The CIMMYT Maize Program

1997-98 Research Highlights

The CIMMYT Maize Program helps the poor in developing countries by increasing the productivity of resources committed to maize while protecting natural resources. It accomplishes this by preserving, improving, and distributing seed; by developing and disseminating environmentally friendly crop management practices; by perfecting research methodologies and sharing this and other useful information with partners worldwide; and by strengthening maize research in developing countries through training and consulting.

The following highlights provide an overview of the Program's recent progress and achievements in collaboration with partners in developing countries and advanced research institutes worldwide — all in benefit of developing country farmers and consumers.

CIMMYT

Sustainable Maize and Wheat Systems for the Poor

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Research for Sub-Saharan Africa: Feeding the Needy, Shepherding Scarce Resources

Household food security and resource conservation are the watchwords of the Program's work to help farmers in sub-Saharan Africa, who are among the world's neediest. For example, under a project funded by the Swiss Agency for Development and Cooperation and executed through the CIMMYT-Zimbabwe office, a CIMMYT maize physiologist is helping breeders in drought-prone eastern and southern Africa to develop drought and low-nitrogen tolerant varieties and hybrids using a stress-selection methodology perfected at CIMMYT headquarters. Though scarcely two years old at this writing, the work has already begun to bear fruit: breeders in the region are now widely applying the approach and one maize genotype, 169(M37W/ZM607#bF37sr// P43C9-1), shows great promise under both drought stress and favorable conditions (meaning that farmers who use such stress tolerant seed would obtain at least 25% better yields in dry years but suffer *no* yield penalty in seasons of good rainfall). To help farmers avoid late-season drought damage or fit an additional crop into intensive, multi-cropping systems, Program breeders at headquarters and in Zimbabwe, in collaboration with national program researchers, have recently developed high yielding, early maturing, open-pollinated varieties adapted to sub-Saharan African environments.

The Maize and Wheat Improvement Research Network (MWIRNET), a network of national program breeders and CIMMYT established in 1994 and funded by the European Union, supports 23 research projects on soil fertility, drought, early maturity, and disease resistance across Angola, Botswana, Lesotho, Malawi, Mozambique, Swaziland, Tanzania, Zambia, and Zimbabwe. Several good maize genotypes have been developed and over 260 scientists trained through the network.

The Maize Program's recently initiated efforts in the African highlands involve collecting and classifying local varieties for their heterotic patterns and, with these and other selected sources, developing superior populations for use by national maize research programs. Other germplasm-related research focuses on improving resistance to maize streak virus, an ever-present threat for the region's harvests, and to gray leaf spot, a once-minor disease caused by the fungus *Cercospora zeae-maydis* that increasingly attacks local maize fields. Finally a hybrid based on two CIMMYT maize inbred lines, CMLs 202 and 206, was released in Uganda in mid-1998.

Resource-conserving practices for subsistence farmers

The Soil Fertility Research Network for Maize-Based Cropping Systems in Malawi and Zimbabwe is a web of some 80 national program agronomists and extension staff working on soil fertility issues. With funding from the Rockefeller Foundation and coordination and technical input from an agronomist in CIMMYT's regional office at Harare, Zimbabwe, the network has

sharpened the research focus of participants, enhancing their interactions and those with farmers, and allowed them to pool resources to address common problems. Among its many achievements, the network has developed best-bet technologies for a range of soil conditions, especially more efficient organic and inorganic fertilizer practices and the use of various grain legumes (such as naturally nodulating soybean) or green manures in association with maize. Maize Program regional staff in Kenya have successfully explored similar options in collaborative research with the Kenyan Agricultural Research Institute, particularly a maize-cowpea rotation that increases maize yield and reduces weed pressure, while helping to maintain soil fertility.

Regional sharing of information

Professional meetings are another form of networking through which researchers can exchange experiences and access cutting-edge technical expertise. Some 150 maize scientists from 23 countries shared results and viewpoints at the 6th Eastern and Southern African Regional Maize Conference in Addis Ababa, Ethiopia, in September 1998. Organized by CIMMYT and the Ethiopian Agricultural Research Organization, the conference covered among other issues biotechnology and intellectual property policies and community-based seed production models being tested in Kenya, Tanzania, Ethiopia and West Africa. In addition, CIMMYT maize agronomist Joel Ransom (recently moved to Nepal) was honored for 13 years of service in eastern Africa and his active role in promoting research to control *Striga* spp., a parasitic plant that annually reduces African grain harvests by four million tons.

Helping Asian Maize Farmers Keep Pace with Rising Demand

Through its Asian Regional Maize Program (ARMP) based in Bangkok, Thailand, CIMMYT works with national maize programs to develop high-yielding, stress-tolerant, input-efficient maize varieties and hybrids suited to Asia's intense cropping systems and helping farmers meet the explosion in demand for maize. In recent advances, results of four cycles of simultaneous recurrent selection in ARMP maize populations show a 12% average reduction in infection by downy mildew (the region's most widespread maize disease), a 10% reduction in turcicum disease, and 4.7% yield increase per cycle – an overall gain of 1.2 tons per hectare in grain yield (Fig. 1).

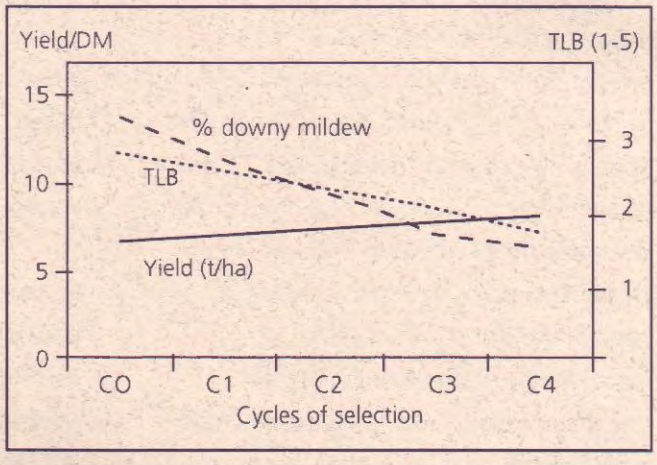

Figure 1. Average grain yield over four cycles of selection for resistance to downy mildew and turcicum leaf blight (TLB) in two early-maturing maize populations, Indimyt 100 and 145. Data from Nagenahalli, India, and Suwan, Thailand. The left axis applies to yield and % downy mildew infection; the right axis to TLB infection (1-5 scale).

The ARMP has made available to partners two new heterotic maize populations (351 and 352) and 30 superior lines inbred to S_3. To help researchers in their vigorous efforts to develop and disseminate hybrid technology, the ARMP has organized a series of regional training courses on maize population improvement and hybrid breeding, dealing with such topics as heterotic patterns, testers, seed production, experimental designs, and computer applications, among many others. Courses have been offered so far in India, China, Nepal, Philippines, and Thailand, in collaboration with the agricultural research programs and universities of those countries. The most recent event in Thailand drew 80 participants from a range of public and private institutions, including practically all maize seed companies operating in Thailand, and provided a cost-effective opportunity for researchers to interact and share practical solutions on issues of common interest.

Seed, Soil, and Science in Central America and the Caribbean

A review of maize research impacts in Central America and the Caribbean in early 1998 showed that 75% of improved seed used in the region is based on CIMMYT germplasm, contributing about 50 million dollars annually to the regional economy — *100 times* the center's annual budget there. Work with research partners in El Salvador to fine-tune and disseminate improved crop residue management practices, along with use of hybrids and adequate fertilization, has helped subsistence farmers in the Guaymango area increase their maize yields from from 1 to 4 tons per hectare, while improving soil fertility. Work to promote zero tillage in Azuero, Panama, began in 1985. Now, more than 60% of the farmers there use this technology and its popularity continues to rise. These and other achievements belong to the Regional Maize Program for Central America and the Caribbean (the Programa Regional de Maíz, or PRM), a network of maize researchers from nine countries and CIMMYT that is funded by the Swiss Agency for Development and Cooperation. Maize Program staff are now working through the PRM, in concert with national programs and other entities, to help restore the maize seed production and breeding capacity of several countries that were catastrophically hit by hurricane Mitch.

The South American Regional Maize Program: Stress-Tolerant Maize for Acid Savannas

Acidic soils limit maize yields on large tracts of land in West and Central Africa, Southeast Asia and, most widely, in South America. Recent advances in CIMMYT's South American Regional Maize Program (SARMP) include work to develop maize with combined resistance to diseases, insects, and other biotic stresses, while improving its tolerance to acid soils. Staff there have made available to research partners 10 outstanding CIMMYT maize lines (CMLs) that are also acid tolerant; nearly 70 more should be ready soon. For an idea of the potential of this germplasm, experimental hybrids developed using selected CMLs outyield Sikuani (a popular acid-tolerant variety developed by the Colombian Agricultural Research Corporation in 1994 using CIMMYT germplasm) by 50% in acidic soils and provide 25% more grain than commercial

and local checks in *normal* soils. Most SARMP efforts are targeted to South America, but its products are tested and distributed worldwide and research partners working for farmers in distant Asia have found SARMP seed useful. The Central Mindanao University, Musuan, Mindanao, the Philippines, for example, recently released several maize cultivars — CMU9422 and CMU9424 in 1996 and CMU9421, CMU9423, and CMU9425 in 1997 — that contain germplasm from CIMMYT maize research in South America.

Breeding and Other Maize Research Activities at CIMMYT Headquarters

For the ***lowland tropics***, recent results show that new CIMMYT hybrids yield 15% more than the best commercial checks. A three-way hybrid, H-59, developed using two CIMMYT inbred lines and germplasm from El Salvador, took only three years to go from research "drawing boards" to farmers' fields in El Salvador. Some 200 tons of H-59 seed was sown by farmers in 1998 and 210 hectares planted by seed producers for sale in 1999. The Maize Program will continue to develop hybrid-oriented germplasm for niches not served by private companies but is also renewing its emphasis on open-pollinated varieties targeted to small-scale farmers in more marginal areas. One approach is to produce "synthetics" — varieties developed by inter-mixing several inbred lines. In this case, Program staff are selecting lines that possess high general combining ability, superior performance, and morphological uniformity.

In the ***subtropical*** *maize* subprogram, staff had previously identified a hybrid, CMS 935005, which outyielded the best checks at 14 of 16 sites in tests during 1994 and 1995. Newer hybrids yielded more than CMS 935005 and the best checks at 15 of 16 sites in 1997. Similarly, in 13 of 14 trials in 1997, still newer hybrids were superior to both the Maize Program's best reference entry *and* local checks. Breeders have begun experimenting with modified single-cross hybrids involving related lines, and several have shown outstanding yields. Maize products from the subtropical subprogram have performed especially well in trials in India and China and are being used extensively in breeding programs in those countries.

The ***highland maize*** subprogram can rightly claim a contribution to the increased interest in maize for this ecology in Mexico: 19 hybrids currently sold by public and private institutions in the Mexican highlands contain CIMMYT germplasm. While continuing to serve producers of all types, the highland maize subprogram is re-dedicating itself to developing and disseminating products — especially open-pollinated varieties — for the many small-scale, tropical highland farmers who have yet to benefit from improved maize technology.

In the meantime, in 1998 CIMMYT maize breeders made available to our partners 58 outstanding ***new inbred lines*** — 29 adapted to the lowland tropics, 19 for the subtropics, and 10 targeted to tropical midaltitudes — along with detailed information on their performance, ecological adaptation, grain type, maturity, and stress tolerance (Fig. 2).

Maize Program ***entomology*** research has aided in identifying 40 inbred lines that possess tolerance to fall armyworm and maize stem borers, the crop's most damaging field pests in the tropics. The lines are being tested in hybrid and synthetic combinations. With regard to resistance mechanisms, staff have observed that leaf toughness lowers insect feeding and is *not* negatively correlated with yield. Molecular research at CIMMYT has found five markers associated with segments on chromosomes 1 and 8 that account for nearly two-fifths of the phenotypic variation for leaf toughness. In the field, on-farm tests of CIMMYT's insect resistant maize populations have shown that, in addition to high yields, the populations have better grain quality because they avoid *Stenocarpella maydis* ear rot. One interesting finding of recent research is that the presence of certain abiotic constraints – such as low nitrogen conditions – actually *reduces* field damage from insects. Finally, an overriding concern of maize farmers throughout the tropics is damage to grain from storage pests, especially larger grain borer, *Prostephanus truncatus*, and maize grain weevil, *Sitophilus zeamais*. Maize Program staff have identified source materials that possess resistance to these pests, and are now working in cellular and DNA studies to single out the mechanisms underlying resistance, with an eye to transferring this trait into elite maize genotypes.

The Maize Program ***pathology*** unit performs invaluable research on ear rots, stalk rots, leaf diseases, corn stunt, and other major maize diseases, as well as helping Program scientists to screen and evaluate their experimental varieties for disease resistance. This work has led to the identification of outstanding inbred lines that possess resistance to more than one

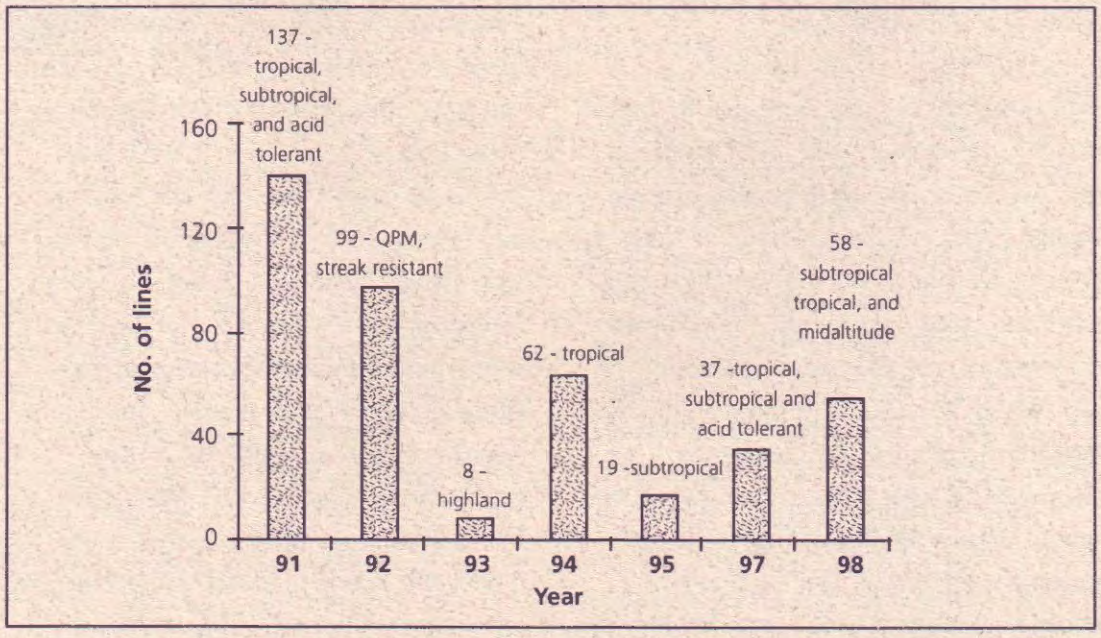

FIGURE 2. NUMBER AND TYPE OF CIMMYT MAIZE LINES (CMLS) MADE AVAILABLE TO RESEARCH PARTNERS, 1991-98.

maize disease or pest: CML 202, which is resistant to maize streak virus (the crop's most damaging disease in sub-Saharan Africa), and MBR-ET{W}10-2-2-1-B-5-B-#, which is partially resistant to Southwestern corn borer (*Diatraea grandiosella),* are also highly resistant to turcicum disease, and both lines perform very well in hybrid combinations. CIMMYT's maize pathologist has also been particularly active in designing and fine-tuning more effective, less costly techniques for applying disease pressure to experimental maize. In one example, he has found that applying virulent isolates of maize streak virus directly to the plant through a vascular puncture technique is just as effective in identifying resistant maize genotypes as the traditional, more expensive method of mass rearing leaf hoppers (the insect carrier of the virus), letting them feed on infected plants in the greenhouse, and then placing them onto experimental maize plots. In another example, results of a recent test of 50 subtropical inbred lines for tolerance to turcicum blight suggest that tolerance can be best characterized by the latency period and the number and size of lesions.

After several years' discontinuance for lack of funding, research on maize with enhanced protein quality, also know ***quality protein maize*** (QPM), has been resumed in response to renewed interest from donors and research partners. China, for example, has committed to increasing its QPM maize area from 100,000 to 200,000 ha by the year 2000. The Mexican Secretary of Agriculture has expressed personal interest in promoting the use of QPM in *tortillas*, the corn cake that underpins the diet of all Mexicans and is especially important to the poor. The Mexican National Institute of Forestry, Agriculture, and Livestock Research (INIFAP) has responded with enthusiasm, and there are projections for some two million hectares of QPM on-farm by 2001. The Maize Program has sent QPM germplasm for testing in Brazil, Colombia, Ethiopia, Ghana, Guatemala, India, Mexico, Mozambique, Thailand, and Zimbabwe, among other countries. Hybrids with enhanced protein quality are comparing well with the normal hybrids in yield, endosperm hardness, ear rot resistance, and other key agronomic traits. An associate scientist from Ethiopia is working at CIMMYT to convert lines from the Ethiopian national maize program and CIMMYT synthetics into QPM, as well as increasing seed of CIMMYT QPM for international testing. Much of this work is funded by the Nippon Foundation.

Human resource development of all types is a long-term Maize Program concern. In 1998, the Program offered another in its series of advanced breeding research courses for experienced researchers and research directors from partner countries. On this occasion, invited speakers included such internationally renowned US maize scientists as Jim Coors (University of Wisconsin), Mike Lee (Iowa State University), Don Gordon (Ohio State University,) and Dawn Luthe (Mississippi State University). The Program also helped organize and support regional crop management research training courses for Asia (located in Bangkok, Thailand), and Latin America and Portuguese-speaking Africa (operated by the Brazilian Agricultural Research Enterprise, EMBRAPA, at Sete Lagoas, Minas Gerais, Brazil). Many other training courses in stress tolerance, seed production, hybrid breeding, and population improvement have been organized by the Program's regional scientists.

The Program is pursuing ***collaborative research in CIMMYT*** designed to enhance the quality and targeting of its outputs. With the CIMMYT Applied Biotechnology Center, initiatives include DNA fingerprinting of selected germplasm, molecular marker-assisted backcrossing to endow elite lines with resistance to maize streak virus, and the development and careful deployment of transgenic maize that possesses insect resistance and other locally valued traits for Africa and Asia. With the CIMMYT Natural Resources Group, geographic information systems (GIS) are being applied to address crucial maize research issues in Africa and Nepal. With the CIMMYT Economics Program, staff are assessing the impacts of international maize research in Asia and Latin America and examining research priority setting and maize demand and supply issues in Asia (especially Nepal and Indonesia) and Africa.

Staff, Strategies, and New Directions

One notable, recent change was the appointment in late 1997 of Shivaji Pandey, a respected researcher and leader of a highly successful CIMMYT regional effort, as Director of the Maize Program. In his new position, he has spearheaded efforts to adapt the Program to rapidly changing circumstances, among other things working with staff to develop a document that outlines strategies for 1998 and beyond, identifies niches and areas of comparative advantage for Program efforts, and describes opportunities for collaboration and complementation with research partners in developing countries and within CIMMYT. Specific points in the new strategy include:

- Strengthening work in genetic resources and pre-breeding, uniting the two activities.
- Increasing efforts to develop relevant maize technologies for the many maize farmers not serviced by the private sector. (Hybrid research will continue, though, particularly in support of national programs and incipient, domestic seed industries.)
- Improving complementation between headquarters and regional activities.
- Restoring an aggressive, pro-partner international testing and germplasm distribution system.
- Increasing collaboration with the CIMMYT Applied Biotechnology Center (ABC), Economics Program, and Natural Resources Group (NRG) to enhance research efficiency, priority setting, and technology targeting, as well as to maximize spill-over effects.
- Seeking enhanced research cooperation with partners and, where appropriate, farmers.

Long-time regional agronomist Joel Ransom, formerly posted in eastern Africa, was chosen to head a project in Nepal to develop and deploy productivity-enhancing, resource-conserving technologies appropriate to farmers' circumstances and fragile hill environments. Dennis Friesen, a highly experienced agronomist and soil scientist with the International Fertilizer Development Center (IFDC), is replacing Joel in Kenya. Fernando González, former CIMMYT research fellow and later breeder with DeKalb in Mexico, was appointed to work in CIMMYT's Asian Regional Maize Program.

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FUTURE HARVEST

CIMMYT supports Future Harvest, a public awareness campaign that builds understanding about the importance of agricultural issues and international agricultural research. Future Harvest links respected research institutions, influential public figures, and leading agricultural scientists to underscore the wider social benefits of improved agriculture—peace, prosperity, environmental renewal, health, and the alleviation of human suffering (www.futureharvest.org).

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