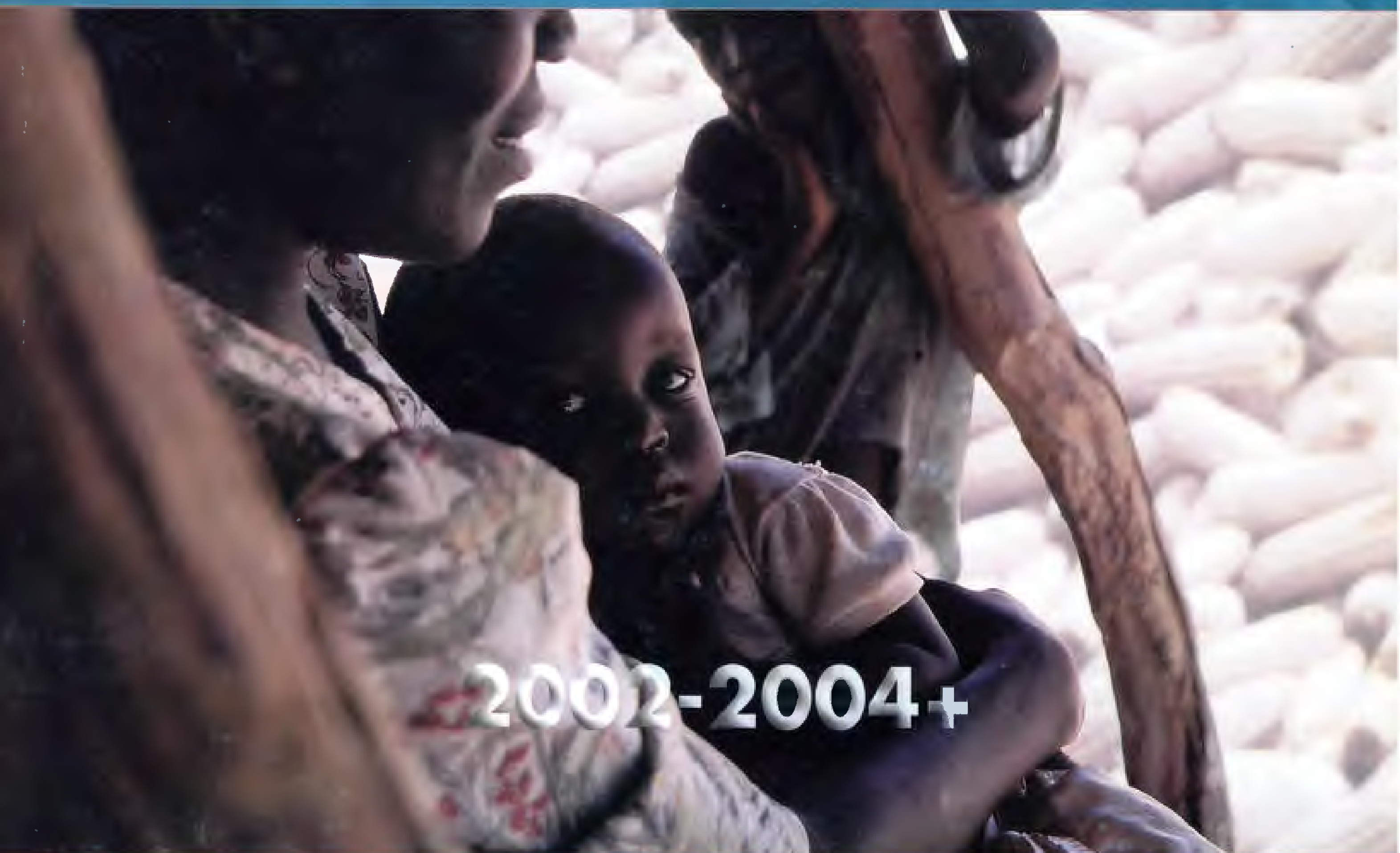
People and Partnerships

to Build Sustainable Livelihoods



2002-2004+

MEDIUM-TERM PLAN

of the International Maize and Wheat Improvement Center

CIMMYT®

People and Partnerships to Build Sustainable Livelihoods

Medium-Term Plan of the
International Maize and Wheat Improvement Center
(CIMMYT)

2002-2004+

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CIMMYT® (www.cimmyt.org) is an internationally funded, nonprofit, scientific research and training organization. Headquartered in Mexico, CIMMYT works with agricultural research institutions worldwide to improve the productivity, profitability, and sustainability of maize and wheat systems for poor farmers in developing countries. It is one of 16 food and environmental organizations known as the Future Harvest Centers. Located around the world, the Future Harvest Centers conduct research in partnership with farmers, scientists, and policymakers to help alleviate poverty and increase food security while protecting natural resources. The centers are supported by the Consultative Group on International Agricultural Research (CGIAR) (www.cgiar.org), whose members include nearly 60 countries, private foundations, and regional and international organizations. Financial support for CIMMYT's research agenda also comes from many other sources, including foundations, development banks, and public and private agencies.

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Contents

Acronyms and Abbreviations

AMBIONET	Asian Maize Biotechnology Network
ANU	Australian National University
APSRU	Agricultural Production Research Systems Unit, Department of Primary Industries, Queensland, Australia
ARIs	Advanced research institutes
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CAAS	Chinese Academy of Agricultural Sciences
CAC	Central Asia and the Caucasus
CDRI	Crop Diseases Research Institute, Pakistan
CENTA	Centro Nacional de Tecnología Agropecuaria y Forestal, El Salvador National Agricultural Technology Center
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CINVESTAV	Centro de Investigación y de Estudios Avanzados, Mexico
CORAF	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
CIP	Centro Internacional de la Papa
CTD	Canopy temperature depression
DICTA	Dirección de Ciencia y Tecnología Agropecuaria, Honduras
EARO	Ethiopian National Agricultural Research Organization
EGPSN	Eastern Gangetic Plains Screening Nursery
EGPYT	Eastern Gangetic Plains Yield Trial
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Brazil
ETH	Eidgenössische Technische Hochschule Zürich
GIS	Geographic information systems
GMO	Genetically modified organism
HTWYT	High Temperature Wheat Yield Trial
HLB	Helminthosporium leaf blight
IARCs	International agricultural research centers
IAT	International Adaptation Trial
IBSRAM	International Board for Soil Research and Management
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	International Centre of Insect Physiology and Ecology
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICTA	Instituto de Ciencia y Tecnología Agrícola, Guatemala
IDIAP	Instituto de Investigación Agropecuaria de Panamá
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
INIA	Instituto de Investigaciones Agropecuarias, Ecuador
INTA	Instituto Nicaragüense de Tecnología Agropecuaria
IPGRI	International Plant Genetic Resources Institute
IPO	Research Institute for Plant Protection, University of Wageningen
IPR	Intellectual property rights
IPTT	International Progeny Testing Trial
IRD	Institut de Recherche pour le Développement
IRMA	Insect Resistant Maize for Africa
IRRI	International Rice Research Institute
IWIS	International Wheat Information System
IWMI	International Water Management Institute
KARI	Kenya Agricultural Research Institute
LAC	Latin America and the Caribbean
LAMP	Latin American Maize Regeneration Project
MAS	Marker-assisted selection
MGBS	Maize Germplasm Bank System
NARC	Nepal Agricultural Research Council
NARSs	National agricultural research systems
NGOs	Nongovernmental organizations
NRM	Natural resource management
OPV	Open-pollinated variety
PCR	Polymerase chain reaction
PMIS	Project management information system
PRA	Participatory rural appraisal
PSNL	US Plant, Soil, and Nutrition Laboratory
QPM	Quality protein maize
QTL	Quantitative trait loci
R&D	Research and development
RIL	Recombinant inbred line
RRA	Rapid rural appraisal
RWC	Rice-Wheat Consortium for the Indo-Gangetic Plains
SACCAR	Southern African Center for Cooperation in Agricultural and Natural Resources Research and Training
SADLF	Southern African Drought and Low Soil Fertility
SAT	Stomatal aperture-related trait
SPIA	Standing Panel on Impacts Assessment
TAMNET	Tropical Asian Maize Network
TSBF	Tropical Soil Biology and Fertility
UAAAN	Universidad Autónoma Agrária Antonio Narro
WANA	West Asia and North Africa
WAWSN	Warm Areas Wheat Screening Nursery
WECAMAN	West and Central Africa Maize Network
WECARD	West and Central African Council for Research and Development

Meeting the Needs of the World's Poor through Wheat and Maize Research

Around one billion people in the developing world live on less than one dollar per day (Table 1), and their numbers are growing. These are the poorest of the poor, populations living in abject poverty and under extremely high levels of food insecurity. Nearly two-thirds (62%) of those struggling to survive on less than one dollar per day live in South Asia, and another one-fifth (20%) live in Sub-Saharan Africa. Latin America accounts for 5% of the world's absolute poor, with the vast majority living in southern Mexico and Central America.

Table 1. Distribution of global population living below one dollar per day, late 1990s

Region	Total population (millions)	Population living on less than US$ 1/day: Millions	Population living on less than US$ 1/day: As percentage of total population
Latin America and Caribbean	423	49	12
West Asia and North Africa	204	5	3
Sub-Saharan Africa	388	169	44
South Asia	1,266	515	41
East and Southeast Asia	1,726	320	19

Source: World Bank (2000), *World Development Indicators.*

Across the developing world, the numbers of absolute poor living in rural areas are disproportionately concentrated in the lower potential tropical production environments relative to the more favorable subtropical and temperate environments. Meeting the needs of the rural poor continues to be of predominant importance to CIMMYT, and we are also facing up to the challenge of providing for the rapidly rising numbers of urban poor. Rural poverty continues to be the overriding concern in Sub-Saharan Africa, Central America, and South Asia, but urban poverty and urban food insecurity are also escalating in South Asia.

Overall economic growth and price levels (particularly food prices) influence urban poverty, whereas several additional factors influence rural poverty. Some are well known, such as rapid population growth, dwindling access to resources, and limited technological options. The effects on rural poverty of new and emerging factors, such as global climate change and the deterioration of natural resources, are less well understood, although it is clear that sustainable management of the rural resource base can significantly enhance food security and improve the livelihoods of the rural poor.

Given these circumstances, how can wheat and maize research make a difference to the world's poor? Together, CIMMYT's research and technology development help:

- ensure sufficient and stable food supplies for subsistence farmers and poor rural households;
- improve the nutritional security of the poorest of the poor;
- ensure adequate food supplies at affordable prices for the urban poor; and
- promote sustainable management of natural resources, especially in marginal production environments.

Research that contributes specifically to these objectives is described here; for additional detail see our project portfolio (p. 36).

Improving the Livelihoods of the Rural Poor

The increasingly commercial orientation of developing country agriculture, aimed at meeting the food needs of burgeoning urban populations, will go a long way towards improving the incomes and livelihoods of a significant proportion of the rural poor, especially small-scale farmers and landless households in the more favorable agricultural environments. A significant number of the poorest of the poor will not see the benefits of increased market orientation, however. These people often live in extremely marginal environments and have little access to production resources. CIMMYT's work helps these desperate households improve their access to food in a number of ways.

Stress-Tolerant Maize

One of the most important ways that our research helps the poorest rural people is by providing maize varieties that tolerate drought and low nitrogen conditions. These resilient varieties increase productivity in marginal environments, especially in Sub-Saharan Africa. In eastern and southern Africa, farmers have few resources to counteract the poor soil fertility and erratic rainfall that severely limit maize yields. Droughts are common and have caused region-wide famine. Now, through CIMMYT's Southern African Drought and Low Soil Fertility (SADLF) Project, farmers are obtaining new technologies that can help them produce a better maize crop even in challenging marginal conditions. Under farmer-managed conditions where grain yields typically average only 1.3 tons per hectare, outstanding experimental open-pollinated maize varieties and hybrids from CIMMYT, tested widely in 2000, gave farmers 30-50% more grain per hectare than the best commercially available maize. For a resource-poor farmer who may sow only two hectares of maize, the new hybrids would add over half a ton to household grain stores each year—a significant contribution to food security in isolated areas where one failed harvest means hunger. The new varieties and hybrids also yield on a par with their commercial counterparts under favorable treatment (i.e., adequate water and fertilizer).

This year, southern and eastern African countries will release several of these new varieties. Their advantages for poor smallholders became particularly apparent during the current season, when drought strongly affected crop production in Zimbabwe and South Africa. As a result, several communities and NGOs immediately started community-based seed production, and companies began to produce seed for sale.

In eastern, western, and central Africa, the Africa Maize Stress (AMS) Project also works to increase the food security and income of African farm families. Maize is grown under difficult conditions where low and declining soil fertility and insect pests significantly reduce harvests. Losses attributed to limited nitrogen in soils are estimated at around US$ 500 million annually. As an example of the severity of insect infestation, Kenyan farmers report losing 15% of their annual maize harvest to stem borers—equivalent to 400,000 tons of maize valued at US$ 90 million—and farmers in some areas have cited losses as high as 45%. Among other activities, AMS Project participants develop and disseminate maize that resists drought, low nitrogen soil conditions, *Striga*, and stem boring insects. To identify insect-resistant maize, the project helped the Kenya Agricultural Research Institute (KARI) develop testing sites to rear and apply thousands of borer larvae each crop cycle. Maize that resists one or more borer species has been identified and is being made available to farmers. Similarly, testing sites where soil nitrogen is low are used to develop locally adapted maize that yields well despite low soil fertility. In the search for inexpensive testing techniques, root pulling strength has shown promise as a means to measure tolerance to low soil nitrogen. CIMMYT scientists also found that the ability of root tissue to conduct electric current was related to traits that affect tolerance to drought and low nitrogen. To screen maize plants for insect resistance without having to infest the plants in the field, project members have begun to use leaf toughness, a trait identified at CIMMYT. In western and central Africa, research addressed cropping patterns for stem borer control, optimum density for maize cultivation in drought prone areas, and soil fertility management using organic and inorganic fertilizers, among other things. Results showed that intercropping maize with cassava or cowpeas can reduce yield losses from stem borers. The work in insect resistance is substantially bolstered by a major project—Insect Resistant Maize for Africa (IRMA)—which involves an integrated pest management approach to insect management, including evaluation of Bt strategies.

To ensure that farmers can observe promising maize varieties and eventually obtain seed, CIMMYT and its partners in Africa have begun widespread on-farm testing using the "mother-baby" approach, which involves complementary sets of experiments grown by researchers and farmers under both optimal and farmer management. Project plans also involve the development, testing, and dissemination of stress-tolerant varieties of quality protein maize (QPM).

Heat-Tolerant Wheat

Our success in raising the yield potential of wheat in hot, drought-prone environments strengthens food security and builds sustainable livelihoods in marginal farm households across these environments, particularly in South Asia, Latin America, and West Asia/North Africa. Three kinds of irrigated environment require wheat with medium to high levels of heat tolerance. In the first environment, wheat is sown significantly later than recommended and exposed to heat during grain filling, as in Pakistan and northern Mexico. The second environment is inherently hot and dry during the crop season, as in Sudan and parts of central India. In the third environment, wheat is grown during a warm part of the year when humidity is high as well. Central Bangladesh, northeastern India, and Paraguay are examples of locations where these two stressful conditions coincide.

To identify wheat that tolerates heat stress, CIMMYT sows yield trials two to three months later than the optimum date, so that grain filling occurs at temperatures between 30°C and 38°C. "Early heat" trials are planted in early October as well, to screen for early season heat response. Researchers have established that canopy temperature depression (CTD) shows particularly high correlations with yield under hot growing conditions. Correlations in the order of 0.5-0.8 have also been noted between CTD values of entries planted in small plots and their yield in larger plots, indicating that a certain level of screening can be done on small plots before lines are entered into expensive yield trials. CIMMYT makes its best heat tolerant wheats available through two international nurseries: the High Temperature Wheat Yield Trial (HTWYT) for hot and dry environments and the Warm Areas Wheat Screening Nursery (WAWSN) for hot and humid environments.

Biotechnology to Secure Valuable Plant Traits

Recent advances in biotechnology, gained through expanding knowledge of genomics and innovations in marker-assisted selection, are helping to improve the success rate in breeding stress-tolerant maize and wheat. Major new efforts in Sub-Saharan Africa to enhance drought tolerance and *Striga* resistance in maize are excellent examples. A particularly exciting area of CIMMYT's biotechnology research—our work on apomixis—is directed at ensuring that valuable plant traits are retained in successive generations of seed. Since 1990, CIMMYT and France's Institut de Recherche pour le Développement (IRD) have studied apomixis, the asexual reproduction of plants through seed, and examined ways of transferring apomixis to maize. Apomictic maize could help bring the benefits of stress tolerance and hybrid vigor to noncommercial farmers in low-potential environments bypassed by private seed companies, but the scope and complexity of the research challenge cannot be overstated.

To accelerate progress in this potentially revolutionary area, CIMMYT and IRD entered into a research collaboration with three seed companies in 1999—Pioneer Hi-Bred International, Groupe Limagrain, and Syngenta Seeds (formerly Novartis Seeds). For the seed-producing partners, enhanced knowledge of apomixis might create new options for improved seed multiplication and quality. For CIMMYT and IRD, the transfer of apomixis to maize (and other cereals) offers the long-term possibility of delivering superior crop traits to poor farmers through apomictic hybrids and varieties. Under the new agreement, CIMMYT and IRD are investigating the transfer of apomixis to cereals through a range of approaches. These include transferring genes conferring apomixis from certain species of *Tripsacum* (a wild relative of maize) to maize, isolating the genes controlling apomictic reproduction in *Tripsacum* for genetic engineering of apomictic cereals, identifying genes in maize and other species that are excellent candidates for producing the apomictic phenotype, and investigating the factors involved in controlling endosperm development in apomictic and nonapomictic species. (This last area of research is extremely important, because seed cannot mature properly without proper embryo and endosperm development.)

Farmer Participatory Research to Secure Valuable Plant Traits

In their own fields in the developing world, in a setting that is very different from high-powered biotechnology laboratories, poor farmers are working with CIMMYT to identify and preserve desirable traits in their food crops. The value of genetic resource conservation (including *in situ* conservation) and participatory plant breeding for bringing desirable traits into varieties is particularly high for poor farmers in marginal environments. Participatory plant breeding (PPB) explicitly benefits disadvantaged rural people by offering methods for developing improved varieties that respond to their particular needs and constraints and thus are more likely to be adopted. In PPB, members of poor farm households, breeders, and social scientists engage in a systematic dialogue to identify traits valued by household members. Varieties with these traits are then developed and/or tested under farmers' conditions, which are usually limited by serious stresses, such as low soil fertility, drought, and weed infestations. Because the benefits to the poor depend on the extent and quality of their involvement in PPB, it is important to generate an interaction between farmers and scientists that produces suitable varieties at little cost and low risk for the farmers involved. The costs of participation may be particularly high for poor people, who usually have less time available or may be less able and willing to take risks compared to other groups. For this reason, a particularly valuable type of PPB for reaching the poor is participatory varietal selection (PVS). In PVS, farmers evaluate a set of finished or nearly finished varieties (either on the experiment station or in their fields, under their management) to identify which varieties are most appropriate for their circumstances, and, eventually, to obtain the varieties for themselves. Both PPB and PVS are proceeding with promising results for wheat in South Asia and for maize in both southern Africa and Mexico.

For example, in South Asia over the last three wheat seasons, PVS and PPB have been used to achieve two goals: 1) to obtain farmers' assessments of new improved wheats and gain an understanding of the criteria farm households use to evaluate them, and 2) to promote adoption of new varieties and site-specific resource conservation technologies, and demonstrate the value of their combined use. Thanks to the active participation of resource-poor farmers, both approaches, especially PVS, have proved effective. In two villages in Uttar Pradesh, India, farmers identified a new variety that they preferred, HUW-468, and compared it during 1999-00 with their old variety, HUW-234, under conventional planting using the normal planting date and under zero tillage using a late planting date. HUW-468 yielded 15% more than HUW-234 under both planting regimes. HUW-234 is also highly susceptible to diseases such as leaf rust. Because of the PVS activities, HUW-234 may be replaced soon, diversifying the spectrum of varieties grown in farmers' fields. In Nepal, women and men farmers engaging in PVS preferred the recently released variety BL-1473 because of its early maturity, lodging tolerance, and bold, white grain. Based on these results, the Nepal Agricultural Research Council (NARC) will speed multiplication of BL-1473 seed. In the northern hills of Pakistan, the top three varieties identified by farmers in Sultanabad, Gilgit District, yielded 30-40% more than Suneen, the popular local variety. These varieties will be multiplied more extensively in 2000-01 to obtain enough seed to distribute to as many farmers as possible.

Providing Technology Where It Is Most Needed

To ensure that our products are directed at meeting the needs of the poorest of the poor in rural areas across the developing world, we rely not only on the extensive experience of our researchers and research partners (including farmers), but also on a great deal of data, other technical information, and information technology. Applications of GIS, crop models, and *ex ante* technology assessment, for example, help orient our research in ways that are most consistent with our mission.

Improving Nutritional Security of the Poorest of the Poor

The diets of the rural and the urban poor tend to be deficient not only in calories but also in protein quantity and quality (i.e., amino acid balance), vitamins, and micronutrients. Women and children, who make up the vast majority of people living in poverty, usually suffer most from these deficiencies. Nutritionally fortified maize and wheat being developed at CIMMYT could make an enormous difference in nutritional security for poor rural and urban households. This research relies on the complementary tools of conventional breeding and biotechnology, as well as information from nutritional and socioeconomic studies, to ensure that the most appropriate varieties are developed.

Maize for Nutritional Security

Quality protein maize (QPM), which has been introduced into more than a dozen developing countries through the efforts of CIMMYT, national programs, and Sasakawa-Global 2000, can increase protein availability in regions where maize consumption is high and better sources of protein are unobtainable—often because people cannot afford them. Because it contains nearly twice the lysine and tryptophan—amino acids essential for human nutrition—as normal maize, QPM delivers better quality protein to consumers than they would obtain simply by consuming normal maize. CIMMYT and its partners have developed stable, high-yielding, and disease-and storage-pest resistant QPM hybrids and varieties for diverse settings. In tests in over 40 nations, QPM hybrids often had a yield advantage of one ton or more per hectare over the best normal maize hybrids. New QPM synthetics—superior open-pollinated varieties formed from inbred lines—feature special characteristics such as low and uniform ear placement, resistance to ear rot and root lodging, and (most notably) levels of tryptophan (0.11% of the whole grain), lysine (0.475% of the whole grain), and protein (11.0% of the whole grain) all far beyond those contained in normal maize. Molecular markers and other advanced laboratory techniques are being harnessed to transfer and maintain the quality protein genes, which are the product of a natural mutation in maize. As a result, in recent years 14 developing countries have released dozens of new QPM hybrids and varieties for farmers, and several have launched major QPM promotion programs. More than 730,000 hectares in developing countries are sown to QPM today, and there is great potential for expanding its use.

Aside from improving the protein quality of maize, researchers have examined ways of increasing its micronutrient content in an intercenter project coordinated by the International Food Policy Research Institute (IFPRI), "Identifying Agricultural Strategies for Reducing Micronutrient Malnutrition." Initially CIMMYT's research on improving micronutrient levels in maize has been directed towards southern and eastern Africa, where white-grained maize is the major staple food and deficiencies of micronutrients and vitamin A are often acute. Researchers systematically evaluated nearly 2,000 maize varieties and landraces, representing the entire genetic base of white-grained tropical maize, to identify maize with higher iron and zinc concentrations. This undertaking was not as straightforward as one might think, partly because the environment in which a variety is tested greatly influences the concentration of micronutrients in maize kernels and partly because high micronutrient varieties often show lower yields. After considerable preliminary work, researchers developed experimental hybrids that could meet an additional 30%, 20%, and 10% of the daily iron demand of men, women, and pregnant women, respectively, without compromising yield, and they are exploring strategies to further boost nutritional value.

The challenge in developing maize with higher vitamin A content for southern Africa is to disguise its yellow grain color. Most maize consumers in the region strongly reject yellow maize for cultural and historical reasons. Researchers are investigating targeted incorporation of vitamin A in the embryo or disguising yellow grain color with other pigments, such as anthocyanins.

Wheat for Nutritional Security

As with maize, breeding for high micronutrient concentration in wheat is a complementary and perhaps more sustainable means of reducing micronutrient deficiencies than supplementation and fortification programs. CIMMYT has identified significant variation in wheat varieties for iron and zinc, but the lines with the greatest concentration of these elements are either low-yielding or are wild relatives of wheat (the maize research described earlier produced similar findings). Research has concentrated on understanding the genetic bases of micronutrient concentration. This information will make it possible to transfer the ability to produce higher concentrations of iron and zinc from low-yielding wheats into higher yielding and/or widely adapted wheats. In addition to simply adding quantities of iron and zinc, it is also important to lower the amounts of other factors that often reduce their availability in the diet. One major negative factor is phytic acid, a powerful chelator of elements such as iron. CIMMYT is introducing low phytic acid mutants into tropical maize varieties to determine the effect on the bioavailability of micronutrients; similar options are being investigated for wheat.

Improved Nutrition and Bioengineering

Iron, zinc, magnesium, and other micronutrients can be enhanced in maize and wheat by engineering new enzymes that control micronutrient uptake, movement, and storage. In addition, by modifying key enzymes, negative factors such as phytic acid can be reduced. As mentioned earlier, levels of critical vitamins such as vitamin A and folic acid may also be improved in maize and wheat. In an effort to improve grain protein quality, scientists from CIMMYT and CINVESTAV (Mexico's Centro de Investigación y de Estudios Avanzados) inserted a gene for a seed protein from amaranth into maize. The protein produced has very high levels of lysine and tryptophan, much like QPM (which is not transgenic). This approach provides an additional boost to the amino acid profile in maize and could help to develop wheat (and other cereals) with better protein quality.

Enhancing Urban Food Supplies

A key strategy for enhancing urban food supplies is to increase the competitiveness and profitability of wheat and maize production at the farm level. Dramatic reductions in the cost per ton of food crop production contribute substantially towards increasing and/or sustaining the profitability of wheat and maize production. The cost per ton of crop production can be reduced by a combined approach involving a shift in the yield frontier and an increase in the efficiency of input use.

CIMMYT's efforts to shift the yield frontier of wheat, particularly in irrigated and high rainfall environments, along with its work on improved disease resistance, nitrogen- and water-use efficiency, and zero tillage, are all directed at reducing the unit costs of wheat production, raising its profitability, and increasing surpluses at the farm level. Particularly noteworthy is our collaborative work on enhancing the productivity and the sustainability of the rice-wheat systems in the Indo-Gangetic Plains, a major source of food for South Asia's urban poor. In the case of maize, the development and promotion of high-yielding hybrids, particularly in Latin America and in Africa, contributes to increased food supplies for the urban poor.

Water-Use Efficiency in Wheat

The amount of water available for agriculture is likely to decline steadily during the next 50 years as more water is diverted to meet the needs of urban centers. This problem will be most acute in developing countries where wheat and rice are grown under irrigation and urbanization is proceeding at alarming rates. Water shortages may affect more than 30 million hectares of irrigated wheat land, at a time when demand for wheat will be even higher than it is today. CIMMYT's wheat breeders have crossed promising sources of drought tolerance (synthetic wheats, landraces, related species, and some adapted cultivars) with high-yielding, disease-resistant wheats. Their aim is to improve yield by combining tolerance to drought with responsiveness to improved soil moisture status. Disease resistance is also a key component of the strategy. The progeny of these crosses are evaluated under a combination of gravity basin and drip irrigation schemes. Drip irrigation gives breeders greater flexibility in controlling the timing of drought stress—a critical factor affecting yield in many production systems—and uses up to 50% less water compared to gravity fed irrigation to obtain the same yield. Wheats that respond well to water deficits at different stages of growth are identified and advanced in the breeding program. These materials are screened for rust and *Septoria tritici* resistance and further yield tested under drought and semi-drought conditions prior to inclusion in CIMMYT's international yield evaluation network.

Nitrogen-Use Efficiency in Wheat

Breeders have developed a method to identify wheats with better nitrogen-use efficiency. They crossed wheats that were good at absorbing nitrogen with others that utilized nitrogen exceptionally well. After eight years of testing, they confirmed that alternately applying first high and then low nitrogen levels to successive cycles of offspring produced lines that yielded better than all the others. This method, used throughout the breeding process, will ensure that all CIMMYT wheats combine good nitrogen uptake and good nitrogen utilization.

Conserving the Resource Base for Current and Future Food Security

Especially in marginal environments, enhanced food security and improved livelihoods for very poor households are closely linked to management of the agricultural resource base. CIMMYT's research addresses immediate concerns in resource management, such as soil and water conservation, and longer-term concerns, such as climate change.

In recent years, CIMMYT has actively promoted research on conservation tillage practices for wheat and maize production systems across the developing world. This emphasis is reflected in the launching of a new global project (Project 9: G9, p. 58) that focuses on the development and dissemination of conservation agriculture practices, especially zero tillage, and incorporates a knowledge management component. A smaller, related project (F7) was closed in 2000; this frontier project had focused on methods and knowledge management for the development and dissemination of sustainable systems. This change was made for several reasons. First, conservation agriculture and conservation tillage are specific themes that tie together much of CIMMYT's systems research in Asia, Africa, and Latin America. Second, research on conservation agriculture is critically important and is likely to remain so over the longer term. Finally, compared to the project that was closed, the new global project will have the stature, level of resourcing, and permanence commensurate with its importance to CIMMYT's mission.

The Rice-Wheat Consortium of the Indo-Gangetic Plains, for which CIMMYT is the convening CGIAR center, has been instrumental in developing improved tillage technologies that are being adopted rapidly throughout South Asia (see "Do Not Disturb the Earth," p. 10). Mulching and residue retention techniques are being promoted in smallholder wheat production systems in the Bolivian highlands. Conservation tillage has also made significant progress in subsistence maize production systems in the hillsides of Central America. This work by CIMMYT and its partners has confirmed once again that poor farmers, with access to proper techniques and knowledge, manage their resources as adeptly as more well-to-do farmers.

CIMMYT is strongly concerned about the future impacts and implications of climate change. Global warming could significantly increase the area under drought and high temperature stress, thereby affecting maize and wheat productivity in many areas. The good news is that the research agenda that CIMMYT is pursuing today for managing climatic stress will provide maize and wheat technologies that will help farmers adapt to climate change and mitigate its effects (see "Changing Technology for a Changing Climate," p. 11).

Our work on developing drought- and high temperature-tolerant maize and wheat is a particularly important case in point. The area where stress-tolerant germplasm is needed will increase significantly over time. Similarly, the area that will benefit from our work on conservation tillage and water management will increase over time. Large-scale adoption of conservation tillage practices could help alleviate the effects of climate change through reduced emissions of greenhouse gases and reduced losses of soil carbon.

Conclusions: Research Resources to Reach the Poor

These highlights of our research indicate CIMMYT's commitment to providing strategies that will enable poor people to overcome poverty and malnutrition and to cope better with climate change, economic uncertainty, and other forces that threaten to divide rather than unite the peoples of the world. The projects described in the pages that follow present a research agenda that is ambitious but necessary to accomplishing this mission.

The geographic allocation of CIMMYT's research resources (Table 2) is consistent with the regional distribution of the world's poor. More than one-third of our resources are spent in Sub-Saharan Africa, the region with the highest share of poor people in its population (Table 1) and lowest share of trained scientists and research infrastructure. South Asia accounts for 22% of CIMMYT's resources, and Central America, with the third highest share of the global poor, accounts for 15%.

Table 2. Allocation of CIMMYT research resources by region of the developing world

Region	Percentage of research resources
Central and Western Africa	4
Eastern and Southern Africa	33
Central and West Asia and North Africa	10
East and Southeast Asia	6
South Asia	22
Central America and Caribbean	15
South America	10
Total	**100**

Do Not Disturb the Earth: A Greener Revolution for South Asia's Poor

An agricultural revolution is beginning in South Asia. Greener than the Green Revolution, it promises lower costs and significant environmental benefits as well as higher yields and increased production. It promises to benefit the landless and the resource-poor through opportunities for increased employment.

Although it draws inspiration from similar experiences in the Southern Cone of Latin America, it is largely locally developed. It is a tillage revolution, based on the principles of conservation agriculture. CIMMYT and the Rice-Wheat Consortium for the Indo-Gangetic Plains, in collaboration with other national and regional partners and stakeholders, have played a central role in its development.

Over the past three years, farmers' use of zero tillage for wheat has increased dramatically, especially in rice-wheat rotations. In the 2000-01 crop season, the use of zero tillage in the western Indo-Gangetic Plains increased to around 100,000 ha, expanding from about 12,000 ha in the previous year and about 1,200 ha in the year before that. The speed of adoption is now driven by the pace at which privately owned implement shops can manufacture the necessary equipment. Initial surveys indicate that the bulk of adoption has been by smallholders. Many observers foresee millions of hectares of zero-tillage wheat in the Indo-Gangetic Plains within a brief span of years. Adoption is also proceeding in eastern India, the Terai of Nepal, and Bangladesh.

It is no surprise that farmers, policymakers, and environmentalists are all enthusiastic about these events. For a seemingly simple practice, zero tillage has an astonishing range of benefits. Yields are increased because it allows timely sowing. Costs are slashed because, compared to conventional methods, zero tillage uses little fuel for preparing land and pumping water. Herbicide use is cut or eliminated because the wheat, sown earlier, can more effectively shade out weeds. Cropping systems are diversified because up to six weeks are freed in the crop rotation. Diversified systems bring more employment. Greenhouse gas emissions are slashed because less fuel is used, less soil carbon is released from soil movement, and less nitrous oxide is emitted (nitrogen is used far more efficiently). Adoption of zero tillage on less than half of the rice-wheat area in the Indo-Gangetic Plains would save millions of tons of carbon emissions (or their equivalent in methane or nitrous oxide) and billions of cubic meters of irrigation water.

Adaptations of zero tillage have been developed for four-wheel and two-wheel tractors. A variant is available that requires no implements or machinery at all. New resource-conserving practices are also being developed, such as bed systems, which are even more exciting. Bed systems are finding favor in farmers' fields in India and Pakistan because they save water, reduce fertilizer and pesticide use, and offer tremendous opportunities to diversify cropping systems. The development and dissemination of zero tillage and other conservation agriculture practices requires a partnership involving many participants:

- farmer experimenters to lead in technology adaptation,
- private implement manufacturers to simplify implement designs and make them commercially available,
- state extension officials and workers to enable large numbers of farm families to become acquainted with the practice,
- national agricultural research managers who provided critically important leadership and vision,
- university and national program scientists who adapted the first prototypes to local conditions, fostered farmer experimentation, and assessed longer-term and environmental consequences, and
- the Rice-Wheat Consortium for the Indo-Gangetic Plains, convened by CIMMYT, which facilitated the process.

Note: Information on specific activities in South Asia over the planning period can be found in the project portfolio in this publication, especially in Project 12: R3, p. 67.

Changing Technology for a Changing Climate

Many experts agree that human-induced climate change is a reality. They also agree that the people most vulnerable to such changes are the poor. As global temperatures rise, extreme weather events, from floods to droughts, will increase. Changing rainfall patterns, combined with population growth, will exert more pressure on water supplies. Currently 1.7 billion people live in areas where water resources are scarce; in the next 25 years, this number may rise to 5.4 billion. In drought-prone areas of Africa, reduced crop yields will lead to worsening malnutrition.

Agricultural science can help poor people cope with global climate change in at least three ways, by providing information to understand climate change, technology to adapt to it, and technology to mitigate its effects. All are important, and CIMMYT is making vital contributions to each one.

First, agricultural science can provide information to help us understand the consequences of global warming on agriculture, including projections of changes in agricultural productivity over time. We can compare favorable outcomes (e.g., improved plant growth from increased atmospheric carbon) with unfavorable outcomes (e.g., crop yield loss from drought and heat stress) for different geographical regions, agroecosystems, and climate change scenarios. For example, CIMMYT's crop simulation modeling has shown that the net effect of global warming on developing country wheat production is likely to be neutral, because wheat yields are reduced with warmer (and therefore shorter) growing seasons, but they increase by about the same amount from a greater concentration of carbon dioxide in the atmosphere.

Second, agricultural science can help farmers adapt to climate change as it unfolds. Drought- and heat-tolerant cereal varieties can be made available in affected areas, for instance. These varieties become even more effective when they are grown with management practices that make the most of limited water resources. CIMMYT is committed to the development and dissemination of stress-tolerant germplasm and complementary management practices. Among these are several conservation agriculture techniques that improve yields and productivity with large water savings.

Third, science can help reduce emissions of greenhouse gases, especially carbon dioxide, methane, and nitrous oxide. Zero tillage practices introduced to South Asia by the Rice-Wheat Consortium for the Indo-Gangetic Plains and CIMMYT may foster large reductions in such emissions. In South Asia, zero tillage saves diesel fuel used to plow land and pump water. Where conventional practices may use up to 100 liters of diesel fuel per hectare, zero tillage cuts this back to 10-15 liters. Even more important, zero tillage slows or reverses the loss of soil organic matter, cutting carbon dioxide emissions even further. Zero tillage also improves nitrogen-use efficiency, so crop yields can be increased while fertilizer use actually goes down. As use efficiency improves, nitrous oxide emissions drop. Altogether, the introduction of conservation agriculture practices in the Indo-Gangetic Plains may save up to three million tons of carbon equivalent[1] every year.

These are only a few examples of how CIMMYT research responds to the exigencies of climate change. Many more examples may be found in the project portfolio in this publication.

1 Carbon equivalent is a measurement tool for expressing methane, nitrous oxide, and carbon dioxide in a common term, taking into account the relative contribution of each greenhouse gas to climate change.

Financial Highlights

2000 Operating Budget

CIMMYT's budget in 2000 was US$ 38.6 million, higher than initially projected in September 2000 (US$ 37.5 million).

Additional resources in 2000 came from a combination of targeted funds, core restricted contributions from the European Commission (EC) and the Netherlands, and core special projects supported by the Rockefeller Foundation and other foundations.

This increase in targeted contributions reflects several circumstances, both within and outside CIMMYT. First, our research portfolio continues to be highly relevant to the priorities of those who have traditionally supported international agricultural research. As we have shown in this *Medium-Term Plan*, our research products will help address some of the most serious development concerns that have emerged in recent years, such as the effects of climate change.

Second, throughout the nonprofit research sector, there is growing impetus and scope to support research with nontraditional sources of income. CIMMYT is developing an increasing number of highly focused partnerships with nontraditional supporters to address high-priority challenges for maize and wheat research. Nontraditional sources of funding accounted for approximately 17% of CIMMYT's budget in 2000, including new resources from foundations and from advanced research institutes in the public and private sector. CIMMYT enters into such alliances only if they enhance our ability to achieve our mandate of service to the resource-poor and the environment. We are extremely cognizant of the debate over the potential of the private sector to distort the research agenda of the public sector, a debate that is perhaps most vigorous in academia but is nevertheless extremely relevant for international centers such as CIMMYT. At CIMMYT, if an alliance helps us to more quickly develop new, appropriate technologies and deliver them to farmers' fields in developing countries, we regard it as a "win-win" alliance in which we can participate. [2]

Third, the private sector and civil society as a whole have demonstrated a growing awareness of the need for private organizations to assume a greater share of responsibility for such development goals as human and ecological health. This awareness is likely to expand the opportunities for private and public research alliances oriented toward humanitarian goals.

2001 Estimated Budget

During 2000, CIMMYT contributed US$ 539,000 to its financial reserve, slightly less than anticipated. As at December 2000, CIMMYT's reserves stood at US$ 5.521 million. Owing to the devaluation of most currencies against the US dollar and the re-valuation of the Mexican peso, CIMMYT managed exchange rate losses in excess of US$ 2 million (in core unrestricted, core restricted, special project, and peso-denominated expenses) during 2000.

Our budget estimate for 2001 is US$ 38.2 million, as projected in the September 2000 review of the financing plan for the 2001 research agenda. For 2001 we are forecasting that core unrestricted contributions will be at the same level as in 2000. Additional support through targeted funds will allow us to increase our emphasis on improving drought tolerance in maize and wheat though functional genomics

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[2] A new publication, *Global Public Goods for Poor Farmers: Myth or Reality?* (Mexico, D.F.: CIMMYT, 2001) highlights CIMMYT's approach to the development of global public goods.

and other approaches, to expand research in participatory plant breeding, to reinforce our efforts to further develop and disseminate QPM, particularly in Sub-Saharan Africa, and to strengthen our training initiatives.

Projected Trends over the Planning Period

During the 2002-04 planning period, we foresee an increase of about 2% per year, in real terms, in the Center's budget. Most of the additional support will come from traditional CGIAR investors, but to command greater flexibility in responding to new challenges and opportunities, we will continue to pursue a resource mobilization strategy focusing on nontraditional sources of income and research support. We will also continue periodic reviews of our main activities to identify opportunities for cost savings.

Given current trends, targeted funding is likely to constitute a growing share of research resources. We anticipate that more than 60% of Center income will be targeted in one form or another during 2001.

Approximately half of CIMMYT's expenses are in Mexican pesos, and the peso continues to perform strongly against the US dollar (over 2000, the Mexican peso appreciated by about 8.5% in real terms). Inflation was 8.9% in Mexico during 2000 and is projected to decline to about 7.0% in 2001. During the remainder of the planning period, the Mexican government projects inflation to fall by a further 3-4%.

Total expenses for salaries and allowances are targeted to remain below 60% of the total budget, as mandated by Center policy. Other operating costs are projected to remain consistent with long-term trends.

The most recent audited figures, including full project costing, indicate that indirect costs, as currently defined, are 26.5%. Full recovery of these costs from targeted contributions remains a critical component of our financial structure, helping to ensure the delivery of high-quality research products. Although we have been able to improve the rate of overhead recovery from previous years, we are still below the level of 20% (on average).

Center Staffing

Numbers of internationally recruited staff will increase slightly in 2001, in response to new challenges and opportunities. Two key positions are being added to Center Management in response to the changing environment in which CIMMYT operates. A Resource Mobilization Specialist will focus on nontraditional sources of income. An Intellectual Property Manager, recruited during 2001, will oversee CIMMYT's portfolio of intellectual property and technical property (IP/TP), manage IP/TP rights, and ensure that CIMMYT is managing IP/TP issues for the benefit of our partners in developing countries.

On the research side, a Postdoctoral Fellow will join our Applied Biotechnology Program to work on cereal functional genomics, funded by special projects. In addition, several new Postdoctoral Fellows will join the Maize, Wheat, and Economics Programs. We also plan to recruit two specialists in modeling and farmer experimentation to reinforce our Natural Resources Program in southern Africa and at headquarters in Mexico. We anticipate that the number of adjunct staff (researchers working at CIMMYT on fixed-term projects or by agreement with other institutions) will grow as CIMMYT continues to expand its range of partnerships and access to complementary expertise in advanced research institutes.

The number of nationally recruited staff declined very slightly over 2000 and is projected to remain steady during the planning period.

Financial Indicators and Capital Investments

As previously indicated, CIMMYT's reserves increased by US$ 539,000 during 2000. A steady increase in our working capital is projected for 2002-04, to reach a target of 90 days by 2004. To achieve this steady improvement in the reserve, CIMMYT has initiated a number of restraint measures, including reduced capital expenditure.

We continue to identify strategies for increasing the flexibility in our capital budget. The Center's capital leasing program continued in 2000 for computer equipment, vehicles, and some field equipment. In 2001, an internally administered cost recovery system for the vehicle fleet (more than 300 vehicles), one of our major capital expenditures, takes effect. Under this new system, an annual capital purchase levy is charged on each vehicle to create a vehicle-purchasing fund. Vehicle operating costs may thus be funded from a range of sources and not solely from our capital budget.

Our most important capital investment in 2000 was the acquisition of 50 hectares in Puebla for a lowland tropical maize research station to replace the Poza Rica Experiment Station, which was severely damaged by flooding in October 1999. We are preparing the site (leveling the land, installing irrigation and drainage systems) and seeking additional resources to build the administrative office, training facilities, and other essential infrastructure. These resources will complement the generous support received from the CGIAR Finance Committee and the Australian Centre for International Agricultural Research (ACIAR).

Table 1a. CIMMYT research agenda requirements, by output, 2000 (expenditure in US$ million)

Center projects		Germplasm improvement	Germplasm collection	Sustainable production	Policy	Enhancing NARSs	Project totals
001.	Conservation and management of genetic resources	0.721	1.740	0.000	0.349	0.348	3.158
002.	Developing core germplasm and integrating interdisciplinary approaches for the improvement of maize	0.883	0.394	0.305	0.000	0.591	2.173
003.	Developing core germplasm and integrating interdisciplinary approaches for the improvement of wheat	1.514	0.650	0.756	0.000	0.422	3.342
004.	Increasing maize productivity and sustainability in stressed environments: abiotic and biotic stress	0.369	0.220	0.534	0.000	0.135	1.258
005.	Increasing wheat productivity and sustainability in stressed environments: abiotic stress	0.664	0.369	1.395	0.000	0.206	2.634
006.	Increasing wheat productivity and sustainability in stressed environments: biotic stress	0.387	0.404	1.066	0.000	0.188	2.045
007.	Gauging the productivity, equity, and environmental impact of modern maize and wheat production systems	0.000	0.000	0.000	0.531	0.198	0.729
008.	Building partnerships through human resource development	0.000	0.000	0.000	0.000	4.245	4.245
009.	Improving food security in Sub-Saharan Africa	1.851	0.371	1.316	0.123	0.452	4.113
010.	Meeting the accelerating demand for maize development, production, and delivery in South and Southeast Asia and China	0.485	0.162	0.561	0.176	0.454	1.838
011.	Sustainable wheat production systems in the Indo-Gangetic Plains and China	0.271	0.108	1.067	0.109	0.253	1.808
012.	Increasing cereal food production in West Asia and North Africa (WANA)	0.713	0.227	0.338	0.000	0.506	1.784
013.	Enhancing Latin American maize and wheat production systems	1.872	0.409	1.409	0.124	0.963	4.777
014.	Increasing cereal food production in Central Asia and the Caucasus (CAC)	0.193	0.096	0.034	0.048	0.110	0.481
015.	Raising the yield potential of wheat	0.378	0.000	0.000	0.000	0.047	0.425
016.	Apomixis — equity in access to hybrid vigor for resource poor farmers	0.324	0.061	0.054	0.000	0.000	0.439
017.	Biotechnology for the improvement of maize and wheat in developing countries	0.553	0.253	0.648	0.000	0.126	1.580
018.	Improving human nutrition by enhancing bio-available protein and micronutrient concentration in maize, wheat, and triticale	0.231	0.000	0.088	0.000	0.079	0.398
019.	Genetic approaches to reducing post-harvest losses	0.108	0.000	0.178	0.000	0.018	0.304
020.	Priority setting and technology forecasting for increased research efficiency	0.125	0.000	0.187	0.151	0.057	0.520
021.	Learning to more effectively confront problems of resource degradation in maize and wheat systems	0.000	0.092	0.215	0.034	0.156	0.497
Output totals		**11.642**	**5.556**	**10.151**	**1.645**	**9.554**	**38.548**

Table 1b. CIMMYT research agenda requirements, by output, 2001 (expenditure in US$ million)

Center projects	Germplasm improvement	Germplasm collection	Sustainable production	Policy	Enhancing NARSs	Project totals
001. Maize and wheat genetic resources: use for humanity	0.632	1.511	0.000	0.302	0.302	2.747
002. Improved maize for the world's poor	0.866	0.394	0.478	0.000	0.417	2.155
003. Improved wheat for the world's poor	1.480	0.625	0.756	0.000	0.428	3.289
004. Maize for sustainable production in stressed environments	0.369	0.210	0.534	0.000	0.134	1.247
005. Wheat for sustainable production in marginal environments	0.664	0.346	1.394	0.000	0.208	2.612
006. Wheat resistant to diseases and pests	0.372	0.404	1.066	0.000	0.187	2.029
007. Impacts of maize and wheat research	0.000	0.000	0.000	0.530	0.194	0.724
008. Building human capital	0.000	0.000	0.000	0.000	4.209	4.209
009. Conservation tillage and agricultural systems to mitigate poverty and climate change	0.074	0.000	0.296	0.074	0.050	0.494
010. Food and sustainable livelihoods for Sub-Saharan Africa	1.858	0.372	1.321	0.124	0.454	4.129
011. Maize for poverty alleviation and economic growth in Asia	0.778	0.315	0.262	0.102	0.365	1.822
012. Sustaining wheat production in South Asia, including rice-wheat systems	0.242	0.097	0.950	0.097	0.225	1.611
013. Food security for West Asia and North Africa	0.713	0.327	0.329	0.000	0.391	1.760
014. Agriculture to sustain livelihoods in Latin America and the Caribbean	1.745	0.330	1.509	0.216	0.915	4.715
015. Restoring food security and economic growth in Central Asia and the Caucasus	0.192	0.096	0.084	0.048	0.057	0.477
016. New wheat science to meet global challenges	0.378	0.000	0.000	0.000	0.044	0.422
017. Apomixis: seed security for poor farmers	0.607	0.115	0.099	0.000	0.000	0.821
018. Biotechnology for food security	0.580	0.265	0.679	0.000	0.132	1.656
019. Biofortified grain for human health	0.231	0.000	0.084	0.000	0.079	0.394
020. Reduced grain losses after harvest	0.108	0.000	0.176	0.000	0.018	0.302
021. Technology assessment for poverty reduction and sustainable resource use	0.243	0.000	0.096	0.135	0.095	0.569
Output Totals	**12.132**	**5.407**	**10.113**	**1.628**	**8.904**	**38.184**

Table 2. CIMMYT research agenda: allocation of resources (expenditure in US$ million)

Output	Allocation of resources by output logical framework format				
	2000 (actual)	**2001 (estimate)**	**2002 (plan)**	**2003 (plan)**	**2004 (plan)**
Germplasm improvement (Activity: Germplasm enhancement and breeding, plus networks, as appropriate)	11.642	12.132	12.375	12.622	12.875
Germplasm collection (Activity: Saving biodiversity, plus networks, as appropriate)	5.556	5.407	5.515	5.625	5.738
Sustainable production (Activity: Production systems development and management, protecting the environment, and networks, as appropriate)	10.151	10.113	10.315	10.522	10.732
Policy (Activity: Improving policies, plus networks, as appropriate)	1.645	1.628	1.661	1.694	1.728
Enhancing NARS (Activity: Strengthening NARS - the three subactivities, plus networks, as appropriate)	9.554	8.904	9.082	9.264	9.449
Total	**38.548**	**38.184**	**38.948**	**39.727**	**40.522**

	2000 (actual)	**2001 (estimate)**	**2002 (plan)**	**2003 (plan)**	**2004 (plan)**
Increasing productivity, of which:	14.043	13.924	14.202	14.487	14.776
Germplasm enhancement and breeding	11.265	11.397	11.625	11.857	12.095
Production systems development and management	2.778	2.527	2.578	2.629	2.682
Protecting the environment	7.381	7.338	7.485	7.634	7.787
Saving biodiversity	5.511	5.436	5.545	5.656	5.769
Improving policies	1.541	1.559	1.590	1.622	1.654
Strengthening NARS, of which:	10.071	9.927	10.126	10.328	10.535
Training and professional development	5.372	5.403	5.511	5.621	5.734
Documentation, publications, information dissemination	1.492	1.422	1.450	1.479	1.509
Organization and management counselling	1.701	1.651	1.684	1.718	1.752
Networks	1.506	1.451	1.480	1.510	1.540
Total	**38.548**	**38.184**	**38.948**	**39.727**	**40.521**

Table 3. CIMMYT research agenda project and output cost summary (in US$ million)

		2000 (actual)	2001 (estimate)
001.	Maize and wheat genetic resources: use for humanity	3.158	2.747
002.	Improved maize for the world's poor	2.173	2.155
003.	Improved wheat for the world's poor	3.341	3.289
004.	Maize for sustainable production in stressed environments	1.258	1.247
005.	Wheat for sustainable production in marginal environments	2.634	2.612
006.	Wheat resistant to diseases and pests	2.045	2.029
007.	Impacts of maize and wheat research	0.729	0.724
008.	Building human capital	4.245	4.209
009.	Conservation tillage and agricultural systems to mitigate poverty and climate change	0.000	0.494
010.	Food and sustainable livelihoods for Sub-Saharan Africa	4.194	4.129
011.	Maize for poverty alleviation and economic growth in Asia	1.838	1.822
012.	Sustaining wheat production in South Asia, including rice-wheat systems	1.620	1.611
013.	Food security for West Asia and North Africa	1.783	1.760
014.	Agriculture to sustain livelihoods in Latin America and the Caribbean	4.777	4.715
015.	Restoring food security and economic growth in Central Asia and the Caucasus	0.481	0.477
016.	New wheat science to meet global changes	0.425	0.422
017.	Apomixis: seed security for poor farmers	0.439	0.821
018.	Biotechnology for food security	1.639	1.656
019.	Biofortified grain for human health	0.398	0.394
020.	Reducing grain losses after harvest	0.304	0.302
021.	Technology assessment for poverty reduction and sustainable resource use	0.570	0.569
021.	Learning to more effectively confront problems of resource degradation in maize and wheat systems	0.497	0.000
Total		**38.548**	**38.184**

Summary by output:	2000 (actual)	2001 (estimate)
Germplasm improvement	11.642	12.132
Germplasm collection	5.556	5.407
Sustainable production	10.151	10.113
Policy	1.645	1.628
Enhancing NARS	9.554	8.904
Total	**38.548**	**38.184**

Table 4a. CIMMYT allocation of project costs to CGIAR activities, 2000 (in US$ million)

Project	Activity	2000 actual
001. Conservation and management of genetic resources	Enhancement and Breeding (Maize)	0.351
	Enhancement and Breeding (Wheat)	0.351
	Saving Biodiversity	1.755
	Improving Policies	0.352
	Strengthening NARS—Training	0.142
	Strengthening NARS—Information	0.209
		3.158
002. Developing core germplasm and integrating interdisciplinary approaches for the improvement of maize	Enhancement and Breeding (Maize)	0.873
	Production Systems (Maize)	0.109
	Protecting the Environment	0.199
	Saving Biodiversity	0.397
	Strengthening NARS—Training	0.397
	Strengthening NARS—Information	0.199
		2.173
003. Developing core germplasm and integrating interdisciplinary approaches for the improvement of wheat	Enhancement and Breeding (Wheat)	1.499
	Production Systems (Wheat)	0.055
	Protecting the Environment	0.707
	Saving Biodiversity	0.655
	Strengthening NARS—Training	0.141
	Strengthening NARS—Networks	0.284
		3.341
004. Increasing maize productivity and sustainability in stressed environments: abiotic and biotic stress	Enhancement and Breeding (Maize)	0.372
	Production Systems (Maize)	0.068
	Protecting the Environment	0.470
	Saving Biodiversity	0.178
	Strengthening NARS—Training	0.034
	Strengthening NARS—Information	0.068
	Strengthening NARS—Org & Mgt	0.034
	Strengthening NARS—Networks	0.034
		1.258
005. Increasing wheat productivity and sustainability in stressed environments: abiotic stress	Enhancement and Breeding (Wheat)	0.566
	Production Systems (Wheat)	0.099
	Protecting the Environment	1.308
	Saving Biodiversity	0.349
	Strengthening NARS—Information	0.104
	Strengthening NARS—Org & Mgt	0.104
	Strengthening NARS—Networks	0.104
		2.634
006. Increasing wheat productivity and sustainability in stressed environments: biotic stress	Enhancement and Breeding (Wheat)	0.375
	Production Systems (Wheat)	0.187
	Protecting the Environment	0.887
	Saving Biodiversity	0.408
	Strengthening NARS—Information	0.094
	Strengthening NARS—Org & Mgt	0.094
		2.046
007. Gauging the productivity, equity, and environmental impact of modern maize and wheat production systems	Improving Policies	0.439
	Strengthening NARS—Training	0.065
	Strengthening NARS—Information	0.065
	Strengthening NARS—Org & Mgt	0.065
	Strengthening NARS—Networks	0.096
		0.729
008. Building partnerships through human resource development	Strengthening NARS—Training	3.369
	Strengthening NARS—Information	0.132
	Strengthening NARS—Org & Mgt	0.621
	Strengthening NARS—Networks	0.124
		4.245

Table 4a. Cont'd.

Project	Activity	2000 actual
009. Improving food security in Sub-Saharan Africa	Enhancement and Breeding (Maize)	1.850
	Production Systems (Maize)	0.617
	Protecting the Environment	0.699
	Saving Biodiversity	0.371
	Improving Policies	0.118
	Strengthening NARS—Training	0.005
	Strengthening NARS— Information	0.007
	Strengthening NARS—Org & Mgt	0.117
	Strengthening NARS—Networks	0.329
		4.113
010. Meeting accelerating demand for maize development, production, and delivery in South and Southeast Asia and in China	Enhancement and Breeding (Maize)	0.489
	Production Systems (Maize)	0.216
	Protecting the Environment	0.334
	Saving Biodiversity	0.163
	Improving Policies	0.178
	Strengthening NARS—Training	0.147
	Strengthening NARS—Information	0.050
	Strengthening NARS—Org & Mgt	0.096
	Strengthening NARS—Networks	0.163
		1.838
011. Sustainable wheat production systems in the Indo-Gangetic Plains and China	Enhancement and Breeding (Wheat)	0.271
	Production Systems (Wheat)	0.434
	Protecting the Environment	0.615
	Saving Biodiversity	0.108
	Improving Policies	0.108
	Strengthening NARS—Training	0.163
	Strengthening NARS—Information	0.109
		1.808
012. Increasing cereal food production in West Asia and North Africa	Enhancement and Breeding (Wheat)	0.719
	Protecting the Environment	0.332
	Saving Biodiversity	0.229
	Strengthening NARS—Training	0.292
	Strengthening NARS—Information	0.042
	Strengthening NARS—Org & Mgt	0.082
	Strengthening NARS—Networks	0.088
		1.783
013. Enhancing Latin American maize and wheat production systems	Enhancement and Breeding (Maize)	1.303
	Enhancement and Breeding (Wheat)	0.326
	Production Systems (Maize)	0.523
	Production Systems (Wheat)	0.130
	Protecting the Environment	0.767
	Saving Biodiversity	0.413
	Improving Policies	0.113
	Strengthening NARS—Training	0.404
	Strengthening NARS—Information	0.230
	Strengthening NARS—Org & Mgt	0.309
	Strengthening NARS—Networks	0.259
		4.777
014. Increasing cereal food production in Central Asia and the Caucasus	Enhancement and Breeding (Wheat)	0.194
	Production Systems (Wheat)	0.034
	Saving Biodiversity	0.072
	Improving Policies	0.048
	Strengthening NARS—Training	0.072
	Strengthening NARS—Information	0.012
	Strengthening NARS—Org & Mgt	0.024
	Strengthening NARS—Networks	0.024
		0.481
015. Raising the yield potential of wheat	Enhancement and Breeding (Wheat)	0.381
	Strengthening NARS—Information	0.022
	Strengthening NARS—Org & Mgt	0.022
		0.425

Table 4a. Cont'd.

Project	Activity	2000 actual
016. Apomixis — Equity in access to hybrid vigor for resource poor farmers	Enhancement and Breeding (Maize)	0.163
	Enhancement and Breeding (Wheat)	0.163
	Production Systems (Maize)	0.027
	Production Systems (Wheat)	0.027
	Saving Biodiversity	0.058
		0.439
017. Biotechnology for the improvement of maize and wheat in developing countries	Enhancement and Breeding (Maize)	0.363
	Enhancement and Breeding (Wheat)	0.190
	Protecting the Environment	0.648
	Saving Biodiversity	0.269
	Strengthening NARS—Training	0.063
	Strengthening NARS—Information	0.047
		1.580
018. Improving human nutrition by enhancing bioavailable protein and micronutrient concentrations in maize, wheat, and triticale	Enhancement and Breeding (Maize)	0.158
	Enhancement and Breeding (Wheat)	0.075
	Production Systems (Maize)	0.057
	Production Systems (Wheat)	0.027
	Strengthening NARS—Training	0.025
	Strengthening NARS—Information	0.030
	Strengthening NARS—Org & Mgt	0.025
		0.398
019. Genetic approaches to reducing post-harvest losses	Enhancement and Breeding (Maize)	0.055
	Enhancement and Breeding (Wheat)	0.055
	Production Systems (Maize)	0.010
	Production Systems (Wheat)	0.011
	Protecting the Environment	0.156
	Strengthening NARS—Information	0.019
		0.304
020. Priority setting and technology forecasting for increased research efficiency	Enhancement and Breeding (Crops)	0.125
	Production Systems (Crops)	0.094
	Protecting the Environment	0.094
	Improving Policies	0.151
	Strengthening NARS—Org & Mgt	0.056
		0.520
021. Learning to more effectively confront problems of resource degradation in maize and wheat systems	Production Systems (Maize)	0.026
	Production Systems (Wheat)	0.026
	Protecting the Environment	0.164
	Saving Biodiversity	0.088
	Improving Policies	0.034
	Strengthening NARS—Training	0.052
	Strengthening NARS—Information	0.055
	Strengthening NARS—Org & Mgt	0.052
		0.497

		2000 (actual)
Summary by undertaking	Increasing Productivity	14.044
	Protecting the Environment	7.381
	Saving Biodiversity	5.511
	Improving Policies	1.541
	Strengthening NARS	10.071
	Total	**38.549**
Summary by output	Germplasm Improvement	11.642
	Germplasm Collection	5.556
	Sustainable Production	10.151
	Policy	1.645
	Enhancing NARS	9.554
	Total	**38.548**

Table 4b. CIMMYT allocation of project costs to CGIAR activities, 2001-04 (in US$ million)

Project	Activity	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
001. Maize and wheat genetic resources: use for humanity	Enhancement and Breeding (Maize)	0.302	0.308	0.314	0.320
	Enhancement and Breeding (Wheat)	0.302	0.308	0.314	0.320
	Saving Biodiversity	1.538	1.568	1.600	1.632
	Improving Policies	0.302	0.308	0.314	0.320
	Strengthening NARS—Training	0.138	0.141	0.144	0.146
	Strengthening NARS—Information	0.165	0.168	0.172	0.175
		2.746	**2.801**	**2.857**	**2.914**
002. Improved maize for the world's poor	Enhancement and Breeding (Maize)	0.865	0.882	0.900	0.918
	Production Systems (Maize)	0.108	0.110	0.112	0.114
	Protecting the Environment	0.198	0.202	0.206	0.210
	Saving Biodiversity	0.393	0.401	0.409	0.417
	Strengthening NARS—Training	0.393	0.401	0.409	0.417
	Strengthening NARS—Information	0.197	0.201	0.205	0.209
		2.154	**2.197**	**2.241**	**2.286**
003. Improved wheat for the world's poor	Enhancement and Breeding (Wheat)	1.480	1.509	1.539	1.570
	Production Systems (Wheat)	0.065	0.066	0.068	0.069
	Protecting the Environment	0.691	0.705	0.719	0.733
	Saving Biodiversity	0.657	0.670	0.684	0.697
	Strengthening NARS—Training	0.132	0.135	0.137	0.140
	Strengthening NARS—Networks	0.263	0.268	0.274	0.279
		3.288	**3.353**	**3.420**	**3.489**
004. Maize for sustainable production in stressed environments	Enhancement and Breeding (Maize)	0.368	0.376	0.383	0.391
	Production Systems (Maize)	0.067	0.069	0.070	0.071
	Protecting the Environment	0.466	0.475	0.485	0.494
	Saving Biodiversity	0.177	0.181	0.184	0.188
	Strengthening NARS—Training	0.034	0.034	0.035	0.036
	Strengthening NARS—Information	0.067	0.069	0.070	0.071
	Strengthening NARS—Org & Mgt	0.034	0.034	0.035	0.036
	Strengthening NARS—Networks	0.034	0.034	0.035	0.036
		1.247	**1.272**	**1.297**	**1.323**
005. Wheat for sustainble production in marginal environments	Enhancement and Breeding (Wheat)	0.560	0.572	0.583	0.595
	Production Systems (Wheat)	0.099	0.101	0.103	0.105
	Protecting the Environment	1.296	1.322	1.348	1.375
	Saving Biodiversity	0.345	0.352	0.359	0.367
	Strengthening NARS—Information	0.104	0.106	0.108	0.110
	Strengthening NARS—Org & Mgt	0.104	0.106	0.108	0.110
	Strengthening NARS—Networks	0.104	0.106	0.108	0.110
		2.612	**2.665**	**2.718**	**2.772**
006. Wheat resistant to diseases and pests	Enhancement and Breeding (Wheat)	0.371	0.379	0.386	0.394
	Production Systems (Wheat)	0.187	0.190	0.194	0.198
	Protecting the Environment	0.879	0.897	0.915	0.933
	Saving Biodiversity	0.404	0.412	0.420	0.429
	Strengthening NARS—Information	0.094	0.096	0.098	0.100
	Strengthening NARS—Org & Mgt	0.094	0.096	0.098	0.100
		2.029	**2.069**	**2.111**	**2.153**
007. Impacts of maize and wheat research	Improving Policies	0.435	0.444	0.453	0.462
	Strengthening NARS—Training	0.064	0.065	0.067	0.068
	Strengthening NARS—Information	0.064	0.065	0.067	0.068
	Strengthening NARS—Org & Mgt	0.064	0.065	0.067	0.068
	Strengthening NARS—Networks	0.096	0.097	0.099	0.101
		0.723	**0.737**	**0.752**	**0.767**
008. Building human capital	Strengthening NARS—Training	3.337	3.403	3.471	3.541
	Strengthening NARS—Information	0.130	0.132	0.135	0.137
	Strengthening NARS—Org & Mgt	0.615	0.627	0.639	0.652
	Strengthening NARS—Networks	0.123	0.125	0.128	0.130
		4.203	**4.287**	**4.373**	**4.461**
009. Conservation tillage and agricultural systems to mitigate poverty and climate change	Enhancement and Breeding (Maize)	0.074	0.075	0.077	0.079
	Protecting the Environment	0.200	0.204	0.208	0.212
	Saving Biodiversity	0.096	0.098	0.100	0.102
	Improving Policies	0.074	0.075	0.077	0.079
	Strengthening NARS—Training	0.029	0.030	0.030	0.031
	Strengthening NARS—Networks	0.020	0.020	0.021	0.021
		0.493	**0.503**	**0.513**	**0.523**

Table 4b. Cont'd.

Project	Activity	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
010. Food and sustainable livelihoods for Sub-Saharan Africa	Enhancement and Breeding (Maize)	1.858	1.895	1.933	1.972
	Production Systems (Maize)	0.619	0.631	0.644	0.657
	Protecting the Environment	0.702	0.716	0.730	0.745
	Saving Biodiversity	0.372	0.379	0.387	0.395
	Improving Policies	0.124	0.126	0.129	0.132
	Strengthening NARS—Training	0.011	0.011	0.011	0.012
	Strengthening NARS— Information	0.009	0.009	0.009	0.010
	Strengthening NARS—Org & Mgt	0.124	0.126	0.129	0.132
	Strengthening NARS—Networks	0.310	0.316	0.323	0.329
		4.129	**4.212**	**4.296**	**4.382**
011. Maize for poverty alleviaton and economic growth in Asia	Enhancement and Breeding (Maize)	0.484	0.494	0.504	0.514
	Production Systems (Maize)	0.214	0.218	0.223	0.227
	Protecting the Environment	0.331	0.338	0.345	0.352
	Saving Biodiversity	0.162	0.165	0.168	0.172
	Improving Policies	0.176	0.180	0.183	0.187
	Strengthening NARS—Training	0.146	0.149	0.152	0.155
	Strengthening NARS—Information	0.050	0.051	0.052	0.053
	Strengthening NARS—Org & Mgt	0.096	0.098	0.100	0.102
	Strengthening NARS—Networks	0.162	0.165	0.169	0.172
		1.821	**1.858**	**1.895**	**1.933**
012. Sustaining wheat production in South Asia, including rice-wheat systems	Enhancement and Breeding (Wheat)	0.242	0.247	0.252	0.257
	Production Systems (Wheat)	0.386	0.394	0.402	0.410
	Protecting the Environment	0.547	0.558	0.569	0.580
	Saving Biodiversity	0.097	0.099	0.101	0.103
	Improving Policies	0.097	0.099	0.101	0.103
	Strengthening NARS—Training	0.145	0.148	0.151	0.154
	Strengthening NARS—Information	0.097	0.099	0.101	0.103
		1.611	**1.643**	**1.676**	**1.710**
013. Food security for West Asia and North Africa	Enhancement and Breeding (Wheat)	0.712	0.726	0.741	0.755
	Protecting the Environment	0.329	0.335	0.342	0.349
	Saving Biodiversity	0.227	0.231	0.236	0.240
	Strengthening NARS—Training	0.289	0.294	0.300	0.306
	Strengthening NARS—Information	0.042	0.043	0.044	0.045
	Strengthening NARS—Org & Mgt	0.081	0.083	0.084	0.086
	Strengthening NARS—Networks	0.087	0.088	0.090	0.092
		1.765	**1.801**	**1.837**	**1.873**
014. Agriculture to sustain livelihoods in Latin America and the Caribbean	Enhancement and Breeding (Maize)	1.290	1.316	1.342	1.369
	Enhancement and Breeding (Wheat)	0.323	0.329	0.336	0.343
	Production Systems (Maize)	0.518	0.528	0.539	0.550
	Production Systems (Wheat)	0.129	0.132	0.134	0.137
	Protecting the Environment	0.760	0.775	0.790	0.806
	Saving Biodiversity	0.409	0.417	0.425	0.434
	Improving Policies	0.112	0.115	0.117	0.119
	Strengthening NARS—Training	0.400	0.408	0.416	0.425
	Strengthening NARS—Information	0.227	0.232	0.237	0.241
	Strengthening NARS—Org & Mgt	0.306	0.312	0.318	0.325
	Strengthening NARS—Networks	0.257	0.262	0.267	0.273
		4.731	**4.826**	**4.923**	**5.021**
015. Restoring food security and economic growth in Central Asia	Enhancement and Breeding (Wheat)	0.192	0.196	0.200	0.204
	Production Systems (Wheat)	0.034	0.034	0.035	0.036
	Saving Biodiversity	0.072	0.073	0.075	0.076
	Improving Policies	0.048	0.049	0.050	0.051
	Strengthening NARS—Training	0.072	0.073	0.075	0.076
	Strengthening NARS—Information	0.012	0.012	0.012	0.013
	Strengthening NARS—Org & Mgt	0.024	0.024	0.025	0.025
	Strengthening NARS—Networks	0.024	0.024	0.025	0.025
		0.477	**0.486**	**0.496**	**0.506**
016. New wheat science to meet global challenges	Enhancement and Breeding (Wheat)	0.377	0.385	0.393	0.400
	Strengthening NARS—Information	0.022	0.022	0.023	0.023
	Strengthening NARS—Org & Mgt	0.022	0.022	0.023	0.023
		0.421	**0.429**	**0.438**	**0.446**

Table 4b. Cont'd.

Project	Activity	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
017. Apomixis: seed security for poor farmers	Enhancement and Breeding (Maize)	0.304	0.310	0.316	0.323
	Enhancement and Breeding (Wheat)	0.304	0.310	0.316	0.323
	Production Systems (Maize)	0.049	0.050	0.051	0.052
	Production Systems (Wheat)	0.049	0.050	0.051	0.052
	Saving Biodiversity	0.115	0.117	0.120	0.122
		0.821	**0.837**	**0.854**	**0.871**
018. Biotechnology for food security	Enhancement and Breeding (Maize)	0.381	0.388	0.396	0.404
	Enhancement and Breeding (Wheat)	0.199	0.202	0.207	0.211
	Protecting the Environment	0.679	0.692	0.706	0.720
	Saving Biodiversity	0.282	0.288	0.293	0.299
	Strengthening NARS—Training	0.066	0.067	0.068	0.070
	Strengthening NARS—Information	0.049	0.050	0.051	0.052
		1.654	**1.687**	**1.721**	**1.755**
019. Biofortified grain for human health	Enhancement and Breeding (Maize)	0.157	0.160	0.163	0.166
	Enhancement and Breeding (Wheat)	0.074	0.076	0.077	0.079
	Production Systems (Maize)	0.057	0.058	0.059	0.060
	Production Systems (Wheat)	0.027	0.028	0.028	0.029
	Strengthening NARS—Training	0.025	0.026	0.026	0.027
	Strengthening NARS—Information	0.029	0.030	0.031	0.031
	Strengthening NARS—Org & Mgt	0.025	0.026	0.026	0.027
		0.394	**0.402**	**0.410**	**0.418**
020. Reducing grain losses after harvest	Enhancement and Breeding (Maize)	0.054	0.055	0.056	0.057
	Enhancement and Breeding (Wheat)	0.054	0.055	0.056	0.057
	Production Systems (Maize)	0.010	0.010	0.010	0.010
	Production Systems (Wheat)	0.011	0.011	0.011	0.011
	Protecting the Environment	0.155	0.158	0.161	0.164
	Strengthening NARS—Information	0.018	0.019	0.019	0.019
		0.302	**0.308**	**0.314**	**0.320**
021. Technology assessment for poverty reduction and sustainable resource use	Enhancement and Breeding (Crops)	0.134	0.137	0.140	0.143
	Production Systems (Crops)	0.100	0.102	0.104	0.107
	Protecting the Environment	0.100	0.102	0.104	0.107
	Improving Policies	0.163	0.166	0.169	0.173
	Strengthening NARS—Org & Mgt	0.066	0.067	0.068	0.070
		0.563	0.575	0.586	0.598
		38.183	**38.947**	**39.726**	**40.521**

		2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
Summary by undertaking	Increasing Productivity	14.189	14.473	14.762	15.058
	Protecting the Environment	7.332	7.478	7.628	7.780
	Saving Biodiversity	5.345	5.452	5.561	5.672
	Improving Policies	1.530	1.561	1.592	1.624
	Strengthening NARS	9.789	9.985	10.184	10.389
	Total	**38.184**	**38.948**	**39.727**	**40.523**
Summary by output	Germplasm Improvement	12.132	12.375	12.622	12.875
	Germplasm Collection	5.407	5.515	5.625	5.738
	Sustainable Production	10.113	10.315	10.522	10.732
	Policy	1.628	1.661	1.694	1.728
	Enhancing NARS	8.904	9.082	9.264	9.449
	Total	**38.184**	**38.948**	**39.727**	**40.522**

Table 5. CIMMYT research agenda, 2000-04: investments by sector, commodity, and region (in US$ million)

Production sectors and commodities		2000 (actual)	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
1/ Germplasm improvement						
Crops		**11.642**	**11.132**	**11.355**	**11.582**	**11.814**
Barley						
Maize		5.881	5.624	5.736	5.851	5.968
Wheat		5.761	5.509	5.619	5.731	5.846
Livestock						
Trees						
Fish						
	Total	**11.642**	**11.132**	**11.355**	**11.582**	**11.814**
1/ Sustainable production						
Crops		**10.151**	**11.663**	**11.896**	**12.134**	**12.376**
Barley						
Maize		7.613	8.747	8.922	9.100	9.282
Wheat		2.538	2.916	2.974	3.033	3.094
Livestock						
Trees						
Fish						
	Total	**10.151**	**11.663**	**11.896**	**12.134**	**12.376**
2/ Total research agenda						
Crops		**38.548**	**38.184**	**38.948**	**39.727**	**40.521**
Barley						
Maize		17.956	17.786	18.142	18.505	18.875
Wheat		20.592	20.398	20.806	21.222	21.647
Livestock						
Trees						
Fish						
	Total	**38.548**	**38.184**	**38.948**	**39.727**	**40.521**

Region		2000 (actual)	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
Central/West Africa		1.541	1.528	1.559	1.590	1.622
Eastern/Southern Africa		12.722	12.600	12.852	13.109	13.371
East/Southeast Asia		2.312	2.292	2.338	2.385	2.432
South Asia		8.481	8.400	8.568	8.739	8.914
Central America/Caribbean		5.782	5.727	5.842	5.959	6.078
South America		3.855	3.818	3.895	3.972	4.052
West Asia and North Africa		3.855	3.818	3.895	3.972	4.052
	Total	**38.548**	**38.184**	**38.947**	**39.726**	**40.521**

Table 6. CIMMYT research agenda, 2000-04: expenditure by functional category, and capital investments (in US$ million)

Object of expenditure	2000 (actual)	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
Personnel	19.879	19.689	20.111	20.541	20.980
Supplies and services	15.042	14.879	15.177	15.480	15.790
Operational travel	2.237	2.216	2.260	2.306	2.352
Depreciation	1.391	1.400	1.400	1.400	1.400
Total	**38.549**	**38.184**	**38.948**	**39.727**	**40.521**

Capital Investments	2000 (actual)	2001 (estimate)	2002 (plan)	2003 (plan)	2003 (plan)
Physical facilities					
Research	0.420	0.100	0.100	0.100	0.100
Training					
Administration					
Housing					
Auxiliary units					
Subtotal	**0.420**	**0.100**	**0.100**	**0.100**	**0.100**
Infrastructure and leasehold furnishing and equipment					
Farming	0.191	0.100	0.100	0.300	0.300
Laboratory and scientific	0.054	0.100	0.100	0.195	0.195
Office	0.021			0.069	0.069
Housing					
Auxiliary units	0.003				
Computers	0.321	0.316	0.443	0.400	0.400
Vehicles	0.387	0.200	0.300	0.300	0.300
Aircraft					
Subtotal	**0.977**	**0.716**	**0.943**	**1.264**	**1.264**
Total	**1.397**	**0.816**	**1.043**	**1.364**	**1.364**

Capital fund cash reconciliation	2000 (actual)	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
Balance, January 1	**-0.154**	**-0.154**	**-0.124**	**0.233**	**0.269**
Plus: annual depreciation charge	1.391	1.400	1.400	1.400	1.400
Plus / minus: disposal gains/(losses)	-0.056	0.030	0.000	0.000	0.000
Plus / minus: other	-0.148	-0.584	0.000	0.000	0.100
Minus: asset acquisition costs	-1.187	-0.816	-1.043	-1.364	-1.364
Equals: Balance, December 31	**-0.154**	**-0.124**	**0.233**	**0.269**	**0.405**

Table 7. CIMMYT research agenda financing summary (in US$ million)

Member	2000 (US$ actual)	2000 (nat. currency)	2001 (US$ estimated)	2001 (nat. currency)
Unrestricted contributions				
Australia	0.558	0.880	0.558	0.880
Austria	0.150		0.150	
Belgium	0.067	3.000	0.069	3.000
Brazil	0.040		0.040	
Canada	0.693	1.025	0.691	1.025
China	0.120		0.120	
Denmark	0.542	4.500	0.508	4.500
Germany			0.178	0.400
India	0.112		0.112	
Japan	2.297	262.000	2.090	238.420
Korea	0.050		0.050	
Mexico	0.040		0.040	
Netherlands			0.084	0.200
Norway	0.186	1.600	0.186	1.600
Peru	0.020		0.020	
Philippines	0.012		0.012	
Portugal	0.100		0.050	
Spain	0.020		0.020	
Sweden	0.223	2.000	0.225	2.000
Switzerland	0.209	0.350	0.238	0.400
Thailand	0.060		0.020	
USA	4.300		4.300	
World Bank	4.130		3.950	
Subtotal	**13.929**		**13.711**	
Targeted contributions				
ADB	0.393		0.763	
Argentina	0.038		0.030	
Azerbaijan			0.106	
Australia				
AusAID	0.201		0.139	
Australian Centre for International Agricultural Research	0.407		0.199	
CRC Molecular Plant Breeding	0.286		0.208	
Grains Research and Development Corporation	0.538		0.525	
Bangladesh	0.160		0.110	
Belgium	0.333		0.294	
Bolivia				
Protrigo	0.324		0.326	
Brazil	0.032		0.040	
Canada				
Canadian International Development Agency	0.862		0.366	
Agriculture and Agri-Food	0.113		0.075	
International Development Research Centre	0.122		0.067	
CGIAR Centers				
Centro Internacional de Agricultura Tropical	0.010		0.010	
International Centre for Research in Agroforestry	0.017			
International Food Policy Research Institute	0.076		0.138	
International Livestock Research Institute	0.075			
International Plant Genetic Resources Institute	0.068			
CGIAR Finance Committee	0.873		0.311	
SPIA			0.045	
China				
CAAS	0.293		0.313	
Colombia				
Ministry of Agriculture and Rural Development	0.167		0.144	
Colciencias				
Corpoica			0.095	
Denmark	0.068		0.163	
EC	2.964		2.652	
Ecuador (PROMSA)				
FIRA	0.047		0.019	

Cont'd.

Table 7. Cont'd.

Member	2000 (US$ actual)	2000 (nat. currency)	2001 (US$ estimated)	2001 (nat. currency)
Foundations				
Carter Center			0.080	
Eiselen Foundation	0.057		0.047	
Ford Foundation	0.081		0.041	
Fundación Guanajuato Produce A.C.	0.027		0.016	
Fundación Hidalgo	0.018		0.030	
Fundación Sonora	0.136		0.160	
Hilton Foundation	0.076		0.035	
Nippon Foundation	0.273		0.251	
Novartis Foundation	1.518		1.468	
Other foundation	0.564		0.584	
Patronato Sonora			0.040	
Philanthropic foundation			1.600	
Rockefeller Foundation	1.112		1.917	
Sasakawa-Global 2000	0.020		0.030	
France	1.078		1.192	
Germany	0.677		0.565	
India				
NATP			0.020	
Inter American Development Bank	0.609		0.172	
International Fertilizer Development Center				
International Fund for Agricultural Development	0.788		0.238	
Iran, Islamic Republic of	0.214		0.190	
Italy			0.194	
Japan				
JIRCAS	0.114		0.100	
Kenya	0.020		0.050	
Korea	0.067		0.070	
Mexico	0.561		0.563	
Miscellaneous Research Grants	0.192			
Netherlands	0.435		0.205	
OPEC Fund for International Development	0.034			
Peru	0.045		0.040	
Portugal	0.100		0.100	
Private sector				
Agrovegetal, S.A.	0.123		0.100	
Bimbo	0.048		0.040	
Club Cinq	0.050			
GE Group			0.038	
ICAMEX	0.041		0.101	
Monsanto Company	0.153		0.195	
Private Sector Consortium	0.691		0.600	
Private Sector Southern Cone			0.010	

Table 7. Cont'd.

Member	2000 (US$ actual)	2000 (nat. currency)	2001 (US$ estimated)	2001 (nat. currency)
South Africa				
Agricultural Research Council	0.102		0.075	
National Department of Agriculture	0.083		0.083	
Spain	0.113		0.120	
Sweden	0.183		0.103	
Switzerland	1.841		1.339	
Tajikistan	0.181			
UK	1.353		1.203	
UNDP				
United Nations Development Programme (Africa Bureau)	0.832		0.250	
United Nations Development Programme (SEED)	0.152		0.090	
Universities				
Cornell University	0.120		0.073	
Oklahoma State University			0.022	
Stanford University	0.082		0.112	
Uruguay	0.171		0.150	
USA				
United States Agency for International Development	0.338		0.907	
United States Department of Agriculture	0.423		0.606	
World Bank	0.246		0.277	
Subtotal	**24.609**		**23.630**	
Total contributions	**38.538**		**37.341**	

Total agenda financing	2000 (US$ estimate)	2001 (US$ estimate)
Member contributions	**38.538**	**37.341**
+ **Center income**	**0.554**	**1.412**
= **Total financing**	**39.092**	**38.753**

Table 8a. CIMMYT allocation of 2000 member financing to projects by undertaking (in US$ million)

Project	Member	Total
Conservation and management of genetic resources	Australia	0.080
	Canada	0.189
	Denmark	0.068
	EC	0.727
	IDRC	0.052
	IFPRI	0.050
	IPGRI	0.068
	France	0.185
	Japan	0.250
	Private Sector Consortium	0.432
	Unrestricted + center income	1.057
	Total project cost	**3.158**
Developing core germplasm and integrating interdisciplinary approaches for the improvement of maize	CGIAR Finance Committee	0.200
	Colombia	0.050
	France	0.193
	Germany	0.034
	IDB	0.055
	IFAD	0.174
	Japan	0.200
	Nippon Foundation	0.177
	Sweden	0.083
	Switzerland	0.141
	Novartis Foundation	0.383
	United Kingdom	0.083
	UNDP	0.300
	USAID	0.100
	Unrestricted + center income	0.000
	Total project cost	**2.173**
Developing core germplasm and integrating interdisciplinary approaches for the improvement of wheat	Australia	0.320
	Bimbo	0.048
	Brazil	0.016
	CGIAR Finance Committee	0.300
	China	0.193
	Club Cinq	0.050
	Fundación Guanajuato	0.027
	Fundación Hidalgo	0.018
	Fundación Sonora	0.136
	Germany	0.350
	ICAMEX	0.041
	IDB	0.132
	Iran	0.050
	JIRCAS	0.114
	Mexico	0.065
	Monsanto	0.153
	Other foundations	0.208
	South Africa	0.102
	USAID	0.050
	Unrestricted + center income	0.969
	Total project cost	**3.342**
Increasing maize productivity and sustainability in stressed environments: abiotic and biotic stress	Colombia	0.017
	EC	0.155
	Germany	0.188
	IDB	0.090
	IFAD	0.033
	Kenya	0.020
	Rockefeller Foundation	0.100
	Sweden	0.060
	Switzerland	0.185
	UNDP	0.232
	United Kingdom	0.080
	USAID	0.050
	Unrestricted + center income	0.047
	Total project cost	**1.257**
Increasing wheat productivity and sustainability in stressed environments: abiotic stress	Australia	0.190
	Canada	0.452
	Iran	0.064
	Others	0.150
	Portugal	0.100
	Spain	0.045
	Unrestricted + center income	1.633
	Total project cost	**2.634**
Increasing wheat productivity and sustainability in stressed environments: biotic stress	Australia	0.180
	Belgium	0.140
	France	0.070
	IDB	0.122
	Japan	0.200
	Spain	0.048
	Switzerland	0.050
	USDA	0.148
	Unrestricted + center income	1.087
	Total project cost	**2.045**
Gauging the productivity, equity, and environmental impact of modern maize and wheat production systems	France	0.130
	Rockefeller Foundation	0.194
	Switzerland	0.350
	Unrestricted + center income	0.055
	Total project cost	**0.729**
Building partnerships through human resource development	ADB	0.314
	Australia	0.160
	Bangladesh	0.097
	Iran	0.080
	Other foundations	0.356
	Rockefeller Foundation	0.608
	USDA	0.275
	Unrestricted + center income	2.355
	Total project cost	**4.245**

Table 8a. Cont'd.

Project	Member	Total
Improving food security in Sub-Saharan Africa	Australia	0.050
	Canada	0.221
	CIAT	0.010
	EC	0.500
	IFAD	0.200
	IFPRI	0.026
	ILRI	0.075
	Netherlands	0.039
	Nippon Foundation	0.096
	OPEC	0.034
	Rockefeller Foundation	0.158
	Sasakawa-Global 2000	0.020
	South Africa	0.083
	Sweden	0.040
	Switzerland	0.655
	Novartis Foundation	0.785
	UNDP Africa	0.452
	United Kingdom	0.650
	Unrestricted + center income	0.019
	Total project cost	**4.113**
Meeting accelerating demand for maize development, production, and delivery in South and Southeast Asia and in China	ADB	0.079
	Australia	0.132
	IFAD	0.167
	Others	0.042
	Unrestricted + center income	1.418
	Total project cost	**1.838**
Sustainable wheat production systems in the Indo-Gangetic Plains and China	Bangladesh	0.063
	Belgium	0.193
	China	0.100
	Cornell University	0.120
	Japan	0.200
	Stanford University	0.082
	Netherlands	0.267
	USAID	0.100
	Unrestricted + center income	0.683
	Total project cost	**1.808**
Increasing cereal food production in WANA	Australia	0.130
	EC	0.404
	Unrestricted + center income	1.250
	Total project cost	**1.784**
Enhancing Latin American maize and wheat production systems	Agrovegetal	0.123
	Argentina	0.038
	Brazil	0.016
	Colombia	0.055
	EC	0.714
	Ford Foundation	0.081
	France	0.160
	Hilton Foundation	0.076
	IDB	0.100
	IDRC	0.036
	IFAD	0.214
	Mexico	0.396
	Peru	0.045
	Protrigo	0.324
	Switzerland	0.360
	United Kingdom	0.290
	Uruguay	0.171
	Unrestricted + center income	1.579
	Total project cost	**4.778**
Increasing cereal food production in CAC	Germany	0.035
	Tajikistan	0.181
	World Bank	0.246
	Unrestricted + center income	0.019
	Total project cost	**0.481**
Raising the yield potential of wheat	Australia	0.080
	Iran	0.020
	Unrestricted + center income	0.326
	Total project cost	**0.426**
Apomixis — Equity in access to hybrid vigor for resource poor farmers	France	0.175
	Mexico	0.060
	Private Sector Consortium	0.159
	Unrestricted + center income	0.045
	Total project cost	**0.439**
Using biotechnology for the improvement of maize and wheat in developing countries	Australia	0.050
	EC	0.377
	France	0.135
	Germany	0.127
	Japan	0.200
	Korea	0.067
	Netherlands	0.040
	Novartis Foundation	0.350
	Private Sector Consortium	0.100
	Rockefeller Foundation	0.052
	Spain	0.020
	CGIAR Finance Committee	0.023
	Unrestricted + center income	0.039
	Total Project Cost	**1.580**
Improving human nutrition by enhancing bioavailable protein and micronutrient concentrations in maize, wheat, and triticale	Mexico	0.040
	CGIAR Finance Committee	0.350
	Unrestricted + center income	0.008
	Total project cost	**0.398**
Genetic approaches to reducing post-harvest losses	Agriculture and Agri-food	0.113
	Switzerland	0.100
	Unrestricted + center income	0.092
	Total project cost	**0.305**
Priority setting and technology forecasting for increased research efficiency	EC	0.087
	France	0.030
	IDB	0.110
	IDRC	0.034
	Unrestricted + center income	0.259
	Total project cost	**0.520**
Learning to more effectively confront problems of resources degradation in maize and wheat systems	Australia	0.060
	Colombia	0.045
	FIRA	0.047
	ICRAF	0.017
	United Kingdom	0.250
	USAID	0.038
	Unrestricted + center income	0.040
	Total project cost	**0.497**

Center totals		Total
Total targeted funding		**25.570**
Total unrestricted funding		**12.968**
Total center income		**0.554**
	Total allocations	**39.092**

Table 8b. CIMMYT allocation of 2001 member financing to projects by undertaking (in US$ million)

Project	Member	Total
Maize and wheat genetic resources: use for humanity	Australia	0.071
	Canada	0.066
	Denmark	0.163
	EC	1.041
	IDRC	0.025
	IFPRI	0.068
	France	0.050
	Germany	0.150
	Japan	0.250
	Other foundations (new)	0.430
	Unrestricted + center income	0.433
	Total project cost	**2.747**
Improved maize for the world's poor	Carter Center	0.080
	CGIAR Finance Committee	0.050
	Colombia	0.044
	France	0.050
	Germany	0.062
	IDB	0.025
	IFAD	0.078
	Japan	0.200
	Mexico	0.158
	Nippon Foundation	0.163
	Other foundations (new)	0.246
	Sweden	0.020
	Switzerland	0.339
	Novartis Foundation	0.388
	United Kingdom	0.100
	UNDP	0.127
	USAID	0.025
	Unrestricted + center income	0.000
	Total project cost	**2.155**
Improved wheat for the world's poor	Australia	0.100
	Bimbo	0.040
	Brazil	0.020
	CGIAR Finance Committee	0.111
	China	0.235
	Fundación Guanajuato	0.016
	Fundación Hidalgo	0.030
	Fundación Sonora	0.160
	Germany	0.158
	ICAMEX	0.101
	IDB	0.055
	Iran	0.050
	Italy	0.097
	JIRCAS	0.100
	Mexico	0.050
	Monsanto	0.195
	Netherlands	0.000
	Other foundations	0.213
	Patronato Sonora	0.040
	South Africa	0.050
	USAID	0.300
	Unrestricted + center income	1.168
	Total project cost	**3.289**

Project	Member	Total
Maize for sustainable production in stressed environments	Colombia	0.025
	Germany	0.142
	IFAD	0.075
	Kenya	0.050
	Rockefeller Foundation	0.221
	Sweden	0.053
	Switzerland	0.158
	UNDP	0.133
	United Kingdom	0.183
	USAID	0.207
	Unrestricted + center income	0.000
	Total project cost	**1.247**
Wheat for sustainable production in marginal environments	Australia	0.150
	Canada	0.225
	Iran	0.025
	Oklahoma State University	0.022
	Portugal	0.100
	Spain	0.070
	Unrestricted + center income	2.020
	Total project cost	**2.612**
Wheat resistant to diseases and pests	Australia	0.128
	Belgium	0.194
	France	0.100
	IDB	0.020
	Japan	0.200
	Korea	0.070
	Spain	0.030
	Switzerland	0.042
	USDA	0.302
	Unrestricted + center income	0.943
	Total project cost	**2.029**
Impacts of maize and wheat research	France	0.200
	Rockefeller Foundation	0.328
	Switzerland	0.125
	Unrestricted + center income	0.070
	Total project cost	**0.723**
Building human capital	ADB	0.663
	Australia	0.072
	Bangladesh	0.085
	Iran	0.060
	Other foundations	0.371
	Other foundations (new)	0.604
	Rockefeller Foundation	0.472
	USDA	0.304
	Unrestricted + center income	1.578
	Total project cost	**4.209**
Conservation tillage and agricultural systems to mitigate poverty and climate change	Australia	0.050
	Colombia	0.065
	France	0.098
	United Kingdom	0.065
	USAID	0.140
	Unrestricted + center income	0.076
	Total project cost	**0.494**

Table 8b. Cont'd.

Project	Member	Total
Food and sustainable livelihoods for Sub-Saharan Africa	Australia	0.050
	Canada	0.075
	CIAT	0.010
	EC	0.405
	IFAD	0.050
	IFPRI	0.070
	Netherlands	0.050
	Nippon Foundation	0.088
	Novartis Foundation	0.877
	Rockefeller Foundation	0.780
	Sasakawa-Global 2000	0.030
	South Africa	0.108
	Sweden	0.030
	Switzerland	0.325
	UNDP Africa	0.080
	United Kingdom	0.658
	Unrestricted + center income	0.443
	Total project cost	**4.129**
Maize for poverty alleviaton and economic growth in Asia	ADB	0.100
	Australia	0.150
	IFAD	0.035
	Switzerland	0.100
	Unrestricted + center income	1.437
	Total project cost	**1.822**
Sustaining wheat production in South Asia, including rice-wheat systems	Bangladesh	0.025
	Belgium	0.100
	China	0.078
	Cornell University	0.073
	Japan	0.200
	Stanford University	0.112
	NATP	0.020
	Netherlands	0.105
	USAID	0.235
	Unrestricted + center income	0.663
	Total project cost	**1.611**
Food security for West Asia and North Africa	Australia	0.100
	Unrestricted + center income	1.660
	Total project cost	**1.760**
Agriculture to sustain livelihoods in Latin America and the Caribbean	Agrovegetal	0.100
	Argentina	0.030
	Brazil	0.020
	Colombia	0.105
	EC	0.389
	FIRA	0.019
	Ford Foundation	0.041
	France	0.100
	Hilton Foundation	0.035
	IDB	0.022
	IDRC	0.021
	Mexico	0.255
	Other foundations (new)	0.320
	Peru	0.040
	Private Sector Southern Cone	0.010
	Protrigo	0.326
	Switzerland	0.150
	United Kingdom	0.197
	Uruguay	0.150
	Unrestricted + center income	2.385
	Total project cost	**4.715**

Project	Member	Total
Restoring food security and economic growth in Central Asia and the Caucasus	Azerbaijan	0.106
	Germany	0.044
	World Bank	0.277
	CGIAR Finance Committee	0.050
	Unrestricted + center income	0.000
	Total project cost	**0.477**
New wheat science to meet global challenges	Australia	0.150
	Iran	0.055
	Unrestricted + center income	0.216
	Total project cost	**0.421**
Apomixis: seed security for poor farmers	France	0.200
	Mexico	0.021
	Private Sector Consortium	0.600
	Unrestricted + center income	0.000
	Total project cost	**0.821**
Biotechnology for food security	Australia	0.050
	EC	0.770
	France	0.094
	Germany	0.056
	Italy	0.097
	Japan	0.200
	Netherlands	0.050
	Novartis Foundation	0.203
	Rockefeller Foundation	0.116
	Spain	0.020
	Unrestricted + center income	0.000
	Total project cost	**1.656**
Biofortified grain for human health	Mexico	0.079
	CGIAR Finance Committee	0.100
	Unrestricted + center income	0.215
	Total project cost	**0.394**
Reducing grain losses after harvest	Agriculture and Agri-food	0.075
	Switzerland	0.100
	Unrestricted + center income	0.128
	Total project cost	**0.303**
Technology assessment for poverty reduction and sustainable resource use	EC	0.047
	France	0.300
	GE Group	0.038
	IDB	0.050
	IDRC	0.021
	SPIA	0.045
	Unrestricted + center income	0.068
	Total project cost	**0.569**

Center totals		Total
Total targeted funding		**24.679**
Total unrestricted funding		**12.091**
Total center income		**1.412**
	Total allocations	**38.182**

Table 9. CIMMYT research agenda staff composition, 2000-04

	2000 (actual) Hired by:		2001 (estimated) Hired by:		2002 (proposal) Hired by:		2003 (plan) Hired by:		2004 (plan) Hired by:	
	Center	Other	Center	Other	Center	Other	Center	Other	Center	Other
Internationally recruited staff (IRS)										
Research and research support,	**93**	**25**	**96**	**24**	**96**	**27**	**96**	**27**	**96**	**27**
of which:										
Post-doctoral fellows	11	4	15	3	15	3	15	3	15	3
Associate professionals	9	7	10	7	10	10	10	10	10	10
Training / communications,	**6**	**0**	**6**	**0**	**6**	**0**	**6**	**0**	**6**	**0**
of which:										
Post-doctoral fellows										
Associate professionals										
Research management,	**7**	**0**	**8**	**0**	**8**	**0**	**8**	**0**	**8**	**0**
of which:										
Post-doctoral fellows										
Associate professionals										
Total IRS	**106**	**25**	**110**	**24**	**110**	**27**	**110**	**27**	**110**	**27**
Support staff										
Outreach national staff	110		105		105		105		105	
Mexico national staff	640		640		640		640		640	
Total support staff	**750**		**745**		**745**		**745**		**745**	
Grand total staff	**856**	**25**	**855**	**24**	**855**	**27**	**855**	**27**	**855**	**27**

Table 10. CIMMYT cash requirement, revenue flow, and currency shares (in US$ '000)

	Monthly cash uses and sources											
2000	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Cash requirement	2.803	2.457	2.936	2.944	3.281	2.302	2.650	1.530	2.144	2.476	2.717	3.170
Member and center income	1.208	2.015	1.850	0.492	2.717	4.065	2.064	0.783	2.203	2.774	2.345	6.857
Net monthly position	**-1.595**	**-0.442**	**-1.086**	**-2.452**	**-0.564**	**1.763**	**-0.586**	**-0.747**	**0.059**	**0.298**	**-0.372**	**3.687**
Accumulated position	**-1.595**	**-2.037**	**-3.123**	**-5.575**	**-6.139**	**-4.376**	**-4.962**	**-5.709**	**-5.650**	**-5.352**	**-5.724**	**-2.037**
2001	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Cash requirement	2.980	2.510	2.360	2.650	2.430	2.780	1.810	2.590	2.130	2.570	2.730	2.650
Member and center income	4.525	0.910	2.150	1.680	2.450	1.980	2.850	1.950	3.530	3.220	3.120	6.304
Net monthly position	**1.545**	**-1.600**	**-0.210**	**-0.970**	**0.020**	**-0.800**	**1.040**	**-0.640**	**1.400**	**0.650**	**0.390**	**3.654**
Accumulated position	**1.545**	**-0.055**	**-0.265**	**-1.235**	**-1.215**	**-2.015**	**-0.975**	**-1.615**	**-0.215**	**0.435**	**0.825**	**4.479**

	Currency structure of expenditures					
	2000 (actual)			2001 (estimate)		
Currency	**Amount**	**$ value**	**% share**	**Amount**	**$ value**	**% share**
US Dollar	22.222	22.222	58%	21.000	21.000	55%
Currency A	154.421	16.330	42%	171.820	17.182	45%
Others						
Total		**38.55**			**38.18**	

Table 11. CIMMYT statement of financial position, 2000-04 (in US$ '000)

Assets	2000 (actual)	2001 (estimate)	2002 (plan)	2003 (plan)	2004 (plan)
Current assets					
Cash and cash equivalents	3,909	4,479	5,725	5,840	6,091
Accounts receivable					
Donors	8,266	7,425	7,574	7,725	7,879
Employees	420	300	225	230	234
Other	980	1,400	1,428	1,457	1,486
Inventories	218	210	214	218	223
Total current assets	**13,793**	**13,814**	**15,166**	**15,469**	**15,913**
Fixed assets					
Property, plant, and equipment	33,925	34,741	35,784	37,148	38,512
Less: accumulated depreciation	-19,633	-21,033	-22,433	-23,833	-25,233
Total fixed assets - net	**14,292**	**13,708**	**13,351**	**13,315**	**13,279**
Total assets	**28,085**	**27,522**	**28,517**	**28,784**	**29,192**
Liabilities and net assets					
Current liabilities					
Bank indebtedness					
Accounts payable					
Donors	2,819	3,395	3,675	3,749	3,823
Employees	385	74	75	50	51
Others	1,677	500	510	520	531
In-trust accounts	0	125	128	130	133
Accruals and provisions	3,549	3,441	3,510	3,248	3,313
Total current liabilities	**8,430**	**7,535**	**7,898**	**7,697**	**7,851**
Long-term liabilities	558	300	300	450	550
Total liabilities	**8,988**	**7,835**	**8,198**	**8,147**	**8,401**
Net assets					
Capital invested in fixed assets					
Center owned	13,728	13,788	14,064	14,345	14,632
In custody					
Capital fund	-154	-124	233	269	405
Operating fund	5,523	6,023	6,023	6,023	6,023
Other funds					
Total net assets	**19,097**	**19,687**	**20,320**	**20,637**	**21,060**
Total liabilities and net assets	**28,085**	**27,522**	**28,517**	**28,784**	**29,460**

Project Portfolio

CIMMYT's portfolio of multidisciplinary research projects is divided into nine global, six regional, and six frontier projects. Global (G) and regional (R) projects, as their titles indicate, encompass research that is best conducted from either a worldwide or specifically regional perspective, though the interaction between the two kinds of projects is considerable. (For example, many of the experimental maize and wheat varieties developed through global projects find their ultimate testing ground in the regions, and information from the regions often proves valuable for orienting global breeding efforts). In line with agreed CGIAR initiatives, there will be greater regional input into the priorities and planning for both our global and our regional projects. Frontier (F) projects often involve more novel research approaches or more specialized research objectives than global or regional projects, but all frontier projects are designed to produce results with specific regional and/or global applications.

Project 1 (G1): Maize and wheat genetic resources: use for humanity

Overall goal	Indicators	Assumptions and risks
Productivity of resources in maize and wheat production is increased, and the sustainable management of natural resources is improved. This goal reflects CIMMYT's commitment to the Global Plan of Action for Plant Genetic Resources for Food and Agriculture as a means of implementing the Convention on Biological Diversity.	• Global food security is increased. • Environmental well-being is improved.	• In studies of the impact of germplasm improvement research, improved food security and environmental well-being can be attributed to the use of genetic resources.
Intermediate goal	**Indicators**	**Assumptions and risks**
Agrobiodiversity in sustainable farming systems is enhanced through research involving the collection, conservation, evaluation, and equitable sharing of genetic resources of maize, wheat, triticale, and appropriate related species.	• Continued conservation and *ex situ* management of maize, wheat, and related genetic resources. • Increased evaluation and utilization of maize, wheat, and related genetic resources by researchers and farmers. • Increased information for researchers, farmers, and policymakers on social, economic, and policy issues in maize and wheat genetic resource management and conservation, *ex situ* and *in situ*.	• Policy environment is conducive to international exchange and dissemination of genetic resources, information, and collaborative research.
Purpose	**Indicators**	**Assumptions and risks**
CIMMYT researchers and partners worldwide obtain, maintain, and share germplasm, information, and other products needed to develop superior, genetically diverse seed for farmers' maize and wheat production systems.	Reduced genetic vulnerability in farmers' fields, leading to improved production and food security.	
Outputs	**Indicators**	**Assumptions and risks**
1. Better conservation of genetic resources *ex situ* and *in situ*. 2. Improved characterization and evaluation of germplasm. 3. Improved methods for conservation, evaluation, and economic assessment of genetic resources. 4. Novel germplasm with new genes/ desirable traits for future breeding efforts is developed through novel conventional and molecular technologies. 5. Improved and more widely available information (agronomic, economic) on genetic resources. 6. Information for policy related to genetic resources and genetic diversity.	• The safe, sustainable care of genetic resource collections. • Measurably enhanced conservation and utilization of genetic diversity. • Measurable increase in genetic diversity available to breeding programs. • Measurable increase in productivity, genetic diversity in farmers' fields, or other crop improvement and natural resource management goals.	
Activities	**Milestones**	**Assumptions and risks**
1. Bioinformatics: information related to genetic resources used to enhance the conservation and utilization of genetic diversity (contributes to all outputs).	Over the planning period: • Include passport and characterization data on new introductions in the Maize Germplasm Bank System (MGBS), as well as information on race-oriented breeding core subsets of the maize collection. • Integrate all information on wheat genetic resources (including data on the origin, pedigrees, and characteristics of CIMMYT genebank accessions) into the International Wheat Information System (IWIS) and provide to partners without charge via CD-ROM.	

Activities	Milestones	Assumptions and risks
	• Integrate all information on maize genetic resources (as with wheat genetic resources, above) into the International Maize Information System (IMIS) as it is developed. • Develop a database to manage the distribution of germplasm.	
2. Dynamics of diversity on farm: conserving and utilizing genetic diversity (contributes to outputs 1 and 3-6).	Over the planning period: • Improve the methodology for interaction between breeders and farmers, including access to and use of farmers' extensive knowledge of crops and crop varieties, breeding criteria, and consumption and production constraints. • Develop methods for assessing the economic value of accessions in the wheat collection, the economic impact of different types of genetic resources and their diversity on productivity and yield stability at aggregate and household levels, and the economic and genetic impact of on-farm improvement of landraces in rural communities. • Develop methods to assess the feasibility of *in situ* conservation strategies and the implications of policy alternatives for farmers' behavior. • Explore possible economic incentives for conservation of genetic diversity on the farm. • Assess morphological and genetic changes of improved maize varieties and landraces under farmer management. • Analyze the structure and function of farmers' social networks in relation to seed flows.	
3. Maize conservation, *ex situ:* Landraces and wild relatives of maize are collected and maintained; improved lines and populations are preserved; prebreeding techniques—conventional as well as cytogenetic and molecular—are developed to enable researchers to incorporate diversity into new germplasm (contributes to outputs 1 and 4).	Over the planning period: • Maize genetic resource holdings will exceed 20,000 accessions with introductions from Latin American Maize Regeneration Project (LAMP); most of these will be bar coded. • Develop/refine and implement techniques for prebreeding. • Develop and use heterotic maize germplasm pools. • Collect local races in Latin America to fill gaps in the Latin American maize collections and promote on-farm conservation. • In addition to the LAMP core subsets, designate and publish information on some 1,500 maize accessions as a race-oriented breeding core from the evaluation trials.	
4. Wheat conservation, *ex situ:* Landraces and wild relatives of wheat are collected and maintained; improved lines and populations are preserved; prebreeding techniques—conventional as well as cytogenetic and molecular—are developed to enable researchers to incorporate diversity into new germplasm (contributes to outputs 1 and 4).	• By 2002, further evaluate material selected from screening 10,000 wheat landraces from Iran, Turkey, and Oaxaca and characterize it for yield components and physiological and agronomic traits. • By 2002, evaluate about 500 synthetics derived from emmer wheat for resistance/tolerance to Russian wheat aphid, leaf and yellow rust, and septoria leaf blotch. • By early 2003, complete initial germination tests of all material grown out to eliminate Karnal bunt disease. Check these lines for "orange" color to identify accessions with high carotene to produce "golden" wheat. Over the planning period: • Cross selections from the 5,000 accessions of *Triticum* spp. evaluated for resistance to yellow rust, tan spot, and fusarium head blight with improved wheats, and distribute to cooperators.	

Activities	Milestones	Assumptions and risks
	• Verify the identity of cultivars in the overall wheat collection and identify gaps in the collection (on-going activity). • Develop/refine and implement techniques for prebreeding. • Improve passport information by allocating coordinates to place names.	
5. Development of new tools for the characterization and evaluation of genetic resources (contributes to outputs 1-5).	Over the planning period: • Through pilot studies, identify the main techniques that CIMMYT will use to fingerprint maize lines and populations and wheat lines. • Optimize large-scale fingerprinting of maize lines, populations, and races and wheat lines, landraces, and synthetic varieties and proceed with fingerprinting as an ongoing project; compile and analyze data. • For prebreeding, evaluate part of the core subset collections of maize for heterotic patterns using molecular markers. • Conduct molecular mapping of the multi-ovariate trait in wheat. • Develop new screening techniques for aphid resistance in wheat. • Apply new statistical methods to determine the minimum number of molecular markers, and the identity of the most discriminating markers, for use in characterization studies.	

Duration: 2002–2004+
Collaborators: NARSs
IARCs
NGOs
ARIs
Costs: US$ 3.117M
System linkages: Germplasm improvement (22%)
Germplasm collection (56%)
Policy (11%)
Enhancing NARSs (11%)

Project 2 (G2): Improved maize for the world's poor

Overall goal	**Indicators**	**Assumptions and risks**
The productivity and nutritive value of maize and the sustainability of maize-based farming systems in the developing world will be enhanced.	• Impact surveys will indicate a 5% increase in maize grain yields. • Nutritional levels of poor farmers in developing countries will improve.	• Governments in Latin America and Africa will implement policies in support of agriculture. • Maize imports will be reduced. • Prices of maize in the international market will remain unchanged.
Intermediate goal	**Indicators**	**Assumptions and risks**
New, high-yielding, input-efficient, stress-tolerant maize germplasm and innovative technologies will be developed and partially adopted.	• Progress reports will provide evidence of the efficiency of maize breeding methods. • CIMMYT impact studies will indicate adoption of new hybrids and varieties. • Policymakers in national programs will endorse CIMMYT Maize Program activities. • Use of CIMMYT germplasm in the seed industry and NARSs will be documented.	• Comprehensive national agricultural research policies will follow national development plans in developing countries. • Credit and agricultural inputs are available at the national level.
Purpose	**Indicators**	**Assumptions and risks**
A network of maize scientists in the developing world will provide high-yielding, input-efficient, stress-tolerant germplasm, as well as information concerning its proper use and ways to increase the productivity and sustainability of maize-based farming in general.	• The research capacity of national maize programs will be enhanced. • CIMMYT's stress-resistant inbred lines used by 80% of maize breeders in NARSs and the seed industry. • Seventy percent of the improved varieties in developing countries contain at least some CIMMYT germplasm.	• Private seed companies will disseminate varieties containing CIMMYT germplasm. • National programs will receive more support from the public and private sectors.
Outputs	**Indicators**	**Assumptions and risks**
1. High-yielding, input-efficient, stress-tolerant, lodging-resistant, stable, highly nutritive, and environmentally compatible cultivars for maize-based systems in developing countries. 2. Stable experimental germplasm with broad adaptation, superior performance, and stress tolerance, 3. The enhanced global exchange of germplasm and capacity for creating novel genotypes. 4. A forum for the efficient exchange of germplasm, experiences, and information among global maize scientists. 5. Through NARSs and CIMMYT's regional programs, the more efficient transfer of CIMMYT's research outputs to benefit resource-poor farmers. 6. Information on population and line performance in a broad array of environments and on efficient means to develop broadly adapted germplasm using molecular and conventional approaches. 7. Information on relationships among important maize germplasm groups from NARSs, advanced research institutes, and CIMMYT, resulting in the more efficient development of superior cultivars and international use of improved maize germplasm. 8. NARSs and CIMMYT maize germplasm classified according to heterotic patterns.	1. By 2004 and in collaboration with NARSs and via international testing, the CIMMYT Maize Program will have developed and identified new hybrids and synthetics with 20% higher yield than the current best seed industry checks. 2. By 2004, the CIMMYT Maize Program will have developed inbred progenitors, hybrids, and synthetic varieties with excellent yield stability and resistance to biotic and abiotic stresses. NARSs, in collaboration with CIMMYT, will have released hybrids and synthetics with broad adaptation, added nutritive value, and 15% higher grain yields than the best seed industry checks. 3. The exchange of germplasm and information will improve. 4. Farmers will have quicker access to useful outputs of maize research. 5. Information on the performance of new experimental varieties, as well as on the relative advantages of conventional and nonconventional breeding approaches, will be available. 6. More information on the relationships among important maize germplasm groups will be available. 7. By 2004, CIMMYT-Mexico will have completed the study of testers and heterotic groups and will have distributed results to partners in the public and private sectors.	• The budget of the CIMMYT Maize Program will remain stable. • CIMMYT Maize Program staffing will remain stable. • Collaboration with the private sector will be enhanced. • National programs will receive priority and relationships with CIMMYT will be strengthened. • Public and private extension services will improve.

Activities	Milestones	Assumptions and risks
1. Form, evaluate, and select among early and late maturing white and yellow maize inbred lines adapted to tropical, subtropical, midaltitude, and highland environments (contributes to outputs 1, 2).	• Over the planning period, provide partners 130 broadly adapted, stable inbred lines that possess good general combining ability and known heterotic response; general resistance to major foliar diseases, ear rots, insect pests, and abiotic stresses; and added nutritive value.	• Resources (staff and budgets) will continue to be available.
2. Assemble and distribute nurseries for early (9,000 lines), advanced (900 lines), and elite (200 lines) generations of inbred lines (contributes to outputs 1-5).	• Over the planning period, form and distribute 3 different nurseries.	• Weather conditions permit effective work.
3. Germplasm development and population improvement: evaluate early (including. IPTTs) and advanced generation testcrosses (contributes to outputs 3, 6).	Over the planning period: • Develop 7 new populations, introgress landraces and exotic germplasm, and provide data. • Test 1,500 hybrids.	
4. Evaluate testcrosses simultaneously under abiotic stresses (drought, low N, high density) and biotic stresses (foliar diseases, ear rots, and insects; contributes to outputs 1, 2, 5).	Over the planning period: • Data become available. • Yield stability enhanced.	
5. Form, evaluate, and select among synthetics with the following characteristics: early maturity, late maturity, disease resistance, tolerance to drought and low N, and midaltitude and highland adaptation (contributes to outputs 1, 2).	• Over the planning period, develop and test some 80 new OPVs and synthetics of both normal and quality protein maize (QPM) through international trials.	• Collaboration between the CIMMYT seed health and international testing units will continue at its current, high level. • Mexican quarantine authorities will issue import permits on time.
6. Form and evaluate advanced single-cross and testcross hybrids for subtropical, midaltitude, and highland regions; form and evaluate stress-resistant hybrids (contributes to outputs 1, 2).	• Over the planning period, develop and test about 150 new, high-yielding, stable hybrids (normal and QPM) through international trials.	• The CIMMYT Seed Health and International Testing Units will maintain their current level of efficiency.
7. By 2002, respective national agencies release QPM hybrids in India, Vietnam, Venezuela, Nicaragua, and Honduras, and hybrids and OPVs in eastern and southern Africa, Asia, and Latin America (contributes to outputs 1, 2, 4).	Over the planning period: • Approximately 40 inbred lines and 25 OPVs and hybrids (normal and QPM) will be released by national programs; seed will be produced by national and private seed companies. • Characterize all products for abiotic and biotic stress tolerance. • In collaboration with G4, R2, R5, and F4, release normal and QPM hybrids, synthetics, and lines resistant to stresses.	• Effective seed providers will be in place. • Extension services will be active in target countries.
8. Develop 2 white and 2 yellow heterotic maize populations with tolerance to acidic, aluminum-toxic soils and adaptation to the lowland tropics (contributes to outputs 1, 2).	• Over the planning period, in close collaboration with G4, identify 10 source OPVs with specific stress tolerance and excellent performance through testing in Mexico and elsewhere.	
9. Select among 440 testcrosses between inbred lines and 2 testers under low N for the 10% best lines for hybrid formation and pedigree projects (contributes to outputs 1, 2).	• Over the planning period, in close collaboration with G4, identify 20 inbred lines with good general combining ability, specific abiotic and biotic stress tolerance, and excellent performance potential in unstressed environments.	
10. Select and evaluate subtropical, tropical, and highland QPM lines with the assistance of molecular markers (contributes to outputs 1, 2, 5).	• Over the planning period, marker-assisted breeding used routinely for at least two traits.	• Activities of the CIMMYT Maize Program and Applied Biotechnology Center will be fully integrated.
11. Evaluate QPM and normal maize for industrial quality (tortillas) in Mexico, Central America, and Venezuela (contributes to outputs 1, 2)	• Over the planning period, food quality traits (color, flour recovery rate, cooking time, texture) assume greater importance in breeding.	• Effective relationships between the milling industry and maize grower associations will be in place.
12. The respective CIMMYT maize subprograms undertake detailed studies on the heterotic patterns in tropical, subtropical, and highland germplasm (contributes to outputs 1, 2, 7).	• Over the planning period, major heterotic patterns in tropical and subtropical maize are identified, reported widely, and used by several NARSs to guide their work.	• CIMMYT reports will reach all intended audiences.

Activities	Milestones	Assumptions and risks
13. During 2002, conduct three types of training: 1) maize breeding courses in Spanish and English at CIMMYT-Mexico; 2) advanced breeding course for NARSs leaders at CIMMYT-Mexico; and 3) visiting scientist appointments to CIMMYT maize subprograms and to national programs in Africa, Latin America, and Asia (contributes to outputs 3, 4).	• Over the planning period, train about 80 national researchers in applied maize breeding.	• Potential trainees will be available in developing countries.

Duration: 2002-2004+

Collaborators: NARSs: Including KARI, Kenya; EARO, Ethiopia; ICAR, India; CAAS, China; EMBRAPA, Brazil; La Molina, Peru; CENTA, El Salvador; ICTA, Guatemala; INTA, Nicaragua; DICTA, Honduras; IDIAP, Panama; INIAP, Ecuador; INIA, Peru; INIFAP, Mexico; and UAAAN, Mexico

IARCs: CIAT, ILRI, ICRISAT, CIP

NGOs: Including Sasakawa-Global 2000, World Vision

Universities: Including Texas A&M University, USA; Iowa State University, USA: and Oklahoma State University, USA

Private companies: Including MASECA, Mexico

Costs: US$ 2.155M

System linkages: Germplasm improvement (55%)
Germplasm collection (18%)
Sustainable production (7%)
Enhancing NARSs (20%)

Project 3 (G3): Improved wheat for the world's poor

Overall goal	Indicators	Assumptions and risks
To increase food production and enhance food security in the irrigated and high rainfall environments of the developing world while protecting the environment and preserving the biodiversity of wheat, triticale, and barley.	• Increased wheat, triticale, and barley production in the irrigated and high rainfall regions of the developing world. • Increased adoption of resource-conserving technologies by farmers. • Greater diversity in the wheat, triticale, and barley varieties sown in farmers' fields.	• Governments in developing countries will continue with policies that support agricultural development, although an actual, continual decline is noted.
Intermediate goals	**Indicators**	**Assumptions and risks**
1. Improved food production through the introduction of higher yielding, disease-resistant wheat, triticale, and barley varieties in irrigated and high rainfall environments of the developing world. 2. Enhanced food security as a result of greater yield stability in farmers' fields. 3. Improved crop management strategies to ensure that farmers take full advantage of the improved characteristics of modern varieties.	• Higher wheat, triticale, and barley yields. • Farmers adopt higher yielding wheat, triticale, and barley varieties with improved disease and pest resistance. • Farmers adopt improved crop management practices that go with improved varieties. • Greater genetic diversity of sown varieties, which as a result are less vulnerable to diseases, pests, and environmental variability.	• NARSs will use CIMMYT germplasm to develop and release adapted varieties to farmers. • NARSs have reduced resources for crop improvement.
Purpose	**Indicators**	**Assumptions and risks**
To produce high-yielding, disease-resistant wheat, triticale, and barley lines that NARSs can use to develop and release varieties adapted to local conditions, and to generate sustainable crop management practices that allow varieties to reach their full yield potential.	• Superior, disease-resistant wheat, triticale, and barley germplasm with broader genetic diversity is developed and distributed to NARSs. • Improved, sustainable crop management strategies are developed and transferred to NARSs.	• NARSs will continue to evaluate and release germplasm adapted to local conditions.
Outputs	**Indicators**	**Assumptions and risks**
1. High-yielding, disease-resistant germplasm combining stability, input efficiency, and input responsiveness for irrigated and high rainfall conditions. 2. Improved levels of durable resistance to diseases (the three rusts, Karnal bunt, tan spot, *Septoria tritici*, Helminthosporium leaf blight, barley yellow dwarf, and Fusarium head blight, among others). 3. Wheat, triticale, and barley germplasm with improved industrial and nutritional quality. 4. Genotypes that are better adapted to current and future management situations, and perform better under reduced tillage, residue retention, and other relevant cultural practices. 5. New genetic sources of selected traits available from the germplasm bank. 6. New stocks in 42- or 28-chromosome backgrounds, including new translocations from alien species and wheat relatives, provided to NARS breeders. 7. Improved integrated nutrient management systems that increase nutrient-use efficiency and minimize adverse environmental effects.	1. Improved germplasm of appropriate adaptation disseminated to cooperators in irrigated and high rainfall environments. 2. Improved resistant germplasm disseminated to cooperators. 3. Germplasm with improved quality disseminated to cooperators. 4. Improved germplasm that performs well under different cultural practices disseminated to cooperators. 5. Genetic stocks available. 6. Development of 42-chromosome wheats containing "small" alien segments carrying traits relevant for irrigated and high rainfall wheat production. 7. Management systems under development.	• CIMMYT resources for the development of wheat, triticale, and barley germplasm are maintained. • Germplasm exchange remains free and open, although a small reduction is noted, partly owing to quarantine issues.

Activities	Milestones	Assumptions and risks
1. Empirical breeding combined with trait-oriented analytical and molecular approaches to develop parental stocks for irrigated and high rainfall production conditions (contributes to outputs 1, 3).	• Every year, transfer to NARSs in target environments 500 lines with improved yield potential and resistance to the most important biotic stresses. • Exotic genetic stocks identified, including related genera, wheat wild relatives, landraces, and unadapted cultivars, for incorporation into germplasm adapted to irrigated and high rainfall wheat production. • Each year, 50 lines derived from crosses involving diverse genetic stocks.	• See above.
2. Pre-breeding to produce new genetic stocks in 42- or 28- chromosome backgrounds (contributes to outputs 5, 6).	• Each year, 10 lines derived from new genetic stocks.	
3. Quality requirements for NARS partners researched and documented (contributes to output 3).	• By 2003, precisely target quality requirements by mega-environment.	
4. More efficient quality procedures developed to facilitate the development of better quality and more specific germplasm (contributes to output 3).	• By 2002, develop new quality procedures.	
5. Transfer of newly identified sources of adaptation, yield traits, and disease resistance using new sources of diversity such as synthetic wheats (contributes to outputs 2, 4, 6).	• By 2003, distribute 100 lines with new sources of resistance.	
6. Germplasm distributed through the International Nursery System to NARSs in target environments for testing and collection of performance data (contributes to outputs 1, 2, 3, 4, 6).	• Each year, distribute 9 international nurseries.	
7. Conduct strategic crop management research to identify management solutions to factors limiting production and productivity in irrigated and high rainfall environments (contributes to outputs 4, 7).	• Within the next 5 years, disseminate promising crop management strategies to NARSs.	

Duration: 2002-2004+

Collaborators: NARSs: 100 NARSs in 30 countries (larger national research systems include Argentina, Brazil, China, Ethiopia, India, Iran, Mexico, Pakistan, and South Africa)

IARCs: ICARDA, IRRI

Universities: Kansas State University, Oklahoma State University, USA; Autonomous University of Chapingo, Mexico; among others

ARIs: ETH, Switzerland; IPO, the Netherlands; among others

Costs: US$ 3.314M

System linkages: Germplasm improvement (43%)
Germplasm collection (13%)
Sustainable production (24%)
Enhancing NARSs (20%)

Project G4: Maize for sustainable production in stressed environments

Overall goal	**Indicators**	**Assumptions and risks**
Contribute to food security, natural resource conservation, and poverty reduction by increasing the productivity, stability, and sustainability of maize in the presence of abiotic and biotic stresses.	• Greater and more sustainable food security and economic stability of maize-based farming communities across countries and regions of the developing world.	• Socioeconomic, climatic, and edaphic factors dictate that most maize in the developing world continues to be produced in the presence of abiotic and biotic stress factors.
Intermediate goal	**Indicators**	**Assumptions and risks**
Stabilize and increase maize production in a sustainable manner in tropical and subtropical environments that are affected by abiotic and biotic stresses, with special emphasis on research targeted at resource-poor farming systems.	• Increased and more stable aggregate maize production in regions characterized by large variability in pests, weather, and other production factors. • Higher and more stable family incomes in unfavorable environments, benefiting the poorest, especially women and children. • Reduction in the unfavorable environmental impacts of maize farming systems in stress environments. • Enhanced biodiversity through the deployment of diverse genetic resources, reduced use of pesticides, and reduced expansion of maize farming systems into valuable ecologies. • Trained researchers familiar with research options for stress environments, to accelerate the development of sustainable maize farming systems for a wider range of environments. • Larger impacts of maize-related research, particularly in stress environments.	• Genetic variability and agronomic options exist, and information can be developed and compiled, to increase the maize productivity and sustainability in the presence of abiotic and biotic stresses, especially in view of the specific socioeconomic circumstances and preferences of resource-poor farmers.
Purpose	**Indicators**	**Assumptions and risks**
Achieve increased, more stable, and sustainable maize production in the presence of abiotic and biotic stresses.	• Adoption of improved and sustainable maize production systems by resource-poor farmers in unfavorable environments. • More appropriate use of genetic and natural resources in stress environments.	• See above.
Outputs	**Indicators**	**Assumptions and risks**
1. Characterization of the relative importance of biotic and abiotic stress factors in maize growing environments, and of farmers' preferences in stress environments. 2. Conventional and molecular breeding methodologies for identifying germplasm with resistance/tolerance to major biotic and abiotic stresses. 3. Germplasm that tolerates/resists stresses such as acidic and phosphorus-deficient soils, drought, low N, insects, and diseases. 4. Agronomic interventions and decision support systems for stress environments (in conjunction with projects R1, R2, R4, R5). 5. Information on germplasm resources, breeding methodologies, and crop management options for stress environments, and information on their potential impact.	1. Quantitative estimates available of the importance of various abiotic and biotic stresses for maize production, food security, economic stability, and the status of natural resources, resulting in improved priority setting by research managers and maize researchers. 2. Accelerated development of maize germplasm that is more appropriate for stress environments and that meets the specific needs of resource-poor farmers. 3. Maize germplasm sources available that carry tolerance/resistance to the most relevant biotic and abiotic stresses and that are adapted to the major agroecologies. 4. Environment-specific agronomic interventions and decision support systems are available that are attractive to resource-poor farmers in unfavorable environments and that manage natural resources sustainably. 5. NARS scientists and policymakers are aware of and use maize germplasm and research methods to increase, stabilize, and sustain maize production in unfavorable environments.	• Continued development and availability of GIS databases and related information. • Genetic variability in maize germplasm; access to that variability. • New scientific options are and continue to became available; access to those options. • Interest by NARS partners in achieving increased, more stable, and sustainable maize production. • Constant-to-increased commitment by donors to contribute to greater and more sustainable food security and economic stability of maize-based farming communities in countries and regions across the developing world.

Outputs	Indicators	Assumptions and risks
6. Capacities to work with national researchers to access germplasm and apply technologies that increase maize productivity and sustainability in stress environments (in conjunction with projects G8, R1, R2, R4, R5, F3).	6. Maize researchers are trained in technologies that increase maize productivity and sustainability in stressed environments, and facilities for developing stress tolerant maize germplasm are available to NARS breeders in different agroecological zones.	

Activities	Milestones	Assumptions and risks
1. Compile and make available geo-referenced data on environment, population, and maize production in the tropics and subtropics to increase research effectiveness and the sustainable use of genetic and natural resources, particularly in stress environments (contributes to output 1).	Over the planning period: • Revise definition of maize mega-environments at the global level. • Upgrade the Africa Maize Research Atlas: integrate maize distribution and production maps with data on climate, soil, elevation, land use, population, and nutrition at the continental level. • Develop Country Almanacs for 8 countries in sub-Saharan Africa. • Establish similarities of maize growing environments in sub-Saharan Africa and Latin America for more effective use of Latin American maize genetic resources in Africa. • Through collaboration with other institutions, gain better access to improved geo-referenced soils and maize distribution information.	• Further development of GIS databases by other public institutions. • Continued access to GIS databases developed by public institutions. • Collaboration and continued funding of partner institutions. • Increased funding.
2. Compile information on the importance and distribution of major insect pests and diseases of tropical maize and their interactions with the environment and management factors (contributes to output 1).	Over the planning period: • Develop standard maize nurseries for identifying the presence and variability of pathogens and insects, and distribute them to collaborators, who return geo-referenced site data. • Identify hot spots for disease and insect stress; develop maps for those sites. • Complete survey of major insect pests of maize, based on published reports and information from local experts. • Complete survey on pathogen diversity of the corn stunt complex, *Cercospora zea-maydis*, *Exserohilum turcicum*, *Puccinia sorghi*, maize streak virus, downy mildews. • Improve quantification of losses from stem borer damage in selected ecologies.	• Collaboration and continued funding of partner institutions. • Continued-to-increased funding.
3. Enhance knowledge of the physiology and genetics of mechanisms that confer tolerance/resistance to major biotic and abiotic stresses in maize (contributes to outputs 2 and 5).	Over the planning period: • Establish relationship between promising physiological mechanisms and tolerance/resistance to abiotic and biotic stress factors. • Establish relationship among mechanisms that confer tolerance to several abiotic stress factors for more effective selection of maize germplasm adapted to complex stress environments (focus on flowering process; root development; leaf senescence/stay-green). • Complete inheritance studies in relevant germplasm for mechanisms that confer tolerance/ resistance to drought, low soil N, acid soil/low pH, *E. turcicum*, *C. zea-maydis*, *P. sorghi*, downy mildews, *Rhizoctonia solani*, *Physopella zeae*, potyviruses and fijiviruses. • Identify QTLs in relevant germplasm for mechanisms that confer tolerance/resistance to drought, low soil N, low soil pH/Al toxicity, low soil P, *Busseola fusca*, *Chilo partellus*, *E. turcicum*, *C. zea-maydis* maize streak virus, downy mildews, *Fusarium moniliforme*. • Identify QTLs that are related to drought tolerance and are stable across maize materials.	• Collaboration and continued funding of partner institutions • Continued-to-increased level of funding • Other public and private institutions progress on technologies that identify and isolate genes, and are willing to share that knowledge and to give access to technologies.

Activities	Milestones	Assumptions and risks
	• Significant progress towards identifying and isolating genes and physiological pathways of traits associated with drought tolerance; explore options for following a candidate gene approach and for functional genomics for one additional stress tolerance /resistance mechanism. • Publish 20 articles in referred journals. • Provide 50 contributions to scientific conferences.	
4. Develop improved and more efficient selection methodologies for identifying maize with resistance and tolerance to major stresses, which is acceptable to resource-poor farmers (contributes to outputs 2 and 3).	Over the planning period: • Apply MAS strategies to improve resistance/ tolerance of selected germplasm to drought, *Busseola fusca, Chilo partellus*, downy mildews and maize streak virus. • Develop cost-effective methods for testing cultivars at the release stage in a manner that better considers stress environments and preferences of resource-poor farmers. • Develop and disseminate user-friendly statistical design and data analysis and management techniques that improve efficiency of integrating resistance mechanisms into maize germplasm.	• Collaboration and continued funding of partner institutions. • Continued-to-increased funding.
5. Develop sources that provide highest levels of resistance and tolerance to various stresses on a broad genetic background; focus on priority stresses in different environments (eastern Africa; southern Africa; South American lowlands; Mesoamerican lowlands; Asian lowlands; highlands; and subtropics) (contributes to output 3).	Over the planning period: • Recommend 30 synthetics or OPVs and 250 inbred lines to national research programs because of relevant/superior tolerance/resistance in adapted genetic background. • Map genetic sources with highest stress tolerance/ resistance available for drought, low soil N, low soil pH/Al toxicity, low soil P, *Spodoptera frugiperda, Diatraea* sp., *B. fusca, C. partellus, E. turcicum, C. zea-maydis*, maize streak virus, downy mildews, *F. moniliforme*. • Make sources of resistance for all major maize diseases available as elite maize inbreds for use by breeders. • Identify sources of resistance for potyviruses (MDMV, SCMV) and fijiviruses (Maize Rough Dwarf Virus and Mal de Rio Cuarto Virus).	• Collaboration and continued funding of partner institutions. • Continued-to-increased funding.
6. Develop environment-specific agronomic interventions and decision support systems that are attractive to resource-poor farmers in unfavorable environments and that manage available natural resources in a sustainable manner (in collaboration with R1, R2, R4, and R5) (contributes to output 4).	• See descriptions of R1, R2, R4, and R5 in this publication.	• Most environment-specific agronomic interventions and decision support systems are developed as part of regional projects. • Collaboration and continued funding of partner institutions. • Continued-to-increased funding.
7. Analyze interactions between cultivar, management practices, and farmers' preferences under the influence of unfavorable environments (in collaboration with R1, R2, R4, and R5) (contributes to output 5).	Over the planning period: • Evaluate cultivar x management practices under farmers' conditions, obtaining farmers' evaluation as well as assessment of socioeconomic and institutional constraints of improved and sustainable maize production systems, with priority given to: acid soil tolerant germplasm and related agronomic practices, Latin America; drought and low N tolerant germplasm and related resource management techniques, eastern and southern Africa; stem borer resistant germplasm and pest management strategies, Mexico and eastern Africa; *Striga*-tolerant germplasm and related management practices, eastern Africa (see R1). • Hold global scientific workshop on approaches that achieve increased, more stable, and sustainable maize production in the presence of abiotic and biotic stresses.	• Collaboration and continued funding of partner institutions. • Increased funding.

Activities	Milestones	Assumptions and risks
8. Provide partners with easily accessible information on stress-tolerant maize germplasm and molecular information (in collaboration with G2) (contributes to output 5).	Over the planning period: • Use regional and global trials and networks for systematically and collaboratively evaluating elite maize germplasm for the most important stresses for that ecology, and for establishing and using molecular information. • Annual publication on stress tolerance/resistance of globally and regionally available elite maize germplasm from CIMMYT (and if possible from NARSs).	• Collaboration and continued funding of partner institutions. • Continued-to-increased funding.
9. Develop training material/technical reports on selection methodologies and agronomic interventions that increase maize productivity and sustainability in stressed environments (contributes to output 5).	Over the planning period: • Develop training material/technical reports that document: 1) proven breeding techniques for selecting maize tolerant to low soil pH/Al toxicity; 2) insect resistance breeding and the use of leaf toughness as a surrogate for artificial infestations; 3) inoculation techniques for important maize diseases; 4) development of resistance to the corn stunt complex; 5) options for farmer participatory variety selection in stress environments. • Revise field guide on tropical maize diseases. • For training material/technical reports on agronomic interventions that increase maize productivity and sustainability in stressed environments, see R1, R2, R4, R5.	• Collaboration and continued funding of partner institutions. • Continued-to-increased funding.
10. Train maize scientists in technologies that increase maize productivity and sustainability in stress environments (in collaboration with G8) (contributes to output 6).	Over the planning period: • Train 250 national scientists in the use of GIS data, resulting in more appropriate planning and execution of agricultural research projects and in increased collaboration across country boundaries. • Train 150 NARS scientists through short courses, workshops, or visiting scientist fellowships in 1) developing and identifying stress tolerant maize cultivars suited to resource-poor farmers' conditions and preferences; and 2) developing agronomic interventions suited to stress environments and resource-poor farmers' socioeconomic conditions (in collaboration with R1, R2, R4 and R5). • Over the planning period, 15 PhD/MSc students will finish their theses on subjects related to increasing maize productivity and sustainability in stress environments.	• Increased funding.
11. Develop facilities that NARS breeders in different agroecological zones can use to develop stress tolerant maize germplasm (in collaboration with R1, R2, R4, and R5) (contributes to output 6).	Over the planning period: • Establish regionally accessible sites for: 1) MAS in Kenya, Zimbabwe, and selected Asian countries; 2) drought, low N, and low pH screening in Africa, Asia, Latin America; 3) screening for *Striga* in Africa (see R1); 4) screening for stem borers in Africa, Asia, Latin America. • Support national research programs' use of artificial inoculation or infestation techniques for screening regionally relevant germplasm.	• Increased funding.

Duration: 2002–2004+

Collaborators: NARSs: In Africa, Latin America, and Asia

IARCs: CIAT, ICIPE, ICRAF, ICRISAT, IITA, ILRI, and IRRI

NGOs

Universities: Universidad Nacional de Sao Paulo, Brasil; University of Ottawa, Canada; Universidad Nacional de Colombia, Colombia; University of Hannover, Germany; Punjab Agricultural University, India; Colegio de Posgraduados and UNAM, Mexico; University of the Philippines; Swiss Institute of Technology, Zurich, and Université de Neuchatel, Switzerland; Cornell University, Iowa State University, University of Minnesota, Mississippi State University/USDA, Ohio State University, Texas A&M University, and Texas Tech University, USA

ARIs: European research team involved in INCO-DC project; John Innes Centre and Natural Resources Institute, UK.

Private seed companies

Costs: US$ 1.247M

System linkages: Germplasm improvement (45%)

Germplasm collection (10%)

Sustainable production (30%)

Enhancing NARSs (15%)

Project 5 (G5): Wheat for sustainable production in marginal environments

Overall goal	Indicators	Assumptions and risks
Generate benefits for resource-poor farmers in marginal areas subject to abiotic stress by improving yield, stability, profitability, and sustainability of wheat production systems.	• Improved rural livelihoods in marginal environments.	• Wheat genetic resources for marginal environments are available.
Intermediate goal	**Indicators**	**Assumptions and risks**
Develop and disseminate superior wheat and triticale germplasm, in conjunction with crop management technologies, appropriate for abiotic stress environments of developing countries.	• Adoption of improved wheat and triticale germplasm in developing country areas subject to abiotic stress. • Adoption of improved crop management technologies.	• Resources continue to be available for the development of improved germplasm and crop management.
Purpose	**Indicators**	**Assumptions and risks**
CIMMYT and NARS partners collaborate to obtain, maintain, and share germplasm and information needed to develop and disseminate superior wheat and triticale germplasm suitable for abiotic stress environments.	• Improved wheat and triticale germplasm available for researchers and farmers in developing countries.	• See above.
Outputs	**Indicators**	**Assumptions and risks**
1. New sources of drought adaptive traits identified and incorporated into adapted elite germplasm. 2. Germplasm that performs better under different moisture-conserving crop management technologies (e.g., reduced tillage) and suitable residue retention. 3. New sources of adaptation for heat and cold tolerance identified, incorporated into adapted germplasm, and disseminated to NARS collaborators. 4. Environments suffering nutrient stress mapped, and technologies to reduce nutrient constraints made available. 5. Genetic sources of tolerance to nutrient stress identified and incorporated into germplasm. 6. New, more efficient methodologies for selecting wheat and triticale cultivars under abiotic stress conditions. 7. Improved crop management technologies—including reduced tillage systems and implements, residue management, and nutrient management—developed for rainfed wheat and triticale cropping systems. 8. A crop information concept that provides decision support through improved characterization of wheat germplasm and of production and selection environments with respect to abiotic stresses, and which increases the efficiency of experimental trials.	1. More productive, drought-tolerant, input-responsive varieties available to farmers growing wheat and triticale in variable, risky rainfall environments. 2. Wheat and triticale varieties suitable for reduced tillage and other management strategies available to farmers in variable, risky rainfall environments. 3. Germplasm with heat and cold tolerance characterized and made available for farmers in areas suffering heat and cold extremes. 4. Geographical information on nutrient stress available for technology development and dissemination. 5. Germplasm with adaptation to nutrient stress made available to NARSs. 6. Adoption of more efficient selection methodologies by CIMMYT and NARS breeding programs. 7. Information available on residue management, and adoption of reduced tillage by smallholder farmers. 8. Adoption of a crop information concept that increases research efficiency in developing wheat and triticale cultivars for abiotic stress environments.	• Genetic resources and screening methodologies available. • Active collaboration with research partners. • Germplasm exchange unrestricted. • Data available for mapping. • Adoption encouraged by locally available, inexpensive implements, no competing uses of crop residues, and other important conditions for success. • Suitable data and resources available to develop information system.
Activities	**Milestones**	**Assumptions and risks**
1. Development of new parental materials using genetic diversity from a range of sources containing relevant traits for grain yield, biotic and abiotic stress tolerance, and end-use quality (contributes to output 1).	• By 2003, identify 30-150 sources of drought-tolerance.	• See above.

Activities	Milestones	Assumptions and risks
2. Drought adaptive traits will be incorporated using trait-oriented analytical and molecular approaches together with empirical breeding methods (contributes to output 1).	• By 2003, CIMMYT and national breeding programs adopt improved screening methodologies.	• See above.
3. Germplasm distributed through the International Nursery System and information about performance in targeted environments incorporated into a crop information concept (contributes to output 1, 8).	• Over the planning period, provide improved drought tolerant germplasm to NARSs.	• See above.
4. Parental materials tolerant of heat and cold identified and evaluated (contributes to output 3).	• Over the planning period, identify 100-200 sources of heat and cold tolerance.	• See above.
5. Crop improvement using empirical, analytical, and molecular approaches, shuttle breeding, genotype x management interactions, and multilocation testing (contributes to output 3).	• Over the planning period, adapted germplasm with heat and cold tolerance available.	• See above.
6. Germplasm and related information disseminated (contributes to output 3, 8).	• Over the planning period, increased understanding of environments with heat and cold stress.	• See above.
7. Characterization of potential progenitors and development of new parental materials adapted to nutrient stresses, including N, P, Zn, B, Mn, Cu stresses (contributes to output 5).	• Over the planning period, genetic sources of tolerance to nutrient stresses available.	• See above.
8. Crop improvement using empirical, analytical, and molecular approaches to develop tolerant germplasm and appropriate management practices (contributes to output 5).	• Over the planning period, determine nutrient status of collaborating research sites.	• See above.
9. Specialized International Adaptation Trial (IAT) developed to better understand target drought environments, moisture stress patterns, and underlying traits to better tailor germplasm (contributes to outputs 1, 3, 5, 6, 8).	• Over the planning period, establish nursery.	• Support from collaborating institutions available.
10. Identification of potential stress adaptive traits, evaluation of field screening methodologies, and determination of genetic basis of these traits (contributes to output 6).	• By 2004, identify and confirm relevant stress adaptive traits.	• See above.
11. Development of molecular, physiological, and conventional selection tools (contributes to output 6).	• By 2004, CIMMYT and national breeding programs adopt more efficient selection methodologies.	• See above.
12. Develop and adapt improved crop management strategies, including reduced tillage, residue management, machinery, rotations, nutrient management, and bed systems (contributes to output 7).	Over the planning period: • Develop zero-till animal traction seeder in Bolivia. • Develop other prototype implements.	• Support from collaborating institutions available.
13. Disseminate crop management strategies to NARSs, NGOs, and farmers (contributes to output 7).	Over the planning period: • Information on appropriate strategies available. • Smallholder farmers adopt reduced tillage systems.	• Limitations to dissemination not present (e.g., inadequate extension infrastructure, inappropriate policies).
14. Advise CIMMYT and NARS breeding programs on appropriate management practices for germplasm screening (contributes to output 7).	Over the planning period: • Germplasm screened at CIMMYT under different management strategies.	

Activities	Milestones	Assumptions and risks
15. Study the biological basis of genotype x abiotic stress interactions, and improve the characterization of germplasm, production environments, and selection environments for abiotic stresses (contributes to outputs 1, 5, 8).	• Over the planning period, improved characterization of wheat germplasm and greater research trial efficiency.	• See above. • See above.
16. Develop a crop information concept as a decision support system (contributes to output 8).	• Over the planning period, better utilization of data and information by breeding programs in research on abiotic stresses.	• Resources available for system development.

Duration: 2002-2004+
Collaborators: NARSs
IARCs
ARIs
Costs: US$ 2.612M
System linkages: Germplasm improvement (15%)
Germplasm collection (5%)
Sustainable production (60%)
Enhancing NARSs (20%)

Project 6 (G6): Wheat resistant to diseases and pests

Overall goal	Indicators	Assumptions and risks
Wheat, triticale, and barley productivity is increased, yield stability is enhanced, and the impact of agriculture on the environment is reduced.	• Results of CIMMYT impact studies.	
Intermediate goal	**Indicators**	**Assumptions and risks**
Increase the stability of wheat, triticale, and barley production through the strategic deployment of more genetically diverse germplasm with durable disease and pest resistance, and the dissemination of relevant epidemiological information.	• Better understanding of global epidemiology and improved knowledge of the disease resistance present in wheat, triticale, and barley cultivars on the part of CIMMYT researchers and NARS partners. • Identification of diverse sources of resistance to wheat, triticale, and barley diseases and pests. • Wheat, triticale, and barley germplasm with more durable disease resistance distributed to NARSs. • Reduced application of chemical pesticides due to the use of disease-resistant cultivars. • Development of molecular markers and marker-assisted selection (MAS) strategies for use in disease resistance breeding.	• Patents on molecular markers and techniques may prevent their unrestricted use.
Purpose	**Indicators**	**Assumptions and risks**
Genetic vulnerability in farmers' fields is reduced and yield stability is increased as NARSs release improved,disease-resistant varieties and are better able to manage the diseases and pests that attack wheat, triticale, and barley.	• High-yielding, disease-resistant wheat, triticale, and barley varieties developed and released by NARSs from CIMMYT's improved, disease-resistant germplasm. • Improved global and regional pathogen surveillance. • Global and regional networking and strengthening of NARSs' capability to conduct their own disease surveys and forecast important changes in pest populations.	• Limited research capacity of certain NARSs in the areas of disease and pest etiology and epidemiology.
Outputs	**Indicators**	**Assumptions and risks**
1. Wheat, triticale, and barley cultivars with broader based genetic resistance to emerging and mutating pathogens that could cause extensive crop losses. 2. Strategies for the effective control of diseases and pests in current and changing production systems. 3. Information on occurrences at the global and regional levels of diseases, pests, and new virulences, as well as of their relevance to cultivars sown in farmers' fields. 4. More efficient field and lab diagnostic techniques and better characterization of pathogens and pests. 5. MAS strategies effective for incorporating various resistance genes.	1. Availability of germplasm with better genetic resistance. 2. Disease and pest control strategies under development 3. Information on disease and pest distribution and pathogen variation made available to CIMMYT researchers, NARS partners, and other collaborators. 4. PCRs, QTLs, and other markers available for multigenic resistance traits. 5. Application of molecular markers increases efficiency of selection for resistance to biotic stresses.	• Limited capacity of NARSs to use efficient resistance screening techniques and apply modern biotechnological tools.
Activities	**Milestones**	**Assumptions and risks**
1. Advanced wheat, triticale, and barley lines plus materials from the Wide Crosses Unit and the CIMMYT genebank rigorously screened for resistance to various diseases and pests at hot spots in Mexico and around the world (contributes to outputs 1, 2, 3).	• Each year, identify and distribute new sources of resistance.	• Germplasm exchange remains free and open.

Activities	Milestones	Assumptions and risks
2. Continuous determination of the distribution and importance of targeted diseases and pests, and of the crop losses they cause (contributes to outputs 1, 2, 3).	• Annually, data on crop losses caused by targeted diseases and pests are available for making strategic crop protection and breeding decisions.	
3. Strengthening NARSs' capability to conduct their own disease surveys and forecast changes in pest populations that could affect the stability of crop production (contributes to outputs 1, 2, 3, 4).	• By 2003, assess strategies for effectively controlling newly emerging diseases and pests, and make them available to NARSs.	
4. Tagging of genes conferring resistance to biotic stresses to develop diagnostic markers (contributes to outputs 4, 5).	• Apply MAS in breeding on a regular basis.	
5. Mapping genes that confer resistance to leaf rust, yellow rust, fusarium head blight, and Karnal bunt, among other diseases (contributes to outputs 4, 5).	• Each year, provide information on the number, location, and effect of genes conferring resistance to leaf rust, yellow rust, Fusarium head blight, and Karnal bunt.	
6. Pathogen surveillance through sampling, diagnostic surveys, disease monitoring, and virulence analyses at the global and regional levels (contributes to outputs 1, 2, 3, 4).	• Data available.	• Support (financial, human resources) and skills available.

Duration: 2002-2004+
Collaborators: NARSs
IARCs
NGOs
ARIs
Costs: US$ 2.029M
System linkages: Germplasm improvement (70%)
Germplasm collection (20%)
Enhancing NARSs (10%)

Project 7 (G7): Impacts of maize and wheat research

Overall goal	**Indicators**	**Assumptions and risks**
Enhance the rate of adoption of agricultural technology to improve the productivity, equity, and environmental sustainability of maize- and wheat-based cropping systems.	• Increased adoption of agricultural technology in developing countries. • More efficient allocation of agricultural research resources in developing countries.	• Developing countries remain committed to raising agricultural productivity as a way of improving the welfare of the poor.
Intermediate goal	**Indicators**	**Assumptions and risks**
Improve our understanding of the adoption of agricultural technology and spell out the implications for improving research resource allocation by studying the processes through which improved germplasm and improved crop and resource management practices diffuse in developing countries.	• Information documenting impacts of research and factors affecting technology adoption. • Information to guide strategies for deploying new technology. • Information for more efficient research resource allocation. • Methods for conducting impact and resource allocation studies.	• Sharing of data and information is unimpeded. • Other organizations may not acknowledge their use of CIMMYT germplasm.
Purpose	**Indicators**	**Assumptions and risks**
Evaluate the impact of research done by CIMMYT and its partners in order to improve general understanding of the factors affecting technology adoption, accelerate deployment of new technology, and improve research resource allocation.	• See above.	• Impacts assessment function will be insulated from public relations function (impacts data will not be manipulated for publicity).
Outputs	**Indicators**	**Assumptions and risks**
1. Updated and expanded knowledge about the development and diffusion of improved maize and wheat germplasm in developing countries. 2. Updated and expanded knowledge about the development and diffusion of crop and resource management practices in developing countries. 3. Improved understanding of factors affecting the adoption and diffusion of new technology in maize- and wheat-based cropping systems. 4. Updated and expanded knowledge about the impacts of CIMMYT's research programs. 5. Improved capacity to set research priorities.	• Information on the productivity, equity, and environmental impacts associated with adoption of improved maize and wheat germplasm in developing countries. • Information on the productivity, equity, and environmental impacts associated with adoption of improved crop and resource management practices in developing countries. • Case studies documenting the adoption of agricultural technology and exploring specific issues related to the adoption process. • Information used for public awareness and resource mobilization. • Information used for the priority setting component of project F6.	• Same as above.
Activities	**Milestones**	**Assumptions and risks**
1. Conduct regional studies documenting the impact of CIMMYT maize germplasm (contributes to outputs 1, 3, 4, 5).	• By 2002, publish Africa and Asia regional impact reports; disseminate information via technical publications, nontechnical reports, public awareness materials, funding proposals.	• Same as above.
2. Conduct global study documenting the impact of CIMMYT maize germplasm (contributes to outputs 1, 3, 4, 5).	• By 2002, publish global impact report; disseminate information via technical publications, nontechnical reports, public awareness materials, funding proposals.	• Same as above.
3. Conduct global study documenting the impact of CIMMYT wheat germplasm (contributes to outputs 1, 3, 4, 5).	• By 2002, publish global impact report; disseminate information via technical publications, nontechnical reports, public awareness materials, funding proposals.	• Same as above.
4. Conduct studies documenting the impact of genetic resource use on wheat productivity in China and Australia (contributes to outputs 1, 3, 4, 5).	• By 2002, publish reports; disseminate information via technical publications, nontechnical reports, public awareness materials, funding proposals.	• Same as above.

Activities	Milestones	Assumptions and risks
5. Identify, characterize, and evaluate crop and resource management technologies generated at the national and regional levels, including processes used to generate and promote technologies (contributes to outputs 2, 3, 4, 5).	• By 2002, produce literature review on zero-tillage experience. • Over 2001-03, continue to document performance and adoption potential of a wide range of soil fertility management practices in southern Africa.	
6. Conduct case studies of the adoption and impacts of crop and resource management technologies at the national and regional levels (contributes to outputs 2, 3, 4, 5).	By 2002: • Publish report detailing the adoption of crop management practices in the hills of Nepal. • Publish report detailing the factors affecting farmers' adoption of conservation tillage practices in Mexico and Central America. • Publish report detailing the factors affecting farmers' adoption of legume intercropping practices in Guatemala. • Publish report on organization of crop and natural resource management research in South America and dissemination of zero-tillage. • Publish report on impacts of zero-tillage technology in Ghana. • Publish reports on farmers' perceptions and adoption potential of soil fertility technologies in Chihota, Zimbabwe. • Publish preliminary study of adoption potential of green manures in Malawi.	
7. Investigate adoption potential of selected natural resource management technologies (contributes to outputs 2, 3, 4, 5).	By 2002: • Publish report on the economic characteristics of selected soil conservation techniques promoted in Central America. • Identify best practice for promoting and measuring adoption of seed and natural resource management (NRM) technologies in southern and eastern Africa (joint activity with R1).	
8. Through networks and workshops, disseminate results of activities under output 2 (contributes to outputs 2, 3, 4, 5).	• Over 2001-03, manage SoilFertNet in southern Africa; implement workshops and technology promotion initiatives.	
9. Case study of the economic impact of wheat disease resistance breeding (contributes to outputs 4, 5).	• By 2002, publish report on the economic impact of wheat disease resistance breeding.	
10. Case studies of the adoption of improved germplasm and crop and resource management technologies in Africa, Asia, and Latin America (contributes to outputs 4, 5).	• Over 2001-03, conduct adoption case studies in collaboration with national research programs.	• Funding available.
11. Case studies of the impact of varietal adoption and participatory plant breeding on the *in situ* conservation of genetic resources (contributes to outputs 4, 5).	• Over 2001-03, carry out case studies, produce working papers, journal articles, and (perhaps) proceedings.	• Funding available.
12. Study of the relationships between maize technology adoption and poverty in southern Mexico (component of a SPIA study) (contributes to outputs 4, 5).	• Over 2001-03, conduct case studies, produce working papers, journal articles, and (perhaps) proceedings.	
13. Case studies of the role of the seed industry in affecting the diffusion of improved germplasm (contributes to outputs 4, 5).	• Over 2001-03, conduct case studies, produce working papers, journal articles, and (perhaps) proceedings. • Over 2001-02, conduct farmer survey in two regions of Honduras (2001); analyze survey data for PhD thesis (2001-02).	• Funding available.

Duration: 2002–2004+
Collaborators: NARSs: 100+
IARCs: IPGRI, IFPRI, and CGIAR Special Panel on Impact Assessment (SPIA) of the Technical Advisory Committee (TAC)
Universities: North Carolina State University, USA
Costs: US$ 0.723M
System linkages: Policy (63%)
Enhancing NARSs (37%)

Project 8 (G8): Building human capital

Overall goal	Indicators	Assumptions and risks
Develop an effective corps of scientists in the public research sector of developing countries to address emerging challenges to the productivity, profitability, and sustainability of maize and wheat.	• Greater development, dissemination, and adoption of technologies that improve the productivity, profitability, and sustainability of maize and wheat in developing countries.	• The kinds of training offered by CIMMYT continue to be valued and supported. • National agricultural research programs will not be further weakened by reduced budgets, high staff turnover, an inability to bridge the knowledge and information gap between developing and industrialized country research organizations, and the funding challenges that weaken support from international public research institutes. • National research systems are not prevented from functioning by civil disorder.
Intermediate goal	**Indicators**	**Assumptions and risks**
Enhance the capacity of scientists in national agricultural research systems (NARSs) to improve their use of research resources through human resource development and research partnerships.	• Higher quality, more relevant maize and wheat research in NARSs. • Technology is more rapidly available to farmers. • Researchers in NARSs can increasingly address locally important constraints and increasingly contribute to strategically important research at the regional and global levels. • Stronger strategic research partnerships established as a result of links between alumni of CIMMYT training efforts and CIMMYT. • As a result of CIMMYT training initiatives, there is increased international awareness of, and support for, research by CIMMYT and its partners.	• Continued availability of in-service training and strong, sustainable human resource development programs in NARSs.
Purpose	**Indicators**	**Assumptions and risks**
Empower researchers in NARSs to conduct research more efficiently, share expertise with others, and improve collaboration across disciplines and institutions.	• See above.	• See above.
Outputs	**Indicators**	**Assumptions and risks**
1. Specialized group training on advanced research tools and methods in research related to maize and wheat (including crop improvement, agronomy, economics, natural resource management, and biotechnology). 2. On-the-job training in areas of mutual interest and high priority for national research programs and CIMMYT. 3. National agricultural research systems are supported in efforts to develop local training capacity and conduct regional training initiatives. 4. Greater communication among researchers supported through international fora, such as conferences and workshops.	1. Improved capacity in NARSs to conduct more innovative and strategic research as needed. 2. Sharing of research skills between national researchers and CIMMYT staff; achievement of mutually important research objectives; improved collaboration between national research programs and CIMMYT. 3. Improved capacity for local and regional training by NARSs. 4. Improved communication and collaboration among researchers from many different organizations, including national programs, advanced research institutes, international centers, and NGOs (plus dissemination of research results through proceedings, Internet, and other media).	• The kinds of training offered by CIMMYT continue to be valued and supported, and suitable candidates are identified for training. • Support exists for regional and local training.

Activities	Milestones	Assumptions and risks
1. Offer courses in strategic research areas at CIMMYT headquarters (contributes to output 1).	• Every year, approximately 80 researchers attend 5-7 courses in strategic research areas at CIMMYT headquarters.	• The kinds of training offered by CIMMYT continue to be valued and supported, and suitable candidates are identified for training.
2. Offer courses relevant to needs of particular countries or regions (contributes to output 1).	• Every year, approximately 8-12 courses are held in individual countries or sponsored by CIMMYT regional programs. • Commencement of phase 2 of the Asian Maize Biotechnology Network (AMBIONET), a major research and training initiative.	• See above.
3. Curriculum is reviewed and new courses and training materials are developed as needed (contributes to outputs 1 and 3).	• New headquarters-based group training on sustainable systems offered to senior researchers from national agricultural research programs. • Training materials (based on case studies) developed for sustainable systems training. • New course on advanced wheat improvement research. • New course on seed production. • Identification of NARS/international center courses to which CIMMYT could contribute through distance learning technology.	• Resources are available to develop new courses of immediate value to national research programs.
4. Host visiting scientists to work on research of mutual interest (contributes to output 2).	• Each year, CIMMYT hosts 100-200 visiting researchers.	• Suitable candidates are identified for visiting scientist fellowships and support is available.
5. Supervise and/or support research towards MSc or PhD (contributes to output 2).	• Each year, approximately 18 theses are produced.	• Suitable candidates are identified and support is available.
6. Offer postdoctoral fellowships in major research efforts at CIMMYT (contributes to output 2).	• At any given time, CIMMYT has from 10-15 postdoctoral fellows.	• Suitable candidates are identified and support is available.
7. Support the availability of crop management research training at the local level in Africa, Latin America, and Asia (contributes to output 3).	• Courses ongoing.	• Funding available for regional and local training; effective partnerships with national programs or other organizations result in high-quality local training.
8. Offer international conferences and workshops (contributes to output 4).	• Each year, approximately 10 international conferences and workshops are organized and hosted.	
9. Human resource development opportunities at CIMMYT announced to national program researchers and other potentially interested persons worldwide (contributes to outputs 1-4).	• Course announcements sent each year. • Conference and workshop announcements sent as needed.	
10. Maintain database of CIMMYT training alumni (contributes to outputs 1-4).	• Database made available for consultation by headquarters and outreach staff. • Data available for analysis of impact of CIMMYT's human resource development efforts.	

Duration: 2002–2004+
Collaborators: NARSs: Every national research program conducting research related to maize or wheat
IARCs
NGOs
ARIs
Costs: US$ 4.209M
System linkages: Enhancing NARSs (100%)

Project 9 (G9): Conservation tillage and agricultural systems to mitigate poverty and climate change

Overall goal	Indicators	Assumptions and risks
Poverty reduced, livelihoods improved, soil and water conserved, fuel use reduced, soil organic carbon loss slowed or reversed, and climate change mitigated, through more productive and sustainable maize and wheat systems based on conservation agriculture.	• Livelihood improvement with reduced emissions of greenhouse gases linked to adoption of conservation agriculture.	• Poverty reduction and climate change mitigation continue to receive high priority in civil society.
Intermediate goal	**Indicators**	**Assumptions and risks**
Practices of conservation agriculture, including zero and reduced tillage, mulch systems, and green manure cover crops, used widely in maize and wheat systems.	• Pace and incidence of adoption of conservation agriculture in maize and wheat systems.	• Government policies do not discriminate against conservation agriculture. • Inputs, e.g., prototypes of implements and seed of green manure crops, available for farmers.
Purpose	**Indicators**	**Assumptions and risks**
CIMMYT and its partners and stakeholders, including NGOs and farmer groups, collaborate to develop and accelerate the use of conservation agriculture around the world.	• Networks of stakeholders working in partnership to develop and promote conservation agriculture.	• Transactions costs can be kept acceptably low.
Outputs	**Indicators**	**Assumptions and risks**
1. New prototype conservation agriculture implements and practices developed, for evaluation and adaptation in regional projects through farmer experimentation and the involvement of multiple stakeholders.	• Implements and practices available and characterized.	• Same as above.
2. Updated and synthesized knowledge available about the performance of conservation agriculture practices in different environments.	• Publications, databases on technology performance.	• Resources available for synthesis work. • Stakeholders are willing to share data.
3. Improved understanding attained of the longer-term and environmental consequences of introducing conservation agriculture, including consequences for climate change, for agroecosystem diversity, for input use efficiency, and for land and water quality.	• Publications, datasets, verified models on longer-term and environmental consequences.	• Same as above. • Models adequately portray future consequences of adopting conservation agriculture.
4. Improved knowledge attained about methods for developing and scaling up conservation agriculture.	• Publications, training manuals on scaling up.	• Same as above.
5. Improved knowledge gained about interactions between conservation agriculture practices and maize and wheat germplasm.	• Datasets on germplasm x management interactions used by breeders.	• Genetic variability exists relevant to performance of germplasm with conservation agriculture practices.
6. Processes in place for systematic sharing with partners and stakeholders of knowledge on conservation agriculture options.	• Publications, web pages, distributed databases, study tours developed and used.	• Same as above.
Activities	**Milestones**	**Assumptions and risks**
1. Assemble information on experiences with conservation agriculture from different sites and regions, draw conclusions, develop principles, and use these to help scale out conservation agriculture practices (contributes to outputs 2,4).	Over the planning period: • Produce at least 5 case studies of conservation agriculture. • Produce publications and hold workshops on synthesis and lessons learned. • Produce publications on methods for scaling out.	• Resources available for synthesis and methods development work.

Activities	Milestones	Assumptions and risks
2. With other stakeholders, develop a decentralized, web-based, spatially referenced database on the performance of technology for conservation agriculture. (contributes to output 2).	• Over the planning period, develop database that is used by stakeholders	• Stakeholders are willing to share data. • Agreements can be reached on standards. • Resources are available for user support and awareness training.
3. Implement and maintain long-term experiments to quantify changes in greenhouse gas emissions, and soil and water quality, associated with conservation agriculture (contributes to output 3).	• Over the planning period, establish and characterize long-term experiments.	• Same as above.
4. Develop and validate models of the effects of conservation agriculture on greenhouse gas emission, and use these models to assess alternative conservation agriculture scenarios for different environments (contributes to output 3).	• Over the planning period, produce publications describing the application of validated models to important scenarios.	• Existing models are capable of portraying and forecasting impacts of conservation agriculture on greenhouse gas emissions.
5. Identify, assess, and help improve prototype implements for use in conservation agriculture (contributes to output 1).	• Over the planning period, implements become available.	• Same as above.
6. Conduct studies of germplasm performance as affected by conservation agriculture practices in different environments. Use this in breeding improved varieties for use with conservation agriculture (contributes to output 5).	• Over the planning period, tailor varieties for use with conservation agriculture.	• Management x germplasm interactions are important.
7. Foster the use of conservation agriculture practices with CIMMYT regional programs and associated stakeholders (contributes to output 6).	• Over the planning period, conservation agriculture practices are used in regional research.	• Regional stakeholders give priority to poverty reduction and climate change mitigation.
8. Organize study tours and scientific exchanges on applications of conservation agriculture in maize and wheat systems (contributes to output 6).	• Over the planning period, conduct study tours.	• Same as above.

Duration: 2002-2004+

Collaborators: Farmers
NARSs
IARCs
NGOs
Universities
ARIs
Private equipment companies

Costs: US$ 0.494M

System linkages: Germplasm improvement (15%)
Sustainable production (60%)
Policy (15%)
Enhancing NARSs (10%)

Project 10 (R1): Food and sustainable livelihoods for Sub-Saharan Africa

Overall goal	**Indicators**	**Assumptions and risks**
Enhance food supplies, food security, and livelihood opportunities for the rural and urban poor in Sub-Saharan Africa.	• Greater and more sustainable food security and economic stability of maize- and wheat-based farming communities across countries and regions of Sub-Saharan Africa.	• Food security, livelihoods, and increased food supplies are a priority for governments of countries in Sub-Saharan Africa. • National economies and political stability do not deteriorate substantially.
Intermediate goal	**Indicators**	**Assumptions and risks**
Enhance the development and dissemination of efficient, productive, and sustainable maize and wheat technologies and systems, including germplasm with resistance to pests and diseases and tolerance to environmental stresses, natural resource management technologies, and human resource development.	• Increased development and dissemination of improved maize and wheat varieties. • Increased use of better cereal-legume and cash crop production systems, especially for soil fertility maintenance and pest management, that conserve natural resources and increase productivity. • Increased understanding of the economics and impacts of improved maize- and wheat-based farming systems in Sub-Saharan Africa. • Trained researchers from NARSs who contribute to the development of sustainable maize and wheat farming systems.	• Genetic resources and management options exist, and information can be developed and disseminated to promote sustainable maize and wheat farming systems.
Purpose	**Indicators**	**Assumptions and risks**
CIMMYT and NARS partners in Sub-Saharan Africa collaborate to develop improved maize and wheat germplasm, technologies, and systems for resource-poor farmers.	• Adoption of improved and sustainable maize and wheat cropping systems by resource-poor farmers in Sub-Saharan Africa.	• See above. • Farmers and other clients find maize and wheat cropping system technologies attractive.
Outputs	**Indicators**	**Assumptions and risks**
1. At least 20 high-yielding maize cultivars, with resistance to biotic stresses (e.g., maize streak virus, gray leaf spot, and stem borers) and tolerance to abiotic stresses (drought and low N). 2. Comprehensive maize germplasm development and evaluation program fully implemented with partners in eastern and southern Africa. 3. More than 200 on-farm testing sites developed in collaboration with public extension agencies, NGOs, and universities to screen maize germplasm for drought and low N tolerance. 4. Maize seed provided to NGOs for production and distribution in Mozambique, Angola, Zimbabwe, Ethiopia, and Malawi. 5. New wheat cultivars (2 durum, 10 bread wheat) with waterlogging adaptation developed for Ethiopia and with rust resistance for eastern Africa. 6. "Best bet" soil fertility technologies identified and disseminated to 5,000 farm advisers and 40,000 farmers. 7. Policy guidelines and economic information developed on soil fertility issues. 8. Improved farming systems developed and tested with farmers: 5 alternate crop management options, and N management strategies for maize and legumes in Malawi and Zimbabwe.	1. NARS releases of CIMMYT derived germplasm. 2. Maize germplasm evaluation sites established across eastern and southern Africa for a range of traits. 3. On-farm testing sites established with a range of partners. 4. NGOs deploy improved maize seed in Mozambique, Angola, Zimbabwe, Ethiopia, and Malawi. 5. Wheat cultivars released in Ethiopia and eastern Africa. 6. Smallholder farmers adopt a range of cereal-legume, organic, and mineral "best bet" technologies for improving soil fertility. 7. Information on the costs and benefits of external inputs such as seed, fertilizer, and lime available to NARS researchers. 8. Farming systems that provide at least 20% marginal rate of return above current practice adopted in Malawi and Zimbabwe. 9. Farmers use *Striga* management strategies in western Kenya. 10. Maize and wheat researchers trained in eastern and southern Africa. 11. Information on benefits and impacts of improved maize and wheat production technologies available. 12. Policy briefs and recommendations available. 13. NARS researchers and extensionists are more productive. 14. Field testing of maize developed using biotechnology tools initiated in Kenya.	• NARSs and donors continue to invest in maize and wheat plant breeding and crop management programs. • Risk that human resources in NARSs will continue to decline. • Clients find the seed and NRM technologies attractive. • Recipients will use economic and policy outputs. • NARSs have in place the appropriate framework for the use of biotechnology tools.

Outputs	Indicators	Assumptions and risks
9. In western Kenya, 5,000 farmers participating in *Striga* management demonstrations. 10. Trained maize and wheat researchers. 11. Impact studies showing benefits of improved maize and wheat production technologies for resource-poor farmers. 12. Policy briefs and recommendations that encourage improved maize and wheat production systems in the region. 13. Key NARS networks managed, allowing more efficient use of staff and funds. 14. At least 5% of farmers growing stem borer-resistant maize in Kenya and other interested countries.		

Activities	Milestones	Assumptions and risks
1. Development of maize germplasm adapted to biotic and abiotic stresses in Sub-Saharan Africa, through a range of funded projects in the region, including: 1) characterization of the region for maize stresses, using GIS, models, and crop distribution data; 2) development and evaluation of maize germplasm for resistance to *Striga* and stem borers and tolerance to drought and low N; 3) establishment of collaborative maize breeding programs with NARSs through exchange of germplasm in regional trials and through exchange of technical information; 4) development of maize germplasm adapted to highlands; 5) development of methodology for control of *Striga* using herbicide as a seed treatment; 6) standardization of contracts and material transfer agreements for germplasm and intellectual property issues, and 7) development of stem borer-resistant maize for the region (contributes to outputs 1, 2, 3, 4, 14).	• During 2002-04, make a wide range of improved maize source populations and experimental varieties available to breeding partners, directly and in regional trials. • During 2002-04, announce at least 20 elite lines as CMLs for hybrid development. • By 2003, release 20 maize cultivars yielding at least 10% more than the best local checks. • By 2002, establish acid soil test sites in southern Africa. • By 2002, a systematic eastern and southern Africa maize germplasm testing structure for a range of traits and sites will be fully in place. • By 2005, establish a QPM germplasm base in southern Africa, identify elite materials for the region, and verify the best QPM hybrids. • By 2002, characterize disease resistance of inbred lines from regional nursery. • By 2004, make well-adapted, insect-resistant maize available in the region.	• As above. • Funding for maize breeding can be maintained. • Component breeding projects continue to consolidate. • Continue to find useful sources of tolerance to biotic and abiotic stress in maize.
2. Dissemination of maize germplasm adapted to Sub-Saharan Africa, including: 1) on-farm evaluation of new maize hybrids and OPVs; 2) establishment, with NARSs, of seed production activities; 3) seed delivery and seed testing procedures; 4) promotion of farmer participatory methods for the improvement and dissemination of maize; and 5) economic analysis of on-farm experiments (contributes to outputs 3, 4).	• During 2002-04, maize cultivars become available with high and stable yields, as well as excellent resistance to maize streak virus, gray leaf spot, and increased and more stable production under drought and low N, yielding 10% or more than the best local checks in intended environments. • By 2002, expand farmer participatory on-farm testing of drought and low N tolerant maize germplasm, in collaboration with public extension, NGOs and universities, to more than 500 sites per year in southern Africa, with similar work underway in eastern Africa. • By 2002, make maize seed available to NGO seed production and distribution initiatives in Angola, Ethiopia, Malawi, Mozambique, and Zimbabwe. • By 2002, develop cultivar descriptors relevant to smallholders and use them on seed packs. • By 2002, obtain acknowledgement from many seed companies in the region of their use of CIMMYT germplasm, including lines resistant to gray leaf spot.	• Regional and national testing and release mechanisms maintained or improved. • On-farm testing conditions suitable. • Farmers and seed agencies demand seed. • Sufficient extension service, NGO, and other quality partners can be found. • Private seed companies are willing to provide information on use of CIMMYT germplasm.

Activities	Milestones	Assumptions and risks
	• By 2002-03, develop more routine farmer feedback and farmer seed production initiatives.	
3. Development and dissemination of wheat germplasm adapted to Sub-Saharan Africa, including: 1) shuttle breeding program between Ethiopia and CIMMYT-Mexico for durum wheat; 2) regional collaboration through the exchange of wheat germplasm and information; and 3) on-farm demonstrations of new wheat varieties utilizing farmer participatory approaches (contributes to output 5).	• By 2003, release 2 durum wheat cultivars for waterlogged conditions in Ethiopia with a yield advantage of 15%. • By 2003, release 2-5 bread wheat cultivars with resistance to stem and stripe rust. • By 2003, release 2-5 additional, well-adapted cultivars in African countries where wheat is an important food commodity. • Establish a regional testing site to improve the efficiency of selecting for durable resistance to yellow rust (part of the international testing scheme described in G6).	• CIMMYT continues to undertake wheat breeding for the region with partners.
4. Promotion of sustainable maize- and wheat-based systems in Sub-Saharan Africa, involving: 1) investigating long-term trends in productivity and sustainability of cropping systems; 2) studying the dynamics of nutrients in smallholder fields, measuring organic efficiency of N inputs, and determining "best bet" soil fertility improvement technologies; 3) identifying and evaluating soil and moisture conservation technologies and integrating appropriate methods with soil fertility management practices; 4) evaluating organic practices for the control of *Striga;* 5) evaluating herbicide seed treatments for *Striga* control, devising strategies to manage the development of herbicide resistance, and evaluating integrated approaches to *Striga* control; 6) developing NARSs' capacity to undertake economic evaluation, priority setting, and policy research for "best bet" management technologies; and 7) synthesizing information on "best bet" technologies and preparing management brochures, research reports, and a newsletter (contributes to outputs 6, 7, 8, 9).	• By 2002, develop systems models of nutrient flows in selected crop-livestock systems (with ILRI). • In 2002, publish soil fertility maintenance effects of maize + green manure and maize + groundnut rotation systems on smallholder farms in Malawi and Zimbabwe. • By 2004, accumulate results on complementarity of maize + agroforestry systems (with ICRAF). • By 2002, identify at least 25 soil fertility technologies for smallholder farmers that are promising for improved productivity, sustainability, household needs, and income in region. • By 2002, promote at least 12 "best bet" soil fertility technologies, through partners, with 5,000 farm advisors and 40,000 farmers. • By 2002, publish and distribute information brochures and research reports on "best-bet" soil fertility technologies. • By 2003, provide economic assessments and policy guidelines for soil fertility interventions including seed, fertilizer, and lime. • By 2002, APSIM model and farmer participatory risk assessments show several whole-farm legume and N management scenarios for maize systems that provide significantly greater investment returns than current practices in Zimbabwe and Malawi. • By 2004, farmers will adopt at least 5 other types of crop management options for maize, providing 20% gains in returns. • By 2002, results from on-farm experiments in Zimbabwe available on the N response of drought-tolerant and N-use efficient maize (with G4). • By 2002, develop and begin to implement a strategy for conservation tillage research (with G9). • By 2002, determine soil- and rainfall-specific parameters of tied-ridge technology for moisture conservation for maize in on-farm trials with east African farmers. • By 2003, at least 5,000 farmers in western Kenya will have participated in cropping systems trials and adopted technologies to reduce the impact of *Striga.* • By 2002, define parameters of herbicide-coated seed for *Striga* control for specific soil and rainfall regimes in Kenya and southern Africa. • By 2002, document costs and benefits of *Striga* control via herbicide-coated maize seed. • By 2002, have a plan in place for monitoring and managing the development of herbicide resistance in *Striga.*	• Several new projects under development (including projects with other IARCs) will be implemented. • CIMMYT staff specializing in natural resource management will be recruited for the region. • A sufficient number of promising soil fertility and crop management technologies can be found. • Increased funding and partners for technology dissemination can be found.

Activities	Milestones	Assumptions and risks
5. Enhancing human resources and partnerships by: 1) identifying training opportunities for graduate students; 2) establishing links with other training institutions in the region; 3) developing training materials; 4) developing and presenting short courses for NARS scientists; 5) organizing and conducting regional maize and wheat conferences; and 6) facilitating networks on crop systems research and development (contributes to outputs 10 and 13).	• Over 2002-04, identify and implement a range of short courses and other training opportunities (e.g., on seed production, environmental economics, economic analysis, on-farm and participatory research methods) (with G8). • Over 2002-04, provide research facilities and supervision for at least 10 higher degree research students. • In 2002, organize and run regional maize conference (produce proceedings). • By 2002, establish new networks with regional partners. • By 2002, ensure that collaborative research projects in the various networks address high priorities and are multidisciplinary and regional or subregional in nature. • During 2002-04, networks on crop improvement, systems research and development, and soil fertility issues show increased quality and quantity of work and results, leading to more impact.	• Increased funding available to meet training needs. • Risk that losses of NARS staff from resignations and illness are greater than the ability to build capacity through training. • Regional research organizations and donors enable current networks to be maintained and new regional networks to begin.
6. Impact assessment and socioeconomic analysis, including 1) studies to describe, understand, and document socioeconomic change in maize and wheat production systems; 2) studies to assess economic profitability of improved germplasm and new natural resource and crop management technologies; 3) develop policy information and advocacy on the above; and 4) interactions among NARS socioeconomists through regional networking and training (contributes to outputs 7, 11, 12).	• By 2004, document the impacts and benefits of a range of profitable and sustainable maize and wheat production technologies for resource-poor farmers (with G7). • In 2002, publish study of the impact of maize research in eastern and southern Africa (with G7). • By 2002, produce several reports on the adoption of soil fertility technologies in Zimbabwe and Malawi (with G7). • By 2003, develop policy guidelines and economics information on soil fertility issues, particularly for external inputs such as fertilizer, lime, and seed (with G7). • By 2002, produce policy briefs and recommendations to enhance the uptake of improved maize germplasm technologies in the region (with G7). • By 2002, Coordinator Task Force examines how to improve CIMMYT impacts in the region. • In 2002, incorporate aspects of the Sustainable Livelihoods Strategy into CIMMYT work in southern Africa, following a 2001 consultancy report. • By 2002, fully establish the SoilFertNet Economics and Policy Working Group; at least 5 cooperative proposals from NARS will be funded and operating.	• Project members contribute fully in these activities. • Smallholder farmers show continued interest in using soil fertility technologies. • Risk that policy failures and high economic costs prevent adoption of soil fertility and crop management technologies. • Additional resources become available to allow more sophisticated impact assessments.

Duration: 2002-2004+

Collaborators: Smallholder farmers, farmer groups, and farmer unions in most countries of the region

Secondary schools in the region

NARSs: Government agricultural research institutes in all countries of eastern and southern Africa, and extension organizations in many of them

IARCs: Especially ICRISAT, ICRAF, ILRI, IITA, CIAT, IFPRI, TSBF, IFDC, and IBSRAM

NGOs: Local and international, including Sasakawa-Global 2000, World Vision, Care International, Concern Universal, Intermediate Technology Development Group, and Action Aid, especially in Kenya, Ethiopia, Zimbabwe, Mozambique, Angola, and Malawi.

Universities: Including Alemaya University, Ethiopia; Egerton, Kenyatta, and Nairobi Universities, Kenya; Makerere University, Uganda; University of Zimbabwe and Africa University, Zimbabwe; University of Malawi; University of Zambia; Sokoine University, Tanzania; University of the North and Natal, Pretoria, and Free State Universities, South Africa; Göttingen, Kassel, London, Reading, and Sheffield Universities in Europe; and Michigan State, Texas A&M, Tuskegee, Cornell, Kansas State, and Oklahoma State Universities in the US

ARIs: APSRU, Australia; Silsoe, UK; Weizmann Institute, Israel

Seed companies: Local and international, private and public, including SENSAKO, Seedco, National Tested Seeds, PANNAR, Pioneer Hi-Bred International, Ethiopian Seed Enterprise Agency, Zamseed, Kenya Seed, and SEMOC

Close links with networks: ASARECA, SACCAR, and WECAMAN (CORAF/WECARD)

Costs: US$ 4.159M

System linkages: Germplasm improvement (45%)
Germplasm collection (8%)
Sustainable production (30%)
Policy (6%)
Enhancing NARSs (11%)

Project 11 (R2): Maize for poverty alleviation and economic growth in Asia

Overall goal	Indicators	Assumptions and risks
Enhanced productivity, profitability, sustainability, and nutritional quality of maize-based systems in South and Southeast Asia and China.	• Increased maize production. • Increased incomes derived from maize production. • Increased area grown to QPM genotypes.	• Adequate policy support for the agricultural sector in countries of the region.
Intermediate goal	**Indicators**	**Assumptions and risks**
Efficiently develop and disseminate maize germplasm and crop management practices that increase the productivity, sustainability, and economic and nutritional value of maize systems in the region.	• Increased use of cost-effective, efficient breeding methods and strategies. • Increased focus on hybrid development and stress-tolerant germplasm. Greater adoption of improved germplasm, particularly hybrids. • Increased requests for products of CIMMYT international/regional maize trials. • Increased use of CIMMYT germplasm by NARSs and private sector. • Better understanding of constraints and processes affecting maize production • Enhanced development and adoption of improved crop management practices. • Adoption of QPM varieties.	• Adequate funding and government policies that favor maize/ agricultural research and production. • Seed and technology delivery systems are in place and functional. • Policies favor the adoption of new technologies by farmers.
Purpose	**Indicators**	**Assumptions and risks**
Enhance cooperation among maize researchers in the region to develop germplasm products, crop management practices, and policies that address clearly defined constraints to maize production, sustainability, and profitability in the region, using efficient research techniques and methodologies.	• Increased maize research collaboration, including greater participation of public and private sector research organizations in regional networks. • CIMMYT-developed OPVs, inbreds, and inbred-based maize germplasm are increasingly used (directly and indirectly) by the public and private sectors. • Research agendas of national research programs reflect farmers' constraints and potential for impact through research. • Greater interest in securing and using germplasm from CIMMYT, particularly germplasm possessing downy mildew and other stress-resistance traits. • More diverse germplasm available at farmers' level to reduce genetic vulnerability to biotic stresses.	• See above. • Continuous seed industry growth and NARSs ability to obtain support for some activities requiring active collaboration.
Outputs	**Indicators**	**Assumptions and risks**
1. Hybrid-oriented germplasm with the desired grain color, texture, and maturity and with tolerance/resistance to major biotic and abiotic stresses prevalent in different maize production environments. 2. Superior general and special trait OPVs and synthetics. 3. More trained researchers in breeding, hybrid development, biotechnology, crop management, and socioeconomic research and seed production. 4. New methodologies and tools that improve the efficiency of research are developed and disseminated. 5. OPVs and hybrid-oriented germplasm with enhanced nutritional quality (QPM) are developed and disseminated. 6. Increased availability at the farm level of seed of improved varieties and hybrids through increased production and distribution by the public and private sector, NGOs, and community-based seed growers.	1. New and better synthetics and hybrids available with enhanced yield performance comparable to or better than commercial hybrids and other local checks (identified via global maize testing system). New releases of 30-40 tropical maize inbreds for strengthening hybrid development efforts in different maturity groups. Reliable sources of donor stocks for transferring stress resistance to other potentially useful germplasm. Stress-tolerant inbreds available. Sufficient maize inbred testers in different maturity groups and colors to strengthen breeding efforts in population improvement and to develop specific hybrid combinations. Improved sources of germplasm with improved tolerance/ resistance to several biotic and abiotic stresses. 2. NARS test and release OPVs and synthetics. 3. Scientists in the region attend training courses. 4. More rapid development of improved maize germplasm for Asia. 5. QPM genotypes are tested and released by NARSs. 6. Greater availability of improved seed for farmers.	• Sustained levels of budget and staffing in NARSs and IARCs. • Collaboration with NARSs and private sector maintained or further enhanced. • Availability of good testing sites in NARSs. • Enough trained and skilled maize researchers in NARSs. • Methods can be developed and adapted for use in a range of national program settings. • Interest and funding available to support seed production, especially for a wider range of farmers. • Availability of skilled researchers and support for interdisciplinary collaboration.

Outputs	Indicators	Assumptions and risks
7. Better characterization of maize production environments and constraints and the characteristics farmers prefer in maize varieties. 8. Country-specific maize technology R&D plans. 9. Policy options that enable sustained, increased maize production. 10. Crop management practices that improved the productivity, sustainability, and profitability of maize-based systems.	7. RRA and baseline survey synthesis reports. 8. Country-specific maize technology R&D plans. 9. Published policy recommendations. 10. Recommendations on crop management practices and research reports.	• Institutions and arrangements for technology dissemination are in place and working properly.

Activities	Milestones	Assumptions and risks
1. Improvement of source populations for hybrid-oriented traits and stresses, particularly downy mildew (contributes to output 1).	Over the planning period: • Complete 2 additional cycles of selection in 4 early and 4 late maize populations. • Expectations for further improvement of 2.5% per cycle in yield and reduced percentage of downy mildew affected plants. • Improve inbreeding tolerance for better extraction of inbred lines. • Increase use of germplasm by several countries.	• No budgetary constraints. • Cropping cycles favorable for progeny regeneration and evaluation.
2. Formation and evaluation of synthetics and OPVs (contributes to output 2).	Over the planning period: • Eight to ninety synthetics formed and tested. Seed increase of 6-8 superior ones for further testing in NARSs. • Two OPVs released in Nepal.	• Normal cropping season for growth, and no serious climatic hazards.
3. Inbred line development and evaluation (contributes to output 1).	• Over the planning period, identify 50-60 inbred lines for release, having good combining ability and hybrid performance.	
4. Development of general and special trait pedigree populations as sources for extracting lines (contributes to output 1).	• Over the planning period, announce 80-100 S3 bulks for accelerating inbred line development efforts.	
5. Screening germplasm for resistance/ tolerance to abiotic (drought, low N) and biotic stresses (downy mildew, BLSB, stalk rots, leaf blights) (contributes to outputs 1, 2).	• Over the planning period, identify 60-10 superior inbreds for each stress.	• Good environment for evaluation of stress(es) under natural and/or artificial conditions.
6. Hybrid formation and evaluation (contributes to output 1).	Over the planning period: • Identification of 12-15 superior early and late maturity hybrids for further extensive testing and release in different countries. • One hybrid released in Nepal.	• Good retrieval of data from well-conducted experiments.
7. Identification of inbred testers that improve the efficiency of identifying superior hybrids (contributes to outputs 1, 4).	• Over the planning period, identify at least 4 early yellow and 4 late yellow inbred testers for accelerating hybrid development efforts.	• Good field experimentation and retrieval of data.
8. Strengthen regional testing of hybrids, lines, and OPVs (contributes to outputs 1, 2, 3).	• Over the planning period, evaluate 100 early and 100 late yellow pretested promising hybrids; 150 early and late yellow lines in each category; and about 100 early and late synthetics.	• Enough seed for testing each trial at 25-30 locations.
9. Development and testing of QPM hybrids, inbreds, and OPVs (contributes to output 5).	Over the planning period: • Release 5 QPM hybrids in at least 3-4 countries in the region. • Release 1 QPM OPV in Nepal.	• Need support in QPM germplasm and in collaborative efforts.
10. Support activities of regional networks: TAMNET and AMBIONET (contributes to outputs 1, 5).	• Over the planning period, early and late hybrid trials constituted and tested across the region. Ten to twelve superior hybrids identified for further testing and release in some countries.	• Adequate seed quantities, testing sites, and cooperation of NARSs and private sector.
11. Evaluation of RILs and transfer of stress resistance using molecular marker assisted selection (MAS) techniques (contributes to outputs 1, 5).	• Over the planning period, identify QTLs and line improvement (drought, downy mildew, and viruses) through MAS.	• Functioning of biotech laboratories and availability of lab supplies and appropriate germplasm.

Activities	Milestones	Assumptions and risks
12. Strengthening human resources in hybrid maize technology, crop management research, biotechnology approaches, problem identification, research prioritization, and seed production (contributes to output 7).	Over the planning period: • Give courses to 150-200 participants. • Conduct 5 in-country courses in Nepal dealing with research techniques and seed production. • Train socioeconomists from 7 countries in conducting PRAs and RRAs. • Conduct seed production and field trial training for 200-250 participants in 6-7 countries. • Train breeders and other scientists from 6 countries in biotechnology.	• In-country interest and availability of resource persons. • Availability of information and suitability of researchers for training.
13. RRAs, surveys, and GIS tools used to characterizing production environments and identify and prioritize production constraints. (contributes to output 7).	Over the planning period: • Conduct PRAs in 7 countries. • Publish synthesis reports on production systems and constraints in 7 countries. • Prioritize researchable constraints in 7 countries.	• In-country interest and availability of resource persons.
14. Country-specific maize technology R&D plans (contributes to output 7).	• Over the planning period, design specific maize technology R & D plans for 7 countries and identify research and investment priorities for relevant organizations to pursue.	• In-country interest and availability of resource persons.
15. Participatory, community-based seed production facilitated (contributes to output 6).	• Over the planning period, 20 communities produce certified seed of improved varieties in Nepal.	• Demand for seed of improved OPVs exists.
16. Crop management research on priority constraints is conducted in Nepal (contributes to output 9).	Over the planning period: • Identify 2 or 3 new post-harvest management options for hill farmers in Nepal. • Develop recommendations on manure/compost management and use of inorganic fertilizers in combination with organic fertilizers in Nepal. • Determine major limiting nutrients to maize growth for each region of Nepal. • Conduct 10 experiments to determine the best combinations of maize and millet, soybeans and other legumes. • Test strategies for the control of white grubs in Nepal.	• Good and relevant testing sites for making general recommendations exist.
17. Design of country-specific key policy recommendations for sustainable and equitable maize productivity growth in the Asian uplands (contributes to output 8).	• Over the planning period, conduct a number of key policy dialogues based on specific recommendations and policy briefs.	• Governments are interested in the sustainable productivity growth of upland maize.

Duration: 2002-2004+

Collaborators: Progressive farmer groups: Including Tuki Association
NARSs: Center for Chinese Agricultural Policy, National Center for Agricultural Economics and Policy Research-India, Nepal Agricultural Research Council
NGOs: Li-Bird, Nepal Agro-Tech and Input, and ECARDS, Nepal
Other development projects in the region: Hill Agriculture Research Project and Sustainable Soil Management Project, Nepal
Universities: University of Philippines-Los Baños; Chiang Mai University, Thailand; University of Agriculture and Forestry-Ho Chi Minh City, and Hanoi Agricultural University, Vietnam
Seed companies: Local and multinational

Costs: US$ 1.822M

System linkages: Germplasm improvement (50%)
Germplasm collection (10%)
Sustainable production (10%)
Policy (10%)
Enhancing NARSs (20%)

Project 12 (R3): Sustaining wheat production in South Asia, including rice-wheat systems

Overall goal	Indicators	Assumptions and risks
Contribute to the alleviation of poverty and increased sustainability of agriculture in South Asia through the development and dissemination of more efficient, productive, and sustainable technologies for the wheat production systems in this densely populated, impoverished region.	More productive, profitable, and sustainable technologies are available and adopted by farmers, whose welfare and livelihoods improve.	• Conducive policy environment for the diffusion and adoption of more efficient, productive, and sustainable technologies. • New technology available for farmers.
Intermediate goal	**Indicators**	**Assumptions and risks**
Reverse declining productivity and improve yields to meet growing demand for food in the 4 distinct wheat production environments in the region, through a combination of efficiency-enhancing, cost-reducing crop management practices and well-adapted varieties that help slow or reverse resource degradation.	• Productivity trends stabilize or improve. • Increased adoption of efficiency-enhancing crop management practices and well-adapted varieties. • Improvement in natural resource properties.	• Unrestricted exchange of germplasm and crop management technologies. • NARSs have sufficient research and extension capacity to develop and extend new technologies. • Timely availability of suitable local machinery and agricultural products and credits for farmers. • Robust methods, models, and techniques for assessing long-term productivity trends.
Purpose	**Indicators**	**Assumptions and risks**
Overcome declining productivity in wheat-based systems and help South Asia meet increasing food demand, especially for the region's 500 million poor people.	• Availability of more productive, profitable, and sustainable technologies and adapted varieties.	• See above.
Outputs	**Indicators**	**Assumptions and risks**
1. The agroecologies of wheat systems in South Asia are characterized and a project management information system (PMIS) is developed for handling information from RWC partners. 2. Improved wheat germplasm adapted to the eastern Subcontinent. 3. Farmer varietal selection and participatory plant breeding in South Asia. 4. Epidemiological, crop surveillance, and crop loss assessment studies for the helminthosporium leaf blight (HLB) complex and the rust diseases of wheat. 5. Better understanding of soil health in relation to the sustainability of rice-wheat systems. 6. Reduced and zero-tillage systems for timely planting, improved crop stands, increased water and nutrient efficiency, and higher yields in rice-wheat systems. 7. Bed planting systems to increase the efficiency and productivity of irrigated wheat systems in South Asia. 8. An assessment of productivity trends in rice-wheat systems. 9. A better understanding, through enhanced social science input, of factors affecting rice-wheat system productivity and profitability, and farmer welfare. 10. Successful management of the Rice Wheat Consortium (RWC) for the Indo-Gangetic Plains	1. More effective use of GIS and crop modeling; user-friendly almanacs to improve targeting of technologies; a web-based PMIS. 2. Wheat productivity and farmer income increase with greater availability of suitable cultivars for rice-wheat cropping systems and enhanced wheat diversity in farmer's fields. 3. Higher, more stable on-farm yields, resulting from the development of more resistant germplasm and better information on agronomic factors, HLB incidence, and problems. 4. Wheat varieties with improved rust resistance used by farmers. 5. Recommendations used by farmers to reduce yield losses from soil-borne factors. Methods for soil and root health studies available. 6. Rapid adoption of resource-conserving tillage practices, with accompanying benefits for system sustainability, profitability, productivity, natural resource use and degradation, the environment, and farmer welfare. 7. Greater adoption of bed planting systems, with accompanying benefits as listed in point 7 above. 8. Based on a better understanding of causes of declining productivity, solutions to productivity problems are developed; farmers adopt them. 9. Improved national program capacity to identify and address farm-level and policy constraints to sustained or improved productivity; accelerated adoption of technology because of farmer participation; better-trained national multidisciplinary research teams. 10. Members of the RWC actively participate.	• National programs committed to providing resources and working in partnership with the many stakeholders in project activities. • Unrestricted exchange of germplasm and crop management technologies. • NARSs have sufficient research and extension capacity to develop and extend new technologies. • Project participants can interact with other service providers in the NGO and private sector. • Timely availability of suitable local machinery and agricultural products and credits for farmers. • Robust methods, models, and techniques for assessing long-term productivity trends. • Sufficient funding available.

Activities	Milestones	Assumptions and risks
1. Develop data and information management tools to facilitate research and handle the large quantity of data from partners in the region, including 1) a "rice-wheat atlas," 2) a rice-wheat component for country almanacs, and 3) an effective PMIS (train researchers and GIS specialists in their use and maintenance) (contributes to output 1).	By 2002: • Make 200 copies of the RW Atlas V0.9 and 1,200 of V1.0 available for RWC partners; post data on website. • Test Country Almanacs in all 4 countries in the region; provide more complete datasets for the RW component of country almanacs. • Hold a workshop for GIS specialists to characterize rice-wheat systems. • Hold familiarization workshops to promote use of Atlases and Almanacs. • Test an on-line PMIS (PMISnet) with IASRI in IARI, India; 3 other countries in the region adapt PMISnet to their own management needs and enter information. • Provide a tested web-based information system (PRISM) on the RWC website for handling rice-wheat data.	• Data of acceptable quality and scale are available and shared by NARSs. • NARSs scientists cooperate in compiling and sharing data. • GIS specialists available in partner countries. • Equipment and trained scientists available in the NARSs. • The IASRI group can maintain specialists to work on the PMIS; other NARSs can share the PMIS; NARSs can provide data for the PMIS; and suitable consultants can be identified and funded.
2. Develop and evaluate improved wheats through: regional nurseries and yield trials for the eastern Gangetic Plains; the use of HLB and leaf rust resistance from synthetics and wild relatives of wheat; adaptive farmer participatory research; evaluation of varieties' performance under surface seeding and zero-tillage establishment; evaluation of breeding methodologies; exchange of information on the association of morpho-physiological traits with grain yield under late heat stress; and visits in the region and to CIMMYT-Mexico for scientists and farmers. (Links with G3, G5, G6, G8, and other R3 activities; contributes to output 2.)	By 2002: • Distribute 15 sets each of 5th EGPSN and 3rd EGPYT in region. Analyze and distribute data on grain yield, adaptation, and phenological data from 4th EGPSN and 2nd EGPYT. • Make 100 new crosses with high grain yields and grain quality, and combined resistance to HLB, leaf rust, and heat. • Identify 30 parental lines with combined resistance to the biotic and abiotic stresses in the eastern Gangetic Plains. • Increase farmers' awareness/adoption of superior varieties and crop management techniques. • Modify technologies based on farmers' feedback and an improved understanding of constraints to adoption. • Appropriate methodologies adopted by network members in eastern Gangetic Plains. • Preliminary physiological studies on late heat stress available as a selection aid. • Scientists and farmers have increased awareness of varietal development activities.	• Unrestricted sharing of germplasm in the region. • Germplasm sent and received on time through the proper channels. • Cooperative partnerships develop among wheat scientists (including data sharing) and with extension. • Funding. • Suitable disease resistance available. • Suitable methods and equipment available for testing germplasm. • Physiologists and other scientists available.
3. Conduct participatory varietal selection (PVS) trials in farmers' fields with elite wheat lines and/or released varieties under current and reduced tillage; assess the impact of the trials and farmer preferences through farmer field days. In more remote, less productive areas, conduct participatory plant breeding (PPB) trials using feedback from farmers regarding desirable traits. Multiply and disseminate seed of farmer-preferred wheat varieties. (Links with G3 and other R3 activities; contributes to output 3.)	By 2002: • Conduct and evaluate 2 PVS trials in 4 locations. • Identify at least 5 farmer-preferred improved wheat lines and provide information on preferred traits to breeders. • Develop 12 wheat populations to initiate PPB trials. • Increased diversity of new wheat lines in farmers' fields. • Document increased use of resource-conserving technologies, use of improved germplasm, and improved wheat production in selected locations. Over 2002-04: • Publish reports on the results and potential value of these technologies and methods.	• Cooperative farmers and scientists. • Mobility and funding. • Suitable material available for testing and multiplication.
4. Identify pathogen populations associated with HLB, pathogen aggressiveness and virulence, primary source of inoculum, and effects of alternate hosts, crop residue (especially under reduced tillage), or soil in pathogen survival. Study the effect of soil fertility and heat stress on HLB severity. Evaluate new sources of genetic resistance	By 2002: • Obtain a better understanding of the epidemiology of HLB complex in the region to develop better germplasm and management practices for rice-wheat systems. • Identify agronomic factors interacting with HLB. • Identify agronomic practices to reduce losses from HLB for farmer testing.	• NARS cooperation and availability of trained scientists. • NARS cooperation and availability of scientists. • Cooperation of NARSs and funding available. • Sources of resistance available. • Cooperation of NARS and funding available.

Activities	Milestones	Assumptions and risks
and advanced germplasm for resistance to the HLB complex. Conduct the HLB monitoring nursery in the eastern Gangetic Plains and quantitative HLB disease surveys using GIS/GPS and other criteria. (Links with other R3 activities; contributes to output 4.)	• Develop germplasm with improved HLB resistance and make it available for testing. • Identify 350 parental lines with combined resistance to HLB and heat tolerance. • Evaluate 46 new sources of resistance to HLB complex. • Improve the characterization of HLB prevalence in wheat systems. • Publish survey results. • Identify genetic stocks with HLB resistance for further evaluation.	• Resistance or tolerance to HLB available.
5. Conduct epidemiological and rust surveillance studies in the region; test potential sources of resistance; screen for slow disease progress and durable resistance; strengthen national capacity to monitor rust virulence and characterize rust races; improve national links with centers of excellence in rust genetics; increase the flow of information on rust in the region and from neighboring countries; and evaluate genotypes developed by national programs in areas where new yellow rust virulence has developed. (Links with G3, G6, G6, and other R3 activities; contributes to output 4).	By 2002: • Reduce wheat yield losses through faster deployment of durable resistance to emerging rust races. • Evaluate 400 leaf-rust-resistant advanced lines (adapted to ME1) for use as parental material. • Identify rust pathotypes at Shimla, India. • Assess training needs in Pakistan for monitoring rust and evaluating development of yellow rust epidemic in North West Frontier Province. • Implement a system to predict changes in rust virulence. • Provide sets of differentials to NARSs. • Evaluate genotypes for yellow rust resistance. • Test 200 advanced lines from Nepal for resistance to new yellow rust races at CDRI-Pakistan.	• Cooperation of NARSs and sharing of information. • Availability of scientists for research and training. • No problems importing plant material through national channels. • NARSs make germplasm available in time to be sent to cooperators.
6. Identify soil-borne nematode and fungal pathogens and microbiota associated with rice-wheat systems (and provide training in identification); identify putative soil health bio-indicators under changing cropping practices in relation to soil organic matter; identify the impact of tillage practices on soil health indicators; evaluate soil health in long-term experiments; develop information on how farmers can overcome soil health problems and extend this information through participatory approaches. (Links with other R3 activities; contributes to output 5).	By 2002: • Identify fungal pathogens and micro-biota and relate them to tillage and management options. • Develop and validate isolation and quantification methods. Improve scientists' skill in identifying soil-borne pathogens. • Identify putative soil health bio-indicators for different cropping systems; assess the indicators' significance and their relative prevalence in rice-wheat systems. • Clarify the role of tillage in soil health, and determine whether soil health parameters limit yields in continuous rice-wheat systems; if so, develop recommendations for controlling soil pathogens. • Farmers adopt recommended solutions for soil health problems.	• NARS collaborators identified and cooperate at the site level. • Scientists available for training; suitable lab equipment available; samples can be sent for identification. • Assume that there is a soil health problem, that prospective solutions are available to farmers, and that participatory approaches can be used.
7. Using participatory approaches, develop recommendations for the tillage options promoted for wheat; promote the development of appropriate equipment; help implement planned, proactive use of participatory methods; promote longer-term monitoring of new tillage options in farmers' fields where they have been adopted; conduct medium-term experiments to evaluate the effects of reduced tillage on soil and biotic factors (including use of dry-seeded rice establishment); and develop public awareness and training materials for farmers, administrators, and other interested parties. (Links with G3, G5, G9, and other R3 activities; contributes to output 6.)	By 2002: • Publish recommendations on reduced and zero-tillage options for rice-wheat farmers; obtain farmers' feedback to improve the technologies. • Farmers use tillage equipment extensively and a network of engineers and manufacturers exchanges information on how to improve equipment. • National programs use farmer participatory research to develop technologies and recommendations and accelerate adoption of resource-conserving technologies. • Publish information on farmers' adoption and use of the new technology. • Produce videos for farmers and others on resource-conserving technologies; produce bulletins for extension workers and NGOs to accelerate adoption.	• Cooperation of all project participants and free exchange of information. • Ability to organize efficient stakeholder participatory approaches. • Equipment and funds available. • NARS scientists have the resources and mobility to get to the field, and the training and facilities to make the various measurements. • Suitable land and resources available to conduct experiments and monitoring. • Professional videographers and facilities in the region.

Activities	Milestones	Assumptions and risks
	By 2003: • Quantify benefits and problems (socioeconomic and environmental) of the new technologies. • Incorporate information on the technologies into curricula for universities, colleges, training centers, and farmer training.	
8. Quantify short- and long-term benefits of bed planting systems, encourage local manufacture of improved prototype equipment, introduce prototype equipment from outside the region, arrange traveling seminars and visits to improve awareness of work on tillage and bed planting and exchange ideas, collect data from tillage experiments to verify models that provide a better understanding of the longer-term implications of reduced tillage, collect data to verify predictive models for performance of bed-planted wheat, and (through GIS and crop modeling) determine areas suitable for bed planting and resource-conserving tillage practices. (Link with other R3 activities; contributes to output 7).	By 2002: • Provide data on quantifiable agronomic and economic benefits of bed planting. • Provide suitable bed planting equipment to farmers in sufficient numbers and quality for experimentation. • Locally manufacture and sell quality equipment. • Identify prototype equipment from within and outside the region to make better machinery. • Establish a network of scientists motivated to conduct good research on tillage and bed planting practices in rice-wheat systems. • Improve awareness of the benefits of resource-conserving technologies among stakeholders. By 2003: • Develop and use a map showing areas suitable for bed planting and other resource-conserving tillage options. By 2004: • Develop and use predictive models for understanding longer term implications of bed planting and other resource-conserving tillage options.	• Bed planting equipment is available for farmer experimentation, farmers are willing to experiment, and scientists are trained and available to take the proper measurements. • Local manufacturers invest in developing appropriate equipment. • Equipment can be imported. • Scientists and manufacturers are aware of bed planting and its advantages. • Scientists are allowed to travel, especially outside their countries; travel funding is available. • A suitable model is available and scientists are trained to use it and collect data to verify it.
9. Quantify and interpret trends in rice-wheat system productivity as a basis for developing strategies to reverse negative productivity trends; develop district-level maps of soil survey and agronomic monitoring data to be used for extrapolation; assess the roles of nutrient mining, degradation of soil physical properties, organic matter declines, and root and soil health in negative productivity trends; and conduct soil solarization experiments to quantify the role of soil-borne pathogens in yield declines. (Links with other R3 activities; contributes to output 8.)	By 2002: • Publish papers on methodologies, models, and techniques for trend and socioeconomic analysis of long-term experiments and agronomic monitoring data. • Make recommendations to farmers to overcome problems of declining productivity. • Develop district-level map showing agronomic monitoring data in relation to soil survey data. • Develop a methodology for conducting soil and root health studies in long-term trials. By 2003: • Publish report on the extent of productivity declines, factors involved, and suggestions on how to reverse declines. • Develop a set of sustainability indicators to help explain productivity declines. • Use an available model to explain trends in experiments to assess sources of negative productivity trends.	• Data from long-term experiments available for additional analysis. • GIS facilities and trained scientists available. • A suitable model is available. • Funds and facilities are available.
10. Strengthen farmer participatory approaches and gender analysis methods in R3 research; continue work on a food systems approach to improving human nutrition in Bangladesh using whole family training methods; and conduct country-level policy studies and farm-level constraints studies to provide information and foster better interaction between social and biological scientists. (Contributes to output 9).	By 2002: • NARS scientists actively use participatory research approaches and gender analysis for accelerating the adoption of new technology. • Conduct a large number of whole family training programs; farmers use information obtained from the training. • Organize a network of social scientists to address constraints to productivity in rice-wheat systems.	• Resources available for scientists to get to the field. • Incentives from national programs to promote this extension methodology. • Social scientists available. • Funding available.

Activities	Milestones	Assumptions and risks
	• Identify policy and macro-level constraints to enhancing/sustaining productivity growth in rice-wheat systems. • Identify farm-level constraints to technology adoption through multidisciplinary research in farmers' fields. • Identify technology and policy instruments for enhancing/sustaining rice-wheat productivity growth.	

Duration: 2002–2004+

Collaborators: Farmers
NARSs: Bangladesh, India, Nepal, Pakistan and China, including universities and research centers and stations in the region
IARCs: CIP, CIAT, ICRISAT, IRRI, and IWMI
NGOs
Universities: Melbourne University and University Sydney, Australia; University of Louvain-la-Neuve, Belgium; IAC, Wageningen University, the Netherlands; Cornell University and Texas A&M University, USA; and others
ARIs: Rothamsted and CABI International, UK, and others
Local equipment manufacturers
Private sector consultants

Costs: US$ 1.606M

System linkages: Germplasm improvement (20%)
Germplasm collection (5%)
Sustainable production (40%)
Policy (5%)
Enhancing NARSs (30%)

Project 13 (R4): Food security for West Asia and North Africa

Overall goal	Indicators	Assumptions and risks
Greater food and feed self-sufficiency and poverty alleviation in West Asia and North Africa (WANA) through increased productivity and stability of wheat production systems, which will reduce pressure to cultivate marginal lands, thus protecting the environment.	• Cereal imports in the WANA countries will not increase as domestic production starts to rise and keeps pace with the growing population. • Contribution to poverty alleviation through increases in farm income brought about by higher on-farm productivity.	• Population growth will be brought under control.

Intermediate goal	Indicators	Assumptions and risks
Cereal productivity in WANA increased through the development and dissemination of improved bread wheat and durum wheat germplasm.	• Modern varieties sown in regions of Turkey, Iran, and Morocco where large areas are still under unimproved cultivars. • Replacement of old improved cultivars with new bread and durum varieties with better resistance to biotic and abiotic stresses and improved quality characteristics.	• Government policies support dissemination of improved agricultural technologies. • Improved agronomy practices are developed and adopted by farmers.

Purpose	Indicators	Assumptions and risks
Farmers and consumers in WANA benefit from increased crop productivity, as a result of bread and durum wheats with higher yield potential, greater stability, improved disease resistance, improved tolerance to abiotic stresses, and better end-use quality.	• Increased productivity, fewer disease epidemics, and use of wheats with improved grain quality in farmers' fields.	• Commitment of NARSs and support from local institutions.

Outputs	Indicators	Assumptions and risks
1. Winter and facultative bread wheats with enhanced yield potential, yield stability, disease resistance, abiotic stress tolerance, and better end-use quality. 2. Spring bread and durum wheats with higher yield potential, resistance to biotic and abiotic stresses, and better grain quality developed for dryland conditions. 3. New breeding methodologies for stress environments developed and disseminated. 4. Better classification of WANA into mega-environments to allow identification of locations most suitable for selecting for specific traits and for shuttle breeding. 5. Integrate the use of physiological traits and molecular markers in conventional breeding. 6. Use synthetic wheats and other biotechnological products for widening genetic diversity. 7. Resistance to root rot disease and nematodes incorporated into elite wheat germplasm. 8. A winter and facultative durum wheat breeding program to enhance yield potential, yield stability, disease resistance, abiotic stress tolerance, and better end-use quality established. 9. A regional germplasm exchange system for winter and facultative durum wheats established. 10. NARS research capabilities enhanced. 11. Improved information on consumption and production characteristics of priority to farm households 12. Triticale used as feed and fodder crop.	1. Improved winter and facultative bread wheats available for cooperators; wheats of desirable quality available to local processing industry. 2. Improved spring wheats available to cooperators; wheats of desirable quality available to local processing industry. 3. New breeding methodologies developed and disseminated. 4. Classification of environments within WANA improved. Increased selection efficiency for specific traits. 5. Application of MAS in breeding bread and durum wheats. 6. Greater genetic diversity available to breeders. 7. New wheat varieties in WANA are more tolerant to root rot disease and nematodes; reduced losses from root rot disease and nematodes in farmers' fields. 8. Crosses and subsequent segregating generations of winter and facultative durum available. 9. System established for exchanging winter and facultative wheat germplasm. 10. Post-course employment assignment in NARSs for trainees. 11. Greater and faster acceptance of new varieties by farmers. 12. Increased triticale area.	• See above. • Funds are available to establish a winter and facultative durum wheat program and distribute the germplasm (for output 8).

Activities	Milestones	Assumptions and risks
1. Selection and promotion of facultative and winter wheat germplasm with tolerance to abiotic (heat, cold, drought, zinc) and biotic (yellow rust, bunts, and smuts) stresses and improved quality traits for WANA (contributes to output 1).	• By 2002, identify 5 winter and facultative bread wheat cultivars with high yield potential, disease resistance, and acceptable quality for promotion.	• CIMMYT continues to maintain resources for activities in WANA. • NARSs and other CG centers give more emphasis to agronomy research.
2. Classify winter wheat growing environments (contributes to outputs 1, 3).	• By 2002, prepare nurseries for all major mega-environments.	
3. Use of molecular markers for improving nematode resistance in bread wheat, and for quality and drought tolerance in durum (contributes to outputs 3, 5).	• By 2003, new designs and techniques are used by the CIMMYT/ICARDA bread wheat and durum breeding programs, as well as by 3 NARSs in the region.	
4. Identify physiological traits and molecular markers for resistance to abiotic and biotic stresses and improved grain quality (contributes to outputs 3, 5).	• By 2003, map 4 specific populations for the 3 main environments; identify physiological selection criteria and QTLs for improving quality traits.	
5. Evaluation of synthetic wheats from CIMMYT's Wide Crosses Unit and development of doubled haploid populations (contributes to output 6).	• By 2003, evaluate 20 synthetic wheats and develop 200 doubled haploid populations.	
6. Breeding for biotic and abiotic stress resistance, as well as for improved grain quality for specific end-products (contributes to outputs 1, 2, 8, 9).	• Every year, develop 150 facultative and winter wheats, 150 spring durum wheats, and 150 spring bread wheat genotypes resistant to biotic and abiotic stresses, plus 50 each with improved grain quality. • Every year, distribute 8 winter wheat, 8 spring bread wheat, and 10 spring durum wheat nurseries to 20-25 NARSs.	
7. Elite and advanced wheat evaluated for root rot and nematode disease (contributes to output 7).	• By 2003, understand and document reaction of elite and advanced wheat lines to root rot and nematodes. • Document frequency and distribution of root-rot-causing organisms in Turkey. • Every year, evaluate 500 advanced and elite winter wheat lines for root rot reaction. • Determine genetic control of current and newly identified sources of resistance to root lesion nematode (*Pratylenchus thornei*). • Document frequency and distribution of cereal cyst nematode in Turkey.	
8. Crosses and evaluation of segregating generations of winter and facultative durum wheats accomplished (contributes to output 8).	• Every year, select 200 crosses and evaluate their subsequent segregating generations (F2-F5) for biotic and abiotic stresses.	
9. Cultivars and elite winter and facultative durum wheats from the region distributed to NARSs upon request (contributes to output 9).	• Distribute 20-30 genotypes per year to NARSs.	
10. Human resource capacity of regional NARSs developed through research collaboration and training in sustainable crop management practices (contributes to output 10).	• Over 5 years, train 10 NARS scientists trained.	
11. Investigate current technology use, technological and institutional constraints, factors influencing farmers' choice of variety, and implications for income equity, genetic resource conservation, and future breeding and research priorities (contributes to output 11).	Over the planning period: • Farm-level surveys implemented to collect primary data for economic analysis of household decision-making behavior. • Develop an understanding of the specific requirements for wheat and wheat products and the ability of existing varieties (traditional and improved) to satisfy household requirements.	

Activities	Milestones	Assumptions and risks
	• Identify obstacles to adoption of improved varieties and analyze implications for crop breeding research in regions of widespread landrace cultivation. • Estimate and understand the impacts of technology adoption on household wealth.	
12. Triticale lines tested and promoted for grazing (contributes to output 12).	• Over the planning period, triticale accepted by at least one country as fodder crop.	

Duration: 2002–2004+
Collaborators: NARSs
IARCs
NGOs
ARIs
Costs: US$ 1.760M
System linkages: Germplasm improvement (50%)
Germplasm collection (12%)
Sustainable production (9%)
Policy (5%)
Enhancing NARSs (24%)

Project 14 (R5): Agriculture to sustain livelihoods in Latin America and the Caribbean

Overall goal	Indicators	Assumptions and risks
To enable resource-poor maize/wheat farmers in Latin America and the Caribbean (LAC) to move from an economy of subsistence and resource degradation to one based on surplus and accumulation, while conserving natural resources.	• The relative number of farmers participating successfully in the market increases.	• The strength of research and extension organizations in the region is not further eroded by loss of trained staff, by unreliable funding, or other factors. • Exchange of germplasm, other technology, and information is not restricted by intellectual property legislation. • Political will exists to support regional research, extension, and/or policy initiatives. • The strength of agricultural innovation systems increases thanks to a greater interaction among agents.
Intermediate goal	**Indicators**	**Assumptions and risks**
To increase the profitability and sustainability of the most important maize and wheat cropping systems in LAC.	• See above.	• See above.
Purpose	**Indicators**	**Assumptions and risks**
Build on CIMMYT's extensive experience with regional research networks to develop, validate and promote the adoption of profitable and sustainable maize and wheat technologies and processes for smallholders farmers in LAC.	• Increased adoption of agricultural technologies that increase productivity and profitability while ameliorating problems with the natural resource base.	• See above.
Outputs	**Indicators**	**Assumptions and risks**
1. Innovation and production systems are characterized, major problems diagnosed, and priorities established for research. 2. Technological components (technology and processes) for those production systems are generated and made available to partners in the region. 3. Adoption and impact of past and current R5 activities assessed. 4. Regional research partners, including national innovation systems, strengthened.	1. Improved characterization of maize and wheat production systems (e.g., economic and social importance of system; status of natural resources; factors affecting system productivity and sustainability; factors affecting technology adoption, system competitiveness) leads to the development of workplans to address prioritized constraints. 2. Appropriate technologies (e.g., germplasm, crop management and resource conservation practices, integrated pest management strategies) for high priority regions/problems are developed; they are disseminated through a greater effort in extension and information dissemination—promotion, publications, bulletins, seminars, workshops, and other media. 3. The adoption and impact of technologies developed for increased, more stable, more profitable, and more sustainable crop production are documented; researchers and policymakers have better knowledge of factors that influence adoption and impact of such technologies. 4. More effective partnerships formed to achieve R5 objectives. Stronger innovation, research, and extension capacity among regional partners achieved through traditional means, such as training and consulting, and new institutional arrangements, all enhanced by CIMMYT serving as an honest broker on issues related to intellectual property legislation, biotechnology, biosafety, Stable and more long-term regional research	• Mechanisms for sharing data and information can be established and accessed. • Genuine commitment by organizations in the region to devise more effective means of working together.

Outputs	Milestones	Assumptions and risks
	arrangements improve the likelihood of achieving the overall goal of R5 transgenic cultivars.	

Activities	Milestones	Assumptions and risks
1. Develop a better understanding of regional cropping systems and their productivity and sustainability challenges (contributes to output 1; links with CIMMYT's Natural Resource Group).	Over the planning period: • Diagnose problems in maize production systems in Central America. • Develop GIS and modeling interface in Honduras and Mexico; conduct site similarity analysis for Bolivia. • Diagnose problems in wheat production systems in Bolivia. • Characterize competitive areas of sustainable maize production in Central America.	
2. Develop, test, and promote maize/wheat germplasm (contributes to output 2; links to other global and regional CIMMYT projects).	By 2002: • Restructure the wheat breeding effort in the Bolivian valleys. • Bolivia releases one new wheat variety (based on CIMMYT germplasm) for the highlands and one for the lowlands (also based on CIMMYT germplasm). • Colombia releases maize germplasm with tolerance to acid soils. Over the planning period: • Establish advanced breeders' trials that are seeded without tillage at some sites in lowland Bolivia. • Develop QPM germplasm that is released in Central America, Mexico, Colombia, Venezuela, and Peru. • Specific countries release maize with tolerance to corn stunt disease, and selected countries in LAC release maize with tolerance to other biotic stresses.	• Regional mechanisms for germplasm exchange and technology extension function well.
3. Promote production of improved seed of maize and wheat (contributes to output 2).	Over the planning period: • Attain wider availability and adoption of improved germplasm. • Evaluate international wheat nurseries at 11 locations. • Restore maize germplasm in countries affected by Hurricane Mitch. • Characterize maize seed markets in selected Central American countries.	• Private companies have an interest in producing seed of germplasm appropriate for farmers who are not yet commercial producers.
4. Conduct strategic agronomic research on main production constraints (contributes to output 2; links to other global and regional CIMMYT projects).	By 2002: • Develop recommendation for reducing risks of wheat seeding in lowland Bolivia based on soil moisture and rainfall probabilities. Over the planning period: • Establish rotation and preceding crop trials in the lowlands of Bolivia. • Develop and test mechanistic models for understanding/extrapolating key technologies.	• Regional/local mechanisms exist for testing and extending complex technology.
5. Conduct applied participatory agronomic research (contributes to output 2).	Over the planning period: • Test methods for efficient participatory technology development. • Suitable germplasm, agronomic practices, and laboratory facilities become available for evaluation and testing. • Validate and demonstrate a package of practices involving five interacting factors in the highland valleys of Bolivia (complete the initial stage of this work before 2002).	• Regional/local mechanisms exist to develop/adopt component technologies. • Local capacity to conduct on-farm research exists.

Activities	Milestones	Assumptions and risks
6. Conduct applied participatory research on conservation technologies (contributes to output 2).	Over the planning period: • Test animal-drawn seeder for no-till seeding of wheat in 10 communities of the Bolivian valleys. • Test machinery for conservation tillage (animal drawn and motorized) in southern Mexico.	• Markets for important rotation crops, especially maize, exist.
7. Conduct applied participatory research on integrated pest management (contributes to output 2).	• Over the planning period, develop an improved strategy for defining chemical disease control of wheat diseases in lowland Bolivia.	
8. Conduct strategic and applied research on the long-term consequences of conservation technologies (contributes to output 2; links to G9).	• Over the planning period, assess the long-term physical and economic consequences of conservation tillage in selected sites.	
9. Conduct studies of the adoption and impact of technologies developed through this project (contributes to output 3; links with G7).	Over the planning period: • Better knowledge of factors affecting adoption becomes available to improve the adoption of productivity-enhancing, resource-conserving technologies. • Develop a common framework for analyzing the adoption and impact of conservation tillage. • Assess the impact of germplasm research in Latin America. • Conduct policy studies and develop recommendations to facilitate extension and adoption of technologies. By 2002: • Publish a synthesis of factors affecting adoption of new technologies by small farmers in Central America. • Complete a final impact survey of PROTRIGO in the Bolivian valleys.	• Information can be obtained from private seed companies on their use of CIMMYT germplasm.
10. Carry out strategic and applied research on the organization of agricultural innovation systems in selected Latin American countries (contributes to output 4, links with F6).	Over the planning period: • Publish reports on the organization of 7 Latin American agricultural innovation systems. • Produce report on sources of productivity in public breeding institutions. • Produce report on incentives systems in Latin American public research institutions.	
11. Carry out local, in-country, and regional training (contributes to output 4; links with G8).	• Each year, 20 participants attend short courses on conservation tillage, participatory technology development (including breeding), and modeling. • Over the planning period, develop instructional material on key themes; offer seed production courses. • By 2002, complete the final impact survey of PROTRIGO in the Bolivian valleys (this work has a training component).	• Suitable candidates available for training.
12. Carry out in-service training (contributes to output 4; links with G8).	• Each year, 15 participants attend specialized in-service training courses.	• Suitable candidates available for training.
13. Support academic training in universities (contributes to output 4; links with G8).	• Over the planning period, 2 researchers receive graduate training.	• Suitable candidates available for training.
14. Contribute to the development of special research skills (contributes to output 4; links with G8).	• Conduct 10 field days/workshops on special topics.	
15. Establish effective, efficient alliances with key regional partners, including national innovation systems (contributes to output 4).	• By 2002, 2 regional networks promote germplasm developed through R5. Over the planning period: • Establish relations at specific sites with public and private partners to transfer technologies developed through R5. • Establish agreements with private companies and NGOs for seed and machinery production.	• Funding, staffing, and legal framework enables networks to be established. • Possible to identify topics of mutual interest for collaboration with advanced research institutes, NGOs, farmer groups.

Activities	Milestones	Assumptions and risks
	• Establish additional projects with ARIs, farmer groups, and other CGIAR centers to achieve the goals of R5.	
16. Develop, manage, and search for funding of regional projects (contributes to output 4).	• The final stage of PROTRIGO project successfully managed (project terminates in December 2001); by start of 2002, project developed and funded to continue wheat research and extension in Bolivia, including public and private institutions and CIMMYT. • By 2002, collaborative project between Bolivia and Ethiopia (including CIMMYT) on wheat-livestock interactions submitted to the CGIAR Systemwide Livestock Project. • Over the planning period, develop stable and more long-term research arrangements. • Over the planning period, participate actively in establishing research priorities for Latin America (with FORAGRO, FONTAGRO, IICA, and other regional and international institutions).	• Governments recognize that it is in their long-term interest to devise more sustainable research arrangements for the region. • Ministry of Agriculture has little clout under globalization.

Duration: 2002–2004+
Collaborators: Farmer groups
NARSs
IARCs
NGOs
Universities
ARIs
Private companies
Costs: US$ 4.715M
System linkages: Germplasm improvement (37%)
Germplasm collection (7%)
Sustainable production (32%)
Policy (5%)
Enhancing NARSs (19%)

Project 15 (R6): Restoring food security and economic growth in Central Asia and the Caucasus (CAC)

Overall goal	Indicators	Assumptions and risks
Poverty will be alleviated, food security enhanced, and the ecology of the region protected through increased wheat production as a result of using higher yielding wheats in conjunction with sustainable crop management practices and renovating the research infrastructure.	• An invigorated agricultural sector will produce more food and generate more income for resource-poor farmers and consumers, thereby acting as an engine of growth for the economies of CAC.	• Countries of CAC provide policy support for their agricultural sectors.

Intermediate goal	Indicators	Assumptions and risks
Wheat production in the region will increase through the development of higher yielding, disease and pest resistant varieties, and sustainable cropping systems.	• The average wheat yield per hectare in CAC will increase as a result of improved varieties and more appropriate cropping systems.	• NARSs of CAC have appropriate germplasm and related management technologies.

Purpose	Indicators	Assumptions and risks
The national wheat breeding and dissemination activities in CAC countries will be strengthened to enable NARSs to deliver new, more appropriate varieties and cropping practices to farmers.	• NARSs benefit from improved wheat germplasm and better coordinated regional testing activities. • Farmers benefit from new varieties that have improved resistance to diseases and pests.	• NARSs have the capacity to deliver improved germplasm and cropping practices to farmers.

Outputs	Indicators	Assumptions and risks
1. Superior winter and facultative wheat germplasm for CAC. 2. Superior high-latitude spring wheat germplasm targeted to northern Kazakhstan. 3. Modern, sustainable cropping practices for high latitude spring wheat and irrigated facultative/winter wheat. 4. Regional wheat improvement and genetic resources network established. 5. Strengthened NARS wheat breeding/ research capacity. 6. Economic analyses of wheat production in CAC.	1. New wheat cultivars with resistance to pests and diseases tested in farmers' fields; enhanced quality and diversity of wheat germplasm adapted to CAC; segregating populations for selecting lines adapted to rainfed and irrigated conditions. 2. New high-latitude cultivars adapted to northern Kazakhstan. 3. Cropping practices available. 4. Exchange of information among NGOs, CIMMYT, and ARIs on regional ecology, disease spectrum, and soil and plant performance. 5. An active, targeted training program operating in CAC. 6. Economic analyses available.	• Exchange of germplasm at the regional level continues. • NARSs have sufficient staff resources.

Activities	Milestones	Assumptions and risks
1. Identification and promotion of winter wheat germplasm suitable for the region, its formal testing, and promotion among farmers (contributes to output 1).	By 2003: • Identify at least 50 lines to include in advanced testing by regional NARSs. • Include at least 20 lines in official varietal testing in at least 6 countries, and promote them with farmers through on-farm trials and demonstration plots. • Establish regional winter wheat improvement network. • Test effective models of wheat variety promotion and seed multiplication in 3 countries.	• See above.
2. Characterization and classification of breeding environments in winter wheat and spring wheat regions (contributes to outputs 1, 2).	By 2003: • Produce 3 documents describing environment and important constraints. • Reorient winter and spring wheat breeding programs in Mexico and Turkey based on identified constraints.	

Activities	Milestones	Assumptions and risks
3. Breeding suitable spring wheat germplasm and establishment of shuttle breeding program (contributes to output 2).	By 2003: • Regularly send preselected segregating populations to the region for testing under local conditions. • Establish Kazakhstan-Mexico shuttle breeding program. • Yield-test best germplasm identified in region. • Establish regional spring wheat network.	
4. Identification and promotion of new technologies through on-farm trials and demonstrations (contributes to outputs 1, 2, 3).	By 2003: • Conduct experiments in 3 countries to identify suitable technologies for promotion. • Conduct wide-scale on-farm trials and demonstrations in 8 countries to promote new technologies. • Conduct training courses on how to promote new technologies.	
5. Improved wheat breeding capacity and renovation of machinery and equipment (contributes to outputs 4, 5).	By 2003: • Conduct a review of wheat breeding in 3 countries and develop a plan for improvement. • Support the provision of machinery, equipment, and infrastructure in 3 countries. • Introduce new breeding approaches in 6 countries. • Introduce a competitive grant scheme for priority research areas in 1 country.	
6. Analyses of prospects and policies for wheat production in the region (contributes to output 6).	• By 2003, analyze current production practices and future prospects in the region.	

Duration: 2002–2004+
Collaborator: NARSs: Ministry of Agriculture, Armenia; Ministry of Agriculture, Azerbaijan; Georgian Academy of Agricultural Research, Georgia; National Academic Center of Agricultural Research, Kazakhstan; Kyrgyz Agricultural Academy, Kyrgyzstan; Tajik Academy of Agricultural Research. Tajikistan; Ministry of Agriculture and Water Resources, Turkmenistan; and Scientific Production Center of Agriculture, Uzbekistan.
ARCs: ICARDA
NGOs: CARE International; Aga Khan Foundation; Armenian Technology Group; German Society Golbshtadt
Costs: US$ 0.477M
System linkages: Germplasm improvement (15%)
Germplasm collection (10%)
Sustainable production (25%)
Policy (5%)
Enhancing NARSs (45%)

Project 16 (F1): New wheat science to meet global challenges

Overall goal	Indicators	Assumptions and risks
Global food security is improved thanks to increased wheat production through the use of higher yielding wheats, offsetting the need to bring new land under production, thus protecting natural ecosystems.	• Greater production of wheat grain from the same amount of cultivated land contributes to meeting growing food demand in the developing world.	• Population growth predictions and food demand projections are correct.
Intermediate goal	**Indicators**	**Assumptions and risks**
Wheat yield potential is raised over current thresholds through conventional breeding assisted by new physiology-based technologies and molecular approaches	• Greater understanding of the physiological and genetic mechanisms that determine yield in wheat through integration of physiology and genetics (e.g., functional genommics). • The use of physiological selection criteria and MAS as tools for improving yield potential becomes more common in conventional breeding programs at CIMMYT and elsewhere.	• Suitable markers can be found for traits of interest. • Conventional breeding is not already optimal in efficiency.
Purpose	**Indicators**	**Assumptions and risks**
NARS scientists and other researchers have access to improved wheat germplasm with higher yield potential and better yield stability, as well as to more efficient methods for selecting and developing higher yielding plants.	• Farmers realize higher, more stable wheat yields through the adoption of higher yielding, more input efficient cultivars developed and released by NARSs from CIMMYT germplasm with improved yield potential.	• Public sector continues to support agriculture.
Outputs	**Indicators**	**Assumptions and risks**
1. Technologies to facilitate breeding, such as physiological selection criteria and molecular markers, identified and developed. 2. Identification of yield-enhancing traits and genes from a broad genetic resource base. 3. Inbred lines with good male traits developed and improved for use in wheat hybrid production. 4. Improved understanding of how major genes (*Vrn* and *Ppd*) interact with the environment to modify wheat phasic development.	1. These technologies are applied in wheat breeding programs worldwide at different stages of breeding. 2. Information available. 3. Improved cross pollination between female and male lines in hybrid seed production. 4. Data on *Vrn* and *Ppd* interaction with environment available.	• NARSs will continue to have unrestricted access to germplasm and information.
Activities	**Milestones**	**Assumptions and risks**
1. Evaluate genetic gains associated with using physiological selection criteria such as stomatal aperture-related traits (SATs) (contributes to outputs 1, 2).	• By 2003, clarify conditions permitting most efficient and reliable quantification of SATs within a large germplasm improvement program.	
2. Determine the association of physiological traits such as SATs with yield in a set of historic lines with different yield potential (contributes to outputs 1, 2).	• By 2005, understand the physiology of the link between SATs and yield in CIMMYT material.	
3. Assess the potential of genetic sources of variation in physiological traits (e.g., dark green leaves, high biomass production, large spikes) that could become additional selection criteria useful in breeding for increased yield potential (contributes to outputs 1, 2).	• By 2003, quantify traits such as leaf chlorophyll content during grain filling, grain filling rate, and spike size on a small set of lines.	
4. Cross CIMMYT lines with other materials known to have good male traits to develop inbred lines for use in hybrid combinations (contributes to output 3).	• By 2002, lines found to be good general combiners converted to male lines with good anther extrusion and pollen production.	• Risk that male inbred lines developed by CIMMYT breeders will not produce the highest yielding hybrids.

Activities	Milestones	Assumptions and risks
5. Global yield trials through CIMMYT's International Nurseries network (contributes to output 4).	• By 2002, determine the adaptive role of the *Vrn* and *Ppd* genes across diverse wheat-growing mega-environments of the developing world.	

Duration: 2002–2004+
Collaborators: Universities: ANU, Australia; Technical University, München
ARIs: John Innes Centre, UK; CSIRO, Australia
Costs: US$ 0.421M
System linkages: Germplasm improvement (90%)
Germplasm collection (5%)
Enhancing NARSs (5%)

Project 17 (F2): Apomixis: seed security for poor farmers

Overall goal	**Indicators**	**Assumptions and risks**
The development and adoption of apomictic maize that will enable resource-poor farmers to retain superior seed for sowing from one production cycle to the next, leading to reduced genetic vulnerability in farmers' fields, improved production, and greater food security.	• Reduced genetic vulnerability in farmers' fields, leading to improved production and food security. • Farmers retain superior seed from apomictic varieties.	• Policies, regulations, and/or consumer/farmer acceptance do not impede research or prevent farm-level adoption of apomictic maize. • Apomictic varieties can be developed, manipulated, and deployed successfully.
Intermediate goal	**Indicators**	**Assumptions and risks**
Successful introduction and use of apomixis in a crop background, based on a clear understanding of the regulation of the apomictic mode of reproduction.	• Better information on the biology of apomixis in wild apomicts compared to maize-*Tripsacum* hybrid derivatives. • Increased knowledge of factors regulating the expression of apomixis in wild apomicts and maize-*Tripsacum* hybrids. • Improved understanding of the potential for farm-level adoption and impact of apomictic maize, obtained through *ex ante* impact assessment.	• Resources and technology allow a sufficient understanding of the regulation of apomixis in wild apomicts. • Apomixis can be successfully introduced into a crop species.
Purpose	**Indicators**	**Assumptions and risks**
Enable poor farmers to recycle seed without losing part of the beneficial traits embodied in their varieties by identifying the components of apomixis and their genetic regulation, identifying other constraints to the expression of apomixis in grain crops, and introgressing apomixis into maize.	• Same as for overall goal, above.	• See above.
Outputs	**Indicators**	**Assumptions and risks**
1. Apomictic maize. 2. Improved knowledge of the developmental genetics of apomixis. 3. Identification and isolation of major genes involved in apomixis expression. 4. Improved knowledge of the factors affecting apomixis expression in grain crops. 5. Improved understanding of the potential benefits and constraints related to the adoption of apomictic maize. 6. Improved public knowledge about apomixis technology.	• Apomictic germplasm is available to CIMMYT breeders. • Genes are made available for expression studies through genetic engineering and reverse genetics. • *Ex ante* study of impact of apomictic maize conducted.	• Outcomes also depend on results of a risk assessment study examining the mechanisms conditioning geneflow between apomictic plants/species and other plants/species. • Resources and technology are available and adequate.
Activities	**Milestones**	**Assumptions and risks**
1. Produce maize-*Tripsacum* hybrids (contributes to outputs 1-4).	• Over the planning period, obtain apomictic maize-*Tripsacum* addition lines.	• Crop genomes, particularly maize, are appropriate recipients for apomixis.
2. Identify genes and/or regulatory regions/ factors involved in apomixis expression (contributes to outputs 1-4).	Over the planning period: • Clone or acquire candidate genes. • Determine key regulatory factors and their mode of action.	• IPR constraints.
3. Develop and apply strategies for the molecular analysis of constraints resulting from apomixis expression on kernel development (contributes to outputs 1, 4).	• Over the planning period, clone or acquire candidate genes.	• IPR constraints.
4. Functional analysis of candidate genes resulting from Activities 2 and 3 (contributes to outputs 3, 4).	• Over the planning period, select best candidate genes for attempting to produce apomictic maize via genetic engineering.	• Genes can be identified.

Activities	Milestones	Assumptions and risks
5. Estimate the potential economic benefits of apomictic maize for poor farmers in developing countries (contributes to outputs 5, 6).	• Over the planning period, publish paper estimating the potential economic benefits of apomictic maize for poor farmers in developing countries.	
6. Increase public awareness about the potential impacts of apomixis (contributes to outputs 5, 6).	• Over the planning period, publish journal article and/or CIMMYT monograph describing apomixis research, outlining potential impacts of apomixis (e.g., on farmers, seed producers, and researchers), and discussing technology ownership and control issues.	• Current debate over GMOs and biodiversity might limit or eventually ban the use of apomixis technology.
7. Develop models for assessing the risks of deploying apomictic varieties and dissemination of information to the media (contributes to outputs 5, 6).	• By 2004, assemble the information gained (1) from case studies of geneflow and seed management projects (e.g., the Oaxaca project) and (2) from the characterization of apomixis.	

Duration: 2002-2004+
Collaborators: NARS: INIFAP, Mexico
ARIs: IRD, France
Private companies: Pioneer Hi-Bred International, Inc.; Dupont; Limagrain Holding; Syngenta
Costs: US$ 0.436M
System linkages: Germplasm improvement (85%)
Germplasm collection (5%)
Sustainable production (10%)

Project 18 (F3): Biotechnology for food security

Overall goal	Indicators	Assumptions and risks
Sustainable production of maize and wheat while reducing the environmental damage to fragile ecosystems.	• Maize and wheat production is increased and the pesticide, insecticide, and fertilizer load in fragile ecosystems is reduced.	• The current debate over the development and use of products derived via biotechnology leads to policies that will allow their use and acceptance in conjunction with appropriate biosafety measures.
Intermediate goal	**Indicators**	**Assumptions and risks**
The identification of appropriate biotechnology-based methods that can be applied in the development of maize and wheat varieties with enhanced resistance to biotic and abiotic stresses.	• More efficient and effective pest and disease resistant maize and wheat that combine conventional and biotechnology options developed. • Appropriate field conditions for evaluating varieties developed via biotechnology identified. • Appropriate strategies for the deployment of biotechnology-derived maize and wheat in small farmers' fields developed.	• Appropriate regulatory frameworks for biotechnology products in targeted countries are established and implemented. • Appropriate licenses for release of third-party intellectual property can be negotiated.
Purpose	**Indicators**	**Assumptions and risks**
NARSs obtain biotechnology-derived maize and wheat germplasm with improved biotic and abiotic stress resistance, as well as training in using appropriate biosafety measures when testing the varieties.	• Farmers benefit as a result of more efficient and faster introduction of beneficial traits into maize and wheat germplasm. • A regulatory framework developed for deploying biotechnology-derived maize and wheat. • Appropriate biosafety measures and regulations for importing and testing materials in greenhouse and field trials developed by NARSs.	
Outputs	**Indicators**	**Assumptions and risks**
1. Maize and wheat germplasm with enhanced resistance to major insect pests and pathogens for distribution to NARS breeders. 2. Efficient, effective biotechnology methods for maize and wheat improvement. 3. Biotic and abiotic stress resistance genes and associated molecular markers. 4. Molecular breeding strategies for transferring resistance genes efficiently to maize and wheat germplasm. 5. NARS researchers trained in the application of biotechnology and associated biosafety measures in the improvement of maize and wheat and in evaluating such materials in greenhouse and field trials. 6. Management strategies for the deployment of resistant varieties to optimize the effectiveness and durability of engineered stress resistance. 7. Information on the benefits of biotechnology disseminated among potential users.	1. Yield losses caused by biotic and abiotic stresses in farmers' fields reduced. 2. Pesticide and insecticide load in maize and wheat production systems reduced. 3. More durable resistance to pests and pathogens through the combined application of conventional host plant and biotechnology-derived resistance mechanisms developed. 4. Effective biotechnology methods to improve stress resistance available. 5. Effective stress resistance genes identified. 6. Management and monitoring strategies developed. 7. Researchers trained in biotechnology approaches. 8. Information on benefits of biotechnology developed and disseminated.	• The current trend in some countries towards restricting biotechnology-derived products is changed to one of rational application of biotechnology to plant breeding. • Appropriate regulatory frameworks for biotechnology products in targeted countries are established and implemented. • Appropriate licenses for release of third-party intellectual property are negotiated.
Activities	**Milestones**	**Assumptions and risks**
1. Use of biotechnology to develop maize and wheat adapted to tropical and subtropical environments, with enhanced resistance to biotic and abiotic stresses (contributes to outputs 1-4).	• By 2003, develop tropical maize containing genes conferring resistance to targeted insect pests. • By 2003, develop wheat containing fungal pathogen resistance genes.	

Activities	Milestones	Assumptions and risks
	• Over the planning period, develop tropical maize and wheat containing genes conferring enhanced tolerance to abiotic stresses, especially drought. • Starting in 2002, conduct field evaluation of resistant maize and wheat germplasm in Mexico and other developing countries.	
2. Identification and acquisition of genes, promoters, and enhancing sequences that confer resistance to major pests and pathogens and other environmental stresses (contributes to outputs 1, 3).	• Over the planning period, acquire genes and/or germplasm containing such genes for incorporation into maize and wheat.	
3. Develop maize and wheat germplasm that does not contain herbicide or antibiotic selectable markers (contributes to outputs 3, 6).	• By 2002, develop insect resistant tropical maize containing only the gene of interest (i.e., no genes for resistance to herbicides or antibiotics). • By 2002, develop fungal resistant wheat containing only the gene of interest (i.e., no genes for resistance to herbicides or antibiotics).	
4. Develop strategies for the deployment of biotechnology-derived maize and wheat in small-scale farming systems (contributes to outputs 4-6).	Over the planning period: • Determine the environmental soundness of insect-resistant maize and the measures to be taken in order not to compromise the surrounding environment. • Distribute resistant germplasm distributed to NARSs for incorporation into breeding programs.	
5. Training of NARS scientists in the development and deployment of biotechnology-derived materials (contributes to outputs 1, 5).	• Each year, train NARS scientists through in-country, regional, and CIMMYT formal and informal courses and workshops.	
6. Transfer to NARSs accurate information on the advantages and potential risks of biotechnology (contributes to output 7).	• By 2004, understand the benefits of biotechnology and therefore its potential acceptance by a range of stakeholders.	

Duration: 2002-2004+
Collaborators: NARSs
IARCs
NGOs
Universities
ARIs: For example, CRC for Molecular Plant Breeding-Australia
Private companies
Costs: US$ 1.618M
System linkages: Germplasm improvement (50%)
Sustainable production (20%)
Policy (10%)
Enhancing NARSs (20%)

Project 19 (F4): Biofortified grain for human health

Overall goal	Indicators	Assumptions and risks
The effects of poverty are alleviated by helping to reduce nutrition-related deficiencies, disease, and deaths among the most vulnerable groups in the developing world.	• Improved nutrition of poor women and children, especially those whose diet is based primarily on cereals. • Reduced morbidity rates and increased growth rates among recently weaned children in areas where cereal-based diets predominate.	• Nutritional status of the poor in developing countries may be improved with cereal-based diets.
Intermediate goal	**Indicators**	**Assumptions and risks**
The nutritional quality of maize, wheat, and triticale grain is enhanced, making a balanced diet more attainable to poor people.	• Enhanced levels of micronutrients in maize, wheat, and triticale genotypes. • Increased information for breeders on the existing genetic diversity for micronutrient concentration.	• Enhanced levels of micronutrients in maize, wheat, and triticale may be developed.
Purpose	**Indicators**	**Assumptions and risks**
NARSs will have access to micronutrient enhanced maize, wheat, and triticale germplasm from which to develop cultivars with high concentrations of iron, zinc, and vitamin A.	• Resource-poor farmers have access to nutrient-enriched cereal cultivars.	• NARSs and others are able to disseminate nutrient-enriched cereal cultivars.
Outputs	**Indicators**	**Assumptions and risks**
1. Maize, wheat, and triticale germplasm with higher concentrations or improved availability of micronutrients for use in breeding programs and release in developing countries. 2. More efficient screening methods for selecting micronutrient-enriched maize, wheat, and triticale genotypes. 3. Relationship between higher grain micronutrient concentration and agronomic perfromance and quality traits established and documented.	1. Micronutrient-enriched germplasm for use in breeding programs available. 2. Screening methods for use in practical maize, wheat, and triticale breeding programs available. 3. Information on the relationship between nutrient concentration and agronomic performance and quality traits available.	
Activities	**Milestones**	**Assumptions and risks**
1. Examine genotypic variation and genotype x environment interactions for grain Fe and Zn concentrations in improved maize and wheat germplasm by 2001 (contributes to output 2).	• By 2002, identify germplasm with increased grain concentrations or improved bioavailability of Fe and Zn in current improved maize, wheat, and triticale germplasm.	• Genetic variation for the trait available.
2. Evaluate the genetic diversity for micronutrient concentration of Fe and Zn in landraces and wild relatives of maize, wheat, and triticale (contributes to output 3).	• By 2003, identify key landraces and wild relatives of maize, wheat, and triticale as sources of high Fe and Zn concentration or bioavailability.	• Genetic variation for the trait available.
3. Evaluate the inheritance of increased grain Fe and Zn concentration in maize and wheat (contributes to output 3).	• By 2003, develop information to assist breeders in incorporating increased Fe and Zn concentrations from source germplasm into adapted germplasm.	• Inheritance and screening methods prove to be sufficiently cost-effective that breeding for high grain Fe and Zn concentration (or bioavailability) can be incorporated in routine breeding programs.
4. Identify molecular markers associated with high concentrations of Fe and Zn in wheat triticale, and maize (contributes to outputs 2, 3; depends on funding).	• By 2003, identify molecular markers for the multi-aleurone trait and applied them in backcrossing programs.	• Multi-aleurone trait contributes to increase grain Fe concentration. • New funding available.
5. Develop nonconventional, high-vitamin-A maize genotypes (contributes to output 1).	• By 2003, develop white-grained cultivars with high carotene contents in the embryo. • By 2003, develop adapted red- or blue-pigmented cultivars with yellow endosperm.	• Yellow-grained maize is rejected by consumer groups in Africa and Central America for cultural reasons.

Activities	Milestones	Assumptions and risks
		• Access to target genes through collaboration with the private sector. • Genotypes high in carotenes are discovered among colored maize types. • New funding available.
6. Evaluate the likelihood of nonconventional, high-vitamin-A maize being accepted by African consumers (contributes to output 1).	• By 2003, assess acceptance of white-grained cultivars with high carotene content in the embryo with selected farmer groups in Mexico, Kenya, and/ or Zimbabwe. • By 2003, determine Vitamin A intake from processed flour of white-grained cultivars with high carotene content in the embryo. • By 2003, assess consumer preferences of different grain colors with selected farmer groups in southern Africa; assess the potential for disguising yellow endosperm color with other pigments, such as anthocyanins.	• Use of transgenic maize for assessing consumer preferences in Mexico, Kenya, and/or Zimbabwe possible. • New funding available. • Colored pericarp and yellow endosperm traits can be backcrossed into adapted maize cultivars.

Duration: 2002–04+
Collaborators: NARSs
IARCs: IFPRI
NGOs
ARIs: Plant, Soil and Nutrition Laboratory (PSNL), USA
Universities: University of Adelaide, Australia; Cornell University, USA
Costs: US$ 0.394M
System linkages: Germplasm improvement (80%)
Enhancing NARSs (20%)

Project 20 (F5): Reducing grain losses after harvest

Overall goal	Indicators	Assumptions and risks
Generate benefits for subsistence farmers by developing maize and wheat germplasm resistant to storage pests and diseases.	• Grain losses, quantity, and quality reduced (surveys indicate post-harvest losses of 20% in maize and 10% in wheat, and grain quality is compromised with insect debris and production of mycotoxin during storage).	• Food security depends on constant supply of quality cereals. • Grain storage systems will continue to be inadequate for resource-poor farmers.
Intermediate goals	**Indicators**	**Assumptions and risks**
Quantify the losses associated with post-harvest pests in developing countries, and develop new maize and wheat populations and lines with elevated levels of resistance to storage pests and diseases.	• Models developed and published from which good estimates of post-harvest losses can be derived by NARSs. • Maize and wheat varieties with improved grain quality. • Breeding methods which accelerate the development of resistant germplasm. • Policy makers in national programs endorse the adoption of improved storage methods for resource poor farmers. • Extend the use of CIMMYT germplasm in the seed industry and NARSs.	• Models for predicting losses can extend to other pest species and maize growing ecologies. • Resource-poor farmers will store improved varieties with good levels of resistance to post-harvest pests. • NARSs will promote germplasm with such traits. • Grain will be acceptable for food preparation.
Purpose	**Indicators**	**Assumptions and risks**
To develop source germplasm from which the biochemical and genetic basis for such resistance mechanisms can be defined and then exploited within the context of traditional and marker-assisted breeding programs.	• Resistant sources are two-fold more resistant than elite CIMMYT germplasm. • Biochemical resistance mechanisms extend across a wide range of accessions, varieties, and lines. • Resistance can be transferred in a cost-effective and timely manner (based on economic analysis).	• Resistance is available in CIMMYT's germplasm collections. • CIMMYT has access to ARI labs for conducting biochemical analysis. • Molecular tools are sufficiently advanced to monitor quantitative grain quality traits.
Outputs	**Indicators**	**Assumptions and risks**
1. Stress tolerant, high-yielding maize and wheat germplasm with improved resistance to storage pests and diseases. 2. Technical report on breeding methodologies for developing maize varieties with improved resistance to post-harvest pests and diseases. 3. On-farm testing and training of farmers and NGOs to improve dissemination of resistant germplasm. 4. Insure that QPM is moderately resistant to post-harvest pests using rapid screening technologies.	1. By 2002, the CIMMYT Maize Program in collaboration with NARSs will have developed and identified (via international testing) new lines and synthetics that are more resistant to post-harvest pests than local germplasm. 2. By 2004, the CIMMYT Maize Program will have developed inbreds and synthetics with improved drought tolerance and resistance to post-harvest pests for mid-altitude and lowland tropical ecologies. 3. By 2004, the CIMMYT Wheat Program will have developed varieties with elevated levels of resistance to *Fusarium graminearum*. 4. Bu 2002, produce CIMMYT publications on post-harvest resistance research. 5. By 2002, CIMMYT has strong linkages with NGOs to deliver improved post-harvest technology to resource poor farmers. 6. Farmers adopt QPM for both its nutritional and storage attributes.	• CIMMYT Maize and Wheat Program budgets are sustained. • Collaboration with ARIs is enhanced. • National programs receive priority and relationships with CIMMYT are strengthened. • CIMMYT will have access to post-harvest technologies from ARIs and the private sector for testing.
Activities	**Milestones**	**Assumptions and risks**
1. Formation of source populations and synthetics for resistance to the major storage pests and pathogens of maize (contributes to outputs 1, 2).	• By 2002, characterize all CIMMYT elite maize lines for resistance to ear rots and two storage pests (*Sitophilus zeamais* and *Prostephanus truncatus*), and release maize lines with twice the level of resistance to these storage pests. • By 2004, make recycled lines available. • By 2004, quantify the genetic gains associated with weevil screening using divergent selection.	• Genetic variation for resistance to target pests and diseases exists and can be manipulated by conventional breeding methods without yield penalty.

Activities	Milestones	Assumptions and risks
2. Form wheat varieties resistant to *Fusarium graminearum* (contributes to outputs 1, 2).	• Over 2002-04, screen elite wheat germplasm for mycotoxin production under artificial inoculation.	• Genetic variation exists and screening protocol is in place.
3. Biochemical characterization of resistant sources to elucidate resistance mechanism (contributes to output 1).	• By 2002, elucidate biochemical mechanism for resistance to storage pests of maize and publish results in referred journals.	• Access to ARI facilities for biochemical characterization.
4. Characterize the processing qualities of insect-resistant maize germplasm in collaboration with ARIs (contributes to output 1).	• By 2002, establish linkages with ARIs to characterize mycotoxin levels in wheat and maize and processing qualities of QPM.	• Access to ARI facilities and or technology for characterization.
5. The economic importance of post-harvest pests will be defined using GIS and on-farm surveys over a broad range of ecologies and storage practices (contributes to output 1).	• By 2002, present and publish a report on post-harvest losses in Mexico.	• Models used in GIS are sufficiently robust to be adapted to different regions.
6. Evaluation of the performance of new resistant lines/varieties under specific stresses (drought, low N, high density, and stem borers) (contributes to outputs 1, 2, 4).	• By 2004, release elite lines and synthetics with both good yield stability and storage potential.	• Infrastructure is maintained to support screening.
7. Testing the interaction between alternate control tactics and kernel resistance; including biological controls, "soft-technologies" such as diatomaceous earth, storage structures, and drying technologies (contributes to outputs 1, 2, 3).	• By 2002, identify the best storage package, based on ecology and cultural storage practices, which extends the storage time of improved varieties, and publish results.	• Alternate control strategies/ technologies exist which are effective under tropical conditions.
8. Promoting seed conditioning and storage technologies suitable for CIMMYT germplasm (contributes to output 3).	• By 2002, develop/promote drying technologies suitable for small-scale farmers, and over 2002-04 strengthen links with post-harvest agencies to promote existing storage technology.	• Drying technology can be made available with minimal capital investment and operational costs.
9. Test the potential gene products (proteins) which could be used in transformation of maize and wheat kernels for improved storage capabilities (contributes to outputs 1, 2).	• By 2004, publish results of resistance screening using artificial diets and protein toxins.	• Access to technology that is effective against post-harvest pests and diseases.
10. Training of NARS scientists in post-harvest research (germplasm development, storage technologies) (contributes to outputs 1, 2).	• Over the planning period, provide training (doctoral, masters, and short courses); by 2004, 1 PhD and 4 MSc students will have graduated.	• Funding for training is maintained at current levels.

Duration: 2001–2004+

Collaborators: Farmer groups
NARSs
IARCs: IITA
Universities: University of Ottawa, Canada
ARIs: Agriculture and Agri-Food Canada

Costs: US$ 0.303M

System linkages: Germplasm improvement (50%)
Sustainable production (40%)
Enhancing NARSs (10%)

Project 21 (F6): Technology assessment for poverty reduction and sustainable resource use

Overall goal	Indicators	Assumptions and risks
Contribute to poverty alleviation and increased sustainability in the use of natural resources by assessing the potential impact of new technologies and agricultural policies.	• Reduced poverty and increasingly sustainable use of natural resources through the adoption of new agricultural technologies. • Enactment of novel policy approaches that foster development and adoption of new technologies that contribute to poverty alleviation and increased sustainability of agricultural production.	• New technologies that meet farmers' needs will be developed through the interaction of a number of agents, including NARSs, private firms, farmers, NGOs, and IARCs. • The political environment allows development of new institutional arrangements. • The political environment allows use of novel approaches for policy implementation.
Intermediate goal	**Indicators**	**Assumptions and risks**
Technology assessment allows a better identification of research needs, better targeting of research efforts, and building of new policies and institutional arrangements to increase the impact of research activities.	• Economic, social, and institutional issues affecting the development and adoption of conservation tillage technologies identified. • Economic, social, and institutional issues surrounding new research procedures involving biotechnology identified. • Policy options for poverty reduction, environmental protection, productivity enhancement, and food security for Asian upland maize farming systems identified.	• The combined efforts of a number of agents will allow development of adequate technologies. • Sharing of data and information is unimpeded.
Purpose	**Indicators**	**Assumptions and risks**
Build on CIMMYT's extensive experience with research networks and interdisciplinary projects to assess new technologies, research lines, policies, and institutional arrangements.	• Better identification of productivity, economic, and social issues, and policy options leading to increased impact of research efforts.	• See above.
Outputs	**Indicators**	**Assumptions and risks**
1. Increased understanding of the links between poverty alleviation, resource conservation, innovation policies, and agricultural research 2. Analysis of the role of public agricultural research institutions in reducing poverty and increasing sustainability of agricultural systems, with emphasis on public breeding programs and development of resource conservation technologies 3. Guidelines for targeting biotechnology research for the poor and sustainability of agriculture in marginal lands	1. Improved information to increase the flow of improved germplasm among participating countries. 2. Better information available on the plant breeding programs in 9 Latin American countries. 3. Better information to develop a deployment strategy for apomictic maize. 4. A set of guidelines for integrating MAS into plant breeding programs in cost-effective way. 5. A report on the potential impacts of apomictic maize on the farmers in developing countries, the seed industry, and plant breeding programs. 6. Guidelines for research decision makers on integrating *Bt* resistance into maize germplasm. 7. Guidelines for the organization of research on technologies that increase sustainability of agricultural production. 8. A detailed characterization of upland maize production systems in Asia. 9. Country-specific research and development plans for upland maize. 10. A network of researchers and stakeholders interested in Asian upland maize systems.	

Activities	Milestones	Assumptions and risks
1. Identify stakeholders engaged in technology generation and transfer in the 9 participating countries (contributes to outputs 1-2).	• By 2002, identify stakeholders.	
2. Collect information on factors governing national and international innovation systems and, more specifically, detailed information on the most important maize and wheat research institutions (contributes to outputs 1-2).	• In 2002, produce reports for each of the 9 collaborating countries on the organization of its national research system and interactions with CIMMYT.	
3. Analyze the framework and stakeholders for national and international innovation systems and identify constraints and problems in the implementation of maize and wheat research (contributes to outputs 1-2).	• By 2003, provide information to CIMMYT and NARS policymakers to improve the design of research policies.	
4. Identify institutional issues influencing research cooperation in Latin America, in particular the evolution of formal and informal research networks (contributes to outputs 3-5).	• By 2002, analyze and document the organization of research systems in several Latin American countries in case studies.	
5. Estimate research production functions to help identify economies of scale and scope in research; identify the potential for increasing the efficiency of national research programs in Latin America through increased collaboration and reallocation of resources (contributes to outputs 3-5).	• By 2002, estimate research cost functions. • By 2002, publish study on the potential for increasing the efficiency of research systems in Latin America by exploiting spillovers and economies of scale and scope.	
6. Formulate policy recommendations to increase the efficiency of national research programs in Latin America (contributes to outputs 3-5).	• By 2002, formulate and write up policy recommendations. • In 2001, hold workshop to disseminate results of activities and policy recommendations developed under output 4.	
7. Analyze germplasm flows into and out of the 9 participating countries (contributes to output 2).	• By 2002, quantify germplasm flows between 9 countries in Central America and the Caribbean. • By 2002, report on maize and wheat germplasm flows for all 9 collaborating countries.	
8. Analyze experiences of development and adoption of no-till technologies in Latin America and Africa (contributes to output 3).	• In 2003, report on the development and adoption of no-till technologies in selected Latin American and African countries. • By 2002, publish synthesis of main factors affecting farmers' adoption of no-till technologies in Central America.	
9. Evaluate the potential costs and benefits of apomixis for maize farmers in developing countries, for the seed industry, and for plant breeding programs, and generate a deployment strategy for apomictic maize (contributes to output 4).	• In 2003, produce report on potential effect of apomixis on maize seed production costs.	
10. Evaluate costs of achieving plant breeding goals through conventional breeding methods compared to MAS; develop guidelines for CIMMYT and others on integrating MAS into breeding programs (contributes to output 5).	• In 2003, produce report on the economics of MAS versus conventional plant breeding.	

Activities	Milestones	Assumptions and risks
11. Evaluate costs and benefits of *Bt* maize for breeding programs and farmers in developing countries (contributes to output 6).	• By 2003, release report on the expected returns to investment in *Bt* maize research.	
12. Identify 1) constraints to sustainable maize productivity in Asian uplands, 2) key policy issues affecting upland maize, and 3) maize research and development options (contributes to output 7).	• By 2003, develop improved understanding of Asian upland maize farming systems and the key policy issues. • By 2003, evaluate country-specific maize R&D options.	
13. Develop and test participatory methods in technology development, monitor and quantify their impact (contributes to output 9).	• By 2002, evaluate the contribution of participatory methods in selection of maize for low moisture and low N conditions.	
14. Gain a better understanding of the competitiveness and sustainability of maize cropping systems in Central America (contributes to output 3).	• By 2002, characterize areas of competitive maize production in at least 4 countries of Central America. • By 2002, identify main policies aimed at improving the competitiveness of maize production in Central America.	

Duration: 2002-2004+
Collaborators: NARSs
IARCs
ARIs
Costs: US$ 0.569M
System linkages: Germplasm improvement (43%)
Sustainable production (17%)
Policy (29%)
Enhancing NARSs (11%)


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