CIMMYT

Project Week 2002

CONTENTS

Project Week Program 1

Global Project Reports 2

Regional Project Reports 3

Frontier Project Reports 4

Notes 5

Project Week

CIMMYT, El Batan, 25 – 26 February, 2002

Detailed Program

MONDAY, 25 FEBRUARY

Auditorium

6:30 – 8:00		Breakfast – Cafeteria
8:00 – 8:30		Desk at Auditorium – Booklets
8:30		Welcome by Professor T.G. Reeves
8:30 – 8:45	G1	Maize and wheat genetic resources: use for humanity (B. Skovmand)
8:45 – 9:00	G2	Improved maize for the world's poor (H. Cordova)
9:00 – 9:15	G3	Improved wheat for the world's poor (M. van Ginkel)
9:15 – 9:30	G4	Maize for sustainable production in stressed environments (M. Banziger)
9:30 – 10:00		Open discussion
10:00 – 10:30		Coffee/tea break – outside Auditorium
10:30 – 10:45	G5	Wheat for sustainable production in marginal environments (W. Pfeiffer)
10:45 – 11:00	G6	Wheat resistant to diseases and pests (R. Singh)
11:00 – 11:15	G7	Impacts of maize and wheat research (M. Morris)
11:15 – 11:30	G8	Building human capital (R. Villareal)
11:30 – 11:45	G9	Conservation tillage and agricultural systems to mitigate poverty and climate change (P. Wall)
11:45 – 12:30		Open discussion
12:30 – 2:00		Lunch
2:00 – 2:15	F1	New wheat science to meet global challenges (M. Reynolds)
2:15 – 2:30	F2	Apomixis: seed security for poor farmers (O. Leblanc)
2:30 – 2:45	F3	Biotechnology for food security (D. Hoisington)
2:45 – 3:15		Open discussion
3:15 – 3:30		Coffee/tea break – outside Auditorium
3:30 – 3:45	F4	Biofortified grain for human health (I. Ortiz-Monasterio)
3:45 – 4:00	F5	Reducing grain losses after harvest (D. Bergvinson)
4:00 – 4:15	F6	Technology assessment for poverty reduction and sustainable resource use (J. Ekboir)
4:15 – 4:45		Open discussion

TUESDAY, 26 FEBRUARY

Auditorium

6:30 – 8:30		Breakfast
8:30 – 8:50	R1	Food and sustainable livelihoods for Sub-Saharan Africa (S. Waddington)
8:50 – 9:10	R2	Maize for poverty alleviation and economic growth in Asia (J. Ransom)
9:10 – 9:30	R3	Sustainable wheat production in South Asia, including rice-wheat systems (P. Hobbs)
9:30 – 10:00		Open discussion
10:00 – 10:30		Coffee/tea break – outside Auditorium
10:30 – 10:50	R4	Food security for West Asia and North Africa (H. Braun)
10:50 – 11:10	R5	Agriculture to sustain livelihoods in Latin America and the Caribbean (G. Sain)
11:10 – 11:30	R6	Restoring food security and economic growth in Central Asia and the Caucasus(A. Morgounov)
11:30 – 12:00		Open discussion
12:30 – 2:00		Lunch
2:00 – 3:15		Introduction, CGIAR change process – (T. Reeves) Highlights of the three (3) challenge programs selected for fast tracking: ▪ Global genetic resources: conservation, management and improvement for food and nutritional security, agrobiodiversity and sustainable livelihoods (T. Reeves) ▪ Water and agriculture (L Harrington) ▪ Biofortified crops to combat micronutrient deficiency (D. Hoisington)
3:15 –3:45		Coffee/tea break – outside Auditorium
3:45 –5:30		Introduction to IP and related issues: International Treaty; MTAs (T. Reeves) ▪ CIMMYT Material Transfer Agreements (L. Harrington) ▪ IP Management Unit (D. Hoisington) ▪ GMOs; transgenic maize in Mexico (P. Pingali)

Global Project 1

Maize and Wheat Genetic Resources: Use for Humanity

Project Coordinator: B. Skovmand

Oversight Director: S. Pandey

Subprogram 3: Wheat Conservation, *ex situ:* B. Skovmand

Subprogram 4: Development of new tools for the characterization and evaluation of genetic resources: M. Warburton

General Information

Many specific activities contribute to our goal of preserving genetic resources and enhancing their value to our research partners. Primary activities are the collection, conservation, and utilization of landraces, wild relatives, and improved lines and populations as future genetic resources both *ex situ* and *in situ*. To develop prebreeding techniques for incorporating diversity in new germplasm, we are using conventional approaches and cytogenetic/molecular procedures. Because information is a critical aspect of this project, we continue to support the exchange of germplasm, information related to germplasm, and appropriate trial technology. Collections of accessions are to be characterized through the development of trait descriptors, including passport data and DNA fingerprinting. Passport data will also be enhanced by drawing upon farmers' extensive knowledge of crops and crop varieties, we will provide breeders with important information on farmers' criteria and priorities. Data on the origin, pedigrees, and characteristics of gene bank accessions will be integrated into electronic databases. Further, methods for evaluating the economic performance of genetic resource conservation and utilization are developed, with an emphasis on comparing alternative collection and conservation strategies.

From the outset, G1 had five subprograms where subprogram one dealt with data management across all programs. In the project meeting in 2001, there was consensus that this did not belong in G1 but rather deserved to be a Frontier Project on its own. Therefore, the subproject was eliminated and G1 now has four sub projects.

Gene bank cost study

A special project to understand the cost of gene bank operations through a joint project with IFPRI (supported by the SGRP) and to compare the costs of maize and wheat conservation, was completed. The study was published in the July-August 2001 volume of Crop Science. A monograph titled "Saving Seeds: The Economics of Conserving Crop Genetic Resources Ex Situ (B. Koo *et al.*), comparing the different costs of center collections has been prepared and a 2002 publication is expected.

Data Quality

A project was carried out to improve data quality in both the maize and wheat collections in collaboration with SINGER. As a result of this project, further accessions were designated under the FAO/CIMMYT in-trust agreement. Consequently, 20,411 maize and 95,113 wheat accessions have now been designated under this agreement.

Four workshops were held during the year, one with each of the subprograms as follows: June: Russian wheat aphid evaluation and prebreeding activities; August: Maize regeneration, characterization and prebreeding; November: Oaxacan farmer participatory program and January: Fingerprinting and other molecular techniques for genetic resources evaluation.

Subprogram 1: Dynamics of diversity on farm: Conserving and utilizing genetic diversity: M. Bellon

Improved 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.

Organized the workshop "Quantitative Analysis of Data from Participatory Methods in Plant Breeding" in Giessen, Germany, November 2001. A report was prepared and submitted to the PRGA. This workshop dealt with methods to link breeders and farmers for breeding and conservation.

Published a manual which presents methods to elicit farmers' knowledge of crop varieties, breeding criteria and constraints:

Paper currently under review that reports on the methods used to select subsets of landraces for on-farm conservation.

Developed 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.

Conducted Rapid Rural Assessments with farmer groups in 40 villages and Participatory Rural Appraisals in 10 villages in the Chinese provinces of Shanxi, Shaanxi, Sichuan, and Guangxi under an IFAD project entitled "Intensification of Upland Maize in Asia." Special attention was focused on local production practices for and utilization of maize as well as on constraints experienced by farmers in maize production, consumption, and marketing. Information on the role of maize in the context of other household activities was also collected. Data are being analyzed and will be used in workshop for priority setting for maize breeding and research to be held in China in March 2002.

Conducted Rapid Rural Assessments with farmer groups in 60 villages and Participatory Rural Appraisals in 20 villages covering all regions of Azerbaijan (with exception of disputed territory). Data collection was not limited to a particular crop; information on production and consumption constraints for all crops relevant to the region was collected. Data were used in a national priority setting workshop to determine the research agenda for the country's new Competitive Grant Scheme.

Ongoing research on wheat variety use and diversity using survey data and experimental trial results of seed collected from Chinese households in the Chinese provinces of Shandong, Shanxi, and Gansu.

Ongoing research on household variety choice and incentives for the *in situ* conservation of Turkish landraces using survey data collected across six provinces area of Turkey.

Work in progress on an edited volume of research results from the ACIAR project on wheat diversity in China and Australia.

Developed methods to assess the feasibility of *in situ* conservation strategies and the implications of policy alternatives for farmer's behavior.

Continue the implementation of the Oaxaca project. This included the monitoring of the sample of farmers that participated in the project interventions (seed sales, training, testing of silos) during 1999 and 2000.

Several papers and presentations on the Oaxaca project were done.

Explored possible economic incentives for conservation of genetic diversity on the farm.

Continue the implementation of the project "CG Maize Diversity Conservation: A Farmer-Scientist Collaborative Approach, Phase II" (Oaxaca project). This included the monitoring of sample of farmers that participated in the project interventions (seed sales, training, testing of silos) during 1999 and 2000.

Several papers currently in press or under review on this topic that synthesize our experiences.

Assessed morphological and genetic changes of improved maize varieties and landraces under farmer management.

A very limited structure read from molecular neutral markers (SSR, cpSSR); more structure from genes under selection (sh2; rp1). This can be seen as the result of a strong migration between the various landraces (farmers'seed lots). Therefore these various landraces constitute a metapopulation.

A strong structure is detected from agromorphological traits (flowering and ear traits). This is the result of the selection by farmers (which they mainly apply on these traits).

A strong mutation load has been detected in these landraces. It is under test for other landraces (Palomero toluqueno, Cacahuacintle, Tuxpeno) outside of the Oaxaca area.

Made presentations looking into the potential impacts of the introduction of GM maize into maize landraces in relation to farmer management:

Developed a GIS for Oaxaca and Chiapas to assess the distribution of Tuxpeño germplasm in relationship to poverty (Martínez, E. and J. White). This is the basis of a current project looking at the morphological and genetic changes that farmer management generates on improved maize varieties.

Analyzed the structure and function of farmers' social networks in relation to seed flows.

Continue the implementation of the project: "Collective Action for the Conservation of On-Farm Genetic Diversity in a Center of Crop Diversity: An Assessment of the Role of Traditional Farmers' Networks." This included a series of semi-structured interviews and focus group discussion. A manuscript was produced reporting on the first findings of the project.

Subprogram 2: Maize Conservation, *ex situ:* S. Taba

Germplasm introduction and distribution:

We now hold a total of 22,314 accessions in which 20,411 accessions are designated germplasm or FAO in-trust maize germplasm. During 2001 we introduced 1237 landrace accessions under the USDA-CIMMYT Latin American maize regeneration project. The regeneration project with Latin American cooperators has resulted in a total of 9,324 new CIMMYT maize germplasm accessions since the onset of the project.

In 2001 we distributed a total of 4608 samples in 89 seed shipments.

In-situ conservation of Mexican maize races: Zapalote Chico

A total of 81 accessions of Zapalote Chico were evaluated by Mexican cooperators at four sites including *in-situ* site of the race, Istmo de Tehuantepec, Oaxaca during 2000. A race core (16 accessions from 6 clusters) was developed from the evaluation data. Phenotypic diversity was calculated using multivariate cluster analysis . The race is cultivated for totopo production and important to the local economy. It is a good example of a Mexican maize land race that needs on-farm conservation. Best 10 accessions are selected for enhancement of quality and yield potential. The race has been used as sources of early maturity and earworm resistance in Pool 15 and 16. Pool 15 and 16 will be used as donor sources to improve yield potential of the race core. The race core was planted at the Tlaltizapan station for improvement in 2001.

Characterization of Germplasm Accessions

1. Brazilian race "Dentado"

In TL 2001A, the Brazilian race classified as 'Dentado" from the CIMMYT maize bank database was evaluated. These accessions originated in the central states of Brazil where southern US maize germplasm was introduced in 19th century. Most of them have mixed with the local race Cateto, creating the germplasm complex of US southern dent x Cateto. A few accessions remained without much of the introgression. Only a few white germplasm accessions appeared. The multivariate cluster analysis showed six non-overlapping clusters. A core subset (47 accessions) of the race is developed for making breeding crosses in 2002A for subtropical gene pools. Cluster C includes a race type like Cravo and Lenha, having large kernel row numbers.

2. NIR analysis on protein, oil, and starch

Bulked seed samples of breeding crosses that were grown in 2000 were sent to the US-GEM laboratory for the measurements of protein, oil, and starch contents expressed in % dry matter. In general, breeding crosses with CML323 increased protein contents more than with CML 327. CML 327 tends to increase starch contents in the breeding crosses. The other breeding crosses (332 in total) were highland core subsets crossed with CML349 and CML 244. In general CML 349 increased protein level in the breeding crosses as compared with CML 244. A fewer breeding crosses of highland core subsets had high protein contents. Variations in protein, oil, and starch contents seemed similar in both subtropical and highland core subsets. However, subtropical core had more numbers of breeding crosses with high protein and oil contents than highland core. The grain quality traits of the core subsets can be exploited in breeding for the value-added traits. The results are added to the bank evaluation database.

Prebreeding of CIMMYT gene pools

Development and improvement of CIMMYT gene pools (working collections) in prebreeding started in 1999 by characterizing on-going gene pools for phenotypic diversity among the

families. In 2001 some of tropical (12) and subtropical pools (8) had the testcross evaluation of S2 with inbred testers. Results are being summarized and partial results are reported in GP2. For highland gene pools (12 pools) we made the first intercrosses to form the respective gene pools among the selected breeding crosses in 2000. In 2002 we will make S1 progenies in the highland pools.

Tropical breeding crosses of the bank core subsets with CML elite lines were advanced to S2 during 2001. They will be testcrossed with elite tester lines and the testcrosses will be evaluated in 2002. Subtropical breeding crosses are being advanced to S2 during 2002.

Subprogram 3: Wheat Conservation, *ex situ:* B. Skovmand

Germplasm Introduction and Distribution:

During the year, 87 accessions were received from other countries. A number of these had been identified as having resistance to biotic stresses such as tan spot and Helminthsporium leaf blight, Russian wheat aphid, and to abiotic stresses such as drought and sprouting. 17,424 accessions were sent to users from 67 programs around the world.

Evaluation and prebreeding

Multiple ovary trait. The selection of 702 F4s from six crosses planted in the summer at El Batan and mainly selected for plant type since leaf rust development, resulted in, after seed grading, 1,385 F5 is which were selected, planted and screened for leaf rust reaction in 2000-01. Many F5s were susceptible to both leaf rust and stem rust and only about 120 were selected and planted in the summer at El Batan for further screening.

A small set of paired lines from the crosses were selected and yield tested in Cd. Obregon. It appeared that the lines demonstrating the multi overate trait were lower yielding than their paired lines by about ten percent. Some of the materials have been selected and further crossed with wheat genetic resources with desirable spike architecture.

For the molecular work and genetics, we worked only with the cross combination Pastor X Multioverata parent. Based on segregation in two locations, it appears that there is environmental influence on trait expression, and that some sterility is also associated. Segregation indicates that two genes probably control the multioverate trait, one major and another minor.

Transgenic ability of Bobwhite sisters. Of 129 wheat sister lines evaluated for transformation efficiency, eight had a transformation ability above 60% (60 independent transgenic events for 100 immature embryos bombarded). We studied agronomic characteristics (such as earliness) of the eight genotypes identified to identify the most adaptable lines for different lab conditions. The line CMB-Bobwhite S26 has been selected as the most useful transgenic sisterline.

Rust resistance evaluation. In 2001, two new rust races came into existence that caused serious problems in the durum wheat crop and in triticale. A new leaf rust race that attacked the main durum wheat cultivar, Altar 84, in Sonora, Mexico was identified in April 2001. Also a new race of stripe rust which attacked the main new candidates for cultivar release of triticale in Ecuador and Mexico was identified in the summer of 2001.

In the case of durum wheat, nothing was known about the reaction of the breeding material so a large collection (about 4500 accessions) of older breeding lines from International nurseries and landraces stored in the gene bank were prepared and planted in El Batan, Mexico during the summer cycle 2001. Almost 1500 or a third of the accessions displayed various levels of

slow rusting (minor gene) or hypersensitive (major gene) resistance to the new race of leaf rust in artificially inoculated field plots.

In the case of triticale, the genetic resources program had discussed with the triticale program how to add genetic variability to triticale and collectively we had planted a collection of about 1300 primary triticales. Primary triticales are the original triticales derived directly from a cross between durum or bread wheat and rye and the chromosomes then doubled by colchicine treatment. These primary triticales are an underutilized resource as they are difficult to use in crop improvement work and in a sense they can be equated to landraces in durum and bread wheat. These triticale accessions were inoculated with the newly identified stripe rust race which is specific to triticale and more than 300 accessions were identified as resistant.
Russian wheat resistance: Pre-breeding for RWA resistance (Pastor, Weebill); A set of RWA resistant parents was identified from the winter trial in El Batan. It includes: 5 Iranian landraces (IWA 8609292, IWA 8608646, IWA 8611394, IWA8600183, IWA8611131) showing high resistance, lower level of natural BYDV infection, and spring habits. They came from different regions in Iran. Two lines (MTRWA92.91/CHOIX, MTRWA92.121//MILAN/SHA7) from PCME4DN showing RWA resistance combined with drought tolerance and leaf rust resistance. One of them presented some tolerance to BYDV. Two Turkish landrace derivatives, also highly tolerant to BYDV; 84TK520.001.01//VEE#5.3/TRAP#1and 84TK523.006.02//VEE#5.3/TRAP#1 were identified.

These germplasm were crossed to PASTOR/OPATA and WEEBILL 1. In order to combine sources of RWA resistance, the Iranian landraces was also crossed to MTRWA92.91/CHOIX, MTRWA92.121//MILAN/SHA7.

Wide crosses. The Wheat Wide Crosses program has continued to utilize Triticeae genetic resources for wheat improvement by producing genetic stocks for incorporation in a pre-breeding program. The three wheat genomes A, B, and D, possess diploid progenitors (2n=2x=14) that have been combined with elite durum cultivars to produce hexaploid germplasm genomically represented as AAAABB, AABBBB, and AABBDD. Their current number stands at 194, 55, and 800, respectively. Germplasm from AAAABB stocks has been identified to be resistant to *Helminthosporium sativum*, *Septoria tritici*, and *Fusarium graminearum*. The AABBBB stocks have only been seed-increased and tested for *S. tritici,* for which diversity is available.

The AABBDD stocks (synthetic hexaploids or SH), the most advanced lines in our testing program, have provided diversity for resistance to several stresses. A second set of elite synthetics was prepared in 2000. After various screenings, the set will include entries with multiple disease resistance and tolerance to some abiotic stresses. Pre-breeding activities utilizing resistant synthetics of the D genome in crosses with elite bread wheats have provided advanced free-threshing derivatives with superior stress resistance.

Efforts to develop novel genetic stocks have focused on gene pyramiding to facilitate the incorporation of multiple genes in a conventional breeding program. The areas involve: crosses between two resistant SH wheats, selecting F2 plants showing better resistance than either parent, and using doubled haploidy to stabilize the selections.

Develop new tetraploid wheats (2n=4x(AADD) from resistant A- and D-genome diploid species; pyramid across genome genes to enhance the efficiency of multiple transfers to wheat.

Other significant outputs of the Wide Crosses program have led to new resources being identified for salinity tolerance, drought tolerance, and scab resistance.

Utilization of *Aegilops geniculata* genetic resources for wheat improvement

General objective: To create novel wheat germplasm with new resistance traits coming from the wild wheat relative *Aegilops geniculata.* Specific objectives: To transfer *Ae. geniculata* resistance traits for BYDV and nematodes into wheat and to identify molecular markers for detecting the introgressed alien material into cultivated wheat (microsatellites)

Triticum/Ae. geniculata hybrid, amphiploid and BC production

Promising *Aegilops geniculata* accessions possessing resistance traits to barley yellow dwarf virus (BYDV) and cereal cyst nematode (CCN) were identified and crossed with susceptible high-yielding bread (Prinia and Baviacora) and durum wheat cultivars (Kucuk and Sooty9/Rascon37), as well as with Chinese Spring (*ph*) using conventional protocols. From 636 F1 florets pollinated 170 seeds were obtained (27% crossability rate), 161 embryos rescued, and 100 plants are actually available (62% plant regeneration). They represent 28 *Triticum/Aegilops/Triticum* combinations. BC1 plants with a complete chromosome set (2n=8x=56, AABBDDMU and 2n=6x=42, AABBMU) were crossed with bread or durum wheat parent or selfed. The seeds obtained will be evaluated directly for their resistance to different stresses and used for advancing the desired combination for applied purposes via addition/substitution lines.

"ph Strategy"

A crossing program is also underway to hybridize Chinese Spring (*phph*) with *Ae. geniculata* accessions to promote homoeologous chromosome pairing. This strategy facilitates transfer of traits of interest into wheat by recombination. The *ph* genetic stock of Chinese Spring is also used as a backcross parent for the F1 with *Ph* locus. This yields *Phph* heterozygote progeny from which *ph* homozygous derivatives are to be identified and are expected to progress alien introgressions.

Translocation project. A translocation project to transfer agronomically interesting traits from alien materials into a CIMMYT background has been initiated. Although many wheat alien translocation lines have been produced, few have made significant contributions to wheat improvement. The purpose of this project is to collect and transfer alien genes that have not been used extensively in the past. A number of disease resistance, aphid resistance, and yield-related genes of wild relatives of common wheat were obtained from different sources (KSU, Lukaszewski, etc.). Crosses between 20 widely-grown CIMMYT lines and the translocations will be made during the spring of 2001. Once the translocation is stabilized in a CIMMYT background, the pre-bred material will be made available to breeders.

Subprogram 4: Development of new tools for the characterization and evaluation of genetic resources: M. Warburton

Efficient management of genetic diversity in wheat. For the past year, we have been working to set up large-scale fingerprinting techniques for wheat germplasm. Although an AFLP method is being used in the lab, we would like to switch to SSRs, which (unlike our AFLPs) are mapped; therefore information on which genomic region is being characterized is available. Publically available SSRs have required some work on data interpretation, as they are dinucleotide repeats that may be hard to differentiate. Development of trinucleotide SSRs from ESTs was tested but discarded as an inefficient use of our resources, as the gain from this project was extremely slow. Methods for rapid DNA extraction, PCR amplification, and gel electrophoresis have been

worked out, and we currently have 17 SSR primers working well. A further 67 will be optimized during the year 2001 in order to have two per chromosome arm.

Molecular characterization of *Ae. geniculata* and *Triticum* accessions used in the crosses by microsatellite analysis was initiated. The first step consists of finding species/genome specific molecular markers. Twenty-eight wheat microsatellites (WMS) located on wheat chromosomes 1D to7 D were tested until now. Five of them were able to detect specific markers for *Ae. geniculata*: WMS 903 (1D), WMS 455 (2D), WMS 161 (3D), WMS 205 (5D), WMS 37 (7D). Their use for detecting the introgressed material will be later examined in *Triticum/Ae. geniculata* progenies.

Data storage and manipulation tools have been developed to allow efficient access to the large amounts of data this project is expected to develop. Data analysis tools are being worked on with collaborators at the University of Hohenheim. A wheat fingerprinting service based on AFLPs is currently available to all CIMMYT scientists, and will be changed to SSRs by the end of the year. Visiting scientists and two PhD students associated with this project are being trained on the use of markers for genetic characterization of wheat and the analysis of this data. *Managing maize genetic diversity with DNA markers.* The optimization large-scale fingerprinting of maize germplasm has been underway for two years. Eighty-five SSR markers that span the entire genome of maize are available and can be amplified and electrophoresed in very efficient multiplexed conditions. Rapid DNA extraction is also available. The amplification of many lines in one reaction is nearly optimized, and will, by the end of 2001, allow us to characterize maize populations many times more efficiently than is currently possible. Data storage and manipulation tools have been developed that will allow efficient access to the large amounts of data this project is currently developing. Data analysis tools are being worked on with our collaborators at the University of Hohenheim. A maize fingerprinting service based on SSRs is currently available to all CIMMYT scientists. All CIMMYT maize lines (CMLs) should be fingerprinted by the end of the year, as well as many populations and races. Data will be available in the International Crop Information Systems (ICIS) database. Visiting scientists are being trained on the use of markers for genetic characterization of maize and the analysis of this data.

Statistical methods for combining genetic markers and phenotypic data for classifying genotypes were developed. This is a break-through in the sense that it is the first time (that we know of) a integrated statistical approach to combine molecular and phenotypic data has been developed. Developing statistical methods for classifying genetic resources based only on molecular marker was initiated.

Develop reliable, efficient screening technique to test for the presence of transgenes in genebank materials. New techniques were developed and utilized to determine if transgenic maize in the maize collection

Aphid research. To determine the type of resistance mechanisms in Russian wheat aphid (*Diuraphis noxia*) resistant synthetic hexaploid wheat, testing for resistance mechanisms will be started in the spring of 2001. Plants will be selected based on greenhouse and/or field screenings to be tested for antibiosis, antixenosis, and tolerance. Further work will involve setting up reliable screening techniques of seedling and/or adult plants.

Publications by GP1 staff in 2001

Badstue, L., M. R. Bellon, X. Juárez, I. Manuel Rosas and A. M. Solano. Social Relations & Seed Transactions: Small-Scale Farmers´ Access to Maize Landraces in the Central Valleys of

Oaxaca. – Preliminary Findings. Draft. Paper to be presented at the Collective Action Workshop. Aberdere, Kenya February 25-March 1, 2002.

Bellon, M. R. Conceptualizing interventions to support on-farm genetic resource conservation. Submitted to *Economic Botany*.

Bellon, M. R. In situ conservation of maize diversity and gene flow in Mexico. Presented at the OECD Conference on LMOs and the Environment. Raleigh, North Carolina, USA, November 28-30, 2001.

Bellon, M. R. 2001. Participatory Research Methods for Technology Evaluation: A Manual for Scientists Working with Farmers. Mexico, D.F.: CIMMYT.

Bellon, M. R. Analysis of demand of crop characteristics by wealth and gender. Presented at the Workshop "Quantitative Analysis of Data from Participatory Methods in Plant Breeding." Justus Liebig University, Giessen, Germany, August, 23-25, 2001.

Bellon, M. R. Helping farmers to maintain crop infraspecific diversity on farm: can it be done and how? Presented at the Strategy Session of the McKnight Foundation Collaborative Crop Research Program (CCRP). Amsterdam, The Netherlands, December 3-4, 2001.

Bellon, M. R. J. A. Aguirre Gómez, M. Smale, J. Berthaud, I. Manuel Rosas, A. M. Solano y R. Martínez. Participatory maize improvement: Comparing different interventions to enhance farmers' welfare and maintain genetic diversity in the Central Valleys of Oaxaca. Presented at the workshop "In situ conservation of agrobiodiversity review workshop: Scientific and institutional experiences and implications for national policies." Lima, Peru, August 14-18, 2001.

Bellon, M. R., J. A. Aguirre Gómez, M. Smale, J. Berthaud, I. Manuel Rosas, A. M. Solano y R. Martínez. 2001. Intervenciones participativas para la conservación del maíz en finca en los Valles Centrales de Oaxaca, México. Pages 1-7. In D. Danial (Ed.), Memorias de la Conferencia Internacional sobre Futuras Estrategias para Implementar Mejoramiento Participativo en los Cultivos de las Zonas Altas de la Región Andina. PREDUZA, Quito, Ecuador.

Bellon, M. R. and J. Berthaud. Posibles Implicaciones de las Prácticas Campesinas de Manejo sobre la Difusión de Transgenes. Presented at the meeting "Impacto de la introducción de maices transgénicos en la diversidad y ecología del Maíz y ecosistemas asociados en México." Cuernavaca, Mexico July 13-14, 2001.

Bellon, M. R., J. Berthaud, M. Smale, J. A. Aguirre, S. Taba, F. Aragón, J. Díaz and H. Castro. Participatory Landrace Selection for On Farm Conservation: An Example from the Central Valleys of Oaxaca, Mexico. Submitted to *Genetic Resources and Crop Evolution*.

Crossa, J., M. Bellon and J. Franco. A quantitative method for classifying farmers using socio-economic variables. Presented at the workshop "Quantitative Analysis of Data from Participatory Methods in Plant Breeding." Justus Liebig University, Giessen, Germany, August, 23-25, 2001.

DeLacy, I. H., B. Skovmand and J. Huerta. 2000. Characterization of Mexican landraces using agronomically useful attributes. Genetic Resources and Crop Evolution 47:591-602.

Delgado, R., S. Cano, A. Cortes, and A. Mujeeb-Kazi. 2001. Durum wheat/A and B genome amphiploids (2n=6x=42). Agronomy Abstracts. American Society of Agronomy. CD ROM

Gollin, D., M. Smale and B. Skovmand. 2000. Searching an *Ex Situ* Collection of Wheat Genetic Resources. The American Journal of Agricultural Economics 82:812-827.

Gollin, D., M. Smale and B. Skovmand. 2002. Searching an *Ex Situ* Collection of Wheat Genetic Resources. In, S. Polasky (Ed.), Economics and Biodiversity Conservation.

Hede, A. R., B. Skovmand and J. Lopez-Cesati. Acid soils and aluminum tolerance. 2001. In, Eds. Reynolds, M. P., J. I. Ortiz-Monasterio and A. McNab. Application of Physiology in Wheat Breeding. Pp172-182. Mexico D. F.: CIMMYT.

Hede, A. R., B. Skovmand, J.-M. Ribaut, D. Gonzalez-de-Leon, and O. Stoelen. 2002. Evaluation of Aluminum tolerance in a spring rye collection using two different hydroponic screening techniques. Accepted to Journal of Plant Breeding.

Huerta Espino, J. and B. Skovmand. 2000. Origin, botanica, y taxonomia del trigo. 2000. Eds. H. E. Villasenor Mir and E. Espitia Rangel. 2000. El Trigo de temporal en Mexico. Libro Technoco Num 1, Chapter 2, pp25-238.

Huerta Espino, J. and B. Skovmand. 2000. Origin, botanica, y taxonomia. Eds. Solis Moya y A. Rodriguez Guillien. Trigo de riego: origin, variadades, manejo del cultivo, calidad industrial. Libro TecnicNo. 2, Chapter 2pp8-14.

Lage, J, Skovmand, B., and Andersen S. B. 2001. Field evaluation of Russian wheat aphid (Homoptera: Aphididae) resistance in *Triticum dicoccum* derived synthetic hexaploid wheats. ESA 2001 Annual meeting, Poster.

Lage, J, Skovmand, B., and Andersen S. B. 2001. Resistance and resistance mechanisms in synthetic hexaploid wheats to Greenbugs (Homeptera: Aphididae. ESA 2001 Annual meeting, Poster.

Lage, J., M. Warburton, B. Skovmand, A. Mujeeb-Kazi and S. B. Andersen. 2001. AFLP diversity in a group of *Triticum dicoccum* derived synthetic hexaploid wheats. Poster, ASA-CSSA-SSSA Annual meeting Abstracts, Charlotte, NC, 2001.

Maes, B,. R.M. Trethowan, M. P. Reynolds, M. van Ginkel, and B. Skovmand. 2001. The influence of glume pubescence on spikelet temperature of wheat under freezing conditions. Australian Journal of Plant Physiology, 28:141-148.

Maes, B,. R.M. Trethowan, M. P. Reynolds, M. van Ginkel, and B. Skovmand. 2001. Glume pubescense and its influence on spikelet temperature of wheat undet freezing conditions. In, Eds. Bedo, Z., and L. Lang, Wheat in a Global Environment. Kluwer Academic Publishers, the Netherlands. Pp463-470.

Mujeeb-Kazi A, William MDHM, Villareal RL, Cortes A, Rosas V,.and Delgado, R. 2001. Registration of 10 isogenic chromosome 1B and 10 T1BL.1RS chromosome translocation bread wheat germplasms.Crop Science. 41:280-281.

Mujeeb-Kazi A, Cortes A, Rosas V, Cano S, and Delgado R. 2001. Registration of 17 isogenic chromosome 1B and 17 T1BL.1RS chromosome translocation bread wheat germplasms. Crop Science. 41:596-597.

Mujeeb-Kazi, A., A. Cortés, R. Delgado, and V. Rosas. 2001. Cytogenetics of bread wheat/ *Thinopyrum bessarabicum* derivatives based upon *Ph* and *ph* influence. Agronomy Abstracts. American Society of Agronomy. CD ROM

Mujeeb-Kazi A, Cortes A, Rosas V, Cano S, and Delgado R. 2001. Registration of six isogenic T1BL.1RS chromosome translocation and six chromosome 1B durum germplasms. Crop Science. 41:595-596.

Mujeeb-Kazi, A., Fuentes-Davila G, Villareal RL, Cortes A, Rosas V, and Delgado R. 2001. Registration of 10 synthetic hexaploid wheat and six bread wheat germplasms resistant to karnal bunt. Crop Science 41:1652-1653.

Mujeeb-Kazi A, Cano S, Rosas V, Cortes A, and Delgado R. 2001. Registration of five synthetic hexaploid wheat and seven bread wheat germplasm lines resistant to wheat spot blotch. Crop Science 41:1653-1654.

Mujeeb-Kazi, A., R. Villareal. 2001. Wheat: An adaptive, descriptive and futuristic treatment. Book Chapter, Chopra, V.L.(ed.) (In press)

Mujeeb-Kazi A, Cortes A, Rosas V, Delgado R, Shafiq FA, and Vahidy AA. 2001. Three new monosomic chromosome 5B genetic stocks of *Triticum aestivum* L. cultivars. Cereal Res. Commun. 29:49-55.

Payne, T., B. Skovmand, E. Brandon, C. Lopez, J. C. Alarcon, V. Vicarte, J. Norgaard and M. Flores. 2002. International Wheat Information System, Version 4, 2001. On CD-Rom. Mexico, D. F.: CIMMYT

Pardey, P. G., Bonwoo Koo, B. D. Wright, M. E.Van Dusen, B. Skovmand, and S. Taba. 2001. Costing the Conservation of Genetic Resources: CIMMYT's *ex situ* maize and wheat Collection. Crop Science, 41:1286-1299.

Pardey, P. G., B. Koo, E. van Dusen, B. Skovmand, S. Taba, and B. D. Wright. 2002. CIMMYT Gene Bank. In Eds. B. Koo, P. G. Pardey and B. D. Wright. Saving Seeds: The Economics of conserving crop genetic resources *ex situ*. IFPRI publication. In press.

Pellegrineschi A., L. M. Noguera, S. McLean, B. Skovmand, R. M. Brito, L. Velazquez, R. Hernandez, M. Warburton, and D. Hoisington. 2001. Identification of a highly transformable 'Bobwhite' siblings for mass production of fertile transgenic plants. Poster, Kronstad Symposium, Cd. Obregon, March 15-17,2001.

Pellegrineschi A., L. M. Noguera, S. McLean, B. Skovmand, R. M. Brito, L. Velazquez, R. Hernandez, M. Warburton, and D. Hoisington. 2001. Identification of a highly transformable wheat genotype for mass production of fertile transgenic plants. Genome (in press).

Pfluger, L.A. R.D'Ovidio, B. Margiotta, R. Peña, A. Mujeeb-Kazi, D. Lafiandra. 2001. Characterisation of high- and low-molecular weight glutenin subunits associated to the D genome of *Aegilops tauschii* in a collection of synthetic hexaploid wheats. Theor. Appl. Genet. 103:1293-1301.

Reif, J.C., A. E. Melchinger, X. C. Xia, M. L. Warburton, D. A. Hoisington, S. K. Vasal, M. Bohn, and M. Frisch. 2002. Genetic diversity within and between seven tropical maize populations investigated with SSR markters and related to the heterosis of their crosses. Crop Sci (in review).

Reynolds, M., B. Skovmand, R. Trethowan, R. Singh, and M. van Ginkel. 2001. Applying Physiological Strategies to Wheat Breeding. Research Highlights of the CIMMYT Wheat Program, 1999-2000. Mexico D. F. Pp49-56.

Reynolds, M, B. Skovmand, R. Singh, and M. van Ginkel. 2001. Applying Physiological Strategies to Increase the Efficiency of Wheat Breeding. In Proceedingss of the CIMMYT/INIA workshop on yield potential. In M.M. Kohli, (Ed.) INIA, La Estanzuela, Colonia, 25-29 September, 2000, Uruguay.

Skovmand, B., M. Mackay, C. G. Lopez, J. C. Alarcon and G. Grimes. 2001. GRIP III: Genetic resources package for Triticum and related species. On CD-Rom, Mexico D. F.: CIMMYT.

Skovmand, B., S. Rajaram, J. M. Ribaut, and A. R. Hede. 1998. Wheat Genetic Resources: The Foundation Germplasm for the Twenty-first Century. FAO publication chapter. In Curtis,

B.C. ed. Wheat production and improvement. FAO Plant Production and Protection Series (forthcoming).

Skovmand, B., M. P. Reynolds and M. Henry. 2001. Exploring genetic resources collection for marginal areas. In Proceedingss of the CIMMYT/INIA workshop on yield potential. In M.M. Kohli, (Ed.) INIA, La Estanzuela, Colonia, 25-29 September, 2000. Uruguay.

Skovmand, B. 2001. Wheat Cultivar Abbreviations: 1999-2000 additions. Annual Wheat newsletter 47:329-332.

Skovmand, B., M. Henry and C. O. Qualset. 2001. Field evaluation of a large Iranian landrace collection for reaction to Russian wheat aphid. Poster, Kronstad Symposium, March 15-17, 2000.

Skovmand, B., S. Rajaram, A. Pellegrineschi, and A. Mujeeb-Kazi. 2001. Identification of Highly Transformable Bobwhite Sister Lines. Annual Wheat newsletter 47:96-97.

Skovmand, B. and M. P. Reynolds. 2001. Increasing yield potential for marginal areas by exploring genetic resources collections. In CIMMYT. 2000. The 11th Regional Wheat Workshop for Eastern, Central, and Southern Africa. D. Addis Ababa, Ethiopia: CIMMYT.

Skovmand, B., M. Reynolds and I. H. DeLacy. 2001. Searching genetic resourcesa for physiological traits with potential for increasing yield. In, Eds. Reynolds, M. P., J. I. Ortiz-Monasterio and A. McNab. Application of Physiology in Wheat Breeding. Pp17-28. Mexico D. F.: CIMMYT.

Skovmand, B., Matthew Reynolds and I. H. DeLacy. 2001. Mining Wheat Germplasm Collections for Yield Enhancing Traits. Euphytica, 119:25-32.

Skovmand, B., Matthew Reynolds and I. H. DeLacy. 2000. Mining Wheat Germplasm Collections for Yield Enhancing Traits. In, Eds. Bedo, Z., and L. Lang, Wheat in a Global Environment. Kluwer Academic Publishers, the Netherlands. Pp761-771.

Smale, M., M. R. Bellon, A. Aguirre, I. Manuel, J. Mendoza, A. M. Solano, R. Martínez and A. Ramírez. The Economic Costs and Benefits of a Participatory Project to Conserve Maize Landraces on Farms: A Case Study in the Central Valleys of Oaxaca, Mexico. Draft. Paper to be presented at the International Conference on Impacts of Agricultural Research and Development. San José Costa Rica, February 4-7.

Smale, M., M. R. Bellon, and A. Aguirre. 2001. Maize diversity, variety attributes and farmers' choices in southeastern Guanajuato, Mexico. *Economic Development and Cultural Change.* In press.

Smale, M., M. R. Bellon, D. Jarvis, and B. Shtapit. Economic concepts for designing policies to conserve crop genetic resources on farms. Submitted to *Genetic Resources and Crop Evolution.*

Smale, M., M. Reynolds, M. Warburton, B. Skovmand, R. Trethowan, R. P. Singh, I. Ortiz-Monestario, J. Crossa, M. Khairallah and M. Almanza-Pinzon. 2001. Dimensions of Diversity in CIMMYT Bread Wheat Program from 1965 to 2000. Mexico, D. F.: CIMMYT.

Smale, M., M. Reynolds, M. Warburton, B. Skovmand, R. Trethowan, R. P. Singh, I. Ortiz-Monestario, J. Crossa, M. Khairallah and M. Almanza-Pinzon. 2001. Dimensions of Diversity in CIMMYT Bread Wheat Program from 1965 to 2000. Crop Science in press

Taba, S., F. Aragon, and S. Ramirez. 2001. Continued use of maize landrace cultivars in some parts of Mexico. ASA symposium. Oct. 24. 2001.

Warburton, M., B. Skovmand and A. Mujeb-Kazi. 2002. The molecular genetic characterization of the 'Bobwhite' bread wheat family using AFLPs and the effect of the T1BL.1RS translocation. TAG (In press).

Warburton, M. L., X. Xianchun, J. Crossa, J. Franco, A. E. Melchinger, M. Frisch, M. Bohn, and D. Hoisington. 2002. Genetic characterization of CIMMYT inbred maize lines and open pollinated populations using large scale fingerprinting methods. Crop Science (accepted for publication).

Warburton, Marilyn, X. Xianchun, Salvador Ambriz, Leticia Diaz, Emiliano Villordo, and David Hoisington. 2001. Use of Molecular Markers in Maize Diversity Studies at CIMMYT. 7th Eastern and Southern Africa Regional Maize Conference and Symposium on Low-Nitrogen and Drought Tolerance in Maize Nairobi, Kenya

Xia Xianchun, Marilyn Warburton, and Dave Hoisington. 2001. Analysis of Genetic Diversity of CIMMYT Maize Inbred Lines Using SSR Markers. International Conference on Agricultural Science and Technology, Beijing, November 7-9, 2001. Promoting Global Innovation of Agricultural Science & Technology and Sustainable Agriculture Development, Session 4:Agri-biotechnology. p329.

Xia XC, M. Warburton, M. Bohn, M. Frisch, A.E. Melchinger and D. Hoisington. 2000. Optimizing automated fingerprinting of maize germplasm using SSR markers. 3rd International Crop Science Congress, August 17-22, 2000, Hamburg, Germany. Book of Abstracts: p 226

Global Project 2

Improved Maize for the World's Poor

Project Coordinator: **H. Córdova**

Project Oversight Director: **S. Pandey**

G2 is a network of maize scientists who provide high-yielding, input-efficient, stress tolerant germplasm and information to enhance the productivity and sustainability of maize-based farming systems in developing countries.

Project Objectives

- To increase maize productivity in maize farming systems in developing countries through improved cultivars. This includes developing and distributing high-yielding, input-efficient, and stress-tolerant gene pools, populations, inbred lines, OPVs, and hybrids that are both broadly adapted and suitable for specific ecologies.
- To facilitate the global exchange of maize germplasm, with scientific information that fosters its efficient use to develop superior cultivars.
- To identify and use efficient techniques to develop high-yielding, input-efficient, stress-tolerant, and widely adapted maize cultivars, as well as prioritizing maize germplasm and research needs.

Significant achievements for subprojects

Subproject 1 (Prebreeding)

Prebreeding and germplasm bank activities were intensified to produce new sources or germplasm for prebreeding activities, to enhance existing pools and populations, and to create new ones. This outputs will eventually be used in population improvement in the tropical and subtropical maize subprograms.

Tropical Pool 24 C32 TLWD: S_2 lines were crossed to tester CL-03214 from heterotic group "B". Two hundred forty S_2 testcrosses and 16 checks constituting the trial were evaluated in a 16 x 16 alpha lattice design with 2 replications at Agua Fría in cycle 2001 B. The trial had a mean yield of 7.6 t/ha and the best check (CL-02198 "A" x CL-03214 "B") yielded 7.0 t/ha (Table 4). Many testcrosses significantly outperformed the checks. Ear height was a major concern as most testcrosses were very tall. Selection pressure was put on the selected S_2 lines to reduce ear height. Ninety-eight S_2 lines were selected for recombination to form a new cycle of Pool 24. Data on the same trial at TL01B is being summarized.

Tropical Pool 25 C31 TLYF: S_2 lines were crossed to tester CL-02450 from heterotic group "A". Two hundred six S_2 testcrosses and 4 checks were evaluated in a 14 x 15 alpha lattice design with 2 replications at Agua Fría in cycle 2001 B. The trial had a mean yield of 6.9 t/ha with the best check (CL-02450 x CL-G2501) yielding 7.4 t/ha (Table 5). A few testcrosses

performed significantly better than the best check. Ear rot was a major problem in this trial. One hundred twenty-two S_2 lines were selected for recombination to form a new cycle of Pool 25.

Subtropical Pool 33 C22 SIYF: S_2 lines were crossed to tester CML327 from heterotic group "A". Three hundred nine S_2 testcrosses, together with 15 checks, were evaluated in an 18 x 18 alpha lattice design with 2 replications at Tlaltizapán in 2001 B cycle. The trial had a mean yield of 7.1 t/ha, with the best check CML 327 x CML323 yielding 8.6 t/ha (Table 9). Many testcrosses showed no significant difference in yield from the best check. One hundred twenty-seven S_2 lines were selected for recombination to form a new cycle of Pool 33.

Subtropical Pool 34 C22 SIYD: S_2 lines were crossed to tester CML323 from heterotic group "B". Two hundred seventy S_2 testcrosses, together with 18 checks, were evaluated in a 16 x 18 alpha lattice design with 2 replications at Tlaltizapán in cycle 2001 B. The trial had a mean yield of 7.4 t/ha, with the best check (CML 327 x CML323) yielding 9.2 t/ha (Table 10). Pool 33 C22 and Pool 34 C22 performed very poorly per se, with yields of 4.3 t/ha and 4.4 t/ha. Many testcrosses showed no significant difference in yield from the best check. One hundred three S_2 lines were selected for recombination to form a new cycle of Pool 34.

Subproject 2 (Development of Early and Intermediate Maturity Germplasm)

Four hundred early tropical hybrids were tested in 6 trials at 5 locations. Advanced yellow early and white early hybrids were tested in international trials at 60 locations in late 2000 and in 2001. Excellent results were obtained and are described below.

Twenty-one tropical early yellow hybrid trials (CHTTEY) comprising 14 entries plus 2 local checks were grown in Bangladesh, India, Myanmar, Pakistan, the Philippines, and Vietnam during 2000 and 2001. Information from 21 locations indicates 15 to 100% higher yields and a week earlier maturity than local checks (most of which are late maturing). At 16 locations CIMMYT hybrids outyielded the best seed industry checks; where not, the checks were late-maturing hybrids.

Forty tropical early white, three-way cross hybrids were tested at 4 locations in Mexico, Guatemala, and Colombia. Of these, 20 outyielded the single-cross early check by 1-2 t/ha, flowered at 49 to 50 days, and was harvested at 90 days with 15% moisture. Ten experimental hybrids yielded between 6.0 and 6.5 t/ha—an average grain production of 66 to 71 kg/ha/d. By comparison, a late-maturing seed industry hybrid yielded an average 6.5 t/ha (59 kg/ha/d) and was harvested at 110 days with 15% moisture. The potential of this enhanced germplasm is of high enough to warrant testing in farmers' fields as soon as possible.

Fifty tropical yellow, three-way cross hybrids were tested at 4 locations in Mexico and Guatemala. Of these, 10 yielded around 5.7 t/ha and flowered at 47 days, similar to the single-cross check that yielded 3.7 t/ha. The best 10 hybrids produced from 61 to 63 kg/ha/d of grain, while the early check yielded 41 kg/ha/d.

The following early yellow germplasm populations are undergoing improvement: Pool 17 early yellow flint, Pool 18 early yellow dent, and Population 31. Although Pools 17 and 18 are now being handled by the pre-breeding unit, the tropical subprogram improved them for more than 30 cycles and they were included in this study. Our main responsibility now is Population 31; early yellow flint material that has been improved through nine cycles of full-sib recurrent selection.

Preliminary results from five locations indicate that full-sib selection is very important for improving yield and certain economic traits. In Population 31, nine cycles of full-sib recurrent selection improved yield by 245 kg/ha (5.9%) each cycle. In addition, ear rot was reduced from 21 to 7.5%, root lodging from 22 to 15% (even under very heavy storms), corn stunt from 29 to 18%, and fusarium stalk from 11 to 3%. Varieties from the original Population Across 8331 yielded 4.6 t/ha and Suwan 9531 yielded 5.7 t/ha. New varieties from the current cycle (10) will be far superior.

Ten new, early-maturing varieties were derived from the improvement of lowland tropical populations. If adopted, the new, early-maturing varieties and hybrids will help increase maize productivity and food security in the marginal areas.

Forty early yellow and white open pollinated varieties in trials 14A and 14V were tested at 40 locations in marginal, tropical environments. Preliminary results show their superiority over checks.

During 2000-2001, CIMMYT's Asian Regional Maize Program (ARMP) released nine lines resistant to downy mildew, an important disease of maize in the region; five of these were early-maturing and four late-maturing.

Two early lines are direct derivatives of P31 under improvement at CIMMYT headquarters (CML425, CML426). Another line from EY-DMR-G-C5-S2-B-B-3-1-B*4 (CML429) was obtained directly from the lowland tropical maize subprogram. An additional 14 lines have been proposed for release as CIMMYT maize lines (CMLs). Among the 8 early lines, 3 (CA03116, CA03142 and CA03128) are again from P31 and another (CA00106) from EY-DMR-G, a superior performing material obtained from headquarters. Line CA03116 is also being used as a first-level tester and CA00106 as second-level tester. In the TAMNET 2000 early hybrid trial, two top-ranking hybrids involve lines (CA00106 from EY-DMR-G and CML421) from the lowland tropical subprogram. Line CML421 is also involved in some promising hybrids grown in the regional early downy mildew resistance yellow hybrid trial (CAHTY-2000).

With the support from the pathology, entomology and physiology units, the white and yellow maize line evaluation trials (LETW and LETY) were planted under inoculation with *Fusarium moniliforme* and low-N conditions and infested with fall armyworm and SWB. Six tropical early white and two early yellow lines were identified as resistant to f. moniliforme ear rot. No early lines showed resistance to fall armyworm, but 8 lines showed tolerance to low-N conditions.

Subproject 3 (Development of Late-maturing, High Yielding, Stress Tolerant and Stable Hybrids and OPVs for the Lowland Tropics)

Population improvement continues to be a high priority in the lowland tropical subprogram. In 2001 we formed 72 experimental varieties from population improvement research and 30 new synthetics[1] derived from the pedigree selection breeding project. Every eight cycles of selection we measure the gains and make any adjustments needed, enhancing our breeding activities and thus producing new and better products for clients.

[1] "Synthetics" are open-pollinated varieties (OPVs) formed by inter-crossing several inbred lines known to combine very well (i.e., their progeny are outstanding) among themselves. Synthetics offer yields superior to those of normal OPVs but, as with all OPVs, seed from the previous harvest can be sown the following season without losing yield or desirable qualities. This is an advantage for poor farmers, who cannot afford to buy new seed year after year (a requirement in the case of hybrids, for example).

Population 36 showed a gain of 125 kg/ha (2.76%) per cycle—a total gain of 1.25 t/ha over 10 cycles—under full-sib recurrent selection (FS). The yield component that most contributed to this gain was ears per plant, raised from initial values of 0.84 in cycle 0 to 0.97 in cycle 10 and superior to the initial milestone of a 2% increase per cycle. Other important improvements in the population included reductions in ear rot (from 13.3 to 4.8%), root lodging (from 61 to 15.9%), bad husk cover (from 20 to 8.4%), stalk rot (from 12 to 4.8%), and stalk lodging (from 33 to 2.6%).

Population 28 (a yellow semi-dent improved through 10 cycles of FS) showed no progress during 6 cycles. However, the yield increased from cycle 6 to 10 at a rate of 93 kg/ha. Nevertheless, the ultimate gain was only 37 kg/ha—less than 1% per cycle—increasing from an initial 5.09 to 5.46 t/ha.

After 10 cycles of FS recurrent selection, we changed to FSRRS to increase the frequency of good lines for hybrid development. The first cycle of FSRRS did not result in changes in the populations *per se* but a real improvement was observed in the crossability of both populations: 290 kg/ha, or 4.7% per cycle of FSRRS, with an estimated heterosis of 14%.

Elite variety trial (EVT) 13, which included 18 new synthetics (tropical yellow late) and two checks, was grown at 14 locations in Fiji, India, Indonesia, Myanmar, Nepal, Pakistan, and Thailand. The elite varieties outyielded local checks by 10 to 100% and showed superior agronomic traits in Fiji, India, and Nepal. The best open pollinated varieties (OPVs) from the trial should be tested further to speed their release to farmers.

We conducted 23 hybrid trials, including the evaluation of 1,748 tropical late white and yellow hybrids of both normal and quality protein maize (QPM). In addition, 70 advanced normal and QPM hybrids were tested at 50 locations in Africa, Asia, and Latin America.

At seven locations in El Salvador, Guatemala, and Mexico, and two additional sites under low-N and drought conditions, we tested 50 tropical, late, white, single-cross hybrids (stage 3 of evaluation) formed from stress tolerant lines. Hybrid CML340 x CL21114 topped the trial at Cotaxtla, Mexico, with 11.3 t/ha—47% more than the ASGROW check (5.3 t/ha). The same experimental hybrid yielded an average 8.0 t/ha across locations and showed resistance to ear rot and foliar diseases. The best check, the Monsanto hybrid Nutria, averaged 7.7 t/ha across locations. Ten experimental hybrids yielded from 30 to 50% more than Monsanto HZ3440. To compare their yield levels with those of new QPM hybrids, 15 new QPM white hybrids were included in this trial. Three averaged 7.0 t/ha—10 to 20% more than the best checks—and were resistant to ear rot, corn stunt, and root lodging. The best of these materials should be tested in eastern and southern Africa and in Latin America.

Thirty-six tropical late yellow single-cross hybrids were tested at several locations in Colombia, El Salvador, Guatemala, and Mexico. Single-cross CML287 x CML451 topped the trial with yields of 10.8 and 9.8 t/ha at Cotaxtla and Agua Fría and ranked third and fourth at San Andres and Uxmal. This hybrid outyielded by 45% Pioneer 3031 across five locations and was resistant to ear rot, root lodging, and corn stunt, whereas the Pioneer hybrid was susceptible to ear rot.

We tested 100 tropical late white three-way cross hybrids at locations in Mexico (Cotaxtla, Veracruz; Uxmal, Yucatan; Agua Fría, Puebla) and Guatemala (Las Vegas). Four yielded 8.0 t/ha across locations, ranked in the best 10% at individual locations, and demonstrated resistance to ear rot, corn stunt, and lodging. Monsanto check HZ3440 yielded an average 5.87 t/ha, and was outyielded by 25 to 37% by 11 of the experimental hybrids.

Fifty-five tropical yellow late three-way cross hybrids were tested at four locations in Guatemala and Mexico. Of these, 18 outyielded seed industry checks by 25 to 65% across locations, and were superior by a statistically significant value to the best seed industry check, P3031. Hybrid (CML453 x CML287) x CML451 yielded 10.0 t/ha and ranked second at Cotaxtla, first at Uxmal, fourth at Las Vegas, and second across locations with 7.5 t/ha. In contrast, the hybrid check had poor roots and was susceptible to corn stunt and foliar diseases. The resistance to ear rot and foliar diseases of the new hybrids will help increase the productivity of maize in developing countries in Asia and Latin America, where the superior hybrids will be tested.

Evaluating QPM in the developing world

2001 marked the fifth year of the QPM project funded by Nippon Foundation and five years of continuous progress in QPM germplasm development, testing, and promotion in the developing world. CIMMYT's international maize testing unit shipped 80 QPM trials—including 25 white and yellow hybrids—that were grown at tropical, midaltitude, and subtropical sites in Africa, Asia, and Latin America. Additional hybrid and OPV trials were planted at more than 180 locations, both on-farm and on-station, in eastern and southern Africa. Preliminary, special selection trials were grown at 12 locations in the tropics and subtropics, 936 new hybrids were tested in the tropics, and 700 subtropical hybrids were planted in subtropical environments. The evaluation of 1,500 new QPM cultivars in the developing world will provide excellent information for promoting new cultivars in countries where QPM hybrids have been released. The impact of this project is remarkable because in the past five years 17 countries have released QPM hybrids.

The evaluation of hybrids across years and environments provided an assessment of yield stability. Common tropical white QPM hybrids were tested across 47 locations in Latin America and Asia. Hybrids (CML141x CML144) x CML 142, CML141 x CML144, and (CML142 x CML150) x CML176 topped the trial (an average 6.5 t/ha) and consistently outyielded seed industry checks of normal endosperm type during 1999-2001, demonstrating as well yield stability and superior nutritional value (double the tryptophan in the grain). The QPM hybrids were also more resistant to ear rot and lodging and had more ears per plant than seed industry checks. All of the above suggests that the adoption of these hybrids could contribute to food and nutritional security.

Twelve tropical yellow QPM hybrid trials (CHTTYQ) comprising 23 experimental entries and two checks grown at 12 locations in Bangladesh, India, Nepal, Pakistan, Philippines, Thailand, and Vietnam in 2000-2001. At least three equaled or bettered the yields of the best seed industry checks at individual locations, excepting Thailand. The best should be tested in multilocation trials together with the best normal hybrids.

During 2001, several trials were conducted to evaluate newly developed QPM hybrids with advanced and early generation lines derived from recycling normal x QPM elite lines of white and yellow endosperm. Two hundred new tropical white lines were crossed to elite QPM testers from heterotic groups "A" and "B" and evaluated across five locations in Colombia, El Salvador, Guatemala, and Mexico.

Some hybrid combinations outyielded the best seed industry check, Pioneer X1409W, by 19%. Hybrid (CLQ-6203 x CL04321)-B-7-1 x CML159 yielded 8.4 t/ha across locations and topped the trial at Cotaxtla with 11.4 t/ha. Tropical white late normal lines CML264 and CML273 were converted to QPM and the hybrid CML246Q x CML273Q tested for yield. Results are very encouraging because yields are similar but with double the levels of the essential amino acids lysine and tryptophan.

The Asian Regional Maize Program

The ARMP submitted six late yellow lines for release as CMLs. One line (CL02836) developed at CIMMYT headquarters from Population 28 was found extremely useful and is being proposed for release. We screened S_3 QPM lines developed from pedigree populations downy mildew resistance. Each pedigree population included at least one line from CIMMYT headquarters. Although most lines were 100% susceptible, we found seven QPM lines where fewer than half the plants were infected, and for four of these fewer than 25% of the plants were infected. Several promising QPM lines from headquarters were increased and have been supplied to national programs and private seed companies interested in QPM breeding.

Seed of CML161 x CML165 as well as of the parental lines was increased and supplied to some national programs on request. Seed of CML161 x G26Q was also produced. Seed production of G26Q was poor.

A few lines from headquarters have been found to be quite tolerant to banded leaf and sheath blight. Two early lines from EY-DMR-G and one from P28 (P28 C7S5B-13-1-2-2-1-1-B*5) appear to be moderately tolerant to this disease (See Table).

Several countries released new varieties derived from CIMMYT normal and QPM germplasm:

- SHAKTIMAN-1 and SHAKTIMAN-2 (QPM hybrids, India, March 2001).
- Qian 2609 (Guanxi, China; CML 171 is a parent).
- Yanyou 19 in (Yunnan, China; contains CML140).
- Yunyou 167 in (Yunnan, China; CML 194 as a parent).
- HQ2000 (Vietnam; single-cross CML161 x CML165).

South American Regional Maize Program

Using data from regional collaborators, F_1s of 95 new synthetics tolerant to biotic and abiotic stresses were generated and 31 synthetics were advanced to F_2. These will be included in 2002 Acid Soils White or Yellow Trials.

We developed 22 new single-cross hybrids, including 19 of yellow and 12 of white endosperm. Seed of these hybrids is being increased for inclusion in the 2002 Acid Soils IX White or Yellow Trials. Using data generated in the DI White test of 97A, 49 new hybrids were generated. In addition, 40 yellow and 31 white lines selected from the 4 heterotic acid soil-tolerant populations (SA3 through SA7) were crossed in diallels generating a total of 564 single-cross hybrids, including 189 white and 375 yellow endosperm materials. These will be evaluated. We crossed selected CLA lines to CLA283 x CLA282, thereby generating 25 three-way yellow hybrids that will be tested internationally in 2002 in new Acid Soils Trials.

In support of initiatives of the Colombian agricultural research program, Corpoica, in the country's Atlantic-Caribbean and Valle regions, lines involved in 36 new CIMMYT hybrids evaluated during 2001, including 20 yellow and 16 with white endosperm, were increased.

Germplasm Dissemination and Release

Bolivia: At the Tarija research station, in special yellow endosperm (both normal and QPM) trials prepared by CIMMYT's South American regional maize program, the Sistema Boliviano de Tecnología Agropecuaria (SIBTA) identified six new yellow hybrids (one normal and five QPM; Figure 1). These were planted in validation trials for eventual release during 2002. Similar

results were obtained at the CIAT Santa Cruz station; selected hybrids will be planted in validation trials for official release.

Ecuador: At the Portoviejo Research Center, staff of the Instituto Nacional de Investigaciones de Agropecuarias (INIAP) concluded tests of hybrids involving lines from their program crossed to CIMMYT CMLs as male parents. The new hybrids, which are being tested for release during 2002, include two single-crosses, one three-way cross with CML287 as the male parent, and one three-way cross with CML303 as the male parent. At the Pichilingue Research Center, INIAP is testing hybrids formed using CML287 and CLO2411 as male parents, for possible release in 2002.

Colombia: With Corpoica researchers on the Atlantic-Caribbean coast, five selected white or yellow normal and QPM entries were grown in separate trials at four locations and submitted to the Instituto Colombiano Agropecuario (ICA) for official evaluation. A second season evaluation were also planted for final approval of best selected entries. It is expected that the yellow single-cross entry CML161 x CML165 and the white hybrid CML159 x CML144 will be approved and released by June 2002. Also with Corpoica Region 2, special OPV and hybrid yellow endosperm trials were prepared to be planted in the coastal area. These included 17 experimental cultivars and 2 local checks. During 2001, yellow endosperm hybrid and OPV trials were planted at 11 locations. By January 2002, several promising entries have been detected in both hybrids and OPV yellow endosperm trials. This is to be reconfirmed at harvest time. With Corpoica Region 5, a different set of special white and yellow hybrid trials comprised 18 experimental hybrids, both normal and QPM, and 2 local checks. These were grown at 5 locations in the Cauca Valley. Several promising entries have been identified. These results are to be confirmed.

The new, acid-soil tolerant three-way cross hybrid, Corpoica H-111, was officially released for use in the acid soil savannas of Colombia.

Paraguay: In special trials including normal and QPM yellow endosperm entries, six good hybrids were identified (Figure 2). Seed of parental lines was increased for use in further tests.

Peru: Results of tests on 16 test plots in the main corn growing areas of the lowland coast involving yellow flint hybrids were very encouraging. Three single-cross hybrids—CML 287 x CML 413 (HE1), CML 287 x CL 00368 (HE2), and CML 297 x CML 453 (HE3)—were tested against commercial hybrid Dekalb DK 821. Mean yields for were 7.8, 7.0, 8.6, 7.9 and 7.1 t/ha for HE1, HE2, HE3, T1, and T2, respectively. Another 13 test plots were planted in cycle 2001B. The yield was 9.0, 8.3, 9.5 and 9.1 t/ha respectively, for HE1, HE2, HE3, and T1, respectively (Figure 2). Hybrid CML297 x CML453 showed more yield stability and uniformity and ear quality and health. The hybrid check was susceptible to all diseases. Hybrid CML297 x CML453 will be released in early 2002.

For yellow QPM hybrids, strip tests included CML161 x CML165 (HQ1) and (CML161 x CML165) x CML172 (HQ2), and (CML172 x CLQ66022) x CML161 (HQ3). Mean yields across seven plots were 9.5, 8.8, and 9.6 t/ha. (Figure 2). These hybrids will be will be released in 2002.

Venezuela: With the Instituto Nacional de Investigación Agrícola (INIA) at the Portuguesa and Maracay Research Centers, special QPM trials were distributed and planted in multilocation trials. Some of the selected hybrids were extensively tested for official release in 2002. In August 2001, the new three-way cross white endosperm hybrid, Portuguesa 2014, was released by INIA-Portuguesa. This hybrid is 100% CIMMYT germplasm.

Central America: El Programa Regional de Maíz (PRM) para Centroamérica y el Caribe

Honduras: In October, officials released a new QPM hybrid, DICTA HQ-31, which is 100% CIMMYT material (CML144 x CML159). The Dirección de Ciencia y Tecnología Agropecuaria (DICTA) produced around 588 quintals of certified seed for this hybrid, which will be available for farmers in Honduras for the 2002 planting season. In an effort involving DICTA, DEMAHSA, Cristiani/Burkard Seed Co., and farmers for promoting this new hybrid, 560 commercial hectares were grown in Honduras (Yoro Region) during 2001 season.

New white and yellow elite hybrids and/or OPVs (QPM and normal endosperm) involving CIMMYT germplasm were tested in validation plots in several farmers' fields. Field observations of these plots showed high performance from many of the new cultivars under testing, and final harvest information is being processed to consider the chances of releasing some cultivars during 2002 in Guatemala and El Salvador.

Guatemala, El Salvador, Honduras, y Nicaragua: Thirty-two uniform trials, including 12 white tropical synthetics from CIMMYT, were grown, mostly in fields of small-scale farmers in regions where environmental and socio-economic conditions made agriculture a risky. Based on 29 datasets, the best three synthetics outyielded the local checks by 30% and performed better agronomically. Superior synthetics were identified for the four countries where the evaluation was conducted, and extensive tests will be conducted in small-scale farmers' fields during 2002.

Insect Resistant Source Germplasm for Kenya

We advanced 178 lines from the maize borer resistance (MBR) population to S_6 with selection for insect resistance and adaptation. Crosses were made to testers CML78 and CML44. We advanced 500 MBR/MDR lines to S_4 and S_5, with selection for resistance to *Chilo partellus* and adaptation. From these, we selected 181 lines and crossed them to testers CML78 and CML44. Finally, we advanced 234 inbred lines from CIMMYT and the Kenya Agricultural Research Institute (KARI) to S_3 and S_4, with selection for insect resistance and adaptation, made crosses to testers CML78 and CML44, and evaluated some single crosses.

Development of Herbicide Resistant Maize for Striga Control

We initiated a breeding program to improve conventionally bred (i.e., not genetically engineered) imidazolinone resistant (IR) maize germplasm. This is intended for use for use in an approach whereby maize seed is treated with herbicide to avoid attachment of haustoria from the parasitic flowering plant Striga spp.. Specifically we...

1. Advanced 412 IR maize inbred lines to S_2 to S_4, with selection for resistance to the herbicide and leaf blight caused by *Exserohilum turcicum* (Figure 2), and made crosses of 412 IR maize lines to testers CML78 and CML444 to determine their heterotic grouping.
2. Initiated a backcrossing program by making crosses of IR maize inbred lines to the Striga tolerant maize synthetic ECAVL17STR to enhance turcicum resistance and adaptation for Western Kenya (Figure 3); also made BC0F2 and BC1F1 from these top crosses.

In collaboration with the entomology, pathology and physiology units, the lowland tropical subprogram conducted the line evaluation trials LETTW and LETTY under infestation with fall armyworm and southwester corn borer, inoculation with *F. moniliforme,* and under low-N conditions. We selected 9 lines tolerant to FAW, 15 lines resistant to *F. moniliforme,* and 20 lines tolerant to low N.

Screening of Pre-breeding Germplasm in the Entomology Unit

A major effort in prebreeding is under way to ensure broad diversity Maize Program breeding materials. The entomology unit is attempting to characterize top-crosses of bank accessions to eliminate germplasm that is highly susceptible to major pests. During the TL01B cycle, Pools 19, 23, 24, 25, and 26 were screened under artificial infestation with *Spodoptera frugiperda*, involving the evaluation of more than 1,200 families in top crosses. The trial was complicated by an outbreak of white grub (*Phyllophaga spp.*) that was controlled by granular applications of pesticide to the soil and replanting. Of course, the residual effects of the insecticide reduced armyworm feeding, but we were still able to eliminate some 30% of the families, using as a cutoff leaf damage ratings above 6 (7 is considered susceptible). Most promising as resistance sources are Pools 19 and 24.

Regarding resistance to post-harvest pests, several OPVs from the tropics performed well. Interestingly, Cuba 124 was one of the best entries. (Cuban accessions were used to form CIMMYTs source population for *Prostephanus truncatus* resistance.) Of some concern is the poor performance of Obatanpa, which accounts for 75% of Sasakawa-Global 2000's[2] QPM area in Africa. Obatanpa should be considered for conversion into a more weevil resistant variety by crossing in resistance sources identified in this screening. Several QPM pools—including G31 c12 SEWF QPM, G31 c12 SEWF QPM, G31 c12 SEWF QPM, and G17 C8 Q—showed moderate levels of resistance that could be used for this purpose.

Pathology Research

As part of screening for deriving inbreds, we inoculated the quality protein maize nurseries in Cotaxtla, Mexico, with maydis leaf blight parthogens in the A cycle, providing high disease pressure to eliminate susceptible germplasm.

In the Agua Fría B cycle, four tropical line evaluation trials were inoculated with *B. maydis* leaf blight and *Fusarium moniliforme* ear rot. Data were taken on foliar diseases and ear rot for these trials and several QPM experiments, and insect resistant inbreds were identified as having high levels of resistance to diseases, especially ear rot.

A single cross trial formed from lines from the corn stunt resistant Population 73 was evaluated for resistance to infection by the corn stunt spiroplasma (CSS) in the Agua Fría 2001B cycle. Included in the trial was a three-way cross hybrid HN 991, recently released in Nicaragua, and 10 entries yielded more and had less infection than this hybrid. One entry had 0% infection and yielded 27% more than HN 991which had 22% infection.

Private Dissemination of CIMMYT Germplasm

In Mexico three companies—Semillas Correa, Semillas Frías, and Semillas de Veracruz—began producing seed of QPM hybrids released by the Mexican National Institute of Forestry, Agriculture, and Livestock Research (INIFAP).

Monsanto released one hybrid and Pioneer another that contain CIMMYT tropical lines. Regional companies such as Cristiani Burkard (Central America) have started the planting of 280 hectares of the newly released hybrid HS-9 and small quantities of HS-11 and HS-13 released in 2001, including HS-5G eleven year old hybrid (ICTA-HB83) released in 1990. Cristiani Burkard seed company is producing 5000 tons of seed for 2002.

[2] SG2000 is a non-governmental organization dedicated to ending malnutrition and poverty in Africa and a leading promotor of QPM in the region. The organization has cooperated extensively with national programs and CIMMYT to promote the release and adoption of QPM.

Semillas Seminal: Recently releases of Seminal hybrids include HR-99 and HR-ORO in Central America, HR-661 and HR-663 in Colombia, and HR-363, HR435 and HR245 in Venezuela, with approximate sales of 1,500 tons annually.

Several small companies in Venezuela (SEFLOARCA, IMECA, and DANAC) produce some 5,000 tons of seed annually, a rough estimate. Small national private seed companies in El Salvador, Guatemala, Honduras, Nicaragua and Panama also produce hybrids and OPVs that are planted annually on several hundreds of thousands of hectares.

All of the materials mentioned above contain at least one line developed by CIMMYT's lowland tropical maize subprogram and few subtropical and 75% of the hybrids and varieties are entirely CIMMYT germplasm. These materials cover at least 1.5 million hectares in Central America, southern Mexico, Colombia, and Venezuela.

Subproject 4 (Development of Late-maturing, High Yielding, Stress Tolerant and Stable Hybrids and OPVs for the Subtropics)

Population Improvement

Progress in yield and other traits were measured through a "Cycle of Selection Study" conducted at five locations. Preliminary results from two show an 18% gain in yield over three cycles of selection in the population cross. Gains in per-se yield were flat for Population 501 and 4% per cycle for Population 502. Gains in resistance to ear rot were significant: C_3 of the population cross had only 2.9% ear rot, compared with 8% for C_0.

Preliminary results from the genetic diversity study in white grain types grown at four Mexican locations showed that hybrids with genetic distances of less than 0.3 (based on DNA molecular markers) yielded less than 3.68 t/ha. One of the hybrids has two lines coming from different populations. Hybrids with genetic distances larger than 0.7 yielded from 7.4 to 11 t/ha. New hybrid combinations will be formed in 2002 based on genetic distances less than 0.3 and more than 0.7.

Hybrid Testing

We evaluated 1,306 normal hybrids at four sites located in the following Mexican communities: Tlaltizapán, Morelos; Celaya, Guanajuato; and Corralejo, Guanajuato. Of these hybrids, 599 were white grained and 707 yellow grained, 556 were of intermediate maturity and 53 were early among the whites, and 495 were intermediate and 212 early for the yellow grain types.

We crossed S_9 recombinant inbred lines (AC7643/AC7729/TZSRW) to subtropical testers CML311, CML373, and CML384. Preliminary results from Tlaltizapán Mor showed that (AC7643/AC7729/TZSRW)-2-144-#-B-B-B-B-3-1-1 x CML 311 outyielded P-30G40 (12.3 vs 1.0 t/ha) and had low incidences of ear rot and root and stalk lodging.

In two Guanajuato environments (Celaya and Corralejo), the early subtropical yellow hybrid POB.446-10-1-2-B-B-B x POB.445-58-6-4-B-B-B with 61 days to silk outyielded one of the local checks by 0.3 t/ha and was 13 days earlier to silk than the best local check. There was no rot or stalk lodging and only 0.2% *Fusarium* infection.

New subtropical intermediate white lines outyielded reference checks CML311 ("A" tester) and CML384 ("B" tester) at nine locations. The elite lines had low incidences of stem and root lodging. Husk cover of the elite lines was better than those of CMLs 373, 321, 311, or 78, and ranged from 1.5 to 4.4%. Lines P502c2-185-3-4-1-3-B-1-B-B and MBR-ET(W) C1 F139-2-1-B-2-

B-B-B-B-B-B were resistant to *Puccinia* spp., and line P501c1#-500-2-1-2-2-2-1-2-B-B-2-B-B had a 3.8 reaction to the pathogen. These lines will be recommended as possible subtropical CMLs.

QPM Hybrids

A total of 531 QPM hybrids were evaluated at same four Mexican sites mentioned above. Of these hybrids, 293 were white and 236 of yellow grain type.

Of 20 S_5 QPM lines developed by recycling CML384 x CML176 (normal x QPM), 14 had tryptophan contents in the grain ranging from 0.076 to 0.1.09 and lysine contents from 0.0398 to 0.512. The protein contents of grain from these lines ranged from 9.63 to 11.88%. These S_5 lines were crossed to the tropical and subtropical QPM lines, CML149 and CML186, and will be evaluated in 2002.

At Corralejo, Guanajuato, in a trial of S_6 lines from S91SIWQ test-crossed to the subtropical lines CML175 and CML176, 63 hybrids outyielded the local checks. The hybrid S91SIWQ-68-3-1-2-B x CML176 outyielded the best local check by 4 t/ha, had a low *Fusarium* reaction (2.6%), and no ear rot or stalk lodging.

From the hybrid trial CHTSY-2001, grown at Pantnagar, India, hybrid G33Qc25MH103-3-1-4-1-B*4 x G34Qc22MH135-4-2-B-B-4-B*5 outyielded the normal reference check [CML 327 x CML 295] x CML 223 by 1 t/ha and the best local check by 1.8 t/ha.

Subproject 5 (Development of Late-maturing, High Yielding, Stress Tolerant and Stable Hybrids and OPVs for Midaltitude Areas)

Line Development from QPM x Elite MSV-resistant Normal Lines

All maize germplasm targeted to sub-Saharan Africa must be resistant to maize streak virus (MSV). We are trying to develop streak resistant QPM by crossing it with normal lines that carry such resistance. We have 265 S_3 lines of QPM x MSV resistant CMLs in testcross trials (2001/02). More than 200 BC_1F_1 families were grown in 2001/02. More than 2000 BC_0S_1 lines were grown under MSV in 2001/02.

Improvement of PL15Q-SR

We selected S_2 lines for resistance to MSV. We also evaluated yield, MSV resistance, and protein quality (Mexico) in half-sib recombinations; formed PL15Q-SRc1; and grew PL15Q-SRc1F2 in EPOP trial at 100 sites in 2001/02.

MSV improvement of Obatanpa

To improve the resistance of the popular QPM OPV, Obatanpa, we selected 243 S_1 ears from 1,768 F_2 plants grown under MSV inoculation and natural incidence of grey leaf spot (GLS; another disease of maize that has lately become widespread in sub-Saharan Africa) during summer 2000/01. The S_1s were evaluated for protein quality using ELISA and kernels were selected for modification. The 28 best S_1s were recombined during winter 2001 and improvement is continuing in summer 2001/02.

Protein quality improvement of S91SIWQ

We selected 455 F_2 plants for GLS resistance and good ear aspect. The protein quality of 455 S_1 was assessed at headquarters. We also formed S01SIWQ during 2001 and it will be evaluated in the ILPOP trial at 85 sites in 2001/02.

Regional hybrid evaluation

A QPM diallel was used to predict successful three-way and double-cross hybrids. These will be grown in the QHYB trial at 50 sites in 2001/02

We formed 14 new QPM hybrids and tested them with the 5 best QPM hybrids from previous year, Obatanpa, 2 excellent normal checks, and 2 local checks.

Established ELISA laboratory at CIMMYT, Harare

Using funds from the global QPM project provided by the Nippon Foundation and with technical assistance from headquarters lab head, Jaime Lopez Cesati, we set up a protein analysis laboratory in southern Africa. Julien De Meyer also provided valuable technical input.

Dissemination Activities

More than 600 QPM demonstration plots were grown in Malawi in 2001/02 with SG2000 and the Ministry of Agriculture. More than eight tons of QPM seed was produced during 2000/01. A keynote paper on QPM was presented at the Nigerian National Maize Workshop. Two QPM hybrids and one QPM OPV were released in Tanzania during 2001. Links with IITA were strengthened and we formalized the exchange of trials and germplasm for QPM and normal materials. A paper on our QPM research was accepted for publication by Crop Science, pending revisions.

MSV Survey in Zimbabwe

MSV strains were collected from 10 sites in Zimbabwe. We infested four inbred lines and studied line x strain interaction. All MSV strains ranked the lines in the same order from resistant to susceptible. There were statistically significant differences among strains and inbreds for latency period and final symptom severity. There were no practical differences among MSV strains nor line x strain interactions. We thus concluded that the MSV resistance in CIMMYT germplasm is effective against prevalent strains of MSV across Zimbabwe.

Several pedigree type projects have been initiated to develop intermediate maturity germplasm. Segregants from this are being characterized to separate them into early and intermediate maturity. Intermediate maturity lines will be used to form OPVs and hybrids while the line development effort progresses. One entry was submitted for the intermediate to late maturity hybrids regional trial for 2002.

Incorporation of MSV resistance into Populations 401 and 402 from HQ is being initiated. Several lines from these populations are being grown and several trials from HQ (including IPTT401 and IPTT402) are being evaluated in Harare.

Regarding germplasm development, we incorporated exotic elite germplasm by crossing CIMMYT germplasm to materials from the USA and CIMMYT-Kenya. We also formed an OPV using full-sibs from IITA and conducted two seasons of breeding.

Several potential pre-CMLs have been identified. Data from 02A will be used to select a few of these and propose them as CMLs. We also contributed three entries to EPOP02, nine entries to EIHYB02, and one entry to ILHYB02; submitted a concept note on developing early maturity maize for eastern and southern Africa; and developed macros of potential use for helping maize breeders to select more quickly.

Breeding and Other Africa Maize Stress Project (AMS) Activities

We formed 1,800 lines (S_1, S_2, S_3) including: 441 S_2 lines advanced to S_3, 319 early S_1, and 1,000 late S_1. We formed 745 hybrids (single-, three-way, and topcrosses) including 194 single

crosses, 63 early three-way crosses, 38 intermediate three-way crosses, 274 late disease (GLS, *Turcicum*, MSV) resistant top crosses, and 214 early top crosses. We developed herbicide resistant hybrids (as described above for controlling Striga infestations) including: 4 single crosses, 4 three-way crosses, and 4 top crosses. We crossed 11 elite lines to herbicide resistant sources and the BC_0 F_1 were advanced to F_2. Four herbicide resistant single crosses are being tested at 12 Striga infested sites in eastern and southern Africa. Two new extra-early synthetics and 2 disease (GLS, *Turcicum*, MSV) resistant synthetics were formed. Conversion to MSV resistance of 2 QPM synthetics was begun. One extra-early population is also being converted to QPM. One QPM streak resistant synthetic is being formed. We are screening 201 QPM CMLs and segregating lines for MSV resistance. We multiplied seed of 39 OPVs. We formed 14 new OPVs and advanced them to F_2 for regional testing in 2002.

We tested 400 single-cross and three-way hybrids under optimal, low N, and drought conditions. At one site, we tested 293 subtropical three-way crosses from the physiology subprogram at headquarters. We tested 9 sets of 28 subtropical genotypes from headquarters at 8 sites. We tested 19 QPM hybrids at 9 sites and 24 Striga tolerant OPVs at 9 other sites. We evaluated 18 OPVs at 24 sites, 16 extra-early genotypes at 26 sites, 10 sets of transitional adapted materials from Ethiopia (HLGP) at 2-3 sites, and 19 sets of highland and transitional/highland genotypes from headquarters at 2-4 sites.

QPM as feed: The limiting factor in pig production is the cost of feeds, which constitute 75% of production cost. Low levels of crude protein content and of the essential amino acids, lysine and tryptophan, in maize limit its value in pig diets. This necessitates the use of expensive animal products-based concentrates to supplement the diet. Quality protein maize (QPM) containing double the quantity of lysine and tryptophan over that of normal maize has been developed by CIMMYT through a 30-year research effort. We began 2 experiments using QPM as an ingredient in feeds for pigs and poultry.

In a study where pigs were fed a diet containing tropical QPM maize synthetic S99 TLWQ, the purpose was to demonstrate the nutritional advantage of QPM over normal maize. Two groups of 12 weaner pigs each, having similar weight and sex composition, were randomly allocated to one of the two diets: normal maize + mineral/vitamin mix, and QPM + mineral/vitamin mix. The QPM-maintained pigs had gained an average of 5.87 kg body weight (Bwt) while those on the normal maize diet had gained 1.62 kg Bwt. Thus, those fed on QPM had gained more than 3 times the weight of those fed on normal maize.

Subproject 6 (Development of Late-maturing, High Yielding, Stress Tolerant and Stable Hybrids and OPVs for the Tropical Highlands)

We are now aware of at least 25 hybrids in the Mexican market that contain one or more highland CMLs. In the Winter of 2002 we plan to release 10 lines with either highland or transition zone adaptation, early or late maturity, and white or yellow grain type. This is the first time the program has released highland late and transition zone late maturing lines. We also are making available 27 new synthetic varieties with similar combinations of adaptation, maturity and grain color.

One new focus of research for the highland program during the past year was the crossing of elite inbred lines from different adaptation zones in the hopes of both observing more heterosis in resulting crosses, due to their varying genetic backgrounds and more yield stability. Preliminary results suggest that we have achieved the yield boost in numerous cross combinations. In single-cross hybrid combinations made between late highland white lines and

two elite subtropical testers, several hybrids out-yielded the best checks by more than 26% (13.7 t/ha), including the highland late line (Pob.87C5HC95-24-1-1-2-1-B-B-B) in crosses with the subtropical tester lines CML311 and CML384.

Finally, 76 seed shipments, totaling more than 1 ton were prepared by the highland sub-program for Mexican collaborators in 2001. Additionally, about 3 tons of inbred and single-cross foundation seed were produced and distributed in 2001.

Germplasm Development in the Eastern Africa Highland

Pre-screening and germplasm enhancement for the highland zone of eastern Africa were carried out at Ambo in Ethiopia. The following nurseries were planted for selfing and topcrossing: Ecuador 573 S_3 lines (184 rows); Pool 9A SR S_4 lines (444 rows); Pool 9A, Kitale II and Ecuador 573 S_4 lines (86 rows); and BLCO Tardio Advanced Lines (35 rows). Also, 183 local highland germplasm collected and evaluated in Ethiopia were advanced to S_2 at Ambo. About 180 inbred lines pre-screened at the Ambo project site were sent to KARI-Kitale for use in their highland maize program. Similarly, 160 inbred lines were planted by the National Maize Program of Ethiopia to generate hybrids for subsequent evaluation.

A number of lines classed into heterotic groups following topcrossing to Kitale, Ecuador and Pool 9A in 1999-2000 were planted at Ambo to generate experimental hybrids and topcrosses. These were Kitale heterotic group (69 lines), Ecuador heterotic group (64 lines), Pool 9A heterotic group (34 lines).

Variety development and evaluation

The F_2 of 4 synthetics based on topcross performance of Pool 9A lines with streak resistance was produced at Ambo for the highland zone (F1 seed was produced in 2000).

Two hundred three-way hybrids with resistance to the maize streak virus and turcicum leaf blight disease and 33 three-way hybrids with additional resistance to GLS were evaluated in Ethiopia, Kenya, Tanzania and Uganda. Nine experimental topcross hybrids with resistance to the maize streak virus and turcicum leaf blight were evaluated on-farm. One Mother-Baby highland maize trial (12 varieties) was planted on-farm in Ethiopia. The Mother trial alone was evaluated at 7 other sites in Ethiopia, Kenya, Uganda and Tanzania. Results of the various performance trials indicated that some of the experimental hybrids were earlier, shorter, more tolerant to GLS and had equal or better grain yield compared to local checks

QPM Development

Selected QPM hybrids were entered in 8 different trials in the 2001 Regional Variety Trials conducted by the National Maize Program of Ethiopia. One QPM hybrid (CML144 x CML159) x CML176 proposed for release in Ethiopia in 2001 was planted in strip tests at 8 locations for variety inspection prior to release. The QPM three-way hybrid variety was released in Ethiopia under the registered name of BHQP-542 and cultivar name of Gabisa (Strong one) in 2001.

Subproject 7 (International Testing)

Trials announced included 20 from headquarters (12 tropical, 6 subtropical, 2 Highland), 4 from Asia (2 variety and 2 hybrids trials), 3 from South America (2 variety and 1 hybrid trials), 5 from Central and Eastern Africa (3 variety and 2 hybrid trials), and 6 from Zimbabwe (3 Population, 2 hybrids and 1 line trials). A new early elite variety trial containing synthetics from Populations 401, 402, 445, and 446 (EVT16WYE-2002) was announced. The international maize testing unit

(IMTU) sent 782 trial sets comprising 499 seed shipments—a total 10 tons of seed—to 69 countries.

The 1999 Final Report was completed, including data returned from 56% of those to whom trials were sent (total 668). AMMI analysis was included to help to cooperators better understand the performance of the materials. The 2000 Preliminary Report was sent to cooperators and 55% of those receiving trials in 2000 (a total of 957) have already returned data. For 2001 trials we have received 100 data sets of 782 trials sent.

Announcements for 2002 trials were sent to 500 cooperators and published on our home page. The number of trials from headquarters are 32 (15 tropical, 9 subtropical, 8 highland). There are 12 variety trials, 18 hybrid trials, and 2 IPTT. There are also 5 trials for Asia (2 variety and 3 hybrid trials), 6 for South America (3 variety and 3 hybrid trials), 4 for East and Central Africa (3 variety and 1 hybrid trials), and 5 for sub-Saharan Africa (2 variety and 3 hybrid trials). We have received 51 trial requests from 27 countries for a total of 500 trial sets.

A poster on IMTU activities was presented at the ASC meetings in 2001.

Global Project 3

Improved wheat for the world's poor

Project Coordinator: M. van Ginkel

Oversight Director: S. Rajaram

Achievements in 2001

Global Project 3 aims to develop wheat technologies for the irrigated and high rainfall areas of the developing world. To achieve that overall goal, it has been organized in several sub-projects. An overview of achievements is presented for each of those sub-projects.

Bread Wheat (Sub project 1; SPL: M. van Ginkel)

Development and identification of disease resistant advanced lines with adaptation to irrigated production conditions with yields (10.5 t/ha) up to 17-22% over the commercial bread wheat and durum wheat varieties in Cd. Obregon yield trials.

Development and identification of disease resistant advanced lines with adaptation to irrigated production conditions with the highest levels of bread-making quality and protein levels over 12.5%.

Development and identification of disease resistant advanced lines with adaptation and stable yields across varied irrigated production conditions, including full irrigation, reduced irrigation, late planting, both planted on the flat and on beds, yielding 5-8% over the commercial varieties with top industrial quality.

Development and identification of disease resistant advanced lines with adaptation to irrigated production conditions experiencing late heat conditions yielding up to 13% over the heat tolerant check (Bacanora).

Development and identification of disease resistant advanced lines with adaptation to high rainfall production conditions with yields (10.6 t/ha) more than twice that of the commercial bread wheat variety (Romoga), in Toluca yield trials, carrying top-level industrial quality.

Development and identification high-yielding advanced lines with adaptation to high rainfall production conditions, combining resistance to *Septoria tritici*, and high industrial quality, with acceptable resistance to Fusarium head scab.

Development and identification of disease resistant advanced winter and facultative lines yielding up to 56-64% over the check (TAM200) in Toluca yield trials.

Identification of advanced double purpose winter and facultative lines with high forage biomass and grain yield in specially designed Toluca yield trials.

Fusarium head scab resistance from diverse CIMMYT sources being backcrossed into eight South Korean winter wheats.

Karnal bunt resistance in advanced lines is being maintained at about 20%.

About 25% and 43% respectively of advanced bread and durum wheat lines were shown to be tolerant to BYDV.

Global analysis of 20 years of international irrigated yield trial data (ESWYT) identified four distinct macro-environments within the irrigated mega-environment (ME1). Publication submitted to refereed journal.

Global analysis of 8 years of international high rainfall yield trial data (HRWYT) identified four distinct macro-environments within the high rainfall mega-environment (ME2). Publication in preparation.

Distribution of elite high industrial quality germplasm expressing high yield and durable disease resistance to cooperators upon request (ME1IQ01 and ME2IQ01).

Advanced lines have been handed over to cooperators, are being evaluated for possible varietal release, or have been released or in various countries, including Mexico (Details in G1).

CIMMYT line Attila grown on more than 5 million ha in India under the name PBW343.

The four countries in the Indian Sub-continent released ten new varieties.

Four new lines identified with adaptation to bed-planting with reduced tillage, within a rice-wheat rotation system in the Indian Sub-continent.

Combined request by India for CIMMYT's international nurseries increased by 30% in the past three years.

A new more efficient breeding methodology was successfully adopted in Bangladesh.

On-farm adaptive research (Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB)) is being implemented on a small-scale in four countries.

Multiple interactions between G3 and R3: e.g. germplasm testing, variety by tillage studies in all four regional NARS, plus PVS and PPB.

East and Central Africa Wheat Improvement Nursery with germplasm from six regional cooperators distributed to nine countries in the region.

Nine new varieties released in Ethiopia, of which seven of CIMMYT origin.

A severe disease epidemic in Uruguay involving a complex of diseases including Septoria spp. and Fusarium head scab, allowed the identification of elite lines, including common wheats and primary synthetic wheats.

In Uruguay yields were higher under zero tillage than with normal tillage.

A computer module was developed (QUCIM) to simulate wheat breeding and selection processes, specific to CIMMYT. The selected bulk method of selection was shown to always be at least as effective in increasing genetic gain for yield in the Cd. Obregon-Toluca wheat breeding shuttle as the modified pedigree/bulk method. The simulation took into account selection based on ten plant traits, including disease response in the two selection sites. The lines emanating from the selected bulk method also represented a larger genetic diversity in crosses retained. Manuscript in preparation.

About 40 CIMMYT lines were released around the world as varieties.

Durum Wheat (Sub project 3; SPL: W. Pfeiffer)

New generation durum wheats show yield advantage over previous generation.

Rust resistant high yielding durum wheats have been identified, and are being used in crosses to accumulate resistance genes.

The newly released variety in Cd. Obregon Jupare C2001 is leaf rust resistant, outyields the commercial check by 8%, and has an improved SDS value (10%). Also internationally this line is widely adapted and superior under low, medium and high fertility conditions.

New rust resistant lines with improved pigment have been identified.

Advanced lines have been identified that represent top end-use quality traits.

New variety released in Ethiopia based on cross with CIMMYT germplasm.

About 30 CIMMYT lines were released around the world as varieties.

Triticale (Sub project 4; SPL: A. Hede)

Identification of advanced lines resistant to the recent new races of stripe rust in Toluca: 20-31% of all lines probably carry major genes and 7-15% are slow-rusting.

Intercrossing is ongoing between these sources to accumulate resistance genes.

Identification of high digestible dry matter lines, yielding twice as much as other crops used for that purpose (oats, rye, wheat, ryegrass).

Large-scale feeding trials with pigs are in progress in Mexico.

About 10 ICARDA/CIMMYT lines were released around the world as varieties.

Barley (Sub project 5; SPL: F. Capettini)

Germplasm with superior performance was identified.

A stronger focus is being given to malting quality and a reduced emphasis on quality for human consumption.

Agronomy (Sub project 6; SPL: K. Sayre)

Percent yield increase between the late 1960' s and the present for bread wheat and durum wheat is 51% and 45%, respectively.

In the ninth year of this long-term trial yields were higher on permanent beds with residues retained, with residues burned being the poorest yielding.

Retaining residues rather than removing them was particularly beneficial when only a reduced irrigation could be given rather than applying a full irrigation regime. This was due to N uptake by the plant being greater.

Good global performers in international trials could be more easily distinguished from poor international performers by growing them on beds (yield of 8278 kg/ha vs. 7986 kg/ha, or a 3.7% difference), than when planted on the flat (8191 kg/ha vs. 8233 kg/ha, or a –1% difference).

Use of a small sub-soil blade that allowed sub-soil tillage while maintaining the bed structure raised yields by 6% on average under fertilized conditions. This was due to improved N uptake by the plants.

Yellow berry in durum wheat was best controlled if N fertilization was mostly given at first node stage, or split across more than one date.

Planting two rows rather than three on a bed gave higher yields under fully irrigated conditions. The reverse was the case under reduced irrigation.

The past ten years has seen an annual yield increase in the Yaqui Valley of 183 kg/ha or 3.6%.

In El Batan maximum yields were obtained in wheat/maize rotation compared to a wheat-wheat system, if zero tillage was practiced and residues were retained. The worst scenario was also when wheat/maize was zero-tilled, but when residues were removed.

Analysis of remote sensing satellite images enabled the identification of wheat as a crop at a regional level (e.g. within a wheat growing district or valley). At the between-field level high, medium and poor yielding fields could be identified. Also within fields poor patches were distinguishable from good areas. Correlation between sensing data and real biological data ranged from 0.88-0.99. This may aid farmers in improving management practices to obtain optimum yields throughout their fields.

International Data (Sub project 7)

A more detailed global mega-environment map was developed covering all 12 mega-environments.

Within the Indian Subcontinent, the irrigated regions with a moderate temperature profile (ME1) and those with irrigation combined with elevated temperatures and low or high humidity (ME5) were mapped.

Hybrid Wheat (Sub project 10; SPL: K. Ammar)

Yield advantage up to 15% was confirmed.

It was also confirmed that good quality could be retrieved in the hybrid if at least one of the parents has good quality.

Good combiners within the female and male groups were identified.

With Genesis no longer available from Monsanto, the program is being fully redirected towards using the CMS/Rf system.

By 2003 46 high yielding widely adapted female lines converted to CMS and 24 fertility-restoring male lines will become available for international distribution.

Quality (J. Pena)

Increasing protein levels in all bread wheats is an aim that has a positive impact at many levels: increased gluten strength, adding value to products, longer shelf life, and better nutritional supplementation values.

Further refinements in the Mixograph technique using whole meal flour, protein fractionation, and improved testing conditions for better reproducibility. Better definition and interpretation of the Mixograph Type concept.

Further refinement/improvement of quality testing methodology permitted to increase quality-testing capabilities without increasing operational costs.

Glutenin sub-unit composition now also provided for elite advanced lines, besides parental stocks, improving significantly quality selection criteria.

Better understanding of diversity of LMW glutenins in bread wheat and durum wheat, better understanding of LMW-glutenin subunit composition and its relationship with gluten quality.

Diversity in LMW-glutenins in *T. tauschii* (work with D. Lafiandra). Work performed with synthetic wheat has reveled greater diversity in *T. tauschii* than in bread wheat. Quality effects associated to allelic variations are yet to be elucidated.

During 2001 approximately 4000 lines were tested.

Lines from high rainfall trials were evaluated for sprouting with the Falling Number test.

Sifted whole meal flour was found as reliable as refined flour to determine SDS sedimentation and yellow color in durum wheat.

Identification with breeder of elite quality lines for international distribution.

The hybrid wheat population (150 entries) was evaluated in relation to full quality attributes and glutenin composition.

The impact of agronomic practices (fertilization and planting methods) on quality expression and on quality stability of most promising bread wheat and durum wheat advanced lines was examined.

Interaction with CIMMYT Regional programs was considerable. Main support consists in delivering timely quality data of mainly parental lines. Quality classification and/or recommendations were provided and should help to identify germplasm with the best quality for the region.

References

During 2001 GP3 scientists published, submitted or have in press 21 articles in refereed journals, 34 articles, reports and presentations in non-refereed publications, seven book chapters, and four books, proceedings or official bulletins.

Publications in Refereed Journals

Ayala, L. M. Henry, M. van Ginkel, R.P. Singh, B. Keller and M. Khairallah. 2001 (submitted). Identification of QTLs for BYDV tolerance in bread wheat. Euphytica.

Ayala, L., M. Henry, D. Gonzalez-de-Leon, M. van Ginkel, A. Mujeeb-Kazi, B. Keller, and M. Khairallah.2001. A diagnostic molecular marker allowing the study of Th. intermedium-derived resistance to BYDV in bread wheat segregating populations. Theor Appl Genet 102 (2001) 6/7: 942-949.

Ayala, L., van Ginkel, M., Khairallah, M., Keller, B., and Henry, M. 2001. Expression of *Thinopyrum intermedium*-derived BYDV resistance in elite bread wheat backgrounds. Phytopathology 91(1):55-62.

Boru, G., M. van Ginkel, W.E. Kronstad, and L. Boersma. 2001. Expression and inheritance of tolerance to waterlogging stress in wheat. Euphytica 117(2):91-98.

Gaudet, D.A., Fuentes-Davila, G., De Pauw, R.M., and Burnett, P.A. 2001. Reactions of western Canadian spring wheat and triticale varieties to Tilletia indica, the causal agent of Karnal bunt. Canadian Journal of Plant Science 81:503-508.

Huerta-Espino, J., Skovmand, B. and Fuentes-Dávila, G. 2001. Incidence of common bunt (Tilletia laevis Kühn) on wheat landraces in Coahuila, Mexico. Revista Mexicana de Fitopatología 19:116.

Minale Liben and D.G. Tanner. 2001. An agronomic and economic analysis over six years of a wheat-based crop rotation trial in north-western Ethiopia. Ethiopian Journal of Natural Resources 3(2):195-218.

Maes, B., R.M. Trethowan, M.P. Reynolds, M. van Ginkel and B. Skovmand. 2001. The influence of glume pubescence on spikelet temperature of wheat under freezing conditions. Australian Journal of Plant Physiology 28(2):141-148.

Manske, G.G.B., J.I. Ortiz-Monasterio, M. van Ginkel, R.M. González, R.A. Fischer, S. Rajaram, and P.L.G. Vlek. 2001. Importance of P uptake efficiency vs. P utilization for wheat yield in acid and calcareous soils in Mexico. European Journal of Agronomy 14:261-274.

Manske, G.G.B., J.I. Ortiz-Monasterio R., M. van Ginkel, S. Rajaram E., and P. Vlek. 2001 (in press). Phosphorus use efficiency and root growth in tall, semi-dwarf and dwarf near-isogenic lines of spring wheat. Euphytica.

Manske, G.G.B., N. Tadesse, M. van Ginkel, M. Reynolds, and P.L.G. Vlek. 2001. Root morphology of wheat genotypes grown in residual moisture. Sustainable land use in deserts 2001: 400-404.

Pfluger, L.A.; Ovidio, R.D.; Margiotta, B.; Pena, R.J.; Mujeeb-Kazi, A.; Lafiandra, D. 2001. Characterization of high-and low-molecular weight glutenin subunits associated to the D genome of Aegilops tauschii in a collection of synthetic hexaploid wheats. Theoretical and Applied Genetics 103 (8):1293-1301.

Rajaram, S., Peña, R.J. Villareal, R.L., Mujeeb-Kazi, A Singh, R., and Gilchrist, L. 20001. Utilization of wild and cultivated emmer and of diploid wheat relatives in breeding. Israel J. of plant Sciences 49:S-93-S-104.

Rivera-Sánchez, M.P. y Fuentes-Dávila, G. 2001. Diversidad morfológica en la germinación de las teliosporas de Tilletia indica. Revista Mexicana de Fitopatología 19:110-115.

Asefa Taa, D.G. Tanner and A.T.P. Bennie. 2001. Effects of stubble management, tillage and cropping sequence on wheat crop performance in Ethiopia: II. Changes in soil penetration resistance. Ethiopian Journal of Natural Resources 3(1): 39-59.

Asefa Taa, D.G. Tanner and A.T.P. Bennie. 2002 (in press). Effects of stubble management, tillage and cropping sequence on wheat crop performance in Ethiopia: I. Changes in the severity of take-all and eyespot diseases. African Crop Science Journal 10(1).

Amsal Tarekegne and D.G. Tanner. 2001. Effects of fertilizer application on N and P uptake, recovery and use efficiency of bread wheat grown on two contrasting soil types in central Ethiopia. Ethiopian Journal of Natural Resources 3(2): 353-359.

Trethowan, R.M., J. Crossa, M. van Ginkel, and S. Rajaram. 2001. Relationships among bread wheat international yield testing locations in dry areas. Crop Science 41(5):1461 – 1469.

Trethowan, R.M., R.J. Pena, and M. van Ginkel. 2001. The effect of indirect tests for grain quality on the grain yield and industrial quality of bread wheat. Plant Breeding 120:1-4.

Trethowan, R.M., R.P. Singh, J. Huerta-Espino, J. Crossa, and M van Ginkel, 2001. Coleoptile length variation of near isogenic Rht lines of modern CIMMYT bread and durum wheat. Field Crops Research 70:167-176.

Van Ginkel, M., I. Ortiz-Monasterio, R. Trethowan, and E. Hernandez. 2001. Methodology for selecting segregating populations for improved N-use efficiency in bread wheat. Euphytica 119: 223-230.

Publications in Non-Refereed Media

Bechere, E.; Peña, R.J. 2000. Quality of Ethiopian durum wheat cultivars. Demissie Mitiku. p. 34-44. In: Regional Wheat Workshop for Eastern, Central and Southern Africa, 11; Addis Ababa (Ethiopia); 18-22 Sep 2000. Addis Ababa (Ethiopia): CIMMYT, Series: CIMMYT Regional Wheat Workshop for Eastern, Central and Southern Africa. No. 11

Bechere, E.; Peña, R.J.; Demissie Mitiku. 2001. Quality of Ethiopian durum wheat cultivars. Annual Wheat Newsletter 47 :47.

Borodanenko, A.; Ramírez Malagón, R.; Peña, R.J. 2000. Rendimiento y calidad de grano en dihaploides de trigo harinero (Triticum aestivum L.) In: Congreso Nacional de Fitogenética, 18. Memorias de las Notas Científicas; Irapuato, Guanajuato (México); 15-20 Oct 2000. Zavala García, F.; Ortega Paczka, R.; Mejía Contreras, J.A.; Benitez Riquelme, I.; Guillen Andrade, H. (eds.). Montecillo, Tex. (México): SOMEFI,

Braun, H.-J., T.S. Payne, M. Mergoum, M. van Ginkel, W.H. Pfeiffer and S. Rajaram. 2000. International Collaboration on Wheat Improvement. Pp. 125-136 In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9 June 2000, Budapest, Hungary. Z. Bedo, and L. Lang (eds.). Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Kluwer, Dordrecht.

Capettini, F. 2001. Building up Multiple Disease Resistance in Barley. Warren E. Kronstad Symposium, Ciudad Obregon, Mexico, March 15-17.

Capettini F. 2001. The ICARDA/CIMMYT barley breeding program. Invited presentation to the College of Agriculture, University of the Republic, Montevideo, Uruguay, July 12, 2001and to the Cereal Program, La Molina University, Lima, Peru, April 16, 2001.

Capettini F. 2001. Basis Of Resistance For Yellow Rust In Barley. First Regional Yellow Rust Conference for Central & West Asia and North Africa. SPII and ICARDA. Karaj, Iran, May 8-14, 2001.

Capettini F., W. M. Brown and V. R. Velazco. 2001. Occurrence and spread of barley yellow rust in the Americas. First Regional Yellow Rust Conference for Central & West Asia and North Africa. SPII and ICARDA. Karaj, Iran, May 8-14, 2001.

Capettini, F., H. Vivar, L. Gilchrist and M. Henry. 2001. Building Up Multiple Disease Resistance in Barley. First Regional Yellow Rust Conference for Central & West Asia and North Africa. SPII and ICARDA. Karaj, Iran, May 8-14, 2001.

Castro A., F. Capettini, A. Corey, T. Filichkin, P. Hayes, J.S. Sandoval-Islas, and H. Vivar. 2001. Stripe Rust Resistance QTL Pyramids In Barley. First Regional Yellow Rust Conference for Central & West Asia and North Africa. SPII and ICARDA. Karaj, Iran, May 8-14, 2001.

Ceccarelli, S., S. Grando and F. Capettini. 2001. Farmer Participation in the Barley Breeding Program of ICARDA. In International Conference about Future Strategies to Implement Participatory Breeding in the Highland Crops in the Andean Region, September 23-27, 2001, Quito, Ecuador.

Cukadar, B., J.R. Pena, and M. van Ginkel. 2001. Yield potential and bread-making quality of bread wheat hybrids produced at CIMMYT, using the chemical hybridizing agent, Genesis. Pp. 541-550 In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9 June 2000, Budapest, Hungary. Z. Bedo, and L. Lang (eds.). Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Kluwer, Dordrecht.

Fuentes-Dávila, G. 2001. Carbón Parcial: Perspectivas. En: Memorias del IV Congreso Internacional en Ciencias Agrícolas, 25 y 26 de Octubre de 2001. Universidad Autónoma de Baja California, Instituto de Ciencias Agrícolas. pp. 11-24.

Fuentes-Dávila, G., Rajaram, S. y van-Ginkel, M. 2001. La inoculación artificial: una herramienta eficiente para la selección de germoplasma resistente. XXVIII Congreso Nacional de la Sociedad Mexicana de Fitopatología. Querétaro, Querétaro, Julio 15-18, 2001. F-2.

Hayes P., F. Capettini, A. Castro, A. Corey, T. Filichkin, M. Johnston, C. Rossi, S. Sandoval-Islas, I. Vales, H. Vivar, and J. Vonzitzewitz. 2001. Collaborative Stripe Rust Resistance Gene Mapping And Deployment Efforts. First Regional Yellow Rust Conference for Central & West Asia and North Africa. SPII and ICARDA. Karaj, Iran, May 8-14, 2001.

Henry, M., L. Ayala, M. Khairallah, and M. van Ginkel. 2001. The use of molecular markers in selecting for resistance to Barley Yellow Dwarf Virus. Pp. 429-434 In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9 June 2000, Budapest, Hungary. Z. Bedo, and L. Lang (eds.). Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Kluwer, Dordrecht.

Henry, M., M. van Ginkel, and M. Khairallah. 2001. Marker-assisted selection for BYDV resistance in wheat. Pp. 41-44 In: CIMMYT. 2001. Research Highlights of the CIMMYT Wheat Program, 1999-2000. Mexico, D.F.

Maes, B., R.M. Trethowan, M. Reynolds, M. van Ginkel, and B. Skovmand. 2001. Glume pubescence and its influence on spikelet temperature of wheat under freezing conditions. Pp. 463-470 In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9 June 2000, Budapest, Hungary. Z. Bedo, and L. Lang (eds.). Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Kluwer, Dordrecht.

Nicol, J.M., R. Rivoal, R. Trethowan, M. van Ginkel, M. Mergoum, and R.P. Singh. 2000. CIMMYT's approach to identify and use resistance to nematodes and soil-borne fungi, in developing superior wheat germplasm. Pp. 381-390 In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9 June 2000, Budapest, Hungary. Z. Bedo, and L. Lang (eds.). Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Kluwer, Dordrecht.

Nicol, J.M., R. Rivoal, R.M. Trethowan, M. van Ginkel, M. Mergoum and R.P. Singh. 2001. A global approach to develop multiple disease resistant germplasm against soil-borne pathogens (nematodes – CCN and RLN) and rootrot (CR and CRR). In Proceedings of 2nd Soil-borne Disease Congress, Australia.

Peña, R. J. 2002. Contribución de las gluteninas (de alto y bajo peso molecular) y las gliadinas al mejoramiento de la calidad de trigo. In: En: Seminario Internacional sobre estrategias y metodologías utilizadas en el mejoramiento de trigo. Octubre 8-11, 2001. INIA-La Estanzuela, Uruguay. (In press)

Peña, R, J. 2002. Factores que afectan la calidad de trigo. En: 11o Curso Internacional de Actualización en Tecnología de Semillas. UAAAN, Octubre 24-26, 2001. Saltillo, Coah. Mexico. (in press).

Peña, R.J.; Trethowan, R.M.; Ginkel, M. Van. 2001. Bread wheat quality improvement at CIMMYT: Current and projected strategies. Conference Proceedings; Australia; 28-30 Aug 2001. In: Golden opportunities: An Australian and Chinese collaboration on wheat quality.

Pfeiffer, W.H., K.D. Sayre, T.S. Payne and M.P. Reynolds. 2001. Increasing durum wheat yield potential and yield stability. Poster presented at the Kronstad Symposion, Cd. Obregon, Sonora, Mexico, March 14-16, 2001.

Pfeiffer, W.H., K.D. Sayre, M.P. Reynolds and T.S. Payne. 2001. Increasing yield potential and yield stability in durum wheat. In Wheat in a Global Environment, International Wheat Conference, 6th, 5-9 June, 2000. Budapest, Hungary. Developments in Plant Breeding v. 9. Dordrecht, Kluwer Academic Publishers. p.569-577.

Pfluger L A., Peña, R.J. Mujeeb-Kazi, A. Lafiandra, D. 2001. Variability of low molecular weight glutenin subunits associated to the D genome of Ae. Tauschii in a collection of synthetic hexaploid wheats. In: 4th International Triticeae Symposium. September 10-12, Cordoba, Spain. (In press)

Reynolds, M.P., B. Skovmand, R.M. Trethowan, R.P. Singh, and M. van Ginkel. 2001. Applying physiological strategies to wheat breeding. Pp. 49-56 In: CIMMYT. 2001. Research Highlights of the CIMMYT Wheat Program, 1999-2000. Mexico, D.F.

Sayre, K.D., K.W. Freeman, M.P. Reynolds, A.R. Klatt, W.E. Thomason, M. van Ginkel, R.W. Mullen and W.R. Raun. 2001. Prediction of spring and winter wheat grain yields using indirect measures. ASA, CSSA, SSSA Meetings. USA.

Sorkhilalehloo, B., J. P. Tewari, T. K. Turkington, F. Capettini, K. G. Briggs, B. Rossnagel, and R. P. Singh. 2000. Slow-scalding in some western Canadian barley cultivars. Durable disease resistance symposium. Wageningen, Holland, 2000.

Sorkhilalehloo B., J. P. Tewari, T. K. Turkington, F. Capettini, K. G. Briggs, B. Rossnagel, R. P. Singh. 2001. Genetics of Slow-Scalding Resistance in Barley. Annual Meeting of the Plant Pathology Society of Alberta, Waterton National Park, AB, Canada. November 7-9, 2001.

Trethowan, R.M., R.J. Pena, and M. van Ginkel. 2000. Breeding for grain quality: a manipulation of gene frequency. Pp. 263-272 In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9 June 2000, Budapest, Hungary. Z. Bedo, and L. Lang (eds.). Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Kluwer, Dordrecht.

Van Ginkel, M., and L. Gilchrist. 2001. New bread wheats for high rainfall environments: The package. Pp. 8-12 In: CIMMYT. 2001. Research Highlights of the CIMMYT Wheat Program, 1999-2000. Mexico, D.F.

Van Ginkel, M., I. Ortiz-Monasterio, R. Trethowan, and E. Hernandez. 2001. Methodology for selecting segregating populations for improved N-use efficiency in bread wheat. Abstract. Pp. 611-620 In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9 June 2000, Budapest, Hungary. Z. Bedo, and L. Lang (eds.). Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvasar, Hungary. Kluwer, Dordrecht.

White, J.W., M. Van Ginkel, S. Rajaram, and J.D. Corbett. 2001 A GIS-Based Approach to Revising CIMMYT's Wheat Megaenvironment Classification. ASA, CSSA, SSSA Meetings. USA.

Book Chapters

Ortiz-Monasterio, I., G.G.B. Manske, and M. van Ginkel. 2001. Nitrogen and phosphorus use efficiency. Pp. 200-207 In: Application of Physiology in Wheat Breeding. 2000. Reynolds, M. P., J. I. Ortiz-Monasterio, and A. McNab (eds.). Mexico, D.F.: CIMMYT.

Pena, R.J. R. Trethowan W. Pfeiffer, and M. van Ginkel. 2002 (in press). End-Use Quality in Wheat: Compositional, Genetic, and Environmental Aspects of Quality Improvement. Journal of Crop Production (special issue: Quality Improvement in Crops).

Pfeiffer, W.H., K.D. Sayre, and T.S. Payne. 2001. Increasing Durum Wheat Yield Potential and Yield Stability. Research Highlights of the CIMMYT Wheat Program. CIMMYT, Mexico. p. 17-20

Rajaram, S., N.E. Borlaug and M. van Ginkel. 2001 (in press). International wheat breeding approaches to high yield, wide adaptation, and stable performance. FAO Wheat Book.

Rajaram, S., and M. van Ginkel. 2001. Mexico, 50 years of International Wheat Breeding. Pp. 579-608 (chapter 22) in: The World Wheat Book, A History of Wheat Breeding. A.P. Bonjean and W.J. Angus (eds.). Lavoisier Publishing, Paris.

Reynolds, M.P. R.T. Trethowan, M. van Ginkel, and S. Rajaram, 2001. Application of Physiology in Wheat Breeding. Pp. 2-10 In: Eds. Reynolds, M.P., J.I. Ortiz-Monasterio, A. McNab (eds.). Application of Physiology in Wheat Breeding. Mexico, D.F.: CIMMYT.

Samad, A., C.A. Meisner, M. Saifuzzaman, and M. van Ginkel. 2001. Waterlogging tolerance. Pp 136-144 In: Application of Physiology in Wheat Breeding. 2000. Reynolds, M. P., J.I. Ortiz-Monasterio, and A. McNab (eds.). Mexico, D.F.: CIMMYT.

Books, Proceedings and Official Bulletins

Bekele Hundie Kotu, H. Verkuijl, W. Mwangi and D.G. Tanner. 2000. Adoption of Improved Wheat Technologies in Adaba and Dodola Woredas of the Bale Highlands, Ethiopia. Mexico, D.F.: CIMMYT and EARO. 26 p.

Tesfaye Zegeye, Girma Taye, D. Tanner, H. Verkuijl, Aklilu Agidie and W. Mwangi. 2001. Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-Scale Farmers in Yelmana Densa and Farta Districts of North-Western Ethiopia. Mexico, D.F.: EARO and CIMMYT. 39 p.

Van Ginkel, M., R. Trethowan, K. Ammar, J. Wang and M. Lillemo. 2002. Guide to Bread Wheat Breeding at CIMMYT. CIMMYT. Mexico. CIMMYT Wheat Special Report No. 5. (revision) 52 pp.

White, J.W., D.G. Tanner and J.D. Corbett. 2001. An Agro-Climatological Characterization of Bread Wheat Production Areas in Ethiopia. NRG-GIS Series 01-01. Mexico, D.F.: CIMMYT. 14 p.

CIMMYT Project Week 2002

Global Project 4

Maize for sustainable production in stressed environments

Project Coordinator: M. Banziger

Oversight Director: S. Pandey

Activities	Milestones 2001-2003	Progress Report 2001
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).	• Revised definition of maize mega-environments at the global level. • Africa Maize Research Atlas (data on climate, soil, elevation, land use, population, nutrition, and maize production compiled at the continental level) made available in a user-friendly manner to researchers. • Country Almanacs developed for 10 countries in sub-Saharan Africa. • Similarities of maize growing environments in sub-Saharan Africa and Latin America established for more effective use of Latin American maize genetic resources in Africa. • Through collaboration with other institutions, better access to improved geo-referenced soils and maize distribution information.	• A Global Maize Research Atlas has been developed including three CDs covering Africa, Asia and Latin America. This compendium includes spatial data relevant to agricultural scientists such as climate, soils, landuse, elevation, maize mega-environments, climate similarity maps for key maize sites, CIMMYT international maize trial locations etc.
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).	• Standard maize nurseries for identifying the presence and variability of pathogens and insects developed and distributed to collaborators, who return geo-referenced site data. • Hot spots for disease and insect stress identified; similarity maps for those sites developed. • Survey completed of major insect pests of maize, based on published reports and information from local experts. • Survey completed on pathogen diversity of the corn stunt	• Maize nurseries continue to be distributed to hotspots in southern and eastern Africa, Asia and South America targeting specifically MSV, GLS, E.turc. P.sorg, head smut, DMR and stem borers (Africa); DMR, BLSB, E. turc., stalk rots, stem borers (Asia); acid soils, army worm, phaeosphaeria leaf spot, polysora rust, corn stunt and sugarcane mosaic virus (South

	complex, *Cercospora zea-maydis, Exserohilum turcicum, Puccinia sorghi,* maize streak virus, downy mildews. • Improved quantification of losses from stem borer damage in selected ecologies.	America). • Losses due to stem borer damage have been quantified for several maize ecologies in Kenya
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).	• Relationship between promising physiological mechanismis and tolerance/resistance to abiotic and biotic stress factors established. • Relationship established 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). • Inheritance studies completed in relevant germplasm for mechanisms that confer tolerance/ resistance to drought, low soil N, acid soil/low pH, suboptimal temperatures, E. turcicum, C. zea-maydis, P. sorghi, downy mildews, corn stunt complex, Rhizoctonia solani, and Physopella zeae. • Quantitative trait loci (QTLs) identified in relevant germplasm for mechanisms that confer tolerance/resistance to drought, low soil N, low soil pH/Al toxicity, low soil P, suboptimal temperatures, Busseola fusca, Chilo partellus, E. turcicum, C. zea-maydis maize streak virus, downy mildews, Fusarium moniliforme. • QTLs identified that are related to drought tolerance and are stable across maize materials. • Significant progress towards identifying and isolating genes and physiological pathways of traits associated with drought tolerance; options for following a candidate gene approach and for functional genomics explored for one additional stress tolerance	• F3's of two molecular mapping populations are being evaluated for resistance to Mal de Rio Cuarto Virus • In collaboration with the University of Ottawa, a molecular map for the simple phenolics and their cross-linking dimmers in the epidermal cell wall have identified 4 stable QTLs which overlap with armyworm and stem borer QTLs. • Collaboration with the University of Ottawa and Agriculture Canada has resulted in the transfer of the wheat gene (Germin), coding for oxalate oxidase, into maize. This enzyme generates H_2O_2 from calcium oxalte. Transformed lines show a two-fold higher level of H_2O_2 and a high level of resistance to stemborers. • Significant correlations were obtained between silk ABA, ASI, ear number and grain yield under drought. This may be a new step in the understanding of the genetic basis for drought tolerance in tropical maize. • Transfer of five genomic regions involved in the expression of a short ASI from Ac7643 into CML247 has been completed in 2001. A few conversions crossed to CML254 and CML274 performed significantly better compared to the controls

	/resistance mechanism. • Twenty publications in referred journals. • Fifty contributions to scientific conferences	across six water-limited trials. No yield reduction was observed under well-watered conditions. • Inheritance studies have been conducted for DMR with variable results. Resistance was found to be controlled by dominant and resistant genes
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).	• Cost-effectiveness of marker-assisted selection (MAS) compared to conventional selection for stress tolerance/resistance mechanisms where QTLs have been identified, and cost-effective strategies implemented in breeding programs of G2. • Application of MAS strategies to improve resistance/tolerance of selected germplasm to drought, downy mildews, maize streak virus, *B. fusca*, *C. partellus*, and. *F. moniliforme.* • Routine identification of genotypes presenting high and moderated resistance to maize streak virus using molecular markers. • Develop and disseminate user-friendly statistical design and data analysis and management techniques that improve efficiency of maize breeding programs by 30%. • Selection for leaf toughness implemented in selected breeding programs of G2, enabling selection for multiple borer resistance where insect rearing is not possible. • Cost-effective methods developed for testing cultivars at the release stage in a manner that better considers stress environments and preferences of resource-poor farmers.	• Key regions with clusters of genes related to drought tolerance in maize have been identified. This will facilitate marker-assisted selection without mapping the QTL in a target cross. MAS will be implemented in four elite-by-elite crosses targeted at southern Africa. • Leaf toughness measurements were used to make the final selection of lines going into the development of stem borer synthetics in the subtropical program and in Kenya (IRMA). • Mass rearing capacity developed in Kenya for rearing stem borers and for weevil screening. • Collaborative activities were initiated with R. Brown, USDA-ARS in New Orleans to begin the evaluation of CIMMYT elite germplasm for resistance to *Aspergillus flavus* and the production of aflatoxin. • Artificial downy mildew inoculation technique in pots as opposed to field has been perfected. A number of techniques were tried but soaking of seed in spore suspension consistently gave the best results. The pot evaluation technique for DM has special advantages as it permits evaluation of materials all the year

		around. • ·A new location (Menegua) was identified in the Colombian acid soil savanna where evaluation and selection of acid soil tolerance is done including low P levels. P levels were adjusted to 3 and 15 ppm and 55% aluminum saturation. The site is being used for low P screening and inheritance studies.
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 lowlans; highlands; and subtropics) (contributes to output 3).	• Thirty synthetics or open-pollinated varieties and 250 inbred lines recommended to national research programs because of relevant/superior tolerance/resistance in adapted genetic background. • Mapped genetic sources with highest stress tolerance/resistance available for drought, low soil N, low soil pH/Al toxicity, low soil P, *Spodoptera frugiperda*, *Diatrea* sp., *B. fusca*, *C. partellus*, *E. turcicum*, *C. zea-maydis* maize streak virus, downy mildews, *F. moniliforme.*	• Among 135 early lines, 9 lines resistant to FAW, 21 resistant to *Fusarium moniliforme*, and 28 tolerant to low N were identified. • A set of 14 new lines tolerant to DM have been submitted and proposed for announcement during 2001 • Six QPM lines were found to have moderate DM resistance. • Three subtropical inbreds were found to be resistant to both Maize Dwarf Mosaic Virus (MDMV-A) and Sugarcane Mosaic Virus (SCMV-B). • Eight inbreds continued to show high resistance to Mal de Rio Cuarto Virus after evaluation in Argentina, among them CML 255, CML 84 and CML 199 • 10 highland lines with resistance to the maize Bushy Stunt phytoplasma were identified. • Sources for *F. moniliforme* and *S. maydis* ear rot resistance have been identified in elite line trials. A few (QPM and normal) lines were resistant to both ear rot pathogens. • More than 200 inbred lines

		with resistance to stem borers have been incorporated into CIMMYTs lowland tropcial, sub-tropical Kenyan, Columbian and Asian breeding programs.
		• 10 single-crosses with higher yield and less stunt than the three-way hybrid HN 991 released in Nicaragua were identified.
		• Outstanding DM resistant hybrids are grown in demonstrations at 35 sites in several Asian countries
		• Two single and two three-way crosses based on elite advanced highland lines out-yielded the best check by 45 to 53% under low N. One line is common to all these hybrids (BTVC.BA90-5).
		• The two stress breeding projects in eastern and southern Africa continue to produce top-performing hybrids and OPVs as revealed by regional trials.
		• The following experimental synthetics were developed:
		  • 11 highland synthetics including resistance to common rust, *turcicum* leaf blight, *F. moniliforme* ear rot and Stewart's wilt
		  • Several transition zone synthetics with resistance to GLS
		  • 15 subtropical synthetics with resistance to GLS and *F. graminearum/ F. moniliforme* stalk rots
		  • Six synthetics resistant to ear rot, FAW and tolerant to drought and low N
		• Three synthetics SINITS1 (resistant to insects), S97TLW"AB"(2) (yield

		stability), and S99TLWBNS(2) (tolerant to low-N and drought) were evaluated in on-farm trials in Central America. They yielded up to 30% more than the best checks on farmer's fields. • T he Highland Late Yellow Synthetic-2 out-yielded the experimental variety check Batan 8988 by 16%, and Batan 8987 by 42% under low N • A new generation of stress tolerant OPVs for southern Africa has shown further yield increases of 10% over the current elite stress tolerant synthetics (ZM421, ZM521 and ZM621). • Incorporation of MSV resistance, drought and low N tolerances into extra-early germplasm (Populations 401 and 402) and QPM germplasm has been initiated. • Drought and N stress tolerant OPVs (ZM421, ZM521, ZM621) have been released in several southern African countries, and the seed has become commercially available.
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.	• A reference collection of arthropods of major maize growing regions in Kenya has been established to serve as a technical reference while studying target and non-target effects during the monitoring phase of the IRMA project in Bt-maize fields. *C. partellus* and *B. fusca* were the most abundant stem borers • A study at CIMMYT's biosafety greenhouse in Mexico showed that Bt maize is enhancing the efficiency of a parasitic

		wasp in controlling the armyworm even though the Bt maize is not directly controlling the armyworm pest. • In developing appropriate insect resistance management strategies for Bt maize in Kenya, Columbus and Sudan grasses were found the most effective refugia for *C. partellus* and *B. fusca*, and sorghum was the best host for *Chilo* and *Busseola*,
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).	• Cultivar x management practices evaluated 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 nitrogen 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). • Global scientific workshop on approaches that achieve increased, more stable, and sustainable maize production in the presence of abiotic and biotic stresses.	• Germplasm selected for N stress tolerance showed higher efficiency in using small amounts of fertilizer applications in on-farm trials in Zimbabwe
8. Provide partners with easily accessible information on stress-tolerant maize germplasm and molecular information (in collaboration with G2) (contributes to output 5).	• Regional and global trials and networks used 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,	• Vivek, B., M. Bänziger, and K.V. Pixley. 2001. Characterization of maize germplasm grown in eastern and southern Africa: Results of the 2000 regional trials coordinated by CIMMYT. Harare, Zimbabwe. CIMMYT. 56 pp.

	if possible as well from NARSs.	
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).	• Training material/technical reports developed that document: 1) proven breeding techniques for selecting maize tolerant to drought, low N, and 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) use of improved statistical design and analysis techniques for trials executed under the complex and difficult conditions of stress environments; and 5) options for farmer participatory variety selection in stress environments. • Revised 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.	• Tutorial developed for analyzing Mother-Baby trials using ASREML, a spatial data analysis package
10. Train maize scientists in technologies that increase maize productivity and sustainability in stress environments (in collaboration with G8) (contributes to output 6).	• Two hundred and fifty national scientists trained in the use of GIS data, resulting in more appropriate planning and execution of agricultural research projects and in increased collaboration across country boundaries. • One hundred and fifty NARS scientists trained 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). • Fifteen PhD/MSc students finishing their thesis on subjects related to increasing maize productivity and sustainability in	• 23 maize scientists from southern Africa trained in using spatial analysis for stress trials • One field tour conducted with 37 scientists and extension staff from southern Africa visiting trials that evaluate stress tolerant maize varieties with farmers in southern Africa • 13 visiting scientists from southern Africa trained in aspects of stress breeding • One PhD student and one MSc student completed their thesis in collaboration with the entomology program

	stress environments	
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).	• Regionally accessible sites established 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. • National research programs supported in use of artificial inoculation or infestation techniques for screening regionally relevant germplasm.	• In collaboration with DOA, Thailand, early and late inbreds as well as hybrids were evaluated for different abiotic stresses such as drought, low-N, water logging and high density. The trials were jointly constituted by CIMMYT and DOA and had entries from both institutions.

Partnerships

G4 is a project with high levels of partnerships. Most - if not all - research activities are being conducted in collaboration with advanced research institutes, NARS and/or other CG centers. Collaboration with the private sector, particularly in the area of genomics, has been developed.

Project team interactions

No formal project team meeting has been conducted over the past year mainly due to the global distribution of project members. Project team interactions are active and effective in the various sub-projects

1. Improved characterization of maize growing environments: Bänziger, Bergvinson, De Groote, Diallo, Hodson, Jeffers, Twumasi, White
2. Acid and P-deficient soils: Bänziger, De Leon, Friesen, Narro, Pandey, Ribaut, Vasal.
3. Drought and low N tolerance: Bänziger, Beck, Bergvinson, Bolaños, Cordova, De Meyer, Diallo, Gonzalez, Jardinaud, Kirbui, Mugo, Ribaut, Srinivasan, Twumasi, Vasal, Vivek.
4. Insect resistance: Bergvinson, Cordova, De Leon, Diallo, Gonzalez, Mugo, Narro, Srinivasan, Vasal,
5. Disease resistance: De Leon, Diallo, Gonzalez, Jeffers, Narro, Pixley, Ribaut, Twumasi, Vasal, Vivek.
6. Maize production systems for stress environments: Bänziger, Bergvinson, De Groote, De Meyer, Friesen, Waddington.

Evidence of project impact

Most project impact continues to be through links with G2 and regional projects (e.g. application of selection methodologies that result in stress tolerant maize germplasm). G4 research activities are balanced with capacity building and training activities (in-service and formal).
While good information on new methodologies and growing environments has become available, there continues to be a need for more easily accessible and structured information on germplasm sources.

Resourcing issues, constraints and opportunities

- Financial constraints are especially evident for core-supported G4 components.
- Continued funding was obtained for the Africa Maize Stress Project
- The position of the maize physiologist has become vacant.
- Continued attention should be given to have support to pathology, entomology, physiology and the GIS lab built into future special projects (full costing).

Global Project 5:

Wheat for Sustainable Production in Marginal Environments

Project Coordinator: W. Pfeiffer

Oversight Director: S. Rajaram

G5 Accomplishments 2001

Various G5 key achievements are listed below. Collaborations with NARS are reported by Regional Projects. Publications pertinent to G5 are attached.

Major Impact:

- Variety releases: > 50 bread wheat, durum wheat, and triticale varieties have been released during the 2000-2001 period. Target areas for the majority of these varieties include abiotic stress environments.
- CIMMYT team award for Excellence in Drought Research received in December 2001.

SP1: Development of drought tolerant wheat and triticale germplasm.

- Moisture stress simulation experiments for bread wheat, durum wheat and triticale indicate that high rates of genetic progress are being achieved based on the genetic variation present in our core breeding populations. Testing expanded to identify genotypes with input-efficiency and input responsiveness.
- More than 600 advanced lines and 200 early generation germplasm populations (bread wheat, durum and triticale) adapted to abiotic stressed conditions have been disseminated to more than 100 collaborators in developing countries by the International Wheat Improvement Network.
- Bread wheat advanced lines derived from synthetic hexaploids, and bread x durum introgression out performed germplasm from conventional bread wheat crosses under drought.
- New hexaploid synthetic derivatives were identified with grain yield equal to, and higher total biomass, relative to the recurrent parent, under moisture stress.
- Improved rapid ground cover and early prostrate growth in synthetic derivatives confirmed and tested at various sowing depths. Significant advantage recorded at all sowing depths for vigorous material.
- Drought tolerant materials identified by SP4 used to form a "physiology crossing block" and used in directed crosses.
- Bread wheat germplasm for Kazakhstan has been developed via shuttle-breeding and tested in ME6. Durum wheat germplasm developed and distributed.
- Triticale moisture stress screening in large farmer plots started with Menonite groups in Northern Mexico. First year results demonstrated triticale biomass production up to 2.5

times as high as the traditional forage crop oats. Oat area planted approx. 200,000 ha/year depending on precipitation.

- Forage triticale lines with superior biomass production and adapted to the Mexican Central High Plateau identified through multilocation planting of triticale trials on farmer fields in collaboration with local NARS.
- Triticale drought screening expanded to Portugal for grazing/forage and facultative types – NARS Portugal provides the link to North Africa. In Southern Ecuador, the Saraguaro project was established to promote triticale for human consumption. In Northern Ecuador a project for animal feed/forage in a farmer participatory approach was initiated.
- Large scale triticale promotion in the Mexican Central High Plateau and Northern Mexico involving germplasm development, testing, seed multiplication, and extension in collaboration with farmers organizations and NARS.
- Fourth and final year of the G5 strategic drought simulation trial (including bread wheat, durum wheat and triticale) under ME4A, ME4B, ME4C and non-stress treatments using drip and gravity fed irrigation plus late sowing heat combinations. Results exhibit genetic differences in specific and broad adaptation to different drought scenarios.
- Two-year drip irrigation results confirm that various drought scenarios can be accurately simulated. High levels of water use efficiency in non-stress treatments noted. General and specific adaptation to various stress treatments observed. Large crop x stress treatment interactions validated.
- Improved end-use quality, drought tolerance, disease resistant bread wheat, durum wheat, and triticale lines identified/developed. Use of low molecular weight glutenin information in crosses. Use of mixographic properties and sifted flour to enhance evaluation of dough and semolina.
- Increased selection pressure for quality in durum for gluten strength and yellow pigment in developing top export-quality germplasm (for pasta) high quality of local products (couscous and breads).
- HMWG and LMWG combinations in BW were identified in advanced ME4 and ME5 lines. Data used in selection and design of crosses. Superior quality lines identified.
- Quality selection pressure/quality-monitoring was applied for bread wheat at stages in germplasm development (early-, medium-, and late-advanced) during 2001.
- Further refinements in the single-gel electrophoretic technique resulted in increased understanding of "good" and "poor" LMWG subunit blocks allelic variation in BW.
- Best performing synthetic hexaploids yielded higher biomass and specific grain weight compared to checks Baviacora 92 and Dharwar Dry in moisture stressed experiments.
- Similarities/selection ability among global moisture stress test sites and Mexican test environments via analysis of multi site/year international yield trial data expanded to durum wheat. Status of adaptation to target areas in the NARS investigated. Triticale in process.
- Results for bread and durum wheat using up to 20 years of data revealed that progress in yield was greatest in low yielding environments.
- Enhanced knowledge on causal effects of GxE from analysis of global international nursery and Mexican test sites data. Heritability and correlation with key drought affected wheat growing areas was greatest for Mexican sites.
- Breeding and testing methodology to accommodate parallel enhancement of input-efficiency and input-responsiveness now implemented.

- Development of semi-dwarf bread wheat germplasm adapted to drought, early vigor and improve stand establishment (coleoptile characteristics) through use of *Rht8*. Diagnostic marker for Rht8 in use.
- The wide crosses program screened germplasm for drought and developed new materials. The program stabilized breeders germplasm, distributed germplasm, registered germplasm and developed mapping populations.
- Molecular markers routinely used in applied bread wheat breeding to incorporate resistance for cereal cyst nematodes (Cre1 and Cre3). Cre1 gene transferred to durum.
- A crown rot marker for resistance source 2.49 obtained and under evaluation.
- Molecular characterization (fingerprinting) of elite durum and bread wheat that is drought adapted continues to exploit heterotic groups in generating tactical genetic variation.
- The 5 SH/Opata F1 based mapping populations comprising 100 DH's/population were seed increased in 2001 for use in phenotyping and genotyping studies during 2002/2003.
- A sub-set of 23 SH's has been assembled and characterized as drought tolerant. Its phenology descriptors are in place and DNA extracted for evaluating DNA polymorphisms based upon D genome microsatellites.
- The intergeneric combination of wheat/ *Th. bessarabicum* that is highly salt tolerant has been the basis of a cytogenetic manipulation study for producing new wheat/alien chromosome translocations. The alien species also has a spill over effect for the G6 project and end-products from this activity can serve the relevant biotic stress objective associated with *Th. bessarabicum* i.e. Head scab. So far 34 wheat/alien translocations have been identified and their stability is in progress.
- Development of Kazakhstan Siberia Network on Spring Wheat Improvement (KASIB). The network was formalized in 2001 and comprises 14 programs. Two regional nurseries distributed and data obtained used to direct crossing and breeding strategy for drought prone environs. The nurseries served as a vehicle for the regional germplasm exchange.
- Bread wheat germplasm resulting from the Kazakh x Mexican crosses selected in Mexico under extended light were tested in Kazakh conditions and proved that type resembles local varieties with resistance to major diseases. Adaptation and drought tolerance will be evaluated next year through multilocational testing.
- First year of zero tillage experiments conducted in Karagandy and Akmola regions of Northern Kazakhstan enabled conclusions about possible options for fallow management, green manure, nitrogen application under zero and conventional tillage, herbicide selection. Experiments will continue in 2002.

SP2: Development of wheat and triticale germplasm tolerant to temperature extremes.

- New genetic stocks exhibiting high levels of heat tolerance for bread wheat, durum wheat, and triticale were identified.
- Genotypes (>100) combining high temperature tolerance with drought tolerance and value-added traits have been disseminated via international yield and screening nurseries.
- Expanded testing of synthetically derived populations to combine tolerance to heat and drought. Higher anthesis biomass confirmed. New initiative in conventional breeding to combine drought and heat tolerance.

- Fourth year of G5 strategic trial planting under heat. G5 International Adaptation Trial (IAT) planted under heat. Both trials aim to enhance selection efficiency and relevance to heat affected areas globally.

SP3: Development of germplasm and production strategies adapted to pH extremes and related nutrient stresses.

- Soil maps developed for blocks 710 and 810 now used by breeding programs to spatially arrange breeding nurseries and trials to avoid heterogeneity for sub-soil salinity, sodicity, trace element concentrations and highly variable soil texture
- Second year assessment of ITSON test site for salinity research in the Yaqui Valley based on soil maps.
- Investigation of water and nitrogen input use efficiency for bread wheat, durum wheat and triticale.
- Study on the effect of hostile sub-soils (saline and sodic) on grain yield at the Cd. Obregon station under irrigated and drought conditions in third year. Data across two years reveals yield reduction of 10% under irrigation and 28% under moisture stress.
- Third year of phosphorus efficiency studied at zero and optimal levels revealing significant differences among genotypes.
- Evaluation of boron tolerance in a historical set of bread and durum wheats and 40 synthetics completed and results published in BSc thesis. High yielding boron tolerant progenitors identified. Tolerance of Lr19 near-isogenics to boron toxicity under investigation.
- Germplasm for salinity tolerance developed and screened by the wide crosses program. Implementation of new protocols.
- Exploration of the potential use of remote sensing to diagnose salinity problems in wheat fields. Preliminary results from Block 810 show close association between grain yields estimated from satellite images and salinity and sodicity from soil mapping.
- Expansion of soil mapping to Toluca station in progress.
- Two salinity tolerant synthetic hexaploids are being used for the development of molecular mapping populations of 125 DH's/population based upon their F1's with Oasis (Susceptible bread wheat). This collaborative study with UABCS, LaPaz (Dr JL De Leon) has been granted CONACYT support for 3 years from June 2002.

SP4: Establish physiological and genetic basis for abiotic stress tolerance to develop efficient selection methodologies.

- Physiological basis of superior drought tolerance of synthetic derived bread wheats evaluated. Important factors included greater moisture extraction and root density (especially at 30-60cm depth) and cooler canopies (Ph.D thesis of Stacey Copland)
- Physiological traits of germplasm in the drip-strategic trial evaluated.
- Fingerprinting of 'Lucy-Sonoito' lines completed.
- Accessions obtained from the Germplasm Bank (e.g. *T. Dicoccum*) for stress tolerance (in collaboration with G1) now used in pre-breeding.
- An historic cultivar set for quantifying progress under drought underway.
- Physiological characterization of key progenitors. Information now used to design crosses.

- Populations now being developed based on extremes of expression of key physiological characters (osmotic adjustment, soluble stem carbohydrates, CTD, and biomass at anthesis) for divergent selection to determine impact of these characters under drought.
- Pre-breeding program initiated for new sources of genetic diversity with stress tolerance and/or physiological traits associated with stress tolerance.
- Physiological characterization of germplasm developed under deep sowing.
- Screening of germplasm bank accessions for stress associated traits ongoing (in collaboration with G1).
- Heat tolerant *T. dicoccums* now utilized for production of synthetics.
- Drought indicator genotypes disseminated to breeding programs.
- Effect of foliar zinc application on tissue micronutrient status - interaction of drought with zinc availability was completed.
- Bulk segregant analysis (BSA) for drought tolerance traits (Seri/Babbax population) based on confirmation of extremes in expression among 168 recombinant inbred lines. Traits analysed: CTD am and pm and Chlorophyll content, osmotic potential, agronomic components under extreme drought, reduced irrigation and irrigated conditions. (Ph.D thesis of Juan Jose Olivares)
- SR/NDVI for rapid evaluation of stress traits; screening of 200 primary synthetics under drought.
- Carbon isotope discrimination (Δ) of mature kernel in G5 drip trial revealed significant correlations with grain yield under ME4A (r = 0.88***), ME4B (r = 0.58**) and ME4C (r = 0.50*).
- 7DL.7Ag lines associated with yield reduction under drought; in other environments translocation effects were nil or negative when yield was less than 3 t ha-1. No difference was found for carbon isotope discrimination between *7DL.7Ag* and *7DL*, suggesting no difference in stomatal conductance. (work of visiting scientists P. Monneveaux)
- Synthetic derivatives and bread wheats were compared under drought in Tlaltizapan and , Cd. Obregon. Bread wheat had higher chlorophyll and photochemical quenching (qP) than synthetic derivatives. Within the derivatives, yield correlated with PSII (quantum yield) and grain carbon isotope discrimination (r = 0.71**) but synthetic derivatives and bread wheats did not differ significantly. (work of visiting scientists P. Monneveaux)

SP5: Development and dissemination of sustainable crop and resource management strategies to increase productivity and stability of rainfed wheat and triticale systems (RFWTS).

- Long-term trials in the Mexican Central High Plateau confirmed advantages of reduced/zero tillage in combination with residue retention.
- Analysis of 10 years of results from the Long-Term Sustainability Trial in El Batan 2000 show the highest yields of both wheat and maize when the two crops are rotated, all residues are retained and the crops seeded without tillage. This treatment has consistently been among the highest yielding treatments of both crops in all years over the 10-yr. period.
- Small farmers use crop residues of both wheat and maize for fodder. Previous results have shown high forage yields of both triticale and hooded barley, suggesting that these treatments can provide important, alternative sources of strategic, high quality fodder allowing small farmers to retain larger amounts of maize and wheat residues in fields. In

2001, the triticale crop suffered from a yellow rust epidemic, whereas the hooded barley again gave excellent forage yields.

- Recently analysed results of soil moisture measured with a neutron probe during the extremely dry winter of 1998 in eastern Bolivia show the clear benefits of both zero tillage and crop rotation in soil water accumulation. With 32 mm of rain during the crop season, 0.5 ha plots with zero tillage and crop rotation yielded 950 kg/ha while with vertical or conventional tillage without crop rotation yields were 510 kg/ha.
- Continuing analysis of the effects of moisture stored in the soil profile at seeding on crop yields in lowland Bolivia continued with the analysis of results from farmer's commercial crops. Only small effects were found with winter crops, including wheat, as farmers tend to seed directly after the summer harvest. However, major effects on the summer crops in the rotation were found. One hundred millimeters of moisture stored in the profile at seeding gave a yield advantage in soyabeans of 900 kg/ha and in maize of over 3.5 t/ha.
- Appropriate nutrient management: An analysis of results from demonstration and validation plots in farmers' fields in each of three years in the inter-andean valleys of Bolivia have shown that the fertilizer level of 32-23-0 (N-P2O5-K20), equivalent to one bag of amonium diphosphate and one bag of urea per hectare, give optimum yield increases, with an average marginal rate of return well above 100%.
- The small-grain no-till seeder for animal traction developed in Bolivia has undergone another series of modifications based on farmer participatory evaluation, and 15 of the new model have been distributed in the wheat growing areas. Commercial production of the machine is now in progress and the first machines sold to farmers not associated directly with the wheat program.
- A video in both Spanish and Quechua has been produced on "How to grow wheat in the valleys of Bolivia". The video covers land preparation, residue cover, live barriers for erosion control, seeding methods, varieties, weed control and crop fertilization.
- Regional Wheat Breeder's Trials in Santa Cruz were seeded under no-till conditions in an effort to ensure that future varieties are adapted to these conditions.
- Planting of bread wheat, durum wheat and triticale breeding nurseries into residue on semi-permanent beds at El Batan in the 2001 crop cycle.
- Planting of key strategic trials into maize residue on semi-permanent beds at Cd. Obregon.
- Preparations underway to plant 10 hectares of breeding materials at Cd. Obregon under conservation tillage in November 2002.
- Inoculation and screening for tan spot (problem disease in conservation till) implemented for bread wheat breeding populations at El Batan 2001. Inoculation of breeding populations with crown rot at Cd. Obregon 2002.
- Development of an agronomic package for triticale production for low-input reduced, moisture stress and fully irrigated systems for Sonora (planting methods, N-rates, irrigation regimes). Evaluation of triticale elite lines under low N and low water.

SP6: Using information technology and novel approaches in breeding for abiotic stresses.

- GRDC funded G5 International Adaptation Trial (IAT) was distributed globally from January 2001. Data now available from Mexican locations and several international sites. Initial results from Cd. Obregon indicate an influence of Root Lesion Nematode under drought.

The IAT trial contains bread/durum wheat genotypes that will differentiate for the following stresses: boron toxicity and deficiency, Mn deficiency, acid soils (Al toxicity), crown rot, common root rot, cereal cyst nematode, root lesion nematode, major rust genes, plant height, Vrn/earliness, drought tolerance for ME4A, ME4B, ME4C, ME1. IAT test sites were identified combining GIS information with empirical data.

- Collection of key environmental data from IAT locations and other major wheat producing regions, under way by Ky Mathews (Australian project scientist) and CIMMYT collaborators.
- International performance data for bread wheat, durum wheat, triticale for > 5 years was compiled for analysis in 2001.
- The biometrics and statistics unit employed the latest statistical trial analysis models e.g. spatial models for replicated and un-replicated trials based on spatial grid checks and surrounding neighbor plots, which resulted in increased precision.

Achievement of Objectives

All major objectives were achieved given availability of financial and human resources.

Constraints to Progress

No reportable constraints were noted.

Plans for 2002

Areas of future activities were identified. Mostly all mid-term objectives, and outputs as documented in the Strategic Plan and individual Sub-Project work-plans, continue as stated to date. The overall priority-setting is an on-going process. This may result in the setting of new objectives and outputs, pending approval by the G5 Oversight Director.

Publications 2001

Araus J.L., Slafer GA, Reynolds MP, Royo C, 2002. Plant Breeding and Water Relations in C3 Cereals: What to Breed for? J. Exp. Botany (in press)

Atanassov P., Borries C., Zaharieva M., Monneveux P. 2001. Studying hordeins polymorphism and variation of morphological traits for a more efficient use of genetic resources in naked barley. Genetic Res. and Crop Evolution 48, 353-360.

Bechere, E.; Peña, R.J. 2001. Quality of Ethiopian durum wheat cultivars. Demissie Mitiku. p. 34-44. In: Regional Wheat Workshop for Eastern, Central and Southern Africa, 11; Addis Ababa (Ethiopia); 18-22 Sep 2000. Addis Ababa (Ethiopia): CIMMYT, Series: CIMMYT Regional Wheat Workshop for Eastern, Central and Southern Africa. No. 11.

Bechere, E., Peña, R.J., Demissie Mitiku. 2001. Quality of Ethiopian durum wheat cultivars. Annual Wheat Newsletter 47 :47.

Braun, H.-J., M. Mergoum, A. Bagci, H. Ekiz, M. Keser, K. Yalvac, and H. Ketata. 2001: Spring x Winter Derived Germplasm: Adaptation and Performance in Central/West Asia and North Africa. The Warren E. Kronstad Commemorative Symposium, Obregon, March 15 – 17, 2001. CIMMYT, Mexico, D.F.

Braun, H.J.; M. Mergoum, A. Morgounov and J. Nicol, 2001: Adaptation of winter wheat to Central and West Asia. In: Research highlights of the CIMMYT Wheat Program 1999-2000. Mexico, D.F. (Mexico): CIMMYT, 2001. p. 27-32.

Braun, H.-J., T.S. Payne, M. Mergoum, M. van Ginkel, W.H. Pfeiffer and S. Rajaram. 2001. International Collaboration on Wheat Improvement. In: Bedo, Z. and L. Lang (eds). Wheat in a Global Environment. Proceedings of the 6th Int. Wheat Conference, Budapest. June 4-9, 2000. Kluwer Academic. p 125 – 137.

Braun, H.-J. , N. Zencirci, F. Altay, A. Atlı, M. Avci, V. Eser, M. Kambertay and T.S. Payne. 2001, The Turkish Wheat Pool. In. The World Wheat Book. A History of Wheat Breeding. Bonjean A. and W. J. Angus. Lavoisier Publishing Inc. Paris, France, p. 851 – 900.

Crespo M, M.W., Wall, P.C. and Claure S., T.E. 2001. Wheat production systems in the Bolivian Valleys. In "Wheat and Weeds: Food and Feed. Proceedings of Two Stakeholder Workshops " Ed. P.C.Wall. Santa Cruz, Bolivia: CIMMYT. p131-143

Dusunceli, F. L. Cetin, S. Albustan, H.-J.Braun, H. Ketata, Z. Mert and S.P.S. Beniwal: 2001: Evaluation of international wheat nurseries for stripe rust (Puccinia striiformis F.SP. tritici) resistance in Ankara - Turkey in the period 1995-2000. p. 40. In: Regional Yellow Rust Conference for Central and West Asia and North Africa, 1; Karaj, Iran; 8-14 May 2001. Abstracts of oral and posters presentations. Teheran (Iran): Ministry of Agriculture Jihad, Islamic Republic of Iran / ICARDA, Abstract only

Estrada Campuzano G., M. Mergoum, W.H. Pfeiffer, S. Rajaram, O. Abdalla , A. Hede, A. Balbuena Melgarejo, and C.G. Martinez Rueda M. 2001. Registration of 'Maravilla-TCL99' Triticale. Crop Science.

Ginkel, M. van, Ortiz-Monasterio, I, Trethowan, R.M., Hernandez, E. 2001. Methodology for selecting segregating populations for improved N-use efficiency in bread wheat. Euphytica, 119:223 – 230.

Ginkel, M. van, Ortiz-Monasterio, I, Trethowan, R.M., Hernandez, E. 2002. Methodology for selecting segregating populations for improved nitrogen use efficiency in bread wheat. Euphytica (in press).

Ginkel, M. van, Trethowan, R.M., Ortiz-Monasterio, I and Hernandez, E. 2001. Selection methodology of segregating populations for improved N-use efficiency in bread wheats. In 'Wheat in a Global Environment', 611-620. Z. Bedo and L. Lang (eds), Kluwer Academic Publishers

Hafsi M., Mechmeche W., Bouamama L., Djekoune A., Zaharieva M., Monneveux P. 2001. Flag leaf senescence, as evaluated by numerical image analysis, and its relationship with yield under drought in durum wheat. J. Agronomy and Crop Science, 185, 275-280.

Hede, A.R.; Skovmand, B. 2001. Acid soils and aluminum toxicity. Physiology manual. In Press

Hede, A.R.; Skovmand, B.; Ribaut, J. M. 2001. Evaluation of aluminum tolerance in a spring rye collection using two hydroponic screening techniques. Plant Breed. In Press.

Hernandez Sierra A., M. Mergoum, W.H. Pfeiffer, S. Rajaram, and A. Zuloaga Albarran. 2002. Registration of 'Supremo TCL-2000' Triticale. Crop Science (In press).

Ketata, H., A. Yahyaoui, M. Jarrah , H.-J. Braun, M. Mergoum, L. Cetin and F. Dusunceli. 2001. Slow Rusting in Winter and Facultative Wheat Infected with Yellow Rust. In. In: Bedo, Z. and L. Lang (eds). Wheat in a Global Environment. Proceedings of the 6th Int. Wheat Conference, Budapest. June 4-9, 2000. Kluwer Academic. p 391-396.

Kirigwi, F.M, M. Van Ginkel, R. Trethowan, R.G. Sears, and G.M. Paulsen. 2002. Evaluation of selection strategies for drought tolerance in wheat. Crop Science (in press)

Maes, B., Trethowan, R.M., Reynolds, M.P., Ginkel, M. van, and Skovmand. B. 2001. The influence of glume pubescence on spikelet temperature of wheat under freezing conditions. Australian Journal of Plant Physiology, 28, 1-8.

Maes B, Trethowan RT, Reynolds MP, Skovmand B, van Ginkel M, 2001. The influence of glume pubescence on spikelet temperature of wheat under freezing conditions. Australian Journal of Plant Physiology 28: 141-148

Manske G, Tadesse N, van Ginkel M, Reynolds MP, & Vlek P, 2001. Root Morphology of Wheat Genotypes Grown in Residual Moisture. In Breckle SW, Veste M & Wucherer W (Eds), Sustainable Land Use in Deserts. Springer-Verlag, Berlin, Heidelberg, New York.

Merah O., Deleens E., Al Hakimi A., Monneveux P. 2001. Carbon isotope discrimination and grain yield variations among tetraploid wheat species cultivated under contrasting environments. J. Agronomy and Crop Science, 186, 129-134.

Merah O., Deleens E., Monneveux P. 2001. Relationships between carbon isotope discrimination, dry matter production, and harvest index in durum wheat. J. of Plant Physiology, 158, 723-729.

Merah O., Deléens E., Monneveux P. 2001. Relationships between flag leaf carbon isotope discrimination and several morphophysiological traits in durum wheat under Mediterranean conditions. J. Env. Exp. Botany, 45, 63-71.

Merah O., Deleens E., Nachit M.M., Monneveux P. 2001. Carbon isotope discrimination, leaf characteristics and grain yield of interspecific wheat lines and their durum parents under Mediterranean conditions. Cer. Res. Comm., 29, 143-149.

Merah O., Deléens E., Souyris I., Monneveux P. 2001. Ash content might predict carbon isotope discrimination and grain yield in durum wheat. New Phytologist, 149, 275-282.

Merah O., Deléens E., Souyris I., Nachit M.M., Monneveux P. 2001. Stability of yield and flag leaf and kernel carbon isotope discrimination across different Mediterranean environments in durum wheat. Crop Science, 41, 677-681.

Merah O., Deléens E., Teulat B., Monneveux P. 2001. Productivity and carbon isotope discrimination of different durum wheat organs under Mediterranean conditions. Comptes-Rendus de l'Académie des Sciences, 324 , 51-57.

Mergoum M., G. Estrada Campuzano, W.H. Pfeiffer, S. Rajaram, A. Hede, A. Balbuena Melgarejo, and C.G. Martinez Rueda M. 2001. Registration of 'Cerrillo-TCL99' Triticale. Crop Science.

Mezzalama, M., JM Nicol, K Sayre and P Grace (2001) Soil ecological changes under a long term conservation tillage wheat and maize rotation trial in Mexico. 2nd Australasian Soilborne Diseases Symposium

Morgounov A., Sayre K., Hobbs P., Wall P., Ortiz-Monasterio I., Karabayev M., 2001 Sustainable wheat and maize production in developing countries. In: Conservation tillage: A viable option for sustainable agriculture in Eurasia. Proc. of Intern. Workshop, Shortandy, Kazakhstan, p. 86-93

Morgounov A., Zykin V., Sereda G., Urazaliev R. 2001. Siberian and North Kazakhstan Wheat Pool. In Bonjean A., Angus W. (Eds.) The World Wheat Book: A History of Wheat Breeding, 755-772

Mujeeb-Kazi, A., A. Cortés, V.Rosas, S, Cano, R. Delgado. 2001. Registration of 17 isogenic chromosome 1B and 17 T1BL.1RS chromosome translocation bread wheat germplasms. Crop Science. (In press).

Mujeeb-Kazi A, A. Cortés, V. Rosas, S. Cano, R. Delgado. 2001. Registration of six isogenic T1BL.1RS chromosome translocation and six chromosome 1B durum germplasms. Crop Science. (In press).

Mujeeb-Kazi, A., J.L. Diaz De Leon. 2001. Conventional and alien genetic diversity for salt tolerant wheats: focus on current status and new germplasm development. Kluwer Academic Press (In press)

Mujeeb-Kazi, A., M.D.H.M. William, R.L. Villareal, A. Cortes, V. Rosas, R. Delgado. 2001. Registration of 10 isogenic chromosome 1B and 10 T1BL.1RS chromosome translocation bread wheat germplasms. Crop Science 41:280-281

Nicol, J.M., 2002. Chapter: Nematodes of Economic Importance on Cereals. In: Improving World Wheat Production. CIMMYT International, Edited by FOA, Rome. In Press.

Nicol, J.M., and I Ortiz-Monasterio. 2002. Effect of Root Lesion Nematode on Wheat Yields and Plant Susceptibility in Mexico. Submitted to Nematology (In Press).

Nicol, J.M., I Ortiz-Monasterio. 2001. Population Dynamics and Economic Important of the root lesion nematode, Pratylenchus thornei, for wheat productivity and Global Implications for Germplasm Development. 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8th. Porter IJ et al. (eds.). ISBN: 0 7311 8170 0. pp. 119-120.

Nicol, J.M., R Rivoal. 2001. Development of AUS4930 – a source of resistance against both Root Lesion Nematode (Pratylenchus thornei) and the Cereal Cyst Nematode (CCN) Complex for Global Breeding. 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8th. Porter IJ et al. (eds.). ISBN: 0 7311 8170 0. pp.67-68.

Nicol, J., Rivoal, R., Trethowan, R. M., van Ginkel, M., Mergoum, M. and Singh, R.P. 2001. CIMMYT's approach to identify and use resistance to nematodes and soil-borne fungi, in developing superior wheat germplasm. In 'Wheat in a Global Environment', 381-389. Z. Bedo and L. Lang (eds), Kluwer Academic Publishers

Ortiz-Monasterio, J.I., R.J. Peña and W.H. Pfeiffer. 2001. Grain yield and quality in CIMMYT's durum wheat under water and nitrogen stresses. Poster. In Wheat in a Global Environment, International Wheat Conference, 6th. Abstracts. 5-9 June, 2000. Budapest, Hungary, Hungarian Academy of Sciences, Martonvasar. pp. 299.

Ortiz-Monasterio, J.I., R.J. Peña and W.H. Pfeiffer. 2001. Grain yield and quality in CIMMYT's durum wheat under water and nitrogen stresses. Poster presented at the Kronstad Symposion, Cd. Obregon, Sonora, Mexico, March 14-16, 2001.

Pellegrineschi, A., R.M. Brito, , L. Velazquez, L.M. Noguera, W.H. Pfeiffer, S. McLean and D. Hoisington. 2002. The effect of pretreatment with mild heat and drought stresses on the explant and biolistic transformation frequency of three durum wheat cultivars. Plant Cell Report. (accepted).

Pellegrineschi, J-M Ribaut, R. Trethowan, K. Yamaguchi-Shinozaki, and D. Hoisington. 2001.Recent developments in transgenics for water-limited conditions in wheat. Proceeding of the JIRCAS meeting, Thailand, September, 2001.

Peña, R, J. 2002. Factores que afectan la calidad de trigo. In: En: 11o Curso Internacional de Actualización en Tecnología de Semillas. UAAAN, Octubre 24-26, 2001. Saltillo, Coah. Mexico. (in press).

Peña, R. J. 2002. Contribución de las gluteninas (de alto y bajo peso molecular) y las gliadinas al mejoramiento de la calidad de trigo. In: En: Seminario Internacional sobre estrategias

y metodologías utilizadas en el mejoramiento de trigo. Octubre 8-11, 2001. INIA-La Estanzuela, Uruguay. (In press)

Peña, R.J.; Trethowan, R.M.; Ginkel, M. Van. 2001. Bread wheat quality improvement at CIMMYT: Current and projected strategies. Conference Proceedings; Australia; 28-30 Aug 2001. In: Golden opportunities: An Australian and Chinese collaboration on wheat quality.

Peña, R.J.; Trethowan, R.M.; Pfeiffer, W.H., and van Ginkel. 2002. Quality (end-use) improvement in wheat. Compositional, Genetic, and environmental factors. In: Quality improvement in crops, book chapter. Haworth Press Inc. N.Y. (In press)

Peña, R.J., R.M. Trethowan, W.H. Pfeiffer, and M. van Ginkel. 2002. Quality (End-Use) Improvement in Wheat. Compositional, Genetic, and Environmental Factors. Journal of Crop Production, Vol. 5(2). (in press).

Pfeiffer, W.H., Trethowan, R.M. and Payne, T.S. 2001. CIMMYT's new approach to address production constraints in marginal areas - global project 5. Proceedings of the 11th Regional Wheat Workshop for Eastern, Central and Southern Africa. Addis Ababa, Ethiopia, 18-22 September 2000. Addis Ababa, Ethiopia: CIMMYT. p. 6-15.

Pfluger, L.A.; Ovidio, R.D.; Margiotta, B.; Pena, R.J.; Mujeeb-Kazi, A.; Lafiandra, D. 2001. Characterization of high-and low-molecular weight glutenin subunits associated to the D genome of aegilops tauschii in a collection of synthetic hexaploid wheats. Theoretical and Applied Genetics 103 (8):1293-1301.

Pfluger L A., Peña, R.J. Mujeeb-Kazi, A. Lafiandra, D.. 2001. Variability of low molecular weight glutenin subunits associated to the D genome of Ae. Tauschii in a collection of synthetic hexaploid wheats. In: 4th International Triticeae Symposium. September 10-12, Cordoba, Spain. (In press)

Pritchard, D.J., Hollington, P.A., Davies, W.P.,Gorham, J., Diaz de Leon, J.L. and Mujeeb-Kazi, A. 2001. K^+/Na^+ discrimination in synthetic hexaploid wheat lines: Transfer of the trait for K^+/Na^+ discrimination from Aegilops tauschii to Triticum turgidum. Cereal Res. Commun. (In press).

Rajaram, S., Peña, R.J. Villareal, R.L.. Mujeeb-Kazi, A Singh, R., and Gilchrist, L. 2001. Utilization of wild and cultivated emmer and of diploid wheat relatives in breeding. Israel J. of plant Sciences 49:S-93-S-104.

Rekika D., Kara Y., Souyris I., Nachit M.M., Monneveux P. 2001. The resistance of PSII to high temperatures in durum wheat: genetic variation and relationship with yield under heat stress (Cereal Research Communication – in press) , 4, 395-402)

Reynolds MP, Copland S, Olivares JJ, Trethowan RT & Kazi AM, 2001. Physiological Approaches to Stress Breeding for Wheat. Invited paper: Proceedings of European Plant Breeders Meeting (Eucarpia), Edinburgh, Sept, 2001

Reynolds, M.P., Ortiz-Monasterio, I., McNab, A. (Eds.) 2001. Application of Physiology in Wheat Breeding. Mexico, D.F.: CIMMYT.

Reynolds, M.P., Trethowan, R.M., Crossa, J. and Sayre, K.D. 2002. Physiological interpretation of genotype by environment interaction in wheat. Field Crops Research (in press).

Reynolds MP, RT Trethowan, B Skovmand, 2001. Physiological Selection for Stress Resistance. Invited paper presented at The 22nd Hard Winter Wheat Workers Workshop, Kansas City, Feb. 2001.

Reynolds, M.P., Trethowan, R.M., van Ginkel, M. and Rajaram, S. 2001. Application of Physiology in Wheat Breeding. In 'Application of Physiology in Wheat Breeding' Chapter 1:2-10. Reynolds, M.P., J.I. Ortiz-Monasterio, and A.McNab (eds). Mexico, D.F.: CIMMYT.

Rivoal R, S Bekal, M Bel Hadj Fradj, S Valette, A Mokabli, J Javier, M Zaharieva and JM Nicol. 2001. Variability for resistance to cereal cyst nematodes in Triticeae: Potential use for Triticum turgidum L. var. durum improvenment. . In:Durum wheat improvement in the Mediterranean region: new challenges, ed. C. Royo, M.M. Nachit, Di Fonzo and J.L. Araus. INO Reproducciones, S.A., Zaragoza, Spain. Pp 413-416.

Rivoal R, S Bekal, S Valette, JP Gauthier, M Bel Hadj Fradj, A Mokabli, J Javier, J Nicol & A Yahyaoui (2001) Variation in reproductive capacity and virulence on different genotypes and resistance genes of Triticeae, in the cereal cyst nematode species complex. Nematology 3(6): 581-592.

Saulescu N.N. and H. -J. Braun. 2001. Breeding for Adapatation to environmental factors. Cold Tolerance. In: Application of Physiology in Wheat Breeding. M.P. Reynolds, I. Ortiz-Monasterio, and A. McNab (eds.). Mexico, D.F.: CIMMYT. P 111 – 123.

Sayre, K.D. and Martínez, M. 2001. Brief summary of the yield results for the ME-2 sustainability trial located at El Batan for the 2000 summer cycle and the combined analyses for the 1996, 1997, 1998, 1999 and 200 crop cycles. CIMMYT internal report. 6pp.

Sayre, K.D., Mezzalama, M. and Martínez, M. 2001. Tillage, crop rotation and crop residue management effects on maize and wheat production for rainfed conditions in the altiplano of central Mexico. In "Conservation Agriculture, a Worldwide Challenge" Proceedings of the I World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001. FAO – ECAF, Córdoba, Spain. p 575-580.

Skovmand, B. and M.P. Reynolds. 2001. Increasing yield potential for marginal areas by exploring genetic resources collections. In Proceedings 11th Regional Wheat Workshop for Eastern, Central and Southern Africa. D. Tanner (Ed.) ILRI, Addis Ababa, 18-22 September, 2000. Ethiopia.

Skovmand B, Reynolds MP, and Delacy, IH, 2001. Mining Wheat Germplasm Collections for Yield Enhancing Traits. Euphytica 119: 25-32.

Smale, M., M.P. Reynolds, M. Warburton, B. Skovmand, R. Trethowan, R.P. Singh, I. Ortiz-Monasterio, J. Crossa, M. Khairallah, and M.I. Almanza-Pinzon. 2002. Dimensions of Diversity in CIMMYT Bread Wheat from 1965 to 2000. Crop Science (in press)

Tadesse Dessalegn, Bedada Girma, T.S. Payne, C.S. van Deventer and M.T. Labuschagne. 2001. Sources of variation for grain yield performance of bread wheat in north-western Ethiopia. IN: CIMMYT. The Eleventh Regional Wheat Workshop for Eastern, Central and Southern Africa. Addis Ababa: CIMMYT.

Tolay, I., B. Erenoglu, V. Röhmheld, H.-J. Braunand I. Cakmak. 2001. Phytosiderophore release in Aegilops tauschii and Triticum species under zinc and iron deficiencies. Journal of Experimental Botany, Vol 53, 358. p 1-7.

Trethowan, R.M. 2001. Preharvest Sprouting Tolerance. In 'Application of Physiology in Wheat Breeding' Chapter 12: 145 – 147. Reynolds, M.P., J.I. Ortiz-Monasterio, and A.McNab (eds). Mexico, D.F.: CIMMYT.

Trethowan, R.M. 2001. Avances en el Mejoramiento del Trigo para Tolerancia a la Germinacion en la Espiga (brotamiento). Proceedings of a symposium 'Estrategias y metodologias utilizadas en el mejoramiento de trigo', October 2001 (8 – 11), Colonia, Uruguay.

Trethowan, R.M., Crossa, J., Ginkel, M. van and Rajaram., S. 2001. Relationships among Bread Wheat International Yield Testing Locations in Dry Areas. Crop Science, 41(5):1461 – 1469.

Trethowan, R.M., R.J. Peña and M. van Ginkel. 2001. The effect of indirect tests for quality on grain yield and industrial quality of bread wheat. Plant Breeding 120, 1-4.

Trethowan, R.M., Pena R.J.and Ginkel, M. van. 2001. Breeding for Grain quality: a manipulation of gene frequency. In 'Wheat in a Global Environment', 263-271. Z. Bedo and L. Lang (eds), Kluwer Academic Publishers.

Trethowan, R.M., Singh, R.P., Huerta-Espino, J., Crossa, J. and Ginkel, M van. 2001. Coleoptile length variation of near isogenic Rht lines of modern CIMMYT bread and durum wheat. Field Crops Research,70: 167-176.

Trethowan, R.M., van Ginkel, M. and Rajaram, S. 2002. Progress in breeding for yield and

Villareal, R.L, O. Bañuelos, J. Borja, S. Rajaram and A. Mujeeb-Kazi. 2001. Heat tolerant synthetic bread wheat derivatives from CIMMYT Wheat Program.. Annual Wheat Newsletter. Vol. 47 (in press)

Villareal, R.L., K. Sayre, O. Bañuelos, A. Mujeeb-Kazi. 2001. Registration of four synthetic hexaploid wheat (Triticum turgidum/Aegilops tauschii) germplasm lines tolerant to waterlogging. Crop Science 41:274

Wall, P.C. 2001 La Degradación de los Suelos: Causas, Efectos y la Solución. Presentado en la IV Reunión Nacional de Trigo y Cereales Menores, Cochabamba, Bolivia, Octubre 11-12, 2001 (Proceedings in press)

Wall, P.C. ed. 2001. Wheat and Weeds: Food and Feed. Proceedings of Two Stakeholder Workshops. Santa Cruz, Bolivia: CIMMYT.

Wall, P.C., Zambrana, L., Gamez, P., Sims, B. and Calissaya A. 2001. Development of an animal drawn zero tillage seeder. for small grains. In "Conservation Agriculture, a Worldwide Challenge" Proceedings of the I World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001. FAO – ECAF, Córdoba, Spain. p 631-635.

Wang, J., M. van Ginkel, R. Trethowan, D.W. Podlich, I. DeLacy, M. Cooper. 2001. A QU-Gene application module for CIMMYT's wheat breeding programs. Post presented at the Australian Wheat Breeding Assembly. September, Mildura, Victoria. Australia.

Zaharieva M., Dimov A., Stankova P., David J., Monneveux P. 2002. Morphological diversity and potential interest for wheat improvement of three Aegilops L. species from Bulgaria. Genetic Resources and Crop Evolution (accepted)

Zaharieva M., Gaulin E., Havaux M., Acevedo E., Monneveux P. 2001. Leaf temperature and water status regulation in the wild wheat Ae. geniculata Roth (= Ae. ovata L.) under Mediterranean field conditions (Crop Science, 41, 1321-1329)

Zaharieva M., Monneveux P., Henry M., Rivoal R., Valkoun J, Nachit M. M. 2001. Evaluation of a collection of wild wheat relative Aegilops geniculata Roth and identification of potential sources for useful traits (Euphytica, 119, 33-38)

Zhang, J.Y, Li, X.M.,Wang, R.R.-C, Cortes, A., Rosas, V. and Mujeeb-Kazi, A. 2001. GISH, AFLP, and RAPD characterization of E^b-genome chromosomes in five Thinopyrum bessarabicum disomic addition lines of bread wheat. Genome (In press).

Journals

Villareal RL, Sayre K, Banuelos O, and Mujeeb-Kazi A. 2001. Registration of four synthetic hexaploid wheat (*Triticum turgidum/Aegilops tauschii*) germplasm lines tolerant to waterlogging. Crop Science. 41:274.

Pritchard, D.J., Hollington, P.A., Davies, W.P., Gorham, J., Diaz de Leon J.L. and Mujeeb-Kazi, A. 2001. K^+/Na^+ discrimination in synthetic hexaploid wheat lines: Transfer of the trait for K^+/Na^+ discrimination from Aegilops tauschii to Triticum turgidum. Cereal Res. Commun. (In press).

Zhang, J.Y, Li, X.M.,Wang, R.R.-C, Cortes, A., Rosas, V. and Mujeeb-Kazi, A. 2002. GISH, AFLP, and RAPD characterization of E^b-genome chromosomes in five *Thinopyrum bessarabicum* disomic addition lines of bread wheat. Int. J. Plant Sci. 163:167-174.

Annual Wheat Newsletters

Pritchard, D.J., P.A. Hollington, W.P. Davies, J. Gorham, J.L. Diaz de Leon, and A. Mujeeb-Kazi. 2001. Synthetic hexaploid wheats (2n=6x=42, AABBDD) and their salt tolerance potential. Annual Wheat Newsletter 47:103-104.

Diaz-de-Leon, J.L., R. Escoppinichi, E. Molina, J. Lopez-Cesati, R. Delgado, and A. Mujeeb-Kazi. 2001. Salt tolerant bread wheat germplasm. Annual Wheat Newsletter 47:117-118.

Global Project 6

Wheat resistant to diseases and pests

Project Coordinator: R. Singh

Oversight Director: S. Rajaram

Sub project 1: Epidemiology of Major Wheat Diseases

Laboratory to screen fusarium toxins was established in El Batan during 2001, which is now fully operational.

The International Rust Trap Nursery was grown for the first year in South Asia, China, Africa and South America. In WANA and Central Asia, the nursery is being incorporated as part of the existing nursery that is managed by ICARDA.

Yellow rust was very low or absent in most sites in South Asia. However, some yellow rust was found for the first time on PBW343 in farmers' fields in Western Punjab and along the Pakistani border.

Monitoring potential changes in rust virulence continued to be promoted and IDTN was sent to 18 locations in South Asia. Results were returned from 15 locations.

Observations on yellow rust population using the trap nursery is now well established in all major wheat production environments across 15-20 locations in Central Asia and the Caucasus. The yellow rust population in the Caucasus is slightly different from that in Central Asia, as it does not possess the virulence to *Yr1* gene. The major genes providing resistance across the region are *Yr5, Yr10* and *Yr15*. The *Yr18* gene in Jupateco isogenic background reduces the disease severity by 20-40%.

Leaf rust trap nursery employed in the vast areas of Northern Kazakhstan indicated that effective genes were: *Lr9, Lr12, Lr23, Lr26, Lr28, Lr34, Lr35*. The combination of the slow rusting genes in Mexican germplasm essentially provided 0-5% severities. In 2001 the disease severity was lower compared to 2000. Main varieties remain highly susceptible.

The leaf rust epidemic in Northwestern Mexico during 2001 on durum wheat cultivar Altar 84 was contained successfully.

Detailed study of yield losses due to BYDV in several tolerant lines and relationship with various plant traits was conducted during 2001. Lack of clear relationship indicated that no single parameter is sufficient to estimate the effect of BYDV.

Two experiments conducted during 2001 suggest that resistance to aphids is not the mechanisms behind the low level of infection observed in field BYDV inoculation of *Th. intermedium* derived material.

It was shown that the ability of aphids to acquire and transmit BYDV serotypes, PAV, MAV and CYDV-RPV, is lower from lines homozygous for the translocation carrying *Bdv2* gene than from lines that do not possess this resistance factor.

Plant disease surveys in Nepal (>100 farmers fields) showed that tan spot's prevalence in Tarai was higher than expected with around 50% positive identification on samples collected during the 2001 season.

Results from the DFID soil health project confirmed that *Hirschmaniella oryzae* and *Meloidogyne graminicola* are surviving and multiplying in wheat after rice due to sufficient soil moisture resulting from wheat irrigation. Wheat roots appeared rather healthier than expected after rice. *Trichoderma* species were found as favorable bio-agents. *Nakatea* sp. and a new *Fusarium* species were isolated for the first time in rice-wheat system in Nepal. Characterization of this new *Fusarium* using molecular markers is in process in CABI. A total of 80 fungal pure cultures were isolated during the rice season in Nepal. *F. nygami* was again detected in rice-wheat.

Sub project 2: Identification and combining of diverse sources of resistance/tolerance

Over a thousand durum lines were screened as adult plants in the greenhouse with the new durum leaf rust race and resistant lines identified for large seed increases resulting in the emergency release of cultivar Jupare 2002 (= Stot/Altar 84//Ald) in Northwestern Mexico.

Thousands of durum and triticale lines from the breeding programs and germplasm bank were evaluated in the field with leaf rust and yellow rust, respectively, in El Batan and resistant lines identified.

Leaf rust and yellow rust resistant derivatives of Seri 82, Pastor and HUW234 with significant yield increases over their respective recurrent parents were obtained through one-backcross breeding approach.

Several lines identified to carry durable resistance to leaf rust in Mexico showed a similar behavior in multilocational tests for three years in South America.

Recombinants of *Th. elongatum* and *Th. intermedium* alien translocations that combine *Lr19, Bdv2* and high yield potential gene while lacking the yellow pigment in the endosperm were identified.

New genetic stocks with the *Thinopyrum intermedium* introgression (*Bdv2* gene) but without symptoms of yellowing and stunting were developed.

Simple and backcrosses involving several sources resistant or tolerant to BYDV and RWA and selected high yielding wheats were achieved.

Sources of resistance to Karnal bunt: Eighty-nine lines from the 17th Karnal Bunt Screening Nursery showed infection levels below 5% in three artificial inoculation dates. Twenty had "zero" infection.

Advanced bread wheat lines with infection levels below 5% included 13 of 49 tested lines in EPCME1PMKB; 112 of 608 in EPCME1IRKB; 214 of 547 in EPCIBWSN 214/547; and 26 0f 78 in EPCESWYT.

Australian-CIMMYT Breeding for Resistance to Karnal bunt: *The number of entries with infection levels below 5% was 2 out of 44 from the CBAUSSS KB and 55 of 371 for the F6.*

Double Haploids resistant to Karnal bunt: 12 entries out of 35 previously selected, showed infection levels below 5% in WL711/HD29 cross and 12 of 34 in reciprocal cross HD29/WL711. Four resistant entries have good agronomic type and rust resistance.

An integrated protocol was developed that has enhanced the translocation production events and achieved over 30 translocations in less than a year. The stability of these materials is now being addressed and evaluations will be carried out for their usefulness in providing resistance to diseases and pests.

Relationship between resistance to root rot and head scab caused by fusarium was established as several known head scab resistant sources were also resistant to root rot and *vice-versa*.

Helminthosporium leaf blight data from the 4th EGPSN, Eastern Gangetic Plain Screening Nursery, (150 entries tested in 11 locations) were analyzed using the percent diseased leaf estimates and Area Under Progress Curve. About 20% lines combine good plant type and resistance.

A report on the 8th HMN (Helmnthosporium Monitoring Nursery) including a full data analysis was completed and distributed to cooperators. Resistant entries could be identified and some cultivar X isolate (or environment) interaction was evident.

Sub project 3: Development of molecular marker and marker assisted selection strategies for resistance/tolerance

The major yellow rust resistance gene present in Pastor wheat was mapped in chromosome 2BS through bulk-segregant analysis.

Characterization of three populations completed for durable genes that confer resistance to leaf rust and yellow rust. Six to eight loci with varying degree of effects that confer resistance to both leaf rust and yellow rust together or individually have been identified.

A minor leaf rust resistance gene, different from *Lr34* and *Lr46*, was isolated from Parula and F5 population and LR data developed for its mapping (before a gene symbol can be assigned).

A linkage map, which covered approximately 80% of the whole genome with 343 markers, was obtained for Fukuho-komugi x Oligoculm#380 DH population. For scab Type I resistance, two QTLs consistent between the two years were detected on chromosome 4BS and 4BL. Each explained about 5% of total variation. For Type II resistance, one QTL at 1AS distal end showed consistent results across the three years. Stripe rust was evaluated in 5 environments. Joint analysis resulted in 7 significant QTLs. The one on 7DS showed the biggest effects (R2=12-24%) and was considered to be due to *Yr18*. QTL analysis was also performed with two years data for leaf rust. Two QTLs were detected on 1BL (*Lr46*) and on 7DS (*Lr34*). Each QTL explained about 15% and 40% of the total variation, respectively.

Marker identification for *Septoria tritici* resistance commenced in a doubled haploid population.

Tolerance to BYDV in Anza/Bagula: The F6 population from Anza/Bagula cross was sown entirely in El Batan (summer 2001) and partially in Toluca (winter 2001). The primary objective was to collect phenotypic data for the bulk segregant analysis (10 best, 10 worst). The data from Toluca have been analyzed and some tolerant and sensitive lines based on yield results identified. Yield data on hill plots were collected in El Batan during the summer. The molecular analysis was done using 4 markers that show polymorphism in material possessing leaf tip necrosis and the *Lr34* gene. Two of these markers showed polymorphism between the parents Anza and Bagula and were used to screen the entire population. Results need summarization.

A collaborative work between CIMMYT and INRA (France) initiated to improve BYDV resistance in different varieties of wheat (spring and winter) through "Pathogen-Derived Resistance" strategy. Seven constructs were obtained harboring the sequences encoding for replicase, coat-

protein, movement protein and a non-coding sequence corresponding to the promoter of sub-genomic 2 RNA. These fragments have been cloned in the unique *Bam*HI site of the pAHC17 plasmid, in sense and in anti-sense orientation, between UBI promoter and *Nos* terminator. Genetic transformation of wheat was performed in several varieties (Bobwhite SH-9826, Mexicali, Kambara, Pastor, Atilla, PBW343, Soissons, Courtot). Variable number of transgenic wheat has been obtained for each construct and variety. Transformation efficiency was very low for durum wheat Mexicali and a good success achieved with Pastor (not normally used in transformation).Contacts were made to see how molecular markers could be used to assist in selection of genotypes with resistance to HLB. A new research was initiated in 2001-2002 season with DGCI funds. It includes trials in Janakpur (Nepal) to analyze the field reaction in four populations resulting from crosses with different sources of resistance.

Publications

Journal articles

Ayala L., Henry M. , González de León D., van Ginkel M., Mujeeb-Kazi A., Keller B., Khairallah M.A. 2001. Diagnostic molecular marker allowing the study of *Th. intermedium* derived resistance to BYDV in bread wheat segregating populations. Theoretical and Applied Genetics 102: 942-949.

Ayala L., van Ginkel M., Khairallah M., Keller B., Henry M. 2001. Expression of *Thinopyrum intermedium* – derived *Barley yellow dwarf virus* resistance in elite bread wheat backgrounds. Phytopathology 91: 55-62.

Choi I.R.., Hall J.S, Henry M., Zhang L-Y, Hein G.L., French R., Stenger D.C. 2001. Contributions of genetic drift and negative selection on the evolution of three Strains of wheat streak Mosaic Tritimovirus. Archives of Virology 146: 619-628.

Gaudet, D.A., G. Fuentes-Davila, R.M. De Pauw and P.A. Burnett. 2001. Reactions of Western Canadianspring wheat and triticale varieties to *Tilletia indica*, the causal agent of Karnal bunt. Can. J. Plant Sci. 81.

Guillen-Andrade, H., M. M. Khairallah, R. P. Singh, F. C. Gonzalez and D. Hoisington. 2001. Construction of a RFLPs and SSRs map for bread wheat. Rev. Fitotec. Mex. 24: 85-94.

Mujeeb-Kazi, A., Fuentes-Davila G, Villareal RL, Cortes A, Rosas V, and Delgado R. 2001. Registration of 10 synthetic hexaploid wheat and six bread wheat germplasms resistant to karnal bunt. Crop Science 41:1652-1653.

Mujeeb-Kazi A, Cano S, Rosas V, Cortes A, and Delgado R. 2001. Registration of five synthetic hexaploid wheat and seven bread wheat germplasm lines resistant to wheat spot blotch. Crop Science 41:1653-1654.

Rajaram, S., R. J. Pena, R. L. Villareal, A. Mujeeb-Kazi, R. Singh and L. Gilchrist. 2001. Utilization of wild-emmer and wild wheats in breeding. Israel J. Plant Sciences 49:93-104.

Rivoal R, S Bekal, S Valette, JP Gauthier, M Bel Hadj Fradj, A Mokabli, J Javier, J Nicol & A Yahyaoui . 2001. Variation in reproductive capacity and virulence on different genotypes and resistance genes of Triticeae, in the cereal cyst nematode species complex. Nematology 3: 581-592.

Sánchez-Sánchez H., Henry M., Cárdenas-Soriano E., Alvizo-Villasana H.F. 2001. Identification of *Wheat streak mosaic virus* and its vector *Aceria Tosichella* in Mexico. Plant Disease 85: 13-17.

Sharp, P. J., S. Johnston, G. Brown, R. A. McIntosh, M. Pallotta, M. Carter, H. S. Bariana, S. Khatkar, E. S. Lagudah, R. P. Singh, M. Khairallah, R. Potter and G. K. Jones. 2001. Validation of molecular markers for wheat breeding. Aust. J. Agric. Res. 52:1357-1366.

Singh, R. P., K. Nakamura and J. Huerta-Espino. 2001. Leaf rust resistance genes in Japanese wheat cultivars. Breeding Sci. 51:83-87.

Conference proceeding/ abstracts

Baboyev S., Karabayev M., Koishibayev M., Kokhmetova A., Kuklacheva V., Morgounov A., Rsaliev S., Sarbayev A., Yessenbekova M., 2000. Improvement of yellow rust resistance in Kazakhstan and Uzbekistan through sub-regional cooperation. In: Book of Abstracts, The 1st Regional Yellow Rust Conference for CWANA, Karaj, Iran, p. 26-27.

Capettini, F., Vivar, H., Gilchrist, L. and Henry, M. 2001. Building up multiple disease resistance in barley. Warren E. Kronstad Symposium, Cd. Obregon, Sonora, Mexico, March 15, 2001.

Eshanova Z., Kosimov F., Yorov A., Khuseinov E., Morgounov A. 2001. Wheat breeding for yellow rust resistance in Tajikistan. In: Book of Abstracts, The 1st Regional Yellow Rust Conference for CWANA, Karaj, Iran, p. 24-25.

Fuentes-Davila, G. 2001. Carbon Parcial: Perspectivas. En: Memorias del IV Congreso Internacional en Ciencias Agricolas, 25 y 26 de octubre de 2001. Universidad Autonoma de Baja California, Instituto de Ciencias Agricolas. Pp 11-24.

Fuentes-Davila, G., S. Rajaram y M. van-Ginkel. 2001. La inoculacion artificial: una herramienta eficiente para la seleccion de germoplasma resistente. XXVIII Congreso Nacional de la S ociedad Mexicana de Fitopatologia. Queretaro, Julio 15-18, 2001. F-2.

Gilchrist, L. 2001. Perspectives on fusarium head blight resistance in barley. In H.E. Vivar and A. Mcnab (eds.), Breeding Barley in the New Millenium: Proceedings of an International Symposium. Mexico, DF, Mexico.

Henry M, Vivar H.E. 2001. Resistance and/or tolerance to BYDV: Recent advances in Barley at CIMMYT. In "Breeding in Barley in the new Millenium, Proceedings of an International Symposium", Eds H. Vivar and A. McNab, Mexico DF, CIMMYT, pp 72-76.

Mujeeb-Kazi, A., A. Cortes, V. Rosas, S. Cano, J. Sanchez, L. Juarez, and R. Delgado. 2001. Genetic diversity for improving scab resistance in wheat. Warren E. Kronstad Symposium, Cd. Obregon, Son. Mexico. March 15, 2001.

Navabi, A., R. P. Singh, J. P. Tewari and K. G. Briggs. 2001. A genetic study of adult plant resistance to stripe rust (*Puccinia striiformis*) and leaf rust (*Puccinia triticina*) in spring wheat. Can. J. Plant Pathol. 23: 190 (Abstr.).

Nicol, J. M. and I. Ortiz-Monasterio (2001) Population Dynamics and Economic Important of the root lesion nematode, *Pratylenchus thornei*, for wheat productivity and Global Implications for Germplasm Development. 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8th. Porter IJ et al. (eds.). ISBN: 0 7311 8170 0. pp. 119-120.

Nicol, J.M. and R Rivoal. 2001. Development of AUS4930 – a source of resistance against both Root Lesion Nematode (Pratylenchus thornei) and the Cereal Cyst Nematode (CCN) Complex for Global Breeding. 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8th. Porter IJ et al. (eds.). ISBN: 0 7311 8170 0. pp.67-68.

Nicol, J.M., R. Rivoal, R.M. Trethowan, M. van Ginkel, M. Mergoum and R.P. Singh. 2001. A global approach to develop multiple disease resistant germplasm against soil-borne pathogens (nematodes - CCN and RLN) and rootrot (CR and CRR). In Proceedings of 2nd Soil-borne Disease Congress, Australia.

Rivoal R, S Bekal, M Bel Hadj Fradj, S Valette, A Mokabli, J Javier, M Zaharieva and JM Nicol (2001) Variability for resistance to cereal cyst nematodes in Triticeae: Potential use for Triticum turgidum L. var. durum improvenment. . In:Durum wheat improvement in the Mediterranean region: new challenges, ed. C. Royo, M.M. Nachit, Di Fonzo and J.L. Araus. INO Reproducciones, S.A., Zaragoza, Spain. Pp 413-416.

Seidov M., Garayev P., Ibragimov E., Musayev A., Ahmedov M., Makhmudov R., Morgounov A., Yahyaoui A., 2001. Yellow rust in Azerbaijan: distribution, variability, yeld losses, and genetic variation of bread wheat for disease resistance. In: Book of Abstracts, The 1st Regional Yellow Rust Conference for CWANA, Karaj, Iran, p. 47-48.

Singh, D.P., Maraite, H., Duveiller, E., Mercado-Vergnes, D, Renard, M. and Nagarajan, S., 2001. Pathogenicity of three isolates of Alternaria triticina - the causal agent of leaf blight of wheat. Indian Phytopathological Society Annual Meeting, CCS-HAU, Hisar, Haryana, India, Dec. 11-13, 2001 (Poster-Abstract).

Singh, R. P., J. Huerta-Espino and M. William. 2001. Slow rusting genes based resistance to leaf and yellow rusts in wheat. R. Eastwood, G. Hollamby, T. Rathjen and N. Gororo (eds.) Proc. 10th Assembly of Wheat Breeding Society of Australia Inc., 16-21 Sept. 2001, Mildura, Australia. Pp 103-108.

Singh, R. P., J. Huerta-Espino and M. William. 2001. Resistencia durable a roya de la hoja y roya amarilla: genetica y mejoramiento en el CIMMYT. Seminario Internacional Estrategias y metodologias utilizadas en el mejoramiento de trigo, 8-11 de Octubre de 2001, INIA La Estanzuela, Colonia, Uruguay. p. 15 (Abstr.).

Sorkhilalehloo, B., J. P. Tewari, T. K. Turkington, F. Capettini, K. G. Briggs, B. Rossnagel and R. P. Singh. 2001. Slow-scalding in barley, a novel strategy for disease management. Can. J. Plant Pathol. 23:190 (Abstr.).

Villareal, R.L., G. Fuentes-Davila, O. Bañuelos, and A. Mujeeb-Kazi. 2001. Karnal bunt (*Tilletia indica* Mitra) resistant synthetic bread wheat derivatives. Warren E. Kronstad Symposium, Cd. Obregon, Son. Mexico. March 15, 2001.

Wellings, C. R., R. P. Singh and A. H. Yahyaoui. 2001. Current international awareness of pathogen variability in *Puccinia striiformis* f. sp. *tritici*. 1st Regional Yellow Rust Conference for Central & West Asia and North Africa, 8-14 May 2001, Karaj, Iran. Pp 57 (Abstr.).

Zaharieva, M., and A. Mujeeb-Kazi. 2001. Utilization of *Aegilops geniculata* diversity in the CIMMYT wheat program. Warren E. Kronstad Symposium, Cd. Obregon, Son. Mexico. March 15, 2001.

Others

Delgado, R., and A. Mujeeb-Kazi. 2001. *Septoria tritici* resistance in synthetic hexaploids and their advanced derivatives from bread wheat crosses. Annual Wheat Newsletter 47: 109-111.

Duveiller, E., 2001. Evaluation of cropping systems and better resistance to foliar blights. DGCI Project Phase II. Project progress report for 2000, Jan. 2001.

Duveiller, E. and Adhikhari, B., 2001. Report of the 8th HMN trials in Sout Asia. Kathmandu, Feb. 2001.

Duveiller, E. (Coord.) 2001. DFID Project (R7263) (C) Soil Health and Sustainability of the Rice-Wheat Systems of the Indo-Gangetic Plains, RWC-CIMMYT-CABI: 2nd Annual Technical report to DFID for the Apr.2000-Mar.2001 period (13p). (see RWC webpage).

Duveiller, E. (Coord.) 2001. DFID Project (R7263) (C) Soil Health and Sustainability of the Rice-Wheat Systems of the Indo-Gangetic Plains, RWC-CIMMYT-CABI: Third sixth-montlhy report (11p) for Apr. 1-Sept.30, 2001 was sent to DFID (11p).

Fuentes-Davila, G., M. van Ginkel, and A. Mujeeb-Kazi. 2001. A decades progress in evaluation of germplasm for Karnal bunt resistance. Annual Wheat Newsletter 47: 108-109.

Fuentes-Davila, G., R. Delgado, and A. Mujeeb-Kazi. 2001. Screening of a conventional bread wheat mapping population for Karnal bunt. Annual Wheat Newsletter 47: 120.

Fuentes-Davila, G. and A. Mujeeb-Kazi. 2001. Advanced bread wheat/synthetic hexaploid free threshing derivatives resistant to Karnal bunt. Annual Wheat Newsletter 47:120-122.

Henry M., van Ginkel M., Khairallah M. 2001. Marker - Assisted selection for BYDV resistance in wheat –Research highlight of the CIMMYT wheat program, 1999-2000, CIMMYT.

Mujeeb-Kazi, A., R. Delgado, S. Cano, L. Juarez, and J. Sanchez. 2001. Scab resistance in bread wheat/synthetic hexaploid derivatives. Annual Wheat Newsletter 47: 104-105.

Mujeeb-Kazi, A., R. Delgado, S. Cano, and V. Rosas. 2001. New tetraploid germplasm combining *Septoria tritici* resistance of some A and D genome diploids. Annual Wheat Newsletter 47: 113-114.

Mujeeb-Kazi, A., and R. Delgado. 2001. A second elite set of synthetic hexaploid wheats based upon multiple disease resistance. Annual Wheat Newsletter 47: 114-115.

Mujeeb-Kazi, A., R. Delgado, L. Juarez, J. Sanchez, and S. Cano. 2001. Scab resistance (Type II: Spread) in synthetic hexaploid germplasm. Annual Wheat Newsletter 47:118-120.

Singh, R. P. and J. Huerta-Espino. 2001. Global monitoring of wheat rusts, and assessment og genetic diversity and vulnerability of popular cultivars. Pages 38-40, *in* Research Highlights of the CIMMYT Wheat program, 1999-2000. CIMMYT, Mexico, DF.

Singh, R. P., S. Rajaram, J. Huerta-Espino and M. William. 2001. Durable resistance to yellow (stripe) rust in wheat. Pages 45-48, *in* Research Highlights of the CIMMYT Wheat program, 1999-2000. CIMMYT, Mexico, DF.

Smale, M., M. P. Reynolds, M. Warburton, B. Skovmand, R. Trethowan, R. P. Singh, I. Ortiz-Monasterio, J. Crossa, M. Khairallah and M. I. Almanza-Pinzon. 2001. Dimensions of diversity in CIMMYT bread wheat from 1965 to 2000. 40p. Mexico, D.F.:CIMMYT.

Zaharieva, M., A. Cortes, V. Rosas, S. Cano, J. Sanchez, L. Juarez, R. Delgado, and A. Mujeeb-Kazi. 2001. Potential of *Aegilops geniculata* genetic resources for wheat improvement. Annual Wheat Newsletter 47:102-103.

Global Project 7

Impacts of maize and wheat research

Project Coordinator: M. Morris
Oversight Director: P. Pingali

Project Summary

Global Project 7 "Impacts of Maize and Wheat Research" (G7) includes four sub-projects designed to update and expand our knowledge about the processes by which improved maize and wheat germplasm and improved crop and resource management practices are developed and diffused throughout the developing world; to deepen our understanding of the factors affecting the adoption of new technology in maize- and wheat-based systems; to increase our understanding of the optimal allocation of research resources, taking into account the role of technology spillovers and economies of size and scope; and to feed information into the priority setting component of Frontier Project 6 (F6).

The information and methods generated by G7 will create greater public awareness of the achievements of CIMMYT and its partners; provide support for fund-raising efforts within CIMMYT and collaborating institutions; help CIMMYT and other research organizations formulate effective strategies for deploying new technologies; and increase the efficiency of research resource allocation by providing data needed for the priority setting component of F6.

Sub-project 1: Impacts of maize and wheat breeding research

Sub-project leader: M. Morris

Main achievements during the past 12 months:

- impacts of maize breeding research in eastern and southern Africa (report completed)
- impacts of maize breeding research in Asia (report completed)
- global impacts of maize breeding research (report completed)
- global impacts of wheat breeding research (report completed)
- impacts of maintenance breeding in wheat (reports drafted)
- ex ante impact assessment of insect-resistant maize in East Africa (field data collection)
- ex ante impact assessment of stress-resistant maize in East Africa (field data collection)
- documenting "creolization" in maize in Mexico (field data collection)
- international conference on impacts assessment (organized and implemented)

Major activities planned for the next 12 months:

- returns to maintenance breeding in wheat (complete reports)
- documenting "creolization" in maize in Mexico (analyze data, write report)
- global impacts of wheat breeding research (initiate new round of data collection)
- impact of herbicide-resistant maize for controlling striga in East Africa (initiate study)

- impact of transgenics on maize biodiversity in Kenya (initiate study)

Sub-project 2: Impacts of crop and resource management research

Sub-project leader: G. Saín

Main achievements during the past 12 months:

- global review of no-till technologies (report completed for *Wheat Overview and Outlook*)
- SoilFertNet in southern Africa (network management and support provided)
- adoption of conservation tillage in Ghana (report completed)
- conservation tillage in Mexico, Central America (field data collection)
- impact of no-till technologies (funding proposals prepared)

Major activities planned for the next 12 months:

- SoilFertNet in southern Africa (provide network management and support)
- farmers' soil management practices in Zimbabwe (test promising technologies)
- conservation tillage in Mexico, Central America (test promising technologies)
- conservation tillage in Mexico, Central America (write, produce reports)
- impact of no-till technologies (secure funding, initiate research)

Sub-project 3: Incorporating technology spillover information into the design of national and international agricultural research in Latin America

Sub-project leader: J. Ekboir

Main achievements during the past 12 months:

- wheat germplasm flows in Latin America (document drafted)

Major activities planned for the next 12 months:

- none [sub-project terminates]

Sub-project 4: Selected issues in technology adoption and impacts assessment

Sub-project leader: (none)

Main achievements during the past 12 months:

- adoption of MVs and fertilizer in eastern and southern Africa (case studies completed)
- factors affecting diffusion of maize landraces in Oaxaca (field data collection initiated)
- consequences of maize seed recycling in Zimbabwe (case study completed)
- adoption of MVs in eastern and southern Africa (case studies edited, published)
- adoption of MVs in eastern and southern Africa (synthesis report drafted)
- factors affecting the adoption of MVs and soil fertility management practices in Nepal (survey completed, key findings reported).

Major activities planned for the next 12 months:

- adoption of MVs in eastern and southern Africa (complete synthesis report)
- factors affecting diffusion of maize landraces in Oaxaca (field data collection)

- impact of the liberalization of maize input and output markets in Kenya (initiate study)
- impact of reforming market information systems in Kenya (initiate study)

Special activity: International conference on research impacts assessment

In collaboration with the Special Panel on Impacts Assessment (SPIA) of the CGIAR Technical Advisory Committee (TAC), the CIMMYT Economics Program hosted an international conference focusing on the theme, "Why Has Impacts Assessment Research Not Made More of a Difference?" The conference was held in San José, Costa Rica, from February 4-7, 2002. Much of the organizational work for the conference was carried out by members of G7, including fund raising, commissioning of invited papers, solicitation of contributed papers, convening of expert panels to review submitted abstracts, design of the conference program, editing post-conference publications. The conference attracted approximately 145 participants, including many leading authorities on research impacts assessment methods and practices. Information about the conference is available through the CIMMYT web site.

Publications, Completed Manuscripts, and Conference Presentations produced in 2001 under Global Project 7

Note: Due to overlapping research themes, some of the items listed here as outputs of Global Project 7 may also be listed as outputs of other MTP projects.

1. Publications

(a) Monographs

Bellon, M.R. 2001. Participatory research methods for technology evaluation. Mexico, D.F.: CIMMYT.

Bonnal, P., F. Affholder, D. Jourdain, and E. Scopel. 2001. Un modèle bio-économique comme outil d'aide à la réflexion sur les relations entre le risque lié à l'environnement et les choix des agriculteurs. Montpellier. Collection Synthèses. Montpellier, CIRAD.

Degu, G., W. Mwangi, H. Verkuijl, and A. Wondimu. 2001. An assessment of the adoption of seed and fertilizer packages and the role of credit in smallholder maize production in Sidama and North Omo Zone, Ethiopia. Mexico, D.F.: CIMMYT and ARC.

Gerpacio, R. (ed.). 2001. Impact of public- and private-sector maize breeding research in Asia, 1966-1997/98. Mexico, D.F.: CIMMYT.

Hassan, R.M., M. Mekuria, and W.M. Mwangi. 2001. Maize breeding research in eastern and southern Africa: Current status and impacts of past investments by the public and private sectors, 1966-1997. Mexico, D.F.: CIMMYT.

Hodson, D.P., D. Jourdain, B. Triomphe, J.W. White, and H. Garcia Nieto. 2001. Application of GIS to the design of sampling strategies for agricultural surveys: A case study for farming practice surveys in Guanajuato, Mexico. Natural Resources Group Working Papers. Mexico, D.F.: CIMMYT.

Jourdain, D., E. Scopel, and F. Affholder. 2002. Impact of conservation tillage on maize cropping systems productivity and stability: A case study in western Mexico. CIMMYT Economics Working Paper 01-02. Mexico, D.F.: CIMMYT.

Jourdain, D., B. Triomphe, and J.-M. Arreola Tostado. 2001. Detección de obstáculos y necesidades sobre labranza de conservación. Reporte final del proyecto CIMMYT-FIRA: Preparando la Transición Hacia una Agricultura Sostenible con Base en la Generación, Adaptación Difusión de Sistemas de Labranza de Conservación en México. Mexico, D.F.: CIMMYT.

Kotu, B.H., H. Verkuijl, W.M. Mwangi, and D.G. Tanner. 2001. Adoption of improved wheat technologies in Adaba and Dodola woredas of the Bale highlands, Ethiopia. Mexico, D.F.: CIMMYT and ARC.

Makokha, S., S. Kimani, W.M. Mwangi, H. Verkuijl, and F. Musembi. 2001. Determinants of fertilizer and manure use in maize production in Kiambu District, Kenya. Mexico, D.F.: CIMMYT and KARI.

Mussei, A., J. Mwanga, W.M. Mwangi, H. Verkuijl, R. Mongi, and A Elanga. 2001. Adoption of improved wheat technologies by small-scale farmers in Mbeya District of Southern Highlands, Tanzania. Mexico, D.F.: CIMMYT and MARTI.

Paudyal, K.R., J.K. Ransom, N.P. Rajbhandari, K. Adhikari, R.V. Gerpacio and P.L. Pingali. 2001. Maize in Nepal: Production Systems, Constraints and Priorities for Research. Kathmandu: NARC and CIMMYT.

Pingali, P.L. 2001. Milestones in impacts assessment research in the CGIAR, 1970-1999. With an annotated bibliography of impacts assessment studies conductedion the CGIAR, 1970-1999, prepared by Matthew P. Feldmann. Mexico, D.F.: Standing Panel on Impacts Assessment, Technical Advisory Committee, CGIAR.

Smale, M., M. Reynolds, M. Warburton, B. Skovmand, R. Trethowan, R. Singh, I. Ortiz-Monasterio, J. Crossa, M. Khairallah, and I. Almanza. 2001. Dimensions of diversity in CIMMYT bread wheat from 1965 to 2000. Mexico, D.F.: CIMMYT.

Tiruneh, A., T. Tesfaye, W. Mwangi, and H. Verkuijl. 2001. Gender differentials in agricultural production and decision-making in Ada, Lume, and Gimbichu woredas of the Central Highlands of Ethiopia. Mexico, D.F.: CIMMYT and ARC.

(b)Journal articles

Bellon, M.R., and J. Risopoulos. 2001. Small-scale farmers expand the benefits of improved maize germplasm: A case study from Chiapas, Mexico. *World Development 29* (5): 799-811.

Bokonon-Ganta A., H. De Groote, and P. Neuenschwander. 2001. Socio-economic impact of biological control of mango mealybug in Benin. *Agriculture, Ecosystems and Environment.*

Doss, C.R. 2001. Designing agricultural technology for African women farmers: Lessons from 25 years of experience. *World Development 29* (12): 2075-2092.

Doss, C.R., and M.L. Morris. 2001. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. *Agricultural Economics 25 (1)*: 27-39.

Kosarek, J., P. Garcia, and M.L. Morris. 2001. Factors explaining the adoption of hybrid maize: Evidence from Latin America and the Caribbean in support of the life cycle theory of seed industry development. *Agricultural Economics 26(4)*: 267-280.

Pingali, P. L. 2001. Environmental consequences of agricultural commercialization in Asia. *Environment and Development Economics 6*: 483-502

(c) Published conference proceedings

Lantican, M.A., and P.L. Pingali. 2001. "Growth in Wheat Yield Potential in Marginal Environments." In J. Reeves, A. McNab, and S. Rajaram (eds.). *Proceedings of the Warren E. Kronstadt Memorial Symposium, 15-16 March, 2001.* Ciudad Obregon, Mexico: CIMMYT.

(d) Book chapters

Heisey, P.W., M.A. Lantican, and H.J. Dubin. 2002 (in press). "Impacts of CIMMYT's wheat breeding program." In B. Evenson and D. Gollin (eds.), *Impact of the CGIAR on international crop genetic improvement.* Wallingford, UK: CABI.

Mekuria, M., and S. Waddington. 2001. "Initiatives to encourage farmer adoption of soil fertility technologies for maize-based cropping systems in southern Africa." In C. Barrett, F. Place, and A. Aboud (eds.), *Understanding adoption processes for natural resource management practices for sustainable agricultural production in Sub-Saharan Africa.* Wallingford, UK: CAB International.

Morris, M.L., M. Mekuria, and R. Gerpacio. 2002 (in press). "Impacts of CIMMYT's maize breeding program." In B. Evenson and D. Gollin (eds.), *Impact of the CGIAR on international crop genetic improvement.* Wallingford, UK: CABI.

Morris, M.L. 2002 (in press). "Impacts of globalization on national maize seed industries: Lessons from developing countries." In D. Bigman (ed.), *Globalization and the developing countries: Economic potential and agricultural prospects.* Wallingford, UK: CAB International.

Morris, M.L., J-M. Ribaut, M. Khairallah, and K. Dreher. 2002. "Potential impacts of biotechnology-assisted selection on plant breeding programs in developing countries." In P. Pardey and R.M. Banks (eds.), *The future of food: Biotechnology markets and policies in an international setting.* Baltimore: Johns Hopkins University Press.

Pingali, P.L., and P.W. Heisey. 2001. Cereal crop productivity in developing countries: Past trends and future prospects. In J.M. Alston, P.G. Pardey, and M.J. Taylor (eds), *Agricultural Science Policy: Changing Global Agendas.* Washington: IFPRI and Johns Hopkins University Press.

2. Completed Manuscripts

Ekboir, J.M., K. Boa, and A.A. Dankyi. Impact of no-till technology in Ghana.

Gamba, P., C. Ngugi, H. Verkuijl, W. Mwangi, F. Kiriswa. Wheat farmers' seed management and varietal adoption in Kenya.

Gemeda, A., G. Aboma, H. Verkuijl, and W.M. Mwangi. Farmers' maize seed systems in Ethiopia: The case of western Oromia.

Heisey, P.W., M.A. Lantican, and H.J. Dubin. Assessing the benefits of international wheat breeding research in developing countries: The Global Wheat Impacts Study, 1966-97.

Marasas, C.N., M. Smale, and R.P. Singh. The global economic impact of breeding for genetic resistance to leaf rust in CIMMYT-related spring bread wheat.

Muhammed L., K. Njorege, C. Bett, W.M. Mwangi, H. Verkuijl, and H. De Groote. The seed industry for dryland crops in Eastern Kenya.

Morris, M.L. Impacts of international maize breeding research in developing countries, 1966-98.

Okuro, J.O., F.M. Murithi, W.M. Mwangi, H. Verkuijl, M. Gethi, and H. De Groote. Adoption of seed and fertilizer technologies in Embu District, Kenya.

Wekesa E., W.M. Mwangi, H. Verkuijl, K. Danda, and H. De Groote. Adoption of maize production technologies in the coastal lowlands of Kenya.

3. Conference Presentations

Bellon, M.R., and M.L. Morris. 2001. Linking global and local approaches to agricultural technology development: Plant breeding research in the CGIAR. Paper presented at the 2001 Open Meeting of the Human Dimensions of Global Environmental Change Research Community, October 6-8, Rio de Janeiro, Brazil.

Bellon, M., J. Becerril, M. Adato, and J.A. Aguirre Gomez. 2002. The impact of improved maize germplasm on poverty alleviation: The case of Tuxpeño derived material in Mexico. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

De Groote H., C. Bett, L. Mose, M. Odendo, J. O. Okuro, and E. Wekesa. 2002. Direct measurement of maize crop losses from stem borers in Kenya, preliminary results from the 2000-2001 season. Paper prepared for the 7th Eastern and Southern Africa Regional Maize Conference, 11-15 January, Nairobi, Kenya.

De Groote H., B. Overholt, L. Macopiyo, J. O. Okuro, and S. Mugo. 2002. Guiding technology development through a GIS based ex ante impact assessment model: The case of insect resistant maize in Kenya. Poster presentation at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Doss, C., H. De Groote, and W.M. Mwangi. 2001. Adoption of maize and wheat technologies in East Africa. Paper presented at the Regional Workshop "Understanding Adoption and Impact of Soil Fertility Management Technologies in Southern Africa: Constraints, Lessons, and Emerging Issues," December 3-6, Harare, Zimbabwe.

Ekboir, J. 2002. Can impact analysis be used for research evaluation? Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Gerpacio, R.L.. 2002. Impact of public sector vs. private sector R&D and technology generation: The case of maize in Asia. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Gomez, M.I., and P.L. Pingali. 2002. Economic benefits of research collaboration: The case of the regional Maize Program for Central America and the Caribbean. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Hintze, H., M. Renkow, and G. Sain. 2002. Variety characteristics, transaction costs, and maize adoption in Honduras. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Jourdain, D., B. Triomphe, and J.-M. Arreola Tostado. 2001. Differential adoption of direct seeding in Guanajuato, Mexico: A baseline survey. 1st World Congress on Conservation Agriculture, October 1-5, Madrid, Spain.

Karanja, D., and M. Renkow. 2002. The welfare effects of maize technology in marginal and high potential regions of Kenya. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Lantican, M., P.L. Pingali, and S. Rajaram. 2002. Effects of innovative wheat breeding in marginal environments. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Marasas, C., M. Smale, and R. Singh. 2002. Returns to investment in maintenance research: The case of leaf rust resistance breeding in CIMMYT-related spring bread wheat. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Maredia, M., P.L. Pingali, and M. Nelson. 2002. Environmental impacts of productivity-enhancing crop research: A critical review. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Morris, M.L., J-M. Ribaut, M. Khairallah, and K. Dreher. 2001. Potential impacts of biotechnology-assisted selection methods on plant breeding programs in developing countries. Paper presented at the Pre-Conference Workshop on Biotechnology, Annual Conference of the Australian Agricultural and Resource Economics Society, January 23, Adelaide, Australia.

Morris, M.L., and P.W. Heisey. 2002. Estimating the benefits of plant breeding research: Methodological issues and practical challenges. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Neuenschwander, P., B. Douthwaite, and H. De Groote. 2002. Impact assessment of biological control in Africa: Twenty years experience at the International Institute of Tropical Agriculture. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Odendo M., H. De Groote and O.M. Odongo. 2001. Assessment of farmers' preferences And constraints to maize production in the moist midaltitude zone of western Kenya. Paper presented at the 5th International Conference of the African Crop Science Society, October 21-26, Lagos, Nigeria.

Owuor G., H. De Groote, and M. Wangia. 2002. Impact of self-help groups' credit on agricultural production in Siaya, Kenya. Paper prepared for the 7th Eastern and Southern Africa Regional Maize Conference, 11-15 February, Nairobi, Kenya.

Pingali, P.L.. 2002. Milestones in CGIAR impacts assessment. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Ransom, J., K. Padyal, and K. Adhikari. 2002. Factors affecting the adoption of maize technologies in the hills of Nepal. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Ransom, J., K. Poudel and K. Adhikary. Factors affecting the adoption of varieties and soil fertility management practices in two districts of Nepal. Presentation at the International Maize Symposium, December 16-18, Katmandu, Nepal.

Saín, G., and M. Zurek. 2002. Adoption and impact of soil conservation technologies in Central America. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Siziba, S., and M. Mekuria. 2002. A farm-level evaluation of the impacts pf IPM on pesticide use: A comparison of IPM trained and ordinary farmers in Zimbabwe's smallholder sector. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Smale, M., M. Bellon, J. Aguirre, J. Mendoza, A.M. Solano, R. Martinez, and A. Ramirez. 2002. Economic costs and benefits of a participatory project to conserve maize landraces on farms. Paper presented at the international conference "Why Has Impacts Assessment Research Not Made More of a Difference?," February 4-7, San José, Costa Rica.

Triomphe, B., D. Jourdain, J.-M. Arreola Tostado, and H. Escoto Ramirez. 2001. Towards large-scale adoption of no-tillage in central Mexico: A participatory, multi-institutional approach to technology development and diffusion. 1st World Congress on Conservation Agriculture, October 1-5, Madrid, Spain.

Global Project 8

Building Human Capital

Project Coordinator: R. L. Villareal

Oversight Director: L. Harrington/S. Rajaram

CIMMYT's G8 -"Building Human Capital" project seeks to develop an effective corps of scientists in the public research sector of developing countries to address the emerging challenges to the productivity, profitability and sustainability of maize and wheat. Its ultimate purpose is to empower researchers in national agricultural research systems (NARSs) to conduct research more efficiently, share expertise with others, and improve collaboration across disciplines and institutions. CIMMYT addresses this by providing training opportunities and developing study programs for national scientists either at headquarters in Mexico or in other venues. Broadly, our training initiatives can be described as 1) general in-service training for entry-level professional staff in NARSs; 2) specialized in-service training for mid-career and senior staff, mostly from developing countries; 3) advanced training for visiting scientists or graduate students that responds to the demands of well-defined research projects; and 4) assistance in building the training capacity of NARSs. The highlights of the project in 2001 are presented in the sections that follow.

Activities of 2001

- In-service training courses on strategic research areas were offered at CIMMYT Mexico headquarters.
- In-country and regional training courses were conducted in various countries.
- Multi-national visiting scientists were hosted to work on research of mutual interest.
- Organized or co-organized international conferences, workshops and meetings in Mexico and other venues worldwide.
- New specialized training courses offered in Mexico.
- Developed course materials on new training initiatives.
- Courses integrated at headquarters.
- Announcements of CIMMYT's training initiatives were circulated worldwide i.e. courses, conferences, meetings, traveling seminars and workshops.
- Supported crop management research training at the local level in Africa, Latin America, and Asia.
- Training-related policies reviewed after initially being tabled with the MAC.
- Training alumni database maintained at headquarters.
- Researches for BSc., MSc. and PhD. degrees supervised and/or supported.

- Pre- and post-doctoral fellowship opportunities in major research efforts at CIMMYT.
- Increased public awareness on human capital development activities at CIMMYT and its partners.

Gains (Impacts) of 2001

- Eighty-five in-service trainees from 26 countries participated in 9 courses on strategic research at CIMMYT headquarters.
- Seven training courses were held outside Mexico or sponsored by CIMMYT regional programs in Argentina, Brazil, China, Colombia, India, Kenya, Peru, Philippines, Thailand, Uruguay, Venezuela and Zimbabwe.
- Eighteen conferences/workshops offered at headquarters and other venues which benefited more than 600 scientists worldwide resulting better communication among maize and wheat systems researchers.
- CIMMYT hosted 120 visiting scientists from 32 countries at headquarters.
- AMBIONET project Phase 1 extended until the end of 2001.
- CIMMYT's 2002 calendar of international courses and conferences announced and sent to collaborators. Also available on the Web-page.
- Maize improvement training course reviewed by task force appointed by Maize Program Director.
- Advanced wheat improvement course offered for the first time at Cd. Obregon to 10 senior scientists from 9 countries.
- Wheat agronomy - bed and zero till planting for irrigated and rainfed wheat production systems-course offered for the first time in Mexican highlands (El Batan/Toluca) to senior researchers from national agricultural research programs.
- CIMMYT/IRRI collaboration for "On-line" course in Experimental Design and Data Analysis.
- Training database up-dated and made available to interested users.
- Thirty-seven theses were produced from fellowships funded or managed by CIMMYT or funded by CIMMYT during 2000-01 period.
- CIMMYT had 13 pre- and post-doctoral fellows and 11 graduate students.
- G8 output poster presentation on wheat improvement training at the Annual Meetings of the American Society of Agronomy, Crop Science Society of America and Soil Science Society of America in Charlotte, North Carolina.
- New "Spanish version" training brochure printed and circulated to collaborators in June.
- Compilation of CIMMYT training activities 1991-2001 and other training narratives for the TAC-SPIA study on the impacts on CGIAR training.

Plans for 2002

- Nine training courses to be offered at CIMMYT, Mexico.
- Nine training courses to be offered outside Mexico or in the CIMMYT regional programs.

- Eleven conferences, workshops and/or meetings for NARS, NGOs and ARIs will be organized and hosted.
- Degree and post-degree training.
- Impact study of CIMMYT training.
- Inventory of CIMMYT training materials.
- Development of training materials.
- Course description "inserts" to supplement the training brochure.
- Training data input on alumni database.
- Continue applications of CBT (Computer-Based Training).
- Finalize training-related policies
- Web-based training materials development with Oklahoma State University and other ARIs.

Training-Related Publication/Report in 2001

CIMMYT. 2001. La Capacitacion en el CIMMYT. Actividades que enriquecen el conocimiento de los investigadores. CIMMYT, Mexico, D.F.

CIMMYT. 2001. CIMMYT training activities 1991-2001. Compiled by M. Morris for the TAC-SPIA Study on the Impacts on CGIAR Training.

CIMMYT. 2001. Calendar of International Courses and Conferences 2002.

George, M.L. (Editor). 2001. AMBIONET News, Vol. 3 nos. 1-4. CIMMYT and Asian Development Bank, Makati , Philippines.

Villareal, R.L. 2001. G8 - Building human capital. CIMMYT, El Batan, 3p. (Internal report).

Villareal, R.L. 2001. Reference Manual Advanced Wheat Improvement Course (A Compilation). CIMMYT, El Batan.

Villareal, R.L. and O. Bañuelos. 2001. Summary report on advanced wheat improvement training course 2001: a global project output. CIMMYT, El Batan. 11p. (Internal report).

Villareal, R.L. and O.Bañuelos. 2001. Global training for wheat researchers of the 21st century, G8 output in 2001. CIMMYT, El Batan. 17p. (Internal report).

Villareal, R.L. and O.Bañuelos. 2001. CIMMYT's basic and advanced wheat improvement training courses in 2000. Annual Wheat Newsletter. Vol.47.

Villareal, R.L., O.Bañuelos and S. Rajaram. 2001. Building human capital for wheat improvement research at CIMMYT. Agronomy Abstracts. American Society of Agronomy, Wisconsin. Also exhibited as CIMMYT Wheat Program's poster display.

Global Project 9

Conservation agriculture to mitigate poverty and climate change

Project Coordinator: P. Wall
Oversight Director: L. Harrington

What is Conservation Agriculture? Conservation Agriculture covers an array of technologies such as residue retention, zero- and reduced tillage, crop rotations, green manure cover crops, controlled traffic and raised beds, which when used in combination reduce, and often revert, the degradation of soil and water resources. Of these technologies, residue retention is that which distinguishes conservation agriculture from conventional agriculture, and all conservation systems include at least a certain level of surface residue cover.

Global Project 9 is the newest CIMMYT project, initiated in 2001 and consolidated in a Project Workshop in October 2001. Conservation Agriculture is an important theme in most, if not all, of the Regional Projects, and in some of the other Global Projects. In order to try to clarify the division between the activities of the Global Project and the Conservation Agriculture activities undertaken in the Regional Projects, it was decided at the Inception Workshop that field work on conservation technologies undertaken to develop production techniques for particular environments would be considered as part of the Regional Projects, and that the Global project would concentrate on synthesizing, transferring and scaling up these experiences. In the future it is foreseen that the Global Project may well be involved in field work in the various Regions, enhancing and/or intensifying this in an effort to increase the extrapolability of the results.

As GP9 is a new project it is understandable that ongoing activities, even where they clearly fall under the umbrella of GP9, will have been considered within other Projects, both Regional and Global. This will lead to some duplication of reporting until such time as new "boundaries" of Projects are "defined" taking into account the presence of GP9.

Most of the outputs and activities planned for GP9 are new, requiring new funding for their implementation. Initially, therefore, much of the effort of the Project will be towards identifying funding sources, project preparation and presentation.

1. Catalyze the development and/or dissemination of prototype conservation agriculture practices and implements, for evaluation and adaptation in regional projects, in order to overcome identified research gaps and adoption bottle-necks.

- Machinery exchange. Animal-drawn no-till small-grain seeder developed in Bolivia sent to India, Mexico, Paraguay and Ecuador for trial and adaptation. The machine in India has been modified and we propose to get the modified seeder to Mexico for evaluation.
- A multi-crop bed planter developed in India was tested in Nepal for its use in planting maize following rice. The planter worked very well on established beds where rice had been grown the previous season, but where rice was grown on the flat, the seeding depth of the maize was too great and emergence was less than optimum - some adjustments are needed.

- Two case studies developed for the Sustainable Systems Training Course.

2. Updated and synthesized knowledge available and disseminated on research methods, performance and adoption of conservation agriculture practices in different environments.

- Analysis of the adoption of zero tillage systems in South America and Ghana completed and published. Further publications in press and preparation. Analytical studies on the adoption of conservation agriculture practices in South Asia (RWC) initiated.
- Analysis of the adoption of conservation agriculture systems the State of Guanajuato (Mexico) analyzed and published. Further publications in press.
- Review report on Conservation Agriculture Research in CIMMYT in advanced stage of preparation (ready by late 2002)

3. Improved understanding attained of the longer-term biophysical and environmental consequences of introducing conservation agriculture technologies, especially with respect to land and water quality, input use efficiency, agroecosystem diversity and climate change.

- Funding obtained for a German Post-Doc, Dr. Rolf Summer, to work on modeling the impact of reduced and zero tillage systems on soil moisture and organic carbon. Begins July, 2002.
- Root rot diseases on maize and wheat in conservation tillage experiments in Mexico evaluated. Studies underway on the detection, identification and development over time of the most common maize and wheat root rot pathogens under conservation tillage systems in ME2 and ME1.
- The first phase of the 'Soil Health Special Project' with CABI Bioscience on behalf of the Rice Wheat Consortium will be completed in May 2002. The project deals with the comparative effects of zero tillage and conventional tillage on soil pathogens in Rice-Wheat systems in Pakistan, Nepal and India.
- New long-term experiment established in the Bajio (Mexico), allowing the integrated study of four main factors: irrigation systems, tillage, rotations, and fertilization rates.

4. Improved efficiency of scaling up conservation agriculture adoption achieved through relevant training, networking and stakeholder participation.

- Training programs on zero tillage and bed planting held in Mexico with X participants from Y countries.
- Contacts established with Monsanto for funding of future conservation agriculture training efforts.
- Contacts established with the Confederación Americana de Agricultores Para una Agricultura Sostenible (CAAPAS), the International Soil Tillage Research Organization (ISTRO), the African Conservation Tillage Network (ACT). and several national networks established. Leading role played in the GFAR Global Program for Direct Sowing, Mulch Based Systems and Conservation Tillage (GP-DMC).
- Linkage established between the CIMMYT Maize Program and the RWC and some work initiated on the establishment of maize after rice using conservation tillage

5. Improved knowledge gained on interactions between conservation agriculture practices and maize and wheat germplasm.

- Selection of germplasm resistant to Fusarium root rot in wheat initiated in winter of 2001/2002 in Mexico.
- Proposed initiation of a study on genotype x tillage (G x T) interactions in wheat and maize in El Batan in the summer of 2002.
- Study initiated in the Bajio in winter of 2001-2002 on G x T for wheat, barley, chick pea and cartamo, soon to be extended to maize, sorghum, soybean, etc.
- Wheat genotypes identified in G x T studies in South Asia (R3) with respect to adaptability to conservation systems and resistance to diseases prevalent in these systems to be included in El Batan studies.

6. Processes in place for systematic sharing with partners and stakeholders of knowledge on conservation agriculture options.

- Several members of GP9 attended and presented papers and-or posters at the First World Congress on Conservation Agriculture held in Madrid in October, 2001.

Priorities for Funding (Future Activities).

Top priority

Global exchange of relevant equipment

Practical training courses on conservation agriculture (CA)

Next priority

Upgrade the distribution of long-term CA experiments and data collection in these.

Assess research gaps and adoption constraints in major farming systems (with Regional Projects)

Develop an inventory of research gaps and adoption constraints

Organize targeted study tours for G9 members, researchers, extension agents and farmers

Conduct and participate in international technical workshops on CA

Produce training materials on key CA technologies

Next priority

Expansion of data base management systems (Prism-type and others)

Coordinate modification and/or development of CA implements

Identify key traits for genotypic adaptation to CA technologies

Document and disseminate information on G x CA interactions.

Document policy effects on the adoption of CA technologies

Develop and target information on CA for donors and policy makers

Collect and produce materials on CA for the public

Identify, obtain, evaluate and make available CA related training materials

Develop training materials and curricula for undergraduate university courses.

Publications

Barry, E. (2001). Premiers éléments sur la dynamique d'évolution des systèmes de production du Bajio Guanajuatense. Diplome d'Ingénieur Agronome. Toulouse, Ecole Nationale Supérieure Agronomique de Toulouse: pp. 61 + Annexs.

Jourdain, D., E. Scopel and F. Affholder (2001). Impact of conservation tillage on maize cropping systems productivity and stability: a case study in western Mexico. Economics Working Paper, WP 01-02. Mexico, CIMMYT.

Jourdain, D., B. Triomphe and J.-M. Arreola Tostado (2001a). Detección de obstáculos y necesidades sobre labranza de conservación. Reporte final del proyecto CIMMYT-FIRA: Preparando la Transición Hacia una Agricultura Sostenible con Base en la Generación, Adaptación Difusión de Sistemas de Labranza de Conservación en México. Mexico, CIMMYT.

Jourdain, D., B. Triomphe and J.-M. Arreola Tostado (2001b). Differential adoption of direct seeding in Guanajuato, Mexico: a baseline survey (Poster). In "Conservation Agriculture, a Worldwide Challenge" Proceedings of the I World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001. FAO – ECAF, Córdoba, Spain.

Triomphe, B., D. Jourdain, J.-M. Arreola Tostado and H. Escoto Ramirez (2001). Towards large-scale adoption of no-tillage in central Mexico: a participatory, multi-institutional approach to technology development and diffusion. In "Conservation Agriculture, a Worldwide Challenge" Proceedings of the I World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001. FAO – ECAF, Córdoba, Spain.

Sayre, K.D., Mezzalama, M. and Martínez, M. 2001. Tillage, crop rotation and crop residue management effects on maize and wheat production for rainfed conditions in the altiplano of central Mexico. In "Conservation Agriculture, a Worldwide Challenge" Proceedings of the I World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001. FAO – ECAF, Córdoba, Spain. p 575-580.

Wall, P.C. 2001 La Degradación de los Suelos: Causas, Efectos y la Solución. Presentado en la IV Reunión Nacional de Trigo y Cereales Menores, Cochabamba, Bolivia, Octubre 11-12, 2001 (Proceedings in press)

Wall, P.C., Zambrana, L., Gamez, P., Sims, B. and Calissaya A. 2001. Development of an animal drawn zero tillage seeder. for small grains. In "Conservation Agriculture, a Worldwide Challenge" Proceedings of the I World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001. FAO – ECAF, Córdoba, Spain. p 631-635.

Regional Project 1

Food and Sustainable Livelihoods for Sub-Saharan Africa

Project Coordinator: S. Waddington

Oversight Director: S. Pandey

Summary Introduction

2001 was a very exciting year for R1. Abiotic and biotic stress tolerant maize OPVs and hybrids from our projects in southern and eastern Africa were released by several national programs and seed companies and widely exposed to many farmers in the region. Some of these were highlighted during the CG Mid Term meeting in Durban, South Africa. Well adapted wheat varieties were released in eastern Africa. A great deal of new natural resource management (NRM) technology information was generated, particularly on soil fertility, weed management and conservation tillage. Preliminary evidence was obtained about the uptake of certain NRM technologies by farmers. Several initiatives looked at how we can better focus our work on meeting client needs and providing the support they require, including the explicit incorporation of a poverty focus into maize seed product development and delivery and soil fertility, improved quality of adoption and impact studies, policy and private sector support to NRM and skills upgrading in areas such as natural resource economics.

Presentations on R1 achievements in 2000 and our future plans were made at HQ Project Week in March 2001. A very successful 2001 Review and Planning meeting was held in Harare 14-15 August during which we took stock of our achievements and limitations. We examined ways to better integrate breeding projects and schemes, seed release and multiplication procedures, and document the use of CIMMYT maize germplasm. We also re-organized our natural resource management work to better reflect planned activity on the development, deployment and integration of crop and natural resource management technologies, and looked at how to achieve greater impact and raise the quality of adoption and impact studies.

R1 provided opportunities and encouraged members to interact and develop synergistic activities across the existing sub-projects, the disciplines, and the two sub-regions (Eastern Africa and Southern Africa). Significant progress has been made during 2001 with increasing synergy, but this does need further development and support. Interaction among staff has ranged from integration meetings conducted by maize breeding staff and others across the two sub-regions, through the conduct of joint research activities by agronomists, economists and breeders, and during the development of funding proposals to donors. Several new integrated proposals have been developed within RP1 during 2001. Significant interaction with other MTP projects is now apparent and many of these were incorporated into the RP1 2002-2004 log frame during 2001. These include joint work with GP2, 3, 4, 6, 7, 8 and 9. We have also improved links outside of CIMMYT, notably with other IARCS in southern and eastern Africa (within and additional to the CG integration process) and with some additional donors and NGOs.

This report lists achievements by sub-project during 2001, describes progress with integration and synergy, and with resourcing, gives some plans for 2002-04, and lists publications from RP1 during 2001.

Achievements 2001

RP1 continued to operate during 2001 in six sub-projects:

SP 1: Development of maize germplasm adapted to biotic and abiotic constraints

SP 2: Deployment of maize germplasm adapted to sub-Saharan Africa

SP 3: Development and deployment of wheat germplasm

SP 4: Understanding and promoting sustainable maize and wheat-based systems

SP 5: Enhancing human resources and partnerships devoted to maize and wheat cropping systems

SP 6: Impact assessment and socioeconomic analysis of maize and wheat technology.

Achievements are given here by sub-project.

SP 1: Development of maize germplasm adapted to biotic and abiotic constraints

Breeding progress was made by the AMS project in Eastern Africa and CIMMYT-Zimbabwe on developing inbred lines, OPVs, synthetics that have tolerance to drought, low soil nitrogen, streak virus, *Striga* and stem borers for the region.

Several maize synthetics and hybrids developed with turcicum/MSV/GLS tolerance for the highland zones of Ethiopia, following excellent heterotic responses for topcrosses of CIMMYT Pool 9A lines with regional population testers (Kitale, Ecuador 573 and Kuleni).

Characterised elite CIMMYT germplasm for resistance to *Chilo partellus* and *Busseola fusca.* Based on stem borer resistance and general performance, 120 lines were selected for crossing, further screening and advance to the S6 generation in Kenya. These lines have exhibited resistance to stem borers and hold the best potential for developing stem borer resistant germplasm. These will be used for development of hybrids and OPVs containing resistance to stem borers.

Identified Bt cry proteins that are effective against the major Kenya stem borer *Chilo partellus.*

During 2001, major improvements were made to the capacity to mass rear and supply lepidopteran stem borers and screen for weevil resistance in Kenya.

Developed capacity within Kenya for handling GMOs. These included a biosafety level 2 laboratory for use in evaluating Bt maize tissues especially for insect bioassays, a biosafety level 2 biocontainment laboratory and open field quarantine facilities for use in evaluating Bt maize.

Experimental Quality Protein Maize (QPM) hybrids gave very high and stable grain yields across 25 test sites in southern and eastern Africa, and performed well in low N conditions, but streak resistance needs to be improved.

Showed that weaner pigs fed QPM for three months in Kenya gained three times the body weight of those fed normal maize. The body condition of QPM-fed pigs was better than those fed on normal maize. QPM pigs were more robust, inquisitive and had a glossier coat than normal maize pigs.

The Second Phase of the Regional Maize Nursery Project (REGNUR) began late 2001, with collaborators from 8 countries in East and Southern Africa, to facilitate regional breeders to develop biotic and abiotic-stress tolerant germplasm and synergies with other regional projects (e.g. Striga, drought, low-N, QPM).

Initiated a breeding program to improve imidazolinone resistant (IR) maize germplasm for striga control, including advancing of inbred lines to S2 to S4 generations with selection for resistance to herbicide and to *Turcicum* leaf blight, and a backcrossing program by making crosses of IR maize inbred lines to a striga tolerant maize synthetic ECAVL17STR to enhance turcicum resistance and adaptation in Western Kenya.

To develop *Striga* resistance in maize using transposons, 23 lines of transposon tagged maize have been identified which display durable, heritable tolerance and or resistance to the parasitic weed *Striga hermonthica*. Mapping of the tolerant lines has begun with the aim of developing markers for the *Striga* tolerant trait which can be used to aid selection later in the breeding programme.

In the development of *Striga*-tolerant maize germplasm using wild relatives, we have demonstrated in both the field and in the laboratory that tetraploid apomictic *Tripsacum* is tolerant to *Striga*. The growth of *Striga* attached to *Tripsacum* is perturbed to such an extent that no *Striga* emergence occurs.

A collaborative project between IITA, KARI and CIMMYT investigated the transgression of *Striga* tolerance from teosinte to maize. IITA have developed maize lines which have higher yields under conditions of *Striga* infestation than conventional cultivars. We are currently identifying molecular markers for the *Striga* tolerant trait to be used in MAS within the breeding process.

Four sites to screen maize breeding germplasm for acid soil tolerance were established with National Programs in Lesotho, Malawi, South Africa and Zambia.

Developed more work on early maturity maize and established dimba (vlei) evaluation sites in Malawi. Some new early maturity maize varieties (ZEWA/B and ZM303) yield up to 14% better than existing early genotypes under random, low soil N and low pH conditions in Southern Africa.

To widen the gene pool at Harare, introduced and incorporated exotic elite germplasm, including the start of pedigree projects by crossing CIMMYT germplasm to germplasm from the US and CIMMYT-Kenya.

SP 2: Deployment of maize germplasm adapted to sub-Saharan Africa

CIMMYT-related maize OPVs released in 2001 include Longe 4 (Uganda), Obatampa (Mozambique and Uganda), ZM621 (Malawi), ZM521 (Malawi and South Africa), ZM421 (Malawi), Grace (South Africa). Ethiopia released BHQP-542 [3 way cross] (CML144 x CML159) x CML176 and BH-541 [single cross] NSCM 41 1881(32) x CML197, in January 2002.Mother-Baby Trial Schemes for the assessment of drought tolerant/NUE maize were conducted in six SADC countries, with over 70 Mother-Baby sites in 2001. OPVs and hybrids were planted in hundreds of demonstrations in the SADC region 2001, mostly through collaboration with NGOs.

Large-scale on-farm evaluation of AMS maize varieties in Mother-Baby Trials was conducted in East Africa in 2001. Forty-two mothers and 504 babies are testing drought tolerant OPVs and hybrids of a wide range of maturity types, and Striga-tolerant OPVs in a wide range of ecologies in Kenya, and in Tanzania, Uganda and Ethiopia. In addition to seed distributed for the trials,

more than 300 kg of seed of various materials (lines, hybrids, OPVs) were distributed to partners.

54 stress tolerant 3W/DC hybrids and 16 extra-early streak resistant varieties with 10-20% better yield under stressed and unstressed conditions were tested on-farm in Eastern Africa using a Mother/baby trial approach in 2001.

Routine, widespread and in-depth farmer participatory evaluations of drought and low-N tolerant maize in eastern and southern Africa continued to be undertaken by the AMS Project and SADLF project.

Several countries in southern Africa have released or are considering for release SADLF project drought and N stress tolerant maize germplasm. High profile release of SADLF drought tolerant OPV maize (ZM521 and Grace) for South Africa, at the CGIAR Mid Term Meetings, South Africa, May 2001.

Large-scale seed production undertaken for three SADLF OPVs (ZM421, ZM521, ZM621) and one hybrid. An NGO-led effort for community based seed production of ZM521 and ZM421 was developed in Zimbabwe and South Africa. Breeders and Marketing departments from private companies also involved.

Experimental QPM hybrids gave very high and stable grain yields across 25 test sites in southern and eastern Africa, and performed well in low N conditions, but streak resistance needs to be improved.

QPM maize was released in Ethiopia, seed of QPM hybrid increased and distributed to farmers.

Several NGOs used the results of Regional Trials and Mother-Baby Trials to select seed for distribution and/or demonstration.

Six seed marketing/maize adoption studies were initiated in Malawi, Tanzania, Zambia, and Zimbabwe to assess constraints in making seed available to farmers in areas that are currently insufficiently supplied with seed.

Increased seed distribution efforts in East Africa through the "Strengthening Maize Seed Supply systems for small-scale farmers in Western Kenya and Uganda" Seed Project On-farm trials of 24 OPVs and 12 hybrids from CIMMYT, KARI, and private seed companies were assessed in 16 mother trials and 127 baby trials in Kenya, and 15 OPVs and 10 hybrids from CIMMYT KARI, and private seed companies in 9 mother trials and 31 baby trials in Uganda. Increased seed of 19 OPVs to 110 kg each in Kenya and Uganda.

Over 12 examples documented of practical applications of the Maize Research Atlases and Country Almanac's among NARS in Eastern and Southern Africa. These ranged from hybrid maize targeting in Zimbabwe, through G x E analysis and selection of benchmark sites in SADC, selection of trial sites for maize varieties and farmer participatory NRM, wheat production areas in Ethiopia, defining recommendation domains for broad bed maker technologies in Eastern Africa, groundnut cultivar requirements in Zimbabwe, and agroforestry in the Zambezi Basin, as well as widespread incorporation of maps into posters or documents.

GIS data incorporated in Africa Maize Atlas for all the key highland testing sites in Ethiopia. The characterization of 60 testing sites has been initiated and the first edition (CD) of the East and Central Africa Maize Research Atlas has been completed. CD and manuals are available at the CIMMYT office in Nairobi.

SP 3: Development and deployment of wheat germplasm

Four bread wheat cultivars were released in Ethiopia during April 2001; two for specific ecosystems

•HAR2192 [for wide adaptation]

•HAR2508 [for wide adaptation]

•HAR1008 [for moisture stress - Bale]•HAR2029 [for high rainfall area - Adet]

A GIS-based study of the distribution of wheat production environments in Ethiopia suggested the greatest opportunity for expanding wheat production would involve increasing the tolerance of wheat to warmer growing conditions. Site similarity analysis suggest the current distribution of wheat research sites in Ethiopia provides a reasonable coverage of the traditional wheat areas in terms of climate, and support the relevance of Kulumsa station for wheat research throughout much of Eastern and Southern Africa.

SP 4: Understanding and promoting sustainable maize and wheat-based systems

An ECAMAW regional trial evaluating various soil moisture conservation strategies including tied ridges for improved maize production in semi-arid zones of Kenya, Ethiopia and Tanzania with NARS partners produced variable results depending on rainfall received, soil type and variety. Parameters for local adaptation of the technology need to be refined.

Preliminary results from drought-tolerant/NUE maize x N rate experiments conducted at 12 on-farm sites in Zimbabwe during the 2001 season gave no overall N rate x genotype interaction. At sites with a good response to N, the experimental genotypes had higher NUEs with 15 or 30 kg N/ha than did the check hybrid. The experimental OPVs performed as well as the hybrids at many of the sites.

During 2001, there was wider testing of herbicide-coated IR maize technology against *Striga*, through Mother and Baby trials conducted by the Maize Seed Project in Eastern Africa, especially western Kenya. 20-45 g/ha a.i. of acetolactate synthase–inhibitor herbicides (Imazapyr and Pyrithiobac) shown to almost eliminate *Striga* and quadruple maize yield on farmer's fields in Western Kenya. Intercropped legumes (cowpea and yellow gram) are unaffected if planted more than 5 cm from the herbicide-coated maize seed.

ECAMAW regional trials in Ethiopia, Uganda, Tanzania and Kenya of 10-12 GMCC legumes species identified *Mucuna*, *Crotolaria* and *Canavalia* as most adapted for these ECA ecologies. Trials on-station and on farmers fields generally found intercropping or relay cropping of these legumes had little effect on maize production while rotations with maize had significant benefits.

Use of organics such as FYM, compost, and FYM enriched with mineral nutrients were evaluated in on farm trials within the ECAMAW network. Effects were mixed.

Various reports on soil fertility maintenance effects of maize + green manure and maize + groundnut rotations systems on smallholder farms in Malawi and Zimbabwe were produced by Soil Fert Net and some published in a Working Paper. Maize yield gains after sole crop green manures in Malawi can be over 500% on the most favorable neutral sandy soils where N is the clear limiting factor, but are more usually 50% elsewhere. The economics and farmer acceptance of such technologies remains unclear and is the subject of ongoing work 2001-02.

Concluded green manures have to be targeted to where get the biggest effects, and this is underway on sandy soils in central Malawi.

The portfolio of promising soil fertility technologies for southern Africa in Soil Fert Net expanded in 2001 with the inclusion of anaerobically-composted cattle manure for Zimbabwe, rotation of cattle Kholas/kraals, doubled-up groundnut+pigeonpea intercrop rotation with maize for Malawi, several additional species of *Crotalaria* including *C. grahamiana* and *C. ochroleuca*, and *Tithonia* spp. leaf prunings.

Several Soil Fert Net organic soil fertility technologies were officially released by Malawi.

An intensive pilot project led by the extension service under Soil Fert Net to promote a range of best bet soil fertility technologies in Chihota, Zimbabwe, came to an end at the end of 2001. Almost 4000 farmers were exposed to the technologies in three years and 2300 farmers have used one or more of the technologies on their own fields. Over 600 farmers who have participated throughout the project and continue to use the technology received certificates. A comprehensive baseline survey report was published.

The Risk Management Project adapted the APSIM crop systems simulation model to adequately simulate the on-farm performance in Malawi and Zimbabwe of several "African" legumes, including velvet bean and promiscuous soybean, and has been applying the new modules in 2001.

Through a combination of APSIM model runs and farmer participatory risk assessments, generated farmer-selected N management scenarios for maize in Zimuto area of semi-arid Zimbabwe, several of which appear to confirm or improve on farmer practice, e.g. N fertilizer on early planted maize in vleis and simpler N packages conditional on rainfall.

Whole farm resource mapping, farmer experimentation, modification and feedback with a range of green manure and grain legume technologies in Malawi and Zimbabwe are leading to farmer-developed space and time strategies for integrated soil fertility management on whole farms.

Of 32 wheat trial-season data sets analyzed for the 1993-2000 seasons in Ethiopia, zero or minimum till raised soil organic matter, but conventional tillage gave higher or same grain yields than zero or min till in virtually all cases. A major reason for this is brome grass, which is much greater under zero till. Stubble burning controls the grass but eliminates the effect of zero till, while results show that farmers who rotate with Faba bean minimize the risk of an increase in the density of brome grass.

Research highlighted the importance of rotation with faba bean in the cereal-based cropping systems of the south-eastern highlands of Ethiopia, where the total amount of N_2 fixed by faba bean ranged from 139 to 210 kg N ha^{-1} and soil N balances after faba bean were positive (12 to 58 kg N ha^{-1}) relative to the highly negative N balances (-9 to -44 kg N ha^{-1}) following wheat.

Waterlogging tolerant wheat genotypes from Ethiopia accumulate more Cu, Zn, P and K when waterlogged. Selection of wheat genotypes with enhanced ability to overcome waterlogging-induced nutrient deficiency, particularly P and Zn deficiency, should improve wheat productivity in waterlogged soils.

New wheat production recommendations were given to extension services in Ethiopia and Tanzania:

Economically-optimal N and P recommendations were developed for wheat production in central Ethiopia for two major soil types. Optimum nutrient rates were presented in a price-dynamic, user-friendly tabular format for ease of interpretation by extension staff and policy-makers.

To minimize soil losses due to erosion, the adoption of minimum tillage practices for small-scale wheat production in Ethiopia can be recommended. However, farmers adopting minimum tillage for wheat production must be encouraged to practice crop rotation with faba bean in order to minimize the risk of an increase in the density of brome grass (*Bromus pectinatus*).

Assessments of the current economics of small-scale wheat production in northern Tanzania recommend the production of the wheat variety Kware using 30 kg/ha of N fertilizer.

SP 5: Enhancing human resources and partnerships devoted to maize and wheat cropping systems

Several networks, including ECAMAW, SADLF-MWIRNET and Soil Fert Net, were successfully implemented during 2001, leading to the more efficient use of scarce human and financial resources on maize and wheat system research and development in the RP1 region.

Many of our projects held Annual Meetings, Stakeholders Meetings and Steering Committee Meetings during 2001.

The MWIRNET 2 proposal was redeveloped with SACCAR early in 2001, to again involve CIMMYT as the implementing agency. A stakeholder meeting held in Gaborone, Botswana in August 2001 modified and endorsed the proposal which was then submitted to the EU. Implementation of the new project should begin in 2002.

The Eastern and Central Africa Maize and Wheat Research Network (ECAMAW) became fully operational in 2001 as a broad umbrella network for most of our activities in eastern Africa. The EACP wound up its final phase in 2001. The AMS project was successfully reviewed in 2001 and was ranked among the 3 best worldwide UNDP funded projects. However, funding of network activities from AMS during 2001 was suspended when major donors (UNDP and IFAD) withdrew support for AMS. New proposals developed for eastern Africa (CIDA, BMZ, UNDP-AMS2) have large components for network support.

Soil Fert Net developed and implemented a new management structure in 2001, involving Regional Theme Leaders from NARS and an Advisory Committee. There was wider integration across disciplines (especially agricultural and natural resource economics), institutions and countries. Zambia was integrated fully into Soil Fert Net in 2001 and members there developed an integrated research proposal submitted to the Rockefeller Foundation for funding. Mozambique started to participate in network activities. The network participated in two Rockefeller Foundation reviews of the soil fertility work they support in Malawi and Zimbabwe, to assess the effectiveness of its research grants and identify new areas for the targeting of investments.The new Soil Fert Net web site (www.SoilFertNetSouthernAfrica.org) became operational in September 2001.

The SADLF Project contracted scientists from the University of Zambia and the Bunda College in Malawi who assumed regional leadership for on-farm testing (Mother-Baby Trials) and seed marketing/adoption studies in the SADC region, performed well.

A wide range of innovative training courses, some involving participants from both E and S Africa, has been conducted in the region in 2001. These include:

A Learning Workshop on the Economic Evaluation of Natural Resources, Soil Fertility and Cropping Systems: Implications for Sustainability and Food Security, conducted by Soil Fert Net April 2001 in Pretoria, exposed 30 regional participants from Southern Africa and Ethiopia to these methods.

Additional in country GIS training in the use of the African Maize Research Atlas and Country Almanac's was given in March/April 2001 in Kenya, Ethiopia, Zimbabwe, Malawi, Botswana and South Africa.

SADLF workshop on Data Analysis of Mother-Baby Trials for SADC countries, in Harare in August 2001.

Adoption and Impact Assessment Training Workshop for 25 Ethiopian agricultural economists in 2001.

Training in and use of FPR methods, whole farm resource mapping, and use of the APSIM model for Risk Management in Zimbabwe and Malawi.

A range or workshops, conferences and symposia were conducted, including:

A mini-workshop preceded the 2001 ECAMAW SC meetings. It brought together breeders and agronomists to jointly review and plan network activities, to increase collaboration and to foster the development of small grant projects that have a true regional and network perspective.

Soils Research in East and Southern Africa: Strengthening Ties and Synergies Workshop conducted by TSBF and Soil Fert Net in May 2001 in Arusha Tanzania; from which several multi-partner and multidisciplinary initiatives were developed to be conducted on soil fertility across east and southern Africa during 2001-2004.

A travel workshop to visit and discuss Mother-Baby Trials/Seed Production strategies in South Africa with 45 maize researchers, NGO and extension staff (March 2001).

A Southern Africa regional workshop to develop strategies for the management of P and acid soils (SADLF), South Africa (March 2001).

Another Southern Africa regional workshop, on Understanding the Adoption and Impact of Soil Fertility Technologies brought together 45 participants in Zimbabwe to develop a better understanding of adoption processes, review findings from recent soil fertility adoption studies and share relevant methodologies (December 2001, Soil Fert Net).

ECAMAW supported 55 maize small grant projects in 2001, through the EACP and AMS. A total of 14 wheat small grant projects were implemented in 2001, funded by EACP.

Visiting scientists from African NARS worked at CIMMYT Nairobi and CIMMYT Harare to familiarize themselves with methodologies for breeding maize for tolerance to drought, low nitrogen, Striga, and various diseases, and on management tools such as fieldbook/excel and statistical data analysis.

Field tours on soil fertility research and extension were conducted in Malawi (February 2001) and northern Zambia (March 2001).

SP 6: Impact assessment and socioeconomic analysis of maize and wheat technology

A comprehensive study of maize germplasm impacts in Eastern and Southern Africa was completed and published in 2001. Major findings of the study are summarized below:

Impacts of policy reforms on national maize seed industries- In many countries of eastern and southern Africa, policy reforms introduced during the 1980s and 1990s have succeeded in liberalizing national maize seed industries by opening up maize seed markets to increased private sector participation.

Shifting roles of the private and public sectors in maize breeding research- Private-sector investment in maize breeding research has been growing rapidly. In eastern Africa, public-sector scientists still significantly outnumber private-sector scientists; in southern Africa, the numbers are roughly equal.

Shifting roles of the public and private sectors in maize seed supply- During the 1990s, the private sector effectively took over the seed supply function throughout most of eastern and southern Africa. In 1996, the most recent year for which complete data are available, private seed companies controlled more than 97% of all commercial maize seed sales in the region.

Changes in the type of germplasm supplied to farmers- With the emergence of a flourishing private seed industry, the share of hybrids in varietal releases and seed sales has risen steadily. Coupled with the fact that public breeding programs are also concentrating increasingly on hybrids, this has led to a situation in which varietal releases and seed sales are now dominated by hybrids. This could have negative impacts on small-scale subsistence-oriented farmers, many of whom may lack the resources needed to buy fresh seed every season.

Adoption of improved maize germplasm- Based on commercial maize seed sales data, estimates of adoption of improved germplasm increased steadily during the 1990s in eastern and southern Africa. However, adoption patterns have differed between countries and regions. Within individual countries, the percentage area planted to improved maize seed varies from less than 10% to nearly 100% in several major maize producing countries. The variability between countries in adoption rates can be attributed partly to differences in economic, institutional, and policy factors that affect the availability and affordability of improved seed.

Use of CIMMYT materials- Use of CIMMYT germplasm showed a strong positive growth over time; of the varieties released since 1990, over 55% were developed using CIMMYT source materials. In 1996, approximately 1.6 million ha in eastern and southern Africa were planted to varieties that had been developed using CIMMYT germplasm, representing over 20% of the area planted to all modern varieties. Excluding South Africa, where farmers grow mainly temperate materials not targeted by CIMMYT's breeding program, nearly 37% of the area planted to modern varieties in eastern and southern Africa was planted to varieties containing CIMMYT germplasm.

Four projects were implemented by NARS in Malawi and Zimbabwe under the Economics and Policy Working Group (EPWG) of Soil Fert Net, covering factors affecting the adoption of sets of soil fertility technologies in Malawi and Zimbabwe, manure storage practices in Zimbabwe, and measuring the social costs of soil erosion in Malawi. Seven new proposals were presented to EPWG in December 2001 an are being improved for funding in 2002.

An integrated maize breeding and economics study of recycled maize in southern Africa showed yield losses of 32% for recycled hybrid compared with 5% for OPVs. Economic scenarios predict it would be more economic to plant OPV rather than hybrid maize in environments where grain yields of less than 1 t/ha are expected. If savings from the cheaper OPV seed were re-invested in fertilizer, then OPVs would be more economic even if yields were 2 t/ha, i.e. they would be appropriate for many smallholder farms in the region.

Studies concluded the potential adoption of Soil Fert Net Best Bet soil fertility technologies is massive. Farmer feedbacks from Chihota, Zimbabwe on a range of technologies show that many farmers have positive attitude about the technologies they have seen on the on-farm demonstrations and want to use them, but the most common constraints to adoption are knowledge gaps and difficulties in accessing the inputs.

Ways to improve impacts in RP1 were discussed during the RP1 Review and Planning Meeting, August 2001.

A Sustainable Livelihoods Approach consultancy held during May and June 2001 in southern Africa, looking at maize seed and soil fertility issues, gave an overall favourable assessment of the relevance of CIMMYT's work in the region in addressing SLs, plus some recommendations that we are incorporating for 2002. These involve a need to broaden the criteria for selecting maize to include ease of production, storability, processability, marketability, profitability, adaptability and maybe nutritional quality, and the more specific incorporation of target group descriptions and a focus on the poor when developing and deploying soil fertility technologies. Incorporation of SLA will help document and communicate our impact within a broader context.

In an assessment of Soil Fert Net institutional impact 1995-2001, the network now consists of over 200 members, 350 persons have participated in field tours, 450 in workshops and Soil Fert Net has produced just over 100 publications.

We have continued to place even more emphasis on effective publicity of CIMMYT's work in the RP1 region. Examples include the shooting of a Swiss TV/SDC Documentary of SADLF and other projects (March 2001), the more routine use of colour in reports and working paper covers, in brochures, briefs and highlights, and we have developed a web site (September 2001).

Full advantage was taken of opportunities for publicising CIMMYT's work in the RP1 region presented during the CGIAR Mid-Term Meetings in Durban, South Africa (May 2001).

Progress with Synergies and Integration

Significant progress was made during 2001 on integration between CIMMYT funded projects within our sub-regions (Southern Africa and within Eastern Africa), between CIMMYT funded projects across Eastern and Southern Africa, between RP1 and other MTP projects, and between CIMMYT RP1 and other organizations in Eastern and Southern Africa, both through and outside the CGIAR integration process.

Integration between funded projects within and between the sub-regions is now routine. Maize breeding staff work together and conduct joint training programs, nurseries, evaluation trials etc. Economics staff in the sub-regions work mainly on support to other projects and are parts of the IRMA project in eastern Africa and Soil Fert Net in southern Africa. Earlier joint field tours and mini-workshops led to new work in 2001 on synergy from combining appropriate maize germplasm with crop management, such as work to develop N Response Curves for NUE Maize (Soil Fert Net + SADLF). In eastern Africa, our Maize Seed Project for Kenya and Uganda interacts strongly with AMS, SADLF, Economics and Policy, Stem Borers and Striga Biotech projects. Downstream, we have greatly increased joint activity with NGOs, schools, farmer groups etc.

During 2000 and consolidated in 2001, we developed very close links and joint milestones with other MTP projects, including G2, G3, G4, G7 and G9. Much of the germplasm development and impacts work is jointly conceived and implemented.

Links with CGIAR centers have continued to strengthen. With ICRISAT, the Risk Project conducted two joint workshops with ICRISAT in Zimbabwe, and developed and implemented joint research with them in Zimuto, Zimbabwe and in Malawi. We have also been closely involved with maize seed provision for Angola through the Seeds of Freedom project managed by ICRISAT. CIMMYT is also participating in the development of an ICRISAT-led project for INRM in the SAT of Zimbabwe, which is part of the CG Systemwide Integrated Natural Resource Management Initiative.

We have also worked closely with ILRI on two projects under the Systemwide Livestock Program. The first one, "Wheat and Weeds: Food and Feed", is looking at optimal use of wheat straw (including varietal selection), weed management strategies and strategies to better use legumes and manure, in the wheat systems of Ethiopia. The second one, involving maize has been mainly with CIMMYT Zimbabwe, involving the screening of maize germplasm for fodder and feed quality and characterization of maize x livestock interactions in key farming systems in Zimbabwe and Malawi. A major *ex ante* impact assessment of a range of maize system interventions on livestock in smallholder systems in eastern and southern Africa was produced from this project at the end of 2001.

At a major workshop on Soils Research in East and Southern Africa: Strengthening Ties and Synergies Workshop conducted in May 2001, several multi-partner and multidisciplinary initiatives were proposed to be conducted on soil fertility across east and southern Africa with TSBF, CIAT and ICRAF.

One feature of 2001 was a major attempt to bring the CG centers closer together. RP1 has fully participated in the CG process of integration during 2001, especially for E and S Africa, which is under the coordination of ICRAF. Initial summaries of CIMMYT activities and funded projects in E and S Africa (and in West and Central Africa) were developed and submitted to coordinating centers. RP1 was involved in an initial planning meeting on CG integration at ICRAF and FARA/SPAAR meetings in March 2001 and CG mid term Durban meetings in May 2001. We were well represented in further major stakeholder meetings in Nigeria and Kenya in September 2001. The E and S Africa meeting in Kenya came up with eight integrated regional programs on priority themes, within which the CG centers and partners would work together. The RP1 coordinator was one of the team that drafted the final report which was submitted to the CGIAR AGM in October 2001.

Financial and Human Resources

Several of our large networking projects (EACP, MWIRNET and AMS) have reduced over 2000-01. This severely constrained our networking and training. However, prospects are very good for the renewed or replacement funding of some of these and the development of new opportunities.

RP1 staff have continued to put a lot of effort into sourcing new and replacement funding for our work. At least five new projects or renewals of existing projects came on stream late 2000 and in 2001. These have included the Strengthening of Maize Seed Supply Systems for Small-Scale Farmers in Western Kenya and Uganda (Rockefeller Foundation), Wheat and Weeds: Food and Feed in Ethiopia (SLP), a further 3-year funding for Soil Fert Net (also RF), the Eastern and Central Africa Maize and Wheat Network Project (ECAMAW) (EU through ASARECA), a pledge by the Mathile Family Foundation to fund training and QPM maize in Africa, a new phase of the Regional Maize Disease Nursery (Rockefeller Foundation), and Tailoring Maize to the Nutritional Needs and Economic Circumstances of Resource-Poor Farming Families in Eastern and Southern

Africa (CIDA). Funding for the Risk Management Project Phase 2 (AusAID/ACIAR) has been delayed because of concerns about Zimbabwe.

At least 15 new project proposals are under development or have been submitted to donors for consideration. Several of these are more integrative in nature. They include an expanded MWIRNET 2 (EU) that will involve a broader range of disciplines and partners, new versions of the AMS project to develop and disseminate stress tolerant maize for eastern and central Africa (BMZ and UNDP), improving the Yield and Nutritional Value of Popular Maize Cultivars for Resource-Poor Farming Families in Eastern and Southern Africa (Rockefeller Foundation), an OPV/Seeds Project for southern AfricaImproving Maize x Agroforestry Systems in Southern Africa (with ICRAF), Maize x Livestock Systems in Southern Africa (with ILRI), Striga-Killer Maize herbicide seed-dressing technology for Africa (BASF), and Hungry Season (early maturity) Maize for Southern Africa which will combine needs assessments with germplasm development and integration into farming systems (for USAID). Additionally, two further concept notes were developed for USAID on the deployment of agricultural technologies; one covering maize seed and the other somewhat wider in scope, addressing natural resource management technology promotion and target environment characterization.

One concern is that the development and funding of new cross disciplinary, multi-partnership projects remains rather slow. Given the increasingly overcrowded agendas for staff, without obvious overwhelming special support and encouragement for that from CIMMYT management at HQ, many staff can not put the extra effort needed into this.

Expected new staffing 2001-02 will include an NRG Soil and Water Management Senior Scientist to be based in Harare (part funded under Risk 2), a Maize Seed Dissemination Specialist, and a regional coordinator for ECAMAW.

Plans for 2002 Onward

Many of these are listed in the RP1 Logframe 2002-2004. Some new plans were developed during the RP1 Review and Planning Meeting in Harare, August 2001, and during planning meetings conducted by specific funded projects.

SP1

2002-2004, a wide range of improved maize source populations and experimental varieties available directly and in regional trials for use by breeding partners.

2002-2004, at least 20 elite lines announced as CMLs for hybrid development.

By 2003, 20 maize cultivars yielding at least 10% more than the best local checks will be released.

By 2002, acid soil test sites established in southern Africa.

A systematic eastern and southern Africa maize germplasm testing structure for a range of traits and sites fully in place 2002.

By 2005, quality protein maize germplasm base established in southern Africa, elite materials for the region identified and best QPM hybrids verified.

By 2002, characterized disease resistance of inbred lines from regional nursery.

By 2002, expand breeding of Imazapyr resistant maize to cover all eco-zones where *Striga* is endemic.

By 2003, Develop insect resistant source maize germplasm through screen new germplasm from CIMMYT Mexico, Zimbabwe and Kenya.

By 2002, introduce Bt maize seeds in Kenya and develop an open quarantine field site to test Bt maize.

By 2004, well adapted Bt maize available in region.

By 2003, identify early maturity inbred lines from the CIMMYT-Zimbabwe program with good resistance/tolerance to GLS, MSV, *Phaeospaeria* and drought.

By 2004, develop downy mildew resistant materials for southern Africa, especially Mozambique.

2002-04, identify dimba and other sites for early maturity and late planted maize and develop at least one OPV/hybrid suitable for dimba planting.

SP2

During 2002-2004, 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 target environments.

2002, farmer participatory on-farm testing of drought and low N tolerant maize germplasm, in collaboration with public extension, NGOs and universities expanded to more than 500 sites per year in southern Africa, with similar work underway in eastern Africa.

By 2002, maize seed available to NGO seed production and distribution initiatives in Angola, Ethiopia, Malawi, Mozambique and Zimbabwe.

By 2002, cultivar descriptors relevant to smallholders developed and used on seed packs.

In 2002, obtained acknowledgement from many seed companies in the region on use of our germplasm, including GLS-resistant lines.

By 2002-3, develop more routine farmer feedback and farmer seed production initiatives.

By 2002, link with local seed companies/chemical companies to produce Imazapyr resistant maize for wider testing in the region and begin scaling up this technology in SSA where *Striga* is endemic.

SP3

By 2003, 2 durum wheat cultivars will be released for waterlogged conditions in Ethiopia with a yield advantage of 15%.

By 2003, 2-5 bread wheat cultivars will be released 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.

Regional testing site established to improve the efficiency of selecting for durable resistance to yellow rust. (Part of the international testing scheme as described by GP6.)

SP4

A. Technology Development

1. Mineral nutrients

Review and synthesis of progress in understanding the performance of soil fertility technologies and the factors that influence their attractiveness to farmers:

Review and synthesis of experiences with annual legumes in southern Africa [2002]

Review of green manure and legume intercropping research and potential for adoption in eastern and central Africa [2002]

N requirements of drought tolerant and NUE maize varieties assessed in on-farm experiments in Zimbabwe and Kenya [by 2003 with SP2]

Alternative soil fertility technologies (e.g., legumes in systems, organic + inorganic combinations) developed that fit farm environments and farmer circumstances [by 2004]

Recommendations for plant density, especially for extra-early maize varieties, developed and compared with later maturing varieties in east Africa [by 2003]

2. Soil and water conservation

Strategy for conservation tillage research developed and implementation started (with GP9) [2002]

Research, development and dissemination experiences in soil moisture conservation technologies, especially tied-ridges, in eastern and central Africa reviewed and synthesized (with GP9) [by 2002]

Cost-benefit analysis of tied-ridge technology conducted in eastern and central Africa, including development of necessary data as required [by 2002]

Soil and rainfall specific parameters of tied-ridge technology for soil moisture conservation developed for maize in on-farm trials with eastern African farmers [by 2004]

Implements for tied-ridging evaluated and adapted for the circumstances and conditions of eastern and central African farmers [by 2004]

Conservation tillage × weed management strategies developed for wheat in Ethiopia [2002]

3. Striga

Adapted IR-maize varieties with herbicide seed-coating evaluated in striga hot spots in different ecologies in eastern and southern Africa, and seed deployed with partners in several countries of eastern and southern Africa[by 2003]

Parameters of herbicide-coated seed for striga control defined for specific soil and rainfall regimes in Kenya and southern Africa [by 2003]

A plan in place for monitoring and managing the development of herbicide resistance in striga [by 2002]

4. Integration of nutrient management practices, possibly with moisture conservation and germplasm

Natural resource management (NRM) technologies (nutrient management, soil and water conservation and striga control) integrated into systems with stress tolerant maize, agroforestry components and livestock [by 2004 with SP2]

Whole system integrated nutrient management studies implemented for key farming systems in southern and eastern Africa [by 2002-04]

APSIM model and farmer participatory risk assessments conducted to 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 [2002]

5. Scaling up and out

Research initiated on methods for scaling up of NRM technologies, including modelling, decision trees, GIS, community organization/NGOs, etc., and implementation of pilot projects to do this [2002-04 and SP2]

B. Dissemination/extension

At least 12 "best bet" soil fertility technologies for smallholder farmers promoted through partners with 5,000 farm advisors and 40,000 farmers in southern Africa [by 2002]

Information brochures and research reports on "best bet" soil fertility technologies published and distributed [2002-04]

At least five other types of crop management options for maize providing 20% gains in returns promoted [by 2004]

At least 5,000 farmers in western Kenya participate in cropping systems trials and adopt technologies to reduce the impact of striga [by 2003]

Farmers in dry ecologies of Kenya and Tanzania trained in tied-ridge technology on-farm in conjunction with drought tolerant maize varieties [by 2004]

C. Policy Support

Soil fertility input supply initiatives, including input dealer training and support, developed and implemented with partners [by 2002]

Economic assessments and policy guidelines available for soil fertility interventions including seed, fertilizer and lime [by 2003]

Costs and benefits of striga control via herbicide-coated IR-maize seed known [by 2002]

SP5

2002-2004, a range of short courses and other training opportunities (on seed production, environmental economics, economic analysis, on-farm and participatory research methods) identified and implemented. (with GP8)

2002-2004, provide research facilities and supervision for at least 10 higher degree research students.

In 2002, organize and run regional maize conference, with proceedings.

By 2002, new networks established with regional partners.

Closer integration with other CG center activities, through the CG process and projects.

In 2002, ensured that collaborative research projects in the various networks address high priorities and are multi-disciplinary and regional or sub-regional in nature.

2002-2004, networks on crop improvement, systems research and development and soil fertility issues show increased quality and quantity of work and results, leading to more impacts.

2002-2004, more multi-partner and multidisciplinary initiatives to be conducted on soil fertility across east and southern Africa.

In 2002, 7th Eastern and Southern Africa Regional Maize Conference; and Symposium on Low-Nitrogen and Drought Tolerance in Maize, held in Nairobi, Kenya (11-15 February).

SP6

In 2000-2003, RP1 will put more emphasis on technology promotion and policy advocacy.

By 2004, documented impacts and benefits of a range of profitable and sustainable maize and wheat production technologies for resource poor farmers. (with GP7)

By 2002, several reports produced on adoption of soil fertility technologies in Zimbabwe and Malawi. (with GP7)

By 2003, policy guidelines and economics information developed on soil fertility issues, particularly for external inputs such as fertilizer, lime and seed. (with GP7)

By 2002, produced policy briefs and recommendations to enhance the uptake of improved maize germplasm technologies in the region. (with GP7)

In 2002, aspects of the Sustainable Livelihoods Strategy incorporated into CIMMYT work in southern Africa, following a 2001 consultancy report.

By 2002, Soil Fert Net Economics and Policy Working Group fully established with at least five cooperative proposals from NARS funded and operating.

In 2002, conduct policy awareness workshop in southern Africa (with GP7).

Publications from RP1: 2000-01

List of Publications from RP1 in 2001

Some of these publications were developed jointly between RP1 and other MTP projects.

Refereed Journal Articles

Amsal Tarekegne and D.G. Tanner. (2001). Effects of fertilizer application on N and P uptake, recovery and use efficiency of bread wheat grown on two contrasting soil types in central Ethiopia. *Ethiopian Journal of Natural Resources* 3(2): 353-359.

Asefa Taa, D.G. Tanner and A.T.P. Bennie. (2001). Effects of stubble management, tillage and cropping sequence on wheat crop performance in Ethiopia: II. Changes in soil penetration resistance. *Ethiopian Journal of Natural Resources* 3(1): 39-59.

Asefa Taa, D.G. Tanner and A.T.P. Bennie. (2002). Effects of stubble management, tillage and cropping sequence on wheat crop performance in Ethiopia: I. Changes in the severity of take-all and eyespot diseases. *African Crop Science Journal* 10(1): [manuscript accepted and in press].

Bänziger M., and M.E. Cooper (2001). Breeding for low-input conditions and consequences for participatory plant breeding: Examples from tropical maize and wheat. *Euphytica* 122: 503-519.

Bokonon-Ganta A., H. De Groote and P. Neuenschwander. (2001). Socio-economic impact of biological control of mango mealybug in Benin. *Agriculture, Ecosystems and Environment*, forthcoming.

De Groote H., O.-K. Douro-Kpindou, Z. Ouambama, C. Gbongboui, D. Müller, S. Attignon and C. Lomer. (2001). Assessing the Feasibility of Biological Control of Locusts and Grasshoppers in West-Africa: Incorporating The Farmers' Perspective. *Agriculture and Human Values*, forthcoming.

Derera, J., P. Denash Giga and K.V. Pixley. (2001). Resistance of maize to the maize weevil: II. Non-preference. *African Crop Science Journal* 9:441-450.

Derera, J., K.V. Pixley and P. Denash Giga. (2001). Resistance of maize to the maize weevil: I. Antibiosis. *African Crop Science Journal* 9:431-440.

Mickelson, H.R., H. Cordova, K.V. Pixley and M.S. Bjarnason. (2001). Heterotic relationships among nine temperate and subtropical maize populations. *Crop Science 41:1012-1020.*

Minale Liben and D.G. Tanner. (2001). An agronomic and economic analysis over six years of a wheat-based crop rotation trial in north-western Ethiopia. *Ethiopian Journal of Natural Resources* 3(2): 195-218.

Oswald, A. and J.K. Ransom. (2001). Striga control and improved farm productivity using crop rotation. *Crop Protection* 20:113-120.

Oswald, A., J.K. Ransom, J.Kroschel and J. Sauerborn (2001a). Transplanting maize (*Zea mays*) and sorghum (*Sorghum bicolor*) reduces *Striga hermonthica* damage. *Weed Science* 49:346-353.

Oswald, A., J.K. Ransom, J.Kroschel and J. Sauerborn (2001b). Intercropping controls *Striga* in maize based farming systems. *Crop Protection* In press.

Waddington, S.R. and J. Karigwindi (2001). Productivity and profitability of maize + groundnut rotations compared with continuous maize on smallholder farms in Zimbabwe. *Experimental Agriculture* 37:83-98.

Book Chapters

Bänziger M., and J. De Meyer (2001). Collaborative maize variety development for stress-prone environments in southern Africa. In D. A. Cleveland and D. Soleri (ed) Farmers, Scientists and Plant Breeding: Integrating Knowledge and Practice. CABI (in press).

Mekuria, M. and S.R. Waddington (2002). Initiatives to Encourage Farmer Adoption of Soil Fertility Technologies for Maize-Based Cropping Systems in Southern Africa. In: (C. Barrett, F. Place and A. Aboud eds.). "Understanding Adoption Processes for Natural Resources Management for Sustainable Agricultural Production in Sub-Saharan Africa", Wallingford, UK:CAB International. Forthcoming.

Published Proceedings

Kanampiu F.K., D.K. Friesen, J.K., Ransom, V. Kabambe, D. Jewell and J. Gressel. (2001). Seed dressing of corn as an appropriate treatment for Striga control while allowing intercropping. Proceedings of the Third International Weed Science Congress; 2000 June 6-11; Foz do Iguassu, Brazil, Manuscript number 282, CD-ROM. Available from: International Weed Science Society, Oxford, MS, USA. 7 p.

Monographs

Hassan, R., M. Mekuria and W. Mwangi (2001). Maize breeding research in eastern and southern Africa: Current status and impacts of past investments made by the public and private sectors, 1966-97. Mexico, D.F.:CIMMYT.

Kamanga, B.C.G., G.Y. Kanyama-Phiri and S. Snapp (2001). Experiences with farmer participatory mother-baby trials and watershed management to improve soil fertility options in Malawi. Soil Fert Net Methods Working Paper 5. Harare, Zimbabwe:CIMMYT. 17p.

Makokha, S., S. Kimani, W. Mwangi, H. Verkuijl and F. Musembi (2001). Determinants of fertilizer and manure use for maize production in Kiambu District, Kenya. Mexico, D.F.:CIMMYT and KARI. 25p.

Mekuria, M., T. Gatsi and T. Pfumayaramba (2001). A preliminary assessment of the performance, adoption and economics of hybrid, open pollinated and recycled maize production in Chihota and Zimutu districts of Zimbabwe. Harare, Zimbabwe: CIMMYT.

Mussei, A., J. Mwanga, W. Mwangi, H. Verkuijl, R. Mongi and A. Elanga (2001). Adoption of improved wheat technologies by small-scale farmers in Mbeya District, Southern Highlands, Tanzania. Mexico, D.F.:CIMMYT and United Republic of Tanzania. 20p.

Palm, C., A. Bationo and S. Waddington (2001). Integration of soil research activities in eastern and southern Africa. TSBF, Nairobi, Kenya and SoilFertNet, Harare, Zimbabwe. 48 p.

Tesfaye Zegeye, Girma Taye, D. Tanner, H. Verkuijl, Aklilu Agidie and W. Mwangi. 2001. Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by Small-Scale Farmers in Yelmana Densa and Farta Districts of North-Western Ethiopia. Mexico, D.F.: EARO and CIMMYT. 39 p.

White, J.W., D.G. Tanner and J.D. Corbett (2001). An agro-climatological characterization of bread wheat production areas in Ethiopia. NRG-GIS Series 01-01. Mexico, D.F.: CIMMYT. 14 p.

Other Publications

De Groote, H., D. Friesen, M. Siambi and A. Diallo (2001). Participatory plant breeding guidelines for the AMS on-farm trials for 2001 in East Africa. Nairobi, CIMMYT: Africa Maize Stress Project.

Hodson, D.P., and J.D. Corbett (2001). Almanac characterization tool at work. Impacts in Africa, Asia and Latin America. CIMMYT, Mexico D.F. 19p.

Mekuria, M., T. Gatsi and T. Pfumayaramba (2001). A preliminary assessment of the performance, adoption and economics of hybrid, open pollinated and recycled maize production in Chihota and Zimutu districts of Zimbabwe. Harare, Zimbabwe:CIMMYT. Forthcoming.

Mugo S.N., D. Bergvinson and D. Hoisington. (2001). Options in Developing Stemborer Resistant Maize: CIMMYT Approaches and Experiences. Paper originally presented during Workshop and conference on the management of cereal stem borers in Africa Oct 16-20 2000 at ICIPE Nairobi, Kenya (Submitted to Insect Science and Its applications Journal)

Pixley, K.V. (2001). Mid-term review of germplasm development and dissemination strategy. Increasing the productivity and sustainability of maize-based cropping systems in the hills of Nepal. In short: Hill maize research project (HMRP).

Songa, J., D. Bergvinson and S. Mugo (2001). Impacts of Bt-gene based resistance in maize on non-target organisms in Kenya. Characterization of target and non-target organisms of Bt-gene based resistance in two major maize growing regions in Kenya. In: Insect resistant Maize for Africa, Annual Report 2000. IRMA Project Document No. 4. Nairobi, Kenya: KARI and CIMMYT.

Tanner, D.G. and T.S. Payne (2001). CIMMYT wheat research and capacity building in eastern, central and southern Africa. In: *Research Highlights of the CIMMYT Wheat Program.* Mexico, D.F.:CIMMYT. pp. 57-60.

Vivek, B., Bänziger, M. and Pixley, K.V. (2001) Characterization of Maize Germplasm Grown in Eastern and Southern Africa: Results of the 2000 Regional Trials Coordinated by CIMMYT. CIMMYT, Harare, Zimbabwe. 56 pp.

Waddington, S.R. (editor/compiler) (2001). Target. The Newsletter of the Soil Fertility Network for Maize-Based Cropping Systems in Malawi, Zimbabwe and Zambia. Issues 25-28.

Training Materials

Bellon, M.R. (2001). Participatory research methods for technology evaluation: A manual for scientists working with farmers. CIMMYT, Mexico DF. 93 p.

De Groote H., D. Friesen, M. Siambi and A. Diallo. (2001). Participatory Plant Breeding, Guidelines for on the Africa Maize Stress on-farm trials for 2001 in East Africa. CIMMYT, AMS project: Nairobi, Kenya. 17 pp.

De Groote H., with M. Bellon, C. Bett, M. Siambi, A. Diallo, D. Friesen, and J. De Meyer. (2001). Farmers' Participatory Research, Applications for Maize Breeders in East Africa. A short guide based on CIMMYT's experience with stress resistant maize varieties in Eastern Kenya. CIMMYT, AMS project: Nairobi, Kenya. 18 pp.

TV Programs/Web Sites, etc

Bänziger, M. (2001). Swiss TV documentary on SADLF project. CIMMYT/SDC. In preparation.

Soil Fert Net web site (2001). www.SoilFertNetSouthernAfrica.org

Presentations

De Groote H. J. O. Okuro, C. Bett, L. Mose, M. Odendo, E. Wekesa. (2001). Assessing the demand for insect resistant maize varieties in Kenya combining Participatory Rural Appraisal into a Geographic Information System. Paper presented at the International Symposium on Participatory Plant Breeding and Participatory Plant Genetic Resource Management: An Exchange of Experiences. Bouake, Ivory Coast, May 7-10, 2001.

Friesen, D., S.R. Waddington and A.O. Diallo (2001). Breeding and Agronomic Approaches to Managing Abiotic Stresses in Maize. Given at the Second Ethiopian National Maize Workshop, EARO, 12-16 November 2001, Nazret, Ethiopia.

Mugo, S., D. Bergvinson, D. Hoisington, D. Poland and H. De Groote. (2001). The Role of CIMMYT - a Future Harvest Center - in the Development and Deployment of Biotechnology Products. Paper Presented at the Workshop on "Experiences in and the Future of Kenya's Biosafety System" African Biotechnology Stakeholders Forum (ABSF) and National Biosafety Committee (NBC), Held at the Grand Regency Hotel, Thursday April 26. Nairobi, Kenya.

Pixley, K.V. (2001). Quality Protein Maize: Overview, breeding strategy and Recent Research Results for Southern Africa. Invited paper presented at the National Maize Workshop, Samaru, Zaria, Nigeria, September 2001.

Siambi M., H. De Groote, C. Bett, A. Diallo, D. Friesen, J. Kavoi, W. Muasya. (2001). Participatory Plant Breeding for Drought Resistant Maize Varieties in Eastern Kenya. Paper presented at the International Symposium on Participatory Plant Breeding and Participatory Plant Genetic Resource Management: An Exchange of Experiences. Bouake, Ivory Coast, May 7-10, 2001.

Waddington, S.R. (2001). Regional Project 1: Food and Sustainable Livelihoods for Sub-Saharan Africa. Presentation given at CIMMYT Project Week, El Batan, Mexico, 19-23 March 2001.

Waddington, S.R. and D. Friesen (2001). Conservation Agriculture and Smallholder Maize Systems in Eastern and Southern Africa. Given at CIMMYT Global Project 9, "Conservation Agriculture", Planning Meeting, 18-20 October, CIMMYT, Texcoco, Mexico.

Waddington, S.R. and M. Mekuria (2001). Best Bet Soil Fertility Technologies For Maize-Based Smallholder Farming Systems in Zimbabwe and Malawi. Given at the Rockefeller Foundation Soil Fertility Research Review, 29 October-2 November 2001, Harare, Zimbabwe.

Waddington, S.R. and M. Mekuria (2001). Soil Fertility Management and Policy Network for Maize-Based Cropping Systems in Southern Africa. Given at the Rockefeller Foundation Soil Fertility Research Review, 29 October-2 November 2001, Harare, Zimbabwe.

Publications Produced by the Soil Fertility Network for Maize-Based Farming Systems in Southern Africa during 2001

Series and Number	Title	Author(s)	Date Produced
Newsletters:	Target (Issues 25 to 28)	Compiled by Soil Fert Net Coordinator. Open to contributions from all	January, April, July and October 2001
Working Papers: Research Results Working Paper 7	The potential of green manures to increase soil fertility and maize yields in Malawi	Webster Sakala, John Kumwenda, Alex Saka and Vernon Kabambe	May 2001
Methods Working Paper 5	Experiences with farmer participatory mother-baby trials and watershed management improve to soil fertility options in Malawi	Bernard Kamanga, George Kanyama-Phiri and Sieglinde Snapp	February 2001
Workshop Report:	Integration of Soil Research Activities in Eastern and Southern Africa	Cheryl Palm, Andre Bationo and Stephen Waddington (Eds).	October 2001
Annual Report:	Soil Fert Net annual report for 2000	Soil Fert Net coordinators	November 2000

Regional Project 2

Maize for Poverty Alleviation and Economic Growth in Asia

Project Coordinator: J. Ransom

Oversight Director: S. Pandey

1. Major Achievements summarized by outputs for 2001

Output 1. Adapted stress resistant hybrids developed and disseminated in the region

A New lines developed

- 5 early and 4 late CMLs, developed by CIMMYT-Thailand, with a high level of downy mildew resistance (DMR) and combining ability were formally announced by CIMMYT.
- 8 early and 6 late lines developed by CIMMYT-Thailand with DMR were proposed for announcement.
- 145 lines and 50 hybrids screened for tolerance to drought, low N, water logging, and high density in a collaborative program with Thailand. A few lines did very well across all stress environments.
- 6 QPM S3 lines identified with moderate DMR, a first step in developing QPM genotypes with DMR.
- AMBIONET is mapping the genes for resistance/tolerance to stresses (downy mildew and SCMV; drought and low N) and on marker assisted breeding for these stresses. Crosses are currently at various stages of advancement in five countries.
- To accelerate hybrid development efforts, CIMMYT-Thailand provided seed of 20 promising CA lines to 31 cooperators.
- Inbreds of two good performing hybrids were provided to Nepal to enable pilot seed production.
- Thirty lines from Pop. 390 (MIRT) have been identified with good adaptation to Thailand and India and have been screened under *Chilo partellus* by IARI. These can serve as future sources of resistance to stem borers in Asia.
- Seed of 1500 tropical lines were provided to the region for screening for Banded Leaf and Sheath Blight resistance.

B Improvement of populations from which lines will be extracted

- No population improvement work per se was carried out in 2001. However, downy mildew screening was carried out in lines from Populations 31 and 28 being improved in Mexico.

C New Hybrids developed

- 13 new hybrids, some made from CIMMYT-Mexico lines with CIMMYT-Thailand lines were identified and will be included in a regional trial in 2002.
- 55 early yellow hybrids were formed with 11 elite lines that were crossed in a diallel mating system in CIMMYT-Thailand.
- 304 yellow hybrids were formed in the late maturity group. Hybrids were derived from 120 lines crossed to several testers in CIMMYT-Thailand.
- 10 new yellow hybrids were identified in 10 locations in Mexico and are recommended for testing in Asia.

D CIMMYT Hybrids and lines tested by NARS

- Early and late line evaluation trials with 49 entries each for drought (8 locations), water logging (4 locations), high density (3 locations) general performance (17 locations), banded leaf and sheath blight (9 locations), downy mildew (8 locations) and borers (5 locations) were assembled in CIMMYT-Thailand and tested in the region.
- Early and late hybrid trials with DMR from CIMMYT-Thailand were distributed to 99 locations.
- TAMNET hybrid trials (early and late) were assembled in Thailand (including entries from CIMMYT) and distributed for testing to 25 locations.
- The most outstanding hybrids (early and late) from trials in 2000 were assembled in strip trials of 8 entries, which were grown in 10 countries in 36 different locations. These strip trials allowed for the evaluation of larger plots with the intent of decreasing the amount of time needed to release new materials.
- 41 sets of trials of acid tolerant hybrids and lines from CIMMYT-Colombia were evaluation in the region.
- 30 hybrid or line trials from CIMMYT-Zimbabwe were evaluated in the region.
- 163 hybrid or line trials (LT 107, ST 49, HL 7) from CIMMYT-Mexico were tested in the region. Data consistently indicate the value of these materials for the region as in most locations CIMMYT entries out yield the local check hybrids.

E Hybrids released

- HQ2000 was released in Vietnam.
- NSX72, a hybrid with a line derived from P28 was released in Thailand.
- Vivek 9, Vivek 4 and Vivek 5 were released in India. They each contain one CIMMYT line.

Output 2. OPVs and synthetics developed and disseminated

A New OPVs developed

- 49 early and late DMR synthetics were formed and advanced to F2 in Thailand.

B CIMMYT OPVs tested by NARS

- 29 trials of early and late OPV from CIMMYT-Thailand with DMR were tested in 29 locations.
- 17 trials sets from CIMMYT-Zimbabwe were tested in the region.
- 76 EVT sets (47 52, ST 29) from CIMMYT-Mexico were tested in the region. Data indicate 10-100% superiority in several countries where these materials were tested.
- 4 EVT sets from Colombia with acid tolerance were tested in the region.

C OPVs released by NARS

- Data on Pop 22 has been submitted for review for its release in Nepal.
- ZM621 was the best performer in the final stage of testing in Nepal and will be considered for release in 2002.

Output 3. Researchers and farmers in the region trained

A Training courses

- A training course on maize breeding, agronomy, seed production and statistics was held in Bangladesh with 33 participants.
- 208 maize growing families in Bangladesh were trained for one week on maize production techniques using the whole family training approach. A local language maize production manual was prepared and used in this training.
- An in-country training course on field plot lay out and management was held in Nepal with 22 participants.
- 10 participants from Nepal attended a special 2-month training course on trial implementation and management at CMRT in Kenya.
- A regional training workshop on QTL mapping was held in the Philippines with 23 participants.
- AMBIONET sponsored the participation of 13 NARS scientist in the CIMMYT-IRRI workshop on drought functional genomics in the Philippines.
- A training course on QPM was held in Vietnam, with 90 participants.

B Visiting Scientist programs

- 3 NARS scientists visited the ABC lab in Mexico.
- 2 NARS scientists visited the AMBIONET service lab in IRRI, Philippines.
- A NARS scientist from AMBIONET-Indonesia visited CIMMYT ARMP and the biotech/breeding program of Thailand
- 2 Visiting Scientists from Nepal visited the breeding program with CIMMYT staff in Pantnagar and Almora, India.
- 6 researchers from the Philippines, China and Bangladesh visited CIMMYT-Thailand for 5 days.

- A researcher from Vietnam visited CIMMYT-Thailand for 6 weeks.

Output 4. New research methods and tools developed and deployed

- The DMR inheritance study concluded in 2001 found that the number and type of genes involved in resistance/tolerance in the several lines tested differed. Resistance appeared to be governed by dominant genes in two lines, one each with a few modifying genes. In two other important lines, recessive genes controlled resistance.
- Two lines, Nei 9008 and a line from P345 were found to have stable resistance across a range of DM biotypes.
- Country (north and south China, India, Thailand, Philippines) and regional (AMBIONET service lab) databases for maize diversity studies were developed.
- Maize Standard Allele kits were developed and distributed for genetic diversity studies in the region.
- Two QTL maps for downy mildew resistance (by AMBIONET-Philippines and one done as a collaborative effort of India, Indonesia and Thailand); one QTL map for Sugar Cane Mosaic Virus (by AMBIONET-China); and one for low nitrogen tolerance (by AMBIONET-Thailand) were developed.
- F2/3 populations for mapping downy mildew resistance (India) and drought (India, China, Thailand) were developed.
- 10 new lines with potential for use as testers were identified.
- A technique for screening for DMR using pots was perfected. This technique allows for efficient screening throughout the year. It was used to screen QPM S3s effectively for DMR.
- Screening methodology for evaluating weevil resistance is in place in Nepal.

Output 5. Germplasm with enhanced nutritional quality developed and disseminated

- Released QPM lines screen for DMR. Only one had an infection rate below 25%.
- CIMMYT-Thailand using lines from CIMMYT-Mexico and China formed 3 QPM synthetics.
- HQ2000 (CML161 x CML165) was released in Vietnam
- Shaktiman-1 and Shaktiman-2 were released in India from lines developed by CIMMYT-Mexico, who also facilitated their initial seed production.
- Several S3 QPM lines were identified with DMR.
- AMBIONET phase 2 funding support was secured for 2002, including work for the development of QPM maize using molecular tools.
- In Guizhou, China the seed certification department registered province Qian 2609. Yunyou 167 and Yanyou 19 were released in Yunnan province. All have one CIMMYT line in their crosses.
- Two white QPM hybrids from CIMMYT lines have been identified for Vietnam.

- 10 kg of QPM populations and lines were sent to Vietnam to help expand their breeding program.
- Seed of 4 QPM hybrids selected in trials from Mexico were shipped to Nepal for testing in 2002.

Output 6. Availability of seed of improved varieties increased

- 3 late and 3 early varieties were increased for multilocation testing and initial dissemination in East Timor. (ACIAR project)
- 21 community groups produced 45 tons of improved OPV seed with the involvement of 227 farmers in Nepal.
- 200 plus families on 20 ha in Vietnam carried out community-based seed production of HQ2001.
- 110 ha were devoted to demonstrations of HQ2001 in Vietnam.

Output 7. Better characterization of maize production environments

- A synthesis report of the RRAs, PRAs and a baseline survey entitled, "Maize in Nepal: Production Systems, Constraints and Priorities for Research" was published.

Output 8. Country specific maize technology research and development plans developed

- The fourth annual meeting of AMBIONET to review and develop workplans for five countries was held in May 2001.
- An International Maize Symposium was organized in Nepal. 54 scientific papers were presented and recommendations for further development of the maize sector in Nepal were developed.
- Using the results from the characterization survey of maize production environments in Thailand, the basic framework for a maize R&D plan has been established.

Output 9. Policy options that enable sustained increased maize production identified

- Preliminary analysis of maize sector policies and programs in 4 countries were presented in the Fourth Annual Workshop of the Asian Maize Socio-Economics Working Group held in Kathmandu, Nepal, June 4-8, 2001.

Output 10. Crop management practices developed and availed to farmers in the region.

A Improved soil fertility in Nepal

- Efficiency of applied urea can be enhanced by applying part of the total amount at planting (as opposed to applying all at the knee high stage as is currently practiced).
- Multi-site trials determined that P and K are generally not limiting in the maize growing areas of the hills when manure has routinely been applied. This finding substantially reduced the recommended dose of fertilizers required for optimum economic yield.
- Several long-term organic by inorganic fertilizer trials are ongoing.

- Several maize genotypes provided by CIMMYT-Columbia with acid tolerance were identified for production in the valley regions of Nepal.

B Improved cropping systems and crop protection in the hills of Nepal

- Several different experiments explored the potential for the inclusion of legumes in the maize cropping system in Nepal, which currently is predominated by maize relayed with millet. All trials showed that a range of legumes could profitably be included.
- Trials to determine the best varietal combinations of maize-millet and maize-wheat for different zones of Nepal were conducted.
- Chemicals and bio-pesticides were screened for their use for control of white grubs. *Bacillus popilliae,* that is recommended for control of white grub species in the USA was not effective against the species found in Nepal.
- Research to monitor losses due to stored grain pests was initiated.
- A new dryer was developed to meet the grain conditioning needs of Nepal. The dryer is a modification of existing storage structures. Grain can be dried from 20% GMC to 10% GMC in 4-5 days with good weevil control being achieved during drying.

C Improved tillage practices

- Reduced tillage research in the hills of Nepal, found that savings on land preparation cost could be made, but that management of applied manure becomes critical to the productivity of the system.
- Research on methods of planting maize following rice was initiated in the Terai of Nepal and in Bihar, India. Bed planting shows promise in low-lying areas. Hand-planting without tillage also shows promise, especially in allowing for earlier planting.
- Machine zero till maize planting research in Thailand has been planned for the 2002-growing season.

2. Awards

- Dr. Vasal was awarded the Chinese Friendship Award.

3. Interaction between R2 and other projects

- With G2 in the development, testing and targeting of germplasm products.
- With G4 in facilitating the development of adapted stress tolerant materials (i.e. acid tolerant, borer and virus resistance, etc.).
- With G7 in documenting the past impact of research in the region.
- With G8 in training regional scientists in Mexico and Kenya.
- With R1 in germplasm development and in soil fertility related research.
- With R3 in developing maize methods of establishing maize following rice.
- With F3 in the development of methodologies and in training.

- With F5 in developing research activities on monitoring and controlling post-harvest losses in Nepal.

4. Status of Projects

- AMBIONET phase II was secured and will start in 2002.
- Bridging funds from USAID for 2002 for Bangladesh.
- Phase I of HMRP ends December 2002. Phase II (2003-2006) is under development.
- Seeds of Life project (East Timor) is in its 2nd year and will finish in 2003.
- IFAD Asia Maize Project, in its second year, ends June 2003. Very preliminary and informal talks of a Phase II with IFAD last November 2001.

5. Publications and Presentations

Adhikari, K., D. Sharma, J. Ransom and N. Rajbhandari. 2001. Three decades of achievements through NARC-CIMMYT partnership in maize research and development. In: Three Decades of NARC-CIMMYT Partnership in Maize and Wheat Research and Development (1970-2000). Kathmandu: NARC and CIMMYT. Pp 1-11.

Adhikari, K., D. Sharma, J. Ransom and N. Rajbhandari. A maize research strategy for Nepal. Presented at the Maize Symposium, December 2001. To be published in 2002.

Cordoba, Hugo. 2001. Presented the Keynote Address at the International Maize Symposium in Nepal on QPM.

George, M.L.C. 2001. AMBIONET News. Vol 3: 1-4.

George, M.L.C. and D. Hoisington. 2001. CIMMYT's Asian Maize Biotechnology Network: Creating Regional Synergy for Maize Improvement. Proc. ASEAN-AVRDC Regional Network on Vegetable Research and Development. 24-26 September 2001. Shanhua, Taiwan. Gerpacio, R.V. (ed.) 2001. Impact of public- and private-sector maize breeding research in Asia, 1966-97/98. Mexico, D.F.: International Maize and Wheat Improvement Center (CIMMYT). (With case studies / chapters from 6 countries)

Balla, O.; Vasal, S.K.; Gonzalez Ceniceros, F. 2001. Alternatives for screening downy mildew resistance in maize at CIMMYT-ARMP. ASA / CSSA / SSSA. Abstract.

Gonzalez Ceniceros F.; N N Singh. 2001. Maize – A crop of options for nutrition and profitability. Indian Farming. Vol. 51 (No.8):29-32

Gonzalez Ceniceros F.; Vasal S.K. 2001. Towards an efficient maize seed industry in Bangladesh. Lesson From Past Experiences And Current Research. Presented at National Maize Workshop. June, 2001.

Gonzalez Ceniceros F.; Vasal S.K. Grudloyma, P. 2001. Heterotic Characterization of CIMMYT - DOA Lines. ASA / CSSA / SSSA. Abstract.

Grudloyma, P.; Vasal, S.K.; Gonzalez Ceniceros, F. 2001. Research between CIMMYT-ARMP and DOA Thailand to identify abiotic stress tolerant maize germplasm. ASA / CSSA / SSSA. Abstracts.

Manandar, D.N., J.K. Ransom and N.P. Rajbhandari (eds.). 2001. Developing and Disseminating Technology to Reduce Post-harvest Losses in Maize – Proceedings of a Working Group Meeting of the Hill Maize Research Project. Kathmandu: NARC and CIMMYT. Pp. 63.

Panwar,V.P.S. N.N. Singh, S.K. Vasal, and D.J. Bergvinson. 1999. Evaluation of insect and disease resistant subtropical maize germplasm for resistance to Asian corn borer, *Chilo partellus* (Swinhoe). Ann. Agric. Res. 20: 418-422.

Paudyal, K. and J.K. Ransom. Resource use efficiency and effective incentives for maize farmers in Nepal. Presented at the Maize Symposium, December 2001. To be published in 2002.

Paudyal, K.R., J.K. Ransom, N.P. Rajbhandari, K. Adhikari, R. Gerpacio and P.L. Pingali. 2001. Maize in Nepal: Production Systems, Constraints and Priorities for Research. Kathmandu: NARC and CIMMYT. Pp. 48.

Manandar, D.N., J.K. Ransom and N.P. Rajbhandari (eds.). 2001. Developing and Disseminating Technology to Reduce Post-harvest Losses in Maize – Proceedings of a Working Group Meeting of the Hill Maize Research Project. Kathmandu: NARC and CIMMYT. Pp. 63.

Rajbhandari, N.P. Developing a strategy for sustainable maize seed supply in Nepal: Challenges, potentials and options. Presented at the Maize Symposium, December 2001. To be published in 2002.

Rajbhandari, N. 2001. Participatory farmer's group managed maize seed enterprise: HMRP experiences towards developing a sustainable public-private partnership model. Presented at the Third National Seed Seminar, Hotel Himalayan, August 6-7 Patan, Nepal.

Rajbhandari, N.P. 2001. Post-harvest loses of maize in the mid hills of Nepal: Insights from Rapid Rural Appraisals. In: Manandhar, D.N., J.K. Ransom and N.P. Rajbhandari (eds.). 2001. Developing and Disseminating Technology to Reduce Post-harvest Losses in Maize – Proceedings of a Working Group Meeting of the Hill Maize Research Project. Kathmandu: NARC and CIMMYT. Pp. 10-13.

Ransom, J. 2001. Factors affecting post-harvest losses in maize. In: Manandhar, D.N., J.K. Ransom and N.P. Rajbhandari (eds.). Developing and Disseminating Technology to Reduce Post-harvest Losses in Maize – Proceedings of a Working Group Meeting of the Hill Maize Research Project. Kathmandu: NARC and CIMMYT. Pp. 14-18.

Ransom, J., K. Adhikari, N. Rajbhandari. The Hill Maize Research Project: Objectives and Progress. Presented at the Maize Symposium, December 2001. To be published in 2002.

Ransom, J.K. K.B. Koirala, N. Rajbhandari and K. Adhikari. 2001. Involving farmers in the development process to improve adoption of varieties developed by national maize-breeding programs. In: An Exchange of Experiences from South and South East Asia. Proceedings of the International Symposium on Participatory Plant Breeding and Participatory Plant Genetic Resource Enhancement. Pp. 367-372.

Ransom, J. K. Paudyal and K Adhikari. Factors affecting the adoption of Varieties and Soil Fertility Management Practices in Two Districts of Nepal. Presented at the Maize Symposium, December 2001. To be published in 2002.

Vasal S.K. 2001. Quality protein maize development and exiting experience. Presented at National Workshop on Alleviating Micronutrient Deficiency: Role of Horticulture and Home Gardens, M.S. Swaminathan Research Foundation, Chennai, Jun. 29th.

Vasal S.K. 2001. High Quality Protein Corn. p. 85-129. In: Specialty Corns. Hallauer A. R. (ed.). Florida (USA): CRC Press LLC 2001.

Vasal S.K.; Gonzalez Ceniceros F. 2001. Hybrid maize revolution in Bangladesh: opportunities and challenges. Presented at National Maize Workshop, Jun 8-10, Dhaka Bangladesh.

Vasal S.K.; Gonzalez Ceniceros F. 2001. Research on maize tester in CIMMYT-Asian Regional Maize Program. Bangkok Thailand.

Vasal, S.K. 2000. The Quality Protein Maize story. Food and Nutrition Bulletin 21 (4): 445-450.

Vasal, S.K. 2001. Public forum on how food secure is India. Session of Indian Science Congress, 88; p. 1- 3.

Vasal, S.K.; Gonzalez Ceniceros, F. 2000. The Improvement And Promotion of Quality Protein Maize In Selected Countries of Asia. p. 13.

Vasal, S.K.; Gonzalez Ceniceros, F.; Balla, O. 2001. Research activities and some achievements of CIMMYT-ARMP. The Thirtieth National Corn and Sorghum Research Conference, Bangkok (Thailand); 19-23 Jun 2001. p. 22-26. Bangkok (Thailand): CIMMYT.

Regional Project 3

Sustainable Wheat Production Systems in the South Asia, including rice-wheat systems

Project Coordinator: P.R. Hobbs

Oversight Director: S. Rajaram

Project Summary:

This project will strengthen existing linkages and partnerships with national research programs (NARSs), other international centers, advanced institutions and the private sector working in the region to develop and deploy more efficient, productive and sustainable technologies for the diverse wheat production systems in South Asia. Emphasis will be placed on integrating the various discipline and commodity scientists more efficiently and on forging stronger linkages with extension and farmers, private companies, NGO's and manufacturers at selected sites. Germplasm development, crop protection, agronomy, natural resource management and socioeconomic issues are important research components, together with human resource development. There will be a strong link with the Rice-Wheat Consortium (RWC) since this eco-regional initiative and partnership, for which CIMMYT is the convening center, is active in many of the activities listed in this document.

Project Goals (Problems Being Addressed)

Cereal food security is a household priority for many of the growers of South Asia (especially those with smaller land holdings) and for national governments. In South Asia the demand for cereals (especially for rice and wheat) will continue to increase in the coming decades. Population growth alone will lead to increase in foodgrain demand of about 2.5% per year. Growth in incomes is also anticipated and will further accelerate this trend. Food imports can help meet this increased demand. However, port and transport infrastructure may not be adequate to handle the required volume. In addition, any increases in global foodgrain prices will threaten regional food security. The 500 million poor who live in the region would be especially affected.

Growth in the area devoted to the major cereals (about 100 million hectares of rice, wheat and maize) in the region is slowing. In some places, cereal area is actually declining as agricultural land is converted to urban and industrial uses. The growth in cereal production required to meet increasing demand cannot come from expansion in cultivated area; the principal sources of growth will have to be higher yields and sustainable productivity increases. However, in many areas, traditional sources of yield and productivity growth have virtually been exhausted. Farmers in these areas are already using modern varieties, fertilizer and irrigation and additional yield gains will not be easy to achieve. The project will attempt to achieve the above goal by:

1. Studying long-term trends in rice-wheat productivity to gain a better understanding of socioeconomic, biotic and abiotic factors determining productivity growth in these areas.

2. Combating land degradation, in particular the declining soil fertility that threatens productivity growth, in areas currently enjoying relatively high yields.
3. Increasing the productivity of wheat based systems in South Asia through a combination of well-adapted varieties and efficiency-enhancing resource conserving crop management practices.
4. Encouraging a more efficient research paradigm that will achieve sustainable growth in cereal system productivity. NARS scientists, in partnership with CIMMYT and other partners, will work to develop suitable participatory approaches and solutions to farm-level constraints to higher productivity that will be more readily adopted by farmers.
5. Broadening and improving the genetic base of currently cultivated varieties to achieve better resistance to leaf, head, and root diseases.
6. Helping to expand the scientific knowledge base of human resources in the region and encourage them to work in site-specific multidisciplinary teams. Promote closer linkages with farmers and farmer participation in technology generation.

Objectives

1. Include farmers and other stakeholders in problem identification, variety and technology assessment and development of solutions for their production problems using participatory approaches.
2. Characterize the agroecology of wheat systems in South Asia and develop a user friendly digital almanac using geo-referenced databases,
3. Develop, identify, diversify and promote the adoption of improved wheat germplasm adapted to the Subcontinent including germplasm developed for new tillage systems.
4. Conduct epidemiological studies, crop surveillance, and crop loss assessment for the helminthosporium leaf blight complex and for the rust diseases of wheat.
5. Increase the overall wheat production including the reversal of partial total factor productivity decline by addressing soil health problems.
6. Develop reduced, zero-tillage, and bed-sown systems for timely planting, improved crop stands, increased efficiency and cropping diversity of irrigated rice-wheat systems in South Asia.
7. Assess productivity trends in the rice-wheat systems of the Indo-Gangetic Plains.
8. Assess socio-economic impacts and constraints to adoption of improved technologies and identify policy interventions needed to accelerate adoption.

Production Environments:

Because of staff and resource constraints and the large acreage of wheat in the region, this regional project concentrates its activities in the following two regions in the Indo-Gangetic Plains:

1. The higher yielding, more mechanized areas of NW India and Pakistan (>15 m ha), where farmers readily adopt new improved varieties, fertilizer use is high, and irrigation is available. Relatively high productivity but questions of sustaining yields have been raised. Electricity and water pricing policies are important economic issues for this area.

Represented by ME1 in CIMMYT's wheat mega-environment classification and home to the high production rice-wheat systems of South Asia.

2. The lower yielding but potentially productive areas of Eastern India, Nepal and Bangladesh (10 m ha). Improved varieties are grown but replacement with newly developed lines is slow. Fertilizer use is lower and irrigation less reliable. Infrastructure development is poor; therefore socioeconomic and policy issues that constrain productivity need to be considered. On the borderline between ME1 and ME5. This region is also dominated by rice-wheat systems.

China is included in this regional project as a source of innovative technology and germplasm for use in meeting the above objectives. Exchange of materials and visits of scientists between South Asia and China will be encouraged.

Sub-Project 1: Characterizing the agroecology of wheat systems in Southeast Asia and developing a suitable project management information system.

Sub-Project Leader: J. White and Raj Gupta

Sub-Project Goal:

Increase the overall efficiency of research and development activities in the IGP through improved understanding of geographic variation in biophysical, socioeconomic and institutional factors. Furthermore, methods should be developed for continued expansion of the regional databases available with the NARS.

Highlights for 2001:

1. Continued work on the Nepal Almanac (with R2 funds) and a Rupandehi district Almanac.
2. The RWC Atlas was continued despite funding shortfalls.
3. IASRI in IARI, Delhi with support from IAC Wageningen continued to develop an on-line PIMS system for database management for the World Bank NATP project.
4. Continued working with Wis Int. in Wageningen and local India software developers and had the web based database management system (PRISM) for the RWC operational on the RWC web page.
5. The RWC web page was remade and continued to be updated and added to throughout the year.
6. Continued collaboration with CIMMYT-Bangladesh and NARS/NGO/Private contacts in Bangladesh for a Country Almanac. Data gathered and a first draft of the Country Almanac for Bangladesh was published internally to the partners.
7. CIMMYT Bangladesh maintained a web page that entailed site descriptions and GIS maps of the R-W sites as well as each of the partner's research programs for 2002 and results for the past years.

Future anticipated impacts

1. Improved targeting of promising technologies, both agronomic and germplasm-based.
2. Improved priority setting and impact assessment within the region.
3. More effective use of GIS and modeling throughout the region.

4. An effective web based system for management of databases and project management.
5. Improved and up to date web pages for the RWC and national programs available for access of useful information.

Deliverables for 2002

1. 200 copies of the Rice Wheat Atlas as V0.9 (beta release). 1200 copies of the Rice Wheat Atlas V1.0.
2. WWW pages for the RWC server based on data in the Rice Wheat Atlas.
3. Data sets for rice-wheat/maize systems component of Country Almanacs.
4. Written characterization on geography of rice-wheat regions.
5. A tested and working PRISM system for handling RWC data.
6. A PIMSnet system tested and working for IASRI and the WB NATP project and available for other NARS partners of the RWC.
7. More data will be gathered and a second draft of the Country Almanac for Bangladesh will be published and distributed more widely.
8. ADB sites characterized and data available in a RWC almanac

Linkages:

The project will link to ongoing GIS and PIMS projects in the region and elsewhere:

- SDC-funded characterization of the Nepal Mid-Hills, which supports development of the Nepal Country Almanac (RP2) with help from Texas A&M.
- USAID-funded (pending approval) project for development and promotion of the Bangladesh Country Almanac.
- USAID-funded project with the help of Texas A&M for development of Almanacs in Africa, which supports general Almanac software maintenance and development.
- RWC and its activities on PIMSnet in IASRI in India with help IAC Wageningen.
- Development of PRISM on the RWC web-page with help WisInt., Netherlands and local software companies.
- ADB project on RW systems for S.Asia and use of GIS/PMIS for project management

Sub-Project 2: Development and identification of improved wheat germplasm adapted to the Eastern Subcontinent

Sub-Project Leader: G. Ortiz-Ferrara

Project Goal/Purpose (Problems Being Addressed)

Helminthosporium leaf blight, leaf rust, and late heat stress are important stress factors responsible for reduced yields in the Eastern Gangetic Plains of India, Bangladesh and Nepal. Other characteristics such as amber-lustrous bold seed, high and stable yield, and appropriate maturity also play an important role in the adoption of wheat varieties in these highly populated, poor areas of the world. New sources of genetic tolerance to these stresses are needed to enhance the adaptation of the crop. Similarly, there is an urgent need to understand

the mechanisms of late heat tolerance/escape at the plant and crop level. Information on breeding methodologies and selection criteria has to be gathered and utilized for developing stress tolerant, highly adapted cultivars. Development of germplasm for the new resource conserving technologies listed below is also a priority.

Highlights for 2001:

1. The Eastern Gangetic Plains Network was fully implemented. Collaborators have praised the leading role of NARC-Nepal and the CIMMYT-South Asia Wheat Program in distributing the EGPSN and EGPYT nurseries (linked with G3).
2. More than 770 genetic stocks with resistance to the biotic and abiotic stresses common in the EGPs have been distributed and selected in 92 locations over the last five years. Breeders from Eastern India, Terai of Nepal and from Bangladesh have been requesting more and more sets of these nurseries and they have reported and praised the good adaptation and the value of the germplasm in their breeding programs.
3. Fifteen sets of the 5th Eastern Gangetic Plains Screening Nursery (5th EGPSN) and fourteen sets of the 3rd Eastern Gangetic Plains Yield Trial (3rd EGPYT) were distributed in September 2001. Summary reports of previous EGPSNs and EGPYTs have been sent annually to collaborators in electronic form, allowing them to use that information in their own breeding programs.
4. Grain quality data were distributed for the first time to EGPs cooperators for EGPSN and EGYPT material (linked with G3).
5. Two hundred new crosses with targeted parents from the region and new synthetics from CIMMYT-Mexico were made by NARC, Nepal. Several outstanding crosses made during the last four years, with combined resistance to HLB, leaf rust, heat tolerance, bold white grain etc., are now in the F6 stage of the breeding program. One third of these crosses were included in the 5th EGPSN (linked with G3, G5, G6 and R3 Sub Project 4).
6. Cluster analysis of EGPs locations and EGPYT material was conducted allowing refinement of breeding methodology (linked with G3).
7. Participatory Varietal Selection (PVS) activities with the top performing lines of the EGPYTs were conducted (Linked with G3 and R3 Sub Projects 3 and 7).
8. Increased linkages have been established with G3, G5, G6 and G8 in the areas of germplasm exchange, feedback on germplasm adaptation, research on G x T interactions, quality testing, advanced training, dissemination of technology, and joint publications.
9. Three new wheat sterility resistant lines were identified in Bangladesh. P-efficiency screening was also expanded in Bangladesh and lodging and heat screening reinforced. (Linked with G3 and G5).
10. G x T interaction studies were conducted in Nepal, Bangladesh and Eastern India. Responsive varieties were identified. (Linked with G3 and R3 Sub Projects 3, 4, 7, 8 and RWC).
11. National Traveling Wheat Seminars were organized in Bangladesh and Eastern India with breeders and pathologists of the EGPs. Collaborative scientists in this network have exchanged visits to familiarize themselves with the wheat research in other participating countries.

Future activities (2002):

1. Continue to strengthen the Eastern Gangetic Plains regional network for germplasm and information exchange.
2. Continue emphasis on the less productive areas of the IGPs.
3. By the end of 2002, fifteen sets of the 6th EGPSN and fifteen sets of the 4th EGPYT would have been distributed to collaborating NARS (India, Bangladesh and Nepal) and Mexico.
4. Fifty new parental wheat lines with resistance/tolerance to biotic and abiotic stresses, with high yield potential and suitable for use in reduced tillage systems will be available by mid 2002.
5. Start HLB epidemiological and inheritance studies.
6. Nutritional and Industrial quality will be emphasized.
7. Emphasize the research on boron, phosphate and wheat sterility in Bangladesh and Nepal.
8. Strengthen the research on G x T interactions in South Asia.
9. Joint research on salinity screening will be initiated in India (linked with RWC).
10. Initiate the preservation of new genetic stocks in the CIMMYT gene bank.
11. Exploit new sources of HLB resistance (synthetics, etc).
12. Conduct TWS to improve the research interaction among EGPs NARS.
13. Continue the research on heat stress, lodging, and waterlogging.

Sub-Project 3: Farmer Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB) in South Asia.

Sub-Project Leader: G. Ortiz-Ferrara

Project Goal/Purpose (Problems Being Addressed):

Accelerating the adoption of new-improved wheat varieties by farmers is essential if the current progress made in plant breeding is going to make significant impact on total productivity. The involvement of farmers and other stakeholders in the process of varietal selection has been shown to be essential to make this process efficient. There is also an urgent need to diversify the number of varieties in farmer's fields in order to reduce the risk of rust epidemics. With this in mind, participatory approaches such as Participatory Varietal Selection (PVS) and Participatory Plant Breeding (PPB) will be promoted by CIMMYT in close collaboration with NARS in South Asia.

Highlights for 2001:

1. PVS trials were conducted in 15 villages in Nepal, Eastern India and N. Pakistan. More than 875 male and female farmers participated in these activities.
2. Eight new-improved varieties that respond well to zero tillage and surface seeding were increasingly popularized in Eastern India and in Nepal.
3. Farmers have preferred wheat varieties BL-1473 and BL-1813 identified in the hills of Nepal. Three tons of seed were distributed to farmers.

4. Farmer's preferred traits were identified and used in national breeding programs.
5. Twelve PPB Bulk Populations were tested and multiplied in Nepal for use in South Asian PPB trials during the 2002- 03 season.
6. The variety HUW-468 and 0-Till increasingly adopted in UP, India (more than 1000 ha during 2001- 02).
7. Increased partnership and linkages on PVS approaches within NARS.
8. PVS trials were conducted in five villages in the low, mid and high hill areas of Northern Pakistan. Nine tons of seed of three farmer preferred winter by spring wheat lines were multiplied. The actual yield advantage of these lines over the local varieties ranged from 20-60 %.
9. Over 16 tons of breeders/improved seed of recently released varieties in Bangladesh were passed to BADC and other NGOs in the country.
10. A paper on the results and value of PVS/PPB approaches in South Asia was published.
11. PVS/PPB South Asia Project approved by DFID.

Future Activities (2002):

1. PVS and PPB activities will be expanded to 25 villages in India, Nepal, Bangladesh and Pakistan.
2. Awareness by farmers of the availability of improved wheat varieties and agronomic packages will continue. Adoption of the improved technology will be promoted.
3. Participation of NGOs, extensionists, seed producers and other stakeholders working on PVS/PPB in South Asian countries will be expanded.
4. Training of people in the areas of PVS and PPB approaches will be done.
5. Diversification of wheat varieties in farmer's fields will be encouraged.
6. Increased wheat grain yields in farmers' fields in South Asia will be increased through adoption of improved varieties and RCTs.
7. The impact of the last two years PVS activities will be assessed through monitoring.
8. Research on G x T interactions in South Asia will be expanded and identified and responsive varieties promoted.
9. Identification of varieties that respond well under maize-wheat rotation (linked with R2).
10. Continue efforts to obtain special project funding for extended PVS/PPB work in South Asia.

Sub-Project 4: Epidemiology, crop surveillance and crop Loss assessment for Helminthosporium leaf blight

Sub-Project Leader: E. Duveiller

Project Goal/Purpose (Problems Being Addressed)

Helminthosporium leaf blight (HLB), a disease complex caused by two fungal species (*B. sorokiniana* and *P. tritici-repentis*) is the major biotic factor limiting yield in the wheat based

cropping systems in the Gangetic plains, particularly in the eastern plain zone. A coordinated effort is needed at the regional level to address and limit the effects of this biotic constraint. Understanding foliar blights epidemiology, the effect of stresses on genetic resistance stability and factors associated with yield losses in the rice-wheat sequence will allow us to recommend a set of cropping practices that maximize the benefits from using improved germplasm and will increase the sustainability of wheat production in South Asia.

Highlights for 2001:

Funding has been secured for foliar blights activities for three more years and collaboration with UCL, is in full swing. During the visit of Tarai key sites with the associate scientist hired on the project at UCL, a wide range of leaf samples were randomly collected and showed that about 50% of the leaves harbored tan spot.

1. Support was provided to NARC scientists conducting surveys on foliar diseases in Nepal and mineral content of diseased leaves was analyzed in Belgium. Support was given for statistical analysis by a newly hired local biometrician.
2. Evaluation of severity of foliar blights was done in Karnal, Varanasi, Pantnagar, Rampur (IAAS and NARC), Bhairhawa, Parwanipur, Tarahara, Ragunatpur and Santapur.
3. Additional genetic stocks (120 entries) with resistance to HLB were identified and sown in Bhairhawa, Tarahara, Rampur (Nepal) and Jessore (Bangladesh) for evaluation in 2002.
4. Specific collaborative trials were supported at IAAS (Rampur-Nepal): one student has been supported and a trial was conducted (1st year) in Rampur and Janakpur (on-farm) to understand the effect of stress on HLB development and the stability of resistance to foliar blights under stress conditions (heat, reduced soil fertility, minimum irrigation). Evaluation of stress effects along with HLB resistance using a SPAD chlorophyll meter was also done.
5. Joint visits were made by breeders and pathologists to evaluate HLB resistance in Dinajpur and Jessore stations (Bangladesh). Participation by the same scientists in the wheat planning meeting at Joydebpur and a mini- workshop conducted in Dhaka to strengthen the research on HLB in Jessore also occurred.
6. One Indian visiting scientist from DWR (Dr. D.P. Singh) spent 6 weeks at UCL in Louvain-la-Neuve, Belgium.
7. The 10th Helminthosporium Monitoring Nursery was distributed in the region and observations from the 9th HMN were collected from 9 sites in the Gangetic plains.
8. Yield loss studies continued in Rampur's NARC station.
9. HLB data of the 3rd EGPSN and 2nd EGPYT is being processed (linkage with SP-2).

Future Activities: 2002

1. Member of the organizing committee for the 4th tan spot and related foliar blights meeting to be held in Milwaukee (USA) and delivering a keynote at the next APS meeting (USA).
2. Continuing support to annual foliar diseases surveys in Nepal.

3. Annual germplasm assessment will be conducted in Bangladesh, India and Nepal and special attention will be given to quantitative resistance evaluation in EGPYT, EGPSN, and HMN.
4. Genetic stocks with HLB resistance available from South Asia and other regions will be tested in a stock nursery at four key sites, plus about 150 double-haploids under Nepal conditions.
5. More data on the effect of low fertility and other stresses on HLB severity will be provided: 2-years of data will be analyzed from two collaborative trials with IAAS.
6. Training will be provided in Belgium and collaborations in eastern India will be strengthened via concerted efforts with DWR.
7. Two MSc students will be supported at IAAS and collaborations with UCL will be encouraged.
8. Increase the collaboration with WRC (Bangladesh) and disciplinary research in Jessore.
9. Continued efforts on yield loss studies due to HLB and characterization of relations between physiology (growth stage) and resistance.
10. Continued efforts in epidemiology encouraging the use of plant disease watchdog stations.

Sub-project 5 -- Epidemiology, crop surveillance and crop loss assessment for rusts

Sub-Project Leader: E. Duveiller

Project Goal/Purpose (Problems Being Addressed)

Rusts are potentially the most serious pathogens in the sub-continent due to their airborne distribution over long distances and their rapid virulence shift. Proper race typing of rust pathogens is necessary to anticipate the resistance genes that need to be deployed in improved genotypes. Since the support received in the past from specialized centers of excellence in US and Europe is no longer available for rust race/virulence identification, the capacity of NARSs to determine rust pathotype and to monitoring changes in virulence must be enhanced to avoid major epidemics.

Highlights for 2001:

The SAARC nursery data collected in Pakistan (3 sites), Bangladesh (2 sites), Nepal (2 sites) was returned to DWR-Shimla. In Pakistan conditions were extremely dry with very little rust. Overall leaf rust screening was good in Nepal. There was absolutely no leaf rust in Jessore and almost none in Dinajpur for the second year in a row in 2001.

- Contacts were made with Iran where two SAARC nursery sets were sent at the end of 2001.
- Representative samples collected during surveys in Nepal were sent to DWR, Shimla and results were returned to the Nepali scientists attending the all India coordinated wheat meeting in IARI-Delhi with CIMMYT support. Yr9 virulence is in Nepal and no change in virulence was reported in 2001.
- One Pakistani scientist from Murree (CDRI) attended an advanced training in Mexico with support from the CIMMYT wheat program.

- Data from differential lines (IDTN) to test the prevailing virulence types of yellow and leaf rust were obtained from a total of 15 sites in Pakistan, India, Nepal and Bangladesh. Only a few cooperators did not return the data. Results were returned from Islamabad, Karachi, Faisalbad and Pirsabak in Pakistan (4/5); Karnal, Varanasi, Pantnagar in India (3/5:Ludhiana missing and Wellington pending); Dinajpur and Jessore (2/2) in Bangladesh, Tarahara, Hardinath, Rampur, Bhiarahawa, Nepalgunj and Surkhet (6/6) in Nepal.
- Visits were made to CCRI, Pirsabak close to Peshawar and to NIFA with Javed Iqbal Mirza. YR was rated in about 190 Nepal advanced lines (25th advanced lines set) screened in Islamabad, Pakistan.
- In India, yellow rust was detected for the first time in PBW343 in farmers' fields in 2001 during a joint 'scouting visit' with DWR staff to western Punjab and along the Pakistani border. The infection occurred very late in the season with no effect on yield and surprisingly amidst very dry growing conditions. Only YR traces (1 or 2 plants up to 10-30S) were found in PBW343 at Baba Bukhala (Gurdaspur road) but in Batala 3-4 foci were observed, one of them with 30 plants scoring 10-20S. Traces of YR were also found near Amritsar (Punjab) and Pantnagar (Uttaranchal).
- NILS from Cobbity were also tested at 3 locations in Pakistan: Islamabad, Pirsabak and Faisalabad but YR infection was negligible. Results in three sites of Nepal showed that more attention will be needed on keeping the purity of the isolines since the results obtained with Yr10 and Yr18 virulence were unexpected.

Future Activities : 2002

1. Annual survey of foliar diseases will continue to be supported in Nepal and collected rust samples will be sent to Shimla for pathotype identification.
2. Evaluation of foliar diseases and YR epidemic development in NWFP and Northern Areas of Pakistan will continue.
3. Evaluation and data collection of IDTN for rust monitoring in South Asia will continue. The main challenge will be to continue the effort because most cooperators (except Pakistan) face problems with the multiplication of several Thatcher derivatives -- almost no viable grains were produced due to the hot climate. A new multiplication site needs to be identified in the hills of Nepal.
4. Continued collection of regional information on RDN (SAARC nursery) in Nepal, Bangladesh, Pakistan, Iran.
5. Collection of rust inoculums will be reorganized in Bangladesh and dispatched from Dinajpur WRC) instead of Joydebpur.

Sub-Project 6: Soil health and sustainability of the rice-wheat systems in the Indo-Gangetic Plains

Sub-Project Leader: E. Duveiller

Project Goal/Purpose (Problems Being Addressed)

Reverse yield stagnation/decline in the rice-wheat cropping systems of the Indo-Gangetic Plain through the productive and sustainable use of soil resources.

Highlights for 2001:

1. An international meeting on soil health was held in Kathmandu on 16-20 Jan. 2001, to bring together scientists from India, Pakistan, Nepal and Bangladesh who work on related subjects in three different projects: the soil health project with CIMMYT-CABI (Pantnagar, HAU); Cornell University CRSP (Bangladesh and Nepal); CIMMYT-DFID tillage project (Bangladesh, India, Nepal and Pakistan). Including scientists from CABI and Cornell, 35 delegates attended this meeting. The meeting was followed with a field visit to the Tarai with CABI to define further actions.
2. CIMMYT and CABI scientists participated in wheat sampling and microbiota isolation in Pantnagar (India) and in Pakistan.
3. Results confirmed that *Hirschmaniella oryzae* and *Meloidogyne graminicola* are surviving and multiplying in wheat after rice due to sufficient soil moisture resulting from wheat irrigation. Wheat roots appeared rather healthier than expected after rice. *Trichoderma* species were found as favorable bio-agents.
4. Full hands-on training workshop on soil health (nematology and mycology) was organized during the rice season in Nepal at NARC, Khumaltar and IAAS, Rampur. More than 80 fungi strains that were isolated in the Tarai were sent to CABI for full identification.
5. One new species of *Fusarium* probably identified in Nepal soil samples. Molecular studies are in process for confirmation. Isolation of *F. nygami* like in 1994 studies (see Desjardine).
6. *Meloidogyne graminicola* was found to occur during the wheat season after rice; survival in wheat crop is probably favored by residual moisture after irrigation.
7. One visiting scientist from CDRI-Pakistan (Shamim Ifthikar) and one from NARC-Nepal (S. Sharma) attended a special one month training at CABI Bioscience –UK.
8. Seven sets of the CABI Crop Protection Compendium are made available to cooperators.
9. Visit to CABI (Egham) by CIMMYT staff and preparation of a new project proposal for 2002 onward.

Future activities 2002:

1. With the support of CABI, pathogens isolated by NARS will continue to be identified.
2. Comprehensive results are being compiled through 'pivot tables' and will be summarized in 2002.
3. Last sampling and isolation of microbiota conducted in Nepal, Pantnagar, Kaul (India) and Pakistan (Muridke and MONA).
4. End of project workshop to be held in April 2002 with participation of members of CIMMYT's zero tillage adoption DFID project.
5. Fungi and nematode diseases associated with rice and wheat are quantified and results are integrated with those from other disease studies in the region.
6. Putative bio-indicators of soil health are identified for each crop system.
7. Impact of change in tillage practices on pathogens and associated micro-organisms are determined.

8. Factors promoting soil health and sustainability in rice-wheat systems are identified and data summarized.
9. A new proposal prepared on monitoring biotic constraints and socio-economical impacts related to the adoption of zero tillage.
10. Participation in RTCC RWC meeting.

Sub Project 7: Reduced and zero-tillage systems for timely planting, improved crop stands, and increased water and nutrient efficiency in the irrigated rice-wheat systems of South Asia

Sub-Project Leader: P.Hobbs

Project Goal/Purpose (Problems Being Addressed)

To develop, fine-tune, extend and monitor new resource conserving zero- and reduced tillage technologies for establishment of wheat after rice in the Indo-Gangetic Plains of South Asia. Assess the impact of these technologies socio-economically and determine policy needs for accelerating adoption.

Highlights for 2001:

1. Farmers continued to extensively adopt zero-tillage in Haryana in India and Punjab of Pakistan. 40,000 plus hectares was planted in Haryana and 30,000 ha in Pakistan with considerable savings in cost, higher yields and increases in water and fertilizer efficiency. Weed problems were also less and with less fuel use, positive benefits were seen for GHG emissions.
2. No-till was also tested in farmer fields in Punjab, UP and Bihar in India, in Nepal and Bangladesh with success.
3. Improvements in the no-till drill continued to be improved by local manufacturers. This included a new multi-crop distribution system in the Indian drill and better seed distribution in Pakistan drills. A larger drill was manufactured for larger tractors in Pakistan. The Indian no-till cum bed planter was shipped to Pakistan for testing.
4. A traveling seminar was held in September in Bangladesh, Nepal and Eastern India for scientists and other stakeholders to see the work on both sides of the border. This stimulated confidence in the technologies of smaller machinery on small landholders.
5. Monitoring of longer-term consequences of the new RC technologies continued at the selected benchmark sites under the DFID tillage project. The annual technical report was prepared and sent to DFID in October.
6. The RWC Facilitator and 3 Indian manufacturers used Australian funds to visit Australia and exchange ideas on developing drills for use after combine harvesting and where loose residues are a problem.
7. Tillage work at the 6 ADB sites was started this wheat season after initial workshops in April. Workplans have been developed for each site. The ADB 6-month technical report was furnished to ADB.
8. The NZODA project for accelerating the adoption of new tillage options in Nepal and Pakistan was started with initiation workshops in both countries in October. Sites were selected and work started in the wheat season. This included community assessments in

the selected villages, procurement of equipment, training of farmers and service providers and identification of responsibilities of the respective partners.

9. Farmers in Eastern India, Nepal and Bangladesh experimented with the Chinese hand tractor and its accessories with positive results. The seed drill attachment now is locally manufactured in Bangladesh. There were 45 seeders distributed to participatory stakeholders throughout Bangladesh that demonstrated seeder-sown wheat, lentils, and mustard on over 100 ha. Through these efforts power tillers and accessories also became available to Nepali farmers in project areas.
10. Farmers also experimented with surface seeding in Eastern India, Nepal and Bangladesh on lower lying, poorly drained soils and were very happy with the results.
11. The national programs of India and Pakistan published bulletins that described the new technologies.
12. A participatory stakeholders group formed in 1998 in Bangladesh composed of NARS Ag engineers, NGOs, and private manufacturers continues to meet twice a year to fine-tune the seeders manufactured in Bangladesh. A 4-day training course with the WRC was held in October for the tiller operators and owners. Over 80 persons attended.
13. An NGO in Bangladesh was identified to receive 9 tillers, seeders, reapers, pump sets, improved cage wheels and hose pipe in western Bangladesh in an area deemed the least developed agricultural area of Bangladesh. These were given to the NGO on a rotating loan basis. They will recoup the funds and purchase more seeders in the future for further loans to growers.
14. Bullock-drawn zero till implements was given to Bangladesh, Nepal and India where growers will test them during the 2002 season for wheat.

Future Activities in 2002:

1. Continued expansion of zero-tillage throughout the region as more farmers are made aware of the technology and can obtain the equipment for experimentation. More than 300,000 hectares are expected in India and 200,000 in Pakistan in 2001. Expansion will move into new areas in Eastern UP and Bihar and Sind in Pakistan.
2. The locally made implements that enable farmers to adopt the new tillage options will be further modified and refined with particular emphasis on finding models that work well in loose residue using ideas from an Australian trip for local Indian manufacturers.
3. Work will continue to scale up power tiller and bullock drawn based RCT equipment for small landholders in the Eastern IGP.
4. A traveling seminar will be organized for the Western Gangetic Plains of the region so scientists can see the work there.
5. The longer-term consequences of the newer tillage technologies will continue to be monitored at the selected sites although the DFID funding will end in March. A new project will be submitted to DFID for further financial support in early 2002.
6. The ADB project initiated at 6 sites in the 4 RWC countries will continue to be implemented. Each site is being handled by a different IARC center and each site has its own unique workplans.

7. The NZODA project will continue to be implemented in Nepal and Pakistan with a strong emphasis on community need assessments and tailoring RCT's to all social strata of farmers.
8. The interaction of non-puddled rice establishment together with 0-till wheat on system productivity will continue to be assessed.
9. Attempts will be made to initiate a joint venture with China to manufacture Chinese hand tractors and accessories in the region.
10. Work will start on looking at variety by tillage interactions with the hope of finding germplasm better suited to this system
11. Scientists will evaluate the soil health implications of the technology over time.
12. A USAID-funded bilateral program will begin in 2002 for 3 years whereby 10 sets of Chinese hand tractors, seeders, reapers, specially adapted cage wheels, and a pump set with hose pipe will be loaned through NGOs—all coordinated by the Participatory Stakeholders' Group of Bangladesh.

Sub Project 8: Application of bed planting for increasing both efficiency and productivity of irrigated wheat systems in South Asia

Sub-Project Leader: P.Hobbs

Project Goal/Purpose (Problems Being Addressed)

To develop, fine-tune, extend and monitor bed-planting technologies for establishment of wheat, rice and other crops in South Asia that will result in better yields, less cost and improved resource utilization. Make this technology and equipment available to farmers for experimentation and accelerate its adoption. Assess the socio-economic and policy implications and needs of these new innovations.

Highlights for 2001:

1. Bed planting systems were introduced to farmers in the Pakistan Punjab and the Haryana and Punjab in India with success. More than 1,000 hectares was planted using this system in 2001.
2. In both Pakistan and India, improved designs for the bed planter equipment were developed with the local manufacturers. These allow planting of the crop and making the beds in one operation. A multi-crop seeding mechanism was made by local manufacturers in India.
3. Bed-former and bed-seeder prototypes were successfully developed and demonstrated in Bangladesh and Nepal to fit the Chinese power tillers.
4. Bed planting studies of rice were continued in India, Pakistan and Bangladesh. Both direct seeded and transplanted rice was used. Yields ranged as high as 9t/ha in western India and in some cases out yielded flat planting because of less lodging. The main benefit was savings in water, up to 60% in some farmer fields. This will allow scientists to experiment with permanent bed systems. Weed control is a major issue for direct seeded, bed planted rice.
5. Other crops like maize, legumes (lentil and chickpea), mustard and vegetables especially peas are using this system with success.

6. Relay planting of sugarcane in the furrows of bed planted wheat is also caught the attention of farmers and sugar industry people.
7. The traveling seminar to Bangladesh, Nepal and Eastern India allowed scientists from the region to see the results of this technology.
8. Scientists from India and Pakistan attended bed planting training in Mexico in May (2 scientists) and November (one) with support from the wheat and NRG programs at base.

Future Activities:

1. A network of regional scientists conducting research on bed planting systems using participatory approaches will be continued with emphasis placed on eastern areas for crop diversification and more efficient resource use and higher yielding crops in the West.
2. Prototype equipment for bed planting systems will continue to be improved especially for use on permanent beds and adaptation to 2-wheel tractors in eastern areas.
3. Quantification will be done of short and long-term benefits of bed planting systems, such as water and nutrient use efficiency, reduced lodging, improved weed control, crop diversification and yield potential expression. This will be done in the DFID monitoring project, ADB and NZODA projects.
4. Clarification of the effect of bed planting systems on the control of *Phalaris minor* will be done in Haryana where herbicide resistant Phalaris is a problem.
5. Economic analyses comparing bed planting and conventional planting systems will be done.
6. More scientists will be selected for the bed planting courses in Mexico in 2002.

Sub-Project 9: Assessment of productivity trends in the rice-wheat systems of the Indo-Gangetic Plains

Sub-Project Leader: P. Hobbs

Project Goal/Purpose (Problems Being Addressed):

Obtain a better understanding of the problems associated with the decline or stagnation in productivity growth in rice-wheat systems and identify suitable solutions to reverse the trends.

Highlights for this project:

1. Results from years of solarization work are being published while over 50 grower demonstrations on 'healthy rice seedlings" were distributed throughout Bangladesh combining solarization, seed treatment, and other simple combined technologies that have been shown to increase yields up to 40% with little cost. This work is being led collaboratively with CIMMYT by Cornell University.
2. An IRRI soil scientist as the main author prepared papers for journal publications of the long-term data from soil fertility rice-wheat experiments at Bhairahawa and Parwanipur in Nepal. See list below.
3. 90 soil samples from the Bhairahawa monitoring work were collected and sent to Cornell and Rothamsted for analysis.

4. A methodology for conducting soil and root health studies from long term trials, tillage trials and monitored fields was developed through the DFID soil health project. Benchmark soils were sampled and studied.
5. A PhD student from Nepal was funded to conduct research in farmer fields in Bhairahawa and to use the data from the monitoring work for his thesis.

Future activities:

1. A report for the Rupandehi and Naldung sites of the monitoring projects will be written up in 2002 once the soil samples data is ready.
2. Recommendations for reversing the trend of productivity declines in rice-wheat systems will be published.
3. A report on the role of soil organic matter in productivity trends will be written by Rothamsted..
4. An improved set of data and GIS information at a District level available for scientists to use to predict areas of similarity.
5. The PhD student will finish his thesis and publish some papers that highlight the results from the monitoring work.

Sub-Project 10: Identifying policy interventions and assessing socio-economic constraints to accelerated adoption of improved technologies[1]

Sub-Project Leader: M. Morris

Project Goal/Purpose (Problems Being Addressed):

The overall goals of the proposed project are (1) to identify farm-level constraints that are limiting productivity growth in the Indo-Gangetic Plains of India, Nepal, Pakistan and Bangladesh and (2) to identify policy interventions needed to facilitate the adoption of technologies that will ensure sustainable intensification. This will be done using a strong participatory approach of partners.

Highlights of Sub-project 10 in 2001:

1. CIMMYT, Nepal's growing role in advocacy was evidenced by:
   a. Madan Pariyar's mechanization baseline survey with policy recommendations was released and distributed among the high level official in Ministry of Agriculture and Cooperatives as RWC research series number ??? in (date??).
   b. The Nepal Agriculture Ministry asked and received from CIMMYT (Scott Justice and Peter Hobbs), Nepal a policy recommendation on how to foster an appropriate and selective mechanization process to be included in the 10th Five Year Plan.

[1] ***As of January 2002, Subproject 10 has been split into SP 10 Identifying assessing socio-economic constraints and policy interventions to accelerated adoption of improved technologies, and SP 11 Fostering the application of participatory farmer research methods into CIMMYT and NARS research projects.***

c. The Agriculture Ministry was included in more functions such as the Participatory Varietal Selection village programs at Kotange, Nepal (see Sub-Project three)

2. China's Ministry of Agriculture Director of Agricultural Machinery and two private sector agricultural machinery factory representatives were invited to visit the South Asia region by the RWC in November, 2001. They provided policy advice to various ministry, department and agriculture research officials in Bangladesh, Nepal and India. The private sector established trading contacts and discussed possibilities to establish factories in the region to make RCT machinery, especially 2-wheel tractors and accessories, available to farmers.

3. Socioeconomic surveys were conducted by national scientists with RWC support in Pakistan's Punjab, Haryana and Nepal's tarai in 2001 to assess the impacts of no-till technology (surface seeding in Nepal) on production and profitability in these countries..

Future Activities:

1. A meeting will be held in May 2002, in Kathmandu with the CIMMYT base economics program and members of the RWC partners involved in the ADB project to review past work and develop a program of action for the coming years and to determine ways to link social science research with on-going RWC and RP3 activities. Two areas that will receive attention include:

   a) Farm level constraints to technology adoption, especially sustainability enhancing technologies, identified through multi-disciplinary research on farmers' fields.

   b) Policy and macro-economic constraints to enhancing/sustaining productivity growth in the rice-wheat production system identified.

Sub-Project 11: Fostering the application of participatory research methods into CIMMYT and NARS research projects.

Sub-Project Leader: C. Meisner and S. Justice

Project Goal/Purpose (Problems Being Addressed):

To foster gender-sensitive, participatory research methods and promote their use in technology development, including resource conserving technologies. Evidence is mounting that user participation early in technology development is critical for accelerated adoption of certain types of research. Users help set priorities, define criteria for success, and determine when an innovation is "ready" for release.

Highlights of Sub-project 10 in 2001:

1. CIMMYT's and RWC's various participatory initiatives within its RCT programs has increased adoption rates of zero tillage, power tillers and their attachments and bed planting among farmers in the region (see SP 7 and 8).

2. Active farmer groups earlier formed in Nepal's Tarai area continued to experiment with Chinese hand tractor and accessories for improving agricultural productivity. Similar farmer groups developed for testing surface seeding in Nepal continued to expand this useful technology for wheat establishment.

3. A Participatory Stakeholders group was established in Bangladesh in 1998 for the Chinese hand tractor and continues to meet twice a year.

4. The first Participatory Stakeholders group meeting was conducted at Bhairahawa for the Chinese hand tractor. Problems, especially obtaining loans by small holders, was identified by farmers and importers and noted by the Nepal Agricultural Development Bank officials who were participating.
4. Successful "Whole Family training" continues to be conducted in Bangladesh on wheat production, now entirely funded and managed by the WRC, BARI. Over 6,000 grower families have been trained and a NARS –driven impact study shows the training to be quite successful. CIMMYT with BARI has developed Whole Family Training for maize with over 200 families trained. Power shellers will be loaned to strong communities of maize growers for one season, with options to purchase at depreciated prices.
5. Participatory community technical development has been initiated under the NZODA project in Nepal and Pakistan. Villages have been identified, facilitators identified and plans made for assessments to be started in 2002.

Future Activities:

1. CIMMYT and NARC scientists active in participatory technology adoption procedures.
2. Accelerated adoption of resource conserving technologies by farmers resulting in better production, more efficient use of natural resources, more profit, environmental benefits and improved farmer livelihoods to continue using stronger user participation and farmer experimentation in RWC sites and activities.
3. Document the processes and benefits that the current participatory methods have had in increasing new technology adoption by farmers versus the older farming systems approach.
4. Continue to encourage CIMMYT and NARC scientists to utilize participatory methods within their own adaptive research projects.
5. Whole Family training will be WFT will be expanded to train over 1,000 farm families and will include maize production and technologies. WFT will also look into starting or incorporating WFT into new/existing projects outside of Bangladesh.
6. Continue with the Participatory Stakeholders group meetings in Bangladesh and Nepal. Explore the possibility of creating a stakeholders group in India.

Publications:

1. Ortiz-Ferrara, G. 2000. Experiences, Difficulties and Prospects for Abiotic Stress Resistance Breeding in Wheat. Proceedings of the International Conference on Engineering and Technological Sciences 2000, Session 6: Technology Innovation and Sustainable Agriculture, Edited by: Jiang Song and Maohua Wang. ICETS 2000. Chinese Academy of Engineering, Beijing, China, October 11-13, 2000.
2. Sivapalan, S., O'Brien, L., Ortiz-Ferrara, G., Hollamby, G.J., Barclay, I. and Martin, P.J. 2000. An adaptation analysis of Australian and CIMMYT/ICARDA wheat germplasm in Australian production environments. Aust. J. Agric. Res., 2000, 51, 903-915.
3. Duveiller, E., Ortiz-Ferrara, G., Bhatta, M.R., Nagarajan, S. Shakhawat, A.B.S. and Adhikari, B. 2001. Comparison of wheat resistance to Helminthosporium leaf blight at key locations in Eastern Gangetic plains of South Asia. Proceedings of the Conference on "Role of Resistance

in Intensive Agriculture". Karnal, India, Feb. 15-17, 2000. Chapter 23, 233-237. Eds. Nagarajan and D.P. Singh, Kalyani Publishers, Ludhiana.

4. Ortiz-Ferrara, G., Bhatta, M.R. and Duveiller, E. 2001. Results of the 3rd Eastern Gangetic Plains Screening Nursery (3rd EGPSN) 1999-2000. NWRP/NARC- CIMMYT South Asia Program. February 2001.
5. Ortiz-Ferrara, G., Bhatta, M.R. and Duveiller, E. 2001. Results of the 1st Eastern Gangetic Plains Yield Trial (1st EGPYT) 1999-2000. NWRP/NARC-CIMMYT South Asia Program. February 2001.
6. Ortiz-Ferrara, G. 2001. CIMMYT-South Asia Wheat Program: Regional Issues and Opportunities for Collaboration. Presentation made at the 40th All India Wheat Research Workers Annual Meeting. IARI, Pusa Campus, Delhi, India, 21-24 August 2001. (Proceedings in Press).
7. Bhatta, M.R., Ortiz-Ferrara, G., Gurung, B., Pokrel, T.P., Gautam, N.R., Gurung, P. and Neupane, R.B. 2001. Present status of Participatory Plant Breeding research on wheat at the National Wheat Research Program of Nepal. In: "An Exchange of Experiences from South and South East Asia: Proceedings of the International Symposium on Participatory Plant Breeding and Participatory Plant Genetic Resources Enhancement", Pokhara, Nepal, 1-5 May, 2000. Cali, Colombia: Participatory Research and Gender Analysis Program, Coordination Office; ICTA, 2001. pp: 391-400.
8. Ortiz-Ferrara, G., Bhatta, M.R., Pokharel, T.P., Mudwari, A., Thapa, D.B., Joshi, A.K., Chand, R., Muhammad, D., Duveiller, E. and Rajaram, S. 2001. Farmer Participatory Variety Selection in South Asia. In: CIMMYT. 2001. Research Highlights of the CIMMYT Wheat Program, 1999-2000., Mexico, D.F. pp: 33-37.
9. Duveiller, E., 2001. Evaluation of cropping systems and better resistance to foliar blights. Project progress report for 2000, Jan. 2001.
10. Duveiller, E. and Adhikhari, B., 2001. Report of the 8th HMN trials in Sout Asia. Kathmandu, Feb. 2001.
11. Duveiller, E., Ortiz-Ferrara, G., Bhatta, M.R., Nagarajan, S., Shekhawat, A.B.S. and Adhikari, B., 2001. Comparison of wheat resistance to Helminthosporium leaf blight at key locations in Eastern Gangetic plains of South Asia. Proceedings of the Conference on 'Role of Resistance in Intensive Agriculture, Karnal, India, Feb.15-17, 2000. Chapter 23, 233-237, Eds. S. Nagarajan dnd D.P. Singh, Kalyani Publishers, Ludhiana.
12. Singh, D.P., Maraite, H., Duveiller, E., Mercado-Vergnes, D, Renard, M. and Nagarajan, S., 2001. Pathogenicity of three isolates of *Alternaria triticina* - the causal agent of leaf blight of wheat. Indian Phytopathological Society Annual Meeting, CCS-HAU, Hisar, Haryana, India, Dec. 11-13, 2001 (Poster-Abstract).
13. Duveiller, E. and Dubin, H.J. 2001. Helminthosporium leaf blights: spot blotch and tan spot, FAO Wheat Book, Ed. Byrd Curtis (in press).
14. Duveiller, E. 2001. Helminthosporium leaf blights of wheat: challenges and strategies for a better disease control. First National Wheat Breeding Conference, May 10-12, 2000, Jinan, Shandong, People Republic of China (in press).
15. Duveiller, E., Dubin, H.J., Reeves, J., and McNab, A. (eds.), 1998. Helminthosporium blights of wheat: spot blotch and tan spot, Proceedings of the International Workshop on Helminthosporium Diseases of Wheat: Spot Blotch and Tan Spot, El Batán, Feb. 9-14, 1997, CIMMYT, Mexico, 376p.

16. Banu, S. P., Razzaque, M. A., Hossain, A.B.S., Sarker, Rahman, M., Rahman and Meisner, C. A. Improving control for spot blotch (*Bipolaris sorokiniana)* of wheat in Bangladesh. Submitted to Conservation Tillage Workshop, Lahore Pakistan, Feb 2001.
17. Singh A., Singh, U.S., Singh, V., Zeigler, R.S., Hill, J.E., Singh, V.P., Duveiller, E., Santa Cruz, P. and Holderness, M., 2000. *Rhizoctonia solani* in rice-wheat system. Journal of Mycology and Plant Pathology, 30, No 3, 343-349.
18. Banu, S. P., Razzaque, M. A., Meisner, C. A., Duxbury, J. M. and Lauren, J. G. Effect of Solarized Rice Seedlings in None-Solarized Main Field Under Rice-Wheat Cropping System of Bangladesh. Abstract submitted to the International Soil Science Congress for August 2002.
19. Banu, S. P., Razzaque, M. A., Lauren, Julie, Duxbury, J. M. and Meisner, C. A. Abstract. Soil Solarization - A cropping systems perspective research to increase productivity. Abstract submitted to the International Soil Science Congress for August 2002.
20. Hobbs, P.R., R.K.Gupta, R.K.Malik and S.S.Dhillon. 2001. Adoption of conservation agriculture for rice-wheat systems in South Asia: A case study from India. A poster paper presented at the 1st Conservation Agriculture Congress Meeting in Madrid Spain, October 2001.
21. Grace, P., M.C. Jain, and L. Harrington. 2001. Global Environmental Impacts from Conservation Agriculture. Proceedings of a Workshop held February 6-9, 2001, Lahore, Pakistan.
22. Hobbs,P.R., R.K.Gupta, J.K.Ladha and V. Balasubramanian. 2002. Crop Establishment and Management: new opportunities for enhancing rice-wheat system productivity. Proceedings of a WB sponsored International workshop on "Developing an Action Program for Farm-level Impact in Rice-Wheat Systems of the Indo-Gangetic Plains. September 25-27, 2000, New Deli, India.
23. Ladha, J.K., K.S. Fischer, M.Hossain, P.R. Hobbs and B.Hardy. Progress towards improving the productivity and sustainability of rice-wheat systems: a contribution by the consortium members. IRRI Discussion Paper No. 40.
24. Hobbs, P.R., Singh,Y. , Giri, G.S. , Lauren, J. and Duxbury, J. 2002. Direct seeding and reduced tillage options in the rice-wheat systems of the Indo-Gangetic plains of South Asia. Proceedings of an IRRI Workshop entitled " Direct Seeding in Asian Rice systems. Bangkok, Thailand 25-28 January 2000.
25. Hobbs, P.R., Raj Gupta and Larry Harrington. 2001. Sustaining the Green Revolution by resource conserving technologies: The example set by the Rice-Wheat Consortium. ILEIA Newsletter December 2000. pps. 8-10.
26. Hobbs,P.R., and Raj K. Gupta. 2001. Sustainable Resource Management in Intensively Cultivated Irrigated Rice Wheat Cropping Systems of the Indo-Gangetic Plains of South Asia: Strategies and Options. Paper presented at the International Conference on "Managing Natural Resources for Sustainable Production in the 21st Century" February 14-18, 2000, Lahore, Pakistan.
27. Hobbs, P.R., and Raj K. Gupta. 2002. Rice-wheat cropping systems in the Indo-Gangetic Plains: Issues of water productivity in relation to new resource conserving technologies. Paper presented at a Water productivity workshop held at IWMI, Colombo, Sri Lanka from 15-16th November 2001
28. Hobbs P.R., and R.Gupta. 2002. Resource Conserving Technologies for Wheat in Rice-Wheat Systems. Proceedings of the International Symposium on Rice-wheat at the 2001 annual meetings of ASA-CSSA-SSSA, Charlotte, N. Carolina (U.S.A.), October 21-25, 2001

29. Raj K. Gupta, P.R. Hobbs, J.Jiaguo and JK Ladha. 2001. Sustainability of post-Green Revolution agriculture: The rice wheat cropping systems of the Indo-Ganagetic Plains and China. Proceedings of the International Symposium on Rice-wheat at the 2001 annual meetings of ASA-CSSA-SSSA, Charlotte, N. Carolina (U.S.A.), October 21-25, 2001.
30. Raj K. Gupta, P.R. Hobbs, and J.K. Ladha. 2001. Resource conserving Technologies-Transforming the rice wheat systems of the Indo-Gangetic plains. Rice Wheat Consortium – A success story. APAARI –FAO, Bangkok . Publication, (in press).
31. Hossain, M. I., Talukder, A. S. M. H. M., Sufian, M.A., Hossain, A.B.S., and Meisner, C.A. Paper presented in Pakistan workshop. Performance of Bed Planting and Nitrogen Fertilizer under Rice-Wheat Cropping System in Bangladesh. Submitted to Conservation Tillage Workshop, Lahore Pakistan, Feb 2001.
32. Meisner, C.A., M. Bodruzzaman, M. R. Amin, E. Baksh, A.B.S. Hossain, M. Ahmed and M.A. Sadat. 2001. Conservation tillage options for the poor, small landholders in South Asia. Abstract given to the Conservation Tillage Workshop, Madrid Spain, October 2001.
33. Talukder, A.S.M.H.M., Sufian, M.A., Hossain, M.I., Majid, M.A., Hossain, A.B.S., Meisner, C.A., Duxbury, J.M. And Lauren, J.G.. Rice, Wheat and Mungbean Yields in Response to N Levels and Management under a Bed Planting System. Abstract submitted to the International Soil Science Congress for August 2002.
34. Anant P. Regmi, Jagdish K. Ladha*, Estela M. Pasuquin, Himanshu Pathak, Peter R. Hobbs, Laxman L. Shrestha, Dhana B. Gharti, Etienne Duveiller. 2002. Potassium in Sustaining Yields in a Long-term Rice-Wheat Experiment in the Indo-Gangetic Plains of Nepal. Submitted to Agronomy Journal for publication.
35. S.K. Gami, J.K. Ladha, H. Pathak, M.P. Shah, E. Pasuquin, S.P. Pandey, P.R. Hobbs, D. Joshy, R. Mishra. 2001. Long-term changes in yield and soil fertility in a 20-year rice-wheat experiment in Nepal. Biol Fertil Soils. 34:73-78.
36. J.K. Ladha, D. Dawe, R.L. Yadav, H.P. Pathak, A.T. Padre, P. Hobbs, R.K. Gupta. 2001. Productivity Trends in Intensive Rice-Wheat Cropping Systems in the Indo-Gangetic Plains. Proceedings of a WB sponsored International workshop on "Developing an Action Program for Farm-level Impact in Rice-Wheat Systems of the Indo-Gangetic Plains. September 25-27, 2000, New Deli, India.
37. A.P. Regmi, J.K. Ladha*, H. Pathak, E. Pasuquin, D. Dawe, P.R. Hobbs, D. Joshy, S.L. Maskey, and S.P. Pandey. 2002. Analyses of Yield and Soil Fertility Trends in a 20-Year Rice-Rice-Wheat Experiment in Nepal. Submitted to SSSA for 2002.
38. Duxbury, J.M., I.P.Abrol, R.Gupta and K.Bronson. 2000. Analysis of soil fertility experiments with rice-wheat rotations in S. Asia. RWC paper series number 5. New Delhi. Rice-wheat consortium for the Indo-Gangetic Plains and CIMMYT.
39. A.L. Bhandari, J.K. Ladha*, H. Pathak, A.T. Padre, D. Dawe and R.K. Gupta **2001.** Yield and Soil Nutrient Changes in a Long-Term Rice-Wheat Rotation in the Indo-Gangetic Plains of India. Soil Sci. Soc.Am J. (Press).
40. Raj K. Gupta 2000. Nutrient Management in Rice-Wheat Systems for Sustainability of Soil Resources Base. FAO-IEAE Expert Consultations, FAO Rome, August 23-25, 2000. 12p.
41. Gupta, Raj K and I. P. Abrol. 2000. Salinity build-up and changes in the rice-wheat system of the Indo-Gangetic Plains. Experimental Agriculture, 36: 273-284.

42. Bodruzzaman, M., Sadat, M.A., Meisner, C. A., Hossain, A. B. S. and Khan, H. H. Integrated Nutrient Management in a Rice-wheat Cropping System. Abstract submitted to the International Soil Science Congress for August 2002.
43. Bodruzzaman, M., Sadat, M.A., Meisner, C. A., Hossain, A. B. S. and Khan, H. H. Direct and Residual Effects of Applied Organic Manure on Yields in a Rice-Wheat Cropping Pattern. Abstract submitted to the International Soil Science Congress for August 2002.
44. Bodruzzaman, M., Duxbury, J. M., Welch, R. M., Lauren, J. G., Meisner, C. A., Shaheed, A., Sadat, M.A., and Al-Amin, S. Strategies to Address Soil Micronutrient Deficiencies for Flooded Rice. Abstract submitted to the International Soil Science Congress for August 2002.
45. Bodruzzaman, M., Duxbury, J. M., Welch, R. M., Lauren, J. G., Meisner, C. A., Sadat, M.A., and Al-Amin, S. Increasing Rice and Wheat Productivity in Micronutrient Deficient Soils Using Micronutrient Enriched Seed. Abstract submitted to the International Soil Science Congress for August 2002.
46. Samad, M.A., Meisner, C.A,. Rahman,A, Rahman,M., Duxbury, J.M., and Lauren, J. G. Abstract. Wheat Root Growth in Phosphorus Depleted Soils. Abstract submitted to the International Soil Science Congress for August 2002.
47. Meisner, C. A., M. Badaruddin, and R. Amin. Abstract. Nitrogen and Irrigation Management for Direct Seeded Rice in Light Soils in a Rice-Wheat Cropping System. Abstract submitted to the International Soil Science Congress for August 2002.
48. M.A. Rahman, CA. Meisner, J.G. Lauren, JM. Duxbury And A.BS Hossain. Yield Response and Change in Nutrient Availability by Liming in an Acidic Soil Within a Rice-Wheat Cropping System. Abstract submitted to the International Soil Science Congress for August 2002.
49. Madan P. Pariyar, Khadga B. Shrestha, Nara Hari Dhakal. BAseline Study on Agricultural Mechanization Needs in Nepal. RWC paper series number 13. New Delhi. Rice-wheat consortium for the Indo-Gangetic Plains and CIMMYT.
50. S.E. Justice and J.M. Hooper Participatory Farmer Research in Small Farm Mechanization: A Case Study from Nepal's Terai. 2001. Paper presented at XXXV Annual Convention, Indian Society of Agricultural Engineers, January 22 24, College of Agricultural Engineering and Technology, OUAT, Bhubaneswar, Orissa.
51. S. E. Justice. Participatory Technology Development in Resource Conservation Technologies: A Case Study from Nepal. 2001. Paper presented at the 2001 American Society of Agricultural Engineers (ASAE) Annual International Meeting, Sacramento Convention Center, Sacramento, California, USA, July 30-August 1, 2001.
52. Meisner, C. A. 2001. Report of an On-Farm Survey of the Greater Sylhet Region Wheat Growers' Practices, Perceptions, and their Implications. Monograph no. 16. July 2001.
53. Meisner, C. A. Trip Report International Crop Science Congress, Hamburg, Germany, August 17-22, 2000

Regional Project 4

Food security for West Asia and North Africa (WANA)

Project Coordinator: H. J. Braun

Oversight Director: S. Rajaram

All major objectives have been achieved given the availability of financial and human resources and the most important ones are reported below. The project is jointly carried out with ICARDA and with Turkey for the International Winter Wheat Improvement Program (IWWIP). Meetings for R4 were held in Aleppo in April and in Bangkok in May 2001 to discuss and present the latest achievements. The major accomplishments of RP4 in 2001 were:

Winter and facultative bread wheats:

- Seven winter wheat varieties were released in Turkey (6) and Iran (1). For the first time, two cultivars developed by the IWWIP are released for rainfed areas. Ten cultivars are presently included in registration trials in CWANA countries and one in China, Gansu.
- One hundred and thirty-five winter bread and durum wheat lines were distributed in yield trials to 61 cooperators and 406 lines to 118 co-operators as observation nurseries.
- Data for International Nurseries 1999/2000 were analyzed and returned to co-operators In April 2001 on CD-Rom in Excel format.
- The drought in winter wheat areas of Turkey was so severe that 5 of 6 semi-arid yield trials had to be abandoned. Farmers' yields varied from 0.6 to 1.5 t ha-1. The maximum yield in the Elite Yield Trial for semi-arid areas was at 3 locations in Afghanistan: 261 kg ha-1.
- All winter wheat cultivars released for irrigated areas in Afghanistan by FAO/SCA during the last 10 years originated from the IWWIP. These lines are also released in Turkey - though normally 3 years later – and all were among the three highest yielding entries in the Elite Yield Trial for Irrigated areas. The cultivar Shark out yielded the best check (Pamir 94) by 12% across 22 locations and Bezostaya by 26%.
- Results of 3rd WWEERYT confirm previous years findings. The highest yielding entry across locations in CWANA – Shark - originates from the IWWIP, whereas in Eastern Europe local material shows best adaptation.
- In a cluster analysis of genotypes in WWEERYT, 1 –3 entries were clearly grouped by origin. East European material forms one major cluster, and germplasm from CWANA and the US form another cluster.
- More than 80% of all lines developed by the IWWIP carry resistance to the prevailing virulences for stripe rust in CWANA.
- Thirty-three drought tolerant cultivars from Marageh, Iran were crossed to winter wheats with a proven record for drought tolerance from CWANA, the US, Eastern Europe and China and 105 F1s were produced. These F1s form the starting point for the shuttle with Iran to select drought tolerant lines adapted to the semi-arid areas of Iran and Turkey.

- Grain yield of wheats sown on beds was not different from conventional sowing in Eskisehir (5.23 t ha-1 beds vs 5. 30 t ha-1 flat) and Konya (4. 72 t-1 beds versus 4.81 flat). Maize sown immediately after wheat on beds showed the potential for Second crop sowing on the Central Anatolian Plateau.
- In SE-Turkey (GAP area) there were more than 100 ha ofbed-demonstration plots. No yield difference between beds and flat sowing. In 2002, soybeans and maize will be sown in these beds.

Spring bread wheat

- Three spring bread wheat varieties were released in Egypt (2) and Iran (1).
- Hessian fly resistant spring bread wheat cultivars developed under the collaborative program with Morocco were in large scale On-farm demonstrations and concurrently are in large-scale multiplication.
- A total of 11 International spring bread wheat nurseries comprising 5 breeding nurseries, 2 entomology gene pool nurseries for Russian Wheat Aphid (RWA) and Hessian fly and 4 pathology gene pools for Septoria resistance, stem, leaf and yellow rusts were distributed to NARS.
- All simple and/or top crosses targeted for North Africa involved a parent with resistance to Hessian fly, Septoria and quality.
- All simple and/or top crosses targeted for West Asia involved a parent with resistance to yellow rust, wheat stem sawfly and quality.
- Spring bread wheat germplasm from Mexico was utilized in the breeding program to enhance yield potential and quality.
- Around 800 advanced durum lines and 10 000 segregating populations were tested for yield, stability, and resistance to abiotic and biotic stresses.
- Greater emphasis was made to improve end-use quality as a result all PWYTs and AWTYs were evaluated for gluten strength and a total of 30 varieties were evaluated for both gluten strength and gluten extensibility, in addition to the determination of HMW composition.
- More than 90% of all bread wheat lines distributed to NARS carry resistance to the prevailing virulences for stripe rust in WANA.
- Twenty bread wheat cultivars with tolerance to drought, cold, and heat and resistance to the major biotic stresses were tested in joint on-farm trials with NARS in Syria, Egypt, and Lebanon.
- Experimental design used in spring bread wheat yield trails has been improved: in international yield trails, alpha lattice is used instead of randomized complete block design and in the main experimental stations of the CIMMYT/ICARDA joint wheat improvement program, alpha lattice and spatial analysis are used.
- Stress physiology work with spring wheat in collaboration with NARS in NVRSRP has focused on traits associated with heat stress tolerance, and the collaboration with advanced research institutions (Univ. of Barcelona) has focused on drought tolerance.
- Synthetics are crossed to broaden the genetic base of spring bread wheat for Hessian fly and Septoria resistance, in addition to drought, cold, and heat tolerance.

- In spring bread wheat the use of Doubled Haploids (DH) to speed up generation advance has increased (20%) and currently DH is used to develop populations (Hessian fly and yellow rust) for MAS.

- Nine scientists trained in breeding and selection techniques in spring wheat. Two degree scientists trained. Six national research coordination meetings / traveling workshops organized/attended.

Spring durum wheat

- Five durum varieties were released in the Mediterranean region and 3 lines are proposed for release in Syria.
- 15 international nurseries and genetic stocks distributed to NARSs covering all major WANA environments: continental, temperate, and high altitude areas. Around 800 advanced lines and 10,000 segregating populations tested for appropriate morpho-phenology, yield, stability, and resistance to biotic and biotic stresses. Syrian-3, Zeina-3, and Mrb3/Albit-1 combine yield stability with multiple abiotic stress resistance and productivity.
- Genetic diversity: Crosses between high yielding durum genotypes and T. dicoccoides and T. monococcum were made to improve grain quality and resistance to leaf rust, Septoria tritici, and yellow rust. Several high yielding durum lines were identified combining resistance to leaf and yellow rusts, and Hessian fly.
- Carbon Isotope Discrimination (CID) was found to be useful to screen for variation in water use efficiency (WUE). Molecular markers could serve to identify traits that are difficult to identify phenotypically. Relationships between grain yield, yield components, and carbon isotope discrimination (CID) were positively correlated. The association of CID with grain yield was similar to that of number of fertile tillers and number of spike kernels with grain yield. Molecular markers that associated with grain yield had also shown association with CID.
- Biotic stress tolerance: All segregating and advanced lines screened under artificial inoculation for yellow rust, wheat stem sawfly, Septoria tritici and BYDV at Tel Hadya; and leaf rust, stem rust, BYDV, and RWA at Terbol. Advanced lines were tested for common bunt. Screening for dryland root rot resistance was made at the Marchouch station, Morocco and in the greenhouse and several genotypes were selected. For Hessian fly resistance crosses were made with bread wheat carrying H5 genes and with HF resistant Aegilops. The Telset lines (SD8036/Omtel-1//Awalbit-3) are used extensively in the crossing program. These lines combine the Hessian fly resistance with high grain yield under dry and hot conditions.
- Yield and adaptation: On-farm trials were conducted in Syria, Morocco, Turkey, Lebanon, Tunisia, and Algeria. In Syria 2 cultivars of durum were released, in Lebanon one cultivar. In Morocco cultivars with Hessian fly resistance and heat tolerance were registered in the national catalogue.
- Grain quality: All advanced genotypes were analyzed for protein content, sedimentation test, yellow pigment, and kernel weight. They were also analyzed for DNA-LMW glutenin subunits.
- Potential application of marker assisted selection (MAS). Seven mapping populations for the different agro-ecological zones were developed, of which two are mapped and three are under study.

- Consultation and training: In-country training was conducted in Syria (3 days; Abiotic stress breeding), Jordan (5 days: Analysis of data, selection under terminal stress conditions), and Morocco (3 days: Stress breeding and durum grain quality). NARS scientists trained in stress physiology, grain quality, entomology, pathology, and virology. PhD students in stress physiology (Algeria), grain quality and marker assisted selection (Morocco, Algeria, Syria, Turkey, and Lebanon), pathology, entomology, and virology have been working in the breeding program.
- Concluding remarks-Durum: Stress tolerant durum cultivars with improved grain quality are released more and more. Syria, Morocco, Iraq, Egypt, and Algeria increased durum production. Hessian fly resistant advanced lines are now available. Spectacular progress has been achieved for tolerance to drought through the introgression of genes from wild relatives and use of the rotation system with vetch. Promising cultivars originating from crosses with wild relatives are Bcr/Sbl5// Ae. peregrinacylindros 401047 and Lgt3/3/Gdfl/T.dicoccoides-SY 20013//Bcr. Resistance to leaf rust and septoria tritici has been enhanced. Tunisia, Morocco, and Spain are starting to release this material for commercial production.

Root rot diseases and nematodes

- Turkish/Syrian Nematode and Root Rot Survey (Turkey/CIMMYT/ICARDA/INRA) conducted in 2000 indicated the widespread distribution of soil borne diseases on the plateau. Analysis of 30 samples from Turkey indicate 72% of root samples and 83% of soil samples contained Cereal Cyst Nematode (CCN) either being separate or a mix of two species *Heterodera filipjevi* and *H. latipons, H. avenae* was not found. 80% of soil samples contained one or both species of RLN (*P. thornei* or *P. neglectus*). 40% and 57% of soil samples were Fe and Zn deficient and 60% of root extractions contained root rot (both/or *Fusarium* spp. and *Bipolaris*).
- Cumra has proven to be an excellent site to screen wheat germplasm for Root Rot Complex (*Fusarium culmorum, F. pseudograminearum, Bipolaris sorokinana*).
- Optimization of the PCR based molecular marker *Cre3* for Cereal Cyst Nematode (*Heterodera avenae* pathotype Ha13) resistance to be integrated into the winter wheat breeding program (conducted at CRIFC, Ankara).
- Optimization of the RFLP PCR based markers to identify the Heterodera Group of Cereal Cyst Nematodes, later to be used in identification of species of cyst nematode in the region to prioritize breeding needs (at Anadolu, Eskisehir).
- Two hundred crosses were made to winter wheat germplasm identified to contain a high level of root rot resistance in Cumra and advanced germplasm.
- Twenty-three lines showed good tolerance to root rots in Cumra across two years.
- Advanced spring wheat lines from Mexico with root rot and nematode resistance are tested in the WANA region to confirm resistance has been incorporated.
- Crossing block for nematode and roots rots has been formed with the best known current sources of resistance against Cereal Cyst Nematode (*H. avenae* - various pathotypes), Root Lesion Nematodes (*Pratylenchus thornei* and *P. neglectus*), Crown Rot (*Fusarium pseudograminearum*) and Common Root Rot (*Bipolaris sorokinana*).
- Two nematode yield loss trials established on the CAP to investigate the population dynamics of the nematodes and plant yield loss and possible resistance of Turkish winter wheat, barley and triticale against both Cereal Cyst (*Heterodera spp.*) and Lesion

(*Pratylenchus spp*). Nematodes. Known resistance genes from Australian spring wheats against *H. avenae* (Ha13), are included in the trial.

- 1800 lines have been screened for root rots in an unreplicated preliminary screening nursery; 28 lines in a replicated screening nursery and 48 lines have been tested in a replicated yield trial.
- Eskisehir ANADOLU provided a greenhouse have been to screen for nematodes and root rots.
- Training: Master student undertaking a thesis on nematodes and winter wheat. NARS scientists and local CIMMYT staff trained in nematode counting.

Publications

Abdalla, O.S., F.J. El-Haramein, and A.A. Yaljarouka. 2001. Assessment of end-use quality of selected bread wheat varieties from West Asia and North Africa (WANA) Region. In: Annual Meetings Abstracts, ASA, CSSA and SSSA, Charlotte, N.C., USA, Oct. 21 - 25, 2001.

Amri M. M. Boujnah, N. Nsarellah, M. Taghouti and **M.M. Nachit**.Genetic and agronomic approaches to improve durum wheat quality in Morocco . Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 543-547

Araus J.L., J. Casadesus, J. Bort, **M.M. Nachit**, D. Villegas, N. Aparicio and C. Royo. Some remarks on ecophysiological traits for breeding. Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 57-62

Braun, H.-J., T.S. Payne, M. Mergoum, M. van Ginkel, W.H. Pfeiffer and S. Rajaram. 2001. International Collaboration on Wheat Improvement. In: Bedo, Z. and L. Lang (eds). Wheat in a Global Environment. Proceedings of the 6th Int. Wheat Conference, Budapest. June 4-9, 2000. Kluwer Academic. p 125 – 137.

Braun, H.-J., M. Mergoum, A. Bagci, H. Ekiz, M. Keser, K. Yalvac, and H. Ketata. 2001: Spring x Winter Derived Germplasm: Adaptation and Performance in Central/West Asia and North Africa. The Warren E. Kronstad Commemorative Symposium, Obregon, March 15 – 17, 2001. CIMMYT, Mexico, D.F.

Braun, H.J.; M. Mergoum, A. Morgounov and J. Nicol, 2001: Adaptation of winter wheat to Central and West Asia. In: Research highlights of the CIMMYT Wheat Program 1999-2000. Mexico, D.F. (Mexico): CIMMYT, 2001. p. 27-32.

Braun, H.-J. , N. Zencirci, F. Altay, A. Atlı, M. Avci, V. Eser, M. Kambertay and **T.S. Payne.** 2001, The Turkish Wheat Pool. In. The World Wheat Book. A History of Wheat Breeding. Bonjean A. and W. J. Angus. Lavoisier Publishing Inc. Paris, France, p. 851 – 900.

Cakmak, I.; H. Ozkan, **H.-J. Braun,** R. M. Welch and V. Romheld,. 2000: Zinc and iron concentrations in seeds of wild, primitive, and modern wheats. Food and Nutrition Bulletin 21 (4) :401-403.

Dusunceli, F. L. Cetin, S. Albustan, **H.-J.Braun**, H. Ketata, Z. Mert and S.P.S. Beniwal: 2001: Evaluation of international wheat nurseries for stripe rust (Puccinia striiformis F.SP. tritici) resistance in Ankara - Turkey in the period 1995-2000. p. 40. In: Regional Yellow Rust Conference for Central and West Asia and North Africa, 1; Karaj, Iran; 8-14 May 2001. Abstracts of oral and posters presentations. Teheran (Iran): Ministry of Agriculture Jihad, Islamic Republic of Iran / ICARDA, Abstract only

El-Bouhssini M. and **M.M. Nachit.** New sources of resistance in durum wheat and wild relatives to Russian wheat aphid (Homoptera: Aphididae). Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 393-395

El-Shazly M.S., M.A. El-Ashry, **M. Nachit** and A.S. El-Sebae .Performance of selected durum wheat genotypes under different environmental conditions in eastern Egypt. Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 595-600.

Elouafi I., **M.M. Nachit,** A. El-Saleh, A. Asbati and D.E. Mather. QTL-mapping of genomic regions controlling gluten strength in durum (Triticum turgidum L. Var. durum). Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 505-509Estrada Campuzano, G.; **Mergoum, M.; Pfeiffer, W.H.; Rajaram, S.; Hede,** A.R.; Balbuena Melgarejo, A.; Martínez Rueda, C.G.; Abdalla, O.S.; Varughese, G. 2001. Registration of 'Maravilla-TCL99' triticale Crop Science 41 (1) :257-258.

Ferrio J.P., E. Bertran, **M.M. Nachit,** C. Royo and J.L. Araus. Near infrared reflectance spectroscopy as a new screening tool to increase durum wheat yield. Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 141-144

Ferrio J.P., E. Bertran, **M. Nachit,** C. Royo, and J.L. Araus. Near infrared reflectance spectroscopy as a potential surrogate method for the analysis of ?13C in mature kernels of durum wheat. Aust. J.Agric.Res. (2001), 52., 809-816

Jaiti F., S. El-Jaafari, I. El-Hadrami, **M. M. Nachit,** M. Baum, J. De Buyser et E. Picard. Problematique de la culture de microspores chez le ble dur Triticum turgidum L. var. durum. Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 149-152

Ketata, H., A. Yahyaoui, M. Jarrah , **H.-J. Braun, M. Mergoum,** L. Cetin and F. Dusunceli. Slow Rusting in Winter and Facultative Wheat Infected with Yellow Rust. In. In: Bedo, Z. and L. Lang (eds). Wheat in a Global Environment. Proceedings of the 6th Int. Wheat Conference, Budapest. June 4-9, 2000. Kluwer Academic. p 391-396.

Lhaloui S., M. El-Bouhssinin, N. Nsarellah, **M.M. Nachit** and A. Amri. Biotic stress limiting durum wheat production in Morocco-Hessian fly and the Russian wheat aphid: Surveys, loss assessment, and identification of sources of resistance. Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 373-378

Mateo, M.A., P. Ferrio, J. Bort, J. Voltas, **O. Abdalla,** J. L. Araus and A. Yaljarouka. 2001. Effects of water regime on the relationships between grain carbon and oxygen stable isotope composition and yield in wheat under Mediterranean conditions. (Submitted to Plant Cell and Eenvironment).

Mergoum, M.; Hernández Sierra, A.; **Pfeiffer, W.H.; Rajaram, S.**; Zuloaga Albarrán, A.; **Abdalla, O.S.;** Varughese, G. 2001. Registration of 'siglo TCL-21' triticale. Crop Science 41 (1) :273.

Mergoum, M.; Hernandez Sierra, A.; **Pfeiffer, W.H.; Rajaram**, S.; Zuloaga Albarrán, A.; **Abdalla, O.S.**; Varughese, G. 2001. Registration of 'Milenio TCL-3' triticale. Crop Science 41 (1) :272.

Mezzalama, M ., JM Nicol, K Sayre and P Grace (2001) Soil ecological changes under a long term conservation tillage wheat and maize rotation trial in Mexico. 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8th. Porter IJ et al. (eds.). ISBN: 0 7311 8170 0. pp.73-74.

Mossad, M., Z. Ali, A. Abd El-Ghani, A. Elahmadi, **O.S. Abdalla**, N. Haddad, and H. Khalid. 2001. Bread wheat genotypic response under optimum and moisture stress environments. In: Annual Meetings Abstracts, ASA, CSSA and SSSA, Charlotte, N.C., USA, Oct. 21 - 25, 2001.

Nachit M.M., I. Elouafi, M.A. Pagnotta A. El-Saleh, E. Iacono, M. Labhilili, A. Asbati, M. Azrak, H. Hazzam, D. Benscher, M. Khairallah, J.M. Ribaut, O.A. Tanzarella, E. Poreceddu, and M.E. Sorrells. Molecular linkage map for an intraspecific recombinant inbred population of durum wheat (Triticum turgidum L. var durum). Theor Appl. Gene. (2001) 102: 177-186.

Nachit, M., and O. Abdalla. 2001. Wheat breeding for drought tolerance in West Asia and North Africa (WANA) Region: Methodology, Achivements and Challenges. In: Annual Meetings Abstracts, ASA, CSSA and SSSA, Charlotte, N.C., USA, Oct. 21 - 25, 2001.

Nicol, J.M., and I Orti-Monasterio (2002) Effect of Root Lesion Nematode on Wheat Yields and Plant Susceptibility in Mexico. Submitted to Nematology (In Press).

Nicol, J.M., (2002) Chapter: Nematodes of Economic Importance on Cereals. In: Improving World Wheat Production. CIMMYT International, Edited by FOA, Rome. In Press.

Nicol, J.M., &I Ortiz-Monasterio (2001) Population Dynamics and Economic Important of the root lesion nematode, Pratylenchus thornei, for wheat productivity and Global Implications for Germplasm Development. 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8th. Porter IJ et al. (eds.). ISBN: 0 7311 8170 0. pp. 119-120.

Nicol, J.M., & R Rivoal (2001) Development of AUS4930 – a source of resistance against both Root Lesion Nematode (Pratylenchus thornei) and the Cereal Cyst Nematode (CCN) Complex for Global Breeding. 2nd Australasian Soilborne Diseases Symposium, Lorne, Victoria, 5-8th. Porter IJ et al. (eds.). ISBN: 0 7311 8170 0. pp.67-68.

Nicol, J.M.,, R Rivoal, RM Trethowan, M van Ginkel, M Mergoum and RP Singh (2001) CIMMYT's approach to identify and use resistance to nematodes and soil-borne fungi, in developing superior wheat germplasm. In: Wheat in a Global Environment. Proceedings of the 6th International Wheat Conference, 5-9th June 2000, Budapest, Hungary. Kluwer Academic Publishers, Netherlands, pp. 381-389.

Nsarellah N., **M. Nachit** and S. Lhaloui . Breeding durum wheat for biotic stresses in the Mediterranean region. Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 341-347

Rekika D., Kara Y., Souyris I., **Nachit M.M.,** Asbati A., Monneveux. The tolerance of PSII to high tempereatures in durum wheat (T.turgidum conv. Durum): genetic variation and relationship with yield under heat stress. Cereal Research Communications Vol. 23 No. 4 (2000).

Rivoal R, S Bekal, S Valette, JP Gauthier, M Bel Hadj Fradj, A Mokabli, J Javier, **J Nicol** & A Yahyaoui (2001) Variation in reproductive capacity and virulence on different genotypes and resistance genes of Triticeae, in the cereal cyst nematode species complex. Nematology 3(6): 581-592.

Rivoal R, S Bekal, M Bel Hadj Fradj, S Valette, A Mokabli, J Javier, M Zaharieva and **JM Nicol** (2001) Variability for resistance to cereal cyst nematodes in Triticeae: Potential use for Triticum turgidum L. var. durum improvenment. . In:Durum wheat improvement in the Mediterranean region: new challenges, ed. C. Royo, M.M. Nachit, Di Fonzo and J.L. Araus. INO Reproducciones, S.A., Zaragoza, Spain. Pp 413-416.

Saulescu N.N. and **H. -J. Braun.** 2001. Breeding for Adapatation to environmental factors. Cold Tolerance. In: Application of Physiology in Wheat Breeding. M.P. Reynolds, I. Ortiz-Monasterio, and A. McNab (eds.). Mexico, D.F.: CIMMYT. P 111 – 123.

Sorrells M.E., A. Diab and **M. Nachit**. Comparative genetics of drought tolerance. Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 191-201

Tolay, I., B. Erenoglu, V. Röhmheld, **H.-J. Braun** and I. Cakmak. 2001. Phytosiderophore release in Aegilops tauschii and Triticum species under zinc and iron deficiencies. Journal of Experimental Botany, Vol 53, 358. p 1-7.

Veisz, O, **H.-J. Braun** and Z. Bedo. 2001: Plant damage after freezing, and the frost resistance of varieties from the facultative and winter wheat observation nurseries. Euphytica 119 (1-2) :179-183.

Yahyaoui A., S. Hakim, M. Al- Naimi and M.M. Nachit. Multiple disease resistance in durum wheat (Triticum turgidum L.var. durum). Options Mediterraneennes No 40 "Durum Wheat Improvement in the Mediterranean Region: New challenges" Zaragoza (Spain), 12-14 Apr. (2000) pp: 387-392

Zerihun Kassaye; **Abdalla, O.S.** 2001. A study of the host range of wheat stem rust in Ethiopia. . Annual Wheat Newsletter 47 :46.

Regional Project 5

Agriculture to sustain livelihoods in Latin America and the Caribbean

Project Coordinator: **G. Sain**

Oversight Director: **C. Cafati**

1 Introduction

This report covers the main activities and accomplishments achieved by the members of R5 during 2000 and 2001. During this period the Project changed the Coordinator and the Oversight Director. As a consequence this report is a joint product of the four scientists involved with the invaluable contribution of all the members of the Project. However any errors or omissions are the responsibility of the current PC.

R5 has many links with other Global and Regional CIMMYT Projects. Many of the contributions produced by these links are not reported here since they are documented in their respective projects. Furthermore, this report is still incomplete in the sense that some of the activities and results achieved in the context of R5 have not been incorporated in full.

CIMMYT research in Latin America has a long an impressive history of successes and impact that has been very well documented. We hope the achievements and results reported here continue to add to that list.

1.1 Main concerns, threats and opportunities faced by R5

R5 is a project characterized by high diversity in terms of the number of countries and environments involved.

This diversity has raised concerns among project members as well as other CIMMYT scientists about the viability of R5 as a single Project

Most of the activities carried out in the context of the project are funded from special projects that show a declining and uncertain trend. This makes it difficult for the members to plan for the future and frequently donors influence the research agenda.

1.2 Project structure

Four subprojects titles were proposed in previous meetings of R5. They were the following:

SP 1: Reducing poverty while conserving the resource base in Mesoamerica.

SP 2: Increasing maize/wheat supply in the acid soils of tropical Latin America.

SP 3: Competitive maize/wheat production in temperate Latin America

SP 4: Alleviating rural poverty in the highlands of Latin America

However there was not a formal definition of these subprojects in terms of defining a framework and designing responsibilities for each of them.

1.3 The strategic planning meeting

In October 2001 the R5 members carried out a strategic planning meeting with the main objective of defining new subprojects, defining subprojects leaders and defining a funding strategy.

The objectives were partially achieved. Three main subproject ideas were identified and areas where CIMMYT would have comparative advantages to do research were identified (See Table 1 in the Annex). During this year, the Project Coordinator and the Oversight Director will lead a consultative process to define more precisely the subprojects, their leaders and to identify appropriate projects attractive for funding.

2 Achievements 2000 – 2001

2.1 SP 1: Reducing poverty while conserving the resource base in Mesoamerica.

Activities in this Subproject are aimed to increase maize productivity and to conserve the resource base, mainly soil and water.

- Maize QPM germplasm developed, validated and released in El Salvador, Guatemala, and Nicaragua.
- Maize hybrids developed, validated and released in Panama, Guatemala, El Salvador and Nicaragua.
- Maize germplasm with tolerance to corn stunt disease generated, validated and released.
- Diagnosis of maize production systems in Central America completed.
- Competitive areas of sustainable maize production in Central America characterized.
    - Methodology for assessing the unit cost structure of selected areas developed
    - Analysis of competitive clusters of maize production carried at country level for each of the six countries in Central America.
    - Rapid Rural Appraisal methodology applied to identify the structure dynamics in selected areas
    - Experts opinions sought to quantify the variability and uncertainty of the technology structure at the regional level
    - Simulation of the unit cost structure in selected areas in Panama, Costa Rica, Nicaragua and El Salvador. Main factors affecting the cost structure identified.
- Maize seed markets characterized in selected countries of Central America.
    - Two contrasting areas in Honduras selected. Surveys in both areas were carried out. Analysis in progress. A PhD Thesis aimed to find out the impact of transaction costs in the adoption and use of improved maize seed expected to be ready by the end of 2001.
    - Simulation of the cost structure of the national/regional seed industry will be performed to analyze the future of the industry under different scenarios.
- Factors governing adoption PERC technologies in Central America identified.
    - Synthesis of results to be published in 2001.

- Structural and behavioral factors affecting the adoption of legume intercropping in Polochic, Guatemala. A doctoral thesis will be finished by the end of 2001
- Institutional factors affecting the supply of soil conserving technologies in Nueva Concepción, El Salvador. A doctoral thesis will be finished by the end of 2001

- Physical and economics long-term consequences of conservation tillage assessed in selected sites of Mexico and Central America.
  - Using a survey of 54 farmers during four years, the short term and long term economics consequences of soil conservation practices were measured. A Masters Thesis published (awarded as the best Masters thesis by the American Agricultural Economics Association). An Economics Working Paper is in preparation.
- GIS & modeling interface developed for Honduras and Mexico.
- Maize germplasm restored following "Mitch" (seed security).
- Impact assessment of international seed aid to Honduras following Mitch.
- Machinery for conservation tillage (animal traction, motorized) tested in southern Mexico.

2.2 SP 2: Increasing maize/wheat supply in the acid soils of tropical Latin America

The main purpose of the subproject is to develop maize germplasm tolerant to acid soils in the tropical areas. The subproject has important spillover effects. For example, the maize variety Antasena released in 1993 is being successfully tested in Asia and Africa.

Another important activity developed by the subproject has been the promotion of maize germplasm generated in Mexico or in other projects. This is the case of QPM materials and the hybrid released in Venezuela during 2001.

- Colombia:
  - Two acid soil tolerant three way cross maize hybrids: CORPOICA H –108, and CORPOICA H-111 both with 100% CIMMYT germplasm released during 2000 for the acid soils savannas (in collaboration with G2).
  - Single cross white and yellow QPM hybrids validated for release in 2001 –2002 in the Atlantic Coast (in collaboration with G2).
  - Five acid soil tolerant white endosperm hybrids were selected for validation during 2002. It is expected that at least one of them will be officially released in the region of Los Llanos.
- Perú:
  - The acid soil tolerant OPV INIA 601 released during 2000. This is an adapted version of the OPV Sikuani, released previously in Colombia.
  - Several OPVs, as well as single and three way cross QPM hybrids planted in demonstration plots. It is expected that some of them will be released during 2002.
  - Several normal maize hybrids planted in demonstration plots. It is expected that some of them will be released during 2002.

- Venezuela:
  - The three way cross normal hybrid Portuguesa 2002 (initially: FONAIAP 2014), with 100% CIMMYT germplasm released during 2001.
  - Several single and three way cross QPM white maize hybrids planted for demonstration. It is expected that they will be released during 2002.
- Bolivia:
  - Several single and three way cross QPM white maize hybrids planted for demonstration. It is expected that they will be released during 2002.
- Others non country specific achievements
  - Nurseries to select germplasm for tolerance to low levels of P have been successfully initiated.
  - White and yellow endosperm OPVs with tolerance to acid soils and resistance to biotic stresses such as corn stunt, phaeosphaeria leaf spot, sugar cane mosaic virus, polysora and physopella rust have been successfully generated, included and distributed in the acid soil trials.

2.3 SP 3 Competitive wheat production in temperate Latin America

The main purpose of the subproject is to generate improved high yielding maize/wheat germplasm with tolerance/resistance to abiotic/biotic stresses.

- Argentina, Brazil, Chile, Uruguay and Paraguay:
  - Wheat germplasm for abiotic and biotic stresses generated and validated.
  - 10 new sources for sprouting resistance identified.
  - 20 new varieties released during 2000 and 1 during 2001. Two of them are of CIMMYT origin and 11 carry CIMMYT germplasm in direct percentage. Country distribution: 7 in Argentina; 6 in Brazil; 2 in Chile; 3 in Paraguay and 3 in Uruguay.
  - One variety (ITAPUA 50-Amistad) was released to honor CIMMYT-JICA collaboration with the national wheat breeding program.
  - Five of the varieties released in Brazil (BRS 190, BRS 193, CD 106, FUNDASEP 31and FUNDASEP 32) have tolerance to acid soil.
  - 71 yield trials, 112 screening nurseries, 45 segregating populations and 18 special study trials were conducted and evaluated for the four crops involved in the subproject: bread wheat, durum wheat, triticale and barley.
  - Regional germplasm for spring wheat (50 trials) and facultative wheat (20 trials) distributed.
  - Study to evaluate the losses from tan spot under zero-tillage initiated in Uruguay
  - New germplasm for fusarium head blight, septoria leaf blight, and BYDV identified.
  - Special project on "Durable resistance to rusts" submitted and approved.
  - International wheat nurseries evaluated at 11 locations

- Bolivia
  - 3 varieties were released in Bolivia during 2000 -01 in the highlands and one in the lowlands. All three are CIMMYT introductions.
  - One new wheat variety (CIMMYT germplasm) released for the lowlands of Bolivia during 2001.
  - Released of the CIMMYT line PAT/ALD//VEE 5 as "CIAT-Huaytú"
  - Diagnosis of factors limiting wheat productivity in the lowlands of Bolivia. This is a continuing activity. In the lowlands of Bolivia 60 farmer fields were monitored during the 2000 winter season to identify major constraints to productivity. Four major factors were identified: *i)* a large positive effect of the amount of moisture in the soil at seeding, *ii)* a negative effect of soil clay content (associated with moisture availability), *iii)* seeding date and *iv)* the presence of the disease *Pyricularia grisea*.
  - Recommendation for reducing risks of wheat planting in lowland Bolivia based on soil moisture and rainfall probabilities developed by the end of 2001. We are still working on this, and plan to have all the data analyzed and a technical bulletin published by Dec 2001. As it is difficult for farmers to measure soil water content, we are trying to base the recommendation on rainfall between the summer crop harvest and the seeding of the winter crop. At the moment it looks as though the farmer needs to have about 100 mm of rain during this period to ensure that costs, at least, are covered. With less rain between crops, the risk of crop failure is unacceptably high.
  - Improved strategy for defining chemical disease control of diseases of wheat developed in lowland Bolivia. The arrival of a new disease, *Pyricularia grisea* (bruzone in Brazil), has caused a change in priorities, with little time devoted to the development of the new strategy for decision making on chemical control of the more common diseases, leaf rust an helminthosporiosis. This work continues, but will not be completed in the time-frame expected.
  - GIS analysis of similarity sites for Bolivia. Completed and published in Hodson *et al.*
  - Advanced breeders trials planted without tillage at some sites in lowland Bolivia. After managing to overcome breeder resistance, this was successfully completed in 2001, and the results were so good that more trials will be direct seeded in the future
  - An important interaction between crop rotation and direct seeding (without rotation there is little benefit from conservation tillage) has been identified in lowland Bolivia using long-term trials. More rotation and preceding crop trials established in the lowlands of Bolivia. Some trials and large plots have been established, but the results in 2001 have not been good, due to drought and soil variability. This work will be continued and expanded in the future depending on fund availability. Adoption of crop rotation, however, has not advanced very fast, due mainly to yield and price variability of the maize crop. A large field day was organized (largely by CIMMYT) and held on a property where direct seeding and crop rotation are practiced.
  - Promotion of the system of direct seeding (zero tillage) in lowland Bolivia. Fast adoption of zero tillage has been achieved. There are now an estimated 350,000 ha of zero tillage in Santa Cruz, accounting for about 40% of the area cropped with annual crops. About 60% of the wheat area is seeded without tillage. Advances are being made in the promotion of direct seeding on small farms in the lowlands (defined as <

50 ha) using animal traction. Seeders developed for the highlands of Bolivia by CIMMYT, the national wheat program, and a DFID-funded project of the San Simon University in Cochabamba are being used.

2.4 SP4 Alleviating rural poverty in the highlands of Latin America

- Highland maize germplasm has been generated, validated and released for the highlands of Guatemala.
- One new wheat variety (CIMMYT germplasm) released for the highlands of Bolivia during 2001.
- One CIMMYT line, BUC"S"/FLK"S"//MYNA"S"/VUL"S", was released in 2000 as the variety Charcas, and Tepoca T-89 released under the same name in 2001. Both are CIMMYT lines.
- Wheat breeding effort in the Bolivian valleys restructured during the 2000/2001-summer season. Following a workshop to analyze past results and define new strategies, the program was reorganized so that the section in Cochabamba would concentrate on the cooler, wetter areas, and the section in Sucre on the warmer, drier areas. However, in practice this did not work – the local breeders continued just as before, but adding some new work to make it look as though they had reorganized! As from the summer 2001/02 season (again, if we get funding) the section of the program in Sucre will be discontinued, and the section in Cochabamba strengthened slightly, to use available environments in the Department of Cochabamba to select for all environments. Advanced trials will be seeded in all departments.

- Package of practices involving five interacting factors validated and demonstrated in the highland valleys of Bolivia. The initial stage if this has been completed (Obviously the demonstration phase continues). So far few farmers have adopted the whole "package", as expected. However the recommendation of the 5 factors together is necessary, due to the large interactions between them. There has been considerable adoption of four of the five factors. We (The national wheat program, of which I am an integral part) have knowledge of 3073 farmers now growing the new varieties, 1895 farmers using close to recommended fertilizer applications, 1487 farmers using new weed control recommendations, and 2010 farmers who have increased their seed rates to recommended levels. The fifth factor involves moisture conserving technologies and the use of a seeder. There is no real adoption of this as yet, although farmers have borrowed our seeders to seed their own fields (about 10).

- Animal-drawn seeder for no-till seeding of wheat tested in 10 communities of the Bolivian valleys. This was done, in fact in about 20 communities. Based on further participatory evaluation of the seeders, more modifications have been made, and we are presently manufacturing 15 more seeders to increase the demonstration of these in the 2001/02 season (You now know what statement should be in the parentheses!)

- Maize OPV released in Ecuador.
- Several hybrids released in Mexico
- Several agronomic factors that contribute to the long-term sustainability and productivity of Bolivian wheat-based systems have been identified validated and demonstrated.

- Further testing, and definition of recommendation domains, continues with respect to moisture conserving technologies, especially direct seeding and seeding in furrows in tilled fields.
- Final impact survey of PROTRIGO in the Bolivian valleys will be completed by December 2001. This has been designed, and will be conducted by independent professionals over the next two months.

2.5 Developing maize germplasm in Peru

Main researchers involved: M. Barandiaran.

Main links with: G2, G4

- Results of season 2001-A
  - In the normal endosperm yellow hybrids Demo-lots, 17 demonstration lots planted from Chiclayo in the north, to Pisco in the south of Lima. CL 002410 x CML 297 (HE 3) was first in grain yield in 11 experimental sites. CML 287 x CML 413 (HE 1) and CML 287 x CL 00368 (HE 2) were first in one location each whereas the common tester DK 821, barely out-yielded HE 3 in three locations. In most locations, HE3, HE 1 and HE 2. surpassed the hybrid used by the farmer, or second tester. Among these hybrids were DK 834, C-701, C-606, X-3031, Star and Master. The advantages of our hybrids include a good ear aspect, and good grain color (HE 3). HE 3 has an evergreen plant type and shows an excellent plant aspect. An extra advantage is the capacity to perform in high plant density, which needs to be explored to maximize the genetic yield potential of our hybrids. The experimental hybrids are almost a week later in maturity as compared with some of the commercial hybrids in the local market. HE 3 had grain yields over 11t/ha in three locations and over 10.0 t/ha in two locations. The poorest yield for HE 3 was 4.48 t/ha in a field where weeds were not controlled, but it was still superior to the common and local hybrid checks in that location in such conditions.
  - In the OPV-QPM demonstration lots we harvested 5 out of the 6 planted. Results in this summer season were not as expected. Nutrimaiz, a white OPV-QPM released by INIA in the early 90s yielded 6.41 t/ha compared with PR8763 (5.75 t/ha). Among the yellow OPVs, Iquitos 9328 was 6.95 t/ha while the QPM Ac 8765 and S89 yielded 5.1 and 5.53 t/ha.
  - Among the lines (parental) x plant density trials planted, we obtained results only in Viru (Trujillo). CML 287 had a surprising 8.14 t/ha across densities while CML 413, CL 00368 and CL 002410 produced 5.31, 4.05, and 4.77 t/ha. The average production was 5.75, 5.71, 5.73, and 5.08 t/ha for 15, 20, 25 and 30 cm hill spacings. CML 297 was not included in this experimental site. Except for CML 287 and CML 413, the other parental lines had problems with pollen production in the trials conducted in Chincha (south of Lima) and Lima. That was not the case in the winter planting season in the year 2000. On the other hand, pollen production was normal in Viru this year. Despite its high grain production CML 287 as a seed parent is not that suitable because the line starts shading pollen at the same time it shows up.
  - Selfing was done in the so-called Nucleos de semilla Genetica (NSG) of the parental lines planted ear-to-row to ensure enough seed for the next season.

- In the NSG of the two yellow and a white OPV-QPM, and Iquitos 9328, we selected an average of 200 ears to maintain the genetic seed and harvested the remainder for field-testing and nutrition trials.
- We have produced a total of 1200 kg of seed, including F1, NSG, lines, etc

- Season 2001-B.
  - Demonstration lots with normal yellow endosperm hybrids planted at 12 locations. This time we used two reps in all plots. Two experimental sites in Piura were incorporated into the network and for the first time a lot was planted at INIA's Estacion Experimental Vista Florida (Chiclayo). The hybrids are the same as those used in 2001-A.
  - Demonstration lots with QPM yellow endosperm hybrids planted at 5 locations. The hybrids are CML 161 x CML 165, CML161/CML165 x CML 172 (both produced in 2001-A), and CML 172/P66 x CML 161. These lots are planted next to the normal endosperm hybrid lots
  - Demonstration lots with QPM-OPV planted at six locations next to the normal endosperm hybrids.
  - Parental line x plant density at Viru. This time CML 297 was included together with CML 287, CML413, CL00368 and CL002410 planted at 15, 20, 25 and 30-cm spacings between hills. These parental lines were also planted in Vista Florida but not as a trial
  - Yellow QPM hybrid trials planted at 4 locations. 15 hybrids plus the three experimental hybrids in a 3-reps alpha lattice planting design.

2.6 Strengthening NARS and searching for new alliances

Main links with: G8

- 3 courses on wheat offered in South America last year (pathology, agronomy, participatory research). Two courses on direct seeding on small farms were organized and held in Bolivia in 2000. The first of these was for researchers and extension agents, and was held with the support of the PROCISUR zero tillage project (60 participants). The agriculture department of the local government of Cochabamba asked that we organize a course, similar to the first, for all the agricultural technicians of the rural municipalities of Cochabamba. Held in Nov. 2000 with 25 participants
- Field Book training in South America maize regional program, Embrapa course
- Organization of Maiceros Meeting in Brasil
- Several students in postgarduate courses
- Seed production course in Venezuela
- Training course in Cuba (statistics)
- Trainees in Mexico, Embrapa, other courses (seed production in Peru) and postgraduate studies
- Organization and participation in PCCMCA meetings
- Fifteen participants each year in specialized in-service training courses

- Ten field days/workshops on special topics. CIMMYT helps plan, organize and manage the National Wheat Field Days in lowland Santa Cruz. These were held in both 2000 and 2001 to demonstrate a wide variety of technologies. In both years there were about 1000 participants. A field day was organized in September, 2001, in the lowlands of Bolivia, on direct seeding and crop rotation. CIMMYT gave an exposition on the importance and effects of soil moisture storage in the soil profile on crop yields, using data from fields of the property where the field day was held.

- Relations established at specific sites with public and private partners to transfer technologies developed through R5. CIMMYT, through the PROTRIGO project, coordinates activities with a growers' association and three NGO's who undertake the technology transfer component of the program.

- Agreements with private companies and NGO's for seed production and machinery production. The animal traction project of the San Simon University in Cochabamba has now been established as a private company. CIMMYT works with them in the design and production of small machinery, including two seeders and, more recently, a crop sprayer.

- Additional projects underway with advanced research institutes, farmer groups, and other CGIAR Centers to achieve goals of R5

- Project developed (December 2001) to continue wheat research and extension in Bolivia including public and private institutions and CIMMYT. Project prepared, but not funded as yet.

- Collaborative project between Bolivia and Ethiopia (including CIMMYT) on wheat-livestock interactions submitted to the CGIAR System wide Livestock Project July 2001. Not completed. The proceedings of the two stake-holder workshops to design the project were edited and published.

- A project proposal aimed to increase maize production and productivity in Cuba was prepared and presented to the Mexican Group Altex-Bimbo

- Incentives systems in Latin American public research institutions identified. Report in preparation.

- Sources of productivity in public breeding institutions identified. Report in preparation.

- Organization of 7 Latin American agricultural innovation systems characterized. Publication in progress.

- Active participation in the process of establishment of research priorities for Latin America (with FORAGRO, FONTAGRO, IICA and other regional and international institutions).

- Strengthening of social science studies in Central America through the formation of a Foundation aimed to develop research methodology and training national social scientists.

2.7 Specific links between R5 and G2

- **Subproject 1.** As part of the screening process for inbreds derived from the gene pools, disease pressure was applied for maydis leaf blight and *F. moniliforme* stalk rot for tropical lowland germplasm. In subtropical germplasm *F. moniliforme* stalk rot

inoculations were used in the inbred selection process. For the highlands, both turcicum leaf blight and *F. moniliforme* ear rot inoculations were used in the development of new inbreds. Two highland early white synthetics with resistance to *Fusarium moniliforme* ear rot developed in collaborative activities between pathology and the highland maize subprogram were provided for incorporation into the early white gene pool. *F. moniliforme* ear rot resistance highland germplasm developed in Mexico has performed well in the Andean region of South America, and in Ottawa Canada

- **Subprojects 2 and 3.** As part of the screening process for the derivation of inbreds, maydis leaf blight inoculations were provided. Inbreds at the S3 and S5 level of inbreeding derived from the corn stunt resistant populations were evaluated for resistance to mixed infection by the corn stunt spiroplasma (CSS) and maize bushy stunt phytoplasma (MBS) in the TL2000A cycle and with CSS during the 2000B cycle in Agua Fria. Single and triple cross white and single cross yellow hybrids derived from stunt resistant inbreds crossed to the testers were evaluated for resistance to mixed infection with CSS and MBS in the TL2000A cycle. Several hybrids yielded higher than the hybrid checks included in the trials and had less stunt infection. Corn stunt resistant synthetics were evaluated for resistance to CSS in the 2000B cycle in Agua Fria and several synthetics yielded better than the population from which they we formed (refer to tables). A three way hybrid in the trial out yielded all other entries in the trial and this hybrid was liberated in Nicaragua during the last year. A biotic stress resistant synthetic was formed including lines with resistance to sugarcane borer, the corn stunt complex, *Fusarium moniliforme* and *Stenocarpellla maydis* ear rots. Lines will be derived from the synthetic for developing new sources of multiple biotic stress resistant germplasm. Disease resistant lines were also provided for crossing to elite tropical normal and QPM lines for use in the recycling process
- **Subproject 4.** As part of the screening process for the derivation of inbreds, turcicum leaf blight inoculations were provided. A total of 15 disease resistant synthetics are being formed in the subtropical subprogram for gray leaf spot, and Fusarium stalk rot. These synthetics will be useful in Latin America, Africa and Asia where losses are reported for these diseases
- **Subproject 6.** As part of the screening process for the derivation of inbreds, turcicum leaf blight inoculations were provided. Elite line trials were also evaluated for resistance to common rust, *Fusarium moniliforme* ear rot, and Stewart's wilt. A total of 11 disease resistant highland synthetics are being formed based on disease resistance evaluations.

Regional Project 6

Restoring food security and economic growth in Central Asia and the Caucasus.

Project Coordinator: A. Morgounov

Oversight Director: S. Rajaram

R6 Accomplishments 2001

The main activities and results of the sub-projects are listed below. Complete reports for several projects/activities (GTZ-CIMMYT Seed project, Georgia office report, Zero tillage experiments, Kazakhstan IDF Grant Project, Maize in CAC) are available on request. The R6 report prepared for the RCC review of the Asian projects in Bangkok in May, 2001 and the respective feedback was distributed to team members. Publications pertinent to R6 are attached.

Major Impacts:

- Variety releases: 12 bread wheat and 3 triticale varieties are being officially tested in seven countries of the region. Seed production started for most of the varieties and for some the amount available reached 30-40 tons.
- Completion of the 3-year World Bank IDF grant project in Kazakhstan in 2001 showed good potential of the modern wheat production technologies and resulted in dissemination of better varieties and agronomy practices to farmers in three regions of Kazakhstan.
- Tajik National Wheat Breeding Program was established, equipped and made functional as a result of a GTZ-CIMMYT project in the country.
- The Competitive Grant System for Adaptive Research was established in Azerbaijan through the activities of a multidisciplinary team led by CIMMYT.
- Broad training efforts in Mexico and in the region resulted in the establishment of a core of young, motivated scientists with good knowledge of English.

Major Strategic Developments:

- Establishment of CIMMYT-Georgia office working as a hub for the Caucasus (Armenia, Azerbaijan and Georgia) greatly facilitatedactivities in the sub-region.
- Discontinuation of the funding of the CAC Regional Program resulted in a funding shortfall and greater reliance on core funds and special projects.
- Prioritization of the region by the Economics Program and development of the approaches for closer involvement in CAC.

Sub project 1. Superior winter and facultative wheat germplasm for Central Asia and the Caucasus.

- An efficient mechanism of germplasm exchange has been established with the International Winter Wheat Improvement Program (IWWIP), CIMMYT-Mexico and the CIMMYT-ICARDA program at Syria playing important roles in a) supplying the winter/facultative germplasm for the breeding institutions; and b) receiving the best regional germplasm for incorporation into international breeding programs.
- Performance highlights of the germplasm developed through cooperation with international centers:
  - Armenia. The lines identified (3rd EYT-IRR 9806-ZCL/3/PGFN//CNO67/SON64(ES86-8)/4/SERI/5/UA-2837, 9810-OK82282//BOW/NKT) were tested in preliminary and yield trials and exceeded the local check by 15-20%.
  - Georgia. Variety Mtskhetskaya 1 (5th FAWWON 35 – TAST/SPRW//SAR) identified by the Mtskheta Breeding Station demonstrated a yield advantage of 10-15% above the local check and was superior in yellow rust resistance.
  - Azerbaijan. Varieties Azametly (16th ESWYT 12 – PRINIA), Gobustan (RBWON-SAA 2 - PEG//HD2206/HORK) and Nurlu 99 (KAUZ) have been officially tested in 2001 across six locations and demonstrated a yield advantage of 8-13%. Six triticale lines have been identified and included for multilocational testing.
  - Kazakhstan. The breeding line identified as 2902 (BHR/AGA//SNI/3/TRK13) demonstrated excellent yield (10-15% above the local check) in two large plot on-farm trails/demonstrations in the Almaty and Djambul region and has been submitted for official testing in 2001 under the name Egemen. The variety is planted on an area of 50 ha in a 2001-02 season. New triticale lines identified by the Red Fall Breeding Station demonstrated a yield advantage of up to 65% compared to the local check.
  - Kyrgyzstan. Breeding line NS55-58/VEE demonstrated a yield advantage of 22% compared to Bezostaya 1 in the on-farm trial and was submitted for official testing under the name Djamin by Kyrgyz Research Institute of Farming. The wheat breeding program at the MIS private farm submitted for official testing winter wheat varieties Eritrospermum 5 (Hatusha/KAUZ//TRK13), Eritrospermum 7 (CHAM6//F134.71/NAC) and Eritrospermum 8 (1D13/MLT//KAUZ), which exceeded local checks by 10-15%.
  - Tajikistan. Wheat varieties Tacica (5th FAWWON 35 - TAST/SPRW//SAR) and Norman (5th FAWWON 37–ORE F1.158/FDL//BLP/3/SHI4414/CROW) entered official trials in Tajikistan. Norman and breeding line Zander 12 demonstrated 20-22% yield advantage in multilocational (4 sites) trials in 2002. Substantial areas are sown with the varieties Atay, Sultan, Kinaci (imported from Turkey by aid projects); these originated directly or indirectly from CIMMYT.
  - Turkmenistan. Three varieties: Garagum (TRAKIA/KNR), Guncha (HYS/7C//KRC(ES84-16)/3/SERI) and Bitarap (SN64//SKE/2*ANE//3/SX/4/BEZ/5/SERI) entered official testing and multiplication in farmer's fields.
  - Uzbekistan. Variety Dustlik (YMH/TOB//MCD/3/LIRA) entered official trials and demonstrated a 6% yield advantage over the local check in 19 on-farm trials across the country. Two CIMMYT direct selection triticale varieties, Norman (Armino) and Farhad (Farhad) were submitted for official testing and multiplication. Experiments with triticale

green forage started showing that its biomass yield during winter is much higher compared to barley. Wheat breeding lines Bluegill and CHAM4/TAM200//FDL483 exceeded local checks by 10-15%.

- The yellow rust (YR) initiative started in spring 2000 (Kazakhstan, Uzbekistan and CIMMYT), is aimed at enhancement of resistance through targeted crosses, and an understanding of the genetics of resistance and pathogen populations. More than 100 crosses were made and advanced to F2. Multilocational data on YR reaction of the main regional varieties was collected.
- GTZ-CIMMYT project (2nd phase, 1999-2000). "Revitalization of cereals breeding, seed production and variety testing in Tajikistan" started with the following outputs: establishment of a national breeding network including research institute and five stations; seed multiplication (700 t) of adapted yellow rust resistant varieties; provision of essential machinery for breeding and seed production (tractors, combine harvester, threshers, planters, cleaners); and, training.
- GTZ-CIMMYT regional project (1st phase, 1999-2001) "Regional network for winter wheat variety promotion and seed production" aims to establish sustainable and efficient mechanisms of promotion of better varieties and seed production in the chain "research institution-seed farm-administrative unit". The network includes Kazakhstan, Tajikistan and Uzbekistan. The main activities included: regional communication, training, on-farm activities, provision of machinery, operational support to breeding programs and early generation seed production.
- Regional evaluation of bread-making quality has been initiated utilizing the facilities at the Kazakh Research Institute of Farming near Almaty headed by a scientist trained in Mexico. The laboratory up to 300 samples from many breeding programs of the region and provides data which otherwise would not be available.
- Characterization and classification of breeding environments in winter wheat is being completed. The field data from international and special nurseries are being analyzed. The detailed questionnaire was mailed to each program asking for descriptions of target areas and classification of the regions according to mega environment.

Sub project 2. Superior high-latitude spring wheat germplasm targeted for Northern Kazakhstan.

- A shuttle breeding program to combine drought tolerance, disease resistance and end-use quality in a day-length sensitive background is operational. The following activities have been conducted.
  - Mexico. The program makes 300-400 crosses annually. The F3 and F4 lines are grown under normal conditions and extended light to allow evaluation of response to day length. Screening for disease resistance commences with the F2's in Obregon and Toluca. The resulting F4 or F5 lines are sent to three key locations in Kazakhstan and Siberia for selection for adaptation. In 2001 the first 120 lines originating from the program were sent to the region. Their plant type resembles the local wheat and the yield gap between this germplasm and Kazakh wheat is closer. Close to 1000 lines of bread and durum wheat originating from the shuttle breeding will be sent for planting in spring 2002.
  - Kazakhstan/Siberia. The quarantine nurseries were established at key locations. The selection of the most suitable local parents for the shuttle was made and more than 200

lines shipped to Mexico. The selection from CIMMYT nurseries was made and respective information and the seed of 50 lines were sent to Mexico for utilization in crosses. The best bread wheat and durum wheat lines selected from CIMMYT nurseries in 1998-2000 were planted at 12 breeding programs in the region. The best lines across locations will be used for crosses. A regional winter nursery was established allowing multiplication of germplasm during October-May in Tajikistan.

- The leaf rust epidemic in some areas of Northern Kazakhstan in 2000 and 2001 allowed identification of effective Lr genes and sources of resistance through the special nursery obtained from CIMMYT and distributed by the Kazakhstan Institute of Cereals. Detailed information for the released and cultivated varieties was also obtained.

Sub project 3. Modern sustainable cropping practices for high latitude spring wheat and irrigated facultative/winter wheat.

- The third year of the World Bank IDF grant "Improvement of productivity, sustainability and profitability of wheat sector in Kazakhstan" demonstrated to farmers the advantages of the new technologies in producing higher yields with higher returns. For the southern part of the country it was shown that better varieties planted at lower rates with one fertiliser application at a medium rate provide the best returns compared with farmer practice, and maximum yield potential practice. In the north, the role of variety, planting time and preceding crop was clearly demonstrated. The final workshop of the project summarized the results and submitted recommendations to the Government of the Republic of Kazakhstan.
- The experiments on zero tillage started in 2001 in Shortandy and Karagandy to look at practical aspects of the introduction of zero tillage in Northern Kazakhstan. The experiments concentrated on fallow management practices, green manure options, nitrogen response under no-till scenario, and herbicide options. The results of the first year indicate that the yield under no till at least as high as with conventional tillage.
- The first on-farm trials with wheat bed planting technology were conducted on winter wheat in Kazakhstan and Kyrgyzstan. The yield advantage was 20-40% compared to flat planting. For the 2001-2002 season seven on-farm trials were established in Kazakhstan, Kyrgyzstan and Uzbekistan.

Sub project 4. Regional wheat improvement and genetic resources network.

- The Central Asia and Caucasus Winter Wheat Improvement Network (CAC-WWINET joint venture with ICARDA) continued its activities, in 2001-2002: evaluation of the 1st Regional Winter Wheat Exchange Nursery representing germplasm from all eight countries; coordinated evaluation of the germplasm for specific traits (grain quality, diseases); and publication of the second and third newsletter in Russian language.
- The Kazakhstan-Siberia Network on Spring Wheat Improvement (KASIB) is fully functioning. The regional nurseries were distributed and the data analyzed. Three regional meetings took place and one publication prepared. Cooperative evaluation of diseases and quality takes place. The plan for 2002 includes cooperative crosses and several research experiments.

Sub project 5. Strengthened NARS wheat breeding/research capacity.

- Wide scale training was conducted to enhance knowledge and skills:

In-country:

- 30 people received English language training
- 50 people were trained in modern agronomy and breeding methods
- 20 people received PC breeder's software training
- 20 people were trained in the economic analysis of technology testing data
- 10 people were trained in the rapid rural appraisal (RRA) methodology

Regional:

- 15 people were trained in wheat breeding and agronomy

International:

- 10 people were trained in wheat improvement (6 months, Mexico)
- 1 person was trained in wheat end-use quality (2 months, Mexico)
- 1 person was trained on wheat technology (1.5 months, Mexico)
- 1 person trained on maize improvement (3 months, Mexico)
- 1 person was trained in advanced wheat improvement (1.5 months, Mexico)

- Assistance with the introduction of the Competitive Grant System (CGS) to fund priority applied research and extension topics is being provided in Azerbaijan. CIMMYT was contracted by the World Bank "Azerbaijan Agricultural Development and Credit Project " to lead a team of five experts to work on the development of the framework and projects for funding. The CGS was established and the first projects were approved by the World Bank and funded.

Sub project 6. Economic analysis of wheat production in CAC

- The Economics Program project, "Wheat competitiveness, future productivity, and regional linkages in Central Asia and the Caucasus," continued with fieldwork in Tajikistan, Uzbekistan, and Kyrgyzstan completed during 2001. Data were also collected to update the existing wheat productivity and competitiveness report on Kazakhstan. Working papers for these countries, as well as for Azerbaijan and Armenia where fieldwork took place in 2000, are currently being prepared.
- Training on farmer participatory research was conducted for ten scientists under the auspices of the Agricultural Research Reform and Competitive Grant System in the Azerbaijan Agricultural Development and Credit Project. Special emphasis was placed on the use of rapid rural assessment (RRA) and participatory research appraisal (PRA) methodologies. Training included sampling techniques, survey preparation and techniques, and impact assessment.
- Technological needs and constraints at the farm level were identified through farmer surveys carried out in 55 villages spanning all regions of Azerbaijan. Information from these RRA and PRA surveys was utilized to improve priority setting of research goals for the government of Azerbaijan's Competitive Grant System for agricultural research. Additional reports on current technology dissemination channels and marketing are currently being prepared.

- Groundwork was prepared for an expanded presence of the Economics Program in the CAC region. A workshop attended by local economists was held in Almaty to discuss areas of potential collaboration. The following topics were identified:

  - Competitiveness of wheat, including issues of farm structure, farm size, diversification, agrarian policy
  - Issues of production, trade, and related infrastructure
  - Research on crop genetic diversity and crop diversification
  - Structure and organization of agricultural research (regional focus)

  Plans were also tentatively made to hold a regional workshop in 2002 to identify priority areas for economic issues in wheat and maize production at both regional and bilateral levels. Efforts to identify and work with collaborators in CAC countries are already underway.

Tentative Sub project 7. Sustainable maize production in CAC

- The proceedings of the International Workshop on Maize Production and Improvement in CAC conducted September 4-9, 2000 in Almaty and Bishkek were published (editors, G. Srinivasan, M. Karabayev, D. Bedoshvili). The second publication is a Russian version of the bulletin "Managing trials and reporting data for CIMMYT International Maize Testing Program".
- Three maize international trials (eight sets each) were distributed to all maize breeding programs of the region. In most cases the germplasm was by far too late. Selections and the germplasm request for 2002 were made from Kazakhstan, Georgia and Azerbaijan. Kyrgyzstan, Tajikistan and Turkmenistan did not plant the nursery due to the late arrival of seed.
- The first maize scientist from the region (Kazakhstan) attended the maize improvement training course in Mexico in 2002.
- Based on the first year of the germplasm testing, a concept of regional cooperation for maize was drafted and a work plan for 2002 was prepared.

Achievement of Objectives

All major objectives were achieved given availability of financial and human resources.

Constraints to Progress

No reportable constraints were noted.

Plans for 2002

The RCC report on R6 was taken into account while developing the work plan for 2002 and beyond. All mid-term objectives and outputs as documented in the Strategic Plan continue as stated to date. The overall priority-setting is an on-going process and is also affected by the priorities of donor agencies.

Publications relevant to RP6, 2001-2002

Aliev J., Gandilyan P., Naskidashvili P., Morgounov A. 2001. Caucasian Wheat Pool. *In* Bonjean A., Angus W. (Eds.) The World Wheat Book: A History of Wheat Breeding, 831-848

Baboyev S., Karabayev M., Koishibayev M., Kokhmetova A., Kuklacheva V., Morgounov A., Rsaliev S., Sarbayev A., Yessenbekova M., 2000. Improvement of yellow rust resistance in Kazakhstan and Uzbekistan through sub-regional cooperation. In: Book of Abstracts, The 1st Regional Yellow Rust Conference for CWANA, Karaj, Iran, p. 26-27.

Eshanova Z., Kosimov F., Yorov A., Khuseinov E., Morgounov A. 2001. Wheat breeding for yellow rust resistance in Tajikistan. In: Book of Abstracts, The 1st Regional Yellow Rust Conference for CWANA, Karaj, Iran, p. 24-25

Maes, B., Trethowan, R.M., Reynolds, M.P., Ginkel, M. van, and Skovmand. B. 2001. The influence of glume pubescence on spikelet temperature of wheat under freezing conditions. *Australian Journal of Plant Physiology,* 28, 1-8

Meng E., Longmire J. Moldashev A. 2000. Kazakhstan's wheat system: priorities, constraints, and future prospects. Food Policy, 25, 701-717

Morgounov A., Zykin V., Sereda G., Urazaliev R. 2001. Siberian and North Kazakhstan Wheat Pool. *In* Bonjean A., Angus W. (Eds.) The World Wheat Book: A History of Wheat Breeding, 755-772

Morgounov A., Karabayev M., 2000. International collaboration to improve productivity of spring wheat in Kazakhstan and Siberia. In Proceedings of the Conference Development of Agriculture in Kazakhstan, Siberia and Mongolia, July 17-21, 2000, Almaty, Kazkahstan, 16-17

Morgounov A., Sayre K., Hobbs P., Wall P., Ortiz-Monasterio I., Karabayev M., 2001 Sustainable wheat and maize production in developing countries. In: Conservation tillage: A viable option for sustainable agriculture in Eurasia. Proc. of Intern. Workshop, Shortandy, Kazakhstan, p. 86-93

Morgounov A., Karabayev M., 2000. International collaboration to impve productivity of spring wheat in Kazakhstan and Siberia. In Proceedings of the Conference Development of Agriculture in Kazakhstan, Siberia and Mongolia, July 17-21, 2000, Almaty, Kazkahstan, 16-17

Peña, R.J., R.M. Trethowan, W.H. Pfeiffer, and M. van Ginkel. 2001. Quality (End-Use) Improvement in Wheat. Compositional, Genetic, and Environmental Factors. *Journal of Crop Production,* Vol. 5(2). (In press).

Trethowan, R.M., Singh, R.P., Huerta-Espino, J., Crossa, J. and Ginkel, M van. 2001. Coleoptile length variation of near isogenic Rht lines of modern CIMMYT bread and durum wheat. *Field Crops Research* (in press)

Trethowan, R.M., Crossa, J., Ginkel, M. van and Rajaram., S. 2001. Relationships among Bread Wheat International Yield Testing Locations in Dry Areas. *Crop Science* (*in press*)

Seidov M., Garayev P., Ibragimov E., Musayev A., Ahmedov M., Makhmudov R., Morgounov A., Yahyaoui A., 2001. Yellow rust in Azerbaijan: distribution, variability, yeld losses, and genetic variation of bread wheat for disease resistance. In: Book of Abstracts, The 1st Regional Yellow Rust Conference for CWANA, Karaj, Iran, p. 47-48

Smale, M., M.P. Reynolds, M. Warburton, B. Skovmand, R. Trethowan, R.P. Singh, I. Ortiz-Monasterio, J. Crossa, M. Khairallah, and M.I. Almanza-Pinzon. 2001. Dimensions of Diversity in CIMMYT Bread Wheat from 1965 to 2000. Mexico, D.F.: CIMMYT

Trethowan, R.M., Ginkel, M. van and Mujeeb-Kazi, A. 2000. Performance of advanced bread wheat x synthetic hexaploid derivatives under reduced irrigation. *Annual Wheat News Letter* 46: 87-88

Frontier Project 1

New wheat science to meet global challenges

Project Coordinator: M. Reynolds

Oversight Director: S. Rajaram

Sub- Project Updates

I) The role of major phasic development genes (*Vrn* & *Ppd*) in adaptation of wheat to diverse production environments

Team members: J. van Beem (leader), M. William

Collaborating institutions: F. Zeller ,V. Mohler, Technical University of Munchen

Outputs/milestones (project finishing in 2002)

- *Vrn* analysis in 36 CIMMYT lines showed 8 different combinations of known V*rn* genes (from a total of 15 possible combinations) and one new (unknown) *Vrn* gene.
- *EPS* determined in 62 CIMMYT lines, interaction with temperature significant in 12 lines.
- *Ppd 1, 2,* & *3* isolines developed and available.
- Phenology near-isolines (F1BC2) developed and available.
- *Ppd* and *Vrn* RILs developed and available.
- GAWYT distributed to 66 (00-01) & 30 locations (01-02).
- Molecular fingerprinting identified purest *Ppd* and *Vrn* sources.
- Microsatellite marker gwm292 closely linked to Vrn-D1 (2.8 cM, LOD 19.78) identified; presence/absence of Vrn-D1 reliably detected in 32 of 36 CIMMYT lines.
- *Ppd* background of 36 CIMMYT lines to be determined by 2003.
- RILs varying in phenological pattern will be available for characterization in 02-03
- Several publications anticipated for 2002-03.

II) Complementing conventional breeding with novel physiological strategies

Team members: M. Reynolds, M. van Ginkel, P Monneveux

Collaborating institutions: CSIRO & ANU, Australia, INRA France

1) Evaluating genetic gains associated with using stomatal aperture related traits (SATs) as physiological selection criteria under alternate selection methodologies

Activities

- Populations developed from parents varying in expression of SATs

- SATs evaluated in F4 & F5 in Obregon and Tlaltizapan to determine best growth stages and conditions to evaluate SATs

Outputs

- CTD better predictor of yield potential (YP) when measured during grainfill than preheading.
- CTD better predictor of yield if measured in warmer sites with low relative humidity.

2) Identifying underlying physiological and genetic mechanisms of yield

Activities

- Test hypothesis that small extra investment in spike growth (sink) can result in large increases in yield and biomass.
- Evaluate physiological bases of GxE within and between crop species.
- Characterize historic lines for progress in canopy photosynthesis.

Outputs

- Small extra investment in spike growth (approximately 0.5 t/ha) resulted in large increases in yield (1-2 t/ha) in *Lr19* isolines and using source-sink manipulations in elite lines.
- In terms of GxE, durum wheat is very sensitive to low radiation during spike growth stage, tritcales to high radiation in grainfilling, while bread wheat was the most stable of the three crops. Information can be applied to predict yield stability in light of climate change. Information on within species GxE can be used to breed for yield stability.
- Light use efficiency in canopy improved in modern lines in terms of photosynthetic N use efficiency and sensitivity to mild stress

3) Assessing the potential of genetic sources of variation in other physiological traits

Activities

- Fourteen genotypes evaluated for a physiological traits related to source-sink balance
- RILs developed using contrasting parents to evaluate potential genetic gains associated with source and sink traits

Outputs:

Various traits associated with yield potential introgressed into elite backgrounds:

- Long duration of spike-growth phase.
- High RUE in spike growth phase.
- High investment in spike biomass at anthesis.
- High leaf chlorophyll into large spike durum backgrounds.
- Erect leaf in high biomass background (Baviacvora)

III) Hybrid wheat (strategic research)

Team members: K. Ammar (leader) (formerly B. Cukadar)

M. Reynolds, A. Hede, W. Pfeiffer

Collaborating institutions: Monsanto

Activities:

- Physiological basis of heterosis being evaluated in bread wheat.
- Yield advantage of heterosis in different environments being studied in triticale.

Milestone: General and specific combing ability of a group of CIMMYT lines now established.

IV) *Simulation modeling of yield determining processes in wheat*

Team Members: J White, M Reynolds, S Chapman, LA Hunt

Activities:

Data of *Lr19* near isolines being used to improve quantitative understanding of yield potential.

Outputs: see publications

V) Multi-ovary trait as a potential source of increased spike fertility

Team Members: B. Skovmand, M. Reynolds, J-M Ribaut

Activities/Results

- Over 1000 F3 lines (in 5 backgrounds) evaluated for expression of the trait in small plots at high seeding density in Obregon.
- Effect of trait in elite backgrounds evaluated for yield and yield components.
- Genetic basis of traits studied using bulk segregant analysis.

Outputs/milestones

- Trait not associated with yield gains in backgrounds evaluated.
- Genetic basis determined (major gene + minor gene)

VI) Super-wheat (Strategic)

Team Members: M Reynolds and M van Ginkel

Activities

- Comparative value of different source and sink related traits being evaluated in large spike wheat types.

VII) Application of spectral reflectance in breeding

Team Members: M Reynolds, K Sayre, I Ortiz-M, M van Ginkel, A Hede, W Pfeiffer

Activities:

- Evaluate the use of spectral reflectance indeces (especially NDVI) as rapid screening tools for yield, biomass, N use efficiency, early biomass in triticale

- Evaluate SR as a rapid diagnostic tool for nutrient status & other aspects of plant health

Outputs/milestones

- Spectral index NDVI well correlated with triticale forage biomass.
- NDVI significantly better at predicting forage biomass than breeders score.

New & Future Initiatives

- Test expression of multi-ovary in different spike architectures.
- Combine high RUE (UK) with high fertility wheats (e.g. Agropolytetra).
- Use *Lr19* near-isolines to improve understanding of genetic and physiological basis of yield using a functional genomics approach.
- Use partial least squares (PLS) analysis to explain GxE for phenology
- Search for transformation opportunities for male sterility.
- Reinitiate research into lodging resistance.
- Seek NSF funding for gene-based modeling tied to functional genomics.

Principal Publications 2001/02

Araus JL, Slafer GA, Reynolds MP, Royo C, 2002. Plant Breeding and Water Relations in C3 Cereals: What to Breed for *J. Exp. Botany* (in press)

Van Beem J, Worland AJ & van Ginkel, 2001. The influence of earliness per se genes on flowering in CIMMYT wheats. In: The Kronstadt Symposium, 15-16 March, Cd. Obregon. CIMMYT Mexico DF

Van Beem J, van Ginkel M & Rajaram, 2001. Differences in development rate of CIMMYT wheats adapted to irrigated, rainfed, and semi-arid environments. In: Wheat in a Global Environment, International Wheat Congress, Budapest, Hungary, June 5-9, 2000 p281

Blanco I, Rajaram S, Kronstad W Reynolds, M, 2001. Physiological performance of Synthetic Hexaploid Wheat-Derived Populations. *Crop Science* 40: 1257-1263

Calderini DF, Savin R, Abeledo, Reynolds MP, and Slafer GA, 2001. The importance of the immediately pre-anthesis period for grain weight determination in wheat. *Euphytica* 119: 199-204

Federer WT, Reynolds MP, & Crossa J. 2001. Combining Results from Augmented Designs over Sites. *Agronomy Journal.* **93: 389-395.**

Hunt LA, Reynolds MP, Sayre KD, Rajaram S, White JW and Yan W. 2002. Crop modelling and the identification of groups of genes of significance in crop production. *Crop Science (in press)*

Reynolds MP, Trethowan R, Sayre KD, Crossa J. 2002. Physiological interpretation of genotype by environment interaction in wheat. Field Crops Research (in press)

Reynolds MP, Calderini DF, Condon AG, & Rajaram S. 20001. Physiological basis of yield gains in wheat associated with the *LR19* translocation from *A. elongatum. Euphytica* 119: 137-141

Reynolds, M.P., Ortiz-Monasterio, I., McNab, A. (Eds.) 2001. Application of Physiology in Wheat Breeding. Mexico, D.F.: CIMMYT.

Reynolds, M.P. 2001. A Physiologists Wish List for a Robust Wheat Model. In White JW & Grace PR (Eds) Directions in Modeling Wheat and Maize for Developing Countries, CIMMYT, Mexico D.F.

Skovmand B, Reynolds MP, and Delacy, IH, 2001. Mining Wheat Germplasm Collections for Yield Enhancing Traits. Euphytica 119: 25-32.

Frontier Project 2

Apomixis: Seed security for resource poor farmers

Project Coordinator: O. Leblanc

Oversight Director: D. Hoisington

General comments

The F2 logframe was revisited in order to fit better with the overall goal. One output (#6) that takes into account the current debate on GMOs and biodiversity was added for 2002-2004+. Activities are also stated in a more explanatory way particularly with regard to the expected outputs. Two main sub-projects are clearly defined and conducted in a very different way:

1. Development of apomictic maize germplasm (outputs #1 to #4): All F2 members are involved in this sub-project and research activities have been conducted since July 1999 within the framework of the Collaborative Research Agreement signed by CIMMYT, IRD, and three major seed companies (Pioneer/Dupont; Limagrain; Syngenta, ex Novartis). Recently, negotiations with the Australian National University (Canberra, Australia) have been initiated to develop activities related to the identification of genes of interest to artificially induce apomixis in crops.
2. Deployment of the apomixis technology (outputs #5 and #6): Important issues have to be considered prior to delivering the apomixis technology. They cover a wide range of concerns that need to be addressed today for an immediate deployment of apomictic varieties when made available to farmers and breeders: (a) economic impacts both globally and at the farmer level; (b) risks for biodiversity; (c) public and farmer acceptance; and (d) new procedures for breeding and seed multiplication.

To achieve this, expertise was sought from other projects and system linkages were developed through consultancies. Most activities are not directly related to apomixis, but they will all provide information to help assess risks and impacts.

For Sub-project 2, progress reports can be found elsewhere for activities conducted in other MTP Projects (i. e., Oaxaca project, geneflow and dynamics of maize genetic diversity, G1 Subproject 2). With regard to output #6 ("Improvement of public knowledge on apomixis technology"), scientists from the project contributed to several TV programs (e.g., CNN Africa).

Highlight results from subproject 1 are presented in the following section.

Production of apomictic germplasm (Sub-project 1)

Re-orientation of activities - Until recently, activities were mostly focusing on the study of the apomictic development found in *Tripsacum* and on its introduction into maize *via* interspecific hybridizations. However, our results suggest that, because of major biological constraints at various levels (e.g., genetic regulation, seed development), the maize genome might not be an appropriate recipient for that type of apomixis. We are still studying apomixis in *Tripsacum* and

attempting to introduce it into maize. But assuming the risk that such an approach might not be successful, new activities that relate to the development of artificial apomixis have been initiated with the objective of producing maize varieties engineered for apomixis.

Work plans established during progress report meetings with all the partners of the Consortium endorse such strategic issues. Four sub-projects are conducted:

SP1 and SP2 focus on diplospory, the natural apomictic type found in *Tripsacum*;

SP3 focuses on artificial apomixis;

SP4 relates to constraints on kernel development.

Highlight results (2001)

1- New route for the mass production of maize-*Tripsacum* addition lines

- more than 800 addition lines were produced and screened for apomixis. No apomictic plants identified so far.

2- New knowledge on apomixis and regulatory mechanisms

- characterization of meiosis failure in *Tripsacum* and maize-*Tripsacum* hybrids;
- chromosomal dosage effects affect the expression of the genes responsible for diplospory. Progress towards the identification of the chromosomes involved; and
- maize allelic variation affects the expression of apomixis in maize-*Tripsacum* hybrids.

3- New knowledge on kernel development

- defective kernels obtained after interploidy crosses resulting from alteration in cell cycle activities;
- embryos are affected by dosage effects; and
- model for embryogenesis in sexual and apomictic plants.

4-Identification of candidate genes (based on results from 2 and 3) for

- diplospory in *Tripsacum*;
- the induction of artificial apomixis in maize; and
- genes governing kernel development

5- Development of tools for the functional analysis of candidate genes identified in 4 or obtained through MTAs:

- mutagenized apomictic population;
- ectopic expression in maize calli;
- transgenic maize for the study of the role of callose during sexual development;
- mutagenized population for understanding kernel development; and
- proposal for mRNA profiling for understanding the molecular bases of dosage effects in maize endosperm;

system for overexpression of embryo-specific cDNAs in nucellar cells of *Arabidopsis thaliana* (to be built in collaboration with scientists at ANU).

Publications and patents (2001)

Journal articles

Grimanelli D, Leblanc O, Perotti E, Grossniklaus U. 2001. Developmental genetics of gametophytic apomixis. Trends in Genetics 17 p 597-604.

Book chapters

Grimanelli D, Tohme J, González de León D. 2001. Applications of molecular genetics in apomixis reearch. In: Savidan Y., Carman J. G., and Dresselhaus T. (eds.), The flowering of apomxis: From mechanismsto genetic engineering, Mexico, DF: CIMMYT, IRD, European Commission DG VI (FAIR). p. 64-82.

Leblanc O and Mazzucato A. 2001. Screening procedures to identify and quantify apomixis. In: Savidan Y., Carman J. G., and Dresselhaus T. (eds.), The flowering of apomxis: From mechanismsto genetic engineering, Mexico, DF: CIMMYT, IRD, European Commission DG VI (FAIR). p. 121-136.

Flament P, Grimanelli D, Leblanc O. 2001. Apomixis for wheat improvement. In: Bonjean A (ed.), World Wheat Book, Lavoisier Publishing, France. p.1001-1015.

Conferences (presentations and posters)

Perotti E. 2001. Molecular approaches for the transfer of apomixis into maize. Plant and Animal Genome IX, 13-17 January, San Diego, USA. (Invited speaker)

Grimanelli D. 2001. Megasporogenesis in diplosporous *Tripsacum* and maize x *Tripsacum* hybrids. 2nd International Apomxis Conference, 24-28 avril, Côme, Italy. (presentaion)

Leblanc O. 2001. Recipient genomes for "apomictic"genes: does maize fulfill the book? 2nd International Apomxis Conference, 24-28 avril, Côme, Italy. (presentation)

Perotti E, Espinosa E, Soriano AM, Grimanelli D, Leblanc O. 2001. Is it easy to jump into apomixis? 2nd International Apomxis Conference, 24-28 avril 2001, Côme, Italy. (poster)

Patents

Leblanc O and Grimanelli D. 2001. Mutagenesis population and the use thereof for identifying specific genes.18/10/2001. Provisional application (18/10/2001).

Frontier Project 4

Biofortified grain for human health

Project Coordinator: I. Ortiz-Monasterio R.

Oversight Director: D. Hoisington

Sub project 1: Improving human nutrition by enhancing bio-available micronutrient concentrations in maize

In collaboration with PSNL at Cornell, the bioavailability of Fe in three maize inbred lines (two high for Fe, one low for Fe) was assessed using the *Caco-2* bioassay. The bioavailability of Fe in the best high line was approximately 80% higher than the bioavailability of Fe in the low line.

Over the past few seasons, the multi-aleurone layer (MAL) trait has been incorporated into high Fe lines using backcrossing. The MAL trait increases the number of cell layers in the kernel that are particularly rich in iron, zinc and protein, i.e. increases the *sink* size for Fe and Zn. In 2001 we compared the Fe and Zn concentration of BC3-MAL lines with the original lines. No significant difference in Fe and Zn was found between BC3's and the original lines, indicating that establishing a larger *sink* alone does not increase Fe and Zn concentration in the kernel. Other researchers found similar results when they increased the levels of ferritin in the seed through transformation.

Yellow maize contains naturally significant amounts of b-carotene that can be converted to Vitamin A by humans. Unfortunately, most consumers in sub-Saharan Africa reject yellow maize due to cultural and historical reasons. These consumer preferences may be overcome by promoting the consumption of high b-carotene (yellow) maize as fresh maize, boiled or roasted, or by developing high b-carotene maize with a unique or disguised yellow grain color. Carotenoid concentration was evaluated in 72 materials with different grain colors. Carotenoid levels were highest in yellow, orange and sun-red maizes. A back-crossing project was started to introgress high b-carotene in elite, tasty open-pollinated varieties that are well adapted to southern Africa.

Sub project 2: Improving human nutrition by enhancing bio-available micronutrient concentrations in wheat

Preliminary data from a genetic study involving ten different crosses in wheat suggests that Fe and Zn concentration in wheat grains may be a quantitative rather than qualitative trait, indicating that Fe and Zn inheritance is not a simple trait and that several minor genes may be involved.

One of the ten crosses points at the possibility of transgresive segregation, as suggested by the fact that some of the progeny have a higher concentration of Fe and Zn than either of the parents.

Seventy-four hybrids were made between parental lines with significant differences in Fe and Zn in the grain. The results indicated no heterosis for Fe and Zn concentration in the grain.

Additive gene actions were found to be more important than non-additive gene actions (as implied by the lack of female x male interaction and by the intermediate values of Fe and Zn of the hybrids with respect to the parents). Therefore, parental lines with high Fe and Zn concentration in the grain tend to produce hybrids with high Fe and Zn. One can breed inbred lines with desirable levels of Fe or Zn concentration.

A set of material looking at the effect of the Lr19 gene on yellow color and it's association with b-carotene in wheat was sent to Australia for carotene analysis. Problems at the laboratory in Australia delayed the delivery of these results.

Funding

There will be funding by the IFPRI/DANIDA project for one more year for both, wheat and maize. The wheat and maize proposals to the Gates Foundation and a consortium of donors were submitted. As a result of that USAID will support some biotechnology activities in maize. In addition, a biotechnology proposal on Fe was submitted to CSIRO and GRDC.

Achievement of Objectives

All major objectives were achieved given availability of financial and human resources.

Constraints to Progress

No reported constraints.

Plans for 2002

Plans and activities for maize 2001/2002

Conduct a rat study with three high Fe hybrids and one low Fe hybrid (in collaboration with PSBN Cornell)

An M.Sc project was started to further study the genetic variation for b-carotenes in adapted materials and assess consumer perceptions and current and potential uses of yellow maize in Zimbabwe.

Increase seed of best high Fe materials for an impact study

Continue backcrossing of high Fe/MAL lines

Continue introgression of selected grain colors in improved materials adapted to southern Africa.

Publish results of the diallel and landrace study.

Plans and activities for wheat 2001/2002

Segregating populations of high micronutrient lines with drought tolerant lines will be advanced. F3 seed of these crosses will be analyzed for micronutrients to guide the selection of families that will be advanced. Additional F2 seed of selected crosses will be analyzed for Fe and Zn to corroborate a heritability study.

Segregating populations of high micronutrient lines with high yielding lines for optimum environments will be advance. F2 seed of a set of crosses will be analyzed for Fe and Zn for another heritability study.

Recently identified T. dicoccon are being used for the development of new synthetic hexaploids and double haploids.

Fe bioavailability studies using Caco-2 cells and rats in collaboration with Cornell.

Identification inside and outside of the CIMMYT germplasm bank for yellow/orange color wheat.

Publications relevant to FP4 2001-2002

Long, J., I. Ortiz-Monasterio and M. Banziger. 2001. Improving the Nutritional Quality of Maize and Wheat for Human Consumption. *In* I. Cakmak and R. Welch. (eds.) "Impacts of Agriculture on Human Health and Nutrition". Encyclopedia of Life Support Systems. UNESCO-ELOSS. ELOSS Publisher, Co. Ltd. Oxford, UK. (in press).

Calderini, D.F. and J.I. Ortiz-Monasterio. 2002. Grain position modifies grain nutrient concentration in cultivars (Triticum aestivum) and synthetic hexaploid lines (T. durum x T. tauschii) of wheat. Crop Sci. (submitted).

Calderini, D.F. and J.I. Ortiz-Monasterio. 2002. Are synthetic hexaploids and alternative for increasing grain element concentration in wheat? Field Crops Research. (in preparation).

Frontier Project 5

Reducing grain losses after harvest

Project Coordinator: D. Bergvinson

Oversight Director: S. Pandey

Summary

FP5 develops source germplasm, new research tools and methods for germplasm improvement, identifies suitable storage practices to reduce grain losses after harvest and disseminates improved technologies to resource-poor farmers in developing countries. During the year, advances were made in understanding the genetic and biochemical basis for kernel resistance to storage pests. Good progress has been made in the development of a tropical mapping population for weevil resistance and divergent selection studies are currently in progress. These studies build on the published work of graduate students (Derera et al. 2001) collaborating with CIMMYT in which the importance of additive, non-additive and maternal effects were identified for weevil resistance. This information will be useful in designing weevil tolerant hybrids by using the resistant line as the female parent in hybrid seed production. Source germplasm has been identified by the Harare team that not only serves as a source for weevil resistance but also gray leaf spot (GLS) and streak. Lines derived from this source are currently being used in line recycling of 10 elite lines developed at CIMMYT-Harare and Headquarters. Mapping of weevil and larger grain borer resistance identified three important QTLs which also overlap with biochemical factors considered important in post harvest resistance. QPM varieties have also been screened to identify the most promising germplasm for weevil and ear rot resistance, factors that impeded the adoption of QPM in the 1970s. Several QPM synthetics have been identified with weevil and ear rot ratings comparable to normal endosperm synthetics and commercial hybrids. A new method was developed during 2001 that now enables individual kernels to be screened and germinated to accelerate the endosperm modification process.

Advances in 2001-2002

Screening of Maize Germplasm

1) Elite CIMMYT maize germplasm from HQ and Outreach was conducted in 2001 in which 514 entries were evaluated for *Sitophilus zeamais* and *Prostephanus truncatus* under laboratory conditions (kernels) as well as field conditions at Poza Rica (ears with and without husk). During the TL01A cycle, a demonstration block was planted for the Board of Trustees to review the diversity of elite germplasm presently being developed in the Maize Program at both headquarters and outreach. The planting consisted of 4 row plots 5m long at 65,000plants/ha under conventional management. The 2 center rows were sampled to obtain 12 ears for evaluation against storage pests. Contamination rate was estimated at 30%. Four ears with the husk on and four ears without shelling damage were used for evaluation under natural attack in Poza Rica for 6 months. Two replicates consisting of two ears each were labeled and

extended on tables to allow equal exposure to *Sitophilus zeamais*, *Plodia interpunctella* and *Sitotroga cerealella*. Every 2-3 weeks the samples were rotated to ensure a homogeneous infestation.

Laboratory evaluations were conducted under controlled conditions (27°C, 75% RH) using two important storage pests, *Sitophilus zeamais* and *Prostephanus truncatus*. Grain was equilibrated for 3 weeks to adjust GMC to 13±0.5%. Four replicates were prepared for each insect tested. Thirty adults were placed in each sample. The trials were incubated for two months for *P. truncatus* and thee months for *S. zeamais*. Samples were prepared in five blocks: hybrids, lines, OPVs, populations and pools. To facilitate the analysis of several traits, a selection index was used to group resistance parameters together to generate an overall rating. The overall rating included resistance under natural attack and laboratory ratings.

Additional evaluations were made to determine seed vigor under harsh storage conditions, grain density, seed size, and kernel hardness.

Table 1 lists the best and worst entries from the 5 categories tested (hybrids, lines, populations, pools and OPVs). In the hybrid category, among the best hybrids were those containing lines from the Cali program. Cali lines should be screened more closely to identify future sources of resistance to these two important storage pests. These same lines also performed well as lines *per se*. Several important QPM hybrids and lines were among the most susceptible entries, which highlights the importance of screening for post harvest resistance within the QPM breeding program.

Several CIMMYT lines were identified that are already known as sources of resistance to drought, armyworm and stem borers. Such lines should be considered in the formation of synthetics to address multiple stresses.

Of the open pollinated varieties tested, several from the tropics performed well. Interestingly, Cuba 124 was one of the best entries. Cuban accessions were used to form CIMMYT's source population for *Prostephanus truncatus* resistance. CORPOICA H108 (LASP 2*3)xCLA44 was the best performing OPV and should be promoted as a material that will perform well under on-farm storage conditions. The poor performance of Obatanpa is a concern as this OPV accounts for 75% of SG2000s QPM area in Africa. Obatanpa should be considered for conversion into a more weevil resistant variety by crossing in resistant sources identified in this screening. Several QPM pools were identified with moderate levels of resistance that could be used for this purpose. This list included G31 c12 SEWF QPM, G31 c12 SEWF QPM, G31 c12 SEWF QPM, and G17 C8 Q.

Table 1. Range in resistance of CIMMYT hybrids to *Sitophilus zeamais* and *Prostephanus truncatus* under controlled and natural infestations.

Hybrids	S.z.	P.t.	Overall
CTS003176 CA00328 x CA34514	2.63	0.85	1.31
IBOPERENDA 8666	3.62	0.78	2.10
CL02442 x CML413	3.98	3.16	2.14
CTS 993004 CA00334 x CA00302	3.70	1.64	2.24
HS7	4.07	2.81	2.28
CTS003006 CA00370 x CA34502	3.84	3.97	2.30
P68Q c1 HC2491413B1BBB x CML176	4.82	7.90	6.04
(CML142*CML150) x CML173	4.61	7.60	6.14
(CML142*CML150) x CML176	4.96	8.59	6.25
CML216/CML395//CML312	4.40	5.36	6.32
[CML161*CML165) x [89[G25Qc1(STE)	4.97	5.08	6.38
[P43xSC Malawi]F2PL10	5.60	7.81	6.67
Mean	4.05	4.73	4.19
LSD(0.05)	0.76	1.76	1.08
Lines			
CLRCW01[PNVA. BCO.(S/D)xNPH28]FS3 2B	3.53	1.06	1.46
CML343 LP SEQC3H1712321##BBB	3.25	0.51	1.83
CLFAWW11 FAWGCAWhite33122B*4	3.17	0.65	1.85
CA049Y04 Pop.49(Y)S5B124#6BB	3.09	1.74	1.86
CA00312 AMATLC0HS92113E142BBB	3.07	2.29	1.96
CML447 (P43F95*21F219)1BBB1#*4B*9	3.92	1.16	2.08
CML321 POP502 P502c0F1131B*4	2.98	3.96	2.12
MBRET(W) C1 F13921B2BBBBBBB	3.51	2.67	2.26
P43C911111BBBBB	3.42	3.17	2.29
CML322 Recy W89[L/LMBR]17B5314B*4	3.02	4.49	2.44
CML150 G24QPM16921B311BB3B##B*6	6.16	3.25	6.90
Mean	3.85	2.79	3.95
LSD(0.05)	0.75	1.09	1.16
OPVs			
CORPOICA H108 (LASP 2*3)xCLA44	2.59	1.60	1.38
Cuba 124	2.42	2.51	1.68
POZA RICA 9424	4.39	3.36	2.35
PTBF C5 HS	4.22	5.24	2.37
CORPOICA H112 (LASP 2*3) x CLA41	3.28	4.74	2.39
S98DEY1	3.35	5.19	2.51
S98D282	3.66	2.10	2.53
Oaxaca 821 (152)	4.63	3.18	2.54
POZA RICA S9531	3.37	4.08	2.56
ECAVL1	3.72	1.89	2.57
OBATANPA	4.81	5.51	5.52
S87P67 QPM	6.97	3.93	6.31
Mean	4.03	4.37	3.71
LSD(0.05)	0.71	1.20	0.89

Thirteen populations that were represented by two or more cycles of selection were compared to establish the trend in resistance to post harvest pests (Table 2). Only two populations were found to have increased in their level of resistance. From this it is evident that routine screening for post harvest resistance within the population improvement program should be promoted. The populations that seem to be in the most need for improvement to post harvest pests are P45, P32, P27 and stem borer populations (MIRT, MBR). Interestingly, high oil populations do not seem to confer resistance to insect pests.

Table 2. Changes in resistance to post harvest pest of maize over cycles of selection in selected CIMMYT maize populations.

Population	Initial	Final	Change per Cycle
HIGH OIL C13-C15	4.80	5.03	0.11
La Posta Sequia C0-C7	2.97	3.23	0.04
MBR C0- C5 white	4.21	4.53	0.06
MBR/MDR C0 -C3 white	5.11	3.38	-0.58
MIRT C0 -C4 yellow	2.41	3.64	0.31
MIRT C0 -C4 white	2.41	4.54	0.53
P 501 C0 -C3	3.77	3.22	-0.14
P502 C0-C3	3.06	3.64	0.15
P 21 PB C0 -C20	3.54	3.77	0.00
P 27 C0- C9	4.03	4.34	0.03
P 32 C0 –C5	3.50	3.88	0.08
P 32 C0-C3(MRRS)	3.88	4.18	0.10
P 45 c5	3.31	4.91	0.40

Correlations between resistance and physical traits enable the identification of a new screening methodology that will accelerate the evaluation process. By equilibrating the grain prior to infestation, gravimetric methods for grain weight loss correlated well (r=0.85) with number of progeny but had a lower correlation with flour production (r=0.7). Based on this observation, future screening will be based on gravimetric measurements to reduce evaluation time. The correlation between *S.zeamais* and *P.truncatus* damage was 0.3 (P=0.0001).

Several general observations between the mean values of the five groups tested were made. Lines had the lowest density (1.28 g/cm^3) with a seed weight of 0.241g while hybrids had the highest density (1.33 g/cm^3) and a seed weight of 0.308g. Lines were more resistant than hybrids to both *P.truncatus* (36.7 vs 62.4% damage) and *S.zeamais* (79 vs 87.1% damage), probably due to seed compaction in the bioassay jars. Seed viability varied when stored at 30C, 100%RH, with lines being the most susceptible (49%) followed by hybrids (60.7%), Pools (62.1%) and OPVs and Populations (75%). Fortunately, OPVs were among the best in maintain seed viability, which is a valued trait for farmers who recycle seed.

Routine screening of CIMMYT trials will continue with the establishment of the "weevil warehouse" at Agua Fria. There was no correlation between natural attack with and without the husk so it is important that OPVs and F2s from hybrids be evaluated. There was a weak correlation between seed viability and resistance to natural attack (r= -0.31, P<0.0001), which will increase the value of the natural screening proposed for Agua Fria.

Ear rot screening in maize

Fusarium moniliforme screening conducted in line evaluation trials identified several QPM lines with comparable levels of resistance to checks: 6207Q(AMARILLO)-3-4-3-B-B, (6304Q/6303Q)-xb-6-1-2-3-B-B-B, (6207QB/6207QA)-1-4-#-2-2-B-B, G25QC1(STE)-18-8-1-2-B*4-1-BB-4-3, (CML-172*CLQ-6601)-B-10-1-1, and CML 144, 155, 156 and 172. Within the trials, lines with borer and armyworm resistance were also identified with good levels of ear rot resistance: CL-SCBY08=PSCB TUXc0#-5-5-1-1-2-1-B*4, CL-SCBY07=SCB/FAW GCA YELLOW-114-1-1-2-1-B, CL-SCBY03=SCB/FAW GCA YELLOW-23-1-2-2-1-BB, CL-FAWW06 =FAW Non-Tuxp. WHITE-66-1-2-1-2-B, CL-FAWW11 FAWGCAWhite-3-3-1-2-2-B*4. These lines could be used in the development of multiple stress resistant synthetics.

Postharvest screening in wheat germplasm

During 2001, screening of 24 lines representing three breeding programs (rain-fed and irrigated bread wheat and durum) were evaluated against *Ryzopertha dominica*, *Sitophilus granarius*, *S. zeamais*, *Tribolium castaneum*, *Sitotroga cerealella* and *Prostephanus truncatus*. Untreated grain was equilibrated under 27°C and 75 ±5 %RH for 3 weeks prior to infestations. At the time of infestation, 30 g of grain was accurately weighed and placed into a 50ml glass jar and infested with 25 unsexed adults. After 60 days the bioassays were evaluated for grain weight loss, number and weight of healthy and damaged kernels and number of progeny. The entries were also evaluated for kernel force (using a force displacement meter) and hardness (as determined by the wheat quality lab).

Bread wheat was generally more resistance but variation was found in each of the three groups tested. Based on weight loss, the best varieties for resistance in bread wheat was Kanchan and HUW234 which are the main varieties in Bangladesh and the tropical part of Bihar in India, and are grown and stored under warm humid conditions. The best durum varieties were Aconchi 89 and Mexicali 75.

Table 3. Screening of selected CIMMYT wheat varieties against five post harvest pests under controlled conditions.

		Weight Loss						Percent Damage				
Entry	Genotype	Rd	Sc	Sg	Sz	Tc	Rank	Rd	Sg	Sz	Tc	Rank
1	Mexicali 75	3.11	1.44	2.38	10.23	0.39	3	56	39	92	26	8
2	Yavaros 79	5.54	1.62	3.10	11.86	0.60	15	90	50	97	33	24
3	Altar 84	5.20	1.36	3.08	10.21	0.33	11	82	40	91	28	19
4	Aconchi 89	3.59	1.28	1.76	8.84	0.20	2	83	28	90	15	12
5	Nacori C 97	4.20	2.94	2.09	6.72	0.20	7	81	32	84	16	11
6	Sooty_9/Rascon_37 (Atil C 2000)	6.39	2.33	1.99	8.90	0.34	16	88	35	89	40	16
7	SN Turk MI83-84 375/Nigris_5//Tantlo_1	3.47	1.32	2.97	6.44	0.21	5	58	43	84	10	7
8	Cado/Boomer_33	5.09	1.83	2.30	6.97	0.22	8	82	37	86	19	14
9	DUCULA//VEE/MYNA	8.14	1.58	4.65	9.36	0.45	22	89	39	97	27	21
10	PASTOR/OPATA	8.73	2.83	3.87	9.10	0.49	24	88	54	94	30	23
11	KLEIN CHAMACO	7.01	0.69	2.97	7.61	0.37	17	79	43	90	16	18
12	DHARWAR DRY	5.92	1.64	2.30	9.62	0.24	12	80	37	94	15	17
13	CHAM 6	7.49	2.38	4.65	10.93	0.49	23	83	39	97	27	20
14	CROC_1/AE.SQUARROSA (224)//OPATA	5.57	2.38	3.87	11.22	0.42	20	76	54	97	20	22
15	Kanchan	2.15	1.18	2.97	9.19	0.24	1	29	37	87		3
16	P.B.W. 343	4.00	2.09	4.01	9.33	0.44	14	57	54	84		10
17	WH542	2.43	2.01	4.14	7.47	0.27	6	40	45	77		5
18	UP 262	3.54	1.95	3.68	4.32	0.39	9	51	38	69		4
19	HUW 234	3.83	0.53	2.63	4.87	0.37	4	52	57	69		6
20	HD2329	4.03	2.09	3.79	8.59	0.47	3	65	48	88		13
21	INQALAB 91	5.45	2.04	4.31	4.55	0.34	19	79	47	67		9
22	RR21	2.48	3.54	3.64	4.42	0.20	10	39	42	53		1
23	BL1473	4.97	2.38	5.57	7.99	0.20	21	66	67	74		15
24	10-ORI	4.85	1.41	4.86	5.50	0.35	18	53	43	46		2
	Mean	4.88	1.87	3.40	8.09	0.34		69	44	83	23	
	LSD(0.05)	1.34	0.98	1.02	1.98	0.12		14	19	15	10	

Correlations between the different damage parameters were helpful in identifying an efficient screening strategy for wheat (Table 4). Weight loss based on the same method used for maize was significantly correlated with progeny production and percent damage. Future screening efforts should use only weight loss to expedite evaluations. Flour production should also be recorded as the efficiency of conversion index (ECI) was not highly correlated and could serve as an additional parameter used in selection. Correlation between grain hardness and kernel force was 0.77, with hardness correlating with *Sitophilus granarius* resistance (r=0.74). *Ryzopertha dominica* and *Tribolium castaneum* are correlated (r=0.50) but are not correlated with *S. granarius*. Recommendations for future screening would be to use hardness measurements as a surrogate method for *S. granarius* and screen for *R. dominica* to represent *T. castaneum*.

Table 4. Correlation between insect damage parameters for *Sitophilus granarius, Tribolium castaneum, Ryzopertha dominica,*

	Adult weight	Number Adults	Percent Damage	ECI	Flour Prodn	Flour Efficiency	Percent Damage
Number of Adults	0.73						
Percent Damage	0.76	0.86					
ECI	-0.17	-0.50	-0.36				
Flour production	0.07	0.56	0.40	-0.42			
Flour efficiency	-0.46	-0.06	-0.13	0.04	0.71		
Percent Damage	0.76	0.87	0.88	-0.47	0.42	-0.15	
Weight Loss	0.91	0.90	0.83	-0.42	0.34	-0.28	0.89

**P=0.001, r=0.16

Quantifying post harvest losses

Data has been collected in Mexico and is currently being collected in Zimbabwe by Thanda Dhliwayo to be used in generating GIS surfaces for storage losses. Models will be generated for different storage practices on the bases of climate factors (mean Temperature and deltaTemperature or absolute air moisture content) to generate loss surfaces.

Mapping for post harvest resistance

The identification of QTLs and the use of linked markers to accelerate the movement of post harvest resistance into elite germplasm holds considerable promise. Given the time requirements for conventional screening, a planting cycle is lost or an excessive number of families are planted with eliminations being made prior to flowering based on results from laboratory bioassays. The identification of two or three stable and highly correlated QTLs for insect resistance could make line conversion much more efficient.

To this end, a mapping population was formed from two lines derived from Population 28 (Tropical yellow). The population was generated from 163 F2 families and mapped using 89 RFLPs and 196 SSRs. Based on phenotype data from F3s, the most resistant and susceptible fraction (30 from each tail) underwent phytochemcial characterization (cell wall phenolics). QTLs were identified for *S. zeamais* resistance on chromosomes 2, 3, 5, 6 and for *P.truncatus* resistance on chromosomes 1 and 4. QTLs were identified for cell wall phenolics on several chromosomes but the ones of principle interest are those which overlap with insect resistnce.

During 2001, promising lines emerging from the Harare Program and from the Entomology Unit were identified for the formation of a new mapping population. Four F2 populations were planted in TL02A for DNA sampling with parental screenings starting in March 2002.

Biochemical basis of post harvest resistance.

Understanding the biochemical basis of insect resistance is important from both a food safety point of view and to determine the potential limitations of resistant sources. Kernel hardness was determined as a resistance factor but this trait was found not to function when grain was stored above 14% grain moisture content. This finding was important as it emphasized the importance of grain conditioning in delivering an integrated storage management package to resource poor farmers.

CIDA linkage funding has been used in collaboration with the University of Ottawa to identify the putative biochemical basis for storage pest resistance. Good correlations between insect resistance and kernel hardness are also correlated to elevated levels of diphenolic acids located within the pericarp of the kernel. Preliminary studies conducted in collaboration with the University of Ottawa suggest that diferulic acid is correlated with *Fusarium graminearum* resistance in temperate maize. Samples showing a range in *F. moniliforme* resistance have been submitted for phytochemical analysis. Pericarp hardness during the early stages of grain filling did not correlate with ear rot resistance among different genotypes. The private sector (Pioneer Hibred) has expressed interest in using this technology for developing ear rot resistance germplasm.

Testing of additional storage technologies suitable for small-scale storage systems.

The team has investigated the use of several "soft technologies" which have been used commercially (in the case of diatomaceous earth) and traditionally (botanicals, ash, etc.). Diatomaceous earth (Protect-It DE, Headly Technologies Ltd., Canada) provided the best control under tropical conditions but was less effective than published reports coming from temperate climates. Amongst the traditional technologies, ash coming from ocote wood was the most effective. Neem leaves were not found to be effective in our studies.

The use of small, hermetic silos has become very popular with small-scale farmers in the tropics as they provide effective control of post-harvest pests. Any oxygen in the headspace of the silo in converted to carbon dioxide due to respiration of molds, insects and grain. Within 10 days, 100% mortality of weevils and larger grain borer (LGB) was observed using silos fashioned after those produced in Oaxaca. The main limitation to using this technology is grain conditioning, especially when rains impede drying. Because of this, FP5 has worked at testing the efficiency of traditional drying technologies (i.e. sun drying) as well as developing simple, inexpensive dryers that do not require electricity. Using wood fires placed under the storage structure, maize stored in the husk dried in 5 days from >20% down to 10%GMC. The most recent prototype is constructed from half of a metal barrel which collects the heat and smoke from a fire that passes through stove piping to the core of the maize store situated on a bed of gravel. This design minimizes fire hazards and is less expensive to construct.

Models which estimate storage losses have been developed for Oaxaca which when combined with economic survey data suggest that the capital investment of two silos (2T capacity) to store household maize production would be paid off in two years from the reduced losses associated with silo technology. In collaboration with the Economic program and INIFAP, farmers samples were evaluated under controlled conditions. As we observed previously, farmers who store their maize as shelled grain had a higher level of kernel resistance to both *P. truncatus* and *S. zeamais*. This observation confirms that on-farm selection does occur for post harvest pests, depending on the storage form used.

To this end, the entomology unit will be screening 1800 germplasm bank accessions collected from sites below 100masl to identify new sources of resistance. Insect pressure is most intense

from this ecology, with the currently used accession checks for resistance coming from this ecology. A pre-selection will be based on kernel width and planted out in 02B for evaluation under artificial infestation and natural attack.

Additional biotechnology options.

For 2002, bioassays will be conducted to test the efficacy of milled plant tissue from Bt plants (CryI toxins) in controlling *Plodia interpunctella* (Pyralidae) and *Sitotroga cerealella* (Gelechidae). Should these methods work then future constructs for controlling soil pests (*Diabrotica spp.*) which contain Cry3 toxins could be tested for the control of coleopteran pests found in storage (*P. truncatus* and *S. zeamais*).

Training materials

Although a wealth of post-harvest training manuals are available, we are presently developing a manual that focuses on germplasm development for improved storage as well as the complimentary technologies required for extended grain storage. Based on this material, a post harvest workshop will be held for the Asian region from July 29-Aug.2 in New Delhi.

Constraints

The time allotment of members (totaling 0.4 PY plus consultant time) leaves this project largely dependent on graduate students to conduct research under the supervision of CIMMYT scientists. Students are from both developed (Canada and France) and developing countries (Mexico and Zimbabwe).

Funding has been adequate but during 2002 funding will end for both the Rockefeller and CIDA projects, which have been key in supporting post-harvest research in CIMMYT during the past year.

Publications:

Derera, J., K.V. Pixley and P. Denash Giga. 2001. Resistance of maize to the maize weevil: I. Antibiosis. African Crops Science Journal 9: 431-440.

Derera, J., P. Denash Giga and K.V. Pixley. 2001. Resistance of maize to the maize weevil: II. Non-preference. African Crops Science Journal 9: 441-450.

Presentations:

Bergvinson, D.J. Past achievements and future opportunities for host-plant resistance in maize: An international center's perspective. ESA, ESC joint meeting Dec. 3-6, 2000.

Bergvinson, D.J. Novel screening techniques for host plant resistance in maize. ESA, ESC joint meeting Dec. 3-6, 2000.

Bergvinson, D.J., S. García-Lara., A. Ramputh, J.T. Arnason. Bases biozuimicas de la resistencia a plagas de almacenamiento en maize. XXIII Congreso Nacional Sociedad Mexicana de Bioquimica, 19-24 November, 2000.

Bergvinson, D.J., S. García-Lara, and A. Savidan. Biochemical basis for storage pest resistance in maize. XXI International Congress of Entomology, August 20-26, Iguassu Fall, Brazil.

Frontier Project 6

Technology assessment for poverty reduction and sustainable resource use

Project Coordinator: J. Ekboir

Oversight Director: P. Pingali

SP1 Identifying sources of productivity in public agricultural research institutions

SP2 Economics of biotechnology

SP3 Intensification of maize-based systems in Asia's rainfed upland systems

SP4 Competitive zones for maize in Central America

SP5 Millennium ecosystem assessment

SP1: Identifying sources of productivity in public research institutions

- Assessed the research systems of seven Latin American countries
- Analyzed innovation systems that generated no-till in South America
- Five papers in books and journals
- Five working papers
- Three papers presented in conferences
- Six papers still to come

Innovation systems that generated no-till in South America

- No-till adopted where innovation networks emerged
- Components of innovation networks:
  - Catalyzing agent
  - Core assets
  - Internalized complementary assets
  - Learning routines
  - Constraining and focusing factors

Core assets

- Minimum research capabilities
- Institutional cultures that value innovation and networking
- One institution willing to play a catalytic role

- Linkages with international sources of information
- Funds that allowed other agents (in particular, public researchers and extension agents) to participate in the network

Complementary assets

- Formal research capabilities and scientific information
- Farmer participation in research
- Extension network, including farmer participation
- Innovative agents (e.g., machinery manufacturers)

Learning routines

- Participatory research methods
- Multidisciplinary approach to research
- Active gathering and open dissemination of information across the network
- Acceptance of information generated without an experimental design
- Creation of a common language that enabled communication between agents with different backgrounds

SP2: Economics of emerging biotechnologies

1. Marker-assisted and conventional selection
2. Assessing the impact of GM maize in Kenya

Marker-assisted and conventional selection

- Dissemination of research on marker-assisted selection
- A book chapter published and two papers being reviewed
- Three presentations at professional meetings

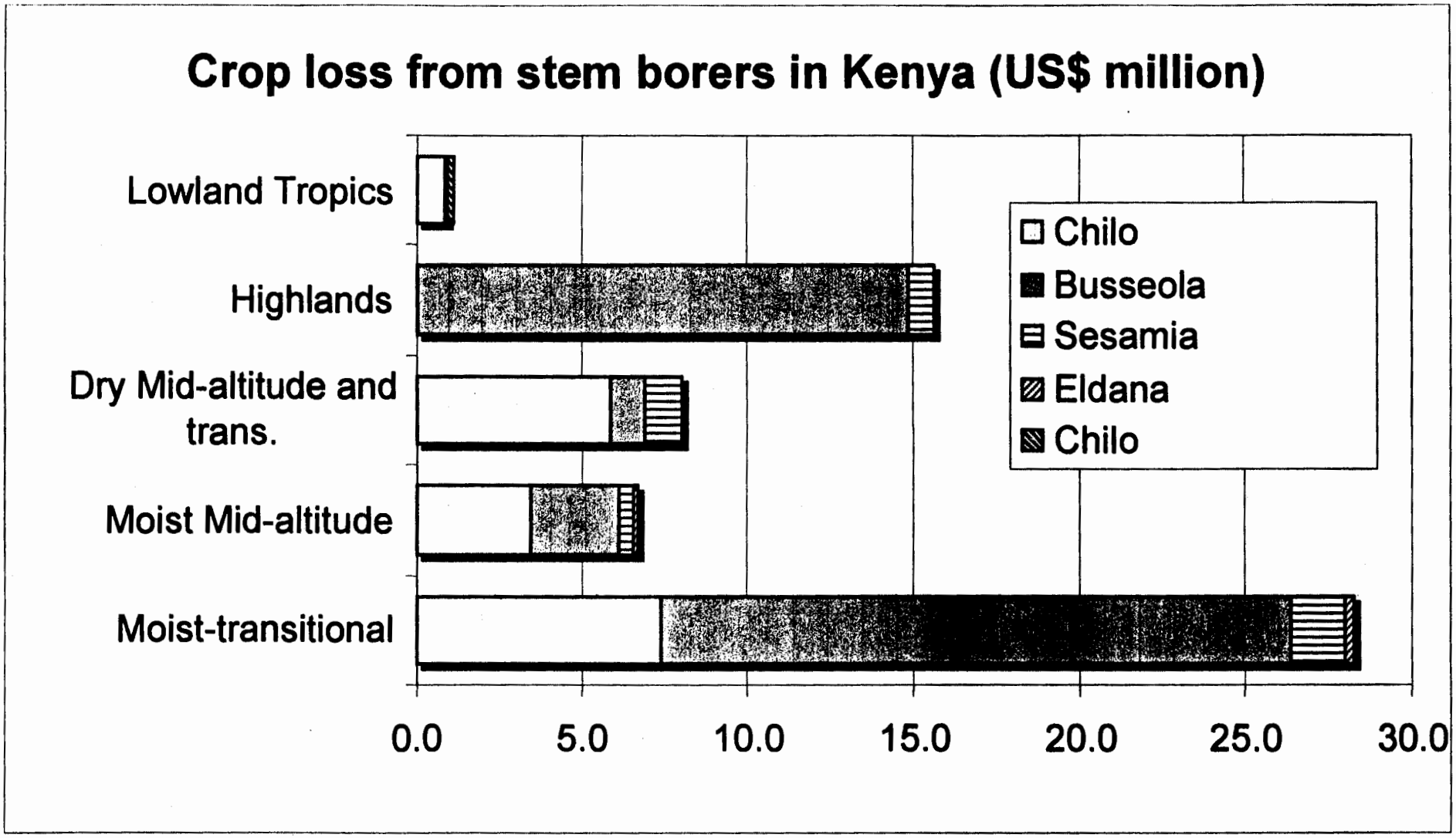
Assessing the impact of GM maize in Kenya

- Participatory rural appraisal completed
- Summary of PRAs being prepared as KARI/CIMMYT document
- Second year of Crop Loss Assessment trials on-going
- Results of year 2001 analyzed
- Building database for impact assessment

Cross loss assessment in maize from stem borers, extrapolated from field data from the long rains (LR) and short rains (SR) of 2000

	Production ('000 tons)			Losses (%)			Losses (US$ million)			Losses (%)
	LR 2000	SR 2000	Total	LR 2000	SR 2000	Total	LR 2000	SR 2000	Total	LR 2001
Highlands	893	16	909	11	11	11	15	0.3	16	6.5
Moist-transitional	11170	64	1234	14	17	14	26.2	1.7	27.6	
Moist-mid-altitude	170	62	231	22.3	6	18	6.1	0.6	6.7	7.3
Dry mid-altitude	167	72	239	26	8	21	6.9	0.9	8	
Lowland tropics	45	8	53	13	13	13	1	0.2	1.1	10.5
Total	2395	276	2671	14.4	14	14	55.2	6.2	59.8	

Assessing the Impact of GM Maize in Kenya (cont.)



Assessing the impact of GM maize in Kenya (cont.)

Source	Farmers (per cent) n=194
Own	51
Stockist	15
Public sector agencies	10
Local market	7
Neighbor	3
Other	14
Total	100

Assessing the impact of GM maize in Kenya (cont.)

- Analysis of agricultural inputs stockists
- Share of seed market:
  - Western: KSC
  - Eastern: Pioneer and Cargill
  - Coast: KSC
- Pesticides:
  - limited use
  - mainly for storage
- Local credit facility has significant impact on use of maize seed and fertilizer but no pesticides
- High market share of new seed companies
- Agricultural technology dissemination was relatively low
- Need for qualified or training the existing staff

SP3: Intensification of Asia's rainfed upland farming systems: Policy options for productivity enhancement, environmental protection, and food security

- Project meeting held in Nepal
- Participation of all collaborators plus directors of national maize research institutes of the 7 countries and representatives from University of the Philippines and Chinese Center for Agricultural Policy
- Constraints were assessed using RRA/PRA techniques
- Nov '00 – May '01 about 200 locations in marginal uplands and mountainous regions across 7 countries were visited and detailed maize production and resources use information was collected

- Prioritization and planning meetings conducted in Vietnam, Thailand and Nepal
- The planning process mainly involves organizing a national maize research priority setting workshop

Workshop goals:

- Present identified constraints
- Identify current and potential technologies to address identified constraints
- Rank proposed technical solutions and identify policies to foster adoption

SP4: Competitive zones for maize in Central America

- Characterization of main maize production areas in four countries: PA, CR, NI, and ES
- Development of a methodology to measure the competitive ability of a region to produce maize
- Characterization of the competitive position of CA countries to produce white maize
- Characterization of the maize cost structure in the regions identified in each country
- Currently running the simulations to obtain stochastic measures of the competitive ability of each region

SP5: Millennium Ecosystem Assessment (MA)

A 4-year international scientific assessment (2001-2004)

Designed to meet a portion of the assessment needs of the conventions of the US (CBD, CCDE, Ramsar Wetlands Convention) and address information needs by decision-makers in national governments, the private sector and civil society.

Goal: To create a mechanism to increase the amount, quality, and credibility of policy-relevant scientific research findings concerning ecosystems and human well-being used by decision-makers, particularly those involved in ecosystem-related conventions.

Focused on ecosystem goods and services, the consequences of changes in ecosystems on human well being, and consequences on other life on earth.

Undertaken at multiple scales (local to global)

Objectives of MA scenarios group

- Illustrate the connection of global changes to ecosystem services and human well-being at many scales.
- Highlight tradeoffs among ecosystem services
- Illustrate the effectiveness of policy in maintaining or increasing the availability of ecosystem services
- Identify critical policy intervention points
- Provide information to users to fulfill user objectives

Activities in 2001 and 2002

- Two technical design workshops to design project set-up (Bilthoven, April 2001 and Cape Town, October 2001)
- Panel meeting (June 2001)
- Board meeting (Kuala Lumpur, January 2002)
- Workshop on Methodologies for Scenario Building (Tlaxcala, February 2002)
- MA Conceptual Framework meeting 1 (Paris, March 2002)
- First Global Scenarios Workshop, together with Caribbean Scenarios Workshop and Workshop on Tools for Building Biodiversity Scenarios (Trinidad, April 2002)
- MA Conceptual Framework meeting 2 (Alexandria?, September 2002)
- MA Conceptual Framework meeting 3 (December 2002)