crop management in CIMMYT's Wheat Program and a tireless proponent of conservation agriculture, returned in July 2003 and was not disappointed. Farmers are now experimenting extensively with bed planting, especially to reduce costs and diversify their mix of crops (see pp. 18–20).

Bed basics

In the bed planting system refined by Sayre, wheat (or another appropriate crop) is planted on raised beds that typically vary from 65 to 90 centimeters in width, with 2 to 3 rows per bed. After the harvest, most farmers remove or incorporate crop residues, destroy the beds by tilling the soil, and make the beds again before planting the next crop. Now, new implements have been developed, and farmers who grow crops on beds can simply reshape the beds before planting the next crop and retain all or part of the crop residues on the surface. This practice is referred to as "permanent bed planting."

Bed planting has numerous benefits, not the least of which is a 30% reduction in production costs through more timely sowing, a 20–40% reduction in irrigation water (compared to flood irrigation), fewer tractor passes, more efficient use of fertilizer, and lower seed planting rates that produce yields equal to or greater than yields obtained under traditional tillage systems. Of long-term import, bed planting, particularly on permanent beds, is environmentally friendly: it improves soil fertility and structure, reduces erosion and water requirements, and facilitates mechanical and manual weeding, which reduces herbicide applications.

The components of the system are not new. Bed planting of wheat was practiced to varying degrees for years in the Yaqui Valley of Mexico. Building on this practice, in the early 1990s CIMMYT scientists worked with Valley farmers to develop the new, permanent bed planting system that integrated raised beds with residue retention, reduced tillage, and irrigation in the furrows between the beds. Farmers in the Valley are adopting permanent bed planting as appropriate implements become commercially available. The tremendous benefits of bed planting, combined with its ready adoption by Mexican wheat farmers, led CIMMYT to pursue its use in other areas.

Options for Asia

Farmers in India, Bangladesh, and Pakistan value the flexibility that bed planting offers for crop rotations and intercropping. They benefit from higher profits and better nutrition by planting high-value crops such as mung bean, potato, pulses, and maize within the system. The development of appropriate rice varieties for transplanting or seeding directly into beds should give farmers even more options and opportunities.

China is also moving ahead with the technology. Shortages of irrigation water from the Yellow River have greatly reduced the area planted to rice and even caused farmers to abandon fields. Given water savings of 30–45%, China's interest in bed planting is not surprising. Sayre has been working with Chinese scientists in four locations in the Yellow River basin to test and extend bed planting. In the province of Shandong, bed planting has grown from a few test plots in 1998 to more than 26,000 hectares today. With two CIMMYT projects being developed under the CGIAR Challenge Program for Water and Food, there is reason to believe that bed planting will reach other parts of this critically important river basin.

Seeing impact from the Yellow River basin to the Indo-Gangetic Plains has given Sayre a new take on whether bed planting in Asia is taking off: "Our Asian colleagues have really initiated big changes. I look forward to working with them to refine bed planting systems, especially for small-scale farmers, who can easily get left behind in the race to intensify production. I won't say it will be easy—but it's not impossible."

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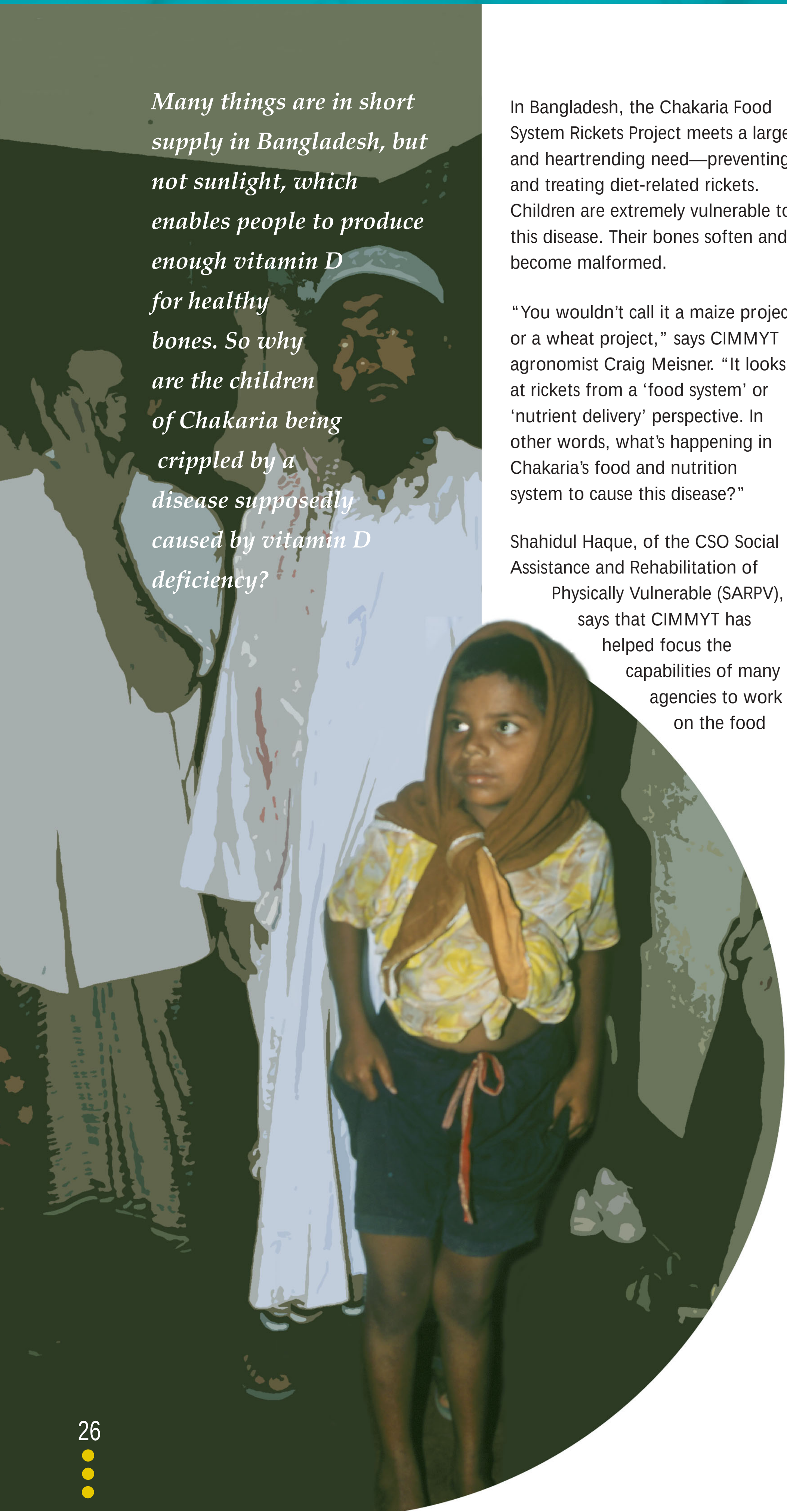
Food Systems to Prevent Crippling Disease in the Children of Chakaria



Many things are in short supply in Bangladesh, but not sunlight, which enables people to produce enough vitamin D for healthy bones. So why are the children of Chakaria being crippled by a disease supposedly caused by vitamin D deficiency?

In Bangladesh, the Chakaria Food System Rickets Project meets a large and heartrending need—preventing and treating diet-related rickets. Children are extremely vulnerable to this disease. Their bones soften and become malformed.

"You wouldn't call it a maize project or a wheat project," says CIMMYT agronomist Craig Meisner. "It looks at rickets from a 'food system' or 'nutrient delivery' perspective. In other words, what's happening in Chakaria's food and nutrition system to cause this disease?"

Shahidul Haque, of the CSO Social Assistance and Rehabilitation of Physically Vulnerable (SARPV), says that CIMMYT has helped focus the capabilities of many agencies to work on the food system–nutrition link as it relates to rickets, including CSOs such as the Bangladesh Rural Advancement Committee (BRAC), national agencies such as BARI and BRRI, and institutions such as Cornell University.

Before meeting Meisner, Haque focused on combating rickets through a school he established, where children receive treatment, an education, and learn about diets to prevent rickets (see photo, next page). The organization also lobbies government officials and has modest public awareness activities. It was through Meisner, however, that Haque saw the connection between agriculture and rickets prevention. He was also brought into the Cornell University–USAID-supported Chakaria Food Systems Project, which further extended his networking and outreach efforts.

"I've worked with CSOs that address nutrition-related diseases and deficiencies," says Haque, "but they never talked about the whole food production system at the family level. Dr. Meisner and Dr. Razzaque from CIMMYT and their Cornell colleagues talk about family nutrition and family food production, and they also tie the issue into generating income and food security. Now I think that rather than reverting just to treatments, we need to look at food production and cropping systems and nutrient availability, if we are to address the affliction of rickets."

Linking agriculture and health

Chakaria, which is located in southeastern Bangladesh, has an abnormally high incidence of rickets. Compared to many other people in South Asia, the people in Chakaria are

Living and learning with rickets in Bangladesh

doing relatively well in terms of access to food, but in the past 20 years the incidence of rickets has gone from very low to high. About 50,000 children show some form of the disease.

"Usually rickets is associated with a lack of vitamin D," Meisner explains. "The body manufactures vitamin D in the presence of sunlight, but there's no shortage of sun here. Based on results of a USAID-funded clinical trial, we surmise that calcium deficiencies are a root cause of the disease, but questions remain. Rickets is not as prevalent in poorer areas of Bangladesh where more rice and a less varied diet are consumed. So why here, why now, and what can we do about it?"

Even when calcium is found in the diet, there are questions about its bioavailability, how the presence or absence of other micronutrients affects its absorption, and agronomic factors that affect calcium levels in the crops themselves. Perhaps the biggest challenge is to produce more calcium-rich vegetables and crops in a farming system heavily disposed to rice, and then get people to consume them.

Catalyzing change in local food and nutrition systems

Aside from acting as a catalyst in the project, CIMMYT is pursuing the food and cropping system side of the disease equation and helping with public awareness.

"We bring CIMMYT's knowledge in cropping systems research to the table together with the knowledge of the Bangladeshi institutes," says Meisner. "Some dark green vegetables, pulses, and maize are high in available calcium, but not all are adapted to Chakaria's acidic soils, and many diseases and pests make it risky for farmers to grow them."

CIMMYT has contributed improved maize varieties to Chakaria, where maize itself is a relatively new crop. CIMMYT also provides expertise to produce seed of a virus-resistant okra developed by BARI so that more farmers can grow it. Aside from its health benefits—okra is rich in calcium—it fetches a high price, so growers like it. Improved cowpea varieties are available through ICRISAT, and project partners are facilitating their adoption along with improved mung beans. Both crops are rich in calcium.

Meisner and Razzaque are excited about increasing the production of calcium-rich foods in local farming systems through other technologies that CIMMYT works with, such as zero tillage and bed planting. Zero tillage would allow farmers to plant mung beans and other pulses more quickly after rice, which means higher yields and less risk of crop loss. Bed planting works well with okra and could encourage more lentil production. CIMMYT provides technical backstopping at a demonstration farm owned by SARPV, where techniques for producing calcium-rich vegetables are evaluated and demonstrated to local residents.

Reaching thousands

Through theatrical productions and a video, the project has reached tens of thousands of Bangladeshis with messages about treating rickets, eating a diverse diet to prevent rickets, and growing the food to support diverse diets. CIMMYT is also developing materials and a cadre of trainers to use the Whole Family Training approach (see p. 37) to promote farming systems that produce calcium-rich vegetables and pulses.

"Being involved in these types of networks extends the impact of agriculture in many ways," says Meisner. For Meisner, those payoffs are important, but they are not his immediate priority. "When you see a mother and father with their bowlegged, rachitic child, and they look into your eyes thinking you are 'Doctor' Meisner who is going to help them, it gets to you. I can't do anything as a medical doctor—my doctorate's in agriculture—but we *can* do something about the delivery of nutrition and food."

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Underground Wheat Diseases: Out of Sight, Out of Mind

Invisible pathogens that live in the soil can cause as much as 20% of wheat yields to be lost, especially in marginal rainfed or low moisture environments where many resource-poor farmers live. A new course offered by CIMMYT brings these pathogens into the open.

Root rots and nematodes (minute insects that suck the sap out of plant roots) attack cereal crops under the ground, but they are not visible, and the symptoms they cause are difficult to identify. For farmers and even most plant pathologists, these pathogens are "out of sight, out of mind."

Helping poor farmers avoid 20% yield losses is good reason to dig into the ground and find out about root pathogens. To date, little research has focused on these problems, compared to above-ground diseases and pests. A prime reason is that research on soil-borne pathogens involves an enormous amount of grunt work, such as digging up roots (lots of them) and washing them to rid them of soil. Nonetheless, when researchers in the affected areas realize the extent to which soil pathogens affect yields, they immediately develop an interest in them.

The countries of Central and West Asia, and North Africa (CWANA), plus China and India, regularly suffer substantial yield losses caused by soil-borne pathogens. "We've been aware for a long time of these problems and of the need to train national program scientists in this field," says Hans-Joachim Braun, head of CIMMYT's office in CWANA, located in Turkey. "The best way to control soil-borne pathogens is to establish research networks for transferring knowledge and exchanging breeding materials among affected countries in the region." The first step towards that goal was taken when CIMMYT assigned Julie Nicol, an expert in soil-borne pathogens, to CWANA.

Since arriving in CWANA, Nicol had explored the possibilities of holding a course on soil-borne pathogens for reseachers in the region. "I'm Australian, so I naturally looked to Australia first for help in funding, organizing, and giving the course," says Nicol. "I was motivated by their interest in holding such a course and their willingness to fund it." She especially cites the guidance and support of Bruce Holloway, director of the Crawford Fund's Master Class Program, and Albert Rovira, coordinator of the Fund in South Australia.

Australia, where wheat is grown in the rainfed environments preferred by these pests, is one of a small number of countries where such research has been systematically conducted. As a result, the country has more than the usual share of experts in this field.

Laying the groundwork to control soil pests

With the invaluable help of local CIMMYT staff, Nicol organized a two-week "master class" and training manual. The course was held in June 2003, mainly at ANADOLU Experiment Station in Eskisehir, Turkey, which has excellent laboratory facilities, classrooms, and accommodations. The group also traveled to key locations within Turkey, such as Konya and Cumra. Twenty-three researchers from Afghanistan, Australia, India, Iran, Kazakhstan, Morocco, Syria, Tunisia, Turkey, and Uzbekistan attended the course.

Lectures in the classroom were combined with visits to farmers' fields and research stations to observe root rot and nematode damage in a wheat crop. Plants collected from those fields were used to extract soil-borne fungi and nematodes in the lab. The instructors also demonstrated how to culture soil-borne pathogens and use molecular markers to identify host plant resistance. All lab sessions were highly interactive and hands-on to give participants the opportunity to try the methodologies themselves. Almost every evening there was a session during which participants would make presentations on the agricultural conditions and problems in their countries, and what they are doing to try to solve them.

Zafer Uckun and Zafer Mert from Turkey commented, "During the course we realized that soil-borne diseases are one of the most important factors limiting our yields." Another participant from Iran indicated that back in their own countries they would "need to convince the breeders of the importance of these problems and then work closely with them."

The teaching staff was made up of Turkish, Australian, and French nationals from various universities, advanced research institutions, national research programs, CIMMYT, and ICARDA. Amor Yahyaoui (ICARDA) and Turkish scientists Mikail Caliskan, Ahmet Bagci, and Illker Kepenekci helped Nicol and Braun prepare and present specific course components. The instructors included Roger Rivoal, a leading nematologist from INRA/France; Lester Burgess of the University of Sydney; Hugh Wallwork, a pathologist from the South Australian Research Development Institute; Ian Riley, a nematologist from the University of Adelaide; and several Turkish researchers (Halil Elekcioglu, Berna Tunali, Mucella Tekeoglu, and Necmettin Bolat). Course participants appreciated the opportunity of interacting with these internationally known experts. As Hussam Abidou, a doctoral student from Syria, pointed out, "Though all the lectures were full of new information, one of the best advantages of the course was the beneficial discussions we had with the scientists."

By the time the course was over, participants were determined to form a strong regional network. The network will improve the control of soil-borne pathogens through the exchange of information and the development of resistant varieties to benefit farmers who depend on wheat for their survival.

The course was funded by the South Australia Branch of the Australian Academy of Technical Sciences and Engineering Master Class Fund, Turkey's General Directorate of Agricultural Research, Australia's Grains Research Development Corporation, and the Kirkhouse Trust in the United Kingdom, in addition to CIMMYT and ICARDA.

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Nicaragua: Quality Protein Maize and Farmers' Fight to Stay Ahead

Jorge Luis Vanegas Ruiz is not your typical small-scale farmer. A young man living in Santa Rosa, at the rural margins of Managua, the capital of Nicaragua, Vanegas is a *gallero:* he breeds fighting cocks as his main source of income. "Farmers here do whatever they can to get by," says Alberto Espinoza, maize breeder in Nicaragua's Instituto Nacional de Tecnología Agrícola (INTA). "They also make and sell furniture, or take day jobs, if they can get them. If there were more opportunities, they'd be able to support themselves well."

Alberto Espinoza and his colleagues work with CIMMYT maize breeders Hugo Córdova and Salvador Castellanos to provide new options for Vanegas and thousands of other Nicaraguan farmers. Their efforts recently culminated with the release of a yellow-grained variety of quality protein maize (QPM), called Nutrinta Amarillo. Grain of QPM has nearly twice the lysine and tryptophan—essential amino acids for humans, pigs, and poultry—as normal maize. "Nearly half the population of Nicaragua is rural, and nearly all rural inhabitants raise pigs, poultry, or both," says Espinoza. "Many cannot afford animal feed, but if they use yellow QPM, the animals will be healthier and more productive, and the farm families better off."

A third of Nicaragua's population—more than 1.6 million out of a total 5.4 million—cannot meet the basic nutritional requirement of at least 2,200 calories a day, according to the United Nations World Food Program. Nearly 0.7 million endure "very high food insecurity." The average maize plot is only about 1.5 hectares. Nutrinta Amarillo is the first yellow maize variety released in Nicaragua. A white-grained QPM variety released in 2000, NB-Nutrinta, is sown on nearly 10,000 hectares.

Fortifying feed

"This QPM gives the animal greater strength and is a lot cheaper and simpler to prepare," says Vanegas, who is growing a stand of yellow QPM. "It also makes chickens lay more eggs."

According to Espinoza, Nutrinta Amarillo has been well received, but its widespread adoption has been constrained by insufficient seed production and promotion. Only INTA is producing QPM seed, and the institute either gives it away or distributes it through a government program, in which farmers pay back loans of improved seed with equal amounts of grain. "We've held field days for farmers on QPM management," says Espinoza. "We recommend that they select seed from the center of the plot and, if possible, grow the QPM in isolation from other maize fields. Farmer groups are organizing to produce lower-priced seed of improved varieties, including Nutrinta Amarillo."

Seed production is just one of the interests of Elvis Curiel Cerratos, a farmer who lives near Managua and works at an INTA research station. He saw Nutrinta Amarillo for the first time when he attended the release ceremony, and now he is growing some for seed. "I was already aware of the experiments with pigs," says Curiel, referring to tests in which piglets that ate QPM-based feeds grew bigger and more quickly than those raised on standard maize-based mixtures. He has 20 pigs, and also breeds fighting cocks and grows maize, beans, bananas, and squash on about 4 hectares—3 of which he rents to support a household of 20. "You can get up to two very big ears of Nutrinta Amarillo per plant," he says.

Self-help for the inaccessible

Civil society organizations are also trying to promote QPM, particularly in remote areas. One is Self-Help International, a small, US-based organization that began working with QPM in Ghana in 1989 and brought that country's successful QPM variety, Obatanpa, to southern Nicaragua in

1999. "We wanted to work in a difficult area, so we chose a community at the southern tip of Lake Nicaragua, near Costa Rica," says Merry Fredrick, Executive Director of Self-Help. "People there are very poor—the community had the second highest maternal death rate in the world. There had been lots of damage from Hurricane Mitch, and farmers had lost their seed. We realized that we needed to establish a seed base." They launched a seed bank, giving farmers a bag of seed to be paid later with two bags that would in turn be given to other farmers. "In June of 1999 five farmers each sowed half a kilo of QPM seed," says Fredrick. "By December of 2002, more than 7,000 were planting and using the seed."

Self-Help staff began with Obatanpa, but they are also working with NB-Nutrinta and are interested in Nutrinta Amarillo. "We don't have to promote QPM now—it promotes itself," says Fredrick. "Women like its texture for cooking, and everyone likes its taste, and the husks in Obatanpa really cover the ears, protecting them from diseases. Farmers also tell us that QPM ears tend to have more and larger kernels per row than traditional maize, and much higher yields."

Self-Help is branching out to new locations in the region and training farmers in seed production and improved crop management. Fredrick credits INTA with assisting her organization to disseminate QPM as widely as possible.

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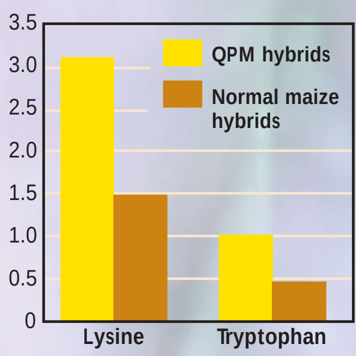
QPM: People-Centered Science at its Best

In 2000, CIMMYT maize breeder Surinder K. Vasal and former CIMMYT cereal chemist Evangelina Villegas shared the World Food Prize for developing QPM. Their work, funded by UNDP, started in the 1970s with *opaque-2*, a naturally occurring mutant gene whose effects on protein quality in maize were discovered in 1963 at Purdue University. Vasal and Villegas overcame the agronomic drawbacks associated with *opaque-2*—chalky grain, low yields, susceptibility to diseases and pests—and kept the protein quality. The photo shows how chalky *opaque-2* maize grain (top) compares to normal maize (bottom left) and QPM (bottom right).

CIMMYT researchers bred high-yielding QPM for nearly all developing country production niches. Sasakawa Global 2000 has successfully promoted QPM in Ghana and elsewhere in Africa. Global testing and promotion of QPM by CIMMYT and its partners is supported by the Nippon Foundation, the Rockefeller Foundation, and CIDA-Canada; QPM is grown in 22 developing countries.



Average amino acid content in maize grain protein (%)

Quality protein maize improves the diets of people who consume a great deal of maize and also shows advantages in animal feed. For example, the Kenyan feed industry could save US$ 0.3 million every year by using QPM instead of expensive protein supplements in chicken feed.

A new breeding approach* uses a molecular tool called RNA interference to suppress production of seed proteins of low nutritional value. This effect resembles that of *opaque-2.* The new approach does not improve protein quality as much as *opaque-2*, but it opens an interesting possibility. *Opaque-2* is a recessive gene, which makes it hard to maintain during breeding or under farmers' circumstances. Using the new mechanism, researchers could produce a dominantly controlled protein quality trait that survives crosses with normal maize.

* Segal, G., R. Song, and J. Messing. 2003. A New Opaque Variant of Maize by a Single Dominant RNA-Interference-Inducing Transgene. *Genetics* 165:387–397.

HarvestPlus: Breedings Crops for Better Nutrition

HarvestPlus

A new breed of crops is being developed to help reduce malnutrition even in remote rural populations—crops such as rice, wheat, maize, and sweet potato packed with more vitamins and minerals. These "biofortified"™ staples are one of the most promising new tools to fight malnutrition.

Over three billion people in developing countries suffer micronutrient malnutrition, often because they lack money to buy enough meat, fish, fruits, legumes, and vegetables, which are rich sources of micronutrients. The introduction of biofortified crops—varieties selected and/or bred for increased mineral and vitamin content—is a sustainable, low-cost way to reach people with poor access to formal markets and health care systems.

A major advantage of biofortification is that it does not necessarily require a change in the behavior of farmers or consumers. Changes in mineral content will not alter the appearance, taste, texture, or cooking qualities of modern varieties of crops that are already widely produced and consumed by poor households.

HarvestPlus is an interdisciplinary, global alliance of research and implementing institutions that will develop these nutrient-rich crop varieties, assess their impact on human nutrition, and distribute them to the people most at risk of being micronutrient deficient.

Initial efforts focus on six staple crops for which feasibility studies have been completed: beans, cassava, maize, rice, sweet potatoes, and wheat. The project will also examine the potential for nutritionally enhanced bananas/plantains, barley, cowpeas, groundnuts, lentils, millet, pigeon peas, potatoes, sorghum, and yams.

Partners include national agricultural research systems in developing countries; International Center for Tropical Agriculture (CIAT); International Maize and Wheat Improvement Center (CIMMYT); International Potato Center (CIP); International Center for Agricultural Research in the Dry Areas (ICARDA); International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); International Food Policy Research Institute (IFPRI); International Institute of Tropical Agriculture (IITA); International Rice Research Institute (IRRI); departments of human nutrition in developing- and developed-country universities; CSOs; University of Adelaide; University of Freiburg; Michigan State University; Plant, Soil, and Nutrition Laboratory/United States Department of Agriculture, Agricultural Research Service (USDA-ARS); Children's Nutrition Research Center Baylor University.

Research is generously supported by the Bill and Melinda Gates Foundation, the World Bank, the U.S. Agency for International Development (USAID), Danish International Development Assistance (DANIDA), and the Asian Development Bank .

HarvestPlus is a global alliance of research institutions and implementing agencies that have come together to breed and disseminate crops for better nutrition. It is coordinated by the International Center for Tropical Agriculture (CIAT) and the International Food Policy Research Institute (IFPRI). HarvestPlus is an initiative of the Consultative Group on International Agricultural Research (CGIAR).

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Innovation to Adapt to Change

Learning uses for a new crop in Bangladesh

Inside Mexico's Traditional Seed Sharing Networks

Doña María is returning from a day in the maize fields, where she has been hacking *acahual*, a weed good for animal fodder, out of another farmer's field. CIMMYT anthropologist Lone Badstue and agronomist Alejandro Ramírez López are waiting at her gate.

When Doña María sees them, she breaks into a wide smile and motions with her machete for them to enter her little compound. The two researchers help her unload the *acahual,* and Doña María fills them in on her life since they last spoke several months ago. Her health has not been good. She could not afford to plow the little field she usually sharecrops, and the plot of communal land where she managed to plant a bit of maize was ravaged by heavy rain.

Nearing 65, Doña María lives alone. Her husband died several years ago, leaving her little money and no land. Her children have all migrated. She works as a day laborer for other farmers and sells tortillas she makes from maize purchased in the village. Even the animals she raises belong to someone else. If they breed well, she may finally have some of her own.

Badstue points to a stand of maize in the corner of Doña María's yard and asks if she is trying out different maize to plant next year. "No, that's just some maize that my friend Josefina gave me that I'm growing for *elote* [fresh maize]," Doña María says. She then pulls some maize grains out of the pocket of her apron. "These I found as I was gathering *acahual*, and I'm going to plant them for *elote,* too." She rolls the seeds between her fingers like worry beads.

This story illustrates two of the countless ways maize seed travels around this community. Seed exchange is one important reason that the genetic diversity of maize in Oaxaca has remained vibrant for thousands of years. This diversity ensures that we still have options for developing maize varieties that withstand problems such as drought, diseases, and pests.

Does collective action regulate seed exchange?

Badstue leads the fieldwork for a project that investigates informal modes of seed exchange. Funded by the CGIAR's System-Wide Collective Action and Property Rights Initiative, the project examines the structure and function of traditional farmers' networks and their role in the evolution and conservation of maize genetic diversity. The research is based in the Central Valleys of Oaxaca, Mexico, an area of significant maize diversity.

The researchers hypothesized that farmers would have strong incentives to act collectively to maintain access to many different maize landraces, for example by forming community seed banks. In principle, collective action would allow farmers to build and safeguard a larger base of genetic diversity than they would be able to maintain individually. Because collective action is common for other purposes in Oaxaca cultures, it seemed likely to play a role in farmers' seed supply systems.

The researchers discovered, however, that seed exchange among farmers was far more fluid, complex, and integrated into the cultural fabric of these communities than they had hypothesized. They found no evidence of collective action for maintaining access to seed of diverse maize landraces. If seed exchange did not follow a pattern of collective action, what pattern did it follow? How did it evolve differently, and why? To answer these questions and assess the implications for maintaining maize diversity, Badstue charted a new course for her research.

The importance of social relations and networks

"To understand how seed exchange is organized, we have to understand the role of seed in the community and in the farming household," Badstue says. Badstue and her team informally interviewed farmers, set up focus groups, and conducted a study to trace seed transactions. Presently they are conducting in-depth ethnographic studies of 18 households in 2 villages, including Doña María's single-person household.

The results of this research suggest that farmers' custom of routinely selecting and saving seed is central to understanding why no specialized networks or social institutions have developed to ensure access to seed. Saving seed is associated closely with being a good farmer, so it is an activity that is undertaken on an individual basis, rather than as part of a larger social group.

Seed exchanges do occur, however. Most transactions are motivated by farmers' interest in experimenting with an unfamiliar variety. Transactions take place between individuals, and the recipient carefully weighs the tradeoffs involved in obtaining seed from one person rather than another. The priority is to obtain seed from someone who can be trusted to provide reliable information and seed with desirable characteristics.

In comparison to the current, highly flexible, ad hoc approach, a permanent institution such as a seed club or community seed bank would be relatively costly. A community seed bank might also draw attention to someone's failure to save seed.

"The more we understand about practices for exchanging and managing maize seed, the better equipped the development community is to support the evolution and conservation of this important mechanism for maintaining diversity," Badstue says.

If social change reduces the effectiveness of these seed exchange networks, what could substitute for them? The answer may lie in Badstue's work. Perhaps it will be learned from Doña María, who is very much alone in a community where kinship networks are safety nets in the worst of times and the primary social and economic outlets all the time.

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Farmer Doña María, heading towards an uncertain future in Oaxaca, Mexico. What happens if social change tears apart the seed networks that sustain farming and diversity?

Telling the Untold Stories of Rural People's Lives: How Anthropological Approaches Make Research More Effective

Lone Badstue walks up and down the rows, dropping maize seeds every three feet or so and swiping dirt over them with her foot. Step, step, swipe, step, step, swipe. Nearby, the other half of the research team, Alejandro Ramírez López, walks alongside Don Leonardo, whose field they are planting today, chatting with him about his maize crop. How do you determine what maize to plant where? How did you select this seed? What other crops have you planted this year?

Don Leonardo is plowing the last few rows of his field. He steers the ox-drawn plow like a rudder as it carves straight lines down the length of the field. The soil is hard-packed after months of uncharacteristically heavy rain in this part of Oaxaca, Mexico. Don Leonardo's daughter Dionisia, dropping beans into the row next to Badstue's, jokes about Badstue's less-than-perfect sowing technique.

Badstue, an anthropologist, spends a lot of time with farmers and their families to understand how their maize production and seed management practices influence the genetic diversity of local maize varieties.

"Of course, they ask me a lot of questions, too, from how to protect their seed against pests, to what farming practices are like in Denmark, my home country," she says. This same desire for information inspires their experimentation with landraces, which is one reason for the high level of genetic diversity in their maize.

Coping with change

"Part of my job is to investigate small-scale farmers' strategies for coping with change," Badstue explains. "Maize isn't grown in a vacuum. In these households, maize production informs and is informed by every other activity. We view it as the product of social processes that change as the socioeconomic and cultural context changes." When maize diversity is conserved or lost, that outcome is the result of complex factors and decisions.

To understand how people accommodate their needs, preferences, and values to economic, political, and social change, Badstue uses an "actor-oriented approach," which acknowledges the individual's power to process experience and determine how to respond to new threats and opportunities. In choosing how to respond, these "social actors" do not passively submit to changes imposed on them from outside. They influence the outcomes of change, in part by making adjustments to their agricultural production methods.

A wider perspective

Researchers like Badstue try to make the priorities of smallholder farmers and the complex realities of their lives understood at CIMMYT and in the wider development community, so that this knowledge is incorporated into the programs, products, and techniques devised to help them. "This perspective is important if organizations like CIMMYT are truly going to work with people to develop sustainable ways of coping with the overwhelming changes occurring in the agricultural sector," says Badstue.

"People sometimes think this kind of research is too specific and localized to make a difference," she continues. "But if it enables us to work with the people of Oaxaca to conserve the diversity of their traditional maize varieties, we've probably had an impact of global importance."

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Smallholders Profit from Lucrative New Crop in Bangladesh

Maize, a new and expanding commercial crop in Bangladesh, offers smallholders options for improving income and food security. But first they have to learn how to grow it. Nur-E-Elahi is happy to help.

Maize production has increased almost three-fold in Bangladesh since 2000. Rising incomes have increased local consumption of eggs and meat, particularly poultry, and maize is the primary ingredient in poultry feed. Because maize is a relatively new crop in Bangladesh, training plays an essential role in empowering smallholders to profit from this new commodity.

The benefits of growing maize, however, are not limited to more income. CIMMYT, as part of its Whole Family Training project for maize, also seeks to improve health and nutrition in poor rural households. The project explores opportunities for households to consume and find alternative uses for the maize they grow, for empowering women in crop production, and for contributing to community development.

CIMMYT affiliate scientist Nur-E-Elahi is optimistic about these formidable objectives, based on the geometric expansion of training, womens' participation in maize production, and one notable example of community development in a poorer region of the country where the training project has played a prominent role.

Spreading the news and the profits

Whole Family Training for maize relies on a system of training trainers—usually village extension workers, either from the government or NGOs. These people conduct short workshops (roughly eight families per workshop, including husband, wife, and two older or adult children) in selected communities. Since early 2002, 228 trainers have been trained. They have facilitated workshops with 7,284 individuals in the 9 districts initially targeted by the project.

A key element of Whole Family Training is the recognition that women, even in the most conservative areas of Bangladesh, provide labor and contribute to decisions related to the production, marketing, and utilization of crops.

"Whole Family Training takes this fact into account," says CIMMYT agronomist Craig Meisner. "It acknowledges that each family determines the roles of its members. The training is inclusive. It provides knowledge and technology for everyone, independent of gender, age, or any other differences among family members."

The success of the training had been well documented for wheat (another relatively new crop in Bangladesh), but would it work for maize? Nur is encouraged by what he has seen, including one very visible indicator: poor maize farmers, even sharecroppers, now earn enough money to cover their children's school fees *and* put tin roofs on their houses (a marked improvement in the quality of life in a land where average annual rainfall is nearly two meters).

Links from farm to industry raise local prosperity

Nur has also seen the potential for broader impact at the community level in Patgram, an area long considered isolated and poor. In Patgram, local entrepreneur Mizanul Hoque, community leader Earshed Hossain, a large CSO (the Bangladesh Rural Advancement Committee, or BRAC), and CIMMYT teamed up to bring better income-producing options to farmers.

Through a business arrangement called Doyel Agro Industrial Complex Limited (DAICOL) 2002, Hoque and Hossain hoped to create a farm-to-industry project. Thanks to rapidly growing demand for poultry feed, they lined up solid commitments within the country and Southeast Asia to purchase high-quality maize. DAICOL 2002 planned to sell seed provided by BRAC (Pacific 11, which contains CIMMYT germplasm) to Patgram's farmers, provide technical backstopping, and guarantee an attractive price at harvest.

Hoque says that when DAICOL 2002 went looking for "the best source of technical support available," they were consistently referred to CIMMYT. In 2002, through the USAID-funded Whole Family Training Project for Maize, Nur and his teams of trainers came on the scene. Aside from training farm families, Nur facilitated critical support from local banks for the DAICOL initiative. "Because farmers were assured a fixed price and market," says Nur, "the local banks were reassured that they could lend farmers enough money for seed and inputs, and get their money back."

Five years ago, only about 121 hectares of maize were planted in the Patgram and Hatibanda sub-districts. In early 2003, 1,821 hectares were planted, with 2,023 hectares anticipated for 2004 as farmers clamor to join the project.

"Based on this success," Nur continues, "we have a lot of interest from government and private banks in supporting farmers and constructing a large drying and silo facility. USAID has pledged technical support for training people to work at the silo. So we can see the economic ball rolling for the area."

Aside from direct gains to farmers, 20 skilled and 40 unskilled people will be needed to run the silo. Others will earn income transporting maize to the silo and providing inputs and services to farmers. All of this creates added economic spin-offs that are greatly welcomed here and fosters optimism that farmers can benefit from Asia's maize revolution.

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CIMMYT was "the best source of technical support" to train families to profit from maize production.

Whole Family Training for Maize: The Short Course

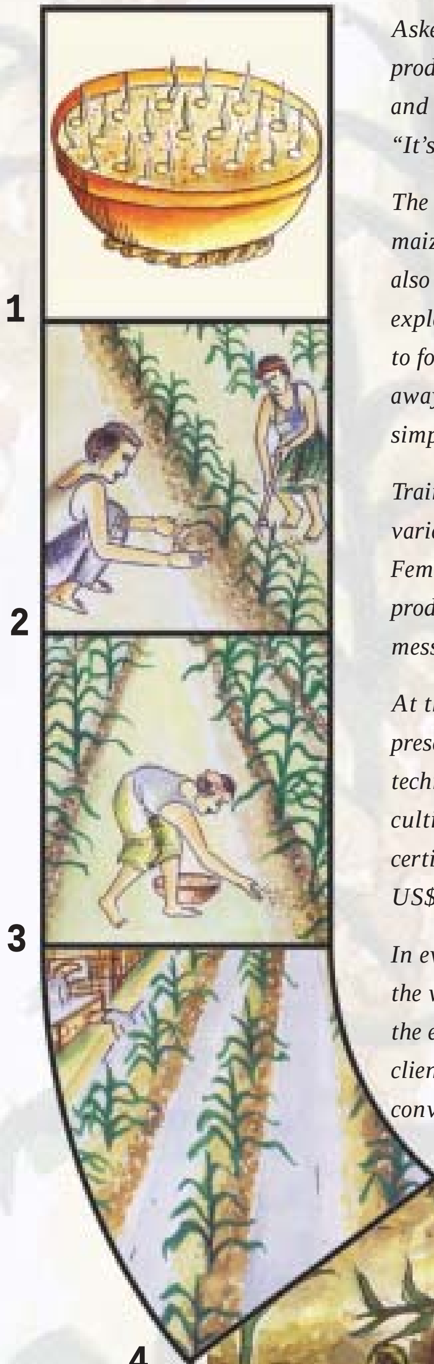
Asked to sum up how Whole Family Training works for maize producers, Nur-E-Elahi, CIMMYT affiliate scientist, grins and tosses a copy of the project's training manual on the table. "It's all right there in the figure on the cover," he says.

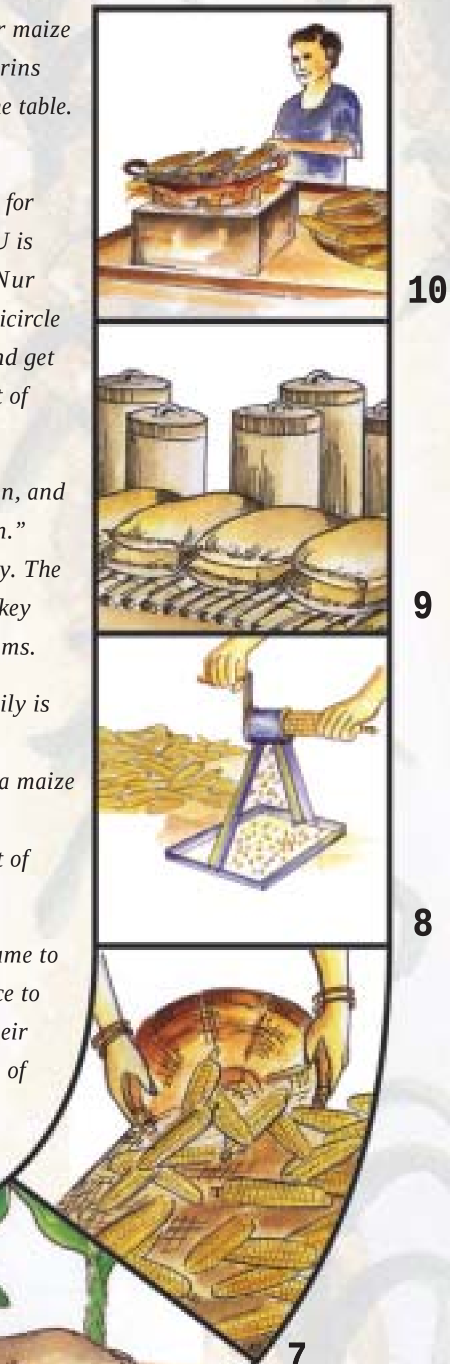
The U-shaped figure summarizes the recommendations for maize production, from seed to food. The semicircular U is also the seating arrangement for the training courses. Nur explains that farmers and trainers sit together in a semicircle to foster a sense of equality, encourage participation, and get away from formal teaching styles. Training aids consist of simple picture posters and props.

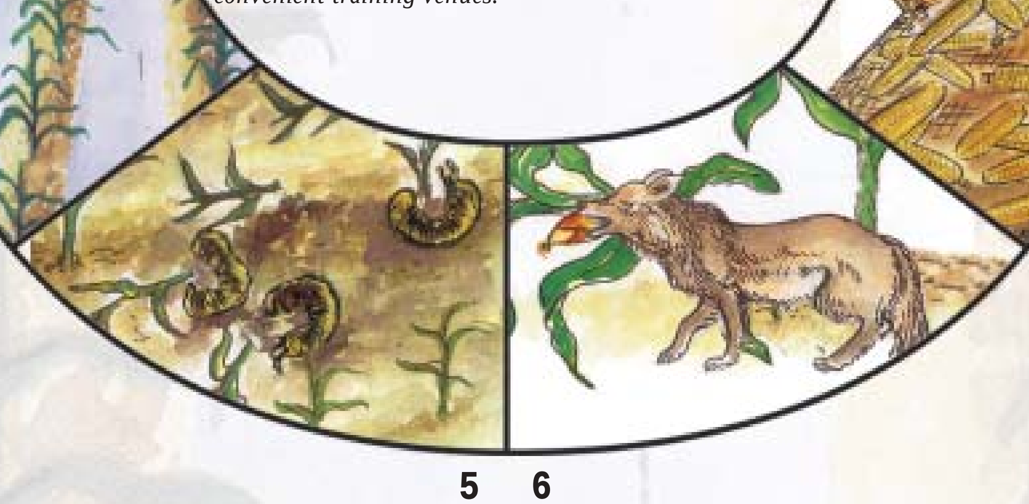
Trainers are asked to "keep training seminars active, fun, and varied to maintain interest levels and enhance retention." Females and males are encouraged to participate equally. The production recommendations are not complicated, and key messages are repeated through different training mediums.

At the end of the two-hour training seminars, each family is presented with practical incentives for trying the new technologies: a two-kilogram bag of hybrid maize seed, a maize cultivation manual depicting key recommendations, a certificate for completing the course, and the equivalent of US$ 2.50 to cover transportation costs.

In every locality, nearly 100% of the invited families came to the workshop. Nur's teams attribute the high attendance to the excellent relationships between field workers and their clientele, the personalized invitations, and the selection of convenient training venues.







1. Before planting, test seed germination.
2. Make the ridge for planting in a systematic manner. Topdress with fertilizer at the 8-leaf stage.
3. Apply the final topdress of fertilizer five days before flowering (when the top leaf appears).
4. Irrigate. The amount and timing of water is determined by soil type.
5. Monitor for cutworm damage at the 4-leaf stage.
6. Monitor for and respond to damage from jackals, birds, rodents, and thieves.
7. Sun dry the harvested crop at the homestead. Learn when maize is ready for shelling.
8. Shell manually or with a power sheller.
9. Store maize correctly to avoid losses.
10. Learn about domestic uses of maize.

Farmers and Researchers Find Common Ground in South Asia

Long before university-trained breeders arrived on the scene, farmers were the world's experts in plant improvement, but today the professional divide between them seems wider than ever. There are ways to bridge the divide—as researchers in South Asia are doing.

At a meeting in Nepal's Lallitpur District, three groups of farmers, mostly women, talk about their experiences with the new wheat varieties they chose through participatory varietal selection (PVS). "We've gotten a 100% increase in yields—from one ton to two," says Saru Godar, who heads one of the groups. "The new wheats germinate better and are resistant to diseases."

Other farmers hasten to point out that a yield of two tons is very good on their tired soils, and that now they work half as much because the new varieties are easier to harvest and thresh. As the session continues, the participants discuss the problems they still face. For example, they have to break up clods of soil by hand after plowing, or the clods will limit nutrient absorption. "Our group is planning to buy a tractor and a power tiller to break the clods. Our yields could go up to maybe three tons," says Maya Devi Silwal, leader of another farmer group.

Listening attentively are Guillermo Ortiz-Ferrara, CIMMYT wheat breeder, and Binod Sharma, head of extension at Nepal's Agriculture Department Organization (ADO) in Lallitpur District. They like what they hear. "Participatory varietal selection is a new approach for ADO," comments Sharma, "but we think it should be applied to other crops in other areas of Nepal. With PVS, farmers participate in research. There's less chance of failure and more accountability."

This interaction is one of many promoted by a CIMMYT-coordinated project on PVS that involves partners in the national agricultural research programs of Bangladesh, India, Nepal, and Pakistan. In its sixth year, the project helps farmers replace their older wheat varieties with new ones that resist disease and yield better. This new line of defense is important. If epidemics gain a foothold in South Asia, they will bring disaster to millions of farmers. The varieties that are integral to PVS are developed through strong collaboration between regional researchers and CIMMYT.

Members of the same club in Varanasi

Near Varanasi, in eastern Uttar Pradesh, India, some of the world's poorest farmers survive by growing rice and wheat in rotation. Five years ago, the Banares Hindu University team of A.K. Joshi, breeder, Ramesh Chand, pathologist, and V.K. Chandola, agriculturalist and water and machine specialist, decided to try PVS.

Prior to PVS, the team's closest contact with farmers was through on-farm trials, in which farmers tested technology as directed by the researchers. Ortiz-Ferrara suggested that PVS would give the researchers two-way communication with farmers. Before PVS, researchers were sometimes apprehensive about such interaction. Farmers might take them to task if a technology failed. Breeders ended their involvement once a new variety was developed and left technology transfer to the extension agents.

With Ortiz-Ferrara, the Varanasi team set up PVS trials in a few villages. Says Joshi, "We started building friendship bridges between us and the farmers, setting up linkages aimed at giving them options." The farmers compared their favorite variety, HUW234, and their usual practice, conventional tillage, with a technology package that included new wheat cultivars and zero tillage.

Farmers have been growing HUW234 for decades. They like its "bold" (large) grain. The variety yields less than newer varieties, but it matures early and tolerates heat. In many places, HUW234 covers as much as 90% of the wheat area, which dramatically increases the risk of a widespread epidemic if HUW234's disease resistance breaks down.

During the PVS trials, farmers identified two varieties that they liked better than their old one. The new varieties have bold grain and mature as rapidly as HUW234, but they can yield up to six tons per hectare.

As for zero tillage, the team obtained five specially adapted zero-tillage planters from the Directorate of Wheat Research in Karnal. Farmers could plant wheat 20 days earlier because they could prepare their fields faster. Farmers further reduced the time between the rice harvest and wheat sowing by growing an earlier maturing rice variety and sowing it 15 days earlier. The result: lower production costs and higher yields.

The information provided by farmers was an eye-opener for Joshi, Chand, and Chandola. Based on farmers' feedback, researchers felt they proposed more relevant solutions to local problems. The farmers were more willing to try the proposed solutions. As word of the benefits of PVS spread, the team set up similar trials in other communities. Soon the researchers were working 365 days a year to keep up with farmers' demand for PVS.

"Farmers gained confidence in themselves," says Chand. "As for us, instead of telling farmers to just take a technology, our message now is 'take only what's good, what suits your needs.'" The team gives high marks to Ortiz-Ferrara for promoting PVS. "Our entire institute has adopted the concept," says Chandola. "Today, farmers and researchers are members of the same club."

Bangladesh: On the brink of an epidemic

The biggest worry for wheat researchers in Bangladesh comes from a tremendous success: Kanchan, a variety released in 1972, occupies about 70% of the wheat area. Kanchan has become susceptible to potentially serious diseases such as leaf rust and foliar blight, so the risk of a devastating epidemic is high.

A few years ago, researchers set out to replace Kanchan with four new, disease resistant varieties derived from CIMMYT wheats. They had heard about PVS through Ortiz-Ferrara, and it struck them as a promising way for farmers to choose whether to try something new. The Bangladeshi team initiated PVS in four locations with farmers from eight villages. In the first year, farmers identified several varieties they preferred over their beloved Kanchan. The researchers are obtaining seed of these varieties to distribute to farmers in the coming season. Next year they plan to repeat the experience in other locations.

Research and funding partners

This project is funded by the Department for International Development–UK. Major partners are NARC, CEAPRED, LI-BIRD (two agricultural CSOs active in the area), the Center for Arid Zone Studies of the University of Bangore, the Rice-Wheat Consortium, the Indian Council for Agricultural Research, the Directorate of Wheat Research, and several CGIAR Centers.

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Solving the Drought Puzzle from the Genome to the Field

As agriculture reaches into more marginal areas and the effects of climate change become more pronounced, the demand for drought-resistant cereal varieties will only increase. CIMMYT, with the support of the Rockefeller Foundation, works with Cornell University and Pioneer Hi-Bred to learn what really makes plants tolerate drought.

Outside temperate ecologies, 15% of the world's maize crop, or 19 million tons, is lost every year to drought. (This loss is nearly equivalent to total annual maize production in Mexico, one of the developing world's largest maize producers.) Conventional breeding has been used to develop drought-tolerant cereals, but progress is often slow.

"Progress could be far more rapid if we understood more about key physiological and genetic aspects of the way plants respond to drought," says CIMMYT molecular geneticist and plant physiologist Jean-Marcel Ribaut. Ten years ago, Ribaut initiated research on drought tolerance at the flowering stage of development in maize, a critical period that makes the difference between crop failure and a sufficient harvest. Since then the effort to unravel the secrets of drought tolerance has gained momentum. Thanks to a dedicated team of scientists and recent collaboration with Pioneer Hi-Bred International and Cornell University, a fuller understanding of how maize plants react to drought is emerging.

Making a mosaic of the genome

Upon Ribaut's arrival at CIMMYT in 1993, he began developing segregating maize populations for drought. Segregating populations are a tool for learning about the genetic basis of a trait. A resistant or tolerant maize line is crossed with a susceptible line for a particular trait, creating what Ribaut calls "a mosaic of the genome." At this stage, by integrating phenotypic screening (an evaluation of a plant's physical characteristics, which indicate how the plant responds to the environment) with molecular analysis (an evaluation of a plant's genetic composition), scientists can begin to identify the genes and/or the genetic regions (quantitative trait loci, QTLs) that contribute to drought tolerance mechanisms.

In the early years, researchers identified QTLs related to yield components and secondary morphological traits of interest, such as flowering traits or senescence. This information is a powerful resource, but it has limitations. "It's great to characterize all those QTLs," Ribaut continues, "but we were really interested in what was going on *beneath* this level—in terms of physiological mechanisms and gene expression—to track the key pathways involved in drought response."

A picture emerges

Plant physiologist Tim Setter of Cornell University had developed techniques to research exactly those aspects of maize drought response, and Ribaut began working with him to identify these pathways in the segregating populations. Setter was interested in CIMMYT's germplasm because it was well characterized at the morphological and genetic levels, and this information was complemented by a large QTL database. Since 2001, the collaboration has intensified. Setter has provided valuable data about levels of plant growth hormones, sugars, and the osmolite proline in Ribaut's segregating material, generating about 20,000 measurements in 2002. Changes in the concentration of those components in target organs are indicative of metabolic activity, and they provide an understanding of why a given plant yields better than another when water is scarce.

"We already had the QTLs related to grain yield and traits of interest, and with Tim Setter's input, we identified QTLs for key physiological pathways related to drought response," Ribaut reflects. "Then the missing link was at the level of gene expression." The differential gene expression observed in plants that react differently under drought makes it possible to identify which particular genes, among the 40,000 present in the maize genome, play a role in regulating drought tolerance.

Ribaut's team wanted to pursue that missing link through functional genomics. Good fortune arrived in the form of Chris Zimselmeier and Jeff Habben, experts in maize functional genomics at Pioneer Hi-Bred International. Ribaut met them at a workshop on molecular approaches to drought tolerance funded by the

Rockefeller Foundation and held at CIMMYT in 1999. Soon the teams from Pioneer and CIMMYT entered a collaboration devoted to using microarrays (a genomics tool) to identify key genes with differential expression under water-limited conditions.

Ribaut's work received a big boost in 2001 when the Rockefeller Foundation funded a CIMMYT project devoted to innovative and integrated approaches to drought tolerance in maize, which was extended for an additional two years in 2003. "We've been incredibly fortunate, because all this new technology, the partners, and the support of the Foundation arrived right when we needed them," says Ribaut. "For the last decade we've been trying to put a picture of drought tolerance together like a puzzle." Ribaut gives great credit to lab companions Maria de la Luz Gutierrez and Mark Sawkins, as well as CIMMYT maize physiologist Marianne Bänziger, who played a critical role in selecting germplasm with different responses under drought and evaluating segregating populations under drought in Zimbabwe. "Through a team effort, we're starting to see the bigger picture," he says.

A wide view

The bigger picture brings three major components of understanding drought tolerance together—gene expression, metabolic pathways, and plant morphology—and reveals their interrelationships. For example, by combining information from functional genomics, data on sugar levels, and the QTL analyses, the important genomic regions involved in regulating glucose have been identified (see figure). "Through the collaborations we developed, we have those three knowledge components at our disposal. This puts us in a unique position to bridge the gap between changes in gene expression and plant phenotype," observes Ribaut.

Equipped with this knowledge, scientists have strong hopes of accelerating the development of drought-resistant maize in three ways: by creating a drought consensus map, which indicates the key genomic regions involved with drought tolerance and uses this information for marker-assisted selection; by identifying elite alleles at target genes, the presence of which would serve as predicting factors for plant breeders; and by using genetic engineering to alter specific genes or pathways.

"By engaging in a multidisciplinary approach with good collaborators, we've gained a much wider view of the problem," Ribaut concludes. "Best of all, there's more to come. The benefits of this research could extend to other cereals such as wheat, as some regulatory genes involved in drought tolerance might be common across genomes."

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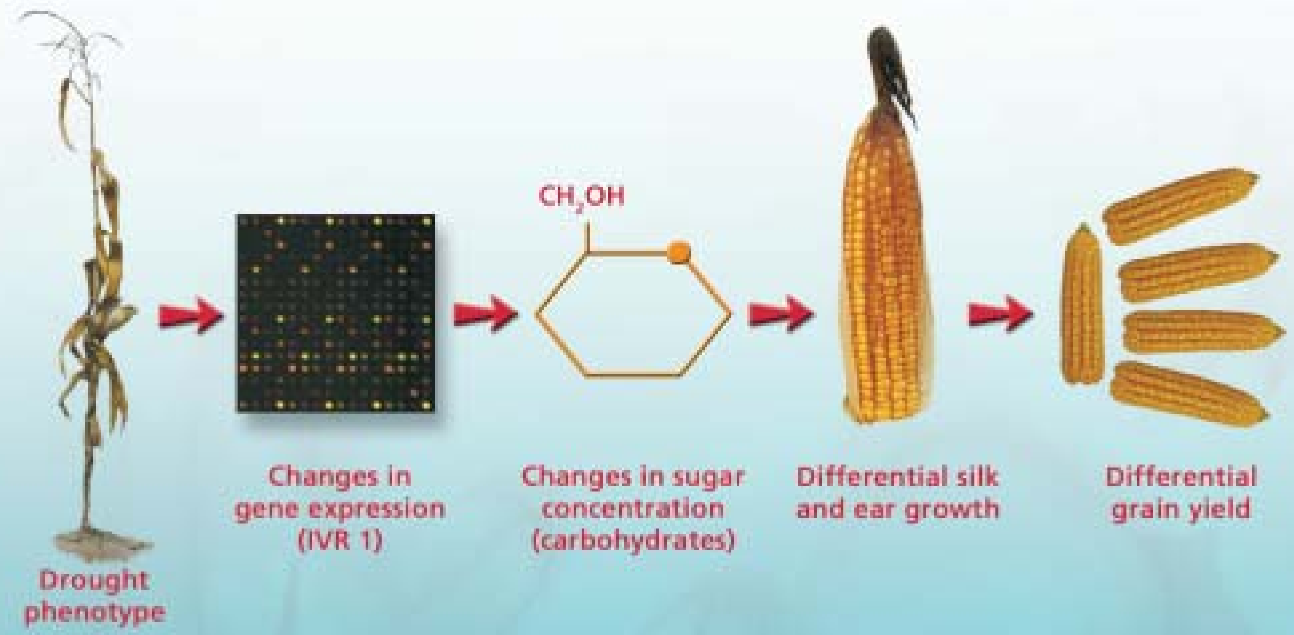
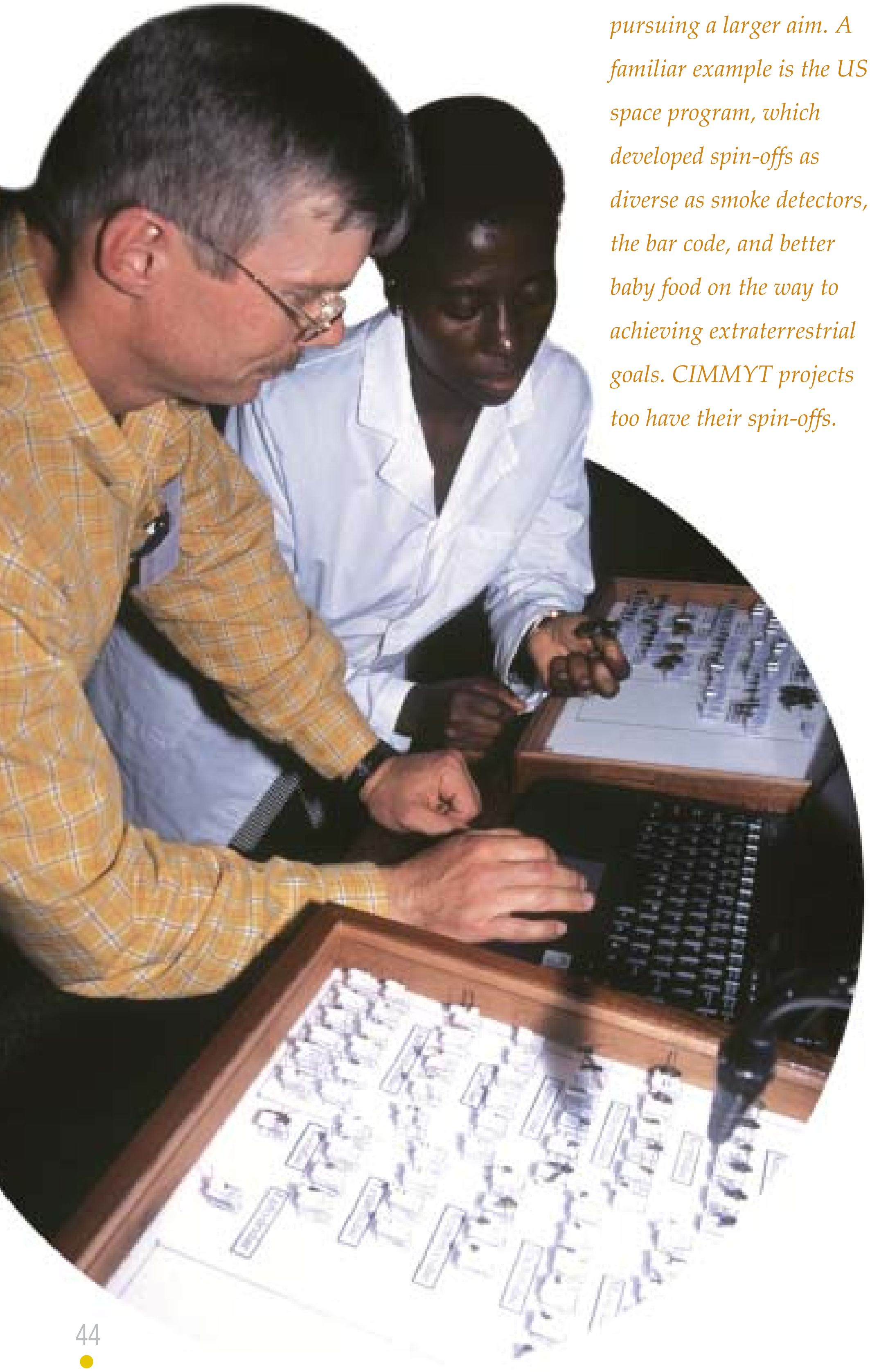


Maize Project Has Valuable Spin-offs

Spin-offs are additional benefits or products that accrue in the course of pursuing a larger aim. A familiar example is the US space program, which developed spin-offs as diverse as smoke detectors, the bar code, and better baby food on the way to achieving extraterrestrial goals. CIMMYT projects too have their spin-offs.

The Insect Resistant Maize for Africa (IRMA) project, extended in 2003 by its primary sponsor, the Syngenta Foundation for Sustainable Agriculture, is an excellent example of a project that has made lasting contributions to related areas of knowledge as it pursues its goal.

The IRMA project seeks to develop maize varieties that resist stem borers, the major insect pests of maize in East Africa. Project scientists from the Kenya Agricultural Research Institute (KARI) and CIMMYT will achieve that goal in two ways: through conventional breeding to produce more resistant plants, and through transgenic Bt maize, which produces its own insecticide targeted specifically to various stem borer species. Two spin-offs from this work are of enduring value: an arthropod reference collection for maize cropping systems in Kenya (arthropods include insects, spiders, and crustaceans), and the systematic collection of farmer's local maize varieties (landraces) and related information for Kenya's National Gene Bank.



Entomologists Josephine Songa of KARI and David Bergvinson of CIMMYT amassed an insect collection that attracted the attention of the National Museum of Kenya and is available digitally to researchers worldwide.

A classic museum collection and a digital arthropod warehouse

Before Bt maize can be released into farmers' fields, potential ecological impacts must be investigated. "To respond to this need, the IRMA project is establishing baseline data and conducting experiments to determine what impacts the technology may have on nontarget arthropods—all arthropods except stem borers," explains KARI entomologist Josephine Songa.

During the past two years, project scientists and extension personnel collected and characterized more than 101,000 arthopod specimens from maize fields in Kenya. This reference collection enables scientists to identify important arthropods associated with maize. It also helps them to monitor and study nontarget arthropods, especially natural enemies of the stem borers. In this way, potential problems can be exposed before Bt maize is released, and monitoring following release will be effective.

The reference collection is presented in two formats: preserved arthropod specimens and a digital database. "The classical wet and dry specimen collections are a necessity and an asset," says Songa, "but the digital database marks a big leap forward for expanding access to the collection through CD-ROMs and the Internet."

The arthropod collection attracted the interest of the National Museum of Kenya (NMK), because it is the first time that arthropods were systematically collected from maize growing regions. For the NMK this information represents a snapshot of arthropod diversity that will be a reference for generations to come. The collection will also be used by other KARI entomologists and university students as a technical reference.

The potential uses of the digital database extend beyond Kenya's borders. According to Songa's CIMMYT collaborator, David Bergvinson, "The digital database enables entomologists throughout East Africa and beyond to classify specimens to family level, which will enhance our monitoring of insect diversity and abundance." The database is Internet friendly and links information on the type of trap used to catch the arthropod, location of catch, and the growth stage of the maize crop at the time of collection. "This information will help many entomologists with their collecting activities, and the system as a whole could serve as a model for efforts in other ecologies and countries," says Bergvinson.

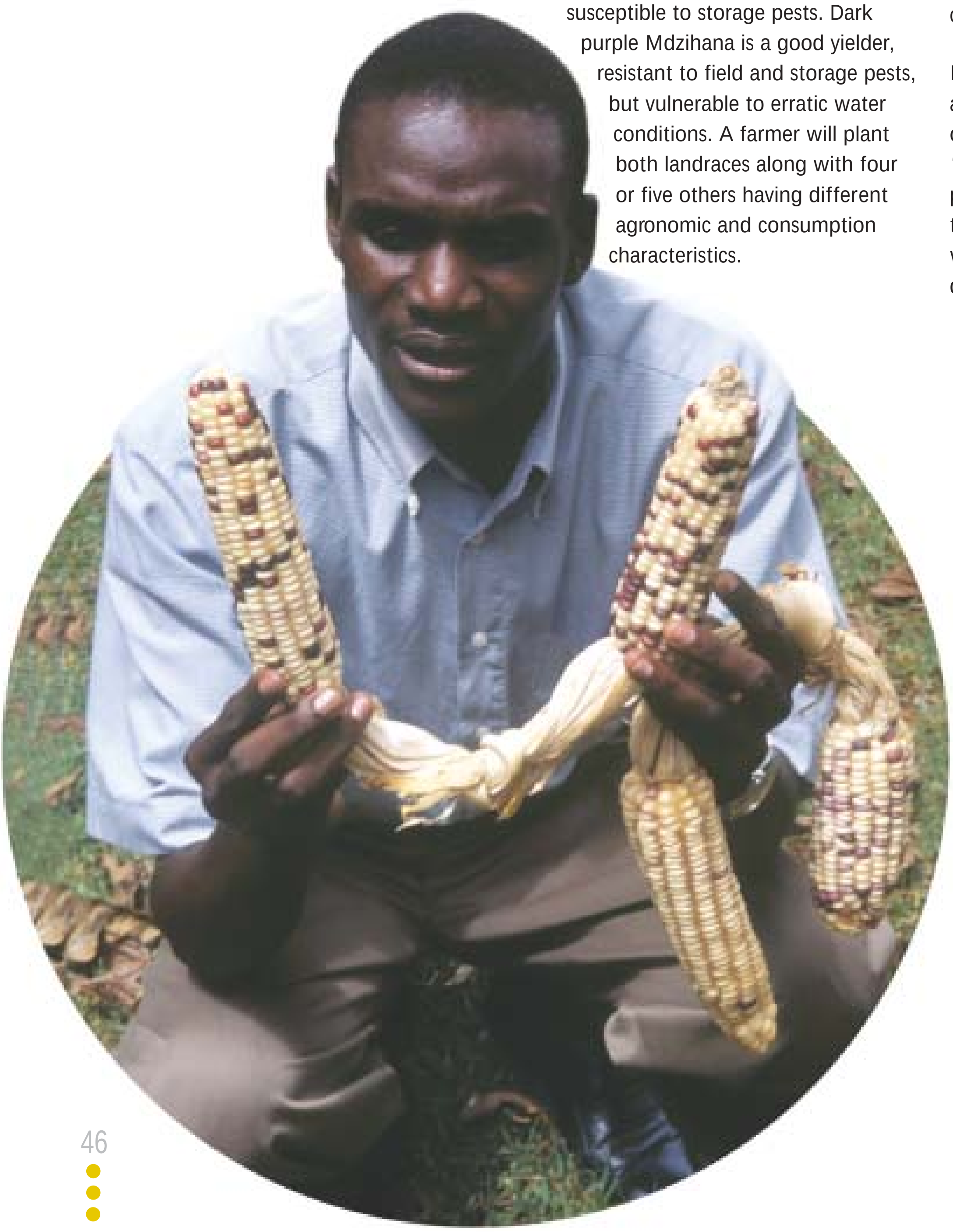
When the database is linked with a geographic information system (GIS) platform, scientists can map and track the distribution and abundance of different arthropod families and cross-reference that information with the treasure trove of environmental and crop data available in GIS databases.

Conserving knowledge of Kenya's maize diversity

Maize diversity is not limited to the cereal's center of origin and domestication in Mesoamerica. A basket of maize from coastal Kenya looks surprisingly like its conterpart in far-off Mexico—a colorful display of black, purple, red, yellow, white, and mixed-color ears of varying length and circumference. In its germplasm, too, Kenyan maize carries traits that breeders and future generations may find extremely useful.

In a modest project, CIMMYT, the International Plant Genetic Resources Institute (IPGRI), the International Food Policy Research Institute (IFPRI), and the National Gene Bank of Kenya joined forces to capture and characterize that diversity for the researchers of today and tomorrow.

CIMMYT socioeconomist Hugo de Groote and George Owuor of Egerton University conducted extensive farmer surveys as part of the IRMA project. Their primary interest was to document varieties that farmers already had in their fields, prior to the release of insect resistant maize varieties, and to learn how farmers selected varieties and seed for planting the following season. De Groote and IPGRI's Dan Kiambi explored the idea of physically collecting samples of local farmer varieties during the surveys. They obtained a small grant for collecting, with the anticipation of further funding for morphological and genetic characterization by IPGRI and KARI scientists. Guidance on collection methodologies came from IPGRI, while IFPRI's Melinda Smale contributed approaches for analyzing maize biodiversity. ▶



George Owuor, as part of the IRMA project, links local varieties and farmer seed selection strategies in his collection activities.

"This is the first such effort in maize conducted in Africa by IPGRI," says Jaime Estrella, Kiambi's successor in the project, "and though it is small, we consider it important." He was surprised by the diversity discovered.

Owuor and de Groote provide a key explanation: risk management by farmers. On the coast, farmers often grow five or six varieties. Kanjerenjere, a yellow landrace, is grown because "even when rains are variable, you get something," but it yields poorly and is susceptible to storage pests. Dark purple Mdzihana is a good yielder, resistant to field and storage pests, but vulnerable to erratic water conditions. A farmer will plant both landraces along with four or five others having different agronomic and consumption characteristics.

It is information on these unique traits and adaptations that Zachary Muthamia, officer-in-charge of the National Gene Bank of Kenya, hopes to capture. Muthamia, a breeder who undertook a two-year training in applied molecular genetics at CIMMYT, is revitalizing a collection that has fallen on hard times. "This project provides a major renewal of our maize materials and allows us to do a systematic and deliberate collection and characterization of these resources. It's an important contribution to the future," he says.

Muthamia's observation rings true for a range of spinoffs from IRMA and other CIMMYT projects. A "contribution" need not be a formal project objective or large undertaking to be significant. Just ask the people whose lives have been saved by smoke detectors.

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The science of genomics has been put to work for human health and well-being, but who benefits from these breakthroughs?

Partners from the public and private sector are marshaling resources to bring the genomics revolution to the world's poorest people.

Within five years, the 19 member organizations of the Challenge Program for Unlocking Crop Genetic Diversity hope that genomics will identify useful genetic variation among the staple crops of developing countries. Researchers will identify genes and pathways to use in improving those crops, identify marker systems to speed the selection of varieties with valuable traits, and develop integrated bioinformatics systems to organize and share the research data.

Within 10 years, in partnership with national research programs in developing countries, the Challenge Program aims to incorporate this valuable diversity into elite breeding materials and locally adapted landraces. The new lines will ultimately be passed to farmers for assessment.

Approved in July 2003, the new Challenge Program has already started its work. At the Technical Planning Workshop in Wageningen, the Netherlands, in August, there was a palpable sense of promise and excitement about focusing international expertise in genomics on crop production in areas left behind by other technological revolutions. The Challenge Program will focus on four crop groups—cereals, roots and tubers, legumes, and bananas and the forages—to ensure that all 22 CGIAR mandate crops benefit from the public development of genomic tools for crop improvement. The tools and products that the Challenge Program develops will be generic—that is, they will be applicable to any crop, any gene, and any trait. Capacity building is an integral part of the Program.

Partners include the national agricultural research systems of China (Chinese Academy of Agricultural Sciences) and Brazil (Brazilian Agricultural Research Corporation); several CGIAR Centers (CIAT, CIMMYT, CIP, ICARDA, ICRISAT, IITA, IPGRI, and IRRI), six advanced research institutes (Agropolis, John Innes Centre, Cornell University, the Comparative Cereal Genomics Initiative at Kansas State University, National Institute of Agrobiological Sciences–Japan, and Wageningen University), the Global Forum on Agricultural Research (representing CSOs and developing country farmer groups), and three private companies (Mahyco Research Centre, Bayer CropScience, and Pioneer Hi-Bred International).

The Program is generously supported by the European Union and the World Bank.

The Challenge Program for Unlocking Crop Genetic Diversity, an initiative of the CGIAR, is a global alliance to make genomics technology and genetic resources widely and publicly available to improve food crops in developing countries. It is coordinated by CIMMYT, IPGRI, and IRRI.

For more information, see **http://www.cgiar.org/pdf/cpunlocking.pdf.**

CIMMYT Funding Overview 2002-2003

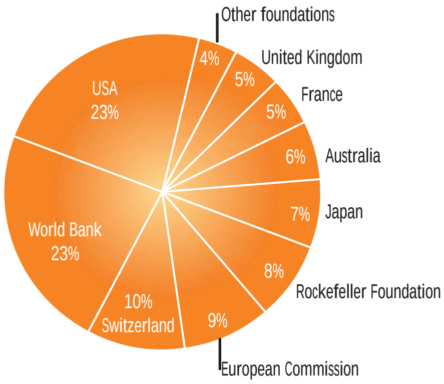

Figure 1. Top donors to CIMMYT, 2002.

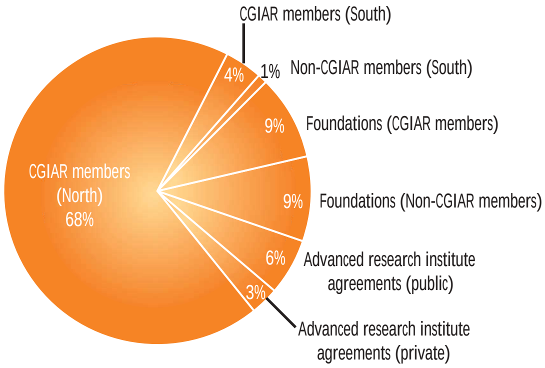

Figure 2. Investors in CIMMYT, 2002.

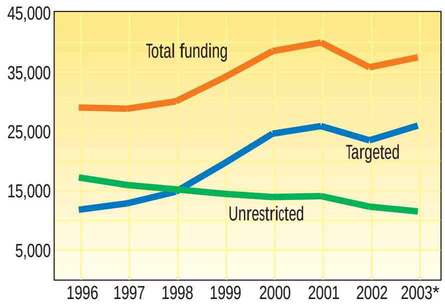

Figure 3. Trends in grants to CIMMYT (US$ 000), 1996-2002.

Funding at a glance

The 10 governments and agencies that provided the largest share of our funding in 2002 are shown in Figure 1. The contributions to CIMMYT's budget by CGIAR member countries, North and South, as well as foundations and advanced research institutes (public and private), are presented in Figure 2.

Sources of income from grants are presented in Table 1. Targeted funding continues to provide almost two-thirds of CIMMYT's research resources (Figure 3). We fully expect that the trend for core unrestricted funding to decline in relation to targeted contributions will continue to provide challenges for managing research and financing the research agenda. Full costing of projects will be more important than ever, along with the recovery of all direct and indirect costs. Indirect cost recovery is currently just less than 13%.

Funding in 2002

Total funding for 2002 was US$ 35.806 million (including other income and overhead recovery); of this funding, 81% came from CGIAR investors and 19% from other sources. Expenditures were US$ 43.933 million. The larger-than-anticipated deficit for 2002 is the outcome of unexpected funding decisions and compliance with a recommendation from our auditors to take a more prudent approach to writing off unfulfilled pledges from donors. The deficit for 2002 comprised an operating loss of US$ 1.441 million (including staff reduction costs of US$ 1.193 million) in addition to US$ 2.312 million in write-offs of unfulfilled pledges from previous years and audit adjustments.

To strengthen financial management at CIMMYT, particular attention has been given to guarding against exchange rate losses through the use of more conservative exchange rate forecasts. The Center has implemented a more thorough and stringent review of unpaid funds to avoid multi-year accumulation of bad debts. It has also taken a much more conservative approach to budgeting activities funded by core unrestricted and core restricted contributions.

Prospects for 2003-2004

The revised budget estimate for 2003 is US$ 38.8 million. Through more conservative financial management and vigorous efforts to raise additional income, CIMMYT expects to increase its working capital reserves by more than US$ 1 million by the end of 2003. The Center has embarked upon a concerted effort to raise working capital reserves to the level of 90 days by the end of 2007. Staff reductions over the past 16 months—voluntary and involuntary—have been undertaken to provide a more flexible cost structure while maintaining core competencies.

The funding landscape will also be transformed as the CGIAR Challenge Programs and other funding mechanisms come into play, and as various donors alter their CGIAR investment strategies. CIMMYT expects that participation in the CGIAR Challenge Programs will somewhat offset changes to the general support allocations of the

Table 1. CIMMYT sources of income from grants by country/entity (US$ 000s), 2002

Investor	Grant
ADB (Asian Development Bank)	**829** [1]
Australia	**1,773**
AusAID	303 [1]
Australian Centre for International Agricultural Research	603 [1]
CRC Molecular Plant Breeding	179 [6]
Grains Research and Development Corporation	683 [6]
Southern Cross University	5 [5]
Austria—IAEA (International Atomic Energy Agency)	**7** [6]
Azerbaijan—Agency for Support to the Development of the Agricultural Private Sector	**43** [3]
Belgium—Ministry of Foreign Affairs, Foreign Trade and International Cooperation	**423** [1]
Brazil—EMBRAPA (Brazilian Agricultural Research Corporation)	**40** [2]
Canada	**970**
Agriculture and Agri-Food	38 [6]
Canadian International Development Agency	924 [1]
International Development Research Centre	8 [1]
CGIAR	**190**
Centro Internacional de Agricultura Tropical (CIAT)	16 [1]
CGIAR Finance Committee	5 [1]
International Food Policy Research Institute	127 [1]
International Livestock Research Institute	3 [1]
International Plant Genetic Resources Institute	8 [1]
Standing Panel on Impact Assessment	31 [1]
China	**453**
CAAS (Chinese Academy of Agricultural Sciences)	300 [6]
Department of International Cooperation, Ministry of Agriculture	130 [2]
Lamsoo Milling Company	23 [7]
Colombia	**191**
CORPOICA (Corporación Colombiana de Investigación Agropecuaria)	41 [3]
FENALCE (Federación Nacional de Cultivadores de Cereales y Leguminosas)	11 [3]
Ministry of Agriculture and Rural Development	139 [2]
Denmark—Danish International Development Agency	**822** [1]
European Commission—Rural Development and Food Security	**2,402** [1]
Ecuador—Promsa	**25** [3]
FAO (Food and Agriculture Organization)	**21** [1]
Ford Foundation	**6** [4]
Foundation for Harvest Solutions	**753** [4]
France	**1,290**
Ministere de l'Education Nationale, de la Recherche et de la Technologie—DRIC (Delegation aux Relations Internationales et a la Cooperation)	1,191 [1]
Club Cinq (Wheat Breeding)	99 [7]
Germany	**886**
Eiselen Foundation	68 [5]
Federal Ministry of Economic Cooperation and Development	813 [1]
University of Hohenheim	5 [6]
India	**149**
Department of Agriculture, Research and Education	113 [1]
Maharashtra Hybrid Seed Co. Ltd. (Wheat Germplasm)	36 [7]
IDB (Inter-American Development Bank)	**95** [1]
IFAD (International Fund For Agricultural Development)	**439** [1]
Iran, Islamic Republic of—Ministry of Agriculture	**283** [2]
Japan	**1,948**
APN (Asian Pacific Network for Global Change Reseach)	39 [6]
Economic Cooperation Bureau, Ministry of Foreign Affairs	1,428 [1]
Nippon Foundation	472 [5]
Sasakawa Global 2000	9 [5]
Korea, Republic of—Rural Development Administration	**154** [2]
Mexico	**706**
CODEPAP (Consejo de Desarrollo de la Cuenca de Papaloapan)	4 [5]
SAGAR (Secretaría de Agricultura,Ganadería, Desarrollo Rural, Pesca y Alimentación)	324 [2]
Fundación Guanajuato Produce A.C.	30 [5]
Fundación Hidalgo	42 [5]
Fundación Sonora	169 [5]
ICAMEX (Maize and wheat improvement)	98 [7]
Grupo Industrial Bimbo (industrial quality in wheat)	39 [7]
Miscellaneous Research Grants	**128** [6]

Table 1. CIMMYT sources of income from grants by country/entity (US$ 000s), 2002

Investor	Grant
Netherlands	**274**
DGIS (Directorate General for International Cooperation)	11 [6]
Ministry of Foreign Affairs	263 [1]
New Zealand—Ministry of Foreign Affairs and Trade	**117** [1]
Norway—Royal Norwegian Ministry of Foreign Affairs	**286** [1]
OPEC Fund for International Development	**50** [1]
Other	**538** [7]
Other Foundations	**992** [5]
Peru—National Institute of Natural Resources	**60** [2]
Philippines—Bureau of Agriculture Research, Department of Agriculture	**12** [2]
Portugal—Institute for International Scientific and Technological Cooperation	**169** [1]
Rockefeller Foundation	**2,350** [4]
SCOPE (Scientific Committee on Problems of the Enviroment)	**73** [6]
South Africa, Republic of	**91**
Agricultural Research Council	40 [6]
National Department of Agriculture	51 [2]
Spain	**293**
Agrovegetal, S.A.	81 [7]
Ministerio de Agricultura, Pesca y Alimentacion	212 [2]
Sweden—Swedish International Development Agency	**277** [1]
Switzerland	**2,837**
Swiss Agency for Development and Cooperation	1,452 [1]
Syngenta Foundation for Sustainable Agriculture	1,385 [5]
Thailand—Department of Agriculture	**9** [2]
United Kingdom—Department for International Development	**1,254** [1]
UNDP (United Nations Development Programme)—Africa Bureau	**209** [1]
Uruguay—National Institute of Agricultural Research	**114** [3]
USA	**6,466**
Cornell University	7 [6]
Kansas State University	15 [6]
Monsanto Company (hybrid wheat)	162 [7]
Oklahoma State University	91 [6]
Pioneer Hi-Bred International	27 [7]
Stanford University	158 [6]
United States Agency for International Development	5,559 [1]
United States Department of Agriculture	357 [6]
Washington State University	90 [6]
World Bank	**4,309** [1]
Total Grants*	**35,806**

1) CGIAR members (North).
2) CGIAR members (South).
3) Non-CGIAR members (South).
4) Foundations (CGIAR members)
5) Foundations (Non-CGIAR members).
6) Advanced research institute agreements (public).
7) Advanced research institute agreements (private).
* Does not include Center Income of US$ 0.736M.

World Bank and other donors. We also anticipate that the introduction of performance-based funding allocations will enable CIMMYT to continue to pursue science that is based on excellence and relevance for developing countries.

In late 2003, CIMMYT anticipates that it will embark upon a new phase with the implementation of its new long–term strategy. A well-articulated strategy that is reflected clearly in CIMMYT's new project and financing plans will more clearly highlight the range of activities that CIMMYT pursues to benefit poor farmers and consumers in developing countries.

Trustees and Principal Staff

As of October 2003

Trustees

* Ex officio position.

Principal Staff

Office of the Director General

Masa Iwanaga (Japan), Director General
Claudio Cafati (Chile), Deputy Director General, Administration and Finance[2]
Pilar Junco (Mexico) Executive Assistant to the Director General
Coenraad Kramer (Netherlands), Senior Advisor to the Director General
Monica Mezzalama (Italy), Scientist, Plant Pathologist, Seed Health Unit
Agustín Muñoz (Mexico), Senior Auditor
Peter J. Ninnes (Australia), Interim Finance Director and Executive Officer
Shawn Sullivan (USA), Intellectual Property Manager and Counsel

Consultants

Anne Acosta (USA)
Norman E. Borlaug (USA)
Gerardo Leyva (Mexico)
Gregorio Martínez (Mexico)

Maize Program

Shivaji Pandey (India), Director
Ganesan Srinivasan (India), Associate Director, Principal Scientist, Leader, Subtropical Maize; Head, International Maize Testing Unit
Marianne Bänziger (Switzerland), Senior Scientist, Physiologist (based in Zimbabwe)
David Beck (USA), Principal Scientist, Breeder/Leader, Highland Maize
David Bergvinson (Canada), Senior Scientist, Entomologist
Hugo Córdova (El Salvador), Principal Scientist, Breeder/Leader of Tropical Maize
Carlos de León G. (Mexico), Principal Scientist, Pathologist/Breeder/Liaison Officer (based in Colombia)
Julien de Meyer (Switzerland), Associate Scientist, Training Coordinator
Alpha O. Diallo (Guinea), Principal Scientist, Breeder/Liaison Officer (based in Kenya)
Dennis Friesen (Canada), IFDC/CIMMYT, Senior Scientist, Agronomist (based in Kenya)
Fernando González (Mexico), Senior Scientist, Breeder (based in Nepal)[2]
Daniel Jeffers (USA), Senior Scientist, Pathologist
Fred Kanampiu (Kenya), Scientist, Agronomist (based in Kenya)
Stephen Mugo (Kenya), Scientist, Breeder (based in Kenya)
Luis Narro (Peru), Senior Scientist, Breeder (based in Colombia)
Marcelo E. Pérez (Mexico), Program Administrator
Kevin V. Pixley (USA), Principal Scientist, Breeder/Liaison Officer (based in Zimbabwe)
Joel K. Ransom (USA), Senior Scientist, Agronomist (based in Nepal)[1]
Efrén Rodríguez (Mexico), Manager, International Maize Testing Unit
Suketoshi Taba (Japan), Principal Scientist, Head, Maize Germplasm Bank
Douglas G. Tanner (Canada), Senior Scientist, Agronomist, East Africa/Liaison Officer (based in Ethiopia)
Strafford Twumasi-Afriyie (Ghana), Associate Scientist, Breeder (based in Ethiopia)
Carlos Urrea (Colombia), Associate Scientist, Breeder (based in Nepal)
Surinder K. Vasal (India), Distinguished Scientist, Breeder[2]

Bindiganavile Vivek (India), Scientist, Breeder (based in Zimbabwe)
Stephen Waddington (UK), Principal Scientist, Agronomist/NRG Associate (based in Zimbabwe)

Adjunct Scientists

Miguel Barandiarán (Peru), Breeder (based in Peru)[1]
Salvador Castellanos (Guatemala), Breeder (based in Guatemala)[2]
Duncan Kirubi (Kenya), Breeder (based in Kenya)
Philippe Monneveux (France), Adjunct Principal Scientist, Breeder/Physiologist
Sarvesh Paliwal (India), Breeder (based in India)
Neeranjan Rajbhandari (Nepal), Agronomist (based in Nepal)
Peter Setimela (Botswana), Breeder (based in Zimbabwe)

Postdoctoral Fellows

Matthew Krakowsky (USA), Breeder[2]
Slobodan Trifunovic (Yugoslavia), Breeder[2]

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Gonzalo Granados R. (Mexico), Training Consultant
Mick S. Mwala (Zambia), Breeder (based in Zambia)
Mthakati A.R. Phiri (Malawi), Socio-economist (based in Malawi)
Jens Riis-Jacobsen (Denmark)
Ashish Srivastava (India), Breeder (based in India)
Narciso Vergara (Mexico), Breeder

Wheat Program

Sanjaya Rajaram (India), Director, Distinguished Scientist[2]
Thomas S. Payne (USA), Interim Director; Senior Scientist, Head, International Wheat Improvement Network
Osman S. Abdalla (Sudan), Senior Scientist, Regional Bread Wheat Breeder, West Asia and North Africa (based in Syria)[2]
Karim Ammar (Tunisia), Associate Scientist, Triticale and Hybrid Wheat Breeder
Hans-Joachim Braun (Germany), Principal Scientist, Head, Winter Wheat Breeding/Liaison Officer (based in Turkey)
Efrén del Toro (Mexico), Administrative Manager[2]
Etienne Duveiller (Belgium), Senior Scientist, Regional Pathologist, South Asia (based in Nepal)
Guillermo Fuentes Dávila (Mexico), Senior Scientist, Pathologist (Bunts/Smuts)[2]
Lucy Gilchrist Saavedra (Chile), Senior Scientist, Pathologist (Fusarium/Septoria)[2]
Arne Hede (Denmark), Scientist, Facultative and Winter Wheat Breeder (based in Turkey)
Monique Henry (France), Scientist, Pathologist (Virologist)[1]
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Alexei Morgounov (Russia), Senior Scientist, Regional Representative Wheat Breeder/Agronomist, Central Asia and Caucasus (based in Kazakhstan)
A. Mujeeb-Kazi (USA), Distinguished Scientist, Head, Wide Crosses
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Roberto J. Peña (Mexico), Principal Scientist, Head, Industrial Quality
Wolfgang H. Pfeiffer (Germany), Principal Scientist, Head, Durum Wheat Breeding
Matthew P. Reynolds (UK), Senior Scientist, Head, Physiology
Kenneth D. Sayre (USA), Principal Scientist, Head, Crop Management
Ravi P. Singh (India), Principal Scientist, Geneticist/Pathologist (Rusts)
Bent Skovmand (Denmark), Principal Scientist, Head, Wheat Germplasm Bank and Genetic Resources[2]
Richard Trethowan (Australia), Senior Scientist, Spring Bread Wheat Breeder (Marginal Environments)
Maarten van Ginkel (Netherlands), Principal Scientist, Head, Spring Bread Wheat Breeding (Optimum Environments)
Reynaldo L. Villareal (Philippines), Principal Scientist, Head, Germplasm Improvement Training[2]
He Zhong-Hu (China), Principal Scientist, Regional Wheat Coordinator, East Asia (based in China)

Adjunct Scientists

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Sae-Jung Suh (Korea), Breeder

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Morten Lillemo (Norway), Wheat Breeder
Garry Rosewarne (Australia), Molecular Geneticist
Jiankang Wang (China), Breeder

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Bram Govaerts (Belgium), Catholic University of Leuven
Sybil Herrera (Sweden), Swedish University of Agricultural Sciences

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David Bedoshvili (Georgia)
Jesse Dubin (USA)
Guillermo Fuentes Dávila (Mexico)
Lucy Gilchrist Saavedra (Chile)
Man Mohan Kohli (India)
Bill Raun (USA)
George Varughese (India)
Reynaldo Villarreal (Philippines)
Hugo Vivar (Ecuador)

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Javier Ekboir (Argentina), Scientist, Economist[1]
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Maximina Lantican (Philippines), Research Associate, Economist
Mulugetta Mekuria (Ethiopia), Scientist, Economist (based in Zimbabwe)
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Adjunct Scientist

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David Watson (UK)

Natural Resources Group

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Eduardo Martínez (Mexico), GIS Analyst
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María Luisa Rodríguez (Mexico), Program Administrator
Marcos Peñalva (Uruguay), Research Associate, Agronomist
Patrick C. Wall (Ireland), Principal Scientist, Conservation Tillage and Agriculture Specialist
Jeff White (USA), Senior Scientist, Head, GIS/Modeling Laboratory[1]

Adjunct Scientists

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Zondai Shamudzarira (Zimbabwe) (based in Zimbabwe)
Bernard Triomphe (France), CIRAD, Agronomist[2]

Pre-doctoral Fellows

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Parvesh Chandna (India), GIS and Remote Sensing (based in India)
Ravish Chandra (India), Irrigation Water Management (based in India)
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Bernard Kamanga (Malawi), Participatory Research Specialist (based in Malawi)
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G. Panaullah (Bangladesh), Arsenic/ Soil Science (based in Bangladesh)
Shahid Parvez (Nepal), Social Sciences (based in India)
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M.A. Razzaque (Bangladesh), Liaison (based in Bangladesh)
Samar Singh (India), Weed Management (based in India)

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D. Jha (India)
Jens Riis-Jacobsen (Denmark)
Ashok Seth (India)
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Applied Biotechnology Center

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Alessandro Pellegrineschi (Italy), Scientist, Cell Biologist
Enrico Perotti (Italy), Scientist, Molecular Biologist (based in Australia)
Mark Sawkins (UK), Associate Scientist, Molecular Geneticist
Marilyn Warburton (USA), Senior Scientist, Molecular Geneticist
Manilal William (Sri Lanka), Scientist, Molecular Geneticist

Adjunct Scientists

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Daniel Grimanelli (France), IRD/ France, Scientist, Molecular Geneticist
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Postdoctoral Fellows

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Gael Pressoir (France), Institut Agronomique de Paris-Grinon/France
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Administration

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Eduardo Mejía (Mexico), Head, Security
Ma. del Carmen Padilla (Mexico), Teacher, Childcare Center
Fernando Sánchez (Mexico), Head, National Staff

Consultant

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Visitor, Conference, and Training Services

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Information and Multimedia Services

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Satwant Kaur (Singapore), Writer/ Editor[1]
G. Michael Listman (USA), Senior Writer/Editor
Alma L. McNab (Honduras), Senior Writer/Editor and Translations Coordinator
Miguel Mellado (Mexico), Head, Publications Production
David Poland (USA), Writer/Editor

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Kristian Harrington (USA)
Jennifer Nelson (USA)

Library

Fernando García (Mexico), Interim Head Librarian
John Woolston (Canada), Visiting Scientist

Experiment Stations

Fernando Delgado (Mexico), Field Superintendent, Toluca
Raymundo López (Mexico), Field Superintendent, Agua Fría
Francisco Magallanes (Mexico), Field Superintendent, El Batán
Rodrigo Rascón (Mexico), Field Superintendent, Cd. Obregón
Abelardo Salazar (Mexico), Field Superintendent, Tlaltizapán[1]

Research Coordinating Committee

Larry W. Harrington, Director, Natural Resources Group
David Hoisington, Director, Applied Biotechnology and Bioinformatics
Masa Iwanaga, Director General
Coenraad Kramer, Senior Advisor to the Director General
Michael Morris, Director, Economics Program
Peter J. Ninnes, Interim Finance Director and Executive Officer
Shivaji Pandey, Director, Maize Program
Thomas S. Payne, Interim Director, Wheat Program

Management Committee

Larry W. Harrington, Director, Natural Resources Group
David Hoisington, Director, Applied Biotechnology and Bioinformatics
Masa Iwanaga, Director General
Coenraad Kramer, Senior Advisor to the Director General
Michael Morris, Director, Economics Program
Peter J. Ninnes, Interim Finance Director and Executive Officer
Shivaji Pandey, Director, Maize Program
Thomas S. Payne, Interim Director, Wheat Program

Visiting Scientists

for terms of at least 2 months, September 2002 to September 2003
Delphine Benard (France), Natural Resources Group
Daniel James Biggs (UK), Wheat Program
Md. Mahfuzul Hoque (Bangladesh), Bangladesh Agricultural Research Institute, Maize Program
Geoffrey Mwimali Murenga (Kenya), Kenya Agricultural Research Institute, Applied Biotechnology Center
Catherine Ongecha Ngaah (Kenya), Kenya Agricultural Research Institute, Applied Biotechnology Center
Claudia Andrea Bedoya Salazar (Colombia), Applied Biotechnology Center
Zahoor A. Swati (Pakistan), Institute of Biotechnology and Genetic Engineering, Wheat Wide Crosses
Antonin Vergez (France), Natural Resources Group

[1] Left in 2002
[2] Left in 2003

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CIMMYT Worldwide

Mission

CIMMYT acts as a catalyst and leader in a global maize and wheat innovation network that serves the poor in developing countries. Drawing on strong science and effective partnerships, we create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources.

Focus

CIMMYT focuses on regions in which maize and wheat, together or separately, are important to people's livelihoods and have potential to help alleviate poverty and sustain the environment. With our partners, we develop solutions tailored specifically to the needs of small-scale farmers.

Partners

We benefit from the expertise of colleagues in national agricultural research and extension programs, universities, and other centers of research excellence throughout the world; in the donor and development community; and in civil society organizations, farmer, community, and self-help groups. Together, we sustain the global innovation network for maize and wheat.

Funding

CIMMYT thanks the many governments and organizations that help us to achieve our mission. We owe a special debt of gratitude to those who support our core activities. The impacts described in this publication would have been impossible to achieve without that support. For information on how to support our work, contact cimmyt@cgiar.org.

Activities

To achieve the UN Millennium Development Goals of eradicating extreme hunger and poverty by 2015, the number of people living on less than US$ 1 per day must fall from 1.3 billion to 650 million. Every year, an additional 22 million people must escape hunger. To reach these goals, many organizations must act on many fronts. CIMMYT and its partners help by:

- Conducting research to develop better seed and cropping practices.
- Conserving and using the great diversity in maize and wheat seed for future generations.
- Advocating appropriate policies to foster food and income security.
- Advising relief organizations on appropriate seed to distribute after famine, floods, war, and other disasters have destroyed farmers' seed stocks.
- Providing other kinds of information, training, and expertise.
- Forming alliances to give farmers access to better seed, cropping practices, and information.

Locations

CIMMYT is an international, nonprofit organization with offices throughout the world.

Visit CIMMYT at www.cimmyt.org.

CIMMYT