CIMMYT
Report on Wheat Improvement
1982

Correct Citation: CIMMYT Report on Wheat Improvement 1982. 1984.

The International Maize and Wheat Improvement Center (CIMMYT) is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, CIMMYT is engaged in a worldwide research program for maize, wheat and triticale, with emphasis on food production in developing countries. CIMMYT is one of 13 nonprofit international agricultural research and training centers supported by the Consultative Group for International Agricultural Research (CGIAR). The CGIAR is sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Programme (UNDP). The CGIAR consists of 50 donor countries, international and regional organizations and private foundations.

CIMMYT receives support through the CGIAR from a number of sources, including the international aid agencies of Australia, Canada, Denmark, Federal Republic of Germany, France, India, Ireland, Japan, Mexico, the Netherlands, Norway, the Philippines, Saudi Arabia, Spain, Switzerland, United Kingdom and the USA, and from the Australian Centre for International Agricultural Research, European Economic Commission, Ford Foundation, Inter-American Development Bank, International Bank for Reconstruction and Development, International Development Research Centre OPEC Fund for International Development, Rockefeller Foundation, and the United Nations Development Programme. Responsibility for this publication rests solely with CIMMYT.

CIMMYT
Report on Wheat Improvement

1982

Contents

	Page
CIMMYT Trustees	**3**
Wheat Program Personnel	**4**
Directors' Introduction	**6**
Bread Wheat Improvement	**12**
Durum Wheat Improvement	**24**
Triticale Improvement	**44**
Barley Improvement	**58**
Base Support Programs	
Pathology	66
Wide Crosses	78
Germplasm Development	88
Germplasm Bank	96
Training	102
Agronomy	108
Milling and Baking Laboratory	118
International Nurseries	120
Regional and In-Country Programs	
Andean Region	124
Southern Cone Region	128
North and West Africa and the Iberian Peninsula Region	144
Eastern and Southern Africa Region	150
South and Southeast Asia Region	162
Disease Surveillance Program	168
Pakistan	176
Bangladesh	178
CIMMYT/ICARDA Cooperative Wheat Breeding Program	180
Glossary	**182**

CIMMYT Trustees

(as of December 31, 1982)

Horacio García Aguilar
President, CIMMYT Assembly
Secretary of Agriculture and Water Resources
Mexico

Virgilio Barco
Chairman, Board of Trustees
Consultant
Colombia

Jesus Moncada De la Fuente
Vice-Chairman, Board of Trustees
Director General, National Institute of Agricultural Research
Mexico

Enrique Ampuero P.
Inter-American Development Bank
Ecuador

Walter P. Falcon W.
Director, Food Research Institute
Stanford University
USA

Robert D. Havener
Director General, CIMMYT
USA

Phaitoon Ingkasuwan
Professor, Kasetsart University
Thailand

H.K. Jain
Director, Indian Agricultural Research Institute
India

James R. McWilliam
Director, Australian Center for International Agricultural Research
Australia

W.A.C. Mathieson
Consultant
United Kingdom

Kan-Ichi Murakami
Professor Emeritus
University of Tsukuba
Japan

Stachys Njagi Muturi
Deputy Permanent Secretary
Ministry of Energy
Kenya

Gerhard Pollmer
Professor of Plant Breeding
University of Hohenheim
Germany

Abdoulaye Sawadogo
Professor of Economic Geography
University of Abidjan
Ivory Coast

O.M. Solandt
Consultant
Canada

Wheat Program Personnel

(as of December 31, 1982)

Director—Byrd C. Curtis, USA

Associate Director—Arthur R. Klatt, USA

Senior Consultant—Norman E. Borlaug, USA

Bread Wheat Breeding—Sanjaya Rajaram, India
Christoph E. Mann, Federal Republic of Germany

Durum Wheat Breeding— Gregorio Vazquez, Mexico
Pedro Brajcich G., Mexico

Triticale Breeding—F.J. Zillinsky, Canada
Bent Skovmand, Denmark

Barley Breeding—Hugo Vivar, Ecuador

Pathology—J.M. Prescott, USA
Enrique Torres, Colombia
Girma Bekele, Ethiopia
Peter Burnett, New Zealand

Wide Crosses—A. Mujeeb Kazi, USA

Germplasm Development—Ricardo Rodriguez, Mexico

Germplasm Bank—Ayla Sencer, Turkey

Training— Homer Hepworth, USA
Edwin Knapp, USA

Agronomy—David A. Saunders, Australia

Milling and Baking Laboratory—Arnoldo Amaya, Mexico

International Nurseries—Maximino Alcala, Mexico

Regional and In-Country Programs:

Andean Region, South America—H. Jesse Dubin, USA
Patrick C. Wall, Ireland
(both based in Ecuador)

Southern Cone Region, South America—Man Mohan Kohli, India
Matthew A. McMahon, Ireland
(both based in Chile)

North and West Africa and the Iberian Peninsula— George Varughese, India
Santiago Fuentes, Mexico
(both based in Portugal)

Eastern and Southern Africa—Gerbrand Kingma, Netherlands
(based in Kenya)

South and Southeast Asia—E.E. Saari, USA
(based in Kenya)

Disease Surveillance Project—Maarteen Van Ginkel, Dutch Associate from the Netherlands
(based in Turkey)

Pakistan—Peter R. Hobbs, United Kingdom

Bangladesh—Larry Butler, USA

Postdoctoral Fellows:

Paul Fox, Australia
Pierre Malvoisin, France
Johann-Peter Neuhaus-Steinmetz, Federal Republic of Germany
Guillermo Ortiz F., Mexico
Joel Ransom, USA
Reynaldo L. Villareal, Philippines

Directors' Introduction

The CIMMYT Wheat Improvement Program serves all the major wheat, triticale and barley-producing countries of the developing world. We maintain the widest possible variation in our germplasm so that advanced materials which are well suited for the important producing regions are available to our cooperators. Since its inception, the Wheat Program has endeavored to produce high-yielding, broadly adapted, and disease-resistant semidwarf germplasm. The Program's research emphasis, however, is shifting toward improved yield dependability under diverse production conditions. This shift is a deliberate attempt to better serve the changing needs of our national program cooperators, both in traditional wheat-producing countries and in those in which wheat is not a traditional crop.

Because our priorities are changing, this introduction (which begins with an update of the world wheat situation) briefly describes some of the more important research we are doing in the area of yield dependability. Regional and cooperative programs, as well as the staff changes that occurred during 1982, are also discussed.

An Update on the Global Wheat Situation

In 1982, the worldwide production of wheat reached a new high of 481 million tons, with the largest production increases occurring in the USA and Canada. Despite the implementation of Government programs in the USA to reduce the area planted to wheat, unprecedented yields produced an additional 2.5 million tons of grain over the record harvest of 1981. Western Europe also enjoyed above average harvests. The EEC produced a record crop, about 60 million tons, even though the wheat area changed little from 1981. The UK alone, with an estimated yield of 6.2 t/ha on 1.7 million hectares, set a new standard for commercial wheat production over a large area. Australia experienced a major drought in 1982, and production dropped to little more than half of the country's 1978-80 average. The USSR again experienced production difficulties; they were able to harvest only 85 million tons in 1982, considerably less than the 120 million tons harvested in 1979.

Dr. Byrd Curtis, Director of the Wheat Program (left) and Dr. Arthur Klatt, Associate Director (photo: T. Harris).

In the developing world, wheat production in 1982 was again close to record levels. The continuing high performance of the "big five" (China, India, Pakistan, Turkey and Argentina, who account for some 93 percent of the wheat produced in the Third World), coupled with rising production in several other countries, was responsible for this good news. China harvested 68 million tons in 1982, nearly 10 percent more than its previous high in 1979. India set a new record of 38 million tons, while Pakistan weighed in with about 11.5 million tons, up 8 percent from its 1979-81 average. Turkey generated a 4 percent increase, to 17.6 million tons, and Argentina produced 14.5 million tons, an impressive 83 percent rise over its 1979-81 average. Morocco made a strong comeback from the drought it suffered in 1981; production rose to a level 22 percent above its 1979-81 average. Mexico also enjoyed a resurgence in wheat production, harvesting 50 percent more wheat than its average for the previous 3 years.

Not all developing countries fared so well. Dry weather adversely affected the 1982 crop in Syria and Algeria, while a 50 percent reduction in the area sown to wheat in Chile, as well as low yields in Brazil (0.6 t/ha), resulted in below average production in these two countries. Several other developing countries experienced production difficulties as well.

Global wheat trade also achieved a record level in 1982: 101 million tons (a 10 million ton increase over the previous record set in 1981). This rapid increase in trade primarily reflects a continuing surge in consumption by Third World countries, especially in the North Africa/ Middle East regions and in the tropical countries of Sub-Saharan Africa and Southeast Asia. China also continued to import large quantities of wheat (about 13 million tons in 1982). For a more detailed reporting of these trends in production, trade and consumption, please see the CIMMYT publication, *1983 World Wheat Facts and Trends-Report Two.*

Implications of these Trends for CIMMYT

To date, most of the benefits of improved wheat, triticale and barley germplasm have accrued to those developing countries in which wheat is a traditional crop. Generally, these countries possess favorable production environments in terms of soils and moisture availability. However, many of them now have a large percentage of their wheat areas sown to high-yielding varieties; therefore, further production increases will be primarily the result of improved management practices and a greater utilization of such inputs as fertilizer and herbicides. CIMMYT has no intention of turning away from these more favored production environments, for we are convinced that substantial yield increases in these environments are both necessary and achievable. We do think, however, that such improvements are likely to come more slowly than in the recent past.

At this time, it appears to us that the greatest potential for increasing wheat production in the developing world lies in the application of new technologies in the more marginal wheat environments, both in traditional wheat-producing countries and in those countries in which wheat is not a traditional crop (e.g., in the tropics and subtropics). In developing new and appropriate technologies for marginal environments, the CIMMYT Wheat Program is placing its research emphasis on improving the yield dependability of its germplasm.

Improving Yield Dependability

A number of research activities are underway at CIMMYT that are designed to enhance the yield dependability of our wheat, triticale and barley germplasm when grown under various stress conditions.

Drought tolerance—Inadequate moisture is one of the world's most pervasive wheat production problems. More than one-third of the total wheat area in developing countries consists of semiarid environments in which available moisture constitutes a primary production constraint. A number of advanced lines are in the late stages of development that are capable of yielding up to

3 t/ha under considerable drought stress. Some of these lines, such as Veery "S," yield up to 10 tons/ha under optimal irrigated conditions. Under limited or supplemental irrigation, these new materials appear to be more efficient in their use of available moisture and other inputs.

Tolerance to extreme temperatures—Many marginal production environments are characterized by either undesirably high or low temperatures. In more tropical locations, heat tolerance at the juvenile and later growth stages is a very important physiological trait for potentially successful cultivars. In this regard, our wheat breeders are working with new germplasm that tillers more profusely under high temperatures; these lines are also being evaluated at the end of the crop cycle for their tolerance to rapidly rising temperatures.

Many wheat-growing areas of the developing world experience cold winters, and therefore need either spring-habit germplasm that has some cold tolerance or true winter types. For a number of years we have been making spring x winter crosses (in conjunction with Oregon State University, USA) and selecting lines that show tolerance to lower temperatures. This crossing work continues, and some of the resultant F_2 populations are sent to national crop research programs so that they can select desirable germplasm directly. In the not too distant future, CIMMYT hopes to expand its winter wheat breeding activities to more rapidly develop high-yielding, winter-habit wheats for the colder environments of the Third World.

Tolerance to aluminum toxicity—It is estimated that highly leached acidic soils characterized by toxic levels of soluble aluminum may cover as much as one billion hectares in the tropical and subtropical areas of Brazil, east and southeast Asia and central Africa. Areas with acidic soils high in soluble aluminum are currently either undeveloped for agriculture or, where cultivated, are not very productive.

In collaboration with Brazilian scientists, CIMMYT initiated a shuttle breeding program in 1973 to develop high-yielding wheat varieties with tolerance to toxic levels of aluminum. In this cooperative breeding effort, several low-yielding Brazilian wheats with outstanding tolerance to acid soils and high levels of soluble aluminum were initially crossed with several high-yielding, broadly adapted Mexican semidwarf wheats.

The segregating populations were grown at three acid-soil locations in southern Brazil and selected materials were shuttled between Brazil and our main breeding sites in Mexico. Strong selection pressure for resistance to acid soil conditions was applied in each Brazilian location, and selections were made for stem and leaf rust resistance in northwest Mexico and for all three rusts and a complex of leaf-spotting diseases in Toluca.

In Brazil, strong selection pressure for tolerance to toxic levels of soluable aluminum is placed on wheat germplasm stemming from the cooperative Brazilian/CIMMYT shuttle breeding program (photo: compliments of Dr. Ottoni de Souza Rosa, Brazil).

Currently, more than 80 advanced-generation lines are in replicated yield tests and one short-statured, aluminum-tolerant line is being increased for distribution in Brazil. These lines appear to have good tolerance to high levels of soluble aluminum, as well as resistance to the three rusts and, surprisingly, to a complex of leaf-spotting diseases present in both Brazil and Toluca, Mexico. Some of these advanced lines yield up to twice as much as the varieties currently under commercial cultivation in Brazil.

Resistance to diseases—On the disease front, we are continuing to improve the resistance of CIMMYT wheats to the three rusts, even though the the levels of resistance are currently adequate for the majority of the developing countries. Acceptable levels of resistance to septoria leaf blotch are now available in CIMMYT germplasm, but higher levels of resistance are desired. We therefore plan to subject our materials to the stronger virulence septorias.

Much more emphasis is now being given to the so-called "minor" diseases of wheat, such as those caused by *Helminthosporium* spp., *Fusarium* spp., *Septoria nodorum*, and barley yellow dwarf virus (BYDV). As wheat moves into warmer production environments, helminthosporium and fusarium diseases are certain to become significant constraints to production; and while the losses attributable to BYD generally are not severe, they are quite widespread and appear to be on the rise. Sources of resistance to these organisms have been identified and we are in the process of pyramiding resistance genes and incorporating them into our high-yielding, semidwarf types.

Earlier maturing wheats—Another important research effort that we expect will benefit marginal production environments involves the development of earlier maturing wheat germplasm. Such materials are needed where there is only a short growing season available for wheat cultivation and/or where farmers seek to intensify their cropping systems, such as the rice/wheat rotations increasingly practiced in South Asia. We anticipate that the development of this trait will enable a significant increase in biomass production per unit of time.

Fuller exploitation of genetic variability—Most wheat breeding programs focus on crossing different strains of wheat within the same gene pool (e.g., spring x spring or winter x winter). As noted earlier in our discussion of cold tolerance, we have been and will continue exploring the potential of crosses between the spring and winter wheat gene pools. Such crosses are not only producing lines with improved cold tolerance, but also higher yield potential, better disease resistance, and many other desirable traits. CIMMYT's new Veery lines, derived from a cross of a Russian winter wheat (Kavkaz) and two CIMMYT spring wheats, are now setting yield records in many parts of the world, and over a surprisingly wide range of environments.

Introduction of alien genes—Another approach to increasing the yield dependability of CIMMYT's germplasm is the transfer to wheat of useful genes from related genera, such as wild grasses. The focus of this kind of wide cross work is not the improvement of genetic yield potential *per se*, but rather higher and more dependable yields through better resistance to pests and diseases and greater tolerance to environmental extremes.

Our first major involvement in wide crosses was with triticale, a program headed by a distinguished Canadian scientist, Dr. Frank Zillinsky (recently retired). Our continuing work on triticale is motivated by two major considerations. One is the observed capacity of triticale to perform better than wheat under a number of environmental and soil stress conditions. These include acid soils, cool highland temperatures, and certain heavy disease stress situations. In such environments, the best triticales often outyield our best wheat materials by as much as 100 percent. A second consideration is the greater total dry matter production of triticale compared with wheat.

Our wheat wide cross program holds great promise as a long-term approach to resolving stubborn production problems in marginal environments. Making such wide crosses generally involves the breaking down of natural barriers between plant species to allow the introduction of useful genes from alien genera into agronomic backgrounds of high crossability. Our breeders then incorporate these more readily accessible genes into our better advanced lines. We are currently focusing on a number of wild species (e.g. *Elymus*, *Agropyron*, *Aegilops* and *Haynaldia* spp.) that possess genes imparting greater resistance to certain diseases, as well as tolerance to salinity, temperature extremes, and moisture stress. The successful introgression of these desirable genes can lead to crop varieties with significantly greater tolerance to environmental stresses.

Changes in Regional and Cooperative Programs

A number of staff changes were made during 1982 to strengthen various regional and in-country programs; in so doing, our Headquarters staff was also strengthened.

- Dr. Patrick Wall, an agronomist, was added to the Andean regional program in South America to focus on a) identifying the farm-level constraints to small grains production and b) when time permits, the training of national program agronomists in the region.

- Dr. Santiago Fuentes, a pathologist, was posted to the North and West Africa and Iberian Peninsula regional program to work with national program pathologists and assist with the on-going disease surveillence activities in North Africa and the Near and Middle East.

- In late 1982, Dr. Homer Hepworth, the CIMMYT's representative in Pakistan, returned to Headquarters as Head of our wheat in-service training program. He was replaced in Pakistan by Dr. Peter Hobbs, a fellow agronomist.

- After 11 years in Turkey as a regional pathologist and our in-country representative, Dr. J.M. Prescott returned to Mexico to coordinate the pathology program activities at Headquarters.

- In mid-1982, the Wheat Program began a bilateral project with Bangladesh, bringing to eight the number of regional and bilateral programs operated by the Wheat Program around the world. Dr. Larry Butler, a breeder/pathologist and former CIMMYT post-doctoral fellow, is assigned to this 5-year project, which is funded by the Canadian International Development Agency (CIDA). His primary duties encompass all activities necessary to strengthen and support the Bangladesh national crop research program in its efforts to enhance domestic wheat production. In 1983, an agronomist will join the team.

- The bread wheat program in Mexico was strengthened by the addition to the staff of Christopher Mann, a former CIMMYT post-doctoral fellow.

- Finally, as mentioned earlier, Dr. Frank Zillinsky retired in mid-1982 from his long-held position as Head of the triticale program.

We would like to make special mention here of our unique relationship with the National Institute of Agricultural Research (INIA) of the Government of Mexico. INIA and CIMMYT share a common history dating back to 1943 and the initiation of the Rockefeller Foundation-Mexican Ministry of Agriculture Office of Special Studies. Both institutions sprang from these early efforts to improve Mexican agriculture, and the spirit of partnership and cooperation that was nurtured in shared adversity has endured. INIA has a strong and independent research program, and there

is a mutually beneficial free flow of germplasm between INIA and CIMMYT. We operate the summer cycle nurseries at El Batan and Toluca, but benefit from regular input by INIA scientists. During the winter cycle, CIMMYT is privileged to work with the Northwest Center for Agricultural Investigations (CIANO), a branch of INIA, on the CIANO experiment station near Ciudad Obregon in the State of Sonora. The farmers' organization of the area, known as Patronato, provides half the funds needed to support these winter nurseries. CIMMYT is very appreciative of this support; our hope is that through these joint efforts, we can continue to supply superior varieties to the farmers of Mexico.

A Personal Note from Byrd Curtis

December 31, 1982, marks the end of my first full calendar year as Director of the CIMMYT Wheat Program. During this period, I've spent much of my time travelling to most of the countries in which we work, meeting with our cooperators and discussing the progress made to date and the challenges that lie before us. I am extremely impressed with the mutual professional respect and personal warmth that pervades our working relationships with national crop program scientists.

The willingness to freely exchange ideas and information, as well as the enthusiasm with which research is undertaken, heartens me as I contemplate all that must be done in the coming years. CIMMYT is blessed with hundreds of allies in the international community of agricultural scientists and, given the time and resources necessary to do the job, I am convinced that together we will succeed in meeting the wheat production challenges of the 1980s and beyond.

Byrd C. Curtis
Director

Arthur Klatt
Associate Director

Bread Wheat

S. Rajaram and C. Mann

Introduction

Rapidly expanding human population in developing countries requires that the best scientific methods and technologies available be used to increase the production of cereals, legumes, and other plant and animal products. Production technologies that are appropriate for one country or region, however, may not be appropriate for other countries or regions. Many developing nations that produce wheat on a large scale, such as China, India, Turkey and Pakistan, can further increase their per hectare production by more fully utilizing improved varieties and by implementing better management practices.

Some smaller scale wheat-producing countries (e.g., Mexico, Egypt, Bangladesh and Zimbabwe) currently enjoy high levels of per hectare production; they can best increase total production by reducing losses due to diseases and by a wider use of appropriate agronomic practices. A third group of developing countries, those in which wheat is not widely grown because of adverse climatic conditions but which consume large amounts of the grain (e.g., Nigeria, Costa Rica and Thailand), should seek to determine whether wheat cultivars suitable for tropical areas can be produced and, if so, whether they can be profitably grown on a commercial scale.

Dr. Sanjaya Rajaram, Head of the bread wheat breeding program, examining materials in the 1982 crossing block (photo: J.L. Castillo).

Program Objectives

Many developing countries are afflicted with adverse production conditions, such as extreme temperatures, drought, soil salinity, toxic levels of aluminum in the soil and/or various diseases of wheat. The CIMMYT bread wheat program strives to increase wheat production in these countries by producing improved germplasm that is tolerant/resistant to specific environmental or disease problems.

To varying degrees, improved germplasm can be used to overcome such environmental problems as the aluminum-toxic, acid soils common to many tropical and subtropical areas (e.g., in Brazil, East Africa and elsewhere), the extreme heat in Sudan, extreme cold in the Middle East, and drought in central India. Pakistan and certain Middle East countries could benefit from germplasm with greater salt tolerance. The Andean region, East Africa, and

the highlands of Central America could increase their wheat yields substantially through the wider use of germplasm that is resistant to fusarium and helminthosporium diseases, as well as to barley yellow dwarf virus (BYDV). Table 1 offers a summary of the diseases that affect the major bread wheat-producing areas of the developing world.

Breeding Methodologies

The CIMMYT bread wheat improvement program employs the following interrelated methodologies:

- Shuttle breeding between two contrasting environments in Mexico: the CIANO experiment station near Ciudad Obregon in the northwestern state of Sonora (40 meters above sea level, 27.5° N latitude) and the high elevation Toluca station near Mexico City in the state of Mexico (2640 meters above sea level, 19.2° N latitude);

- Multilocational testing for disease resistance and tolerance to environmental stresses at more than 100 locations wordwide;

- Large numbers of simple and top crosses are made each year (more than 10,000 per year), using genetic material from around the world;

- Production and utilization of large F_2 populations (more than 3,000 individual plants in each population).

Each successive generation undergoes selection for disease resistance, semidwarf characteristics, spike fertility, plumpness of grain and longer leaf duration. Certain populations are also screened for their tolerance to high levels of free aluminum, saline soils and drought. Early and advanced generations are routinely screened for their milling and baking characteristics.

Germplasm Improvement

High yield potential and wide adaptation—In the development of advanced materials, the genetic variability inherent in thousands of lines is tapped. Crossing and selection for such characteristics as high yield potential, wide adaptation and disease resistance are central to the germplasm improvement process. More than 1,000 advanced lines were tested for their yield potential at CIANO station in 1982; the superior yield performance of fourteen such lines is presented in Table 2. A high correlation exists between the yield potential expressed at CIANO and yields obtained at many locations worldwide, provided that disease resistance is maintained. Advanced lines that perform well at CIANO are entered into CIMMYT's international nursery system to determine their yield potential and disease resistance under diverse production conditions.

Table 3 shows the average yield per hectare over five three-year periods in Mexico's irrigated Yaqui Valley (in the State of Sonora, northwest Mexico), specifying the predominant varieties grown during each period from 1968 to 1982. The significant yield increases registered from 1974 to 1982 resulted from the widespread use of improved varieties. A source of slight distortion in the data is the record average yield of 5.1 t/ha produced in the Yaqui Valley in 1982. Production conditions were better than usual, with temperatures for January, February and March averaging 1-2°C cooler than during the same months from 1960 to 1981 (Table 4).

Table 5 gives the average wheat yield per hectare for all of Mexico over five three-year periods, from 1968 to 1982. The 1982 yields in Mexico were at record levels. Continuous production increases have also occurred in India, Turkey, Argentina and Bangladesh, where CIMMYT-based, widely adapted (but locally bred) wheats are grown. Newly released varieties such as Glennson 81, Genaro 81, Ures 81 and Seri 82, derived from Kavkaz-Buho x Kalyansona-Bluebird cross ("Veery S"), continue to outperform other varieties in Mexico and in international trials.

Breeding for tolerance to drought stress—Breeding wheats for drought-stress environments (low rainfall or limited irrigation) is receiving increasing emphasis in the bread wheat program. We are seeking to identify lines that show a reasonably good response under drought-stress conditions and that respond well to an increased availability of moisture. The progenies of spring x winter crosses are grown under two irrigations at CIANO station. Selection criteria include longer leaf duration, tillering capacity, plumpness of grain and high yield potential. Advanced lines are regularly subjected to limited moisture conditions at CIANO and at CIMMYT's El Batan station (2249 meters above sea level, 19° N latitude). Tables 6 and 7 show the performance of 8 and 18 advanced lines, respectively, under drought-stress conditions in these environments.

Breeding for tolerance to free aluminum—The CIMMYT Wheat Program, the Brazilian wheat research institutes EMBRAPA, FECOTRIGO and OCEPAR, and the aluminum screening laboratory at El Batàn have collaborated for the past nine years in developing wheats with greater tolerance to high levels of free aluminum. Mexican and Brazilian wheats are used in a cooperative shuttle breeding program, and selections are made at alternate locations in Mexico and Brazil. Selection criteria include semidwarf plant type, high yield potential, resistance to diseases and especially tolerance to aluminum. These combined efforts have produced advanced lines with good yields, as can be seen in Table 8. These lines have been tested for disease resistance (Njoro, Kenya; Quito, Ecuador; Patzcuaro, Mexico) and tolerance to aluminum (Brazil), with encouraging results. For more details concerning our work on aluminum tolerance, see the *CIMMYT Report on Wheat Improvement* (1980 and 1981), as well as the *1983 CIMMYT Research Highlights*.

Breeding for highland environments—The highlands of East Africa, Central America and the Andean region are characterized by frequent, virulent and often simultaneous occurrances of *Fusarium* spp., *Septoria* spp., *Helminthosporium* spp., BYDV, *Xanthomonas translucens*, *Puccinia striiformis* (stripe rust), *P. graminis tritici* (stem rust) and *P. recondita tritici* (leaf rust). CIMMYT plant pathologists have produced good epidemics of the diseases caused by some of these organisms at the Toluca and El Batan stations during each of the last two years. High-yielding advanced materials with adequate resistance to the more commercially significant of these disease-causing organisms are now available (Table 9). One of our objectives is to increase the proportion of CIMMYT's wheat germplasm base that is suitable for highland production conditions.

Breeding for tropical areas—Recently, considerable interest has been expressed by donor agencies and potential beneficiaries in developing and promoting the cultivation of wheats for tropical environments. The United Nations Development Programme (UNDP) has funded an additional position within the CIMMYT bread wheat program to explore the potential in this area. A shuttle-breeding strategy is being employed, and one wheat breeder is assigned in Mexico to coordinate with cooperating national programs and to implement the associated breeding activities.

Despite the temperate and sub-temperate origins of wheat, CIMMYT believes that the crop can be grown economically during the cooler months in some tropical countries or regions (e.g., Bangladesh, Sudan, southern China, eastern India, southern Pakistan, West Africa, Paraguay, Brazil and the Chaco in Bolivia). These various areas can be classified by climate into two broad categories:

- Dry and warm, with no disease problems (e.g., Nigeria and Sudan);
- Wet and warm, where leaf rust, stem rust and helminthosporium diseases are prevalent (e.g., Bangladesh and Thailand).
- To develop wheats successfully for such environments, breeding and selection should focus on the following characteristics:
- Heat tolerance;
- Early maturity in some cases (e.g., Bangladesh) and medium maturity in others;

- Tillering capacity;
- Resistance to leaf rust, stem rust, *Helminthosporium* spp., and/or fusarium head scab.

Table 10 presents some of the varieties identified as resistant to *Helminthosporium* spp. in preliminary screening in Mexico, Brazil (Paraná), Bangladesh, and Zambia. Tests at the Toluca station have identified lines resistant to head scab, which will be discussed at some length in the pathology section of this report.

Poza Rica, Veracruz (Mexico) is the tropical location used for the selection of materials resistant to *Helminthosporium* spp. These materials are then screened for early maturity and resistance to leaf rust and stem rust at CIANO, El Batan and Toluca. Further testing for resistance to rust, *Helminthosporium* spp. and head scab is then carried out in Bangladesh and Brazil. It is anticipated that advanced lines will be available for distribution by 1985.

Screening for salt tolerance—Soil salinity is on the increase in such areas as Pakistan, the Middle East and northwestern Mexico, and could be greatly reduced through improved irrigation management and efficient drainage systems. Many governments, however, continue to develop new irrigation systems while ignoring the installation of needed drainage because of its considerable cost. In light of these realities, CIMMYT is attempting to screen for and identify wheats with tolerance to excessive soil salinity.

Intensive screening for salt tolerance began in 1982. Seed from 1500 advanced lines was soaked in 25 decisiemens/M^{-1} of sodium chloride (NaCl) solution; the supposedly salt tolerant variety, Candeal, was used as a standard check. Three hundred and twelve varieties germinated (including Candeal) and were subsequently potted in soil washed with a saline solution of 12 decisiemens/M^{-1}. Crosses will be made on the basis of results from these "pot trials."

Future Plans

Over the next five years, the CIMMYT bread wheat program hopes to achieve the following:

- Production of high-yielding and widely adapted advanced lines for the more marginal production environments in temperate and subtemperate areas, making full use of the genetic variability inherent in spring and winter wheats. Handling of the breeding populations may shift from the strict pedigree system now used to a pedigree-bulk method because of cost constraints.
- Production of high-yielding, widely adapted advanced lines possessing a) greater tolerance to toxic levels of free aluminum, saline soils, extremes in temperature, and moisture stress and b) improved resistance to the major diseases of wheat.
- Production of early maturing advanced lines for use in rice/wheat rotations in Asia.

The bread wheat program is producing high-yielding, disease-resistant germplasm with a range of maturities; early and medium maturities should be especially useful in more tropical production environments (photo: B.C. Curtis).

Table 1. Major spring wheat producing areas of the developing world, with regions and/or countries and their important diseases

Areas	Regions and/or countries	Important diseases or disease-causing organisms
Irrigated areas	Gangetic Plains of India, Indus Valley of Pakistan, Bangladesh, Tarai of Nepal, Egypt, Mexico, Zimbabwe, Libya	Stem rust, Leaf rust, Stripe rust
Non-irrigated areas with rainfall higher than 500 mm	Mediterranean North Africa, Middle East, China, Southern Cone countries	Stem rust, Leaf rust, Stripe rust, *Septoria tritici*
Non-irrigated areas with rainfall lower than 500 mm	Central India, certain areas of the Middle East, North Africa, Southern Cone countries	Bunts, Loose smut, Stripe rust
Aluminum toxic areas	Brazil, certain areas of East Africa	Stem rust, Leaf rust, *Septoria tritici*, *Septoria nodorum*, *Fusarium* spp., *Helminthosporium* spp., *Xanthomonas translucens*
Highland areas (elevation of 1500 MASL or more)	High Plateaus of Mexico, Guatemala, Andean countries, and East Africa	Stripe rust, BYDV, *Septoria tritici*, *Septoria nodorum*, *Fusarium* spp., *Helminthosporium* spp., *Xanthomonas translucens*
Tropical areas (latitudes of 23°N-23°S, excluding highlands)	Central America, Caribbean, South and Southeast Asia, West Africa	Leaf rust, stem rust, *Fusarium* spp., *Helminthosporium* spp., *Xanthomonas translucens*
Areas affected by soil salinity	Certain dryland areas of the Middle East and North Africa, Pakistan	Leaf rust, Stem rust

Table 2. Advanced lines of bread wheat showing high yield performance (10% or more than CIANO 79) grown at Cd. Obregon (CIANO) (40 MASL) under 5 irrigations (approximately 600 mm of water) in 1981-82

Cross and pedigree	Yield* (% of CIANO 79)	Yield (kg/ha)
VEE''S''	126	7924
CM33027-F-12M-1Y-1M-1Y-1M-0Y		
VEE''S''	118	7382
CM33027-F-12M-1Y-4M-0Y		
BJY''S''-JUP	117	6873
CM40038-21M-1Y-2M-0Y-81M-0Y		
BOW''S''	116	6816
CM33203-K-9M-2Y-1M-1Y-2M-0Y		
VEE''S''	114	7156
CM33027-F-12M-1Y-12M-1Y-1M-0Y		
BNQ''S''-HORK''S''xPVN''S''-MN72156	114	6917
CM57988-D-3Y-3Y-2M-1Y-0M		
BUC''S''-BUL''S''	114	6726
CM50609-3Y-1M-3Y-0Y		
BLL-KVZxPIMA	113	6639
SWM6986-1Y-521Y-1M-0Y		
BUC''S''-BJY''S''	112	6594
CM49641-32Y-4M-2Y-0Y		
SAP''S''-MON''S''	112	6581
CM40392-17M-1Y-0M-4M-44M-0Y		
BJY''S''-JUP	112	6580
CM40038-21M-1Y-2M-0Y-88M-0Y		
PVN''S''(PATO(R)-CAL/7CxBB-CN067)	111	6953
CM32535-4M-1Y-1M-1Y-1M-0Y		
PVN''S''-MN70121	111	6756
CM49893-2M-2Y-1Y-1M-1Y-0M		
PIMAxKAL-BB/CUC-HER	111	6743
CM57847-A-2Y-1Y-2M-1Y-0M		

* Yield percentages calculated from different experiments

Table 3. Average yield and predominant wheat varieties grown in the State of Sonora, Mexico, averaged over a 3-year period from 1968-82

Period	Total hectares (in 1000)	Yield (ton/ha)	Predominant varieties
1968-70	375	3.46	INIA 66, Siete Cerros 66
1971-73	294	3.96	Yecora 70, Cajeme 71
1974-76	426	4.80	Jupateco 73, Torim 73
1977-79	296	4.43	Nacozari 76, Pavon 76, Mexicali 76
1980-82	411	4.66	CIANO 79, Yavaros 79

Table 4. Montly average temperature (°C) during the wheat-growing season for the period 1960-81 and 1981-82 at the CIANO Experiment Station, Cd. Obregon, Sonora, Mexico

Period	November	December	January	February	March	April	May
1960-81	21	18	17	18	18	22	24
1981-82	22	17	15	16	17	22	24

Table 5. Wheat yields in Mexico, averaged over 3-year periods from 1968 to 1982

Period	Total hectares (in 1000)	Average yield (ton/ha)
1968-70	2518	2.80
1971-73	1940	2.96
1974-76	2446	3.63
1977-79	2056	3.70
1980-82	2512	4.03

Table 6. Advanced lines of bread wheat showing high yield performance (10% or more than Veery #5) grown at CIANO (40 MASL) under 2 irrigations (approximately 300 mm of water)

Cross and pedigree	Yield* (% of Veery #5)	Yield (kg/ha)
FURY-SLM75 x ALDAN''S'' CM47967-H-3M-2Y-3M-1Y-1Y-0M	116	4951
AZ67xCHR-D.D.05P/F12.71-BL0''S'' CM48326-A-3M-1Y-1M-2Y-1Y-0M	114	4859
MAYA74-NAC76 CM39424-1Y-1M-4Y-1M-1Y-1M-0Y	112	5188
VEE''S'' CM33027-F-12M-1Y-12M-1Y-2M-0Y	111	5701
BUC''S''-BUL''S'' CM50609-3Y-1M-4Y-1Y-0M	111	4744
LIRA''S'' CM43903-H-4Y-1M-1Y-3M-3Y-0B	110	5306
BUC''S'' CM31678-R-4Y-2M-15Y-0M-59B-0Y	110	4821
MAYA74-M0N''S'' CM29251-3M-17Y-4M-0Y-100Y-0B	110	4818

* Yield data from different experiments

Table 7. Advanced lines of bread wheat showing high yield performance (20% or more than Pavon 76) grown at El Batan (2200 MASL) with 376 mm of rainfall

Cross and pedigree	Yield (kg/ha)	Yield* (% of Pavon 76)	Flowering (days)	Maturity (days)	Height (cms)
BUC''S''-PVN''S'' CM52359-12M-2Y-2B-2Y-1M-0Y	5309	150	69	121	70
HER-MAYA CM46680-5M-1Y-3M-1Y-1Y-0M	3318	147	69	110	65
PVN''S''-SIS''S'' CM49894-35Y-1Y-1M-2Y-0M	4244	145	69	122	80
BJY''S''-JUP CM40038-21M-1Y-2M-0Y-81M-0Y	3380	134	68	104	60
F60314.76-ALDAN''S''xTTM''S'' CM60044-E-2Y-2M-2Y-0M	4668	132	66	105	55
PVN''S''-SIS''S'' CM49894-29Y-1Y-2M-1Y-0M	3827	131	64	124	80
ALD''S''-AZ67 CM51821-7Y-1Y-3M-1Y-0M	3812	130	62	107	60
4777(2)xFKN-GB/PVN''S'' CM49912-37M-1Y-1Y-1M-2Y-0M	3210	130	71	113	80
KAL-BB x YD''S'' CM49779-10Y-1M-1Y-2Y-1M-0Y	4576	129	64	108	60
4777(2) x FKN-GB/PVN''S'' CM49912-37M-1Y-1Y-2M-1Y-0M	3164	128	71	112	70
MIRLO''S''-BUC''S'' CM61949-13Y-1M-4Y-0M	3719	127	64	123	70
VEE''S'' CM33027-F-12M-1Y-1M-1Y-1M-0Y	2840	126	68	103	60
URES 81	4537	126	68	111	65
MYNA''S'' SWM4589-7Y-18M-1Y-0M	2778	123	59	107	55
F3.71-TRM SWM5704-10Y-1M-3Y-3M-2Y-3M-0Y	2778	123	67	110	55
BJY''S''-PRT CM50323-12Y-1M-1Y-0Y	2716	121	64	104	65
7C-NADxTOB''S''-8156/TRM CM46261-11M-1Y-1M-1Y-1Y-2M-0Y	3642	120	65	109	65
E7408-PAM''S''xHORK''S''-PF73226 F13906-F-2Y-3M-2Y-0M	3273	120	65	106	70

* Yield data from different experiments

Table 8. Aluminum-tolerant advanced lines of bread wheat showing good yield performance (4% or less than Ciano 79) grown at CIANO (40MASL) under 5 irrigations (approximately 600 mm of water)

Cross and pedigree	Yield* (% of CIANO 79)	Yield (kg/ha)
BNO''S''-CNT8 x ALDAN''S''-IAS58 CM58323-K-1Y-2Y-3M-1Y-0M	100	6407
{/PJxCNO67-7C(CNO67-INIAxBB/PCI''S'')/MENG}ALD''S''xYR-TRF''S'' CM58446-A-1Y-3Y-1M-6Y-0M	98	6333
MON''S''-ALD''S'' CM53460-4M-1Y-6Y-2M-1Y-0M	97	6411
MON''S''-ALD''S'' CM53460-4M-1Y-6Y-1M-2Y-0M	97	6396
MON''S''-ALD''S'' CM53460-4M-1Y-1Y-3M-1Y-0M	97	6393
PF70354-ALD''S'' CM47090-14M-1Y-1F-703Y-10F-705Y-2F-0Y	96	6243

* Yield calculated from different experiments

Table 9. Advanced lines of bread wheat showing high yield performance (10% or more than Chiva triticale) grown at the highland location of Toluca 2640 MASL) under rainfed conditions (100 mm rainfall)

Cross and pedigree	Yield (% of Chiva)	Yield (kg/ha)
BJY''S''-JUP''S'' CM40038-6M-4Y-2M-1Y-2M-1Y-0B	120	7790
F35.70-M0 x NAC CM43367-E-3Y-1M-3Y-3M-1Y-0B	114	7373
/JUP(7C-PATO(B)/LR64-INIAxINIA-BB/ANA CM37760-C-21Y-2M-1Y-3M-0Y	110	7109
YACO''S'' CM41195-A-13M-2Y-3M-1Y-1M-0Y	112	7234
/(KT-BAGExFN-U/BZA)TRM/ALDAN''S'' CM47941-Q-2M-1Y-4M-1Y-0M	120	7748

Table 10. Varieties and advanced lines resistant to *Helminthosporium* spp. currently used for crossing

Cross and Pedigree
BH 1146
CEP 7841
/7(MY54/N10-Y50xK.LINE)CD/7CJ''S'' PAT49 B13981-H-1Z-1Z-1A-1A-0A-1PTZ-0Y /7(MY54/N10-Y50xK.LINE)CD/7CJ''S'' PAT49 C13981-H-1Z-1Z-1A-1A-0A-2PTZ-0Y
MN 72135
PF 7339
PF 71131
CRT-ALD''S'' II 14055-0M-19LD-25LD-1LD-0Y
F3.71-TRM SWM5704-10Y-1M-3Y-3M-3Y-0B-1PTZ-0Y
/WRM(FN-TH(3)xK58-N(2)/MY54-N10BxAN''S'')/7KLT0-PAT19xM0-JUP SWM10703-503Y-1M-0Y
MON''S'' CM8288-A-3M-6Y-5M-1Y-0M
TOB''S''/CN067-JARxKVZ CM20707-A-1Y-8M-1Y-0Y-2PTZ-0Y
VEE''S'' CM33027-F-12M-1Y-1M-1Y-1M-0Y-60B-0Y-1PTZ-0Y
CHAT''S'' CM33090-N-1M-1Y-0M-59Y-0B-1PTZ-0Y
BOW''S'' CM33203-K-9M-2Y-1M-1Y-1M-0Y
BOW''S'' CM33203-K-9M-9Y-4M-4Y-1M-1Y-0M
OLN-TRM CM36820-10Y-1M-1Y-0M
PRT-JUP CM36876-3M-1Y-2M-0Y-1PTZ-0Y

Table 10. (continued)

Cross and pedigree
GH''S'' CM38795-H-6Y-1M-0Y
TES-PAM''S'' CM45984-9Y-1M-1Y-0Y
CAR853-COCxVEE''S'' CM47556-Q-1M-2Y-6M-0Y-2PTZ-0Y
ORE F1 158-FDL x KAL-BB/NAC CM47634-I-2M-3Y-1M-2Y-1Y-2M-0Y
CC-TOB(2) x MN72131 CM50308-5Y-3M-1Y-1Y-1M-0Y
CC-TOB(2) x MN72131 CM50308-5Y-3M-1Y-2Y-1M-0Y
CC-TOB(2) x MN72131 CM50308-5Y-3M-3Y-1Y-2M-0Y
CC-TOB(2) x MN72131 CM50308-5Y-3M-3Y-2Y-1M-0Y
TOB(2)-7C x MN72131 CM50309-3M-1Y-2Y-1M-0Y
TOB(2)-7C x MN72131 CM50309-3M-1Y-2Y-2M-0Y
ALD''S''-COC CM50351-9M-2Y-2Y-4M-0Y
BUC''S''-BUL''S'' CM50609-3Y-1M-2Y-5Y-2M-0Y
BUC''S''-NAC CM52178-2M-1Y-3Y-1M-0Y
PVN''S''-BJY''S'' CM52326-1M-1Y-1Y-2M-0Y
ERA-MN69146 x PVN''S'' CM52349-1MM-0MM
BUC''S''-PVN''S'' CM52359-12M-1Y-2Y-1M-0Y

Durum Wheat

G. Vázquez and P. Brajcich G.

Introduction

Tehuacan 60 was the first improved durum wheat cultivar to evolve from the early cooperative wheat improvement program conducted jointly by the Mexican government and the Rockefeller Foundation through the Office of Special Studies. This variety, which resulted from a cross of Caravaca x Ld 357-Capelli was a tall, good quality wheat, suitable for irrigated and rainfed lands in Mexico.

During the 1957-1958 cycle, bread wheat materials carrying dwarfing genes of several Norin lines were used as females in crosses to tall durums of various origins. The first groups of dwarf bread wheats and durums used in those crosses were the following:

Dr. Gregorio Vázquez, Head of the durum wheat breeding program, comparing medium-tall durum lines intended for drought-prone areas (photo: J.L. Castillo).

- Original dwarf bread wheat crosses used to improve durums:

  Yt54 x N10-B21
  Yt54 x N10-B22
  Yt54 x N10-B24
  Yt54 x N10-B28
  Wt x N10-B21
  Wt x N10-B26
  My54 x N10-B24
  My54 x N10-B26
  Fn x K58-N/N10-B21

- Tall durums used in the first crosses:

  Tremez Rijo
  Tremez Molle
  Aziaizh
  Durum H2
  Tacur Tipo 125
  Sert
  Gov.2325
  Cp^3-Giza
  Amarai Bianco
  Sernai Caich
  No.4 Mico-Jesus
  Ld357
  Ld375
  Beladi 116
  St. 464
  Rojal de Aguilas
  Camadi Abdu 103
  Navarro 302
  T. timopheevi
  T. glutinosum
  T. persicum
  Barrigon Yaqui (*T. turgidum* cv. *turgidum*)

- Heavy conventional back-crossing was then conducted, using the following durum materials:

  Barrigon Yaqui
  Tehuacan 60
  Caravaca 1
  Tremez Molle
  Tremez Rijo
  Sinai No.2
  Ramsey/Langdon
  Ld393/Yuma
  Ld357
  Ld370
  Ld372
  Ld390
  Ld392

The first experimental dwarf durum lines, such as Barrigon Yaqui Dwarf (BY_E), Tremez Molle Dwarf (TM_E), Sinai No. 2 Dwarf and Tacur 125 Dwarf, came from the approximately 625 backcrosses (of variable dosages) made during the late 1950s and early 1960s. These lines comprised the basic parental material for most of the dwarf and semidwarf durum wheats subsequently developed by CIMMYT.

The potential of these advanced lines for revolutionizing world durum wheat production was strengthened still further by increasing their resistance to the rusts (*Puccinia* spp.), particularly to stripe rust (*P. striiformis*). Improvements were also made during the same period in earliness (earlier maturing lines), daylength insensitivity (wider adaptation), fertility and yield stability.

The first dwarf durum cultivar released in Mexico was Oviachic 65, which had adequate disease resistance, good quality characteristics and high yield potential, but lacked daylength insensitivity and yield stability. By the 1968-69 winter cycle, many outstanding advanced lines with yields superior to Oviachic 65 had been identified. This group of lines constituted the parental material used to produce the Mexican cultivars Jori 69, Cocorit 71 and Mexicali 75, which are now very popular in many durum wheat areas of the world.

Continued improvements in adaptation, disease resistance, macaroni quality and agronomic type have made possible the release, to date, of 47 cultivars in 15 countries, all developed either directly or indirectly from CIMMYT durum wheat materials.

Yield Performance

High durum yields have been obtained at many locations around the world under varied production conditions. As grain type and fertility are improved still further in materials currently under development at CIMMYT, significantly greater yields are expected. The potential for increasing head size, test weight and 1,000 kernel weight is very good, and as these improvements are incorporated into the varieties released by national programs the result will no doubt be higher yields under both irrigated and rainfed conditions.

Table 1 summarizes the performance of some of CIMMYT's high-yielding, advanced durum lines, grown under irrigated conditions in Mexico's Yaqui Valley (in northwestern Mexico) during the 1981-82 cycle. Yields of well over 8,000 kg/ha were obtained with the advanced durum lines Shwa"S"-Mexi"S" x Yav"S" (CD24831), Shwa"S"-Yav"S" (CD26406) and others. This represents a 14 percent increase over the best yielding checks included in the trials. Tables 2 and 3 present the top-ranked, advanced lines and cultivars included in the 12th International Durum Yield Nursery (IDYN) and 10th Elite Durum Yield Trial (EDYT), respectively, distributed in 1980-1981 and grown under a wide range of environmental conditions. Samplings of 117 observations for the 12th IDYN and of 107 of the EDYT show average yields of over 4,000 kg/ha. This yield level is very satisfactory, considering the variability inherent in wheat production environments around the world.

Tables 4 and 5 provide some specific examples of widely adapted, advanced durum lines that have produced acceptable yields in multilocation, international testing (irrigated and rainfed environments). Yields ranging from 6,000 to 10,000 kg/ha under irrigation were reported in 1980-81 from a variety of locations around the world (Table 4). Satisfactory yields have also been reported for durums grown under rainfed conditions ranging from 125 mm of moisture per crop cycle in Cadiz, Spain, to 294 mm at Laxia, Cyprus, during 1980-81 (Table 5).

International yield testing of durum materials begins with the distribution of the International Durum Screening Nursery (IDSN). This nursery includes advanced lines that performed well in preliminary tests conducted in Mexico. The number of locations in which the IDSN is planted varies from year to year, ranging from 100 to 125 locations around the world. Cooperators at these testing sites return to CIMMYT such data as

yield, resistance to diseases and other responses, which are then summarized and published as Nursery Bulletins and/or in our annual reports. Tabulating these results constitutes the first step toward selecting widely adapted lines. Table 6 shows the type of summary data obtained utilizing the information returned by cooperators.

Breeding for Disease Resistance

The experiment stations at which CIMMYT operates in Mexico experienced a low and erratic incidence of diseases during the 1981-82 winter cycle and the 1982 summer cycle. Consequently, only limited and inconclusive disease data are presented here for the high-yielding durums harvested in the 1981-82 cycles (Table 1).

Disease data reported for the 10th EDYT and 12th IDYN (1980-81) show high coefficients of infection for stem rust (*P. graminis* f. sp. *tritici*), powdery mildew (*Erysiphe graminis*), septoria leaf blotch (*Septoria tritici*), barley yellow dwarf virus (BYDV), leaf rust (*P. recondita* f. sp. *tritici*) and stripe rust (*P. striiformis*), in that order. The best lines included in the trials, in terms of their resistance to major diseases, are shown in Tables 2 and 3. Table 6 summarizes the data reported for the more resistant lines included in the 12th IDSN (1980-81).

Table 7 presents a summary of the average coefficients of infection for the six most prevalent diseases of durum wheat, as reported in the 10th EDYT and 12th IDYN (1980-81). An average coefficient of 44.7 (11 observations) indicates the need for greater resistance to stem rust. This is particularly true for durum wheat areas with severe stem rust problems, such as Ethiopia and Kenya. Significant progress has been made toward incorporating resistance to stripe rust and leaf rust. Table 7 shows an average coefficient of infection for these diseases of 5.4 and 7.4, respectively, obtained from 18 and 30 observations.

Improving Agronomic Characteristics

Over the last 3 years, CIMMYT has distributed F_2 nurseries composed of medium-tall and tall segregating materials, from which may be selected agronomic types suitable for low rainfall and/or limited input areas. Requests for these materials are most numerous from the Andean region of South America, East and North Africa, and the Middle East.

A combination of North American and Canadian durum lines and high-yielding semidwarfs with good resistance to stripe rust and leaf rust are being used in a conventional backcrossing program to increase resistance levels in the F_2 nurseries. Durums that are well adapted to specific conditions in target areas (traditional and locally improved varieties) are also incorporated into the F_2 backcross program.

As noted earlier, the potential exists for significant increases in yield. The characteristics of 302 new, advanced lines with good yield performance were evaluated during the 1982 summer cycle at El Batan, in central Mexico. Fifty-one percent of these lines formed three or more grains per spikelet. Eighty-three percent had a hectoliter weight of 80 kilos or more, and 84 percent had a 1,000 kernel weight of 50 grams or more, indicating impressive gains in grain plumpness. We are working toward the incorporation of these two traits (more grains per spikelet and plumper kernels) into all the advanced durums being developed at CIMMYT.

The dry highlands of Turkey, Iran, Iraq, Afghanistan, Algeria and Morocco require durums with tolerance to cold temperatures. Crosses are therefore being made between CIMMYT durums and winter durum cultivars from Germany, Austria, France, Italy and Rumania. In addition, winter and facultative durum wheats from Turkey are being continuously and extensively used in the crossing program to enhance the cold tolerance of new germplasm.

Screening for drought tolerance is accomplished by subjecting the F_2 dryland nurseries to a zero irrigation regime during the summer cycle at El Batan, Mexico. These materials include genotypes produced by crosses between medium-tall to tall, drought-resistant materials and high-yielding, semidwarf durums

with good performance characteristics, as observed in the international trials distributed by CIMMYT.

Other characteristics, such as early maturity, reduced foliage, strong straw and solid stems are also being incorporated into CIMMYT durums.

Durum Wheat Quality

Heavy selection pressure for grain type, color and appearance is applied at the end of each crop cycle in Mexico. Ninety thousand individual plants were selected from early generation materials during the 1981-82 winter cycle (CIANO station, northwestern Mexico) and some 60,000 more were made during the 1982 summer cycle (El Batan station). Yellow berry, black point, grain plumpness and vitreousness are all critically appraised when screening these selections.

Grain protein is normally between 10 and 11 percent, and crosses between parental materials containing over 13 percent protein are made during each season. Pigment content in semolina and macaroni color are maintained at a minimum of 5.0 ppm, and gluten strength (medium-strong to strong) is closely monitored. New advanced lines possessing medium-strong gluten and satisfactory loaf volume with good bread-making potential are being developed through the extensive use of the North American cultivars Cando, Edmore, and Vick.

High-yielding, advanced durum lines with satisfactory macaroni quality were included in the 1982 international trials. The best of these are described in Table 8, and Table 9 presents those with satisfactory quality characteristics.

International Nurseries

The demand for international durum wheat nurseries in 1982 was 20 percent higher than in 1981. Table 10 shows the changes in demand for these nurseries over the last five years. Demand for the F_2 cold tolerant and F_2 stem rust-resistant nurseries has increased considerably.

CIMMYT distributes two main groups of durum materials: the F_2 segregating materials, and the advanced line nurseries. The latter group includes the Crossing Block (CB), the Elite Durum Yield Trial (EDYT), the International Durum Yield Nursery (IDYN), the International Durum Screening Nursery (IDSN) and a lesser number of Small Plots (PCs). These nurseries are listed in Table 10. The CB is distributed every other year to allow for better utilization of materials included in the nursery.

Summary and Future Plans

Most of the germplasm improvement work done within the durum wheat program revolves around the crossing block. Materials are classified according to the desirable characteristics they contain. The crossing block is assembled and

Dr. Pedro Brajcich (left) CIMMYT durum breeder, and post-doctoral assistants at work in the 1982 durum crossing block (photo: J.L. Castillo).

modified each year by combining the information obtained by a) the international nursery system, b) our cooperators in national wheat research programs and c) CIMMYT's travelling scientists. The 1982 crossing block consists of 24 groupings that represent a range of characteristics necessary for the production of high-yielding, widely adapted germplasm with good disease resistance (Table 11).

The CIMMYT durum wheat program's overall objective is to produce stable, high-yielding and widely adapted germplasm.

Although yield levels have increased significantly during the last decade, the potential for further improvement is great. The best opportunities for enhancing yields appear to be in improving kernel size and raising test weights. This will be done while maintaining good levels of protein and pigment content, as well as medium-strong to strong gluten, thereby raising the quality of the semolina that can be produced.

Because earliness is a means of escaping drought and certain disease epidemics, our program will emphasize the development and utilization of advanced lines having a short grain filling period. Tolerance to drought and cold will be prime considerations in developing germplasm for the Middle East and North and East Africa. Solid stems is also an important agronomic trait for resisting sawfly attacks in such areas as North Africa.

Breeding efforts will also focus on incorporating greater resistance to stem rust, powdery mildew, *Septoria* spp., BYDV and fusarium head scab. Adequate resistance to leaf rust and stripe rust has been observed in testing locations around the world, but we will continue to monitor resistance levels closely.

Table 1. Yield performance, agronomic and disease data of advanced durum lines, grown at CIANO, Sonora, Mexico, and compared with the best check variety (Y81-82)

Var. No.	Cross and pedigree	Yield (kg/ha)	Rank	% of best check	Days to flower	Plant ht	Yell rust	Leaf rust	Stem rust	Sept rust	Fusarium scab
17	FG''S''-DOM''S'' CM18548-1Y-1Y-1Y-4M-0Y	7785	1	100	79	80	20MS-MR	TMR	0	0	5
21	ATO''S''xAA''S''-PLC''S''/D67.2 CD10023-3M-4Y-4M-1Y-1M-0Y	7539	3	98	80	85	0	TR	0	84	T
43	MEMO''S''-GOO''S'' CD26136-1M-1Y-2Y-0M	7627	2	100	89	85	5MS-S	TMS	0	T	0
62	SCO''S''-RABI''S''xMEX175 CD28164-B-2M-1Y-1Y-0M	7456	3	101	84	75	TMS	5MR	0	0	T
64	BOY''S''-CIT71/(CR''S''-GS''S''xMARTE''S''/TLLO''S'')MEMO''S'' CD28166-F-1M-1Y-3Y-0M	7487	2	102	78	80	TR	TMR	0	41	T
68	SHWA''S''-MEX175xYAV''S'' CD24831-A-1Y-3M-1Y-1Y-0M	7698	1	104	79	85	0	TMR	0	T	5
103	ROKEL''S'' CD1895-12Y-0Y-2E-6B-0Y	7640	2	108	83	95	TR	0	0	53	0
115	SHWA''S''-MEX175-YAV''S'' CD24831-E-3Y-5M-1Y-0Y	8144	1	114	80	90	5MR	TR	0	T	5
154	GUIL''S'' CM14646-C-1Y-1M-1Y-0Y	8022	1	101	84	85	5MS	TMS	0	0	0
203	SHWA''S''-MEX175xYAV''S'' CD24831-A-1Y-3M-1Y-3Y-0M	7809	2	95	73	90	0	TR	0	T	5
211	(MEX175-CUMPI 2 x FAB''S''/P66.270)GOO''S'' CD27137-1M-1Y-6Y-0M	7870	2	97	73	80	TR	TMS	0	0	5
223	MALLARD''S'' CD1894-3Y-1Y-8M-1Y-0M	7813	3	96	76	90	0	TR	0	32	0
244	GDO VZ512-S15-JO''S'' L5-3AP-2AP-0AP	7505	2	96	83	100	10S	TMS	0	22	5
365	SHWA''S''-YAV''S'' CD26406-1B-1Y-2Y-0M-1Y-0B	8382	1	101	83	80	5MS	0	0	21	0
385	SHWA''S''-YAV''S'' CD26406-3B-2Y-7Y-0M-18Y-0B	8280	3	100	84	85	TMR	TR	0	0	T
395	SHWA''S''-YAV''S'' CD26406-3B-2Y-9Y-0M-3Y-0B	8317	3	96	87	85	30MR	0	0	0	T
396	SHWA''S''-YAV''S'' CD26406-3B-2Y-9Y-0M-11Y-0B	8351	2	97	86	85	TR	TR	0	0	T
461	CANDO-YAV''S'' CD-36440-3Y-4M-0Y	7524	2	100	80	95	5MS	TMS	0	31	T
575	SHWA''S''-YAV''S'' CD26406-3B-2Y-1Y-1M-0M	7848	1	101	82	85	TMS	TMS	0	0	T
613	(MEX175-CUMPI 2 x FAB''S''/P66.270)GOO''S'' CD27137-1M-1Y-2Y-1M-0Y	7987	2	99	77	75	0	5MR-MS	0	0	5
615	SHWA''S''-MEX175xYAV''S'' CD24831-A-1Y-3M-1Y-3Y-1M-0Y	7852	3	98	77	85	0	5MS	0	74	5
653	RUFF''S''-FG''S''xMEX175/SHWA''S'' CD22344-A-8M-1Y-1M-1Y-2Y-1M-0Y	7883	1	102	80	90	0	TR	0	0	0
670	CR''S''-MEXI''S'' L.92-6AP-1AP-0AP-2KE-0Y	7677	2	98	82	85	10S	5MR	0	0	10
748	(MEX175-CHUMPI 2 x FAB''S''/P66.270)GOO''S'' CD27137-1M-1Y-4Y-0M	7204	3	98	77	85	TMS	0	0	0	T
6	MEXICALI 75 (CHECK)	5839	-	-	74	90	50S-MS	5S	0	11	5
7	YAVAROS 79 (CHECK)	7717	-	-	80	95	20MR-MS	TR	0	0	5

Yield and agronomic data from Y 81-82. Plant height in cm; Yell rust = Yellow rust. Disease reactions represent the highest readings from several locations in Mexico. R = Resistant, S = Susceptible, M = Moderately, T = Trace. Reactions to *Septoria tritici* and scab are given in percentage terms.

Table 2. Top ranked durum wheat lines and varieties (yield, agronomic characteristics and disease resistance) from the 12th IDYN, 1980-81

Entry No.	Variety or cross and pedigree	Origin	Yield (kg/ha)	Test wt	1000 G.W.	Flow days	Lodg %	Leaf rust	Stem rust	Stripe rust	Powd	Sept trit	BYDV
1	RABI''S''xWLLS-65150/S15-CR''S'' CD4569-D-9Y-0M-0KE	Mexico						4		3	30	12	17
2	PG''S''-GGO VZ380xS15-CR''S'' CD10671-P-8M-3Y-4M-1Y-0M	Mexico						4	30			9	
3	SHWA''S'' HRL861-2B-0Y-2B-100Y-5M-0Y-1B	Mexico					6	3		0		4	17
4	7175/71110	USA						3				2	16
5	GUIL''S''-MEXI''S''xUSA.0575 CD-19576-G-1Y-1M-0Y	Mexico						2	31		23		
6	SHWA''S''xLDS MUT-PTL''S'' CD20631-502B-5Y-9B-1Y	Mexico			47			4		0			
7	DACK''S''-KIWI''S'' CD15647-3M-1Y-1M-1Y-0Y	Mexico					9				16		
8	SCAR''S''-GDO VZ579 CD9885-5M-2Y-1M-3Y-1M-0Y	Mexico		79	48			3		0		12	
9	AMAL72 D24102-10Y-3M-100Y-0M	Tunisia				94	5						
10	TIMGAD D27617-21M-300Y-0BK	Algeria		79	47		10						
11	S15-CR''S'' D33312-8Y-4M-2Y-0M	Mexico	4339										
12	FIRAT 1 CM9757-4D-4D-0D	Turkey	4361		46	95			1				
13	D67.2-GTA''S'' CM19314-3B-1B	Mexico		79		94				0			
14	CHI''S'' CD-1314-A-1Y-2Y	Mexico			45		7						
15	CINC''S'' CD4465-E-4Y-5M-0Y-0KE-1B	Mexico			45								11
16	WIN''S''-AA''S'' CD12454-3Y-11M-1Y-2M-1Y-0M	Mexico		79	49	97				2			
17	TOR''S'' CD12736-1Y-6M-0Y	Mexico									14		
18	OYCA''S''xGGO VZ394-CIT''S'' CD17717-5Y-3M-1Y-0M	Mexico						5					
19	SCA''S''-KIF''S''xAEG.ELONG-TAC.0Y CD19675-C-6Y-1M-0Y	Mexico	4390						13				
20	ALGERIAN 86	Algeria	4411	80						0			
21	NJORO231	Kenya	4404							0			21
22	ARONAS	Cyprus				96			23	2			
23	CANDO	USA					2		19		22	7	12
24	GOEY''S'' CM17274-3L-2L-1L-0K	Kenya				97							
25	DURATI	Australia					5	5					
26	Mexi 75	Mexico	4245		48	95		5					
27	YAV 79	Mexico	4339		46			4	31	0			21
28	CIANO 79	Mexico	4264					4	29		27		
29	CANANEA 79	Mexico	4569			93		0	2	2	8	11	
30	LOCAL CHECK		4492	79	45				24			4	14
	MEAN VALUES		4030.1	76.9	42.9	101.0	18.0	6.9	45.6	6.8	39.1	26.5	27.4
	NUMBER OF OBSERVATIONS		117	50	45	83	24	17	6	12	12	9	7

Reaction to rusts given as coefficient of infection, other diseases as percent
Test wt= Hectolitric weight in kilograms
1000 G.W.= 1000 grain weight in grams
Flow days= Days to flowering
Lodg %= Lodging percent
Powd = Powdery mildew
Sept trit= *Septoria tritici*

Table 3. Top ranked durum wheat lines and varieties (yield, agronomic characteristics, and disease resistance) from the 10th EDYT 1980-81

Entry No.	Variety or cross and pedigree	Origin	Yield (kg/ha)	Test wt	1000 GW	Flow days	Lodg %	Leaf rust	Stem rust	Stripe rust	Powd	Sept trit	BYDV
1	TEAL''S''-WIN''S'' x GAD''S'' CD16467-A-1M-4Y-10M-0Y	Mexico			48				10	0			
2	SCOTER''S'' D27625-0B	MEXICO		79				5					
3	GDO VZ469-PLC''S'' CM377-3M-2Y-1M-0Y-0B	MEXICO		80		102					14	21	
4	GOOSE''S'' CM10143-6M-3Y-1M-2Y-0Y	MEXICO		80			16				24	17	10
5	SNIPE''S'' CM13414-1Y-3M-0Y	MEXICO		79			11			0			
6	KINGFISHER''S'' CM14662-A-10Y-1M-3Y	MEXICO		80			12						
7	FRIGATE''S'' CM17904-B-3M-1Y	MEXICO	4392	79		102				0		14	
8	ZB-MAH x S15-CR''S''/MEXI''S'' CD1283-A-4Y-1Y-1M-0Y	MEXICO			51	102					15		
9	MALLARD''S'' CD1894-3Y-1Y-0M-1B	MEXICO											
10	MEXI''S''-GTA''S''S CD1896-1Y-3Y-0KE	MEX/KENYA	4276							1	20		
11	BOYEROS''S'' CD4404-B-9Y-3M-0Y	MEXICO	4267	79					24				
12	GTA''S''-TC60 x MEXI''S'' CD4853-E-1Y-1M-0Y	MEXICO	4369	79	49							22	
13	(RABI''S''/GLL''S'' x LDS-RL3601)FG''S'' CD7455-4Y-1M-0Y	MEXICO			48	102					20	19	13
14	RALLE''S''-BO''S'' x GTA''S'' CD7482-5Y-1M-1Y-1M-0Y	MEXICO			48					0			13
15	TUBENO''S'' CD7849-3M-1Y-5M-2Y-1M-0Y	MEXICO		79			9	5					
16	ATO''S''-AA''S''-PLC''S''/D67.2 CD10023-3M-4Y-4M-1Y-1M-0Y	MEXICO	4407							0		6	
17	BO''S''-GS''S'' x COOT''S''/RUF''S''-FG''S'' CD10454-5M-3Y-2M-2Y-1M-0Y	MEXICO						4	21				
18	LDS MUT-TEAL''S'' CD12427-6Y-4M-2Y-1M-0Y	MEXICO						3			17		12
19	DACK''S''-RABI''S'' CD12498-6Y-4M-2Y-1M-0Y	MEXICO		80	48					0			15
20	RUFINA''S'' CD12781-5Y-4M-1Y-1M-0Y	MEXICO		80	49			3		0			
21	TEAL''S''-WIN''S'' x GAD''S'' CD16467-A-5M-1Y-2M-0Y	MEXICO		79									
22	OV165-CP x FG''S''/RUFF''S''-FG''S'' CD16696-E-1M-2Y-1M-0Y	MEXICO					6	4	13	0	22		
23	ACU''S'' CD16907-B-1M-1Y-4M-5Y-0M	MEXICO						4	23	0		18	
24	DURO 73-IBIS ''S'' x OYCA''S'' CD17916-5Y-4M-2Y-0M	MEXICO	4310				15			0			14
25	(S15 x T.DIC-GLL''S''/PLC''S'')SNIPE''S'' CD18215-7Y-3M-1Y-0M	MEXICO	4312			101	15			0			12
26	MEXI 75	MEXICO	4480	79	50	98					25	14	
27	YAV 79	MEXICO		80				3	21		21		
28	NACOZARI 76	MEXICO				102	11		24			15	
29	CANANEA 79	MEXICO	4272			98		1	3	1	2	19	
30	LOCAL CHECK		4433	79	48					0		13	7
	MEAN VALUES		4154.3	78.0	45.3	103.4	20.3	7.9	43.9	4.0	31.9	27.9	21.1
	NUMBER OF OBSERVATIONS		107	33	38	80	22	13	5	6	9	7	7

Reaction to rusts given as coefficient of infection, other diseases as percent

Test wt= Hectolitric weight in kilograms
1000 GW= 1000 grain weight in grams
Flow days= Days to flowering

Lodg % = Lodging percent
Powd = Powdery mildew
Sept trit= *Septoria tritici*

Table 4. Highest yielding durum lines in selected irrigated locations, 10th EDYT and 12th IDYN, 1980-81

Nursery	Cross and pedigree	Place of test	Rank	Yield (kg/ha)
EDYT	Ato''S''xAA''S''-Plc''S''/D67.2 CD10023-3M-4Y-4M-1Y-1M-0Y	Manawatu, N.Zealand	1	5986
EDYT	Frigate''S'' CM17404-B-3M-1Y	Upper Nile, Egypt	1	7900
IDYN	Sca''S''-Kif''S''xAeg.Elong-Tac CM19675-C-6Y-1M-0Y	Arizona, U.S.A.	1	8132
IDYN	S15-Cr''S'' D33312-8Y-4M-2Y-0M	Guanajuato, Mexico	1	8644
EDYT	Boyeros''S'' CD4404-B-9Y-3M-0Y	Salisbury, Rhodesia	2	9599
IDYN	Chichicuilote''S'' CD1314-A-1Y-2Y	Sonora, Mexico	1	9612
EDYT	Ato''S''xAA''S''-Plc''S''/D67.2 CD10023-3M-4Y-4M-1Y-1M-0Y	Santiago, Chile	1	10709

Table 5. Highest yielding durum lines at various rainfed locations of the 10th EDYT and 12th IDYN, 1980-1981

Nurs.	Cross and pedigree	Place of test	Amount of rain (mm)	Rank	Yield (kg/ha)
EDYT	FRIGATES''S'' CM17904-B-3M-1Y	Cadiz, Spain	125	1	2840
EDYT	GTA''S''-TC60 x MEXI''S'' CD4853-E-1Y-1M-0Y	Joydebpur, Bangladesh	173	1	2721
EDYT	FRIGATES''S'' CM27904-B-3M-1Y	Alcalá de Henares, Spain	206	1	2378
EDYT	LDS MUT-TEAL''S'' CD12427-4Y-2M-2Y-2M-1Y-0M	Elvas, Portugal	220	1	3974
EDYT	RALLE''S''-BO''S'' x GTA''S'' CD7482-5Y-1M-1Y-1M-0Y	Foggia, Italy	247	1	4258
IDYN	Pg''S''-GGO VZ380 x S15-CR''S'' CD10671-P-8M-3Y-4M-1Y-0M	Foggia, Italy	247	1	3832
IDYN	SHWA''S'' x LDS MUT-PLT''S'' CD20631-502B-5Y-9B-1Y	Sevilla, Spain	262	1	4139
EDYT	ATO''S'' x AA''S''-PLC''S''/D67.2 CD10023-3M-4Y-4M-1Y-1M-0Y	Punjab, Pakistan	276	1	4577
IDYN	RABI''S'' x WLLS-65150/S15-CR''S'' CD4569-D-9Y-0M-0KE	Punjab, Pakistan	276	1	5000
IDYN	S15-CR''S'' D33312-8Y-4M-2Y-0M	Laxia, Cyprus	294	1	4678

Table 6. Superior durum wheat lines and varieties from the 12th IDSN, 1980-81

Variety or cross and pedigree	Values
Yield (26 observations):	kg/ha
GEDIZ"S"-BIT"S" CD24242-4Y-1M-1Y-0Y	4739.6
OVIACHIC 65	4682.0
CYUS"S"-SINCAPE9 x YEL"S"/CFN5-FG"S"xPTL"S" CD19981-I-3Y-3M-2Y-3M-1Y-0Y	4533.9
(GR"S"-S.CP x ST464/CR"S")GTA"S" CM19742-D-5Y-1M-2Y-2Y-0	4530.7
GOOSE"S" CM10143-19M-2Y-1M-1Y-0Y	4510.0
FRIGATE"S" CM17904-B-3M-1Y-0	4507.1
Days to flowering (32 observations):	Days
ROK"S" CD1895-12Y-1Y-8B-0Y	90.9
MAGHREBI 72	91.3
DURO73-IBIS"S" x OYCA"S" CD17916-4Y-3M-1Y-2M-1Y-Y	91.4
MEXICALI 75	91.4
FRIG"S"-REN"S" x RUFF"S"-GRA"S"/REN"S" CD28376-D-2M-1Y-0Y	92.5
GEDIZ"S"-FG"S" x GTA"S" CD16706-B-8M-5Y-3M-0Y	92.5
Days to maturity (8 observations):	Days
DURUM73-IBIS"S" x OYCA"S" CD17916-11Y-16M-0Y	148.4
MAGHREBI 72	148.6
GEDIZ"S"-FG"S" x GTA"S" CD16706-B-8M-5Y-3M-0Y	148.9
MEXICALI 75	148.9
DURUM73-IBIS"S" x OYCA"S" CD17916-11Y-18M-0Y	149.0
ROK"S" CD1895-12Y-1Y-8B-0Y	149.4

Table 6. (Continued)

Variety or cross and pedigree	Values
Resistance to leaf rust (16 observations):	Coefficient of infection
GTA''S''RABI''S'' x USA IV718/SCO''S'' CD16906-H-5M-2Y-7M-0Y	0.7
(PLC''S''xSALTI AUTMA HITI/FG''S'')MEXI''S'' CD16895-A-3M-2Y-2M-0Y	0.8
DACK''S''-KIWI''S'' CD124-9Y-2M-3Y-1M-0Y	0.9
DACK''S'' CM13919-11Y-2M-2Y-0Y-0KE-1B-0	1.0
(PLC''S''xSALTI AUTMA-HITI/FG''S'')MEXI''S'' CD16895-A-3M-2Y-3M-0Y	1.2
(S15-T.DIC-G11''S''/PLC''S'')SNIPE''S'' CD18215-7Y-3M-1Y-0M	1.3
FG''S''-AA''S'' x MAL''S''-MARIO''S'' CD14472-D-4Y-5M-2Y-1M-0Y	1.3
FG''S''-AA''S'' x MAL''S''-MARIO''S'' CD14472-D-4Y-2M-3Y-3M-0Y	1.3
Resistance to stem rust (9 observations):	
OYCA''S''-MAGH''S''-RUFF''S''-FG''S'' CD16913-B-2M-2Y-3M-4Y-0M	3.9
WAHA''S''-YAV''S'' CD23331-5Y-2M-2Y-0Y	4.0
PEN''S'' CD19858-B-2Y-1M-0Y	4.8
BIT''S''-YEL''S'' CD23780-2Y-2M-1Y-0Y	5.2
BIT''S''-GEDIZ''S'' CD20095-5M-1Y-1M-0Y	5.3
BOY''S''-SNIPE''S'' x GEDIZ''S''-CORM''S'' CD19832-A-5Y-1M-0Y	5.4
Resitance to stripe rust on leaf (12 observations):	
RUFF''S'' D27572-20M-3Y-3M-1Y-0M	0.0
FRIGATE''S'' CM17904-B-3M-1Y-0	0.0
(CYUS''S''/BD1814 x BD1708-BD1543)YAV''S'' D22009-B-7M-4Y-1M-1Y-0Y	0.0

Table 6. (Continued)

Variety or cross and pedigree	Values
Resistance to stripe rust on leaf (12 observations):	Coefficient of infection
SCO''S''-FG''S'' x GTA''S''(2)-S0179 CD20124-11M-3Y-2M-1Y-0Y	0.0
KIF''S''xRUFF''S''-FG''S'' CD12781-5Y-4M-1Y-1M-0Y	0.0
SCA''S'' CD12781-5Y-4M-1Y-1M-0Y	0.0
PEN''S'' CD19858-B-2Y-1M-0Y	0.0
DURO-IBIS''S'' x REN''S''/SNIPE''S'' CM18577-11Y-6Y-2Y-0Y-4B-0Y	0.0
JO''S''-CR''S'' x D. COLL 01 CD7473-24Y-1M-0Y	0.0
MISRI''S''-MEXI''S'' x SNIPE''S'' CD10662-F-1M-1Y-2M-3Y-0M	0.0
GR''S''(CP-ST464 x CR''S''/PLC''S'') CM17800-E-6M-2Y-0Y	0.0
Resistance to powdery mildew (5 observations):	Percent
MEXI''S''-MAGH''S'' CD3879-29M-1M-0Y-1B-0	6.6
LDS MUT-TEAL''S'' CD12427-4Y-2M-2Y-2M-2Y-0M	11.0
(PLC''S'' x SALTI AUTMA-HITI/FG''S'')MEXI''S'' CD16895-A-3M-2Y-0Y	11.0
GDO VZ469-PLC''S'' CM373-3M-2Y-1M-0Y	11.0
GTA''S''-MEXI''S'' x CIT71/SHWA''S'' CD22239-A-1M-2Y-5M-1Y-0Y	13.0
GU''S''-MEXI''S'' CD257-1S-2S-1S-0S	13.0
WIN''S''-USA02237 x GAD''S'' CD16559-C-7M-2Y-2M-1Y-0M	13.0
Resistance to *Septoria tritici* (6 observations):	
SCO''S'' D27526	35.0
GOOSE''S'' CM10143-19M-2Y-1M-1Y-0Y-1PTZ-0AP	35.2
BD1814 x BD1708-BD1543 D70-55-0BK	37.2

Table 7. Average coefficient of infection (ACI) for six prevalent diseases of durum wheat lines of the 10th EDYT and 12th IDYN, 1980-81

Disease	EDYT		IDYN		Total	ACI
	Obs.	ACI	Obs.	ACI	Obs.	
Stem rust *Puccinia graminis*	5	43.9	6	45.6	11	44.7
Powdery mildew *Erysiphe graminis*	9	31.9	12	39.1	21	35.5
Septoria *Septoria tritici*	7	27.9	9	21.5	16	27.2
Barley Yellow Dwarf Virus	7	21.1	7	27.4	14	24.2
Leaf rust *Puccinia recondita*	13	7.9	17	6.9	30	7.4
Stripe rust *Puccinia striiformis*	6	4.0	12	6.8	18	5.4

Table 8. Quality data, high-yielding durum lines from yield trials grown at CIANO, Sonora, Mexico, Y81-82

Var. No.	Cross and pedigree	PH	1000 KW	%Yell berry	%Black point	% prot	Car cont	Dry glut	Consis tency	Glut color
64	BOY"S"-CIT71/7(CR"S"-GS"S"xMARTE"S"/TLLO"S")MEMO"S"/7 CD28166-F-1M-1Y-3Y-0M	81.8	54.2	0	28	11.9	4.6	1.01	F	5
68	SHWA"S"-MEXI75xYAV"S" CD24831-A-1Y-3M-1Y-1Y-0M	83.4	49.8	1	2	11.3	5.2	0.84	F	4
98	SHWA"S"-MEXI75xYAV"S" CD24831-A-1Y-3M-1Y-4Y-0M	82.9	51.1	0	0	11.1	4.6	0.88	F	5
103	ROKEL"S" CD1895-12Y-0Y-2E-6B-0Y	80.8	53.2	0	0	10.2	5.7	0.82	F	5
154	GUIL"S" CM14646-C-1Y-1M-1Y-0Y	80.7	49.8	0	0	11.1	7.8	0.83	1/2 F	7
203	SHWA"S"-MEXI75xYAV"S" CD24831-A-1Y-3M-1Y-3Y-0M	83.0	51.5	1	3	11.1	5.0	0.82	F	5
211	(MEXI75-CHUMPI 2 x FAB"S"/P66.270)GOO"S" CD27137-1M-1Y-6Y-0M	83.1	57.5	2	2	10.5	5.4	0.91	1/2 F	7
223	MALLARD"S" CD1894-3Y-1Y-9M-1Y-0M	81.8	61.8	2	2	9.6	7.6	0.78	F	6
385	SHWA"S"-YAV"S" CD26406-3B-2Y-7Y-0M-18Y-0B	85.1	56.3	2	5	9.3	5.4	0.75	F	5
395	SHWA"S"-YAV"S" CD26406-3B-2Y-9Y-0M-3Y-0B	83.6	54.9	1	2	10.6	6.0	0.82	F	5
396	SHWA"S"-YAV"S" CD26406-3B-2Y-9Y-0M-11Y-0B	84.0	52.9	2	3	9.8	6.0	0.80	F	5
531	/MAL"S"(61.130-LDSxGS"S"-CR"S"/GS"S"-MEXI"S")7ROK"S"-MEMO"S" CD32038-B-1Y-4Y-3M-0Y	82.4	54.8	6	4	9.8	5.2	0.77	F	5
575	SHWA"S"-YAV"S" CD26406-3B-2Y-1Y-1M-0Y	84.2	53.5	1	3	10.2	6.3	0.75	F	5
585	/SCAR"S"(ZB-MAHMxS15-CR"S"/MEXI"S")7FRIG"S" CD27276-A-2M-3Y-1Y-1M-0Y	82.8	55.8	0	3	10.9	4.5	0.88	F	4
613	(MEXI75-CHUMPI 2 x FAB"S"/P66 270)GOO"S" CD27137-1M-1Y-2Y-1M-0Y	83.5	61.7	7	4	11.1	5.4	0.93	1/2 F	7
615	SHWA"S"-MEXI75xYAV"S" CD24831-A-1Y-3M-1Y-3Y-1M-0Y	83.1	50.2	1	3	11.3	5.1	0.84	F	5
653	Ruff"S"-FG"S"xMEXI75/SHWA"S" CD22344-A-8M-1Y-1M-1Y-2Y-1M-0Y	83.5	50.5	2	2	10.6	6.9	0.77	F	6
748	(MEXI75-CHUMPI 2 x FAB"S"/P66.270)GOO"S" CD27137-1M-1Y-4Y-0M	83.3	51.9	1	3	11.0	5.4	0.94	1/2 F	7
6	MEXICALI 75 (CHECK)	81.3	58.2	1	2	9.8	6.6	0.77	F	7
7	YAVAROS 79 (CHECK)	83.9	59.0	3	1	10.1	5.4	0.79	1/2 F	5

PH = Hectolitric weight in kilograms. 1000 KW = Grain weight in grams. %Yell Berry = Percentage of grains with yellow berry.
% Prot = Percent of protein. Car cont = Carotene content in parts per million. Dry gluten = Parts in 10 grams.
Consistency = S-Soft, F-Strong. Gluten color = Scale 1-10, ten the best.

Table 9. Durum wheat lines having good performance and good quality characteristics, Y81-82

Cross and pedigree	PH	1000 KW	% Prot	Pigment Cont	Gluten charac Cont	Consis	Color
GUILLEMOT"S" CM14646-C-1Y-1M-1Y-0Y	80.7	49.8	11.1	7.8	0.83	1/2 F	7
ROKEL"S" CD1895-12Y-2Y-2M-0Y	80.7	50.4	10.6	8.1	0.87	F	7
BD1543-INRAT69 * COO"S"/GTA"S" CD135557-J-3Y-3M-1Y-0M	80.1	79.8	10.0	7.8	0.82	F	7
DACK"S"-YEL"S" CD18057-4Y-3M-2Y-2M-1Y-1M-0Y	80.5	-	10.5	8.1	0.87	1/2 F	7
SHWA"S"-YAV"S" CD20626-5M-2Y-1M-0Y	81.7	47.8	11.5	9.0	0.95	F	6
SHWA"S"-YAV"S" CD20626-6M-2Y-1M-0Y	82.9	57.1	12.0	8.7	0.97	F	7
(JO"S"xGLD115-GLL"S"/F8D7)YAV"S" CD22123-B-1M-2Y-2M-1Y-1Y-2M-0Y	81.5	54.4	12.0	7.2	0.87	F	7
ERP"S"-MAL"S" CD23069-6Y-7M-1Y-0Y	84.1	52.8	10.8	7.5	0.78	1/2 F	7
(QFN-GLL"S"xGTA"S"/IBIS"S")B0Y CD23128-5Y-5M-1Y-2Y-1M-0Y	81.4	51.3	11.5	7.5	0.96	1/2 F	7
(S.0179-PH158xGTA"S"-S.0195/JNK)YAV"S" CD25126-A-1Y-3M-1Y-1Y-0M	82.5	45.0	10.7	9.0	0.88	F	7
MEMO"S"-MEXI75 CD26132-21B-1Y-1Y-0M	80.5	52.2	10.9	8.7	0.93	F	7
(MEXI75-CHUMPI 2 x FAB"S"/P66.270)G00"S" CD27137-1M-1Y-1Y-1M-1Y-0M	82.2	53.8	10.9	5.7	0.92	1/2 F	7
SHWA"S"-FG"S"xROK"S"-MEMO"S" CD32054-A-1Y-3Y-1M-0Y	81.9	44.7	10.3	6.4	0.92	1/2 F	7
{/(DACK"S"-CFN5xFG"S"/PTL"S")YEL"S"/RTTE-LDS}(S15-CR"S"/CIT"S"-AA"S"xFG)FG"S"	82.5	55.8	10.1	6.6	0.81	F	7
COCORIT 71 (CHECK)	80.0	53.8	9.8	2.4	0.79	F	2
MEXICALI 75 (CHECK)	81.3	58.2	9.8	6.6	0.77	F	7
YAVAROS 79 (CHECK)	83.9	28.9	10.1	5.4	0.79	1/2 F	5
CANDO (CHECK)	79.9	46.0	10.3	7.2	0.84	S	8

PH = Hectolitric weight in kilograms. 1000 KW = Grain weight in grams. Car. Cont = Carotene content, parts per million in semolin. Gluten cont = grams of dry gluten in 10 gr. Consis = Consistency S = soft F = Strong, Color = score 1-10, ten the best.

Table 10. Number of international durum wheat nurseries distributed during the period 1977-1982

	1977	1978	1979	1980	1981	1982
EDYT	28	14	-	68	40	85
IDYN	77	76	96	82	70	40
IDSN	98	79	101	94	70	114
CB	28	29	42	36	30	0
PC	-	-	10	10	15	10
F2 Dryland	46	50	52	50	40	59
F2 Irrigated	50	49	45	36	35	39
F2 Cold Tolerant	16	55	46	47	40	39
F2 Semi-tall to Tall	-	-	10	-	10	10
F2 Resistant to Stem Rust	-	-	-	-	5	30
Totals	343	352	402	423	355	426

EDYT = Elite Durum Yield Trial
IDYN = International Durum Yield Nursery
IDSN = International Durum Screening Nursery
CB = Crossing Block
PC = Small Increases

Table 11. Durum wheat varieties evolved from CIMMYT materials distributed throughout the world

Variety	Cross and pedigree	Country
KROUB 76	MASA 8Y-0M-0BK	ALGERIA
SAHEL 77	CIT''S'' x PG''S''-AA''S''/RUFF''S'' x ALBE''S'' CM14528-C-1Y-1M-0Y	ALGERIA
TASSILI 77	RABI''S''-FG''S'' CM-10162-76M-4Y-0M	ALGERIA
TELL 76	CR''S''-F3 TUN x AA''S''/FG''S'' CM10200-1BK	ALGERIA
TIMGAD 73	CISNE''S'' D27617-21M-300Y-0BK	ALGERIA
BALCARCEÑO INTA		ARGENTINA

Table 11. (Continued)

Variety	Cross and pedigree	Country
BUCK CANDISUR	(JO''S''xRD119-2W-4Y-/AA''S'')YEMEN''S''-CR''S''xPLC''S'' CD595-1LD-1LD-3LD	ARGENTINA
SACABA 81	AA''S'' CD22234-52M-3Y-1M-0Y	BOLIVIA
QULAFEN	L DE 357-$TC^2$60=$LD357_E$-$TC60^2$ D14540-1C-1Y-1C	CHILE
ARONAS	CIT''S'' D27617	CYPRUS
MESAORIA	AA''S''-VOLUNTEER D31728-3L-0L-1A-0A	CYPRUS
SOHAG 1	MEXI''S'' CM470	EGYPT
BOOHAI	COO''S''-CII CD3862-1BS-1BS-0GR	ETHIOPIA
HORA	TEZ''S'' CD10549-H-5M-2Y-5M-0Y	ETHIOPIA
DWL 5002	UNKNOWN	INDIA
DWL 5023	CR''S''-ID''S'' x CR''S''	INDIA
RAJ 1555	CIT71-RAJ911	INDIA
INBAR	$LD357E\text{-}TC60_2$ x JO''S''	ISRAEL
HAZERA		ISRAEL
GENGEWA	CR''S'' x 21563-GS''S'' CM9723-4M-1Y-D-2	KENYA
MWEWE	FG''S''-LEEDS CM9821-2M-1Y-F-1	KENYA
NJIWA	FG''S''-LEEDS CM9821-2M-1Y-F-2	KENYA
TEHUACAN 60	CARABACA 1- LD357 x CP D 255	MEXICO
OVIACHIC 65	PI 62-SINAI 2 x TC60 D 10224 B	MEXICO
CHAPALA 67	BYE-TC60 D 14571	MEXICO
TEHUACAN 67	(YT54E -N10B x D2/TC^2)1413.3 D 18140	MEXICO
PABELLON 67	PI''S''-ST.464 x $TC60^2$ D-19329	MEXICO

Table 11. (Continued)

Variety	Cross and pedigree	Country
JORI 69	BYE^{2}-TC60 x TC125E-TC60^{3} D-21563	MEXICO
COCORIT 71	RAE-TC60^{4} x STW63/AA''S'' D-27617	MEXICO
MEXICALI 75	GDO VZ469/JO''S'' x 61.130-LDS CM 470	MEXICO
YAVAROS 79	JO''S''-AA''S'' x FG''S'' CM 9799	MEXICO
CELTA	PLC''S''-RUFF''S'' x GTA''S''-RTTE CM17904-B-3M-1Y-OM	PORTUGAL
FAIA	PAME-OVI x MEXICAN DUR	PORTUGAL
FAISCA	OVI-CP	PORTUGAL
HELVIO	JO''S''-AA''S'' x FG''S''-YAV''S'' CM9799-126M-1M-5Y-OM	PORTUGAL
TIMPANAS	GDO VZ469-GR''S'' CM362-21M-2Y-7M-OY	PORTUGAL
SAHL	CR''S''-ALBE''S'' CM199-29M-1Y-1M-OY-OALG	SYRIA
WAHA	PLC''S''-RUFF''S'' x GTA''S''-RTTE CM17904-B-3M-1Y-1Y-OSK	SYRIA
AMAL	BELLE-TC^{2} x ZBW/TME-TC^{2} x ZBW D 24102	TUNISIA
BEN BACHIR 78	MEXI''S'' CM470	TUNISIA
GEDIZ	LD357-TC^{2} x JO''S'' D-27534	TUNISIA
KARIM	YAV''S'' CM 9799	TUNISIA
MAGHREBI	GLL''S''/BR180-LK x GZ-61.130 D26842-21Y-3M-OY	TUNISIA
DICLE 74	CIT71 D27617	TURKEY
DIYARBAKIR 81	LD393 x BELLE-TC^{2}/CIT71 SE 0364-1S-4S-OS	TURKEY
GEDIZ 75	LD375-TC^{2} x JO''S'' D 27534	TURKEY
GOKGOL 79	B BAL x BYE^{2} - TC	TURKEY

Table 12. Durum wheat crossing block, 1982

Group No.	Characteristics	No. of entries
1	Commercial varieties	37
2	High-yielding, advanced lines	27
3	Resistance to the three rusts	11
4	Resistance to stem rust	12
5	Resistance to leaf rust	14
6	Resistance to yellow rust	16
7	Resistance to *Septoria* spp.	29
8	Resistance to Powdery mildew	11
9	Resistance to *Helminthosporium* spp	8
10	Resistance to BYDV	17
11	Resistance to *Fusarium* spp.	18
12	Good quality	16
13	High pigment content	15
14	High protein percentage	11
15	Good test weight and 1000 kernel weight	11
16	High 1000 kernel weight	14
17	High test weight	20
18	High spike fertility	5
19	Large spike	7
20	Reduced canopy	9
21	Stiff stem	5
22	Earliness	14
23	Drought tolerance	6
24	Mutants	4
	Total	347

Triticale

F.J. Zillinsky and B. Skovmand

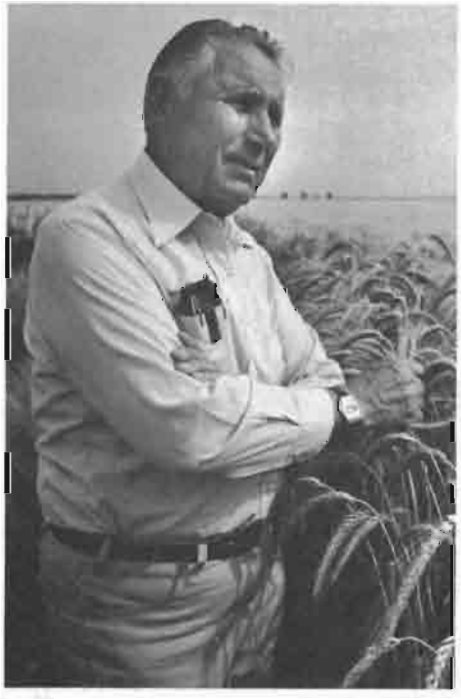
Introduction

As in CIMMYT's other small grains improvement programs, the overall objective of the triticale program is to produce high-yielding, widely adapted and disease-resistant germplasm. Within that context, specific breeding objectives include higher test weights, earlier maturity, improved industrial quality, increased tolerance to drought and aluminum-toxic soils, and greater resistance to various diseases. The latter objective has recently become more important due to the discovery in Australia of a new race of stem rust (*Puccinia graminis* f.sp. *tritici*) having greater virulence on triticale. This underscores the need for increasing the pathology input into the program, despite triticale's apparently high level of resistance to many diseases. One of the program's more recently implemented objectives is that of breeding for resistance to preharvest sprouting.

Breeding Methodologies

Breeding cycles—During the 1981-82 winter cycle in the Yaqui Valley, Sonora, Mexico, 272 lines were selected from 705 evaluated for inclusion in the 14th International Triticale Screening Nursery (ITSN). This nursery was sent to more than 100 locations around the world in the fall of 1982. The 14th International Triticale Yield Nursery (ITYN) was reduced from 50 to 40 entries, and was also sent to more than 100 locations worldwide in the fall of 1982.

The summer cycle suffered setbacks from heavy frost in Toluca that destroyed about 40 percent of the material, and severe drought in Huamantla, with essentially no survival. Heavy frost at the cooperating INIA station in Patzcuaro allowed the collection of only minimal data on resistance to *Septoria* spp. and fusarium head scab. The results obtained at the Toluca station were particularly disappointing, since increased emphasis is being placed on the screening of materials for improved test weights under adverse production conditions at this site, Toluca is representative of many highland areas to which triticale seems well adapted and in which triticale appears to have production advantages over wheat. While significant progress has been made toward improved



Dr. Frank Zillinsky (left) retired in mid-1982 as Head of the triticale program, and Dr. Bent Skovmand assumed leadership responsibilities (photos: T. Harris and J.L. Castillo).

test weights under favorable production conditions, additional research is still needed to enhance the test weights of triticales grown under adverse conditions.

A change in the breeding system—In a move toward greater efficiency, the triticale program recently switched from a straight pedigree selection system to a modified bulk system. This change in the selection system allows much of the genetic variation to be carried forward without flooding the program. Consequently, more "generation time" is available for reducing chromosomal imbalances, and heavy selection pressure in later generations can be applied more effectively. Under the modified bulk system, segregating generations will be managed as populations (through F_5), with each cross constituting a population. The early segregating generations (through F_3) are space planted and undesirable plants are eliminated, primarily on the basis of disease susceptibility.

In the F_4 generation, the populations are planted in yield trials to eliminate substandard populations. Since a fairly large amount of seed will be available it is envisaged that populations can be eliminated not only for poor yields and test weights, but also for inadequate quality characteristics. Individual plant selections are then made in the F_5 bulks and advanced to the F_6 as individual plant rows.

Thus, the modified bulk system allows for less rigidity in selecting substituted x complete crosses in early generations, as well as for the possibility of making earlier assessments of yield. This in turn could result in a considerable savings of time, land and labor. Also thanks to this change, only about 40 percent of the segregating material was lost to frost during the 1982 summer cycle. Under a straight pedigree system, losses could have been as great as 80 percent.

Improved Agronomic Characteristics

Yield and adaptation—Table 1 presents some results from the elite yield trial (second year yield trial); the yields and test weights of a number of substituted and complete triticales are shown, with Caborca 79 used as a check. Some lines from both groups outyielded the check variety by 10 percent, and had improved test weights as well.

Over the last two years, Chiva "S" has outyielded both Cananea 79 and Caborca 79 by an average of 6 percent, and showed a test weight of 73 kg/hl, compared to Cananea's 67 kg/hl and Caborca's 71 kg/hl. We are therefore substituting Chiva "S" for the other two varieties as the standard check in our testing programs; Chiva "S" has also been proposed for official release as a variety in Mexico for irrigated areas.

Table 2 presents some advanced lines from the first year yield trial that show both higher yields and higher test weights than Chiva "S." It therefore appears that the negative correlation between yield and test weight no longer exists; it follows that progress can now be made in breeding for both characteristics simultaneously (see Table 3).

Table 4 gives the yields and test weights from 60 and 44 locations, respectively, of the ten highest-yielding triticales from the 13th ITYN. Rank, yield and test weight of the long-term check varieties Beagle and Cananea 79 and of Caborca 79 are included as well. The top-yielding line was Juanillo 159, with an average yield of 0.5 ton more than the long-term checks, and 10 percent above that of Caborca 79.

Caborca 79 was included as a check in the 18th International Spring Wheat Yield Nursery (ISWYN), and ranked second only to a sister of the Veery cross. As seen in Table 4, some of the newer triticales have greater yield potential and wider adaptation than Caborca 79; it would be interesting to see how they would perform in comparison with the newest wheats. This, however, is not currently feasible as the newer triticales are generally too tall to be included in the ISWYN.

The karyotype information given in Table 4 shows that six of the ten highest-ranking triticales are completes, while four are substituted. A number of publications have suggested that complete triticales have higher yield potential and wider adaptation than the substituted types, and that work on the

latter should therefore be dropped. However, data collected during 13 years of international yield testing does not support the notion that complete triticales have an inherent yield advantage over substituted types; rather, it appears that the two groups have different patterns of adaptation.

Table 5 shows the proportion of complete to substituted triticales that ranked among the top ten lines at each of 19 locations from the 13th ITYN. The completes dominated at 7 locations, while the substituted types performed comparatively better at 12 sites. No pattern was evident across the other 41 locations reporting yields for the 13th ITYN. This indicates that dropping the substituted types from the program would severely reduce the availability of variation for adaptation, and those national programs located where the substituted triticales do best would not be well served by such a decision.

Table 6 presents some of the better yielding lines from the 13th ITSN. Some of these show both better yields and test weights than the checks, although the average test weight is still somewhat below that of wheat. In preliminary results from both the 14th ITYN and 14th ITSN, Juanillo showed similar yields: 4,543 kg/ha and 4,559 kg/ha, respectively. This suggests that still better lines are currently under development, and will be included in future ITYNs.

Test weight—Tables 6 and 7 show test weights and yields from trials in the Yaqui Valley and El Batan, respectively, as a percentage of the check Caborca 79. Progress toward improving test weights is evident.

Table 8 gives test weights of the best lines from the 13th ITSN over 7 locations. For the first time, the long-term checks ranked at the very bottom of the groups for this character. The best test weights averaged 72 kg/hl, which represents a considerable improvement, although still below the wheat check Pavon 76 (test weight 76 kg/hl).

Figure 1 shows the frequency distribution of test weights for over 500 new lines grown in nonreplicated plots at El Batan. Even under stressed conditions, lines have been obtained showing test weights of more than 75 kg/hl. Endosperm development should therefore be of less concern in the breeding program now that improved test weights are being regularly obtained; better test weights should result in higher flour yields.

Drought tolerance—A small scale program was initiated in 1982 to test for drought tolerance. Yield trials were planted in the Yaqui Valley under only two irrigations: one at planting for germination, and one after flowering. Table 9

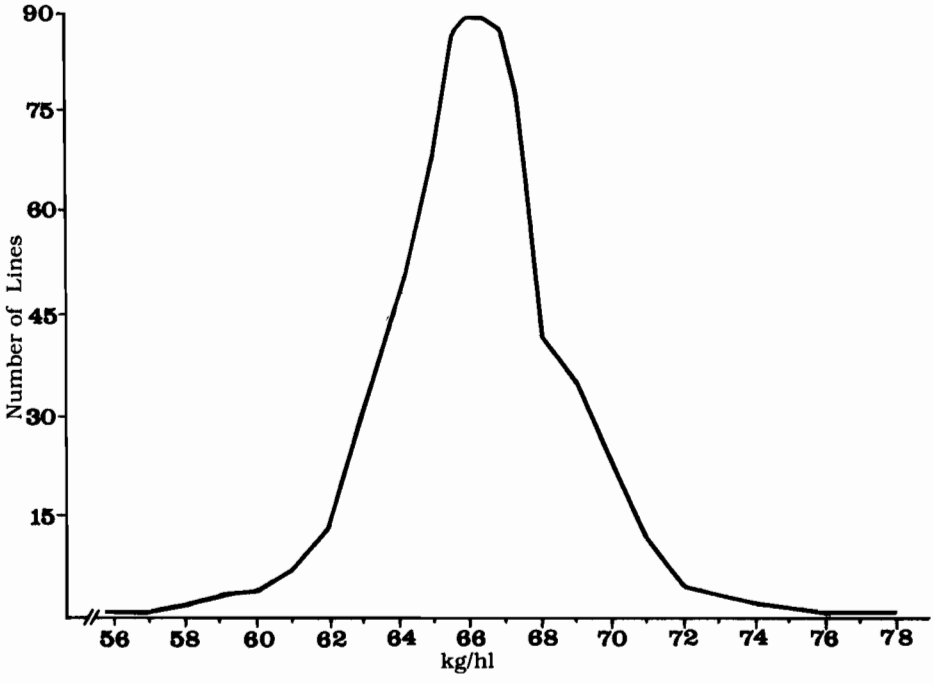


Figure 1. Frequency distribution of test weights for about 500 triticale lines under dryland conditions (< 400 mm).

presents lines that performed well under these conditions, and also under dryland conditions at El Batàn, where rainfall was less that 400 mm. Some of these lines showed yields and/or test weights 15 percent above Caborca.

Table 10 compares seven bread wheats selected for drought tolerance to seven complete triticales and to eleven substituted triticales. The complete triticales showed the best average yields. The best complete triticale outyielded the best wheat by 1,153 kg/ha and the best substituted triticale by 660 kg/ha. The differences among the groups were of considerable statistical significance. The complete complement of rye chromosomes apparently enhances drought tolerance. However, there are different kinds of drought; the substituted triticales may have advantages under specific types of droughty conditions, such as the terminal drought that occurred in Huamantla. In this situation, nine out of the ten best-yielding lines were substituted triticales.

Breeding for disease resistance—Doctor R. McIntosh of the Plant Breeding Institute of the University of Sidney, Australia, has identified stem rust isolates with specific virulence to the triticale resistance gene Sr27. When screening the 12th ITSN, he found about 70 percent of the lines to be susceptible. This indicates that triticales have previosly been protected by only one functional gene.

Because virulence on triticale is apparent only in Kenya and Australia, concern exists that resistance may be eroded during the selection process, where a better agronomic type will supersede a possibly more resistant variety.

Another matter for concern is that inoculum from wheat has normally been used in artificial inoculations of triticale. Thus, triticale that appears to be resistant to wheat stem rust may not be resistant to wheat stem rust with specific virulence on triticale. Efforts are therefore being made to collect biotypes from triticale and to increase the inoculum in the greenhouse, again on triticale. It is also possible that no virulence has been found on triticale because the rust was not recycled from triticale back onto triticale.

CIMMYT's pathology program has identified several lines of triticale with apparent resistance to scab (*Fusarium* spp.). Although more testing is required to confirm this, a number of crosses have been made using these lines.

Earlier maturity—Triticale normally flowers about a week earlier than wheat, but matures seven to ten days later. This pattern does not fit into a number of agricultural production schemes. An example is found in the Mexican highlands, where late rains in the early part of the crop cycle can easily delay planting, exposing farmers to early frosts in the latter part of the cycle.

The initial attempts to obtain earlier maturing triticales involved crossing early wheats to early ryes; the results were late-maturing triticales. However, a number of relatively early maturing lines have now been

This plant is one of the improved agronomic types now coming out of the triticale program; note the more erect heads and elongated peduncles (photo: T. Harris).

identified from among the segregating populations. Using the early wheat variety "Sonalika" as a check, Table 11 lists ten triticales that yielded 5-14 percent higher and matured earlier than the check variety at El Batan.

Preharvest sprouting—Toluca is a particularly good location at which to select for preharvest sprouting under natural conditions, because it rains almost daily during the growing cycle and during harvest. Field selection for sprouting was begun there in 1982. In addition, a rather simple technique borrowed from our Brazillian colleagues is being used to screen for sprouting. Spikes are selected in the field at maturity and submerged in water for about 18 hours. They are subsequently placed in a humidity chamber for an additional 72 hours. About 200 F_2 populations were subjected to this treatment; 25 populations showing less than 20 percent sprouting were selected. These populations will be planted in Toluca next January so as to mature in July and be exposed to daily rainfall though August and part of September. Selection for improved endosperm development appears to have decreased the susceptibility of triticale to preharvest sprouting.

Conclusion

Considerable progress has been made toward eliminating certain poor agronomic traits that have so far limited the adoption of triticale as a commercial crop in the developing world. Improvement in seed quality and test weight has been particularly impressive. Research to improve these and other traits will continue, with an emphasis on disease resistance, early maturity, and greater tolerance to environmental extremes. Moreover, we anticipate that the recently implemented modified bulk selection system will not only increase our efficiency, but will also give us greater flexibility and allow us to carry more genetic variation forward without overloading the program.

Table 1. High-yielding lines identified in the elite yield trial conducted at CIANO, Sonora, Mexico, during the 1981-82 winter cycle

Cross and pedigree	Yield (kg/ha)	As % of Caborca 79	Test weight (kg/hl)	As % of Caborca 79
ETYT I = SUBSTITUTED *				
Tesmo''S'' X 39860-7Y-2M-3Y-2Y-0H	7654	116	70.7	100
Tesmo''S'' X 39860-2Y-7M-1Y-0Y	7601	115	69.2	97
PTR''S'' - Castor''S'' X 31731-24Y-9M-0Y	7375	112	70.5	99
Vaca''S'' X 36437-7M-2Y-3M-0Y	7311	110	69.2	97
CML''S''-KALxIA-IRA X 39651-1Y-1M-2Y-1Y-0M	7311	110	74.2	105
ETYT II = COMPLETE *				
Merino''S''-Jlo B 2736	7590	121	73.9	103
Sika''S'' B 2683	7442	119	72.1	101
Civet''S'' B 2658	7053	113	73.4	103
Elk 37 B 507	6949	111	72.9	102
Elk 32 B 507	6772	108	73.0	102

* Substituted and complete refers to the karyotype, i.e. substituted triticales have one or more R chromosomes substituted by D genome chromosomes from wheat; complete triticales have all 7 rye chromosomes and have no D chromosomes

Table 2. Advanced lines (from experiments conducted during 1981-82 at CIANO, Sonora, Mexico) having better yield and test weight than the check Chiva"S"; relative heights are also given

Cross and pedigree	As a percent of Chiva (100%)		
	Yield %	Test weight %	Height %
PTR"S" x CML-FS1377/IA x CIN-FS658 X 51038-D-4Y-3Y-5M-0Y	106	100	74
Dingo"S" X 41047-A-1Y-2M-4Y-2Y-1M-0Y	104	103	96
UM 2038-GPR"S" x IA-M2A X 50267-F-4Y-2Y-1M-0Y	103	103	100
IRA-BGL/M2A-Arm"S" x BGL B 3023-305-0M	102	102	114
Hare B 2700-358-0M	102	101	125
Hare B 2700-499-0M	109	104	119
BGL"S"-CIN x Muskox B 2681-441-0M	109	104	129
Merino"S"-Juanillo B 2736-501-0M	105	104	113
M2A330-IRA(2) X 48524-3Y-2Y-1M-2Y-0B	102	101	96
Dack"S"-Wiloszanovskie/M2A(2)	101	101	96
(PG"S"-CENT BULK x ABN/IRA(2))M2A-FS3268 X 53751-F-3Y-1M-6Y-0B	103	104	100
Dingo X 41047-1Y-2M-1Y-2Y-2M-4Y-0B	106	104	100

Table 3. Correlation between yield and test weight at CIANO, Sonora, Mexico, for 6 International Triticale Screening Nurseries

ITSN 10 -0.48	
ITSN 11 -0.12	ITSN 13 -0.35
ITSN 12 -0.37	ITSN 14 +0.15

Table 4. Average yield (from 60 locations) and test weight (from 44 locations) of the ten highest yielding lines in comparison with Caborca 79 and the long term checks (C=complete; S=substituted) Cananea 79 and Beagle; karyotype is also given

Rank	Line	Yield (kg/ha)	Test weight (kg/hl)	Karyo-type
1	Juanillo 159	4543	67	C
2	Juanillo 97	4484	67	C
3	Topo 1419	4405	65	C
4	Mula''S''	4341	67	C
5	Boa''S''	4334	65	S
6	Chuu''S''	4229	66	S
7	Ram''S''	4219	63	C
8	Chiva''S''	4202	67	S
9	IRA-Drira=Elk''S''	4189	67	C
10	M2A(2)-STR''S''xIA-ABN=Mono''S''	4182	65	S
11	Caborca 79	4153	65	S
26	Beagle	4023	64	C
34	Cananea 79	3886	62	S

Table 5. The ratio of complete/substituted of the top ten triticales from nineteen locations from the 13th ITYN; the actual yield of the best complete and best substituted lines are given for each location

Location	Rank of 10 best Complete/Substituted	Yield (kg/ha) Best complete/Best substituted	
Ngaoundéré, Cameroon	10/0	3677	2285
Hei Lang Liang, China	8/2	4956	4600
Suwan Farm, Thailand	8/2	3340	2289
Svalöv, Sweden	7/2	3425	2997
Hohenheim, West Germany	7/2	5688	5070
Winnipeg, Manitoba, Canada	7/2	6757	5855
Cruz Alta, Brazil	7/3	1880	1509
Uttar Pradesh, India	1/9	3600	4400
Thessaloniki, Greece	2/6	5436	5705
Volle Bek, Norway	1/9	5000	5915
Krakow, Poland	2/8	3809	4612
Cordova, Spain	1/6	12777	13554
Aleppo, Syria	3/7	4950	5355
Izmir, Turkey	2/8	4885	5385
El Batan, Mexico	2/8	4952	5077
Tlaxcala, Mexico	1/9	5646	6105
Davis, California, USA	2/7	5547	5687
Langdon, North Dakota, USA	2/7	3671	4143
Brookings, South Dakota, USA	1/9	2352	2971

Table 6. Selected lines from the 13th International Triticale Screening Nursery, giving yield and test weight from 24 and 7 locations, respectively, in relation to the long term triticale checks and the wheat check Pavon 76

Cross and pedigree	Yield (kg/ha)	Test weight (kg/ha)
BGL Deriv (CIN-Pj62xPato/Bgl) B2824	5284	68.2
Wombat "S" X-39697-7Y-1M-2Y-0Y	5030	68.4
Muskox"S"-Juanillo B2659	4807	71.7
Muskox"S"-Juanillo B2659	4631	71.3
Merino-Juanillo B2709	4795	69.0
BgL"S"-CoqxIRA-CML B2264	4751	67.7
IRA-BGLxDrira-Kang B2658	4629	71.8
Juanillo	4560	68.7
Mex64-KS64xMIA/YE X32972-A-1Y-1M-1Y-1M-1Y-0Y	4497	68.9
Beagle	4188	63
Cananea 79	3757	63
Pavon 76	3492	77

Table 7. Advanced triticale lines (from three elite yield trials conducted at El Batan, Mexico) with improved test weights as compared to the checks Caborca 79 (triticale) and Genaro 81 (wheat)

Cross and pedigree	Test weight (kg/hl)	Yield as a % of Caborca 79
Trial I		
Sika B 2683	69.7	129
Juanillo 159	68.2	116
Caborca 79	60.0	100
Genaro 81 (wheat)	73.9	91
Trial II		
Dingo "S" X41047-A-1Y-2M-1Y-2Y-1M-2Y-0B	69.3	145
Dack "S"-Wiloszanowskie x M2A X53260-3Y-2M-1Y-0B	68.4	121
Genaro 81 (wheat)	74.4	108
Caborca 79	61.4	100
Trial III		
Merino - Juanillo B2736-298-0M	68.6	122
Zebra "S" B2672-1525-0B	68.7	112
Caborca 79	60.3	100
Genaro 81	74.4	93

Table 8. Lines from the 13th ITSN with good test weights, but only average yields and 1000 GW

Vty. No.	Variety or cross and pedigree	Test weight	Yield (kg/ha)	1000 G.W.
101	Pavon 76 (Hari)	77.3	3439.2	38.6
165	CIN-CNO x BGL/Merino"S" B-2700	72.6	4280.3	45.5
76	PND"S"-LNC X-35786-658H-1Y-1M-1Y-3Y-0H	72.3	3814.0	40.3
127	BCM"S" x M2A-IRA/FS1897 x IRA-CAL X-41047-A-1Y-2M-1Y-2Y-0H	72.0	3845.8	40.8

Table 8. (Continued)

Vty. No.	Variety or cross and pedigree	Test weight	Yield (kg/ha)	1000 G.W.
166	CIN-CNO x BGL/Merino"S" B-2700	72.0	4306.2	44.0
167	CIN-CNO x BGL/Merino"S" B-2700	71.8	4142.3	45.2
149	IRA-BGL x DRIRA-KANG B-2658	71.8	4629.0	47.2
70	PND"S"-Castor"S" X-35781-182H-1Y-2M-1Y-0Y	71.7	4378.7	44.7
153	IRA-BGL x Juanillo B-2659	71.7	4806.9	49.7
28	PTR"S"-Castor"S" X-31731-8Y-3M-1Y-2M-1Y-1Y-0H	71.7	3998.0	40.1
126	BCM"S" x M2A-IRA/FS1897 x IRA-CAL X-41047-A-1Y-2M-1Y-3Y-0H	71.7	3709.8	38.3
156	(IRA-BGL)(2) B-2670	71.7	3971.8	44.7
137	TRR"S"-MPE/PND"S" x M2A-IRA X-47220-A-2M-1Y-1Y-0H	71.4	2996.5	37.1
78	PND"S"-ADX"S" X-35905-423H-2Y-1M-1Y-1Y-0H	71.3	3430.4	41.1
158	IRA-BGL x Juanillo B-2671	71.3	4631.1	45.7
52	STR-PND"S" X-34530-564H-1Y-1M-1Y-0Y	71.2	3471.3	40.7
154	IRA-BGL x Juanillo B-2659	71.2	4233.9	47.7
84	PTR"S"-M1A X-36471-22M-2Y-1M-2Y-2Y-0H	71.2	4070.2	41.5
118	(KLA x OCTO-HEXA/IRA-CAL)M1A X-40912-J-1Y-1M-1Y-0Y	71.2	3584.2	37.6
160	IRA-BGL x Merino"S" B-2672	71.1	4069.8	49.5
60	PTR"S"-M1A X-34824-501M-500Y-504B-500Y-501Y-0M	71.1	4127.5	43.6
31	PTR"S"-Castor"S" X-31731-8Y-3M-1Y-1M-0Y	71.0	3794.8	40.0

Table 9. Performance of 6 complete and 2 substituted triticales under limited irrigation at CIANO, Sonora, Mexico, and under rainfed condition at El Batan (less than 400 mm) in comparison with Caborca 79

Rank	Line	Average yield (kg/ha)	Average test wt. (kg/hl)	Yield in kg/ha	
				CIANO	El Batan
1	MUSKOX[2]	4494	68.6	5030	3958
2	MUSKOX 658	4246	68.3	4867	3625
3	Pg"S"-CENT BULKxABN/IRA-CML* x 39697-7Y-1M-2Y-0Y	4058	64.0	5075	3041
4	CIVET B2658	4018	68.7	4940	3097
5	MULA X18330-3M-2Y-2M-1Y-2M-0Y	3981	64.6	4640	3291
6	HARE"S" B2700	3981	71.5	4838	3125
7	BCM"S"-1A* X31186-6Y-4M-1Y-2M-0Y	3948	66.6	4820	3076
8	BTA"S"-LNC X36535-2H-2Y-1M-2Y-0Y	3945	68.4	4974	2916
9	Caborca	3552	60.4	4563	2541

*substituted triticales

Table 10. Comparison of bread wheat (7 lines), substituted (11 lines) and complete (7 lines) triticales in dryland field trials* at El Batan, Mexico, 1982

Groups	Average yield of groups	Yield range	
		High	Low
Bread wheats (7)	2702	2812	2465
Substituted triticales (11)	2561	3305	1944
Complete triticales (7)	3230	3965	2575

*Yield trial with three replicates and split by groups; 2.4 m^2 harvested with border left on all four sides

Table 11. Earlier maturing triticale lines grown at El Batan, Mexico, 1982

	Cultivar/lines	Pedigree	Yield		Maturity (DAS*)	Test wt: (kg/hl)
			kg/ha	As a % of Sonalika		
1	BCM(INIA-TK x H616.71/FS 477)	X-58617-3YP-2MP-0Y	6062	114	104	65.3
2	TED"S" x M1A-BCM	X-60904-1MP-3Y-1MP-0Y	5910	111	104	64.7
3	PND"S" x M2A-M1A/IRA^{2}-TORO"S"	X-62080-M-1MP-3Y-1MP-0Y	5909	111	106	71.8
4	TCLE^{3}-ARM"S" x IRA-M2A/PND6	X-63073-901M-1YP-1MP-0Y	5866	110	106	68.8
5	RAT"S" x MSF-IRA	X-61178-4MP-1Y-1MP-0Y	5818	109	104	66.0
6	{(IA-M2A x P162/BGL"S") INIA-TK x H616.71/FS477) PND-CASTOR-MPE	X-61884-G-1MP-1Y-2MP-0Y	5802	109	106	68.2
7	FS1018-PND"S"	X-56733-1YP-3MP-0Y	5799	109	104	70.7
8	RATEL"S"	X-38302-D-1M-1Y-2M-0Y	5724	107	103	65.0
9	PND1-RAT"S"	X-59585-1MP-4Y-1MP-0Y	5686	107	107	68.5
10	PND4 x PND"S"-MPE"R"{H 277.69 x TOR"S"-TOB66/FS1023{((TOB-8156 x CC/INIA)SPY) M2A}}	X-63722-A-1YP-1MP-0Y	5573	105	105	69.6
	SONALIKA (early=Bread Wheat check)		5325	100	108	78.4

*Days after seeding

Barley

H. Vivar and P. Burnett

Introduction

During its first decade, the CIMMYT barley program concentrated on generating widely adapted germplasm with high yield potential, resistance to lodging, hulled and hull-less grain, and high nutritional quality. Substantial progress has been made in these areas. The CIMMYT barley program, which is now conducted in close collaboration with our sister institute ICARDA (International Center for Agricultural Research for the Dry Areas), has a number of improved, semidwarf hulled and hull-less barley lines, as can be seen in Table 1. In 1982, maximum yields at the CIANO station (near Ciudad Obregon in the state of Sonora, northwestern Mexico) were on a par with those obtained in previous years, the better lines averaging 5-6 tons/ha.

Dr. Hugo Vivar (right), Head of the barley program, and Dr. Peter Burnett, the pathologist assigned to the program, are giving high priority to improving the disease resistance of CIMMYT's barley materials (photo: T. Harris).

The major problem with this advanced material is its susceptibility to leaf rust (*Puccinia hordei*), stripe rust (*P. striiformis*, a particularly severe problem on barley in the Andean region of South America), scald (*Rhynchosporium secalis*), barley yellow dwarf virus (BYDV) and *Helminthosporium* spp. Thus, the program's current overriding objective is to incorporate much greater disease resistance into the good agronomic types already developed.

Disease Resistance

The 1982 summer cycle was generally successful in furthering the development of barleys with improved disease resistance.One exception to this was our site at Huamantla, which underwent an extreme drought. This limited selection to resistance to stem rust (*P. graminis* f. sp. *hordei*). The Huamantla location experiences considerable climatic variability from one year to the next, calling into question the site's usefulness as a disease-screening location. Since the program is now focusing on disease resistance, the use of Huamantla may be discontinued for the foreseeable future. The only other problem occurred during the 1981-82 winter cycle at the CIANO station, where leaf rust development on barley was poor.

In contrast, good artificial epidemics of both scald and leaf rust were obtained at the El Batan station in central Mexico. The Toluca station (central, highland Mexico) was the site used most extensively for disease screening; excellent epidemics of

scald, leaf rust and *Helminthosporium* spp. were achieved, and many lines were also screened for stripe rust resistance. The program was also able to screen for resistance to lodging.

Efforts to incorporate disease resistance into barley will potentially benefit all barley-growing areas, but most of CIMMYT's activities focus on the Andean region, Ethiopia, Southeast Asia and Bangladesh. The Andean region faces a particular problem with stripe rust (Race 24). Initial screening done in the area has identified a number of CIMMYT lines with good resistance to this disease. These are shown in Table 2, and have been added to the new crossing block. Lines from the VEOLA (Latin American Observation and Disease Nursery) showing good levels of stripe rust, albeit susceptible to leaf rust, have also been included in our crossing program.

A shuttle breeding program has been developed between CIMMYT and the Andean Region. F_2 material is sent from CIANO and El Batan to Quito, Ecuador, where CIMMYT personnel work with local cooperators and regional staff to select and return resistant materials to Mexico. Some of these resistant lines are presentd in Table 3. Based on preliminary results, this approach appears to be an extremely effective way of building stripe rust resistance in our advanced materials.

The variation in resistance to leaf rust observed between one screening site or region and another (see Table 4) has spawned a plan to collect leaf rust inoculum from all areas in Mexico where rust nurseries are located and to use it in field inoculations at the Toluca, El Batan and CIANO stations. In addition, advanced lines that exhibit promising resistance in any location will automatically go into our crossing block. This variation in resistance among regions further underscores the advantages of a shuttle breeding system.

Table 5 presents a number of lines that have shown excellent scald resistance in Ethiopia, considered a scald "hot spot". We plan to expand our scald and leaf rust screening, and to carry out virulence surveys of our target areas with the help of our cooperators.

A persistent problem in our efforts to screen for disease resistance is that we receive very little disease information in the nursery reports returned by our cooperators. We are therefore making a concerted effort to meet or correspond directly with these cooperators to stress the importance of this information, which is so useful to us in directing the crossing program.

The first CIMMYT BYDV nursery was distributed in 1982 to 16 cooperators, with entries selected during the winter in Toluca. Previous crossing block entries have come from screening done at Davis, California, USA (see Table 3) and Quebec, Canada. Shuttle breeding for BYDV could be developed among one or many sites.

Table 6 shows eleven barley lines reported as resistant to fusarium by our Chinese cooperators. Prior to this reporting, we were unaware of any fusarium-resistant barley material. Efforts are underway to incorporate this resistance more widely into our germplasm base.

Greenhouse screening for scald and net blotch (*H. teres*) were initiated during 1982.Initial results show a good correlation between the susceptibility expressed in the greenhouse and that expressed in the field. This type of screening will be very useful for eliminating early generation materials. In the 1982 summer cycle, we eliminated 40 percent of our F_2 lines in the field at El Batan due to scald. By eliminating most of these entries prior to planting, the efficiency with which we use our limited land resources can be improved.

Hull-less Grain

Hull-less barley offers three advantages:

- It has more edible dry matter and retains more vitamins and minerals than the hulled types, which lose part of their nutritive value when the grain is pearled;
- It is threshed more easily, and can be eaten immediately;
- Some hull-less barley lines can be used to make flour mixtures that are suitable for making bread (up to 20 percent barley flour and 80 percent wheat flour of good baking quality).

CIMMYT has made wide use of the variety "Godiva" in developing hull-less types, and currently about 30 percent of our material is hull-less. We have had some difficulty in obtaining lines that suffer no embryo damage during threshing and de-awning for mechanical planting purposes. We may revert to handling the material manually, which in any event would be how it is handled in our target areas since it is a crop that is generally grown by subsistance farmers. Fifteen sets of the first International Naked Barley Yield Trial (INBYT) were distributed to cooperators this year.

Earlier Maturing Lines

Early lines would be of use in areas with environments that are marginal for barley (e.g., high elevation locations with short growing seasons, and areas with short rainy seasons), in areas where earliness can be used to escape disease losses, or in crop rotations where the time to crop maturity is limited. Over the last 5 years, the program has been seeking cultivars that mature 20-30 days earlier, with little reduction in yield. Some of these lines are presented in Table 7.

Spring x Winter Crosses

Our spring x winter crossing program offers new prospects for improved germplasm appropriate to areas in need of long-season varieties, such as Spain, Argentina and Chile. A winter crossing block of 183 entries is grown at Toluca to satisfy this need, and also to impart greater disease resistance and yield potential to spring material. The crossed material is then grown at the CIANO station, where selections are made for spring characteristics. In 1981, fifty-one sets of F_2 generation spring x winter populations were distributed to cooperators in key locations around the world.

Nutritional Quality

The addition of the high-lysine gene from the variety "Hiproly" has led to the development of several advanced lines with considerably higher protein levels than are normal in barley. Fifty sets of the quality crossing block were distributed to cooperators in 1981. While this work is continuing, it has low priority in the program.

International Nurseries

The number of countries and cooperators receiving CIMMYT barley nurseries increased in 1982. Table 8 offers a comparison between the number of nurseries distributed in 1981 and in 1982. We have reorganized the crossing blocks and in the future will be more selective in choosing recipients for our F_2 nurseries.

Commercial Production

Two CIMMYT barley lines have been recently released in Portugal and soon will be going into commercial production. They are:

- Enxara, CM67-U.Sask1744 (CMB72-45-19Y-2B-2Y-1B-1Y-0B).
- Camponesa, Por-U.Sask1766 (CMB72-76-6Y-3B-1Y-0B).

Dr. Art Klatt (left) and Dr. Vivar scoring the disease reactions of potential introductions into the barley program germplasm base (photo: T. Harris).

Table 1. Comparative yields of barley lines from trials conducted at CIANO experiment station, near Cd. Obregon in northwest Mexico (40 MASL) and Toluca (2640 MASL) Mexico

Cross and pedigree	Yield (ton/ha)	
	Cd. Obregon (1981-82)	Toluca (1982)
1. Hull-less genotypes		
(NP842-APMxCM67-U.SASK1800/CAL.MRxDS-APRO)2762-BC	4.9	
/(AS46-KRISTINA/APM-DWARF21xPOR-IB65)CELAYAxDS-APRO/ PRO-BEACON	4.8	
ORE"S"xEMIR-NACKTA, AST9071		4.7
IB65-M66.85xCEL		4.6
2. Hulled genotypes		
PISTACHO	6.0	
DL69-BAHTIM10 x H251	6.0	
BACANORA"S"		5.8
TROMPILLO		5.8

Table 2. Cultivars and lines resistant to stripe rust after field inoculation with race 24 in Cochabamba, Bolivia, 1982

Genotype	Reaction	Cultivar	Reaction
WI 2231	TMR	CI 14032	5MS
DUCHICELA	5MS	BREA"S"-DL70xMOZDOSKY-NOPAL"S" CM-78-1018-9-1Y-1B-1Y-1B-0Y	0
BENTON	0		
KOBER	TMS	M69.77-SHI.R.KCI N087xCELAYA"S"-5106 CMB76A-96-12Y-1B-2Y-2B-1Y-1B-0Y	5MR
NADJA	TMR		
TRIUMPH	0	ZOAPILA* (Mexico)	100S
BIGO	TR	ATLAS* (USA)	90S
Abyssinian	5MS		
Jet	5MR		

Table 2. (continued)

Genotype	Reaction	Cultivar	Reaction
Nigrinudum	TMS		
PI 382318	5MS		
PI 382372	TMR		
PI 382457	0		
PI 382720	TR		
BENTON 4D	TR		

* Commercial check varieties

Table 3. Cultivars and lines showing field resistance to BYDV in 1982 at Davis, California, and good field resistance (20MR or less) to race 24 of stripe rust in Cochabamba, Bolivia, 1982

Genotype	Mean reaction out of 4 disease readings (scale 0-9)
DORADA	0.75
(CI 2375-CI 12225-CAN-MCU29/Tib)xCI 12225-23d	1.00
UNA 1614	1.00
ESC. II.72.83-3E-7E-5E-1E	1.25
BOY-MCU3048.1DxCI 1463.3D II-14127-1PI-5V	1.50
ROW 906/73	1.50
E-II-69-47-5E-2E-7E	2.00
(BOY^2-$SURB^3$) x CI-12225-23d	2.00
(PI-14116-13d-CI 12225)xCI-12917-37d	2.25
CI 2325-CI 12225 x BOY(2)-SURB(3) II-15263-3PT-3V	2.25
CLIPPER*	6.50

* Susceptible check variety

Table 4. Leaf rust reactions of three differential varieties for *Puccinia hordei* (5 locations in Mexico), 1981-82

Genotype	Resistance gene	Reaction in				
		El Batan	Toluca	Refugio	Patzcuaro	Obregon
Bolivia	Pa2+Pa6	20MRMS	10MS	80S	40S	90S
Peruvian	Pa2	TMSMR	TMS	0	TMS	10MR
Gold	Pa4	20MS	20MS-S	10MR-MS	10MS-S	30MS

Table 5. Varieties and lines resistant to scald (*Rhynchosporium secalis*) and net blotch (*Helminthosporium teres*) in Holetta, Ethiopia, 1982

Number	Genotype
1	BREA"S"-BENTON CMB75-522-4Y-500B-0Y-500B-0Y-500B-501Y-0B
2	Il 258.L-2171 7Y-0B
3	LITTLE BEN
4	USDA 11122
5	DUCHICELA
6	PERU
7	76.12.3
8	PI 382720
9	GOBERNADORA"S" CMB78-1176-B-3Y-1B-1Y-1B-0Y
10	PI 323195
11	CONGON"S" CMB74A-967-6M-1Y-500B-0Y
12	EH163/F3-45-3H-3-3
13	EH165/F3-3-8H

Table 6. Scab-resistant CIMMYT lines in China, 1982

Number	Genotype
1	NACKTA 501Y-502B-500Y-0B
2	SM4142-NACKTA CMB77-875-1Y-2B-1Y-1B-1Y-0B
3	NACKTA-HJA A33 CMB76A-261-1B-1Y-1B-1Y-1B-0Y
4	(APM-1B65x11012.2/API-CM67xDS-APRO)NACKTA CMB76A-151-4B-1Y-1B-4Y-1B-0Y
5	B1xMARI-COHO CMB76A-266-4H-4Y-1B-2Y-2B-0Y
6	B1xMARI-COHO CMB76A-266-3H-1Y-1B-1Y-1B-0Y
7	BETZES-COHO KRONSTAD 75-2-5B-500Y-0B
8	FRESNO"S" CMB77A-454-1B-500Y-500B-501Y-500B-0Y
9	FRESNO"S" CMB77A-454-1B-500Y-500B-501Y-502B-0Y
10	CLLO-CI12010xPUEBLA CMB76-950-F-2B-1Y-1B-1Y-1B-0Y
11	GOBERNADORA"S" CMB78-1176-B-3Y-1B-1Y-1B-0Y

Table 7. Yield of barley lines from trials conducted at CIANO, northwest Mexico, 1981-82

Cross and pedigree	Yield (ton/ha)
BAIQUILLO"S" CMB78-369-7Y-1B-1Y-1B-3Y-0B	4.6
HJA A33-M66.85 CMB74A-721-1B-1Y-1B-2Y-1B-0Y	4.3
MONA - GATEWAY 63 x 31 CMB77-302-4Y-3B-2Y-1B-1Y-0B	4.2
ATHS - HJA A33 CMB74A-232-1B-1Y-2B-1Y-1B-0Y	4.1
MONA (Check)	3.7

Table 8. Number of barley nurseries distributed by CIMMYT in 1981 and 1982

Nursery	Number of sets	
	1981	1982
F2 Spring x Spring	40	49
F2 Spring x Winter	50	50
F2 Andean Zone	20	30
CB Crossing Block (Normal)	40	50
CB Crossing Block (Nutritional quality)	25	50
CB Crossing Block (Disease resistance)	50	50
IBON International Barley Observation Nursery	100	118
IBYT International Barley Yield Trial	85	98
INBYT International Naked Barley Yield Trial	-	15
BYDV Barley Yellow Dwarf Virus Observation Nursery	-	16
Total	410	526

Pathology

E. Torres, G. Bekele and J.M. Prescott

Introduction

The work of the CIMMYT wheat pathology program revolves around four main objectives:

- To establish leaf rust (*Puccinia recondita tritici*) and stem rust (*P. graminis tritici*) epidemics in breeders' nurseries at the CIANO, Toluca and El Batan experiment stations, as well as septoria epidemics at the Toluca station, and to manage off-station nurseries so as to assess reactions to these diseases;
- To screen for resistance to head scab (*Fusarium* spp.);
- To identify adequate seed-dressing chemicals for suppressing seed-borne inoculum of Karnal bunt (*Tilletia indica*, syn. *Neovossia indica*), thereby alleviating potential barriers to the international movement of experimental seed;
- To assist in the training of young scientists from developing countries in the philosophy and methodologies of the CIMMYT pathology program.

Dr. Enrique Torres, (second from right), CIMMYT pathologist, working with pathology trainees in the greenhouse (photo: J.L. Castillo).

Leaf and Stem Rust

Selection for resistance—During the 1981-82 winter cycle in the State of Sonora, northwest Mexico, there was no substantial development of either leaf rust or stem rust in commercial wheat fields. The screening of CIMMYT materials for rust resistance on the CIANO station, therefore, continued to depend on artificially induced epidemics, which in this cycle developed very slowly and reached lower levels than in previous years. This pattern can be attributed to unseasonably low temperatures at the onset of the epidemic in February, and to a narrowing of the virulence range in the rust inoculum. The cool weather also resulted in a spotty appearance of stripe rust (*P. striiformis*) throughout the Yaqui Valley (State of Sonora).

The inoculum used to initiate the rust epidemics consisted of spores that were collected in bulk during the previous year in the States of Sonora and Sinaloa (also in northwest Mexico). The lack of naturally occurring rust populations in recent years has led to the use of "tamed" rust inoculum. Table 1 shows the drastic narrowing of the virulence range of spore samples taken in 1982. Over 60 percent of the isolates from northwest Mexico

possessed virulence genes only for resistance genes Lr-1, Lr-2c, Lr-10, Lr-14a, Lr-14b and Lr-17. In 1978, more than 33 percent of the isolates taken from Sonora carried joint virulence against Lr-2a, Lr-2b, Lr-3, Lr-11 (El Gaucho) and Lr-30 (Terenzio), in addition to the current, simpler set of virulence genes. Stem rust inoculum maintained its narrow spectrum of virulence, limited to groups RTQ, RPQ and QFB. (Nomenclature refers to the coding system used at the U.S. Department of Agriculture, Cereal Rust Lab, St. Paul, Minnesota, USA. See *1978 CIMMYT Annual Report on Wheat Improvement*, pp. 82-83.)

No similar problems arose at the Toluca station; rust epidemics developed well, and glume infection by *P. striiformis* was especially common. Leaf rust and stem rust epidemics reached average levels of severity.

Off-station nurseries—These nurseries were grown during the winter cycle at Rio Bravo (State of Tamaulipas in northeastern Mexico) and during the summer cycle in El Refugio (State of Guanajuato, in the fertile Bajio region). The off-station nurseries, which consist of parental material [the crossing block nursery (CB)] and advanced lines [the small plot nurseries (PCs) and the International Bread Wheat Screening Nursery (IBWSN)], are exposed to a broader spectrum of rust populations. Rio Bravo is part of an epidemiological unit that stretches from northeast Mexico through the Great Plains of the US, and into the Prairie Provinces of Canada. El Refugio is on the San Luis Potosi plateau, where populations of *Mahonia* spp. may act as alternate hosts for wheat stem rust.

Leaf rust reached moderate to high levels on susceptible material in Rio Bravo [60S on Jahuara 77 (= Bluejay "S") and Hermosillo 77 (= Magpie "S")]. The reactions of Veery lines recently released in Mexico ranged from MS for Glennson 81 (= Veery No. 1) to 20S for Ures 81 (= Veery No. 2). El Refugio nurseries experienced high infection levels of stem rust, but no change in the reaction of advanced lines was recorded.

Leaf rust and stem rust differentials—CIMMYT and INIA jointly conduct field and greenhouse studies on the virulence composition of leaf rust and stem rust populations. Disease assessments of leaf rust and stem rust differential lines, which consist mainly of single-gene backcross lines, complement greenhouse data of the type given in Table 1. A typical set of leaf rust readings from winter nurseries is shown in Table 2. Some significant regional differences are apparent between Rio Bravo and the northwestern sites: in Rio Bravo, lower infection levels and different infection types were obtained for Lr-14b, and higher values were obtained for Lr-20, Lr-23 and Lr-24.

Septoria Diseases

Selection for resistance—Since 1981, all bread wheat nurseries grown in Toluca have been spray inoculated with laboratory-cultivated *Septoria tritici* and *S. nodorum*. This is done to expedite selection for resistance in segregating populations. In 1982, a supplementary inoculation procedure was introduced; chopped straw from diseased plants was spread along the rows at the late tillering stage. Results show that this method provides sufficient primary inoculum to establish septoria epidemics.

Intense epidemics caused by naturally-occuring septoria inoculum were observed in nurseries planted in Patzcuaro, Michoacan, Mexico. The 3rd through the 9th IBWSNs were devastated by *S. nodorum* and *S. tritici*. In the more contemporary material (current CB and PC nurseries and the 16th IBWSN) families and/or individual plants were selected for their superior performance under this severe disease pressure and planted in the 1982-83 Yaqui Valley nurseries. The best entries (based on agronomic type and rust resistance) will enter the Fourteenth International Septoria Observation Nursery (14th ISEPTON).

Data from the 11th ISEPTON—The 11th ISEPTON was distributed after the 1979-80 crop season. It consisted of 143 entries selected for their resistance to *Septoria* spp. in Patzcuaro, and was sent to 34 countries around the world. Results from 19 sites for *S. tritici* and from 9 sites for *S. nodorum* were subsequently analyzed in 1982.

The resistant check IAS20, a Brazilian line, appears to combine the highest levels of resistance to both pathogens, showing severity levels of 4 on the 0-9 scale. It is also in the parentage of the cross CMH76.480 (=IAS20-H567.71), which occurs as entries 134, 135 and 141. The last entry exhibited a severity rating of 5 for *S. tritici* and 4 for *S. nodorum*. It was also the top yielding entry in the nursery, with an average of 4.5 t/ha (6 sites).

Condor "S" is another advanced line commonly found in the parentage of top-performing crosses, especially that of Kvz-Con (=SE 1006), which is represented in entries 57, 58, 59 and 61. All these sister lines showed a severity index of 4 or less for *S. tritici*, and no more than 5 for *S. nodorum*.

Fusarium Head Scab

Screening for resistance—The screening procedures used for identifying resistance to head scab (caused by *Fusarium* spp.) are still being evaluated by the program. However, data from field and greenhouse inoculations indicate that several bread wheat lines are highly resistant to the disease. These lines are listed in Table 3 according to seed source.

As screening techniques become simpler, it may be possible to induce scab epidemics within entire segregating populations. This would facilitate the selection of resistant lines from early generations.

Karnal Bunt

Background—Karnal bunt (also known as partial bunt) is caused by *Neovossia indica* Mitra, which infects susceptible wheat at anthesis. Heavily bunted kernels may be diagnosed during the grain-filling stage by their gray color and slightly enlarged mass. As the kernels mature, the contrast between the light chaff and the gray-black bunted kernels becomes more evident. In kernels with minimal infection, spore masses are limited to a cavity in the embryo tip on the suture side; when infections are more extensive, spore masses may occur along the middle ridge or all over the suture face. In heavily bunted kernels, almost the entire seed is destroyed and replaced by spore masses; this condition, however, is not common. The fungus probably releases trimethylamine, a volatile compound with a strong fishy odor, which serves as an important diagnostic trait. Infection by and/or epidemics of karnal bunt are restricted by a narrow set of environmental and crop development conditions. First, inoculum usually is not abundant because of low and erratic teliospore germination in the soil. In addition, precise timing is required for infection to occur: inoculum must be present at the point of infection during crop anthesis. Second, because inoculum is easily dispersed by the wind, opportunities for uniform, successful crop infection and/or epidemics are reduced further. And third, the rather specific moisture and temperature conditions necessary for infection seldom occur from one year to the next. This explains the erratic nature of the epidemics reported from various locations within the pathogen's geographical distribution.

Dr. Girma Bekele (second from left), CIMMYT pathologist, helps trainees to evaluate the effectiveness of artificial innoculations for fusarium head scab (photo: J.L. Castillo).

Karnal bunt is currently a definite concern of the quarantine services in major wheat-producing countries. The European and Mediterranean Plant Protection Organization (EPPO) has issued descriptions of the pathogen in an effort to curtail its importation. The USSR has reported two interceptions of bunted grain. The US Department of Agriculture (USDA) has intercepted bunted wheat from India in 1949 and from Afghanistan in 1955 at Washington, D.C., and from Mexico at the Laredo Quarantine Station in 1981.

Evaluation of seed dressings—Wheat pathologists at CIMMYT and CIANO/INIA conducted a number of experiments during 1981 and 1982 for the control of seed-borne karnal bunt. Seed of the variety Nacozari 76, with about 2.5 percent of bunted kernels, was used in all experiments. The bunt originated in natural infections in farmers' fields in the spring of 1981, and is fairly representative of the maximum wheat seed infection levels observed in the Yaqui Valley, northwest Mexico. The experiments have involved about 15 fungicidal seed dressings; the procedures used to determine their effectiveness and the results are described below:

General procedures:

- Seed lots of 1 kg were treated with the respective fungicide. Samples of 100 g were taken 48 hours, 1 week, 1 month, 2 months and several months after treatment. Thirty to forty bunted kernels were picked from each sample and teliospore germination evaluated.
- Seed viability was also tested using some of the remnant seed in each sample; 500 kernels were planted in the greenhouse in 5 rows of 100 kernels each in large plastic trays and kept at about 21°C. Seedlings were then counted a week to ten days later.

Laboratory techniques:

- Bunted kernels were first scratched with a dissecting needle to loosen the teliospores, and then placed in sterile distilled water and stirred for 5 to 10 minutes; the mixture was then filtered through a 120 mm mesh sieve, which retained the large debris while spores and other small particles were collected in the filtrate.
- Teliospores were recovered by centrifugation at about 3,000 rpm for 1 minute. They were then disinfected for 1 minute with a diluted solution of commercial bleach (1:19) and given two rinsings of sterile distilled water. The spores were again recovered by centrifugation and suspended in sterile water.

Karnal bunt (caused by *Neovossia indica*) is a minor disease of wheat, requiring very specific conditions for its development and spread. It has come to the attention of several quarantine agencies, however, and is thus posing some potential problems in the international distribution of experimental germplasm (photo: J.L. Castillo).

- To increase germination frequency, the teliospores were allowed to soak in water for 3 to 4 days at room temperature. One ml of spore suspension was than poured evenly on each of 5 Petri plates containing soil extract agar.

- Incubation took place at 20°C with a light/dark regime of 14/10 hours. After about 10 days, a thick, coiled mycelial growth from each germinating teliospore could be observed under a dissecting microscope.

Results:

- Pentachloronitrobenzene (PCNB) is the only registered chemical available that prevents germination of seed-born Karnal bunt teliopores.

- Other chemicals found to be partially effective included Anticarie (HCB 40%), Mertect (TBZ 60%), Plantvax (oxicarboxin 20%), Benlate (benomyl 50%), Corbel (morpholine 75%), Tilt (propiconazole 25%), Mist-o-matic (phenyl mercury acetate 1.4%), and Vitavax 300 (carboxin 37.5% + Captan 37.5%).

- At a rate of 2 kg/ton of seed, PCNB 75 WP completely supresses teliospore germination for at least 11 months with no major harmful effect on seed viability. A longer evaluation term is being considered. In addition, PCNB presents a minimal health hazard to humans.

Given these results, all CIMMYT wheat seed shipments leaving Mexico will be treated with a mixture of 2 parts PCNB 75 WP, 2 parts of Thiram 75 WP, 2.5 parts of carboxin 75 WP (Vitavax) and 2.5 parts of carbaryl 80 (Sevin) at a rate of 9 kg of mixture per ton of seed.

Evaluation of Fungicides to Control Leaf Rust

An experiment conducted in 1982 compared Bayleton to other systemic fungicides for their effectiveness against wheat leaf rust; the varieties Tanori 71 and Hermosillo 77 were used in the tests. The experimental plots consisted of six 5 meter rows, with 4 repetitions. Harvested plot size was four 4 meter rows. Plants treated with Bayleton and Tilt produced higher yields and had a very light incidence of leaf rust, but differences between the two chemicals were not significant. Yield data appear in Table 4.

Table 1. Percent of wheat leaf rust isolates that carry each of 19 virulence genes, classified by region of origin within Mexico, 1982

Virulence specific for resistance gene Lr-	Regions		
	Northeast (Rio Bravo)	Northwest (Sonora and Sinaloa)	Central (Guanajuato)
1	44	80	86
2a	5	10	21
2b	11	20	23
2c	44	60	38
3	60	30	40
3a	0	0	0
9	0	0	0
10	95	57	86
11	0	0	0
14a	100	100	100
14b	95	100	100
16	0	0	0
17	33	60	63
19	0	0	0
20	0	0	0
21	0	0	0
23	16	26	42
24	0	0	0
30	0	0	0

Table 2. Leaf rust assessment on Thatcher-derived single Lr-gene lines from five locations in Northern Mexico, during the winter cycle, 1982

Lr-gene carried by differential line	Locations				
	CIANO (Sonora)	Mochis (Sinaloa)	Navojoa (Sonora)	Huatabampo (Sonora)	Rio Bravo (Tamaulipas)
1	40S	10M	60S	90S	20S
2a	20S	5MR	5M	80S	20S
2b	50MS	5M	60S	80S	20S
2c	50S	20M	60S	70S	30S
3	40MS	5MS	30S	100S	20S
3ka	20MS	TR	40MS	70MS	5MS
9	0	0	0	0	0
10	80MSS	30S	70S	30S	20S
11	50SMS	20MS	80MS	90S	10S
14a	80S	30S	50S	90S	20S
14b	60MS	30S	50S	60S	20MS
16	90S	20MS	80S	80S	20MS
17	80S	30S	60S	80S	30S
19	0	0	0	0	0
20	5MR	0	0	TR	30MS
21	60S	30S	60S	80S	40S
23	10MR	TMR	40MS	TMS	20S
24	0	0	0	TR	10S
30	20MS	20M	40S	20MS	10MS

Table 3. Bread wheat lines highly tolerant to scab, 1982

Row No.	Cross and pedigree	Origin MV-82 CB-HARI
1	VEE''S CM-33027-F-12M-1Y-6M-0Y-83B-0Y	21
2	BUC''S'' - FLK''S'' CM-50070-24Y-1M-1Y-0Y	52
3	MON''S'' - KVZ SWM-3720-6Y-3M-1Y-2M-1Y-0M	55
4	R37 - GHL121/CN067 - INIA''S'' x HD832 - 0N SWM-4585-30M-1Y-4M-1Y-1M-1Y-0B	56
5	TOW''S'' CM-34709-Q-2M-4Y-1M-4Y-3M-1Y-0M	71
6	NRO/KAL - BB x MRS CM-37185-1Y-1M-3Y-1M-1Y-0M	72
7	MRNG - ALDAN''S'' CM-46961-12M-1Y-1M-4Y-1PTZ-0Y	97
8	JUN''S'' CM-33483-C-7M-1Y-0M-5B-0Y	116
9	F3.71 - TRM SWM-5704-10Y-1M-3Y-3M-3Y-0B-2PTZ-0Y	160
10	F12.71 - COC SWM-5784-17Y-1M-4Y-5M-1Y-0B	161
11	VEE''S'' CM-33027-F-15M-4Y-4M-2Y-1M-1Y-0M-0PTZ	171
12	SNB''S'' CM-34630-D-5M-2Y-1M-1Y-2M-2Y-0M	176
13	JUP - ALD''S'' CM-36867-18Y-17M-3Y-0M-1PTZ-0Y	179
14	LIRA''S'' CM-43903-H-4Y-1M-1Y-3M-1Y-0B	189
15	HD 1944 - CAL x TRM CM-46250-2M-1Y-4M-2Y-0Y-3PTZ-0Y	190
16	(KVZ/TOB - CTFN x BB)BLO''S'' CM-33028-I-1M-3Y-1M-1Y-1M-0Y	196

Table 3. (Continued)

Row No.	Cross and pedigree	Origin MV-82 CB-HARI
17	PEL 73151	204
18	YD''S'' x KAL - BB/HORK''S'' - MO CM-38558-A-7Y-7M-0Y	227 16 IBWSN
19	URES 81	7
20	LIRA''S'' CM-43903-H-4Y-1M-1Y-3M-2Y-0B	114
21	LIRA''S'' CM-43903-H-4Y-1M-4Y-0M	116
22	YR - PAM''S'' CM-46091-16M-1Y-6M-2Y-1Y-2M-0Y	133
23	BLO''S'' [HORK''S'' (TP x CNO 67 - NO/BB - CNO 67)] CM-46919-7Y-1M-1Y-1Y-1M-0Y	146
24	PF 70354 - ALD''S'' CM-47090-14M-1Y-1F-703Y-10F-705Y-3F-0Y	147
25	AZ x CHR - DD.05P/F12.71 - BLO''S'' CM-48326-A-3M-1Y-1M-2Y-1Y-0M	151
26	NAC x WDR(3) - ERA CM-49600-1M-1Y-1Y-1M-1Y-0M	153
27	PVN''S'' - MN70121 CM-49893-2M-2Y-1Y-1M-1Y-0M	164
28	ALD''S'' - PVN''S'' CM-49901-14Y-2Y-1M-1Y-0M	168
29	ALD''S'' - PVN''S'' CM-49901-14Y-2Y-7M-1Y-0M	170
30	HD2206 - SIS''S'' x PVN''S'' CM-52360-10M-1Y-2Y-1M-2Y-0M	194
31	(MON''S''/CMH72A.508 - H570.71 x CMH72A.508)PJ - HN4 x COC CM-57643-F-2Y-1Y-1M-2Y-0M	230
32	BNQ''S'' - CNT8 x ALDAN''S'' - 1AS58 CM-58323-K-1Y-2Y-1M-3Y-0M	236

Table 3. (Continued)

Row No.	Cross and pedigree	Origin MV-82 CB-HARI
33	(CQT - AZ x IAS55 - ALD''S''/ALD''S'' - NAFN) PJN''S''-PELSL1276.69 CM-58478-B-2Y-1Y-1M-1Y-0M	241
34	TOL - BUC''S'' x PIP''S'' - VUL''S'' CM-61139-A-3Y-3M-2Y-0M	246
35	BOW''S'' - NAC CM-61755-13Y-1M-1Y-0M	247
36	VEE''S'' - SNB''S'' CM-61981-4Y-1M-4Y-0M	252
37	BUC''S'' - ALD''S'' CM-62320-8Y-1M-1Y-0M	253
		PC-HARI MV-82
38	HER - HUAC''S'' CM-50224-1Y-1Y-4M-2Y-1M-0Y	46
39	ALD''S'' - COC CM-50351-8M-1Y-2Y-1M-1Y-2M-0Y	49
40	ALD''S'' - COC CM-50351-8M-1Y-3Y-2M-1Y-2M-0Y	51
41	BUC''S'' - PVN''S'' CM-52359-9M-2Y-3Y-2M-1Y-1M-0Y	74
42	BUC''S'' - PVN''S'' CM-52359-11M-1Y-2Y-2M-3Y-1M-0Y	78
43	MON''S'' x KAL - BB CM-52368-3M-1Y-3Y-2M-1Y-1M-0Y	90
44	MON''S'' x KAL - BB CM-52368-3M-1Y-3Y-2M-4Y-1M-0Y	91
45	TSI	101
46	BUC''S'' - CHRC''S'' CM-52421-2M-7Y-2Y-1M-3Y-1M-0Y	112
47	BUC''S'' - CHRC''S'' CM-52421-2M-7Y-2Y-1M-3Y-2M-0Y	113

Table 3. (Continued)

Row No.	Cross and pedigree	Origin MV-82 CB-HARI
48	BUC"S" - CHRC"S" CM-52421-2M-7Y-2Y-3M-1Y-3M-0Y	122
49	BUC"S" - CHRC"S" CM-52421-2M-7Y-2Y-3M-2Y-1M-0Y	123
50	BUC"S" - CHRC"S" CM-52421-2M-7Y-4Y-3M-3Y-1M-0Y	129
51	BUC"S" - CHRC"S" CM-52421-2M-7Y-4Y-3M-6Y-2M-0Y	132
52	BUC"S" - CHRC"S" CM-52421-6M-5Y-3Y-1M-1Y-3M-0Y	148
53	BUC"S" - CHRC"S" CM-52421-14Y-1Y-1M-2Y-1M-0Y	158
54	(NP880 - PJ x CAL/LR64[2] - SN64 x CC)MON"S" CM-53043-1M-2Y-1Y-1M-1Y-1M-0Y	176
55	(TOB"S" - INIA"S"/SN 64 x SKE[6] - AN)BB#4A KAL - BB CM-53116-2M-1Y-1Y-2M-1Y-2M-0Y	184

Table 4. Yield data (mean of 4 replications) from an experiment comparing five fungicide treatments to control wheat leaf rust in the Yaqui Valley, Mexico, 1982

Product	(Active ingredient)	Formulation and dosage	Yield (kg/ha) Hermosillo 77	Tanori 71
Plantvax	(oxycarboxin) :	20 EC 2 1/ha (once)	5835	5775
Plantvax	(oxycarboxin) :	20 EC 1 1/ha (twice[1])	6170	5915
Tilt	(propiconazole) :	25 EC 125 ml/ha	6195	6125
Corbel	(morpholine) :	75 EC 1 l/ha	5845	5830
Bayleton	(triadimefon) :	25 WP 800 g/ha	6065	6245

[1] First application when rust appears; second application one month later

Table 5. Highest yielding durum lines at various rainfed locations, 10th EDYT and 12th IDYN, 1980-81

Nurs.	Cross and pedigree	Place of test	Rainfall (mm)	Rank	Yield (kg/ha)
EDYT	FRIGATES''S'' CM17904-B-3M-1Y	Cadiz, Spain	125	1	2840
EDYT	GTA''S''-TC60 x MEXI''S'' CM4853-E-1Y-1M-0Y	Joydebpur, Bangladesh	173	1	2721
EDYT	FRIGATES''S'' CM279-04-B-3M-1Y	Alcalá de Henares, Spain	206	1	2378
EDYT	LDS MUT-TEAL''S'' CD12427-4Y-2M-2Y-2M-1Y-0M	Elvas, Portugal	220	1	3974
EDYT	RALLE''S''-BO''S'' x GTA''S'' CD7482-5Y-1M-1Y-1M-0Y	Foggia, Italy	247	1	4258
IDYN	Pg''S''-GGO VZ380 x S15-CR''S'' CD10671-P-8M-3Y-4M-1Y-0M	Foggia, Italy	247	1	3832
IDYN	SHWA''S'' x LDS MUT-PLT''S'' CD20631-502B-5Y-9B-1Y	Sevilla, Spain	262	1	4139
EDYT	ATO''S'' x AA''S''-PLC''S''/D67.2 CD10023-3M-4Y-4M-1Y-1M-0Y	Punjab, Pakistan	276	1	4577
IDYN	RABI''S'' x WLLS-65150/S15-CR''S'' CD4569-D-9Y-0M-0KE	Punjab, Pakistan	276	1	5000
IDYN	S15-CR''S'' D33312-8Y-4M-2Y-0M	Laxia, Cyprus	294	1	4678

Wide Crosses

A. Mujeeb-Kazi

Introduction

The practical motivation for making wide hybrids usually stems from the desire to transfer worthy characteristics from related but alien species into their cultivated relatives. Additional motivation arises from the potential for acquiring basic cytological, evolutionary or phylogenetic information about the parental species involved in making the hybrid. Thus, wide hybrids in the Triticeae have been both attempted and studied for a considerable number of years.

CIMMYT's wide cross program objectives include the incorporation of disease resistance (*Helminthosporium sativum* and *Fusarium* spp.) and stress tolerance (salt, drought, aluminum and copper) into wheat (*Triticum aestivum* L.) from alien genera comprised of species of *Aegilops*, *Agropyron*, *Elymus*, *Haynaldia* and *Secale*.

During the 1981-1982 winter season, Dr. A. Mujeeb-Kazi, Head of the wheat wide cross program, moved 3100 advanced intergeneric hybrids into the field to facilitate the selection of desirable plant types (photo: J.L. Castillo).

During 1982, emphasis was placed on four major categories:

- Production of new intergeneric hybrids, and advancing those produced during or prior to 1981 by making additional backcrosses to commercial wheats;
- Cytological analyses of all F_1 hybrids or alien germplasm for:
  a) confirmation of hybridity,
  b) establishment of a breeding methodology, and
  c) employment of chromosome banding techniques, where feasible, to identify alien chromosomes;
- Field studies leading to the selection of desirable plant types from some advanced intergeneric hybrid combinations;
- Developing a futuristic program to use genetic stocks and chromosome manipulation methodology for subtle alien genetic transfers into wheats of greater practical utility for the bread wheat and durum wheat programs.

Production of New Intergeneric Hybrids

Triticum aestivum L. (2n = 6x = 42, AABBDD) cultivars Chinese Spring, Fielder, Fremont, Glennson 81, Nacozari 76 and Pavon 76 were pollinated with a number of *Agropyron* and *Elymus* species. Twenty-three of these species were successfully hybridized with wheat and are listed in Table 1. In each case, the F_1 hybrids differed

phenotypically from the wheat parent, were perennial and self-sterile. All alien species were hybridized with *T. aestivum* cv. Chinese Spring, except *E. angustus*, which formed hybrids only with the variety Fremont. The higher success of the variety Chinese Spring is attributed to the kr_1 kr_1, kr_2 kr_2, kr_3 kr_3 crossability genes this variety possesses for its crossability with rye. Chinese Spring wheat has performed very well in crosses with *Hordeum bulbosum* and *H. vulgare*. It also seems to influence crossability with other genera, as evident from the hybridization results of this study (Table 1).

High seed set was obtained for hybrids of *T. aestivum* cv. Chinese Spring with *A. acutum*, *A.caespitosum*, *A. campestre*, *A. intermedium*, *A. junceum* ($2n = 4x = 28$), *A. pulcherrimum*, *A. repens-A. desertorum* ($2n = 10x = 70$), *A. trichophorum*, and *A. varnense*, where embryo recovery percentages ranged from 9.3 (*A. junceum*, $2n = 4x = 28$) to 48.0 (*A. intermedium*) (Table 1). Except for *T. aestivum/A. campestre* and *T. aestivum/A. repens-A. desertorum* (C-3), endosperm was present for all other combinations. Hence, additional hybrid seed of these combinations were left to mature on the plant and the percent embryo differentiation was not calculated. *Triticum aestivum, A. junceum-meditterranean* ($2n = 6x = 42$) also had endosperm, but because of low seed set all embryos were cultured, of which 1.9 percent differentiated. For some of these high frequency *T. aestivum/Agropyron* spp. combinations possessing endosperm, wheat varieties other than Chinese Spring were successfully hybridized with the same *Agropyron* species. This, however, is not to be generalized since the *T. aestivum* varieties Fremont, Nacozari 76 and Pavon 76 were hybridized with *A. rechingeri (7.6 percent) and A. scythicum* (6.5 percent).

Somatic counts were consistent with the expectation that each parent would contribute half the total chromosome number observed in the hybrids. In all hybrids a 1B and 6B satellited wheat chromosome was present in several cells; a 5D satellited wheat chromosome was occasionally observed. This superior resolution of secondary constriction sites eliminated any problems that would have existed in identifying hybrids with 42 chromosomes, but in no way circumvents the need for meiotic analyses.

The aneuploidy present in 29 *T. aestivum/A. repens-A. desertorum* F_1 hybrids ranged from 35 to 56 plus a telocentric chromosome. All were stable over the sampled growth stages for their somatic chromosome numbers. The expected chromosome number in these hybrids was 56 (21 from *T. aestivum* plus 35 from the amphidiploid pollen parent, with *A. repens* contributing 21 and *A. desertorum* providing 14). Whether the two hybrids with a somatic number of 35 are composed of 21 wheat plus 14 *A. desertorum* chromosomes is at this time open to speculation, as is the possibility that the C-3 amphidiploid pollen parent may itself possess aneuploid propagative tendencies.

It may be some time before fertile amphidiploids of the hybrids herein reported are produced and backcross progenies from amphidiploids derived. We have therefore adopted the swifter route of producing first generation backcross (BCI) progeny by pollinating the self-sterile F_1 hybrids with *T. aestivum* varieties. The *T. aestivum/E. angustus* hybrids have not undergone spike initiation, delaying BCI production, and initial attempts have been unsuccessful in producing BCI seed from *T. aestivum/E. cinereus*.

The scheme of backcrossing and BC progeny advance for these hybrids is similar to that reported in the schematic diagram in the Wide Crosses section of the 1981 CIMMYT Report on Wheat Improvement. However, if the BCI progenies show aneuploidy, as is common among some Triticeae hybrids, cytological studies of the BC progenies will need to be restricted only to more advanced generations of those BC derivatives that have been identified for resistance to disease or stress through controlled environment or field testing. Further advance of the BCI progenies will be facilitated when the F_1 meiotic data are complete. These data will have a significant bearing on wide cross progeny advance, especially after the mathematical inputs of chromosome pairing are put into effect.

Several of these hybrids are new, while others were reproduced so that a germplasm base was readily available to us, and commercially grown spring wheat varieties could be utilized in hybridization. The latter hybrid combinations involved alien species that are broadly classed in the *A. intermedium* complex. These species differ in their meiotic associations with *T. aestivum* and hence need individual consideration rather than being given an *A. intermedium* group complex order. Whether new, or now justifiably reproduced, these hybrids may hold tremendous potential for practical utilization in agriculture.

Cytological Analyses of F_1 Hybrids or Alien Germplasm

Cytological analyses are prerequisites to establishing hybridity. This is initially accomplished on F_1 plants where an hybrid is verified on the basis of its chromosome number, which is half the chromosome complement of each genus forming the hybrid. For the new hybrids in Table 1, the wheat parent contributed 21 chromosomes.

Absolute confirmation and breeding methodology formulation is obtained from meiotic analyses of the F_1 hybrid. Table 2 shows tentative data to illustrate this aspect. Complete analyses with more meiocytes per hybrid will be carried out in 1983.

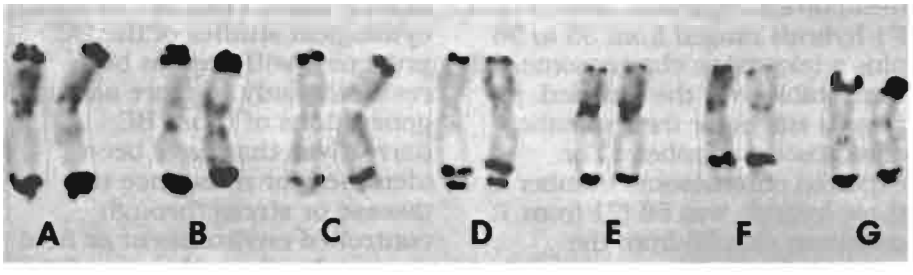


Figure 1. C-banded karyotype of *Haynaldia villosa* (2n = 2x = 14).

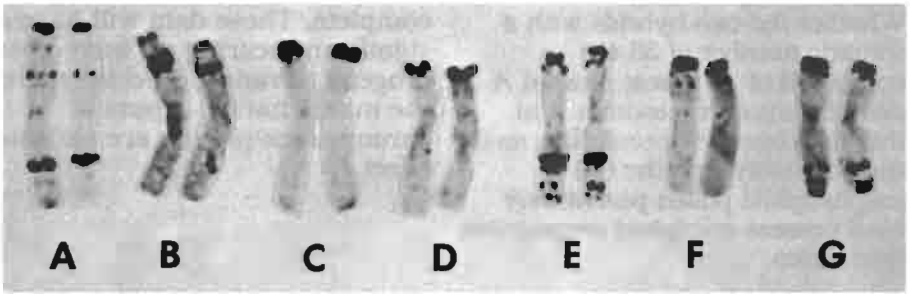


Figure 2. C-banded karyotype of *Elymus junceus* (2n = 2x = 14).

Some objectivity has been introduced into these analyses by the development of numerical methods for assessing genomic affinity; both the pattern and amount of observed chromosome pairing is compared to that expected in models based on various assumptions of synapsis, chiasma formation and the relative affinity of the chromosomes (Ref. G. Kimber, Univ. of Missouri, Columbia, Missouri, U.S.A.; and Mujeeb-Kazi, A. and Kimber, G., *in preparation*). These methods permit the evaluation of meiotic data that influences the choice of the technique to be utilized for alien genetic transfers into wheat. The choices are a) recombination in the F_1, b) suppression of the 5B effect, elimination of 5B, or the use of a PhPh mutant, and c) irradiation.

Different methodologies exist for making intergeneric (wheat/alien species) combinations that also influence chromosome banding techniques. Of these, one is based upon screening the alien germplasm for specific resistances and then combining the resistant species with wheat. The alternative approach, which we have adopted, is to combine the alien species or genera with several wheat varieties, obtain hybrids, clonally propagate them and test the clones for disease or stress tolerance. If clonal testing is not feasible, the F_1 hybrid may be advanced to a backcross self-fertile stage and then be tested. Both procedures have their advantages and limitations, and their exploitation has diversified and numerically increased the genetic base available for wheat improvement.

Chromosome banding techniques are a means of identifying individual chromosomes. They can be applied either to the alien species or to the F_1 hybrid and ultimately to the advanced line. However, not all species are amenable to banding techniques, in which case the classical identifying procedures are used. Figures 1 and 2 are photographs of C-banded chromosomes of two diploid ($2n = 2x = 14$) alien species *Haynaldia villosa* and *Elymus junceus*. The latter is the J genome donor to *E. giganteus* and has as yet not been hybridized with *T. aestivum*. The potential resistances and tolerances of these species are yet to be explored. The *E. giganteus* C-banded chromosomes in Figure 3 were identified in the *T. aestivum/E. giganteus* hybrid ($n = 5x = 35$), and form the basis for the identification of single alien chromosome additions of *E. giganteus* to *T. aestivum*.

Chromosome banding has also enabled the identification of 1B/1R CIMMYT wheats (Figure 4), of which Veery"S", Bobwhite"S", Alondra"S", and Sunbird"S" are examples. The translocation can be identified through a) routine somatic chromosome observation where only 2 satellited chromosomes (6B,6B) express the secondary constriction, b) C-banding and c) N-banding. This service is provided to our bread wheat program, where considerable emphasis is being devoted to exploitation of the 1B/1R translocation.

Field Studies

The intergeneric combinations that will be field tested during the 1982-83 winter cycle at the CIANO experiment station (in northwest Mexico, near Ciudad Obregon), as well as at the Poza Rica station (near Veracruz) in

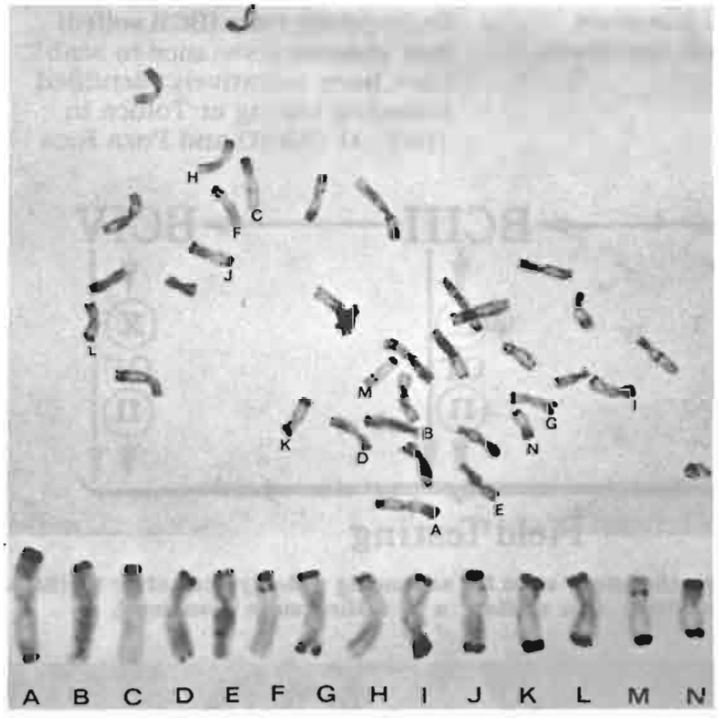


Figure 3. *Triticum aestivum/Elymus giganteus* **F_1 hybrid with n = 5x = 35 chromosomes; the 14 C-banded** *E. giganteus* **chromosomes are readily identifiable.**

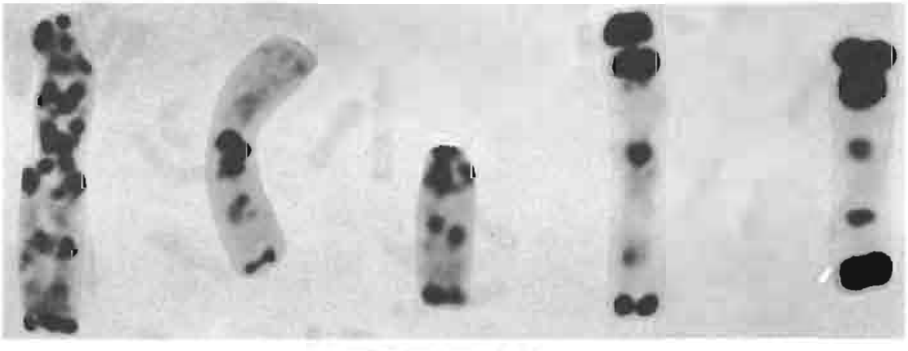


Figure 4. C- and N-banded identification of the 1B/1R translocated chromosomes in *Triticum aestivum* **cv. Genaro 81. From left to right: 1B of** *T. aestivum* **cv. Chinese Spring (N-banded), 1B/1R of** *T. aestivum* **cv. Genaro (1BL N-banded, 1RS with no bands), telocentric 1BL of** *T. aestivum* **cv. Chinese Spring (N-banded), 1B/1R of** *T. aestivum* **cv. Genaro (C-banded), 1R of** *Secale cereale* **(C-banded).**

1982-83, are from advanced backcrosses or the selfed progenies of:

- *T. aestivum/E. giganteus*
- *T. aestivum/A. distichum*
- *T. aestivum/A. elongatum*
- *T. aestivum/A. junceum*
- *E. canadensis/T. aestivum.*

The methodology that will lead to the field testing of 400 lines at the Toluca station (state of Mexico), 3842 lines at CIANO and 2088 at Poza Rica is presented in Figure 5.

Segregating lines (BCII selfed) that possess resistance to scab have been tentatively identified following testing at Toluca in 1982. At CIANO and Poza Rica we will focus on plant type, together with resistance to *Puccinia recondita* (leaf rust), *P. graminis* f. sp. *tritici* (stem rust), *Helminthosporium sativum* and the chromosome history of the plants in the earlier greenhouse generations. The above hybrids characterize a wide spectrum of constraints in intergeneric hybridization, such as lack of recombination in F_1, abnormal BCI production, and the predominance of a grassy phenotype.

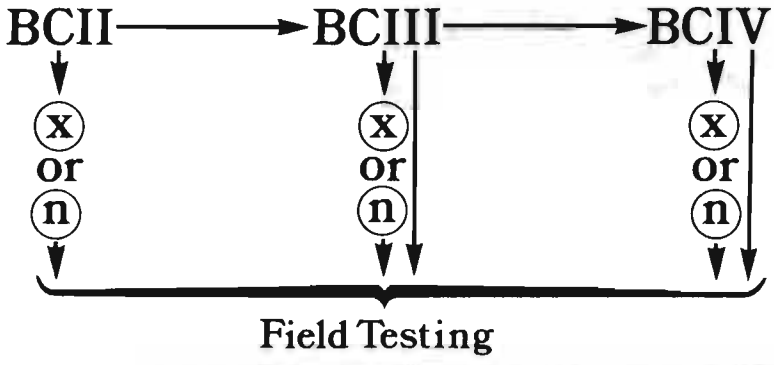


Figure 5. The methodology used for advancing wide hybrids after F_1 (BC = backcross generation; x = selfing; n = selfing more than once).

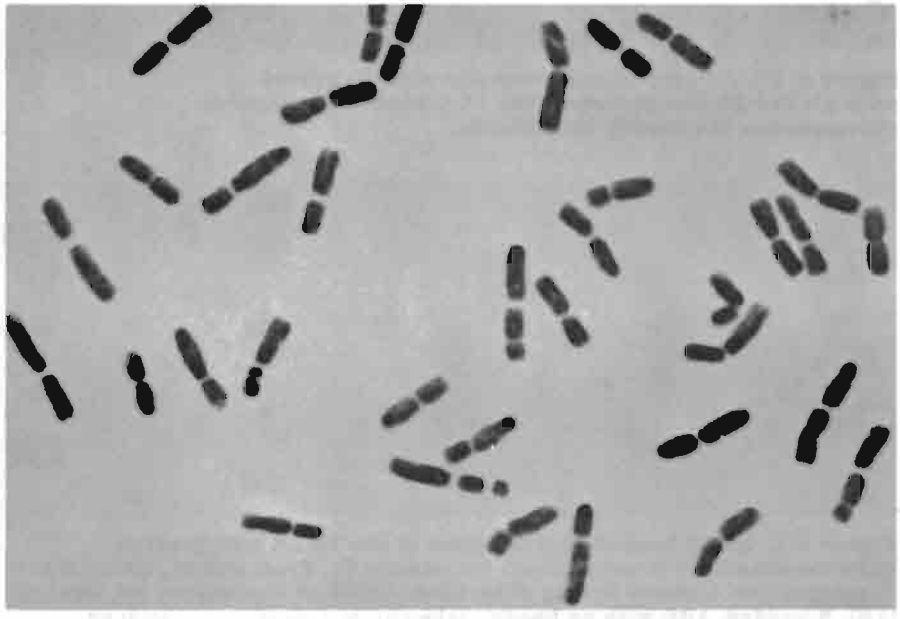


Figure 6. *Triticum aestivum/Elymus giganteus* **F_1 hybrid with 35 chromosomes (ABDJX).**

Our major emphasis is on progenies from *T. aestivum/E. giganteus*. The alien species is moderately salt tolerant, free of leaf-spotting diseases, resistant to scab and amenable to chromosome banding. There was no recombination between the wheat and *Elymus* chromosomes in F_1; the BCI cytology was normal, setting the program course toward identifying addition lines and determining their resistance or tolerance before using genetic manipulations to obtain subtle gene transfers. The progress achieved to date is described below.

The F_1 hybrid had 35 chromosomes (Figure 6), 21 of wheat plus 14 of *E. giganteus*, and the normal BCI (*T. aestivum/E. giganteus//T. aestivum*) possessed 56 chromosomes (Figure 7), 42 of wheat plus 14 of *E. giganteus*. Repeated backcrossing produced self-fertile progenies with varied chromosome compositions. Some single chromosome additions (42 wheat plus 1 *E. giganteus*) exist

that upon selfing form the double addition of this extra *Elymus* chromosome (i.e., disomic addition). Such stocks of 44 chromosomes do form 22 pairs (bivalents) in meiosis (Figure 8). A spontaneous substitution for chromosome 6B of wheat has occurred at low frequency, presumably as a consequence of univalent misdivision plus univalent shift (the mechanism, however, needs elucidation). This substitution is apparent in Figure 9 in which the satellited 6B pair has been substituted. The 43 chromosomes present are 40 wheat, plus 2 of the disomic *Elymus* chromosome substitution, plus 1 extra *Elymus* chromosome. These chromosomes associated meiotically as 21 bivalents plus 1 univalent (Figure 10).

Progenies from *T. aestivum/A. distichum//2*T. aestivum* cv. Veery"S" are similar to the wheat phenotype. The F_1 hybrid indicated possible evidence of recombination between the wheat and *A. distichum* genomes. Thus, at the conclusion of the 1982-83 cycle, we should be able to screen the material for stable lines that are cytologically normal and that possess exchanges as a consequence of chromosomal associations based upon genome affinity in the F_1.

The progenies of the remaining three hybrids require substantially more screening and backcrossing to wheat to eliminate the grassy phenotype. Because their BCI generations are cytologically abnormal, retention of alien chromosomes may be problematical.

Future Program

There are approximately 80 intergeneric hybrids maintained in CIMMYT. For wide hybrids to be of value in practical agriculture, hybrid production is the initial and most critical step. Most of these hybrids show no recombination in the F_1; several hybrids have Chinese Spring as

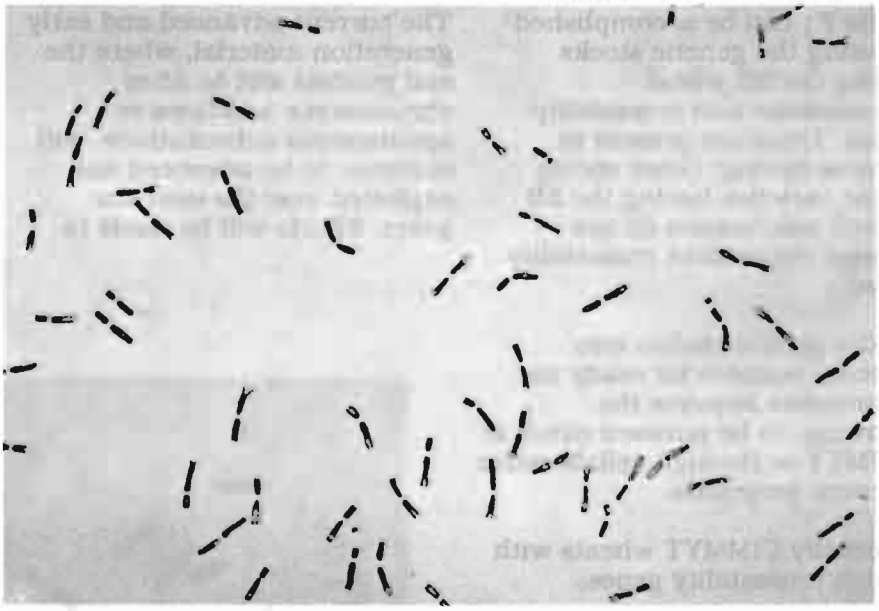


Figure 7. *Triticum aestivum/Elymus giganteus//T. aestivum* **(BCI) progeny possessing 56 chromosomes (AABBDDJX).**

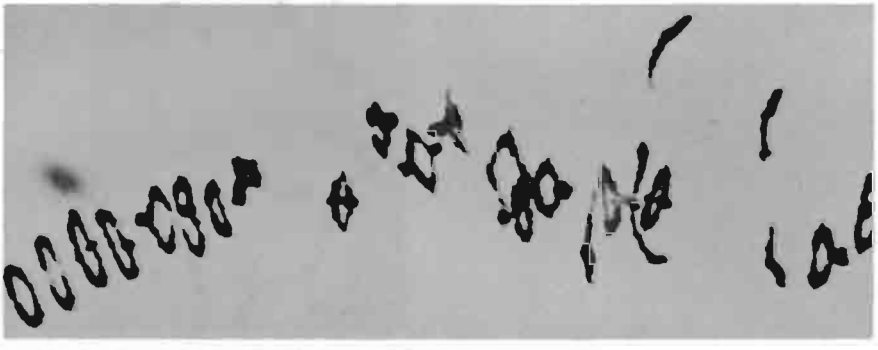


Figure 8. A disomic addition in an advanced backcross selfed progeny derived from the *Triticum aestivum/Elymus giganteus* **hybrid showing 22 bivalents.**

the female parent; and in most the BCI progenies are abnormal. Chinese Spring has consistently crossed satisfactorily with most alien species, the principal constraint to its use being its poor agronomic type. We are overcoming this constraint by backcrossing the Chinese Spring-based F_1 progenies to commercially grown CIMMYT wheat varieties.

Enhancement of recombination in the F_1 can be accomplished by using the genetic stocks having the 5B wheat chromosome and crossability genes. These are present in Chinese Spring. Other spring wheat varieties having the 5B genetic mechanism do not possess the desired crossability genes.

Future gene transfers into material suitable for ready use by breeders requires the following, to be pursued either at CIMMYT or through collaborative research programs:

- Identify CIMMYT wheats with high crossability genes;
- Transfer the 5B stocks of Chinese Spring to these wheat varieties;
- Develop a complete monosomic series in one of these wheat varieties;
- Ascertain the capacity of the highly crossable wheats for tissue culturing (callus formation and regeneration);
- Remake the hybrid combinations using adapted lines with the desired crossability genes.

The current advanced and early generation material, where the end product will be alien chromosome additions or spontaneous substitutions, will continue to be advanced and exploited over the next few years. Efforts will be made to induce subtle exchanges between wheat and alien chromosomes by a) suppression of 5B b) irradiation c) tissue culture, or d) pentaploidy-induced translocations.

Conclusion

Significant practical success from the wide hybridization program is envisioned within the next decade. For this to occur, a balance between basic and applied research is absolutely essential; the cytological input constitutes a prerequisite to achieving practical gains. The fact that genes introduced from alien species into cultivated varieties are not fundamentally different from those already

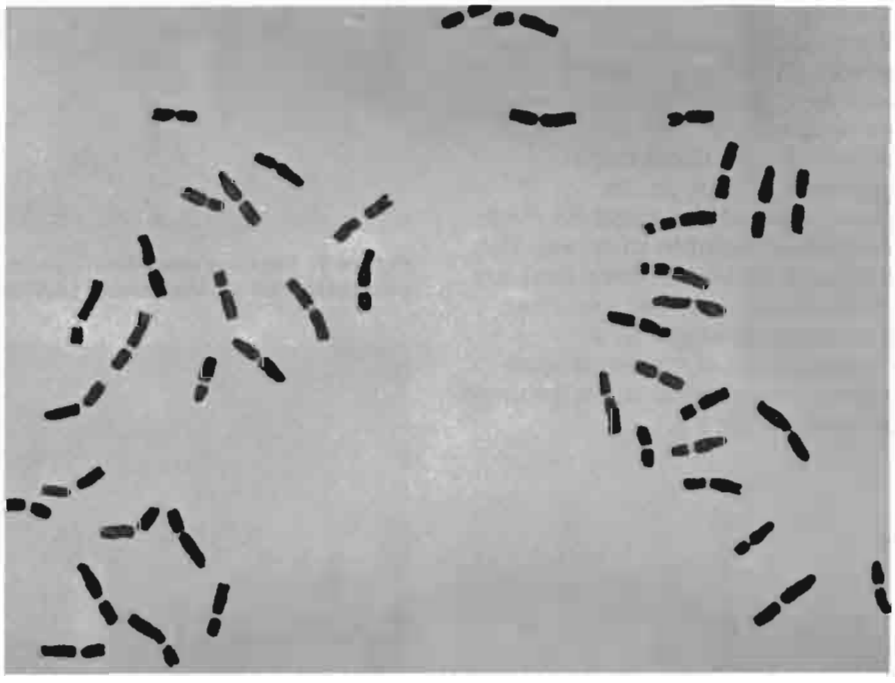


Figure 9. Preferential substitution of a wheat pair with an *Elymus* pair. The 6B6B satellited pair is substituted and hence only one (1B1B) satellited chromosome pair now appears.

present is well understood. They are subject to the same limitations imposed by mutating pathogens that can break the incorporated alien resistance. The potential contribution of wide hybridization may be far greater in the incorporation of genes for stress tolerances where, in the absence of a mutable pathogen, alien transfers may have longer-lasting effects.

Publications

Mujeeb-Kazi, A. and Rodriguez, R. Cytogenetics of hybrids of *Elymus canadensis* x *Hordeum vulgare*. Journal of Heredity 73:77-79. 1982.

Mujeeb-Kazi, A. and Bernard, M. Somatic chromosome variations in backcross I progenies from intergeneric hybrids involving some Triticeae. Cereal Research Communications 10:41-45. 1982.

Jewell, D. and Mujeeb-Kazi, A. Unexpected chromosome numbers in backcross I generations of F_1 hybrids between *Triticum aestivum* and related alien genera. Wheat Information Service 55:5-9. 1982.

Mujeeb-Kazi, A. Some intergeneric hybrids involving wheat (*Triticum aestivum* L.): production, description and practical utilization. Agricultural Abstracts, p.77. 1982.

Mujeeb-Kazi, A. and Bernard, M. Complexities of intergeneric hybridization in some Triticea. Pakistan Journal of Botany 14(Abst.):7-8. 1982.

Mujeeb-Kazi, A. Intergeneric hybridization to induce alien genetic transfers into *Triticum aestivum*. *In*: Proceedings of the International Symposium on New Genetical Approaches to Crop Improvement, Karachi, Pakistan. *in press*.

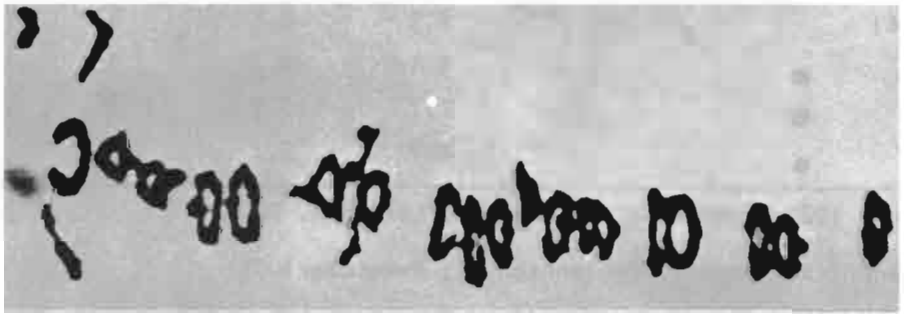


Figure 10. Meiotic association in the 6B6B substituted plant having 43 chromosomes with 21 bivalents plus one univalent.

Table 1. Intergeneric hybrids from hybridizing *Triticum aestivum L.* varieties with *Agropyron* and *Elymus* species: percent embryo recovery, percent embryo differentiation and somatic chromosome number of the hybrids

Pollen parental source	Germplasm id source ✪	Female parent wheat variety source						% embryo recovery	% embryo differentiation	Somatic chromosome number
		C	Fr	Ft	G	N	P			
A. *acutum*	PI 202727	●	●	●		●	●	14.6	X	42
A. *caespitosum*	Jaaska 384	●						43.8	X	35
A. *campestre*	Cauderon 485	●						10.5	7.9	49
A. *curvifolium*	PI 287739	●						7.0	2.8	35
A. *gentryi*	PI 228277	●						5.1	2.8	42
A. *intermedium*	Cauderon 690	●			●	●	●	48.0	X	42
A. *junceum* (2X)	Jaaska	●						1.7	0.6	28
A. *junceum* (4X)	PI 414667	●	●	●			●	9.3	X	35
A. *junceum-mediterrean* (6X)	Cauderon 471	●						6.2	1.5	42
A. *podperae*	PI 228387	●						0.5	0.5	42
A. *pulcherrimum*	PI 401308	●						53.3	X	42
A. *rechingeri*	Heneen	●						7.6	4.3	35
A. *repens*	WS-31-25	●						0.7	0.2	42
A. *repens-A. desertorum* (C-3)	Dewey	●						17.7	10.1	35 to 56+t
A. *scirpeum*	Cauderon	●						1.3	1.3	35
A. *scythicum*	Jaaska-15	●		●		●		6.5	1.5	35
A. *stipifolium*	E-12-30	●						0.5	0.3	35
A. *trichophorum*	Jaaska	●				●		46.6	X	42
A. *varnense*	PI 281863	●	●	●		●	●	42.0	X	42
E. *angustus*	PI 406461			●				1.3	0.5	63
E. *cinereus*	Dewey	●						1.1	0.2	35
E. *giganteus*	Jaaska	●						1.7	0.9	35
E. *triticoides*	E-7-6	●						0.7	0.1	35

✪ : Identification source from 1982 Rangegrass field book of Dr. D.R. Dewey, Logan, Utah, USA.
C : Chinese Spring; Fr= Fielder; Ft=Fremont; G=Glennson 81; N=Nacozari 75; P=Pavon 76.
● : Hybrids obtained. t=Telocentric chromosome

Table 2. Mean meiotic associations in some intergeneric hybrids of Triticum aestivum with Agropyron and Elymus species

Species	Mean chromosome associations					Chiasma per cell
	I	(II) *	[II] *	III	IV	
Rhizomatous						
A. *acutum*	20.8	1.7	8.4	0.4		12.5
A. *campestre*	not analyzed.					
A. *intermedium*	25.6	0.44	7.4	0.2		8.7
A. *pulcherrimum*	34.4	0.2	3.4	0.14		4.1
A. *repens*	28.14	1.25	5.38	0.19		8.3
A. *repens* - A. *desertorum*	28.9	0.05	2.89	0.85		3.15
A. *trichophorum*	34.9	0.02	2.2	0.06		2.4
E. *angustus*	vegetative					
E. *giganteus*	less than 1 open bivalent per cell					
E. *triticoides*	less than 1 open bivalent per cell					
Caespitose						
A. *caespitosum*	28.5	0.01	2.01	0.54		3.75
A. *curvifolium*	31.5	0.02	1.7	0.01		1.75
A. *gentryi*	23.2	1.5	7.8	0.06		11.0
A. *junceum* (2x)	26.02	0.01	0.98			1.004
A. *junceum* (4x)	25.9	0.01	4.5			4.56 (a)
	21.6	0.3	6.2	0.15		7.1 (b)
A. *junceum* (6x)	20.65	1.38	8.58	0.4	0.10	12.38
A. *podperae*	14.3	2.6	7.1	2.5	0.2	17.9
A. *rechingeri*	28.6	0.01	3.2	0.01		3.2
A. *scirpeum*	27.7	0.7	3.0			4.34
A. *scythicum*	22.8	0.48	5.38	0.15	0.02	6.7
A. *stipifolium*	10.6	7.08	4.41	0.54		19.64
A. *varnense*	26.2	0.4	7.0	0.4		8.4
E. *cinereus*	less than 1 open bivalent per cell					

(a) Chinese Spring/A. *junceum* (4x) * (II) = Ring bivalents

(b) Fremont/A. *junceum* (4x) * [II] = Open or rod bivalents

Germplasm Development

R. Rodríguez

Introduction

The primary objective of the germplasm development program is to assist the conventional breeding programs by incorporating desirable characteristics from exotic germplasm into lines with reasonably good agronomic phenotypes. These lines are then used by the breeding programs to transfer the desirable traits into germplasm destined for international distribution. The germplasm development program focuses its attention on bread wheat, durum wheat and triticale. Significant progress has been made, as reported here and previously.

Bread Wheats

Bread wheat germplasm development activities in 1982 focused on improving the following characteristics: protein content, tolerance to soils with high levels of free aluminum, resistance to common diseases and insects, and the components of yield. Each of these activities is discussed below.

Protein content—A number of uniform, early-maturing lines are now available with plump, high-protein grain, short straw and acceptable disease resistance under conditions prevailing at the El Batán and CIANO experiment stations. These lines are currently being tested for grain yield and flour protein content.

Two yield trials were planted in 1981-82; the results are given in Tables 1 and 2. Several lines showed either higher yields or higher protein percentages than the high-protein check CIANO 67, but a negative correlation exists between these two characteristics. In terms of protein production per hectare, the highest values correspond to the highest yields, produced here by Pavon "S", Tesia 79 and other commercial varieties used as checks.

Tolerance to aluminum toxicity—The germplasm development program's work on developing semidwarf wheats that are tolerant of high levels of free aluminum in the soil is nearing completion. In 1982, a nursery of advanced, uniform

Ing. Ricardo Rodríguez, Head of the germplasm development program, evaluating the agronomic characteristics of a promising line (photo: J.L. Castillo).

lines was sent to various locations outside Mexico to test for tolerance to aluminum and general performance under differing environmental conditions.

Disease resistance—A major portion of our work on disease resistance is done in conjunction with efforts to develop advanced materials with improved tolerance to aluminum-toxic soils. We are seeking lines that possess both this improved tolerance, as well as acceptable resistance to the greatest possible number of diseases. This research currently centers on Brazil, for wheat production in this and many other countries is seriously limited by the high aluminum content of the soil and by the incidence of *Fusarium* spp., *Helminthosporium* spp., *Septoria* spp. and *Erysiphe* spp., among others. To achieve this objective, crosses such as the following are being made:

Cross no.	Parents
CMH82.76	FAN 415 x CMH76A.977*
CMH82.79	FAN 415 x Ias 64-Aldan"S"
CMH82.196	FAN 415 x CMH78.443**/SUMEI 3 x RL.6010-Inia 66[4]
CMH82.82	SUMEI 3 x CMH78.390***
CMH82.122	(FKN-Cj 71 x FKN/CNT.8[3])(Ias 20-H567.71 x Ias 20[5])
CMH82.142	(FKN-Cj 71 x FKN/CNT.8[3])(BH.1146-H567.71 x BH.1146[3])
CMH82.70	Ald"S"/S.Sfm.-H567.71 x S.Sfm.[2]
CMH82.101	Ald"S"-CMH76A.977
CMH82.221	Ald 1 x MRNG-Aldan"S"/CMH76A.977
CMH82.71	Ald"S"-CMH78.390
CMH82.118	Ald"S"-CMH78.443
CMH82.201	CMH78.443-Ald 1 x MRNG

* H570.71-Ias 20[2] x P. Ar.
** Ias 20-H567.71 x Ias 20/MRNG[3]
*** Ias 20-H567.71 x Ias 20/Ias 58

With regard to leaf rust resistance, the Lr-9, Lr-19 and Lr-24 genes have been added to isogenic lines derived from Yecora 70, INIA 66, Sonalika, Tanori and other susceptible varieties. Advanced lines that have shown resistance and agronomic uniformity at El Batán and CIANO are currently being tested in yield trials. As can be seen in Tables 3 and 4, some of these lines, especially those derived from Yecora 70, yielded as much or more than varieties now popular among commercial producers in Mexico's Yaqui Valley.

Yecora 70 and Nacozari 76 are currently being used to develop isogenic lines that carry the resistance genes Lr-9, Lr-19, Lr-20, Lr-21 and Lr-24; the intent is to use these lines in the formation of multiline varieties. Another objective is to add the leaf rust resistance provided by these simple genes to germplasm with broad resistance to stripe rust and stem rust. Attempts are also being made to gather all these resistance genes into one single line.

In 1982, a nursery of the best advanced lines showing good rust resistance at El Batán and CIANO was sent to various locations outside Mexico. In addition, some resistant isogenic lines of Sonalika and Yecora 70 were sent to Bangladesh and Pakistan, respectively.

Insect resistance—Solid stems in wheat minimize the damage caused by *Cephus cinctus* larvae. This trait has now been transferred from the variety Fortuna to wheats with better agronomic characteristics. Some solid-stemmed lines with acceptable agronomic traits are now ready for use by the bread wheat breeding program.

Yield components—Segregating lines from the crosses CMH74A.582, CMH76.1084 and CMH77A.917 show the largest spikes in the program, but lack good tillering capacity and good grain quality. Reports were received from cooperators in 1981 to the effect that lines segregating from the cross CMH79A.955 showed large heads and improved grain quality. Segregates from this cross that have thick, strong, vertical straw to support the increased head weight have been isolated.

In 1982, several lines were selected from the crosses CMH80A.768 and CMH80A.702. The latter cross has segregates with 8 to 15 tillers, 5 to 7 grains per spikelet (G/s) and 14 spikeletes per spike (s/S). In addition, its agronomic type is excellent, with a growth cycle similar to that of conventional varieties. We hope to obtain some uniform lines from these crosses in 1983.

CMH78A.368 is an interspecific cross between a large-grain, Buitre-type bread wheat and a long-grain durum. Some lines have been obtained showing a phenotype similar to the bread wheat parent, but with relatively few grains per spikelet; the grain is durum-like in appearance and quality. The best lines produced by this cross are currently being crossed to other large-grain, high-yielding bread wheats.

Durum Wheat

Durum wheat germplasm development seeks to improve the following characteristics, among others: dwarfness, strong stems, yield components, head type and days to maturity.

Some durum lines are now available from our program that have a uniform height of 50 to 60 cm, and others show stiff, strong stems. The agronomic type of large-headed materials has been improved, but little progress has been made on grain plumpness. Some lines with acceptable agronomic type and grains larger than those of conventional durums have been obtained.

Work is proceeding on interspecific crosses that seek to transfer the lax (loose) spike characteristic from bread wheats to durums, but this material has reached only the F_2 generation. Its possibilities will be explored further in the 1982-83 cycle.

Efforts to develop earlier maturing germplasm through interspecific crosses between early maturity bread wheats and the best durums continue. However, when screening for earlier maturity, such yield components as G/s, s/S and tillering capacity tend to decrease dramatically.

Triticale

The scope of the germplasm development program's research on triticale is limited. The objectives are to obtain triticales with reduced plant height (E_3 to E_2), good stability, and grain similar to that of conventional varieties. Work is also being conducted on such traits as erect leaves, solid stems, earlier maturity and yield components.

We are optimistic that some homozygous lines with erect leaves and solid stems will be available for the 1982-83 winter cycle, but additional work will be required to improve their agronomic type.

Semidwarf lines with good agronomic characteristics are currently available from our program. Although their grain is good, it is not as plump as that of conventional triticales. Grain plumpness also tends to diminish in direct proportion to the shortness of the growth cycle.

Increasing the number of grains per spikelet in durum wheat is one objective of the germplasm development program. It has been found that this trait, among others, is adversely affected by screening for early maturity (photo: T. Harris).

The material currently being used to improve G/s and s/S possesses poor to average grain, but the cross CMH78.1131 yields grain that is larger than that of conventional varieties.

Triticale x wheat—Over the last few cycles, crosses between triticale and wheat have received considerable attention as a means to improve both crops. The best triticales are being crossed with bread wheats that have one or more of the following traits:

- Short straw
- Solid stems
- Resistance to various diseases
- Large, fertile heads
- Plump grain
- Good gluten
- Early maturity
- Brazilian germplasm in their pedigrees

As a result of these crosses, semidwarf triticales from our program are now showing better grain quality and earlier maturity; some triticales are also being recovered with solid stems. These crosses allow us to select wheat phenotypes, triticale phenotypes and intermediate phenotypes. Among the latter are several dwarf lines derived from the cross M_2A-Saric"S" x Buitre"S" (CMH76.1330), showing small heads, few G/s and a slight pubescence at the neck. Their grain, however, is larger and plumper than that of conventional wheats. Some of these lines have been crossed with others from CMH77A.917 that have big heads, but poor grain. Segregates have been obtained with phenotypes very similar to wheat, spikes as large as CMH77A.917, and grain as large and plump as CMH76.1330.

We hope to obtain uniform wheat phenotypes by 1983 and to begin testing them for tolerance to aluminum-toxic soils, resistance to disease, and for grain yield.

Table 1. Performance of 25 high protein content bread wheat lines, tested at CIANO, State of Sonora, northwest Mexico, 1981-82

Yield order	Variety or cross and pedigree	Y81-82 Var.no.	Yield (kg/ha)	Protein in flour %	Protein in flour kg/ha	Loaf volume (cc)	Days to flowering	Height (cm)	Leaf rust
1	Pavon"S"	24	6894	10.4	470	875	84	85	TMR
2	Tesia 79	17	6278*	11.4	463	880	84	75	TMR
3	Super X	23	5978**	10.3	409	770	85	70	TMR
4	Nacozari 76	21	5878	11.1	428	775	81	85	40S
5	Ciano 79	22	5633	9.7	355	770	84	70	TMR
6	Cal - NH x H567.71[2] CMH78A.73-1B-7Y-2B-1Y-0B	20	5150	12.1	418	775	77	85	TMR
7	Cal - NH x H567.71[2] CMH78A.73-1B-1Y-4B-1Y-0B	18	4844	12.0	395	705	78	75	TMR
8	Cal - NH x H567.71[2] CMH78A.73-1B-7Y-1B-2Y-0B	19	4539	12.1	370	800	78	80	TMR
9	Fnd - Cno 67[2] x Ron 2 - Fnd CMH75A.66-8B-1Y-4B-1Y-5B-3Y-1B-0Y	2	4417	15.8	459	1010	80	65	0
10	Ron 2 - Fnd x SX CMH77.3-4Y-3B-7Y-4B-1Y-1B-0Y	11	4289	14.2	409	930	75	70	TMR
11	Fnd - Cno 67[2] x Ron 2 - Fnd CMH75A.66-8B-1Y-4B-1Y-5B-1Y-0B	4	4278	15.4	426	960	80	65	TMR
12	Fnd - Cno 67[2] x Ron 2 - Fnd CMH75A.66-8B-1Y-4B-1Y-0B	5	4278	15.9	444	965	80	65	0
13	Cal - NH x H567.71 CMH75A.34-3B-1Y-2B-6Y-1B-0Y	15	4183	12.3	340	755	79	70	TMR
14	Ron 2 - Fnd x SX CMH77.3-4Y-3B-1Y-0B	8	4178	14.0	391	935	75	65	TMR
15	Ron 2 - Fnd x SX CMH77.3-4Y-3B-7Y-4B-1Y-4B-0Y	10	4150	14.1	395	910	79	65	0
16	Cal - NH x H567.71 CMH75A.34-3B-1Y-2B-6Y-0B-4Y-0Y	16	4117	11.9	329	825	79	70	TMR
17	Fnd - Cno 67[2] x Ron 2 - Fnd CMH75A.66-8B-1Y-4B-1Y-1B-1Y-0B	1	4078	15.6	427	1005	80	65	TMR
18	Fnd - Cno 67[2] x Ron 2 - Fnd CMH75A.66-8B-1Y-4B-1Y-5B-0Y-5B-0Y	6	4006	15.8	411	975	80	65	TMR
19	Ron 2 - Fnd[3] CMH77A.16-4B-1Y-3B-0Y	12	3972	13.6	366	815	82	75	0
20	Ron 2 - Fnd x SX CMH77.3-4Y-3B-7Y-4B-1Y-2B-0Y	9	3922	14.5	381	905	79	75	TR
21	Fnd - Cno 67[2] x Ron 2 - Fnd CMH75A.66-8B-1Y-4B-1Y-1B-1Y-1B-0Y	3	3894	15.8	397	960	80	65	0
22	Ciano 67	25	3828	14.3	368	975	69	70	TMR
23	Ron 2 - Fnd[3] CMH77A.16-4B-1Y-3B-4Y-0B	13	3817	13.4	341	815	82	75	0
24	Ron 2 - Fnd x PaBo/Ron 2 - Fnd CMH77.134-9Y-1B-0Y-3B-0Y	7	3456	15.0	343	810	70	60	0
25	CMH76.173 CMH76.173-4Y-3B-6Y-7B-0Y	14	3411	15.8	342	925	65	60	TMR

CV = 10%

** DMS to 1% 1001 kg/ha for grain yield
* DMS to 5% 749 kg/ha for grain yield

Table 2. Performance of 25 high protein content bread wheat lines, tested at CIANO, State of Sonora, northwest Mexico, 1981-82

Yield order	Variety or cross and pedigree	Y81-82 Var.no.	Yield (kg/ha)	Protein in flour		Loaf volume (cc)	Days to flowering	Height (cm)	Leaf rust
				%	kg/ha				
1	Nacozari 76	29	6044	10.7	438	685	85	85	40S
2	Tesia 79	47	6028	11.3	454	825	85	75	TMR
3	Imuris	49	5689	9.8	372	685	85	75	TMR
4	Super X	48	5544*	10.5	391	705	85	80	TMR
5	CMH76.207-Pvn''S'' CMH79.58-1Y-7B-0Y	40	5017**	12.5	421	805	81	85	TMR
6	Cal-NH x Pvn''S''[2] CMH78A.195-1B-1Y-1B-0Y	33	4900	12.2	407	825	80	80	TMR
7	CMH76.173 CMH76.173-4Y-3B-6Y-7B-0Y	28	4183	15.7	424	885	70	65	TMR
8	Cal-NH x H567.71 CMH75A.34-3B-1Y-2B-7Y-1B-0Y	45	4172	13.0	346	855	81	75	TMR
9	CMH73A.497 - Her[2] CMH78A.217-8B-3Y-4B-0Y	36	4167	14.0	393	850	79	75	TMR
10	Ciano 67	50	4156	14.1	398	900	71	70	30MS
11	Cal - NH x Za75/Cal - NH CMH76.164-1Y-2B-1Y-3B-1Y-1B-2Y-1B-0Y	42	4006	14.5	391	855	85	95	TR
12	Cal - NH x Super X[2] CMH77A.125-3B-4Y-1B-2Y-3B-0Y	34	3956	12.7	333	710	82	85	TMR
13	Cal - NH x Za75/Cal - NH CMH76.164-1Y-2B-1Y-1B-0Y-1Y-0B	43	3944	14.7	387	920	84	95	TMR
14	CMH76.217 CMH76.217-3Y-1B-1Y-1B-1Y-3B-0Y	44	3878	12.8	327	755	71	65	TMR
15	CMH73A.497 - Za75 CMH76A.56-4B-1Y-4B-2Y-3B-4Y-1B-0Y	37	3856	12.9	327	825	84	70	TMR
16	CMH76.173 CMH76.173-7Y-4B-3Y-1B-0Y	27	3806	14.6	356	805	71	70	TMR
17	Cal - NH x H570.71/Cal - NH CMH75A.178-5B-3Y-1B-0Y	30	3789	13.8	353	835	83	80	TMR
18	CMH73A.497 CMH73A.497-4B-1Y-1B-0Y	32	3728	14.1	344	795	64	70	TMR
19	CMH75A.66 - CMH76.207 CMH79.119-4Y-1B-0Y	35	3717	15.2	375	960	74	60	TMR
20	(CMH73A.497 - H570.71)(Cal - NH x Cal''S''/H570.71) CMH76.175-1Y-2B-5Y-3B-2Y-3B-1Y-1B-0Y	38	3706	14.5	362	825	69	70	TMR
21	CMH76.173 CMH76.173-4Y-3B-6Y-1B-0Y	46	3567	16.3	376	855	68	60	TMR
22	CMH76.217 CMH76.217-3Y-1B-1Y-1B-1Y-2B-0Y	41	3556	13.4	288	905	73	70	TMR
23	CMH73A.497 CMH73A.497-4B-1Y-1B-0Y-1B-0B	31	3506	14.1	330	765	67	80	TMR
24	CMH73A.497-Hork''S'' x CMH73A.497 CMH78.168-3Y-3B-1Y-5B-0Y	26	3189	14.7	292	860	62	80	TMR
25	(CMH73A.497-H570.71)(Cal - NH x Cal''S''/H570.71) CMH76.175-1Y-2B-5Y-3B-4Y-1B-0Y	39	3161	15.0	323	905	70	65	TMR

CV = 9%

** DMS to 1% 801 kg/ha for grain yield
* DMS to 5% 599 kg/ha for grain yield

Table 3. Performance of 25 bread wheat lines resistant to leaf rust (*Puccinia recondita*), tested at CIANO, State of Sonora, northwest Mexico, 1981-82

Yield order	Variety or cross and pedigree	Y81-82 Var.no.	Yield (kg/ha)	Days to flowering	Height (cm)	Leaf rust
1	Aga - Yec 70^{3} CMH77A.485-8B-3Y-0B	185	6706	83	75	0
2	Aga - Yec 70^{3} CMH77A.485-8B-2Y-1B-0Y	190	6611	83	70	0
3	Tesia 79	197	6211	83	75	5MR
4	Nacozari 76	198	6156	83	85	10MS
5	Aga - Yec 70^{3} CMH77A.485-8B-2Y-1B-3Y-0B	187	6133	83	70	0
6	Ciano 79	199	6106	84	75	TMR
7	Aga - Yec 70^{3} CMH77A.485-8B-3Y-1B-0Y	193	6022	83	70	0
8	RL6010 - Yec 70^{4} CMH78A.669-9B-4Y-1B-1Y-0B	178	5939	80	70	0
9	Aga - Yec 70^{4} CMH78.610-5Y-0B	186	5928	83	70	0
10	Aga - Yec 70^{3} CMH77A.485-8B-5Y-1B-1Y-0B	194	5900	84	65	0
11	Aga - Yec 70^{3} CMH77A.485-8B-5Y-1B-0Y	192	5850	83	70	0
12	Aga - Yec 70^{3} CMH77A.485-4B-3Y-1B-0Y	189	5806*	83	65	0
13	Aga - Yec 70^{4} CMH78.610-5Y-1B-0Y	196	5667	83	65	0
14	Aga - Yec 70^{4} CMH78.610-5Y-6B-0Y	195	5661	83	65	0
15	RL6010 - Yec 70^{6} CMH79A.715-1B-1Y-0B	183	5611	81	70	0
16	RL6010 - Yec 70^{6} CMH79A.714-16B-5Y-0B	182	5522	82	65	TMR
17	Aga - Yec 70^{2} CMH77.490-2Y-2B-10Y-1B-0Y	188	5511	84	70	0
18	Aga - Yec 70^{3} CMH77A.485-8B-4Y-1B-0Y	191	5506**	83	65	0
19	RL6010 - Yec 70^{4} CMH78A.669-9B-4Y-0B	180	5239	81	65	0
20	RL6010 - Yec 70^{4} CMH78A.669-11B-0Y	179	5144	81	65	TR
21	RL6010 - Yec 70^{5} CMH79.734-2Y-2B-1Y-0B	181	5122	82	65	TR
22	RL6010 - Yec 70^{3} CMH78A.675-5B-11Y-1B-1Y-0B	177	5111	79	70	TR
23	RL6010 - Yec 70^{6} CMH79A.715-9B-2Y-0B	184	5089	81	70	0
24	RL6010 - Yec 70^{2} CMH77.478-1Y-2B-5Y-1B-0Y	176	5067	79	70	TR
25	Yec 70	200	4706	82	60	50S

RL6010 carries the gene Lr-9
Agatha carries the gene Lr-19

CV = 11%

** DMS to 1% 1423 kg/ha
* DMS to 5% 1030 kg/ha

Table 4. Performance of 25 bread wheat lines resistant to leaf rust (*Puccinia recondita*), tested at CIANO, State of Sonora, northwest Mexico, 1981-82

Yield order	Variety or cross and pedigree	Y81-82 Var.no.	Yield (kg/ha)	Days to flowering	Height (cm)	Leaf rust
1	RL6040 - Yec 70^{5} CMH79A.716-5B-1Y-0B	208	6833	90	70	0
2	RL6040 - Yec 70^{4} CMH79.742-8Y-10B-2Y	206	6550	90	65	0
3	RL6040 - Yec 70^{4} CMH79.742-8Y-9B-1Y-0B	205	6333	90	65	0
4	Aga - Yec 70^{6} CMH79.724-14Y-6B-2Y-0B	203	6106	90	70	0
5	Aga - Yec 70^{6} CMH79.724-10Y-1B-1Y-0B	202	6100	90	70	0
6	RL6040 - Inia 66^{3} CMH78A.672-3B-1Y-1B-2Y-0B	217	6011	82	90	0
7	RL6040 - Inia 66^{3} CMH78A.672-1B-3Y-2B-0Y	218	6011	81	85	0
8	RL6010 - Inia 66^{6} CMH79.729-3Y-4B-0Y	216	5956	79	95	0
9	Aga - Inia 66^{5} CMH79.713-3Y-1B-1Y-0B	220	5917	80	95	0
10	Aga - Inia 66^{5} CMH79.713-5Y-7B-0Y	222	5917	84	100	0
11	RL6040 - Yec 70^{4} CMH79.742-1Y-6B-2Y-0B	204	5800	90	65	0
12	RL6040 - Yec 70^{5} CMH79A.716-1B-3Y-0B	207	5728	90	65	0
13	Aga - Yec 70^{6} CMH79.724-9Y-1B-3Y-0B	201	5683	90	65	0
14	RL6010 - Inia 66^{4} CMH78.616-6Y-2B-3Y-5B-0Y	212	5633	79	85	0
15	Yecora 70	223	5611	82	65	50S
16	RL6010 - Inia 66^{4} CMH78.616-6Y-2B-3Y-10B-0Y	213	5517*	79	80	0
17	Imuris	224	5400	84	80	TMR
18	RL6040 - Inia 66^{4} CMH79.738-3Y-6B-0Y	219	5350	79	95	0
19	RL6010 - Inia 66^{4} CMH78.616-6Y-7B-0Y	210	5267	79	90	0
20	RL6010 - Inia 66^{6} CMH79.729-1Y-6B-0Y	215	5222	79	85	TMR
21	RL6010 - Inia 66^{5} CMH78A.666-4B-4Y-0B	214	5178	79	90	TMR
22	Aga - Inia 66^{5} CMH79.713-3Y-6B-0Y	221	5156	82	95	0
23	Inia 66	225	5128**	79	85	50S
24	RL6010 - Inia 66^{4} CMH78.616-3Y-9B-1Y-1B-0Y	211	4711	76	85	TMR
25	RL6010 - Inia 66^{3} CMH77A.470-4B-6Y-1B-4Y-1B-0Y	209	4444	79	70	TMR

RL6010 carries the gene Lr-9
RL6040 carries the gene Lr-19
Agatha carries the gene Lr-19

CV = 15%

** DMS to 1% 1966 kg/ha
* DMS to 5% 1423 kg/ha

Wheat Germplasm Bank

A. Sencer

Introduction

The CIMMYT wheat germplasm bank became operational in October, 1981, with the completion of the necessary physical facilities. Additional seed-processing equipment was installed in 1982, and two cold rooms became fully operational. A computer terminal and printer are scheduled for installation in 1983, which will allow access to CIMMYT's VAX 780 computer and enhance the inputing and retrieval of data.

Entries

As can be seen in Table 1, 73,880 entries were taken over from the bread wheat, durum wheat, triticale, barley, germplasm development and pathology programs in 1981. Subsequent elimination of duplicated or undesirable nursery material in the old active collection reduced this number to 31,083. Since the old active collection contained several repetitions of the same entries, and we are in the process of eliminating these repetitions, the final number of entries preserved from the old collection will eventually be still lower. Slightly more than 3,000 entries are being maintained temporarily for the barley and pathology programs.

Table 2 shows a breakdown of the 6,718 entries added to the bank's archives from various CIMMYT programs, Kenya and China during 1982. There are very few duplications among these entries because as new nursery material arrives, duplications are eliminated.

Seed Increase and Rejuvenation

During the 1981-82 cycle, 9,733 entries were rejuvenated, as shown in Table 3. Germination was generally good, and seed samples of 1 kg each were taken from most of the bread wheat, durum wheat and triticale entries. However, most of the barley entries had low rates of germination, especially the El Batan nursery materials; for many entries insufficient seed was harvested, and embryo damage during threshing was common. Because of this, 949 barley entries from previous years will be increased once again during the 1982-83 winter cycle.

Dr. Ayla Sencer, Curator of the wheat germplasm bank, surveying lines being grown in the 1981-82 Germplasm Bank Evaluation-Increase Nursery (photo: J.L. Castillo).

The amount of seed received from the various CIMMYT programs' 1981-82 nurseries and from other sources was generally insufficient; 4,200 entries introduced in 1982 are therefore being increased during the 1982-83 winter cycle, and 4,642 entries from the old active collection are being rejuvenated. Duplicated entries have been eliminated as far as possible.

Mechanical mixtures were eliminated during the seed rejuvenation/increase process. Mixtures and/or segregating materials that could not be purified were also eliminated from the inventory.

Winter crossing-block material received from the 1981-82 nurseries has been prepared for rejuvenation and will be planted at El Batan during the 1983-84 winter cycle.

Evaluation

Morpho-agronomic descriptions—Table 4 shows the morphological and agronomic descriptions made in 1981-82 in the GBIEN (Germplasm Bank Increase-Evaluation Nursery), which consisted of 9,733 entries from the old active collection. Morpho-agronomic descriptions of 8,846 entries comprised of old active stock and 1982 introductions will be made in the 1982-83 GBIEN.

The individual program nurseries have made morphological descriptions of their 1981-82 material, consisting of 3,576 entries. The agronomic description will be made in the seed increase plots during the 1982-83 cycle.

Disease evaluation—The disease reactions of the germplasm bank entries were observed by CIMMYT pathologists at four different locations, as shown in Tables 5 and 6. During 1982, the bank's materials were affected by 17 diseases; for complete evaluation, these materials must be tested further in specific locations and disease "hot-spots" around the world. The first 40 sets of breadwheat and durum wheat materials for disease screening will be sent out to cooperators in 1983.

Storage

Table 7 shows how the old active collection has been reorganized in storage, following the elimination of duplicated or undesirable nursery material. Germplasm entries rejuvenated in the 1981-82 winter cycle were cleaned and one set of 50g samples included in the active collection for short-term storage. The remainder of these entries awaits processing prior to being placed in the base collection under medium-term storage (see Table 8).

Distribution

A total of 56,027 entries were distributed to cooperators around the world in 1982, as shown in Table 9.

Information Bank

The germplasm bank introduction books (GBIBs) for the bread wheat, durum wheat, triticale, barley, germplasm development and pathology programs were written, once the inventory of the old active collection was complete. These books contain information on a total of 34,456 entries. Corrections and updating of the books began in 1982 and will continue through 1983.

The first steps toward developing a computer-based information management system will be taken in 1983 with the arrival of a computer programmer who will serve the needs of the Wheat Program. Meanwhile, CIMMYT's Data Processing Service is assisting in the preparation of the books.

Table 1. Old active collection of the wheat germplasm bank, 1970-1981

Program	Oct., 1981	July,1982	Aug.,1982
Bread wheat	14,006	12,777	8,130
Durum wheat	28,833	14,710	5,649
Triticale *	20,093	14,988	14,457
Barley	9,735	5,548	2,625
Germplasm development	222	222	222
Pathology	991	225	
Totals	73,880	48,470	31,083

* In addition 2,923 and 225 entries are maintained temporarily for barley and pathology programs respectively.

Table 2. Seed introductions of the wheat germplasm bank in 1982

Program	CIMMYT Y81-82	CIMMYT BV,MV82	CIMMYT Y82-83	OTHER 1982	TOTAL 1982
Bread wheat	734	473	589	588	2,384
Durum wheat	667	-	380	-	1,047
Triticale	817	47	288	22	1,174
Barley	1,206	470	106	10	1,792
Germplasm development	68	-	-	-	68
Totals	3,492	990	1,363	620	6,465

Y81-82: Yaqui, winter 81-82
BV82 : El Batan, summer 82
MV82 : Toluca, summer 82
Y82-83: Yaqui, winter 82-83

Table 3. Seed increase/rejuvenation activities of the wheat germplasm bank, 1982

Crop	Y81-82
Bread wheat	2,202
Durum wheat	2,149
Triticale	1,077
Barley	4,305*
Total	9,733

*About 700 entries had very poor or no germination

Table 4. Morpho-agronomic evaluation activities of the wheat germplasm bank in 1982

Crop	Old active collection	Y81-82 nurseries	Total
Bread wheat	2,202	687	2,889
Durum wheat	2,149	654	2,803
Triticale	1,077	775	1,852
Barley	4,305*	1,460	5,765
Germplasm development	-	-	-
Totals	9,733	3,576	13,309

* Characters of about 700 entries couldn't be recorded due to very poor or no germination

Table 5. Wheat germplasm bank disease evaluation nurseries, 1982

Crop	Location and Cycle					
	Yaqui 82 (winter)	Toluca 82 (summer)	Patzcuaro 82 (summer)	Refugio 82 (summer)	Batan 82 (summer)	Total
Bread wheat	2,202	2,110	2,110	2,110	-	8,532
Durum wheat	2,149	1,087	1,087+268	1,087	-	5,678
Triticale	1,077	1,049	1,049	1,049	-	4,224
Barley	-	-	2,698	-	2,698	5,396
Totals	5,428	4,246	7,212	4,246	2,698	23,830

Table 6. Disease readings made on the wheat germplasm bank material, 1982

Crop	Location and Cycle				
	Yaqui 82 (winter)	Toluca 82 (summer)	Patzcuaro 82 (summer)	Refugio 82 (summer)	Batan 82 (summer)
Bread wheat	*P.recondita*	*P.recondita* *P.striiformis* *S.tritici*	*S.tritici*	*P.recondita* *P.graminis tritici*	-
Durum wheat	*P.recondita*	*P.recondita* *P.graminis tritici* *P.striiformis*	*S.tritici*	*P.recondita*	-
Triticale	*P.recondita*	*P.recondita* *P.graminis tritici*	*S.tritici* *Fusarium* spp.	*P.recondita* *P.graminis tritici* *Fusarium* spp.	-
Barley	-	-	-	-	*P.recondita* *P.graminis tritici* *Fusarium* spp. *H.teres*

Table 7. Storage of the active collection of the wheat germplasm bank, 1982

Crop	Old active collection	New active collection	Total
Bread wheat	5,928	6,021	11,949
Durum wheat	3,500	3,605	7,105
Triticale	13,380	3,193	16,573
Barley	747	3,986 2,923*	7,656
Germplasm development	222	-	222
Pathology	225*	-	225
Totals	24,002	19,728	43,730

* Temporarily stored for the respective programs use,not included in the inventory

Table 8. Base collection of the wheat germplasm bank awaiting storage,1982

Crop	GBIEN Y81-82*
Bread wheat	2,190
Durum wheat	2,101
Triticale	1,049
Barley	1,673
Total	7,013

* GBIEN: Germplasm bank introduction, evaluation nursery; Yaqui,winter 81-82

Table 9. Seed distribution from the wheat germplasm bank,1982

Distribution	Number of entries
National cooperators	2,132
CIMMYT programs	889
Germplasm bank	13,084
World,disease evaluation	21,520
Mexico, disease evaluation	18,402
Total	56,027

Training

H.M. Hepworth and E. Knapp

Introduction

CIMMYT's efforts to strengthen and support the research capabilities of cooperating countries continued to increase during 1982. In-service training programs in cereal breeding and pathology, cereal quality, production agronomy and experiment station management were carried out during the year.

CIMMYT training programs continue to emphasize the philosophy of "learning by doing" using the field as the center of the training effort. In addition, emphasis is placed on a team approach to identifying and solving problems. Young scientists work closely with senior CIMMYT staff, thus gaining confidence in their own abilities.

Dr. Ron Knapp (left), wheat production training officer, Dr. Byrd Curtis (second from left) and Dr. Homer Hepworth (third from left), Head of wheat training, discussing on-farm trials being conducted by wheat production trainees (photo: J.L. Castillo).

An increasing number of in-service trainees are now coming from countries where wheat research programs are only just beginning. As expenditures for imported grains, mostly wheat, rise rapidly more and more countries are initiating programs to produce wheat in "non-traditional" areas. Some notable successes have already been achieved. For example, Bangladesh is now producing over 1 million tons of wheat each year. Much interest is also evident in certain areas of Africa. Table 1 indicates the countries of origin of the 1982 in-service wheat trainees.

Training in Cereal Improvement

Breeding and pathology trainees work directly with senior CIMMYT breeders and pathologists in all phases of our germplasm improvement research. The methodology learned by these trainees can be subsequently applied in their national programs upon their return home.

Creating artificial disease epidemics is an important phase of pathology training as this greatly enhances selection of disease-resistant materials. Trainees learn both the theory and practical application of cereal pathology. Often in nontraditional wheat areas, the diseases attacking wheat are less well known than such major diseases as the rusts. Hence disease diagnosis and identification are stressed.

Training in Wheat Production

It has often been demonstrated that the new high-yielding varieties, under farmers' conditions, actually produce significantly less than is possible, given their yield potential. This yield gap clearly illustrates the need for trained production agronomists who can identify production problems under farmers' circumstances and develop practical solutions that will be adopted by farmers.

Using farmers' fields as the classroom, the production agronomy course gives the trainees the methodology, research skills and confidence to develop and execute on-farm research programs in their own countries. The trainees plan, implement and analyze research trials on farmers' fields located in a range of agroclimatic zones. Realizing that farmers decisions are affected by many socioeconomic factors, as well as agronomic conditions and options, CIMMYT's production training course includes a strong socioeconomic component. Farmer surveys and the economic analysis of research data are integral parts of the course.

The Visiting Scientist Program

CIMMYT senior staff, especially those with regional postings, travel to many developing countries every year. This provides numerous opportunities for personal contact with cooperators and allows CIMMYT personnel to make first-hand evaluations of CIMMYT and national program germplasm at many locations.

Perhaps even more important are the fellowships that CIMMYT offers each year to qualified senior scientists from developing countries which enable them to visit CIMMYT in Mexico. These fellowships are usually for a 2 to 3 week period, but may be for as long as one full crop cycle. The extensive breeding nurseries at the CIANO station near Ciudad Obregon, and at the El Batan and Toluca stations, act as a powerful magnet attracting wheat scientists from all around the world.

In 1982, scientists from 30 different countries visited CIMMYT (Table 2). CIMMYT finances many of these visits because it places great value on the personal interaction that occurs both among the visitors, and between the visitors and CIMMYT staff. This is a unique opportunity for the person-to-person exchange of ideas as well as for more formal information-sharing activities, such as seminars. In addition, visiting scientists are encouraged to select germplasm from CIMMYT's wheat, triticale and barley nurseries for use in their own improvement programs.

Conclusion

CIMMYT realizes that well-trained, highly motivated scientists are the first requirement for a successful wheat improvement program. CIMMYT also realizes that the potential impact from the small number of people that can be trained in Mexico, while significant, must somehow be multiplied. This is particularly true in production agronomy. Therefore CIMMYT is considering various ways of increasing the efficiency of its training staff and facilities. More assistance and greater support to developing the training capabilities of cooperating countries is one approach. Regional and in-country training courses may also be useful methods of utilizing CIMMYT training staff and resources more effectively.

— Wheat Production Trainees 1982

— **Wheat Breeding and Pathology Trainees, 1982.**

Table 1. Number and national origin of wheat trainees, 1982

Latin America:	15	Africa, South of Sahara:	8
Ecuador	1	Kenya	1
Peru	5	Camerron	1
Mexico	1	Tanzania	2
Bolivia	4	Nigeria	1
Colombia	1	Lesotho	1
Guatemala	1	Malawi	1
Dominican Republic	1		
Paraguay	1		
Guyana	1		
North Africa & Middle East:	9	South, South East and East Asia:	18
Egypt	1	Thailand	3
Turkey	6	Bangladesh	3
Ethiopia	1	Korea	2
Tunisia	1	Pakistan	3
		Burma	1
		Nepal	1
		Sri Lanka	1
		Philippines	1
Others:		Total trainees:	51
Spain	1	Total countries:	27

Table 2. Visiting scientists, 1982

Argentina	5	Norway	2
Bangladesh	4	Pakistan	1
Brazil	5	Peru	4
Chile	1	Portugal	2
China	1	Rwanda	1
Ecuador	1	Spain	5
France	1	Sudan	3
Guatemala	1	Sweden	1
India	2	Thailand	1
Japan	1	Turkey	3
Korea	1	Uruguay	1
Lebanon	1	USA	9
Mexico	5	USSR	3
Morocco	1		
Mozambique	2	Total countries	30
Nepal	2		
Nigeria	1	Total visiting scientists:	62

Agronomy

D. Saunders and P. Hobbs

Introduction

The agronomy program conducts experimentation in two cycles annually within Mexico. During the summer, work is centered at the El Batan and Toluca experiment stations, where experiments are largely orientated toward maintenance recommendations for the breeding nurseries, and trials to demonstrate broad principles to participants in the wheat production training program. During the winter, research of a more investigative nature is carried out at the CIANO experiment station near Cuidad Obregon in the Yaqui Valley, an irrigated arid environment.

Objectives

In addition to assisting the wheat production training program in both the implementation of on-farm trials and classroom instruction, the agronomy program aims to expose CIMMYT staff and post-doctoral agronomists to as wide a range of agronomic principles and practices as possible, while developing weed control, fertilizer, irrigation and tillage recommendations for the breeding programs, and to investigate techniques which may lead to greater efficiency or faster gains in crop improvement.

Dr. Peter Hobbs (left) and Dr. Sanjaya Rajaram examining wheat being grown in saline soil near Lahore, Pakistan (photo: B.C. Curtis).

Weed Control

Chemical weed control studies—Wild oats (*Avena fatua*) and annual phalaris (*Phalaris minor*) are the dominant grass weed species in the Yaqui Valley and weed control research at CIANO concentrates on these. The broadleaf weeds *Portulaca oleracea, Sisymbrium irio, Amaranthus* spp. and *Chenopodium* spp. are controlled with bentazon (Basagran) applied within ten days of crop emergence and bromoxynil (Brominal) about three weeks later.

Although flamprop-methyl (Mataven) and benzoylprop (Suffix) give excellent weed control and permit high yields of bread wheat in this environment, the somewhat lower and more variable control provided by diclofop (Illoxan) is accepted for nursery and yield trial weed control due to its lack of phytotoxicity in all crop species. In past years, the timing of application of this chemical has been demonstrated to be critical for the relative control of the two main grass weed species; earlier applications give superior phalaris control at the expense of wild oat control, and later

applications favor wild oat control. The poorer wild oat control from earlier applications of diclofop was again apparent this year, as was the value of surfactant for increased weed control (see Table 1).

At the El Batan station, the weed flora is largely broadleaf (*Galinsoga parviflora, Portulaca oleracea, Amaranthus hybridus* and *Ipomea purpurea*) with grassy weeds (*Eragrostis mexicana* and *Eleusine multiflora*) slowly increasing in importance. The current herbicide recommendation, 0.75 kg a.i. diclofop plus 1 kg bentazon applied 7-10 days after crop emergence with bromoxynil (0.24 kg a.i./ha) applied for later germinations, adequately controls this weed flora. However, *Oxalis latifolia* populations have increased in the absence of the other weeds and, although serious yield loss is not thought to occur due to this weed, its control is desirable. This control now seems at least partially attainable by the application of 20 grams a.i./ha of chlorsulfuron (Glean) at about 10 days after crop emergence. Earlier, and particularly later applications have considerably less effect as is evident from the data in Table 2. Chlorsulfuron also controls the other broadleaf weeds present and will replace bentazon and bromoxymil in the control recommendations. It has residual activity for later weed germinations, has shown no phytotoxicity on any crop up to 60 grams a.i. and is unaffected by rain shortly after application.

The main weeds at Toluca are *Commelina sativa, Galinsoga parviflora, Malvastrum peruvianum, Brassica campestris* L. and *Poa annua*. Chlortoluron (Dicuran) applied at the rate of 0.75 kg a.i./ha 7-10 days after crop emergence has controlled these weeds with bromoxynil applied for later weed germinations. The use of chlorsulfuron mixed with chlortoluron appears promising for further increasing the efficacy of weed control. However, neither of these combinations affect nutsedge, *Cyperus esculentis*, which is becoming a problem weed in parts of the station. Bentazon is the only chemical that inhibits this species within a crop, but control is variable. This year, split applications (two weeks apart) were effective in controlling the growth of nutsedge at rates down to less than 0.5 kg a.i./ha.

Cultural weed control—This was the third and final year of an experiment conducted at the CIANO station to examine the effects of various cultural and chemical treatments on the control of wild oats and phalaris, and consequent wheat yields. Five factors were investigated:

- Method of treatment of the previous cycle's crop residue,i.e., stubble-plowing, disc harrowing, burning or no treatment;
- The inclusion of soybeans to replace summer fallow;
- Pre-irrigation followed by discing before seeding compared with dry-seeding of the wheat crop;
- Seeding density of the wheat crop;
- No chemical control in any year compared with chemical control in the first year only, the first and second years or all three years.

The mean effects of treatments in the absence of chemical weed control are shown in Table 3. The factors most affecting wild oat populations and wheat yields were the inclusion of a summer soybeans rotation and pre-irrigation of the wheat crop. Plowing or burning before disc harrowing resulted in consistently higher yields than simply disc harrowing the wheat stubble. Seeding rate had an overall significant effect on wheat yields but none on wild oat density. In general, however, wheat yields were inversely related to wild oat population. No clear relationship was observed between phalaris density and wheat yields.

Where herbicide (flamprop-methyl, 0.6 kg a.i./ha) had been applied each year, the mean yield of wheat was 6.55 t/ha. Wild oats were eliminated (mean population, 0.47 panicles/m^2) but phalaris persisted (generally reflecting the same treatment effects as shown in Table 3), but at lower densities that did not affect wheat yields. Although there was no significant effect due to tillage, summer crop rotation or seeding rate, wheat yields were slightly higher when pre-irrigation was practiced.

Where herbicide had been applied in the first, or first and second year only of the experiment, there were residual effects on the wild oat populations and subsequent wheat yields. Phalaris populations were unaffected.

The lowest wheat yields resulted from discing the wheat stubble, fallowing during the summer and seeding the wheat crop into a dry seedbed at 100 kg/ha. Figure 1 shows the effect on yield of changing individual and multiple components of this basic rotation.

This experiment has effectively demonstrated the influence of various agronomic practices on weed control and subsequent wheat yields. While some of the principles are applicable mainly to irrigated agriculture (e.g., the ability to grow an irrigated summer crop), others have broader applicability. For example, the pre-irrigation treatment in this experiment equates with the practice of allowing weed germination after the opening rains before seeding under rainfed conditions. In these environments, where dry seeding of the crop is practiced, considerable weed problems are experienced.

Fertilizer Studies

Nitrogen and phosphorus studies, envisaged to be of a long-term nature, have been established for the last two years at the three main experiment stations in Mexico used for wheat research by CIMMYT. These studies have three principal objectives: 1) to determine appropriate nitrogen and phosphorus rates to maximize yields in the breeding programs; 2) to examine the long-term effects of continued high fertilizer application rates; 3) to follow the decline in fertility where no fertilizer is applied.

For the second year at the CIANO station, there was no significant response to nitrogen (0 to 180 kg N/ha) nor to phosphate (0 to 80 kg P_2O_2/ha), although there was a tendency for yields to decline with increasing phosphorus application, as shown in Table 4, a tendency that has been apparent in some previous experiments. At the El Batan station, there was a 38 percent yield increase from zero to the highest nitrogen rate; Table 5 shows the response to phosphate to be non-significant. This experiment is sited in an area of heavy *Gaeumannomyces graminis* and *Helminthosporium sativum* infection. The nitrogen plots were split to receive either ammonium sulphate or ammonium chloride to investigate recent reports on the effect of chloride fertilizers on soil-borne pathogens. Although rates of chloride of up to 375 kg/ha were applied, there were no visual or grain yield differences between the two nitrogen sources. Even though nitrogen application significantly increased lodging very late in the growing cycle at Toluca, there were no yield differences, as shown in Table 6.

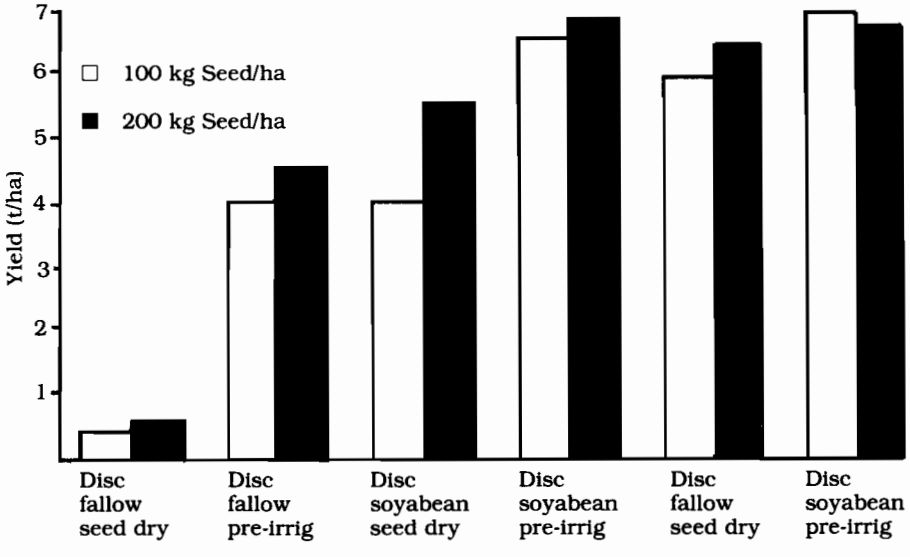


Figure 1. Yield responses to changes in management practices in the third year of the integrated weed control experiment, CIANO, 1981-82.

While these experiments show that fertilizer applications, at least at the Toluca and CIANO stations, are excessive when judged in terms of yield response, the high current recommendations (150 kg N and 40 kg P_2O_5 per hectare) are considered desirable by the CIMMYT breeding programs for expression of lodging susceptibility. However, trends in soil pH related to heavy fertilizer use are indicated (increasing at CIANO, decreasing at El Batan and Toluca), suggesting the desirability of a change in nitrogen source.

Other experiments were carried out at the CIANO station to assess nitrogen response as affected by variety and agronomic variables. These experiments were sited on land that grew unfertilized maize during this and several previous summers, and was consequently of low fertility. Hence, substantial responses to nitrogen by various bread wheat varieties that have been released over the last thirty years is shown in Figure 2. While the differences in responsiveness between more recently released varieties were not large, all were significantly higher-yielding than the old variety Yaqui 50 at all nitrogen application rates. Even where no nitrogen was applied, the advantage of the improved varieties is apparent, although not significant. The effect of nitrogen in increasing yields was primarily due to increasing the number of fertile tillers, with a lesser effect on spike fertility.

In other nitrogen-response experiments that also compared different irrigation frequencies and seeding configurations, no interactions were found with nitrogen application rates. In addition, no benefits were obtained by splitting the nitrogen application (half at seeding, the other half applied either before or after the first supplementary irrigation). The conclusion from these experiments was that both in yield trials and spaced plantings at CIANO, the maximum response to any nitrogen application rate is obtained by applying the entire amount at seeding, regardless of the irrigation regime during the life of the crop.

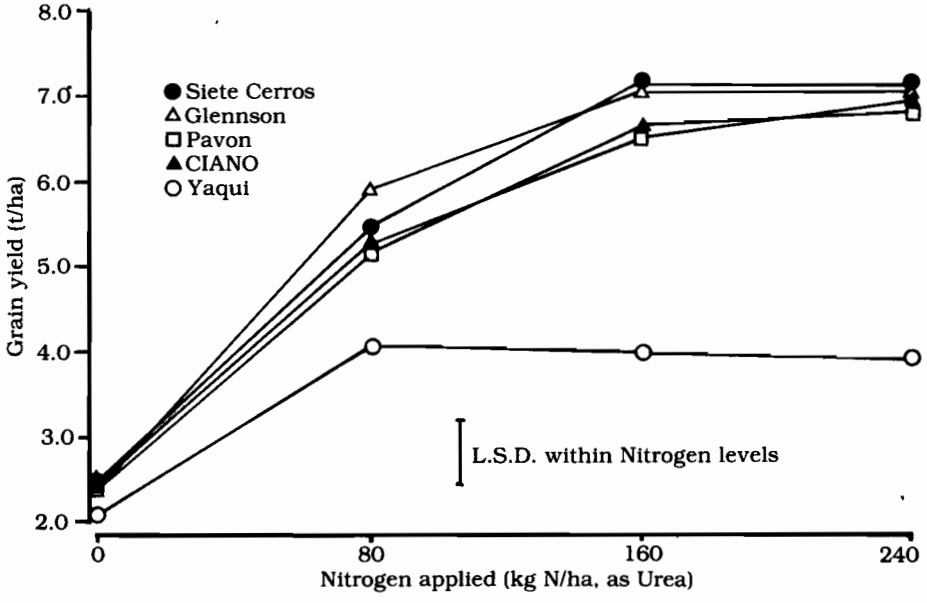


Figure 2. The response of selected bread wheat varieties, released in the last 30 years to nitrogen applied to a low-fertility soil, CIANO, 1981-82.

Other Projects

Studies under reduced irrigation continued in the Yaqui Valley. Using more recently released varieties, previous results demonstrating that the most sensitive period for moisture stress are the flowering and early grain-filling periods were confirmed. The durum variety Yavaros 79 was more sensitive to moisture stress before flowering than the bread wheat variety CIANO 79 or the triticale variety Caborca.

A range of bread wheat, durum wheat, triticale and barley lines were yield-tested under non-stressed and moisture-stress treatments at CIANO (Figure 3). Under the conditions of this experiment, yields under moisture stress (no irrigation from 20 days after crop emergence) demonstrated small differences between lines but

tended to be related to the yields where no moisture stress occurred, apart from when lodging restricted yield. Canopy temperatures were monitored during the crop growing cycle using an infra-red thermometer. There was no relationship between temperatures during growth and final yield under either stressed or non-stressed conditions.

In contrast, infra-red thermometry conducted on irrigated (no stress) and rainfed (stress) plots at El Batan indicated that the technique could predict yield rankings under moisture stress conditions. With a single recording of canopy temperature at flag-leaf emergence, a reasonable prediction of yield ranking could be made, as shown in Figure 4. If further readings were made and the individual temperature recordings were accumulatd, the relationship between temperature and yield ranking was even clearer (Figure 5). Where radical departures from expected yield occurred, the plants were experiencing problems additional to moisture stress (such as a heavy aphid infestation) or were of a different plant type (such as a narrow, erect leaf type).

The differences in plant canopy temperatures between genotypes were much greater at El Batan than at CIANO, probably due to the higher evaporation rate at the former station. This is assumed to be the principal reason for obtaining the yield-prediction relationship at El Batan, but not at CIANO.

While these results give rise to cautious optimism for the use of infra-red thermometry as a selection tool, there are many facets of the technique that are still to be investigated. Present work is involved with defining the minimum plot size and configuration, and the effect of plant density and plant type on canopy temperature.

At CIANO, the grain-filling curve of a selected triticale line was followed and compared to a bread wheat line of similar maturity under conditions of no moisture stress. It was found

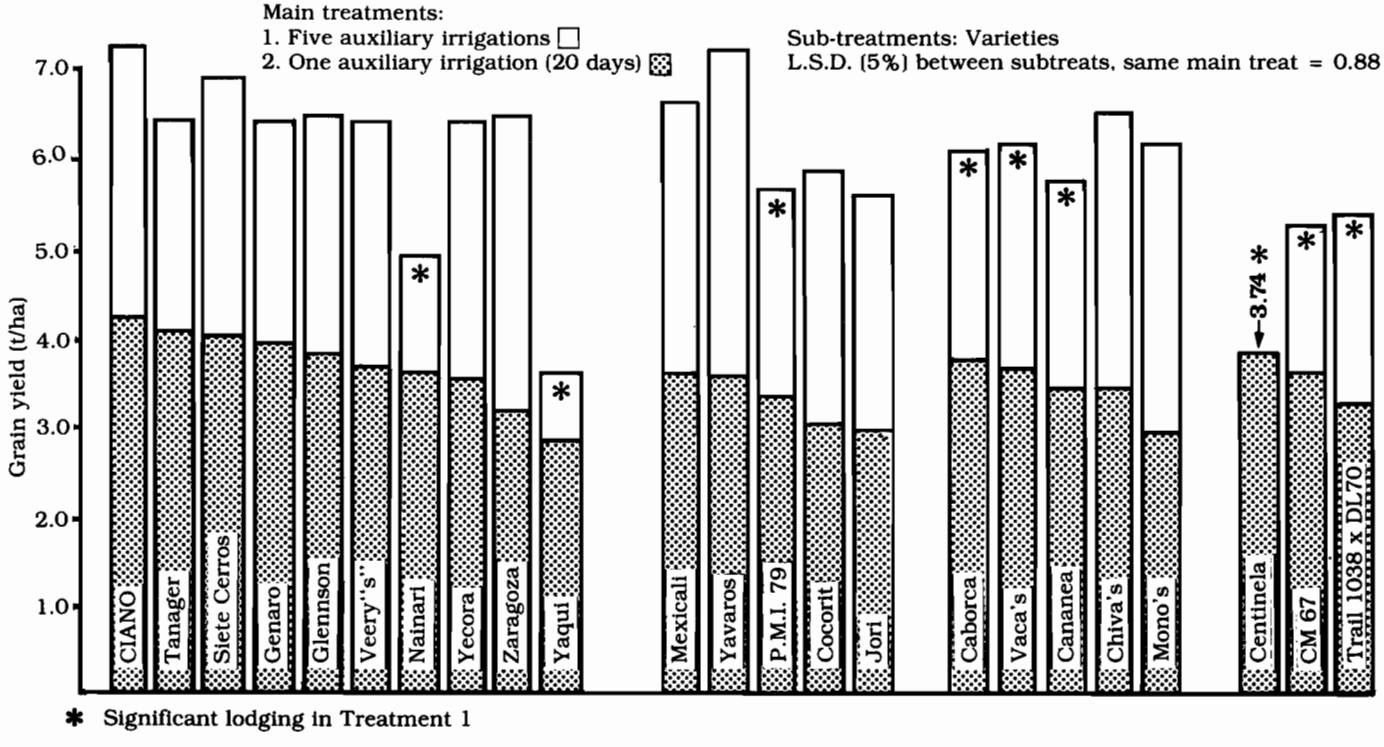


Figure 3. Yields of a range of genotypes under well-watered and water-stress treatments, CIANO, 1981-82.

that the triticale, in contrast to the wheat, had a much greater moisture content during grain-filling and that there was a decline in this moisture content before maximum dry matter accumulation occurred (Figure 6). This presumably contributes to the shrivelling of triticale grain under stress conditions. Work currently underway aims to identify variability in this behavior in triticale, with particular emphasis on early-maturing types.

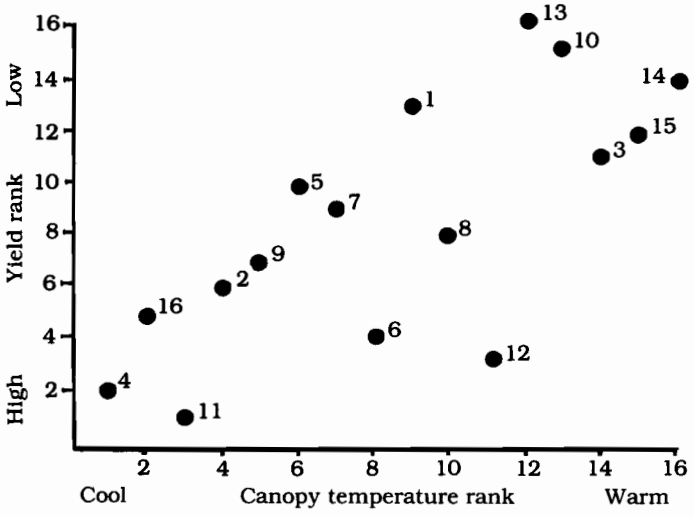


Figure 4. The relationship between crop canopy temperature ranking and yield ranking of 16 bread wheats, canopy temperature rankings being derived from a single measurement at flag-leaf emergence, El Batan, 1982.

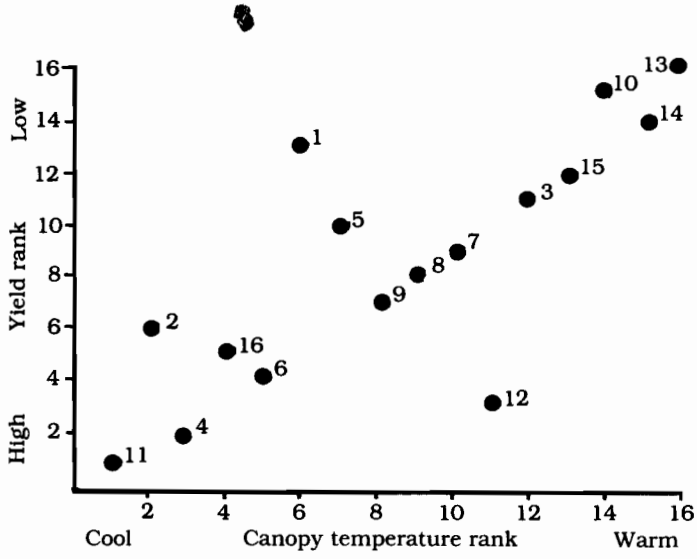
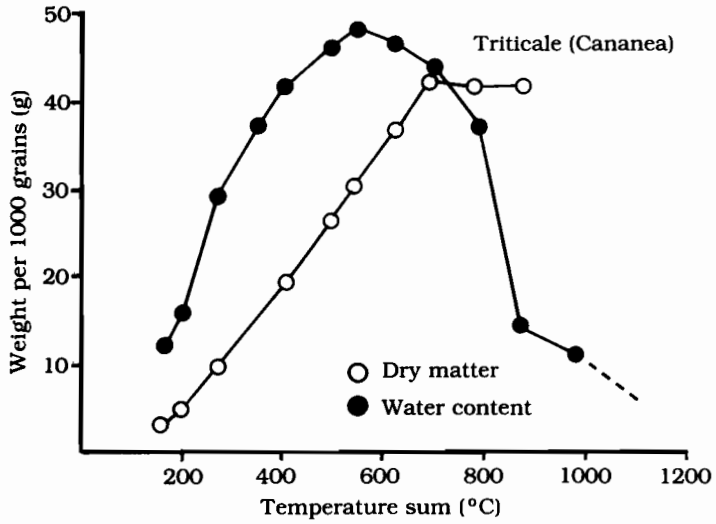


Figure 5. The relationship between crop canopy temperature ranking and yield ranking of 16 bread wheats, canopy temperature rankings being derived from the sum of four measurements between flag-leaf emergence and the beginning of grain-filling, El Batan, 1982.



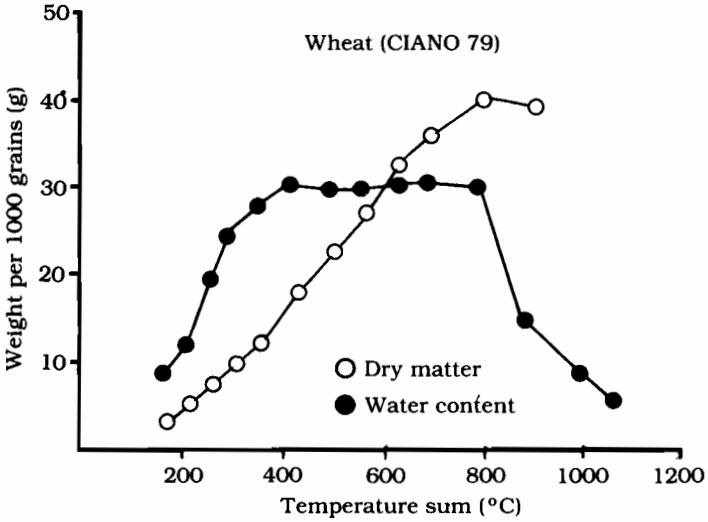


Figure 6. Dry weight accumulation and water content during grain development of a triticale and a bread wheat, CIANO, 1981-82.

Table 1. The effect of three grass weed herbicides and the timing of their application on the yield of bread wheat (CIANO 79) and control of weeds at the CIANO station, Ciudad Obregon, 1981-82 cycle

Treatment	Yield (kg/ha)	Weed Score[2]	
		Avena	Phalaris
0.75kg Diclofop + 0.5% Surfactant, 27d[1]	6326	9	7
0.75kg Diclofop + 0.5% Surfactant, 17d	6230	9.5	7
0.75kg Diclofop + 0.5% Surfactant, 7d	6159	6	7
0.75kg Diclofop, 17d	6125	8	4
0.75kg Diclofop, pre-emerge wet	5906	5	6
1.0kg Benzoylprop, 42d	6457	10	9.5
1.0kg Benzoylprop, 35d	6143	8	6
1.0kg Benzoylprop, 28d	5972	9	8
1.0kg Benzoylprop, 21d	5913	7	3
0.60kg Flamprop-methyl, 28d	6271	10	9
0.45kg Flamprop-methyl, 28d	6211	10	8
0.45kg Flamprop-methyl, 35d	6075	9.5	7
0.45kg Flamprop-methyl, 42d	6011	9	6
0.45kg Flamprop-methyl, 21d	5906	9.5	6
Hand-weeded Check	6020	10	10
Un-weeded Check	5137	0	0

L.S.D. (5%) = 291 kg/ha

1: Application time, days after crop emergence

2: 0 = no weed control; 10 = complete weed control

Table 2. The effectiveness of herbicide mixtures in the control of major weeds, El Batán, 1982

Mixture	Application	*Galinsoga*	*Portulaca*	*Oxalis*	*Eleusine*	*Eragrostis*
Methabenzthiozuron (1kg) Bromoxynil (0-24 kg)	10 days[1]	93[2]	77	7	100	100
Diclofop (0.75 kg) Bentazon (1 kg) Bromoxynil (0.24 kg)	3 days 20 days	70	83	10	100	100
Diclofop (0.75 kg) Chlorsulfuron (20 g)	Pre-emerge	60	100	20	100	100
Diclofop (0.75 kg) Chlorsulfuron (20 g)	3 days	83	100	37	100	100
Diclofop (0.75 kg) Chlorsulfuron (20 g)	10 days	100	100	90	100	100
Chlortoluron (1 kg) Chlorsulfuron (20 g)	Pre-emerge	97	100	73	97	100
Chlortoluron (1 kg) Chlorsulfuron (20 g)	10 days	100	100	83	100	100
Chlortoluron (1 kg) Chlorsulfuron (20 g)	20 days	97	100	33	90	90

1: Application time, days after crop emergence

2: Percent of complete control

Table 3. Main effects on the yield of bread wheat (Ciano 79) and grass weed populations after three years of integrated weed control treatments

Treatments	Wheat yield (t/ha)	Wild oats (panides/m^2)	Phalaris (spikes/m^2)
Plough, disc, fallow	3.39	100	46
Plough, disc, soyabeans	6.13	12	17
Disc, fallow	2.39	153	69
Disc, soyabeans	5.71	29	18
Burn, disc, fallow	3.67	121	15
Burn, disc, soyabeans	6.23	9	21
Leave stubble, fallow	4.03	38	65
Leave stubble, drill soyabeans	4.65	27	42
PF[1]	* **	***	N.S.
Wheat seeded after pre-irrigation	5.79	13	38
Wheat seeded dry	3.26	109	35
PF	* **	***	N.S.
100 kg wheat seed/ha	4.19	62	47
200 kg wheat seed/ha	4.87	60	25
PF	* **	N.S.	*

1: Significance of the F-test

Table 4. The response of bread wheat (t/ha) to nitrogen and phosphorus applications in long-term experiments at CIANO, State of Sonora, northwest Mexico (var. CIANO 79)

		Nitrogen applied (kgN/ha)				Phosphorus means
		0	60	120	180	
Phosphorus applied (kgP_2O_5/ha)	0	5.55	6.12	5.70	5.56	5.73
	40	5.34	5.73	5.39	6.04	5.63
	80	5.18	5.67	5.26	5.00	5.28
Nitrogen means		5.36	5.84	5.45	5.53	5.55

*No significant differences were noted

Table 5. The response of bread wheat (t/ha) to nitrogen and phosphorus applications in long-term experiments at El Batan (var. Glennson)

		Nitrogen applied (kgN/ha)				Phosphorus means
		0	50	100	150	
Phosphorus applied (kgP_2O_5/ha)	0	2.69	3.37	3.46	3.49	3.25
	40	2.86	3.15	3.32	4.07	3.35
	80	2.83	3.24	3.64	3.97	3.42
Nitrogen means		2.79c[1]	3.26b	3.48b	3.85a	3.34

L.S.D. 5%: 0.61 1 = DMRT (5%)

Table 6. The response of bread wheat (t/ha) to nitrogen and phosphorus applications in long-term experiments at Toluca (var. Tesia)

		Nitrogen applied (kgN/ha)				Phosphorus means	Lodging score
		0	50	100	150		
Phosphorus applied (kgP_2O_5/ha)	0	4.38	4.55	3.97	4.34	4.31	29.8
	40	4.28	4.54	4.48	4.49	4.45	38.7
	80	4.80	4.79	4.61	4.11	4.58	35.1
Nitrogen means		4.49	4.62	4.35	4.31	4.44	
Lodging Score[1]		7.5b[2]	4.5b	59.7a	66.5a		

L.S.D. 5% (Lodging) = 34.4
1: Lodging Score = % plot lodged x angle to vertical/90 2: DMRT (5%)

Milling and Baking Laboratory

A. Amaya

Introduction

The milling and baking laboratory has one overriding goal: to maintain the quality characteristics of CIMMYT's bread wheat, durum wheat, triticale and barley germplasm that different countries and regions around the world require for the preparation of local food products. Toward this end, the laboratory engages in three basic and interrelated activities. First of all, laboratory personnel regularly evaluate and screen early generation materials (F_2 and F_4) for grain type, which results in very few advanced lines with low test weights. Secondly, early generation lines that have good grain are further evaluated for such characteristics as gluten strength and pigment content (in durum wheat). Thirdly, advanced materials are carefully screened for their test weights, rheological traits, gluten strength, protein content, and other important milling and baking qualities.

Dr. Arnoldo Amaya, Head of the wheat milling and baking laboratory, demonstrating to trainees the measurement of hectoliter weights (photo: J.L. Castillo).

Bread Wheat

The laboratory has used the micro-Pelshenke, or dough ball test, since 1959 to evaluate gluten strength for individual bread wheat plants selected in F_2 and F_3 generations. This test is designed to separate gluten types into strong, medium and weak, but has a wide margin of error because the dough ball is mixed by hand. Needing more accurate data, the laboratory adopted in 1982 the micro-sedimentation method for evaluation of segregating material from the bread wheat program.

This method requires 3 grams of wheat seed from each individual plant to be tested. The seed is ground in a Brabender Junior mill to produce 0.65 grams of flour, which is then used for the test. In the normal sedimentation test, 3.2 grams of flour are used, following the American Association of Cereal Chemists method no. 56-61. The micro-sedimentation test, however, uses only 1/5 of the sample and reagents required by the Pelshenke test, and 25 cc graduate cylinders are used instead of the usual 100 cc cylinders.

A total of 8,200 F_4 plants and 3,500 F_5 bread wheat plants were evaluated in 1982 using the micro-sedimentation test. A total

of 2,014 advanced lines were also evaluated, including material from the following:

- Spring wheat crossing block;
- Winter wheat crossing block;
- 16th International Bread Wheat Screening Nursery (IBWSN);
- 18th International Spring Wheat Yield Nursery (ISWYN);
- 3rd Elite Spring Wheat Yield Trial (ESWYT);
- F_4 and F_5 spring x winter lines;
- F_2 and F_3 bulk selections.

The 1982 spring wheat crossing block contained 234 lines, including many different gluten types that gave loaf volumes ranging from 650 cc to 870 cc; some of these lines produced cookies of very good quality. This variability in the crossing block allows breeders to make crosses with specific quality requirements in mind. The 16th IBWSN comprised the best lines in the program; all showed good test weight, some greater than 83 kg/hl. Flour protein content ranged from 9.0 to 13.3 percent, and some loaf volumes reached 905 cc.

Some lines in the 1982 winter wheat crossing block had weak gluten, but most of the material had good gluten extensibility. This will aid breeders in obtaining lines with better balanced gluten having less tenacity.

Durum Wheat

In the durum wheat program, 9291 individual plants from the F_3 and F_4 generations were selected in 1982 for grain type and subsequently evaluated for pigment content. Yellow berry is an undesirable occurrance in durums; vitreous kernels with the proper pigment content are preferred. The presence of a high percentage of yellow berry reduces semolina yield, because the starchy parts of the seed become flour instead of granular semolina. All plants with a pigment content lower than 5 ppm were routinely discarded from the segregating early generation materials.

In the advanced material, 600 lines and varieties from the durum wheat crossing block and screening nursery were evaluated for their macaroni quality. In the crossing block, quality data are needed for planning new crosses that will produce lines with desired quality characteristics. The screening nursery contains a number of lines having both good yield and good quality characteristics.

Triticale

In triticale, 623 advanced lines were evaluated for their industrial quality. These included:

- The crossing block;
- The 14th International Triticale Screening Nursery (ITSN) grown at the CIANO station (1981-82);
- 105 lines from the crossing block grown under rainy conditions during the summer cycle at Toluca station.

The crossing block material harvested at CIANO had quality characteristics very similar to those reported in 1981, with no noteworthy advances. Test weight data from the 14th ITSN were impressive: several lines had test weights of over 78 kg/hl, and only 4 of the 272 evaluated weighed in at less than 70 kg/hl. Also, several lines had loaf volumes of more than 700 cc.

The crossing block material harvested at Toluca yielded test weight values ranging from 59 to 70.4 kg/hl (it should be noted that some parental material is included in the crossing block despite poor seed quality); flour yields of up to 73.5 percent were obtained from these materials.

In triticale, visual selection against seed shrivelling is placed on the F_2 through F_6 generations before seed is screened for gluten strength. In 1982, seed of 318 individual plants from the F_7 and F_8 generations were evaluated for gluten strength, using the micro-sedimentation test in the same way as with the wheat segregating material. Only 10.4 percent of these selections had sedimentation values equal to or higher than the wheat variety Pima 77, a weak-gluten variety.

International Nurseries

M. Alcalá

Introduction

Over the years, CIMMYT has established a worldwide network of cooperating agricultural scientists, many of whom are involved in the testing and evaluation of the Wheat Program's international nurseries. This network forms, in fact, an integral part of our wheat improvement team. By growing identical nurseries at many locations under a variety of conditions, plant breeders are able to judge quickly and accurately the adaptability, comparative yielding ability and breadth of disease resistance of each entry. Cooperators who grow CIMMYT nurseries are requested to return performance data for subsequent compilation, analysis and distribution, and are free to use the germplasm they receive in their own programs.

The wheat international nurseries program, headed by Dr. Max Alcalá, distributes nearly one million packets of seed each year (photo: J.L Castillo).

In the summer of 1982, CIMMYT distributed 2751 sets of bread wheat, durum wheat, triticale and barley nurseries to 280 cooperators in 100 countries, as shown in Table 1. Table 2 shows the number of lines in each of the nurseries.

Nursery Categories

Five categories of nurseries are distributed each year by the wheat international testing program:

Crossing block nurseries— Potential parental lines are selected for use in crossing programs, and the entries in each crossing block are arranged according to their previously identified genetic superiority for one or more traits. As many as 500 lines may be included in a crossing block, and the criteria for their selection and grouping within the nursery include the following:

- Resistance to specific pathogens;
- Yield potential;
- Agronomic type and fertility;
- Milling and baking quality;
- Grain type.

Early generation F_2 (segregating populations)—The F_2 populations are comprised of sister plants from the same cross; however, they possess widely differing genetic compositions and their phenotypic expression of agronomic traits is quite variable. Breeders at CIMMYT and in national programs use these segregating populations to choose individual plants that have desirable characteristics. These populations are selected and provided to cooperators according to conditions of climate, soils, moisture availability, local disease spectrum and prevailing cultural practices at the testing site.

Screening nurseries—Advanced lines with good all-around performance in Mexico may be entered into one or more screening nurseries. The lines in these nurseries are grown with wide spacing in one or two rows to facilitate evaluation. Selection is generally made for agronomic appearance and disease resistance.

Screening nurseries serve three primary functions:

- They introduce new genetic variability into the germplasm bases of national wheat improvement programs. These advanced materials may be used in local crossing programs, or promising lines may be selected for eventual release as varieties.
- They provide a means of assessing new advanced lines emanating from the breeding programs in Mexico.
- They provide information on performance over a broad range of climatic and disease conditions.

Yield nurseries—Entries in the yield nurseries may come from national programs, as well as from the CIMMYT program. They are usually advanced materials (from F_6 to F_{10}) or varieties already released commercially. The national program "nominations" are first grown in Mexico and evaluated for possible entry in a subsequent yield nursery. Lines in yield nurseries are grown in six-row plots at commercial planting density with three replications. This experimental design provides a reliable basis for determining yield potential under trial conditions.

Yield nurseries serve four basic functions:

- They provide performance assessments of advanced lines over a wide range of conditions.
- They allow the performance among varieties and advanced lines from many sources to be compared at each trial location.
- They provide cooperators with sources of genetic variability that they would have available in no other way.
- They allow breeders to judge the general adaptation of the entries included in each nursery.

Disease nurseries—These nurseries are sent to locations where particular diseases and/or environmental stresses are likely to occur with regularity, both in terms of incidence and intensity. Their purpose is to provide a means for identifying and evaluating potential sources of resistance and/or tolerance. The agronomic evaluation of entries receives lesser emphasis.

Germplasm development nurseries—As can be seen in Table 1, the Wheat Program's germplasm development unit (indicated by G.D.) distributed its first international nurseries in 1982. The unit's main objective is to transfer genes for desirable traits into lines with good agronomic type. The germplasm developed to date in this way is now sufficiently advanced to warrant international testing.

Table 1. Bread wheat, durum wheat, triticale and barley nurseries distributed by the International Nurseries Program in the summer of 1982

	Bread wheat	Durum	Triti-cale	Barley	G.D		Bread wheat	Durum	Triti-cale	Barley	G.D.
Latin America	285	89	153	123	27	Asia	180	38	73	92	34
Argentina	36	14	17	5	4	Afghanistan	4	5	2	5	-
Bolivia	16	12	7	7	2	Bangladesh	20	3	2	9	3
Brazil	46	7	20	9	8	Burma	8	1	2	1	1
Chile	19	8	6	12	3	China	45	2	16	26	10
Colombia	18	-	6	12	2	India	12	5	7	7	4
Costa Rica	5	2	4	3	-	Indonesia	3	1	1	1	-
Dominican Rep.	3	-	3	5	-	Japan	1	-	-	-	1
Ecuador	15	2	8	11	3	Korea, North	1	-	1	2	-
Guatemala	10	-	5	-	-	Korea, South	2	1	4	4	1
Guyana	7	-	4	3	1	Nepal	9	-	2	3	1
México	62	23	49	22	1	Pakistan	29	5	13	10	4
Nicaragua	1	-	2	1	-	Philippines	16	6	10	5	2
Paraguay	15	1	5	4	1	Sri-Lanka	6	-	-	1	1
Peru	25	20	14	23	2	Taiwan	4	-	1	3	2
Uruguay	6	-	1	1	-	Thailand	18	9	11	13	4
Venezuela	1	-	1	-	-	Vietnam	2	-	1	2	-
Africa	156	87	79	95	18	Oceania	14	7	14	4	4
Algeria	8	11	4	10	-	Australia	7	3	8	1	2
Angola	2	1	2	-	-	New Zealand	7	4	6	3	2
Botswana	2	-	-	-	-						
Burundi	3	-	1	-	-	Europe	136	104	123	99	39
Cameroon	8	2	5	2	-						
Cent. Afr. Rep.	1	-	1	-	-	Albania	10	6	5	5	3
Egypt	10	11	6	2	2	Austria	1	2	3	2	-
Ethiopia	13	10	3	12	-	Belgium	2	-	-	-	-
Ghana	1	-	1	20	3	Bulgaria	-	5	4	-	-
Kenya	11	6	7	14	-	Czechoslovakia	4	-	-	-	2
Liberia	1	-	2	1	-	England	6	-	1	4	2
Libya	8	8	-	7	-	Finland	1	-	-	1	-
Malawi	7	-	3	3	-	France	12	7	11	15	4
Morocco	5	9	2	9	-	Germany, East	2	-	4	5	1
Mozambique	4	1	2	-	2	Germany, West	2	6	2	2	-
Niger	1	-	-	1	-	Greece	7	8	7	7	-
Nigeria	4	1	2	1	-	Hungary	3	1	4	-	1
Rwanda	3	-	2	-	5	Ireland	2	-	-	-	-
Senegal	2	-	-	-	2	Italy	10	14	10	7	-
South Africa	18	13	11	16	1	Malta	-	3	-	3	-
Sudan	3	-	1	-	2	Netherlands	-	-	-	-	1
Tanzania	12	3	6	3	-	Norway	3	-	2	2	1
Tunisia	8	11	5	11	-	Poland	8	-	12	2	2
Uganda	7	-	4	3	-	Portugal	8	10	9	8	2
Upper Volta	1	-	6	1	-	Rumania	6	2	7	7	7
Zaire	1	-	2	-	-	Spain	28	30	24	19	6
Zambia	11	-	7	-	-	Sweden	6	-	4	1	-
Zimbabwe	4	-	-	-	1	Switzerland	-	-	3	-	1
						USSR	7	3	4	2	3
						Yugoslavia	8	7	7	8	3
Middle East	86	66	23	73	10						
Cyprus	3	4	3	6	1	North America	85	24	53	41	30
Iran	6	2	-	5	-						
Iraq	6	6	2	6	-	Canada	17	8	20	15	6
Israel	15	5	2	7	4	U S A	68	16	33	26	24
Jordan	6	8	-	4	-						
Lebanon	2	3	-	1	-						
Qatar	1	-	-	1	-	TOTAL NURSERIES	942	415	518	528	162
Saudi Arabia	4	1	-	2	-						
Syria	21	19	10	21	2	TOTAL COUNTRIES	96	62	84	79	53
Turkey	18	14	4	16	3						
Yemen	4	3	2	4	-						

Table 2. Number of entries in the 1982-83 cycle in the bread wheat, durum wheat, triticale and barley program nurseries

BREAD WHEAT	ENTRIES
Miscellaneous	550
F2 Irrigated	251
F2 Dryland	313
F2 Highland	120
F2 Aluminum	129
F2 Spring X Winter	175
F2 Helminthosporium	21
19th International Spring Wheat Yield Nursery (ISWYN)	49
4th Elite Selection Wheat Yield Trial (ESWYT)	29
16th International Bread Wheat Screening Nursery (IBWSN)	255
Aluminum Screening Nursery (Al*** SN)	228
Drought Screening Nursery	105
Heat Tolerance Screening Nursery	33
Helminthosporium Screening Nursery	96
13th International Septoria Observation Nursery (ISEPTON)	106
Crossing Block Spring (C.B.S.)	
Crossing Block Winter (C.B.W.)	
DURUM WHEAT	
F2 Irrigated	179
F2 Dryland	210
F2 Cold Tolerant	89
F2 Stem Rust Resistance	98
14th International Durum Yield Trial (IDYN)	29
12th Elite Durum Yield Trial (EDYT)	29
14th International Durum Screening Nursery (IDSN)	302
P.C.	710
TRITICALE	
F2 Irrigated	147
F2 Dryland	167
F2 Spring X Winter	150
14th International Triticale Yield Nursery (ITYN)	39
14th International Triticale Screening Nursery (ITSN)	272
Crossing Block Spring (C.B.S.)	99
Crossing Block Winter (C.B.W.)	144
P.C.	796
BARLEY	
F2 Spring X Spring	975
F2 Spring X Winter	205
F2 Zona Andina	230
5th International Barley Yield Trial (IBYT)	49
1st International Naked Barley Yield Trial (INBYT)	24
10th International Barley Observation Nursery (IBON)	239
Crossing Block (Normal)	336
Crossing Block Quality	74
Crossing Block Resistance	74
Barley Yellow Dwarf Virus (BYDV)	169
GERMPLASM	
Yield components (BW)	40
Aluminum Resistance Material	122
Rust Resistance Group	279

Andean Region

H.J. Dubin and P.C. Wall

Background

General background data on wheat and barley in the Andean region are presented in the 1978 through 1980 CIMMYT Annual Reports on Wheat Improvement; some highlights concerning activities in the region during 1982 are presented here.

Colombia—Considerable interest in producing more wheat is being expressed by Columbia; a subsidized price of about US$ 330 per ton is still being paid by the Government. Aproximately 40,000 ha (average yield of 1.3 t/ha) were sown in 1982 and excellent yields were reported in Cundinamarca (average yield of 3.3 t/ha), Boyacá (average yield of 5.2 t/ha), and Nariño (average yield of 3.4 t/ha). ICA has obtained a large loan from the World Bank to revitalize research, and wheat is considered one of the priority crops. However, a coordinated research and extension effort is needed, requiring special emphasis on on-farm research to ensure a significant impact.

Ecuador—It appears that the Government of Ecuador is considering wheat a priority crop, as they have recently raised the price to about US$ 150 per ton. Even so, currency exchange rates act as an extremely strong incentive for the private sector to import wheat and de-emphasize domestic production. As mentioned in our 1981 annual report, the MAG organized PRONACER to promote wheat and barley production, but funding may not be adequate since the organization's resources are spread over all agricultural research.

Some 33,000 ha were devoted to wheat cultivation in Ecuador in 1982, but an average yield of only 1.1 t/ha was achieved. The three northern provinces of Pichincha, Imbabura and Carchi, however, had an average yield of 1.4 t/ha. Barley was planted on 34,000 ha with an average yield of 1.0 t/ha.

Domestic malting barley was in especially short supply. National program staff are confident that a combination of appropriate research and extension activities, along with enlightened government policies to stimulate domestic production, will result in the desired increases in wheat and barley production.

Dr. Norman Borlaug (left), consultant to the CIMMYT Wheat Program, visiting wheat trials in Ecuador with Dr. Jesse Dubin, CIMMYT pathologist in the Andean region (photo: B.C. Curtis).

Peru—In 1982, INIPA-Peru began receiving funds from the World Bank, the Interamerican Development Bank (IDB), and the United States Agency for International Development (USAID) projects relating to Research, Extension and Education. The small grains program (wheat and barley) is considered one of five national production programs within the REE. The current cost of wheat production in Peru is higher than the selling price, and the country imported about 1.1 million tons of wheat in 1982. The area planted to wheat in 1981 was approximately 103,000 ha (average yield of 1.2 t/ha). Barley was seeded on about 150,000 ha, and about the same yields as wheat were achieved.

Bolivia—Data from Bolivia for 1982 are sparse. IBTA personnel noted that the probable area planted to wheat was 75,000 ha (average yield of 1.0 t/ha). There is still strong interest in the North Santa Cruz wheat project and CORGEPAI in the Chaco where CIMMYT is cooperating.

Training

Table 1 lists the ten in-service trainees and eight visiting scientists sent to CIMMYT, Mexico, from the Andean region. Walter Gutièrrez (UNA-Peru) was sent for 3 months for special training in pathology and the project supported two INIAP staff for in-country production training. The project also supported a visit to CIMMYT by INIAP's then Director General, Ing. Mario Lalama.

Future training efforts will emphasize wheat and barley production training in an effort to fortify the regional agronomy program.

Germplasm

The Andean region received a total of 226 wheat, barley and triticale nurseries from CIMMYT, Mexico, broken down as follows: Colombia (43 sets), Ecuador (38 sets), Peru (84 sets), Bolivia (44 sets), Venezuela (2 sets) and Guyana (15 sets).

The regional wheat staff sent out the following nurseries: VEOLA-wheat (22 sets), VEOLA-barley (13 sets), and ELAR (55 sets). The ELAR was sent to cooperators in all countries of South America; the VEOLA nurseries were sent primarily to the Andean countries. The ERTA was not sent in 1982 due to a lack of seed.

The following new wheat and triticale cultivars having CIMMYT parentage were released in 1982:

Colombia:
ICA-Susata = Alondra "S"
CM11683-A-1Y-1M-3Y-11M-0Y

Ecuador:
INIAP-Altar = Tob "S" x Desc-Fr
E-II-3965-1e-0e-0e-4e

INIAP-Tungurahua = Amz [(Fr^{2}-Fn x Y^{3}/4777^{4}) Fr-My54 x 4777]
E-II-68-5512-7e-0e-0e-6e

INIAP-Mana = M$_{2}$A-IA
X-12664-14Y-1Y^{2}-6M

Peru:
El Gavilan = Pavon 76
Released from INIPA-Cajamarca program

Results from the first and second ERTA were enlightening and some salient points are noted here. INIAP-Mana (triticale) in the first ERTA showed the best adaptation over all sites, with an average yield of 4.3 t/ha. In the first ERTA, most lines had a fair amount of susceptibility to yellow rust. In the second ERTA, the two best-adaptated lines were Pavon "S" (CM8399-D-4M-3Y-1M-1Y-1M-0Y) from the ICA program in Colombia and Alondra "S" (CM11683-1Y-1M-1Y-7M-0Y) from the INIAP program in Ecuador. Both lines averaged about 5.9 t/ha over all sites. Most lines tested in the second ERTA had good resistance to the three rusts.

Adaptation studies made on INIAP's regional wheat trials indicated that the new candidates in the regional base program were again equal to or better than the old cultivars at sub-optimal sites and significantly better at good sites.

Agronomy

Two preliminary agronomic trials were conducted at Santa Catalina Experiment Station in 1982, with interesting results. First, a trial was performed to determine the best source and timing of application of nitrogen (N) and phosphorus (P) in the breeding nurseries. Salient conclusions were that an 18-46-0 mixture could be substituted for the 10-30-10 mixture currently in use and that a strong response to banding was observed. It should be noted, however, that in January of 1983 root burning was noted at planting time using the 18-46-0 mixture when applied with the seed.

The second study was to compare bread wheat and triticale lines for efficiency in the use of P. The hypothesis was that Alondra "S" would prove to be most efficient. However, due to stand establishment problems, no significant differences were observed. Two tentative conclusions were reached: INIAP-Altar was the highest yielding variety at all levels of P, and Alondra "S" was extremely susceptible to take-all disease. Both of the above experiments, among others, are being repeated in 1983.

A five-week practical training course in wheat production and on-farm research was conducted by INIAP/CIMMYT, with the financial support of USAID. The course was attended by 25 professionals, mostly extension agents, and was divided into three segments: two weeks at seeding, one week in midseason, and two weeks at harvest. Participants seeded, evaluated, harvested, and analyzed a network of simple trials demonstrating responses to fertilizer and new varieties. The PIP (Production Investigation Program) in the area of Cayambe now recommends the application of 80-80-0 fertilizer, which has given sizeable yield increases in past trials and, at today's prices, an increased economic return to the farmer.

At present, the CIMMYT regional agronomist is participating in on-farm research programs in two areas of Ecuador (one wheat area, one barley area) and two areas of Bolivia (one wheat and barley area, one wheat area). In Peru, there is little on-farm research conducted in small grains, but this approach has been built in as a large part of the proposed National Small Grain Cereal Program, developed by INIPA personnel and the CIMMYT regional staff. Some adaptive on-farm research is conducted on small grains in Colombia, but as yet CIMMYT is not participating in this directly.

Pathology

The rusts—In relation to the Andean region, the possibly new race in Ecuador of yellow (stripe) rust (caused by *Puccinia striiformis*) that is attacking variety 19-INIAP was not confirmed as a new race in greenhouse studies. The moderate susceptibility of variety 19-INIAP appears to have been conditioned by environmental circumstances optimal for the rust. No major virulence changes appear to have occurred in relation to wheat yellow rust or barley yellow rust based upon 1982 ELAR field data. Details are available upon request.

Race analyses of stem rust (*P. graminis tritici*) collections from Peru and Bolivia done by Alan Roelfs, USDA-ARS, indicate a strong similarity between samples from the Peruvian highlands and coast, and the Bolivian highlands and Chaco. RHRS (11-32-113) appears to be the most common race in the areas tested.

Data on wheat leaf rust (*P. recondita tritici*) indicate a need to increase screening for this disease as most Andean region germplasm appears susceptible. This also continues to be true for leaf rust of barley (*P. hordei*).

The year 1982 was notable for the movement of rusts between epidemiological units. Probable yellow rust of barley (Race 24) was found in Bordenave, Argentina; races virulent on Lr24 from Argentina and Brazil were found in Chile; and an epidemic of leaf rust in Paraguay coincided with severe infection in the Bolivian Chaco, where only a very small commercial production area exits.

Other diseases—In Ecuador, *Septoria tritici* and *Septoria nodorum* were prevalent, especially at the Santa Catalina Experiment Station. *Helminthosporium tritici repentis* was less common in 1982. *Fusarium nivale* is common at Santa Catalina but much less so in commercial fields.

Dr. Pat Wall (right), CIMMYT agronomist in the Andean region, discussing with a farmer the results of on-farm demonstrations in Ecuador (photo: V. Lynch).

Barley yellow dwarf virus (BYDV) continues to be damaging in grower fields of wheat and barley. Nariño dwarf also was present this year. Unique mosaics and stripes on wheat at Santa Catalina indicate the presence of other viral-type diseases.

Take-all (*Gaeumannomyces graminis*) was more common in some fields and in some on-farm research trials than in previous years. Especially notable was the extreme susceptibility of Alondra "S" (variety 23-INIAP) at Santa Catalina. Take-all was quite severe in areas of Santa Catalina station where liming was done.

Table 1. In-service trainees and visiting scientists supported by the Andean regional program, 1982

Name	Training received	Country	Sponsor
Oswaldo Chicaiza	Breeding-I.S.	Ecuador	CIMMYT
José María Urbano	V.S.	Ecuador	CIMMYT
Jaime Tola	V.S.	Ecuador	CIMMYT
Marco Melo	Production-I.S.	Colombia	CIMMYT
Rafael López	V.S.	Colombia	CIMMYT
Juan Uceda	Pathology-I.S.	Peru	CIDA
Cesar Olmedo	Breeding-I.S.	Peru	CIDA
Edmundo Vilca	Station Mgt-I.S.	Peru	CIDA
Carlos Rojas	V.S.	Peru	CIDA
Ricardo Mont	V.S.	Peru	CIMMYT
Santiago Franco	V.S.	Peru	CIDA
Felipe Navarro	Production-I.S.	Bolivia	CIMMYT
Carlos Alarcón	Station Mgt-I.S.	Bolivia	IDB
Angel Cartagena	Station Mgt-I.S.	Bolivia	IDB
Rodolfo Castro	Station Mgt-I.S.	Bolivia	IDB
Jorge Castro	V.S.	Bolivia	CIMMYT
Ilan Bar	V.S.	Bolivia	CIMMYT
Lomas Tulsieram	Breeding-I.S.	Guyana	CIMMYT

I.S.: In-service
V.S.: Visiting Scientist
CIDA: Canadian International Development Agency
IDB: Interamerican Development Bank

In Colombia, *H. tritici repentis* was found to cause tan spot in the Samaca valley, as well as at Nariño. *Septoria tritici* was also common in Nariño breeding nurseries. A severe leaf blotching of unknown etiology was observed on barleys in Nariño.

Xanthomonas translucens was common in the breeding nurseries at Cusco, Peru, especially in triticale. *Septoria tritici* and *H. tritici repentis* were also collected on bread wheat in the Cusco nurseries. *Septoria nodorum* was common in the nurseries at Cajabamba.

Collections of foliar blights in the IBTA breeding nursery at San Benito, Bolivia, indicated that *S. nodorum* was common, with *S. tritici* less so. *Xanthomonas translucens* was also observed. Severe *H. sativum* infection was observed in commercial fields to the north of Santa Cruz. Damage caused by this organism was extremely heavy because of unseasonably heavy rains. Judging from field observations, fungicidal control was not adequate with the products used. Any progress in breeding in this area must also take into account *H. sativum*.

Selections of CIMMYT germplasm crossed to cultivars Hybrid Bersee and Little Joss continue to show excellent yellow rust resistance in Quito; however, some selections showed high levels of brown necrosis in 1982.

Southern Cone Region

M.M. Kohli and M.A. McMahon

Introduction

Wheat production in the Southern Cone region of South America reached a record high of over 18 million tons during 1982 (Table 1). This represents about a 60 percent increase over the preceding year; most of the gain came from Argentina. Heavy rains throughout the wheat growing cycle, together with moderately lower temperatures in Argentina, Chile and Uruguay, favored very high yields. In contrast, a wet season combined with high temperatures in Brazil and Paraguay caused severe disease epidemics on wheat, reducing the Brazilian average yield by about 50 percent relative to 1981. Only the timely and widespread use of chemical controls for disease saved the Praguayan crop from total disaster.

Dr. Man Mohan Kohli, CIMMYT's pathologist in the Southern Cone region, recently visited the Peoples Republic of China to evaluate materials showing resistance to fusarium head scab, a significant disease problem in some countries of the Southern Cone (photo: T. Harris).

Crop Status

Argentina—The record crop of 15.1 million tons in Argentina not only underscored the production potential of this country but also the role it can play in stabilizing regional food production. A long and cool grain-filling period produced excellent test weights, but in combination with lower soil fertility, resulted in an average loss of 1 to 2 percent in protein content. The high cost of credit and of fertilizers (grain: nitrogen ratio = 9:1) continues to be a bottleneck in the more widespread use of this input. However, the potentially high gains in production and concern about lower grain quality will probably create a favorable environment for increasing the use of fertilizer in the future (see the agronomy section of this report).

Yields of 4500 kg/ha and higher were obtained by several farmers using new varieties. The national average yield was up by 50 percent over 1981 and 30 percent over the long-term figure of 1600 kg/ha. On the experimental plots, yields of over 7000 kg/ha were recorded for the first time.

Brazil—Brazilian farmers, encouraged by a very attractive support price of US$275/ton, seeded 50 percent more area to wheat than in 1981. Early drought damage to the March-seeded crop (which comprises 15 to 20 percent of the total area) in Parana and the north delayed seedings until May-June, when the rains resumed their normal pattern. However, high humidity

and high temperatures favored severe epidemics of leaf blight (*Helminthosporium sativum*), combined in certain cases with bacterial blight (*Xanthomonas campestris*) and head scab (*Gibberella graminearum*). Chemical controls could only minimize the damage caused by this complex of diseases. In the southern state of Rio Grande do Sul (1.3 million hectares of wheat), an early epidemic of leaf rust and a late epidemic of a complex of foliar and head diseases reduced the average yield from 1187 kg/ha in 1981 to 395 kg/ha in 1982.

Plans to increase wheat production under irrigation in the Cerrado region of central Brazil have been slowed by the high cost of investment and limited infrastructure. However, a potential 1.5 million hectares of irrigated wheat in the Cerrado region, with a yield potential of 3.0 tons/ha, will no doubt eventually have a significant impact on national production.

Chile—The area planted to wheat continued to decline in 1982, primarily due to excessive rains at seeding and to commercialization problems. Excellent crop production conditions and a lack of diseases favored high yields throughout the country. A government decision to open a private commercial channel for the purchase of wheat at about 85 percent of international price increased farmers' earnings significantly. This move alone may contribute to a considerable increase in the area devoted wheat in 1983.

Paraguay—A national campaign to increase wheat production resulted in about 50 percent more area planted to wheat than in 1981. In the initial stages of the campaign, excellent plant development was observed. Heavy disease pressure, however, especially from leaf rust and from bacterial blight at heading, caused grave concern. Potential losses from these diseases were reduced considerably by a chemical control program launched by the government. Similar environmental conditions in 1972 and 1975 resulted in average yields of 550 kg/ha and 889 kg/ha, respectively, compared with the 986 kg/ha achieved in 1982. This speaks well of properly applied technology as a means of saving national production.

Uruguay—Heavy rains at seeding caused a significant decrease in wheat area; over 80 percent of the fields were sown late or not at all. However, the excellent crop production conditions that followed resulted in yields of 4000 kg/ha (or more) with improved varieties and adequate fertilization. The national average yield increase was slight (from 1311 to 1353 kg/ha) due to poor management on many fields having low fertility, and to the increasing problems of Johnson grass and wild oats.

In certain areas, severe epidemics of leaf rust caused damage to specific varieties. Leaf blotch in the south and leaf blight in the north combined with head scab to cause an as yet unassessed degree of damage.

Germplasm Development

Bread wheat—Advanced lines derived from spring x winter (SxW) and Brazilian x Mexican (BxM) bread wheat crosses dominated the regional scene with their excellent adaptation. Their key features are high yield potential and good agronomic type, but they also carry resistance to a number of diseases prevalent in the region.

Winter wheats (e.g., Kavkaz, Aurora, Weique, Golden Valley and F12.71) and Brazilian varieties é.g., Maringa (IAC-5), IAS 58, IAS 63, IAS 64, PAT 19 and PF 70354¿, in crosses with Alondra and other Mexican lines, consistently outyielded the older varieties. Some widely adapted lines representing S x W crosses, such as Veery, Bobwhite, Sunbird, Chat, Hahn, Kvz x Cno-Pj, F12.71-Coc, dominate advanced yield trials in most national programs. Lines from B x M crosses, including IAC 5-Aldan, PF70354 Ald, IAS 64-Aldan and IAS 63-Ald x Gto-LV are in the advanced stages of multiplication. The average yield advantage of selected superior lines ranged from 12 to 34 percent over the best checks. Some overall outstanding lines of CIMMYT origin are presented in Table 2.

Alondra and Jupateco sisters (Jupateco 73, Anahuac and Cocoraque) deserve special mention for their important role in Brazilian production and wheat breeding programs in recent years. Several hundred selections of Alondra, chosen in the mid-1970s for their excellent

plant type, adaptation to acidic soils with high levels of free aluminum, and their resistance to various diseases, became the significant building blocks in all Brazilian wheat breeding programs. Alondra 4546, a multiline, was released for commercial production in 1980 and is spreading quickly. Although its resistance to diseases has been breaking down, newer lines derived from its crosses are present in overwhelming numbers in various programs.

The Jupateco sisters complex has contributed significantly to production in large areas of aluminum-free soils in Parana and the northern regions of Brazil. While Jupateco 73 and Anahuac have become susceptible to leaf rust, Cocoraque still retains its resistance. In addition, Cocoraque has been demonstrating high levels of field resistance to helminthosporium leaf blight.

In the facultative and winter wheat areas of the region, some progress has been made in releasing new varieties with high yield potential, better grain quality and disease resistance. However, the introduction of newer germplasm remains a limiting factor due to its extreme susceptibility to one or more of the three rusts. It is urgent that winter wheat programs around the world make use of the existing screening facilities or develop a regional network to test their germplasm for broad-based resistance.

Durum wheat—Durum production in the region is restricted to the southeastern pampa in Argentina and the central and northern valleys of Chile. Durum area over the past few years has been decreasing because of a reduced market. In addition, Argentina still needs to define specific quality standards. Durum lines of Mexican origin adapt well to these areas, and their yield potential is comparable to the best bread wheat varieties. However, in the northern regions of Argentina and Chile, severe infections of stem rust pose a problem. Field screening of a large number of materials has led to the identification of some resistant materials with high yield potential (Table 3).

Triticale—The commercial production of triticale will likely be enhanced due to a meeting (organized by EMBRAPA) involving researchers, commercial farmers and industry representatives in Brazil; the purpose of the meeting was to develop recommendations for quality standards and pricing.

At this meeting, a detailed examination of agronomic data accumulated over a decade showed triticale to have an average of 30 percent greater yields than wheat, but with an average of 10 percent lower test weights. Better test weights were obtained under irrigation in the Cerrado region. It was also demonstrated that mixing wheat flour and triticale flour (in the proportions of 80 percent wheat and 20 percent triticale) helped increase loaf volume.

As a result of the meeting, a preliminary plan to encourage large scale production of triticale using commercial wheat quality standards and prices was recommended for official consideration. Large scale industrial milling and baking tests are needed to study the quality of commercial products before this plan can be implemented.

As for germplasm development, the earlier Maya II-Armadillo and Panda types are increasingly being outyielded by the newer Beagle and Tejon crosses, which show better adaptation and general disease resistance; however, high susceptibility to helminthosporium leaf blight and grain-storage pests requires further improvement.

EMBRAPA, Brazil, is effectively screening for resistance to pre-harvest sprouting, head scab and barley yellow dwarf virus (BYDV). INTA, Argentina, has made excellent progress in developing double-purpose (forage plus grain) triticale lines for its dry pampa region. There are an estimated 20,000 ha of triticale currently grown in Argentina, and the area is likely to expand as new varieties are released.

Barley—The area devoted to barley remained at around 300,000 ha in the region with about 400,000 tons of production. Most of the barley is grown under contract, while feed barley is losing ground to oats.

Barley stripe rust race 24 has now moved from southern Chile to southern Argentina. Cool and wet environmental conditions were very appropriate for its development at Bordenave, and samples were collected and sent to The Netherlands for analysis. Its northern migration and its impact on barley production must be watched carefully. A local Argentine variety, Klein Forajero, showed high levels of resistance to race 24, and a broader germplasm exchange between the Andean and Southern Cone regions is becoming increasingly important. Chile offered excellent screening conditions in 1982 for resistance to stripe rust and scald. Some of the outstanding materials identified include Benton 68, Robur, Dorada, Duchicela and JMK IP1033 (Oregon).

LACOS nursery—The second Southern Cone wheat screening nursery (LACOS), organised under the IICA-IDB Cono Sur program and coordinated by CIMMYT-INIA, Chile, consisted of 300 advanced lines from most of the region's national programs. A total of 33 sets were distributed within the region and to other specific locations to generate complementary disease data. Over 20 cooperators have returned their evaluation data, which are now awaiting analysis. The material in the second LACOS demonstrated significant superiority over the lines in the first LACOS in terms of wide adaptation. Selected entries from this nursery are being advanced to local yield tests. However, their potential use as progenitors is still quite limited.

Dr. Matt McMahon (center) CIMMYT agronomist in the Southern Cone region, visiting on-farm trials in Ecuador with Drs. Jesse Dubin (left) and Norm Borlaug (photo: B.C. Curtis).

New Releases

See Table 4 for a listing of the wheat varieties released in the region during 1982.

Disease Screening

Hot and wet climatic conditions in part of the region were very favorable for the development of several diseases. Changes in virulences patterns were observed and are of special importance, since they affect breeding strategies directly and crop production in the long run. Some of these changes and the important disease epidemics occurring during 1982 are highlighted below.

Leaf rust was severe throughout most of the region, and its severity was probably due to significant changes in virulence. A single leaf rust-resistance gene from Agent (Lr 24) introduced into two recent commercial varieties, Trigal 800 in Argentina and Tifton in Brazil, lost its effectiveness in 1982. Early and severe leaf rust on these commercial varieties caused high losses in farmers' fields. The mixed reaction of Alondra to leaf rust observed in previous years changed to complete susceptibility in 1982, resulting in the discarding of several advanced breeding lines. Severe leaf rust infection on Veery "S" lines and other materials having Kavkaz parentage may result in a decision to not release some of these high-yielding lines. Infection began late on Veery No. 3, but final readings were similar to other sister lines. The varieties CNT 8 and Pato both registered leaf rust infection for the first time (report from Londrina, Brazil).

INTA, Argentina, identified a strain of stem rust that produces a reaction of 4 (susceptible) on Sonora 64 seedlings, rather than the reaction of 2 observed previously. Field reactions at Pergamino on Sonora 64, although high in severity, remained at 60 MRMS. However, the widely grown Marcos Juárez INTA (Son 64-KL.Rend) suffered from a heavy stem rust infection (60-80S) in Argentina and Uruguay. This was further confirmed by heavy stem rust infection on the new Brazilian variety Nambu (Tzpp-Son 64). This situation needs to be watched carefully because a large number of advanced breeding materials in the region carry Sonora 64 and will require an immediate infusion of other sources of resistance.

Stripe rust race 238 E143, which attacks the varieties Manquefen and Clement, along with race 235 E141 in southern Chile, have resulted in varietal shifts and a greater diversity of spring wheat varieties in the region. The release of four new winter wheat varieties (Lancero INIA, Talafen, As Baer and Astro Baer) may help this situation. At the same time, two new barley varieties, Aramir and Granifen, were released to help safeguard barley production from stripe rust.

Leaf blight (*Helminthosporium sativum*) probably caused the greatest damage in 1982 in Brazil and Paraguay. Reports from Parana, Brazil, indicated seed infection in over 95 percent of the lots, in addition to significant crop losses. This may well cause seed shortages in 1983 and requires strict seed treatment measures.

As for chemical control of leaf blight, both experimental and farm results show that Triadimefon (Bayleton) is not effective. Preventive applications of contact metallic bisdithio-carbamates (Mancozeb, Maneb), especially after rains or at an interval of 10-15 days, proved both economic and effective. A new systemic fungicide, Propiconazole (Tilt), also provides effective control, but genetic resistance is the long term solution to this problem.

As mentioned earlier, the commercial variety Cocoraque and its derivatives (Jup-Zp x Coc, CM37614; F12.71-Coc, SWM5784), as well as some of the Veery and Bobwhite selections, demonstrate adequate resistance at the farm level. In addition, field screening by Dr. Y.R. Mehta at IAPAR, Brazil, (using artificial inoculation techniques) led to the identification of several new sources of resistance to leaf blight with good agronomic type. Some selected lines are listed below:

IA7875 Pamir "S"
CM20834-A-7Y-501M-502Y-OB

IA7878 ZZ-Dzi x Pato-Yr70
CM16679-E-4M-2Y-3M-OY

IA78112 Kvz x Cno-Pj62
SWM1285-2Y-3M-1Y-OM

IA7923 Bobwhite "S"
CM33203-H-4M-1Y-OM

IA8080
TR750538-2R-3R-2R-0R

OC812 IAS64-Aldan "S"
CM47207-6M-103PR-2T-0T

OC8154 IAS64-Aldan "S"
CM47207-6M-103PR-1T-0T

10C812 Au-UP301xGll-SX
CM31154-N-2Y-9Y-5Y-0Y

Appropriate climatic conditions at flowering caused severe head scab development in part of the region. Field notes taken on the Fifteenth International Bread Wheat Screening Nursery (15th IBWSN) at four locations in the region were compared with those from Suzhou, Jiangsu, Peoples Republic of China. Some selected lines are presented in Table 5. These need to be checked using artificial inoculation to confirm their resistance. Two additional lines from the region that have shown resistance to head scab for a number of years are:

LAJ1409 Nad x Bb-INIA
CM7161-9M-1Y-8M-2Y-0J

PF75171
IAS20-Tp x PF70100

Severe septoria leaf blotch, combined with other foliar diseases, proved calamitous in southern Brazil. In Uruguay, *Septoria tritici* heavily infected the early-seeded crop. Artificial

inoculations done at "La Estanzuela," CIAAB, by Ing. Martha Diaz, virtually killed the majority of the lines in the screening test. Some selected resistant lines with good agronomic type are given below:

Sunbird "S" CM34630-D-5M-2Y-1M-1Y-2M-1Y-0M	(2)*
Sunbird "S" CM34630-D-5M-5Y-1M-2Y-3M-3Y-0M	(3)*
Jup-Ald "S" CM36867-5M-1Y-1M-1Y-1B-0Y	(3)*
Kvz-HD2009 SWM2984-1M-1Y-1M-1Y-2Y-1M-0Y	(3)*
Kvz-K4500 LA4 SWO176-3M-1Y-4Y-1Y-1M-0Y-1Ptz-0Y	(3)*
Kvz-K4500 LA4 SWO176-3M-1Y-10Y-1Y-2M-0Y-0Ptz-0Y	(2)*
Kvz-Trm73 SWM3879-9Y-13M-3Y-1M-0Y	(2)*

* Severity (0-9 scale)

Several other lines derived from crosses with Kavkaz, Aurora and Golden Valley measured 4 to 5 on the 0-9 scale.

In general, BYDV infection was lower throughout the region in 1982. A reduction in aphid populations seems to be at least partially due to the successful establishment of natural parasites and predators in the region, as well as toselective chemical control measures. Dr. Roger Plumb, Rothamstad Experiment Station, England, helped to identify the first BYDV strains in Chile. It seems that the PAV strain is now predominate and is replacing the MAV strain; however, mixed infections were also observed.

Screening for take-all was expanded by Ing. Mario Mellado, INIA, Chile, using the infected oat kernel technique. A preliminary analysis indicates that using a proportion of one infected oat kernel to one or two wheat kernels will guarantee severe screening pressure. When verified, these results will be extremely useful in designing large-scale testing of segregating and advanced materials.

Agronomy

During 1982, most of CIMMYT's Southern Cone agronomy activities were concentrated on fertilizer experiments in Argentina. The research was a continuation of work begun by the Argentinian national program several years ago, and significant results can now be reported. It should be noted, however, that the nature and extent of CIMMYT's involvement in these trials is consistent with the Center's objectives and mode of operation within a regional program context; the regional agronomist for the Southern Cone provided advice and guidance to national program scientists, and was directly involved in the implementation of trials and analysis of experimental data.

Over the past three years, a network of fertilizer/wheat trials have been carried out by INTA-Pergamino. These trials have been highly successful and have helped to highlight the need for fertilizer in Argentina. The results of these experiments can be briefly summarized as follows:

- In the Pampa Humeda, there is a universal deficiency of nitrogen (N) for wheat production;
- Phosphorus (P) is also widely deficient in this area;
- A new yield potential for wheat has been established in the Pampa Humeda with the use of fertilizers;
- Information is now available that can serve as the basis of an "economic" fertilizer policy for wheat in the greater part of the wheat-growing area of Argentina.

Wheat is one of the principle crops in the Pampa Humeda. As a result of the level of production from this area, Argentina is able to export significant amounts of wheat to other developing countries around the world. This export market is well developed; in fact, over the past few years, Argentina has greatly increased its exports and it now seems that it will continue to do so in the near future.

In the area of influence of the Pergamino experiment station, the area sown to wheat has increased dramatically; from 625,905 hectares in 1977-78 with a production of 921,209 tons (average yield: 1,470 kg/ha) to 1,327,400 hectares in 1981-82 with a production of 2,417,870 tons (average yield: 1,820 kg/ha).

The main reason for this expansion is the increasing popularity of the wheat-soybean cropping system. This system has replaced to an important degree other crops, such as maize and sorghum. It has also resulted in a reduction of pasture lands.

The feasibility of the wheat-soybean cropping system was enhanced with the introduction of high-yielding, short-season wheat varieties in the mid-1970s. The most important variety at that time was Marcos Juarez INTA, which continues to be widely sown. Over the past five years, there has also been an increase in the average yield per hectare, from 1,470 kg/ha to 1,820 kg/ha. It is thought that this increase comes from two sources: higher yielding varieties and an increase in soil fertility due to the use of soybeans in the cropping sequence.

The reason for the network of fertilizer experiments reported on here was to estimate the response of wheat in the Pampa Humeda to nitrogen and phosphorus under these changed conditions of agriculture.

At the moment, it may be said that wheat production in Argentina is highly modernized: high-yielding varieties are used; there is an adequate seed supply; seeding dates and proper densities are adhered to by most farmers; weed control is excellent. However, Argentinian wheat production is also characterized by a low level of fertilizer use. There are many reasons for this, the most important being the high price of fertilizers relative to grain output. Second in importance is the lack of adequate fertilizer response data.

Characteristics of the experimental area—The area in which the trials were carried out is shown in Figure 1. Soils in the area are derived from loess deposits and they vary in texture as one moves from the northeast to the southwest. The soils in the northeast are classified as Argiudolls with a well-developed (clay) B horizon, which varies in depth over the area. This heavy-textured B horizon can limit root penetration. In the southeastern part of the experimental area, the soils are coarse-textured and they do not have a B horizon; they are classified as Hapludolls.

The area has a temperate climate with minimum temperatures of -6°C to -8°C in winter and maximum temperatures of 38°C to 40°C in summer. Rainfall diminishes from the northeast to the southwest in a range of 1,000 mm to 800 mm annually. This precipitation is concentrated in autumn, spring and summer. A moisture deficit for plant growth usually occurs in December and January. Wheat is sown in the dry winter period in June and July, which means it has to be sown into moisture stored in the profile. Wheat can suffer from moisture stress during this period if it is not sown deeply enough, or if the surface dries out very rapidly.

In the years 1980, 1981 and 1982, some 27, 20 and 18 experiments were established, respectively. In 1980, there were five nitrogen treatments (0, 30, 60, 90 and 120 kg of N per ha) along with two additional treatments of 0-60 and 120-60 (kg of N-P_2O_5). In 1981 and 1982, an incomplete factorial (5 x 5) experimental design was used. The levels of nitrogen were 0, 30, 60, 90 and 120 kg/ha, while those of phosphorus were 0, 20, 40, 60 and 80 kg/ha. An additional treatment of 150-80 N-P_2O_5 was included. The field design was a randomized block with three repetitions in 1980 and two repetitions in 1981 and 1982. Plots were 7 meters wide and either 20 or 30 meters long depending on the site. Phosphorus was applied as triple superphosphate; nitrogen was applied in the form of urea. Both nutrients were applied using the broadcast method before sowing and incorporated with a disk harrow.

Each site was characterized for several variables and the average value, range and standard deviation of these are shown in Table 6. As can be seen, the soils at all sites are slightly acidic to acidic; the range in pH is very limited, varying only from 5.2 to 6.2. Organic matter ranges from 2.0 percent to 4.7 percent, and NO_3 (in ppm) shows great variation. Phosphorus is extremely variable, ranging from 3.4 ppm to 36 ppm. As might be expected, rainfall and stored moisture varies greatly between sites. The number of years of continuous tillage also varies greatly, but in general this figure

is high (an average of 11.9 years), which shows how intensive crop production has become in the area. The fallow period is also quite variable, but the trend is toward shorter fallow periods; the average length of fallow in the experimental area is down to 60 days.

Yield levels—The average yields of the check treatment and average maximum yields (with fertilizer) and their respective rates are shown in Table 7. There is a great deal of variability, both in yield levels and in response levels across years (1982 was the most favorable year). However, the analysis of variance for each experiment shows a significant response to fertilizer in 87 percent of the trials. The response to nitrogen is significant for 75 percent of the sites, while the response to phosphorus is significant in 60 percent of the trials. The coefficient of variation is less than 10 percent in 85 percent of the experiments.

Correlations of various parameters with yield and yield responses—The correlation coefficients between various soil, climatic and management variables and yield and yield responses are shown in Table 8. Some of these correlations are highly significant and have agronomic meaning. The check yields are highly correlated with total rainfall, depth of the A horizon and the previous crop in the cycle. Soybeans are shown to have a highly positive affect on the yield of the subsequent wheat crop. The number of years without alfalfa had a negative correlation with check yields.

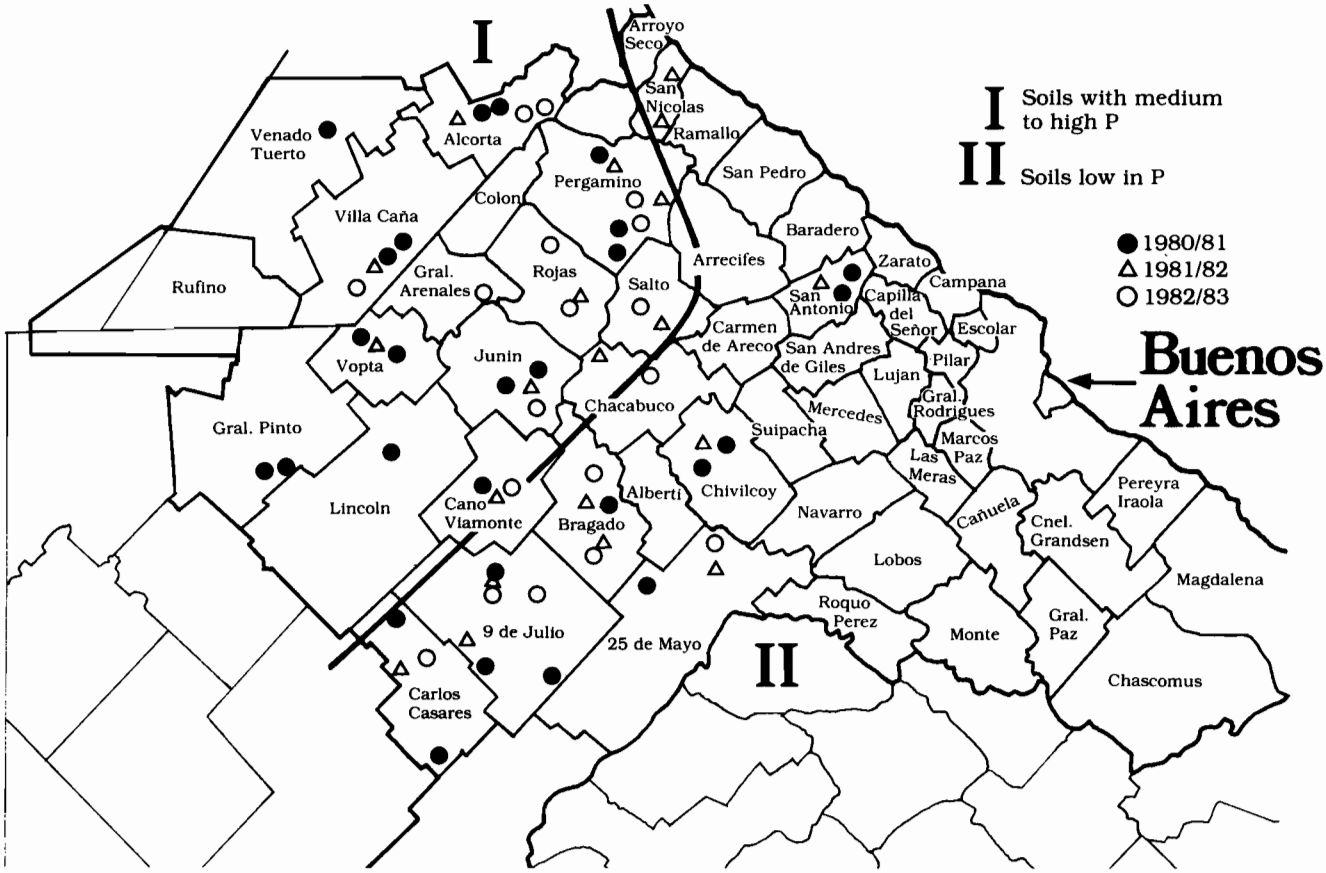


Figure 1. Location of fertilizer experiments in Argentina, 1980/81 to 1982/83.

The yields of fertilized (NP) plots have a highly positive correlation with total rainfall. However, the most important component of the rainfall variable is that which occurs during the tillering to flowering period; the level of rainfall during this period has a highly significant affect on yields. While available soil moisture to a depth of 1.5 meters by itself does not have a significant affect on yields, available soil moisture plus rainfall from sowing to flowering is highly significant for high yields (NP plots).

The only factor that has a high correlation to the response to P is soil P (Bray 1). Of course, the correlation is negative. This is further illustrated in Figure 2, in which it can be seen that the soil P (Bray 1) limit is considered to be 13 ppm. Below this level, there is a response to applied phosphorus. Sixty-five percent of the trials were on soils with a level of P lower than 13 ppm, which shows how widespread the P deficiency is in the area.

The factors that show a highly significant correlation to response to N are rainfall (tillering to flowering) and available soil moisture to 1.5 meters plus rainfall (sowing to flowering). There was a highly significant negative correlation between soil nitrate (at 0-20 cm) and response to nitrogen.

This is further illustrated in Table 9, which shows the response to different levels of nitrogen at various levels of soil nitrates and after different crops. As can be seen from this table, the response after maize is always greater than after soybeans, showing the contribution soybeans make to the following crop. Above 70 ppm soil nitrate, responses to N are marginal.

Training and Conferences

Seven wheat scientists from the region's national programs visited CIMMYT headquarters in Mexico to participate in training courses, bilateral activities or exchange programs. These visits serve to increase the understanding of common goals, as well as to allow a closer look at what is being done in germplasm development and agronomy. They also provide for direct contact with CIMMYT headquarters staff, as well as with wheat scientists from around the world who gather in Mexico each year.

CIMMYT staff in the region participated in the IICA-IDB Southern Cone program of events. A meeting at the national wheat coordinator level helped identify common problems and strengths so as to expand regional cooperation. Two technical meetings, one focusing on the rusts and one on *Septoria nodorum*, were attended by regional staff from both the Andean and Southern Cone regions.

One of the highlights of 1982 was the organization of a three day conference, held in La Estanzuela, Colonia, Uruguay (during September, 1982), which focused on the production aspects of wheat in the Southern Cone. This meeting was organized in conjuntion with the IICA-BID (Cono Sur) Wheat Project, coordinated by Ing. Milton Medeiros (EMBRAPA, Brazil) and with CIAAB (Uruguay), coordinated by Ing. Roberto Díaz. This was the first time such a conference was held in the Southern Cone and it was deemed a success by all participants. The proceedings are published in Spanish as "Seminario sobre Tecnologia de Trigo", Diálogo VI, Convenio IICA-Cono Sur/BID. Eds. Ing. Roberto Díaz and Matthew A. McMahon.

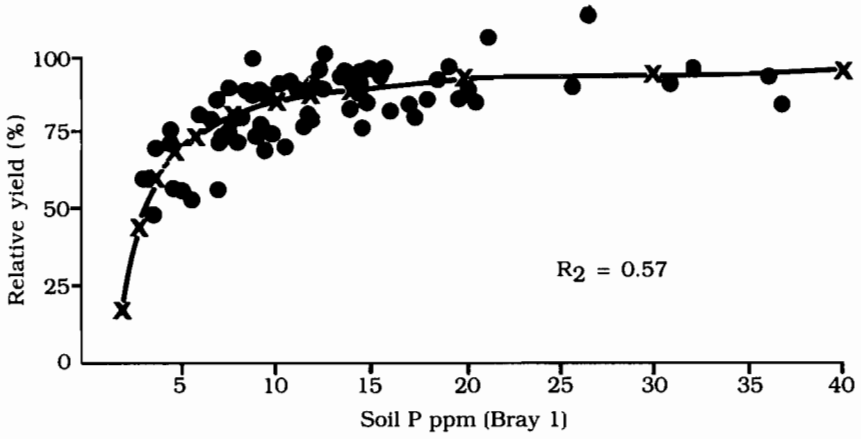


Figure 2. Relation between soil P (Bray 1) and response to applied P.

Table 1. Wheat in the Southern Cone region, 1981 and 1982

Country	Area (1000 ha)		Yield (kg/ha)		Production (1000 t)		Consumption (1000 t)	
	1981	1982	1981	1982	1981	1982	1981	1982
Argentina	5,883	7,320	1,377	2,067	8,100	15,130	4,500*	4,700*
Brazil	1,920	2,829	1,151	654	2,209	1,849	6,972	6,074
Chile	432	374	1,587	1,739	686	650	1,735	1,656
Paraguay*	50	70	1,100	986	55	69	150	150
Uruguay	296	234	1,311	1,353	388	316	392	396
Totals	8,581	10,827	6,526	6,799	11,438	18,014	13,749	12,976

Source: FAO Monthly Bulletin of Statistics, October, 1983 * Estimates by local authorities

Table 2. Overall outstanding bread wheat lines of CIMMYT origin in the Southern Cone region, 1982

Variety or Cross	Pedigree
1. Veery #3 = Genaro 81	CM 33027-F-12M-1Y-6M-0Y
2. Veery'S'	CM 33027-F-12M-1Y-1M-1Y-1M-0Y
3. Kvz x Cno-Pj 62	SWM 1285-2Y-3M-1Y-0M
4. Jup-Ald'S'	CM 36867-7Y-2M-3Y-0M
5. Jup-Ald'S'	CM 36867-18Y-21M-3Y-0M
6. Au-UP301XGll-SX	CM 31154-N-2Y-9M-0Y
7. Kvz-HD2009	SWM2984-1M-1Y-1M-2Y-0M
8. Kvz-K4500 L.A.4	SWO 176-3M-1Y-6Y-1Y-2M-0Y
9. Bobwhite'S'	CM 33203-K-9M-2Y-1M-1Y-1M-0Y
10. Bobwhite'S'	CM 33203-K-9M-15Y-1M-4Y-2M-0Y
11. Sunbird'S'	CM 34630-D-5M-2Y-1M-1Y-2M-1Y-0Y
12. Gov-AzxMus'S'	CM 41257-I-8M-3Y-0M
13. Cndr'S'-AnaxCndr'S'-Mus	CM 44321-A-1Y-2M-2Y-0M
14. Kinglet'S'	CM 33089-W-3M-7Y-3M-0Y
15. IAS 64-Aldan	CM 47207-6M-103PR-1T-0T
16. Thornbird'S'	F.11915-A-502M-1Y-3F-701Y-9F-700Y
17. IAC 5-Aldan	CM 46961-16M-113PR-1T-0T
18. PF 70354-Ald'S'	CM 47090-13M-1Y-1F-702Y-7F-700Y
19. (IAS58-IAS55xAld'S'/IAC5) Ald'S'-IAS58xAld'S'	CM 55517-B-1F-703Y-2F-700Y
20. PF 72640-PF7323xPF7065-Ald'S'	F 11933-D-500M-3Y-1F-704Y-2F-700Y

Table 3. Stem rust-resistant, high-yeilding durum lines, selected in Chile and Argentina, 1982

Variety or Cross	Pedigree
Yavaros 79	
Guillemot 'S'	CM 14646-C-1Y-1M-1Y-0Y
Guillemot 'S'	CM 14646-C-1Y-1M-1Y-4AU
Rokel 'S'	CD 1895-12Y-0Y-2E-6B-0Y
Rokel 'S'	CD 1895-12Y-2Y-2M-0Y
FG'S'-AA'S'xMAL'S'-MARIO'S'	CD 14472-D-4Y-2M-3Y-3M-0Y
[RALLE'S'-FG'S'(GR'S'x CP-ST464/ CH67-GTA'S')]BOY'S'	CD 24803-A-1Y-1M-501Y
QFN-AA'S'x[GTA'S'-PG'S'/BOY'S'	CD 25241-A-3Y-1M-1Y-1Y-0M
MEMO'S'-MEXI 75	CD 26132-8B-1Y-1Y-0M
PLC'S'-CR'S'x[MEXI'S'/ DOMO'S'xDACK'S'-KIWI'S'	CD 27748-B-2M-1Y-1Y-0M
PLC'S'-CR'S'xMEXI'S'/ DOMO'S'xDACK'S'-KIWI'S'	CD27748-B-2M-1Y-3Y-0M
MEDIUM-KIF'S'xSAPI'S'	CD 27945-5B-1Y-2Y-0M
MEDIUM-Kif'S'xSAPI'S'	CD 27945-5B-1Y-6Y-0M

Table 4. Varieties released in the Southern Cone region during 1982

Country	Name	Cross and pedigree	Institution
Argentina	Buck Candisur (Durum)*	JO''S''-RD119xAA''S''/YEMEN-CR''S''xPLC''S'' CD 595-1Ld-1Ld-3Ld	Buck Seeds
	Klein Cartucho*	JUP/PJ62-WRTxCAL CM 28204-KF-13200	Klein Seeds
Brazil	Candeias*	CDLxSON64-KL.RENDIDOR	OCEPAR

Table 4. (continued)

Country	Name	Cross and pedigree	Institution
Brazil	Pavao*	BB-CAL II 30877-62M-3Y-1M-2Y-0M	OCEPAR
	Minuano 82	S71-S474.A_3A_2	FECOTRIGO
	Sulino 82	PLATIFEN-CNO"S" xS67	FECOTRIGO
	Tapejara	LD 7835 (unknown cross)	IAPAR
	Tucurui	IAS 51-IRN 597/70	IAC
Chile	Chasqui INIA*	CC-INIAxTOB-8156/CNO CM 4264-23Y-2M-0Y	INIA
	Millaleu INIA*	Veery #3 CM 33027-F-12M-1Y-6M-0Y	INIA
	Maiten INIA*	Bluejay "S" CM 5287-J-1Y-2M-2Y-3M-0Y	INIA
	Onda INIA*	Pavon "S" CM 8399-D-4M-3Y-1M-1Y-0M	INIA
	Sipa INIA*	Tanager "S" CM 30697-2M-14Y-0M	INIA
	Lancero INIA	BEZO (1150/Y54-N10B/M. DESPREZ-IGA BORDEAUX)	INIA
	Talafen	CAR 487xRIEB47.51-FLEVINA^2	INIA

Table 4. (continued)

Country	Name	Cross and pedigree	Institution
Chile	Rancofen	PANGUIFEN YAFENxHN 110	INIA
	Granifen (Barley)	CARLSBERG-APIZACO T 132-1t-28t-16t-3t	INIA
	Aramir (Barley)		CCU
Paraguay	C7659	PEL 72214	IAN
	Alondra-1*	D6301-NAI 60XWQ-RM/CNO^{2}-CHR CM 11683	IAN
	Cordilleras-3*	Veery #3 CM 33027-F-12M-1Y-6M-0Y	IAN
Uruguay	Estanzuela Dorado	E.TAR/TOBxKL.PET-RAF	CIAAB

(*) CIMMYT origin.

Table 5. Lines from the 15th IBWSN, selected during 1982 in the Southern Cone region for their low levels of scab infection; scab readings from the Peoples Republic of China (PRC) are also presented

Variety or cross		Scab readings in the PRC	
		% head infection	Disease index
Kvz x Cno-Pj62	SWM 1285-2Y-3M-1Y-0M	10.0	2.5
Kvz-Cj	SWM 1430-4Y-3Y-0Y	10.0	2.5
F 3.71-Trm	SWM 5704-10Y-1M-3Y-3M-2Y-3M-0Y	13.3	3.3
F 3.71-Trm	SWM 5704-10Y-1M-3Y-4M-1Y-1M-0Y	6.67	2.5
Veery'S'	CM 33027-F-12M-1Y-6M-0Y-83B-0Y	13.3	5.0
Chat'S'	CM 33090-T-1M-4Y-0M-1B-0Y	3.3	1.7
Chat'S'	CM 33090-T-1M-4Y-0M-57B-0Y	3.3	0.87
Bobwhite'S'	CM 33203-K-9M-24Y-0M-10Y-0B	16.67	5.83
MN 72131-Pvn76'S'	CM 42402-30Y-1M-1Y-1M-1Y-2M-0Y	6.67	2.5
Cmt-Mo 73xTrm	CM 43381-D-1Y-4M-1Y-1M-1Y-0B	10.0	5.83

Table 6. The average value, range and standard deviation of various site parameters (N = 65)

Parameter	Average value	Range	SD
pH	5.9	5.2-6.2	0.2
Organic Matter (%)	3.13	2.0-4.7	0.61
Total N (%)	0.139	0.082-0.196	0.027
NO_3 (0-20 cm) (ppm)	52	15-136	25.4
Soil P bray 1 (ppm)	12.4	3.4-36.0	6.8
Depth of A	27.9	21-34	3.3
Available H_2O to 1.5 m (mm)	221	107-357	52
Total rainfall (mm)	250	111-373	67
Rainfall, sowing to tillering (mm)	55	0-206	48
Rainfall, tillering to flowering (mm)	102	4-239	51
Rainfall, flowering to maturity (mm)	93	16-208	47
Year of continuous agriculture	11.9	0-50	8.8
Length of fallow period	60	10-270	44

Table 7. Average check, maximum yields and ranges for the three years 1980, 1981 and 1982

Year	Average check yield (kg/ha)	Range (kg/ha)	Average maximum yield (kg/ha)	Range (kg/ha)
1980 (n = 27)	2730	1400-4400	3790	2060-4450
1981 (n = 20)	2260	1120-3460	3310	2060-4550
1982 (n = 18)	2890	1790-4280	4960	3490-6070

Table 8. Correlation coefficients between various soil, climatic and management variables with yield and yield responses to N and P

Variable	Check yield	Yield of NP treatments	Response to P	Response to N
Rainfall, sowing to tillering	0.09	0.17	0.11	0.13
Rainfall, tillering to flowering	0.11	0.35**	0.04	0.36**
Rainfall, flowering to maturity	0.11	0.01	0.05	-0.11
Total rainfall	0.33**	0.41**	0.11	0.21
Available soil water to 1.5 m	0.08	0.20	0.11	0.15
Available soil water to 1.5 m, plus rainfall, sowing to flowering	0.26*	0.47**	0.14	0.35**
Depth of A horizon	0.33**	0.26*	-0.23	-0.04
Nitrate (ppm) 0-20 cm	0.19	-0.12	-0.17	-0.41**
Nitrate (ppm) 20-40 cm	0.28*	0.12	-0.01	-0.20
Nitrate (ppm) 0-40 cm	0.21	-0.06	-0.13	-0.35**
Organic matter (%)	0.22	0.10	0.01	-0.11
Total nitrogen (%)	0.26*	0.32**	0.08	0.15
Soil P bray 1 (0-20 cm)	0.08	-0.07	-0.64**	-0.08
Years without alfalfa	-0.26*	-0.16	-0.01	0.14
Length of fallow period (days)	0.03	0.02	0.08	-0.05
Previous crop (Soybeans = 1; Other = 0)	0.37**	0.27*	-0.03	0.05

** = significant at 1% level * = significant at 5% level

Table 9. Response of wheat (kg/ha) to different levels of applied N at various levels of soil nitrates and following different crops

	Soil nitrates (ppm)							
	<30		30 - 50		50 - 70		>70	
	Previous Crop							
Nitrogen applied (kg/ha)	Maize n = 5	Soybeans n = 4	Maize n = 10	Soybeans n = 11	Maize n = 9	Soybeans n = 2	Maize n = 5	Soybeans n = 2
	Response (kg/ha)							
30	691	623	782	404	465	214	216	206
60	1087	980	1280	672	760	344	347	291
90	1192	1096	1496	807	877	390	334	254
120	1005	966	1636	794	766	354	207	132

North and West Africa and the Iberian Peninsula

G. Varughese and S. Fuentes

Introduction

The 1981-82 crop cycle was extremely dry in Portugal, Spain, Morocco and western Algeria, although late rains in parts of this region contributed to a harvest of average size. Northern Tunisia and eastern Algeria had a fairly good distribution of rainfall and as a result experienced an above average harvest.

In West Africa, where most wheat is irrigated, socio-economic factors and the timeliness of planting are the main factors determining the expansion of wheat cultivation in the region. Currently, the predominant varieties are Siete Cerros and Mexipak. A number of countries in the region have an unrealized potential for growing wheat in specific, though not very large, areas.

Dr. George Varughese (left), CIMMYT breeder in the North and West Africa region, and Dr. Art Klatt evaluating the performance of CIMMYT nurseries in one of 14 locations throughout the region (photo: J.L. Castillo).

Varietal Status

Varieties are not a limiting factor in most of West Africa, which is geographically isolated from other major cereal producing areas, and has a short season and dry, desert climate. However, obtaining new varieties is a problem in the Mediterranean Basin. Overly strict seed laws and nonexistent or inefficient public institutions for seed multiplication tend to limit the release and multiplication of new varieties in North Africa and the Iberian region, with the exception of Tunisia.

In Spain, the seed industry is dominated by a number of private companies. INIA is moving aggressively to register new varieties, but is still in the process of developing a system for multiplying the public domain varieties. The predominant cultivars for North Africa and the Iberian Peninsula are listed in Table 1.

Germplasm Evaluation

Visual evaluations of the potential of the various entries in each of the CIMMYT and ICARDA nurseries were made at 14 locations throughout the region in 1981-82. At the end of the season, but before harvest, these data were tabulated and sent to all collaborating locations, to CIMMYT and to ICARDA. This procedure provides the breeders of each cooperating institution with an opportunity to determine before harvest which materials appear most promising as future breeding lines. These data are available from the CIMMYT and ICARDA international nursery programs upon request.

Diseases and environmental stresses

One of the regional program's primary objectives is to screen for resistance or tolerance to the diseases or stresses that are prevalent in the region. This is done at most of the locations where CIMMYT and ICARDA nurseries are grown. At the National Plant Breeding Station of Portugal at Elvas, where the CIMMYT regional program is based, uniform screening pressure is ensured by the use of artificial inoculation techniques. Except for this location and for Sevilla, Spain, which is an irrigated station and also artificially inoculated, very little disease development occurred in the region because of the dry weather.

This was the first year for intensive artificial inoculation at Elvas, and only a limited amount of inoculum (collected strictly from the Elvas area) was available. Bread wheat is the main crop in the area, so all inoculum came from this species.

About 4,000 lines and varieties of bread wheat, durum wheat and triticale from the national program, CIMMYT and ICARDA were evaluated for their resistance to *Septoria tritici* and *Puccinia striiformis* (stripe rust), which comprise the region's greatest potential disease dangers. The nurseries were also inoculated with *P. recondita tritici* (leaf rust) and *P. graminis tritici* (stem rust). The development of septoria and of stripe rust was excellent. However, there was practically no septoria on the durums or triticales; the latter are known to have excellent resistance to *S. tritici*. Lines and varieties of bread wheat with excellent resistance to *S. tritici* are listed in Table 2.

An Acknowledgement

CIMMYT regional staff are extremely grateful for the support and collaboration of all national programs in North and West Africa and the Iberian Peninsula. Special thanks go to the administration and staff of the National Plant Breeding Station of Portugal at Elvas for their valuable help.

Table 1. Distribution of varieties in the North and West Africa and Iberian Peninsula region

Country	Bread wheat	Durum wheat	Barley	Triticale
Portugal	Compodoro Impeto Anza N.Strampelli Mexicano 1481 Mara Cala Mira Tejo	Cocorit Capeitl Prato Amarelo Faisca Timpanas Fala	Beka Union Arivat Carina Ribeka	Armadillo Bacum Beagle Mapache Arabian
Spain Ebro, Andalucia and Extremadura	Anza Cajeme 71 Yecora 70 Aragon 3 Marca Castan Nacozari 76	Mexicali Cocorit Crane Esquilache Abadia Yavaros	Albacete Alpha Hop Secal 1 Tina Zaphir Abacus Bolare Hassan Georgia Logra	Cachirulo Mahisa 26 Cirro Manigero Torote Yoreme Balboa
Morocco	Nasma Siete Cerros Potam Teggey 32 Teggey 9 Pynite	Kyperounda Zeramek Cocorit Oued Zenati Selbara Jori	Rabat 071 Merzaga Tripolis 89 Barlis 628 Brasserie Maroc Arig 8	
Algeria	Mahon Demias Siete Cerros Strampelli Anza Florence Aurore Pumaflor	Oued Zenati Bidi 17 Mohamed Ben Bachir Hedba 3 Saba Polonicum x ZB Capeiti INRAT 69 Cocorit	Saida Tichdrett Robur Ager	
Tunisia	Florence Aurore Ariana Dougga Carthage Tanit Salambo	INRAT 69 Badri Maghrebi Ben Bachir Karim Chile	Martin Ceres	Tcl 3 (Maya II- Arma''S'')

Table 2. Bread Wheat lines and varieties with good tolerance (reading of 5 or below) to *Septoria tritici*: Elvas, Portugal 1981-82

No.	Variety or cross and pedigree	Origin and entry number
1	ORSO	RCBW 2
2	WARBLER"S" CM39814-500M-502Y-0M	26
3	BOW"S" CM33203-S-1M-1Y-0M	27
4	CC/INIA/3/TOB/CFN//BB/4/7C CM8237-G-1M-3Y-3M-0Y	29
5	BLUEBOY	90
6	BEZOSTAYA I	92
7	PAIYUPAO	94
8	NS 2699	95
9	SLAVYANKA	98
10	PEG"S" SWM1368-500Y-1B-501Y-502M-0Y	112
11	PCH/VG9052	131
12	H.604	136
13	CAPPELLE DESPREZ	140
14	P.101	141
15	ERA	144
16	CHRIS	145
17	MT-771	148
18	MT-773	149
19	CAR853-COCxVEERY"S"	ISEPTON
	CM47556-##01M-1Y-2M-1Y-0Y-2PtZ-0Y	69
20	IAS20^2-H567.71xALD/H570.71-ERA^{2}xIAS58 CMH77A.277-11B-2Y-1B-1Y-1PTZ-0Y	119
21	ROMANY x GABO-GAMENYA	141

Table 2. (continued)

No.	Variety or cross and pedigree	Origin and entry number
22	GLENLEA	143
23	LEE-RL2564 x FR/IAS54	148
24	COTIPORA	150
25	BOW"S"	IBWSN
	CM33203-K-10M-7Y-3M-1Y-2M-0Y	73
26	CNOxYMH-TOB66/HUAC"S"	IBWSN
	CM43330-L-2Y-2M-1Y-1M-1Y-0B	128
27	TES 76-PAM"S"	153
	CM45984-9Y-1M-1Y-0Y	
28	YD"S"-PCI"S"	PC BW
	CM35044-110M-1Y-3M-0Y	51
29	YD"S"[(FN-TH(3)xII 44.29-TH(2)/CTJN)(4)SR]	55
	CM35735-1M-2Y-1M-1Y-1B-0Y	
30	PEEP"S"	56
	CM36902-6Y-14M-2Y-0M	
31	PEEP"S"	58
	CM36902-18Y-10M-1Y-1M-1Y-0M	
32	MRS x KAL-BB/AZT	144
	CM43429-H-1Y-1M-1Y-4M-1Y-0B	
33	V.65107.1.10-PCH"S"xANT	150
	CM43784-D-1Y-1M-2Y-2M-1Y-0B	
34	MRS x KAL-BB/AZT	303
	CM43429-H-1Y-1M-1Y-1M-1Y-0B	
35	MRS x KAL-BB/AZT	304
	CM43429-H-1Y-1M-2Y-1M-0Y	
36	TOB-CNOxTOB-ERA/NAC	551
	CM42376-6Y-2M-1Y-2M-1Y-2M-0Y	
37	CNOxYMH-TOB/HUAC"S"	590
	CM43330-L-2Y-3M-1Y-1M-1Y-1M-0Y	
38	CNOxYMH-TOB/HUAC"S"	591
	CM43330-L-2Y-3M-1Y-1M-1Y-2M-0Y	

Table 2. (continued)

No.	Variety or cross and pedigree	Origin and entry number
39	BCH''S''-SKA CM45856-2M-1Y-1M-1Y-QY	646
40	CAR853-COCxVEE''S'' CM47556-EE-1M-1Y-2M-1Y-2Y-OM	849
41	JUP73-FDRxF3.71-TRM CM48544-A-1M-1Y-1M-2Y-2Y-OM	902
42	BUC''S''-BUL''S'' CM50609-3Y-1M-6Y-1Y-OM	952
43	YD''S''-ZZ''S'' CM35048-67Y-3M-2Y-1M-OM	997
44	BUC''S''-PVN''S'' CM52359-12M-2Y-2B-1Y-OB	1068
45	BOW''S'' CM33203-H-8M-8Y-1M-1Y-2M-OY	1084
46	BOW''S'' CM33203-H-8M-8Y-1M-1Y-1M-OY	1085

Eastern and Southern Africa

G. Kingma

Introduction

The CIMMYT regional wheat program based in Kenya has been implemented in three phases. First came the establishment of cooperative arrangements between national programs in East Africa and the Near East, whereby breeders from Lebanon and Egypt sent their advanced and segregating materials to Kenya. This off-season nursery program was formalized by an agreement (signed in 1975) between the Government of Kenya and CIMMYT, and continues to the present time.

In phase two (beginning in early 1976), CIMMYT stationed a regional representative in Kenya, forming the East African base for more intensive exchange and evaluation of germplasm received from abroad by the National Plant Breeding Station (NPBS) in Njoro. In addition to the Near East off-season nurseries, many wheat, triticale and barley nurseries were obtained each year for disease screening at Njoro. A system to handle large numbers of breeding entries was formulated and implemented.

In phase three of the original workplan (the current phase) the most resistant selections with the best agronomic type, obtained from the Near East nurseries and other sources worldwide, are increased in Kenya for distribution to breeding and production programs in Eastern and Southern Africa. This third phase includes a screening nursery, from which entries are selected for yield testing.

Plantings in 1982 in Kenya

Land has been made available at the Kenyan NPBS for the planting of introductions. This long-standing arrangement is a key part of the national wheat program. The high turnover of wheat varieties in the Kenya highlands is a result of changes in the virulence of stem and stripe rust in the area. For Kenyan breeders, the introduction of germplasm from overseas has been the key in the wheat variety development program, as new sources of resistance are identified and used.

Dr. Gerry Kingma, Head of CIMMYT's Eastern and Southern Africa regional office (photo: J.L. Castillo).

Disease screening is very intensive at Njoro, where stripe rust can be severe as it moves downward from the higher elevations and stem rust moves upward from the lower parts of the Rift Valley.

Hill plantings—These have been very useful in reducing the number of new entries with insufficient disease resistance. A small area is used to accommodate several thousand entries. Germplasm from at least 12 countries was reviewed in this way, with the majority coming from Mexico, Turkey, the USA, the Near East, Ethiopia, Tanzania, Zimbabwe and Southern Africa for a total of 17,897 entries (see Table 1). Each nursery, comprising from 50-500 entries, is planted in rows one foot long, which are considered to be modified hill plantings.

F_2 populations—These nurseries were provided to the national program in Kenya with the expectation that with severe rust pressure, breeders could quickly identify parental combinations that offer new material with resistance.

Several thousand F_2 lines are tested each season, and for many years short rows of 1.25 meters seeded at the normal rate have been used to identify the best materials. The best F_2 remnant seed is kept in the original envelopes for the next season when it is planted again. In 1982, some 250 plots of the best F_2 lines of 1981 were grown, in addition to over 2000 short rows of new F_2 material. Close cooperation with the national program breeders assures that this early generation material enters the national system quickly.

Disease nurseries—These nurseries form an integral part of the cooperative projects started many years ago by pathologists and breeders to monitor changes in disease virulence, to identify new sources of resistance, and to distribute new germplasm. In 1982, seed for these disease trials came from the USA, Ecuador, Ethiopia, Turkey, and Mexico. The Kenyan Rust Trap Nursery was planted as well.

Collections—Germplasm collections have been built up at Njoro since the 1960s. Introductions and breeding lines having at least one desirable characteristic, but lacking other traits needed for commercial use, are grouped in these collections. The oldest and best-known group is the Stem Rust Parental Collection (SRPC), built up with materials from the USDA disease nurseries. Kenya has not had serious stem rust epidemics in the last ten years, partially due to the fact that certain lines of the SRPC have been used effectively in developing Kenyan varieties.

The Yellow Rust Parental Collection (YRPC) was started at Njoro in the late 1960s using Frocor-type lines from Colombia. A new collection was begun in 1976, when the seed of the old collection could not be located at the station.

In 1981, a Helminthosporium Parental Collection (Helm PC) was begun, as heavy tan spot infections were present in the nurseries. This group showed very good leaf health in 1982, while most new entries were blotched.

Repeat nurseries—The 1982 Repeat Nurseries (RNs) were made up of selections from all the nurseries grown during 1981. This second observation of the materials initially selected takes place in 5 to 6 meter single rows. A separate RN is prepared for each crop, thereby grouping the better lines and varieties from many sources. A repetition of previously observed resistance reactions, as well as good uniformity, are the selection criteria used for further testing. Ordinarily, only 10 percent of the roughly 2000 lines and varieties in the RNs is retained.

Screening Nursery for the African Cooperative Wheat Yield Trial (SNACWYT)—The 1982 SNACWYT was made up at Njoro using selections from the Repeat Nurseries. Since 1978, the SNACWYT has been sent out every year to countries in the region in an attempt to transfer the best lines from around the world to the East African countries. The 5th SNACWYT (1982) included 92 bread wheats, 21 triticales, 33 durum wheats, 35 barleys and 25 oats. Results form the basis for deciding which entries are to be included in the regional yield trial.

Multiplications for the yield trial—The entries that were screened in more than 20 locations in Eastern Africa in 1982 were multiplied at NPBS in large plots laid out as yield trials. The lines were selected using data obtained in key countries in the region: Kenya, Ethiopia, Tanzania, and Zambia, among others. Yield data in the 138 multiplication plots also helped to identify 24 promising entries for intensive yield testing over the whole region (see Table 2).

African Cooperative Wheat Yield Trial (ACWYT)—This trial was planted for the sixth year at NPBS, using the best 16 varieties available in the 1981 multiplication plots. The 5th ACWYT, prepared in 1980, was also grown again to obtain at least two years of data at NPBS. Data from Njoro can be compared with results returned from programs in surrounding countries. Triticale lines in the ACWYT have often given higher yields than bread wheats, as can be seen in Table 3.

International yield trials—The nurseries received by NPBS are grown as a part of the overall introduction program. In 1982, the CIMMYT international nurseries ISWYN, ESWYT, IDYN, EDYT and ITYN were planted. Over the years, Njoro has proven to be a key location for such yield trials as the ISWYN, a fact confirmed by the excellent yields obtained in the Kenya Highlands with Veery "S".

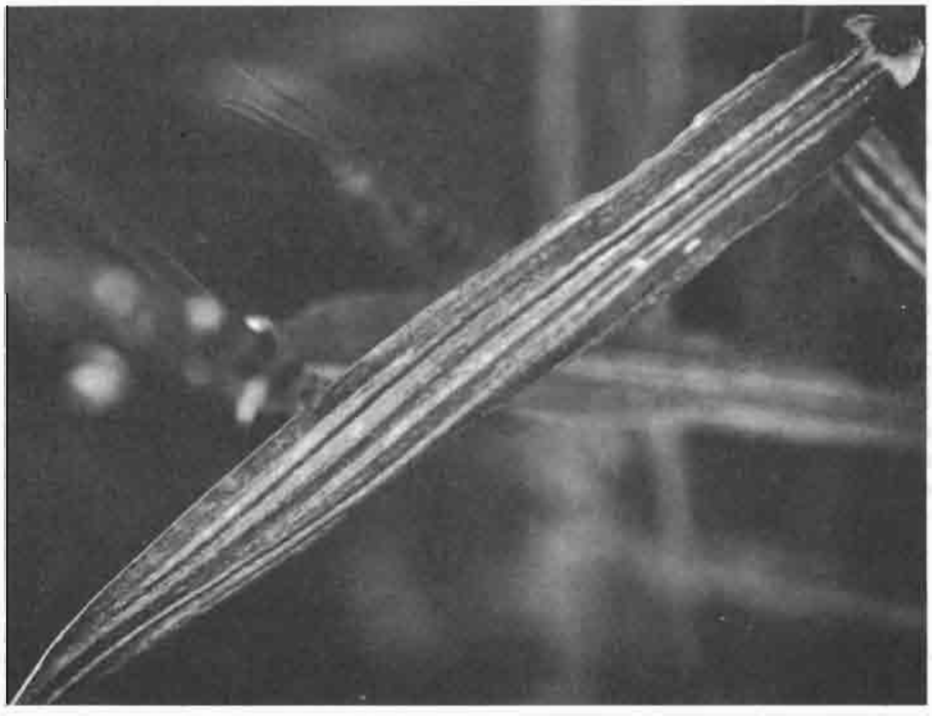
In Table 3, the top-yielding bread wheat is a Veery selection, as is the case in the 5th and 6th ACWYT. In the durum wheat trials (13th IDYN and 11th EDYT), stem rust was very serious; Boohai was the highest yielding variety, thanks to its excellent resistance, but had lower yields than the triticale and bread wheat checks. The local durum wheat check variety, K Njiwa, performed very well in both trials, also due to its lower susceptibility to stem rust.

Among the triticales, the Kenyan variety Tcl 65 has continued to yield very well. In the 13th ITYN it ranked first as the local check and 5th as a regular entry. In the ACWYTs, it again ranked first.

Stripe Rust in Kenya

A heavy stripe rust epidemic in the highest elevation wheat growing areas of the Mau Escarpment in late 1982 underscores the need for continued efforts to obtain resistant varieties.

The variety K Paa was grown on a commercial scale for the second year in Kenya, after a very rapid area expansion in 1981. The resistance of K Paa to stripe rust is probably based on Kavkaz, one of its parents. This resistant parent has been widely used during recent years in a number of crossing programs, and has provided good resistance to several other diseases as well. Furthermore, it has contributed to the outstanding yield performance of Veery.



Stripe rust (caused by *Puccinia striiformis*) is a serious production constraint in the higher elevation areas of Kenya and other East African countries (photo: T. Harris).

The 1982 YRPC was grown in the area where a new stripe rust race appeared. Not only was K Paa seriously affected, but also some Veery and Sunbird lines, certain combinations with Alondra, the cross Golden Valley-Azteca 67 x Musala, and others were newly susceptible (Table 4).

In the bread wheat Repeat Nursery of 1982-83 (191 entries), 34 lines with good stripe rust resistance and plant type were selected at the NPBS (see Table 5). These will be added to the lines in preliminary yield trials 1983. Many lines with the Kavkaz type of resistance were susceptible to the stripe rust race attacking K Paa. A major source of resistance in the selected lines is that of Cno-Gallo (= Maya). Certain Veery lines continue to show resistance, but this may prove temporary after a further build up of the new race.

One group having unacceptable stripe rust resistance levels at Njoro was the large group of Brazil-Mexico lines with tolerance to free aluminum and acid soils. Under the Njoro system of screening, these lines would be discarded, but duplicate screening in the Eldoret area of Uasin Gishu will give these lines a second chance to show their potential.

Some head selections made in 1982 may prove to have sufficient stripe rust resistance for the Kenyan Highlands; these include IAS63/Alondra/-Gaboto/Lagao Vermielha and reselections in Bonanza-Yecora 70/T. aest x Kalyan-Bluebird CM41860, which also have good resistance in areas affected by *S. tritici*.

Stem Rust in Kenya

Stem rust levels in triticale and durum wheat nurseries were very high in 1982. Artificial inoculation with stem rust collections obtained in 1981 at Njoro from triticale and durum wheat plots proved very effective.

A large group of triticales from Mexico, sent as PC-Tcl 1981-82, included two types: Maya II-Armadillo, and a Beagle type. The first group of triticales were more susceptible than the taller Beagle types. In the 13th ITSN planted at Njoro during the main season, the check varieties Caborca 79 and Beagle reached high stem rust levels (50S to 60S). Table 6 lists breeding lines that proved resistant in the same screening nursery.

In the durum wheat nurseries, stem rust was again very serious; only a very limited number of durums survived. The most resistant lines at Njoro were those received from Debre Zeit, Ethiopia. Parental material of these resistant lines include Boohai, Juanillo, Reichenbachii and some lines of Italian and Argentinian origin.

The bread wheat nurseries have also provided very good screening conditions for stem rust. Commercially, stem rust has not been significant in Kenya for ten years. One new release, K Kongoni, has shown susceptibility in Ethiopia and in Kenya. Among the new introductions, stem rust levels are heavy, and continue to provide a good selection criterion. In recent years, virulence in the nurseries appears to be on the increase, possibly due to better artificial inoculations and/or lower levels of resistance. In the 15th IBWSN, stem rust notes from Kenya and Zimbabwe clearly indicated higher levels of susceptibility than previously recorded.

Table 1. Number of lines of small grains breeding materials introduced into the Regional Wheat Program at NPBS, Njoro, and supporting sites during 1982

	Bread wheat	Durum	Triticale	Barley	Oats	Total number of lines
Hills	9555	3094	1612	3157	483	17897
F_2s	2093	845	1436			4374
Collections	611					611
Repeat Nurseries	809	168	617	135	146	1875
Yield trials	205	73	65	17		360
Total number of lines	13273	4180	3730	3305	629	25117

Table 2. Varieties of Bread wheat, triticale and durum wheat in the 5th, 6th and 7th African Cooperative Wheat Yield Trials (ACWYT), 1980-1983

Var. No.	5th ACWYT (1980-81)	6th ACWYT (1981-82)	7th ACWYT (1982-83)
1	Condor-Alondra	Kvz-K4500	KPopo
2	Romany BC	Kvz-Bb-Cha/Torim	ACC4006-75
3	Kvz-Buho/Kal-Bbx Sparrow	GoV-AztxMus	Za75/Ld357E-Tc^3xGll
4	Veery # 5	Kvz x Cno-Pj	Ulc75/Bb4A-TorimxBb-Nor
5	KFahari	Kvz-Cgn	Veery # 3
6	Tcl 65 (Tcl)	Veery #3'S'	Veery S-6
7	Au-Maya	Bobwhite	Veery S-7
8	Chat	Chova	Veery S-8
9	Towhee	Pci-HD2206	Chat
10	Yellowlegs(D)	Hahn	Bb-GalloxCj71/T.Aest x Kal-Bb
11	Bluejay[Tp(Cno-Inia)^3]	Yamhill-TobxRobin	Towhee
12	DZI-Tob	Bgl-M_2A(Tcl)	HD2206-Hork

Table 2. (continued)

Var. No.	5th ACWYT (1980-81)	6th ACWYT (1981-82)	7th ACWYT (1982-83)
13	Ocelot (Tcl)	Kinglet	Chova
14	Chova (Tcl)	KFahari	KFahari
15	Bvr-Arm(Tcl)	Tc 165(Tcl)	Tcl 65 (Tcl)
16	Local Check	L. Check	Beagle-M_2A (Tcl)
17			Veery S-17
18			Beagle Deriv. (Tcl)
19			Veery S=R253
20			Neelkant
21			K Paa
22			Yaqui (IA-M_2AxPj62-Bgl) (Tcl)
23			Juanillo 207 (Tcl)
24			KKulungu
25			L. Check

Table 3. Yield ranking of the best lines in the international and regional trials grown at NPBS, Njoro, 1982

3rd ESWYT - Bread wheat:

Rank	Entry No.	Variety or cross
1	4	Veery #3
2	5	Veery #5
3	16	Neelkant
4	30	K.Paa
5	23	R 37-Ghl 121x Kal-Bb
6	26	Mn 72131-Pavon

18th ISWYN - Bread wheat:

Rank	Entry No.	Variety or cross
1	12	Veery #2
2	19	Tob-CCxPato/Bb-Gll
3	2	Neelkant
4	50	LCheck(K.Paa)
5	15	Veery"S"
6	13	Veery #3

13th IDYN - Durum wheat:

Rank	Entry No.	Variety or cross
1	1	Cananea 79 (Tcl)
2	2	Ciano 79(BW)
3	9	Boohai
4	4	LCheck(K. Njiwa)

11th EDYT - Durum wheat:

Rank	Entry No.	Variety or cross
1	29	Cananea 79(Tcl)
2	28	Ciano 79(BW)
3	30	LCheck(K. Njiwa)
4	10	Lds Mut.-Teal
5	5	Rokel

13th ITYN - Triticale:

Rank	Entry No.	Variety or cross
1	50	LCheck:Tcl 65
2	42	IRA- DRIRA
3	18	Juanillo 67
4	6	Coorong
5	4	Tcl 65
6	43	Topo 1419

5th ACWYT - Regional:

Rank	Variety or cross
1	Tcl 65
2	Bvr-Arm
3	Veery #5
4	Chova
5	K Paa

6th ACWYT - Regional:

Rank	Variety or cross
1	Tcl 65
2	Bgl-M_2A
3	Veery^2#3
4	Chova
5	K.Fahari

Table 4. Entries in the Yellow Rust Parental Collection of 1982, with changes in reaction to stripe rust in Molo, 1982

Entry No.	Variety or cross and pedigree		Stripe rust reactions	
			Njoro 11 Aug. '82	Molo 12 Nov. '82
3	Kvz x Cno-Pj62	SWM1285-2Y-3M-1Y-0M-10Ke-0Ke	5MR-MS	40MS
12	Wq-RmxKal-Bb	SWM1445-8Y-2M-500Y-519M-501Y-0M-6Ke-0Ke	tMR	20MS-MR
34	Musala "S"	CM16780-J-1M-2Y-500M-0Y-7Ke-0Ke	tMR	30MS-S
38	Tob/Cno-JarxKvz	CM20707-A-1Y-8M-1Y-0Y-0PtZ	tR	40MS
39	Pamir	CM20839-A-7Y-501M-502Y-0B-1Ke-0Ke	tR	40MS-S
52	Phoebe	CM30831-D-4Y-2M-1Y-0M	tR	60S
60	Veery "S"	CM33027-F-1M-9Y-0M	5MR-MS	60MS-S
61	Veery # 2 "S"	CM33027-F-12M-1Y-4M-0Y-1Ke-0Ke	tR	10MS
74	Bobwhite	CM33203-N-1M-2Y-0M	0	20MS
76	Ti-TobxAlondra	CM33217-Q-6M-1Y-1M-1Y-3M-1Y-0M	0	20MS-S
85	Hahn	CM33682-L-1Y-1Y-8M-1Y-100B-0Y	5MR-MS	40MS-MR
146	GoV-Azt67xMus	CM41257-I-8M-2Y-1M-3Y-0M	tR	30MS-MR
164	WRm-PtmxCoc	CM43558-N-6y-1M-1Y-2M-2Y-0B	tR	50MS
173	Maringa-Aldan	CM46961-12M-1Y-1Y-1M-004Y-1PtZ-0Y	tR	50MS
176	Bage-HorkxAldan	CM48061-P-2M-1Y-1M-0Y-2PtZ-0Y	tR	30MS
195	K Paa	SE375-12S-3S-0S-4Ke-0Ke	tR	50S

Table 5. Bread wheat selections in Njoro, 1982-83, with low stripe rust levels in the presence of a new race

Entry No.	Variety or cross and pedigree	
2	F12.71-Coc 75	SWM 5784-17Y-2M-2Y-2M-1Y-1M-0Y
3	Pewee "S"	CM 31630-I-1Y-2M-5Y-0M-114B-0Y
7	Veery "S"	CM 33027-F-12M-1Y-6M-0Y-76B-0Y
12	Neelkant "S"	CM 40454-11M-4Y-2M-3Y-0M
14	MN 72131-Pavon "S"	CM 42402-30Y-1M-1Y-1M-1Y-2M-0Y

Table 5. (continued)

Entry No.	Variety or cross and pedigree	
17	Her-Maya	CM 46680-5M-1Y-2M-6Y-0Y
24	RRLxKAL-Bb	CM 49799-10Y-1M-1Y-2Y-0M
29	Veery "S"	CM 33027-F-15M-500Y-0M-126B-0Y-1PtZ-0Y
35	HD 2206-Hork "S"	CM 39808-23Y-1M-1Y-5M-1Y-1M-0Y-1PtZ-0Y
46	Bgs 2-Sort 12.13 x Kal-Bb	SWM 3115-2M-4Y-1M-2Y-1M-2Y-0M
57	Cno "S"-GllxPci "S"	CM 29186-6L-1Ap-2Ap-0Ap
58	Blo "S"-Emu "S"	CM 29946-2Ap-2Ap-0Ap
59	SSD-Blo "S"	CM 29963-2L-4Ap-0Ap-1Ke-0Ap
68	Pima x Rq - Soty/Sis "S"-Pvn	CM 34708-B-3M-1Y-1M-1Y-1M-2Y-0M
72	Cli-Ska	CM 29480-1Ap-3Ap-0Ap-2Ap-0Ap
81	Condor "S"-Ald "S"	CM 36903-1Y-1M-1Y-0M
82	Maya-Bjy "S"	CM 39424-6Y-1M-4Y-2M-4Y-0B
86	I158.57(Maya-Cgn/Cc-Inia x Cal)	CM 40742-27M-1Y-2M-3Y-3M-1Y-0B
88	{(CC-Kal (Az x Nad-LR/Bb)Ti Resel)} Yding "S"	CM 43742-E-1Y-1M-1Y-1M-1Y-0B
91	P106.19/Tzpp-Son 64 x Cno	L485-2L-1Ap-0Ap-3Ke-0Ap
96	Raf-Mag x $Tzpp^{2}$-An^{3}_{E}	L795-1Ap-1Ap-0Ap-1Ap-0Ap
103	Pato R/3/Jar66/14 Re//7C/Tob/61-107/ Tob//Cal	SE 386-8S-1S-1S-0S
107	Acc 4152-73	
114	Tecolote/BbxCC-Inia	CM 22099-10M-4Y-1Y-0Y
118	HD2206-Hork	CM 39808-58M-2Y-1M-1Y-1M-1Y-0M

Table 5. (continued)

Entry No.	Variety or cross and pedigree	
119	Cmt-Yr x Mon "S"	CM 43405-A-2Y-1M-1Y-1M-1Y-0B
139	Ulucak 75-Emu "S"	E29253-1S-5S-1S-0S
142	[Sdy(Fr-Kad x Gb/Bza)] HD 2206	CM 38184-B-3Y-3M-1Y-2M-1Y-0M
144	Veery "S"	CM 33027-F-15M-500Y-0M-126B-0Y
151	Y50E-Kal^{3} x Cut 75	SE 1826-3S-1S-1S-0S
153	ND 2162	
158	T. aest. x Kal-Bb/Ana 75	CM 38236-G-6Y-4M-4Y-3M-1Y-0M
166	T. aest.-Coq/ CC-Inia x Cal	CM 30905- -2Y-1J-6J-0J
187	Veery "S"	CM 33027-F-1M-9Y-0M-99Y-0B

Table 6. Triticale breeding lines with low stem rust scores in the 13th ITSN at Njoro, 1982

Entry No.	Variety or cross	Stem rust score	
		Early	Late
6	Arabian	tS	tMS
9	Muskox	tS	tMR
27	Ptr-Str x 31730	0	0
30	Ptr-Str x 31730	tR	5MR-MS
41	Giraf x 32636	0	0
42	Giraf x 32636	0	0
43	Giraf x 32636	0	0
45	Mex 64-KS 64 x MIA/Ye	0	tMR-MS
47	Lemming	0	0
49	W7 4103-Adx/Bgl-M2A x IRA	0	0
55	Castor x IRA-Cal	tS	5MR-MS
56	Ptr - Gzl	0	0
66	Z4	tS	0,20MS
69	Abn-R-M1A	tS	5MR,10S
79	Pnd-Adx	0	tMS
89	IRA-Cal x Bcm	tMR	5R-MR
90	Z9	tMS	EMR-MS
91	Pg-CentBulk x Abn/Mpe	tMS	5MR
102	Ptr x Cin - FS 658	tS	5MR
103	Ptr - Pnd	0	0
104	IRA - Cal x Ptr	0	0
112	Ptr - MA 106	0	0
113	Ptr - MA 106	0	0
114	Ptr - MA 106	tS	0,5MR

Table 6. (continued)

Entry No.	Variety or cross	Stem rust score	
		Early	Late
120	Ptr x Octo Bulk-Ars/Castor	0	0
123	M_2A-Cin x IRA-Cm1/IGA	0	0
131	Bta-Yo x M1A - M2A(2)	0	0
140	CMH 74 1211 - Bgl (4)	0	0
149	IRA-Bgl x DRIRA- Kang	0	0
151	IRA-Bgl x DRIRA- Kang	0	tR
163	M_2A-Bui x DRIRA- Kang	tMS	20MS-MR
Checks 3	Caborca 79	30 S	60 S
Checks 75	Beagle	40 S	50 S

South and Southeast Asia

E.E. Saari

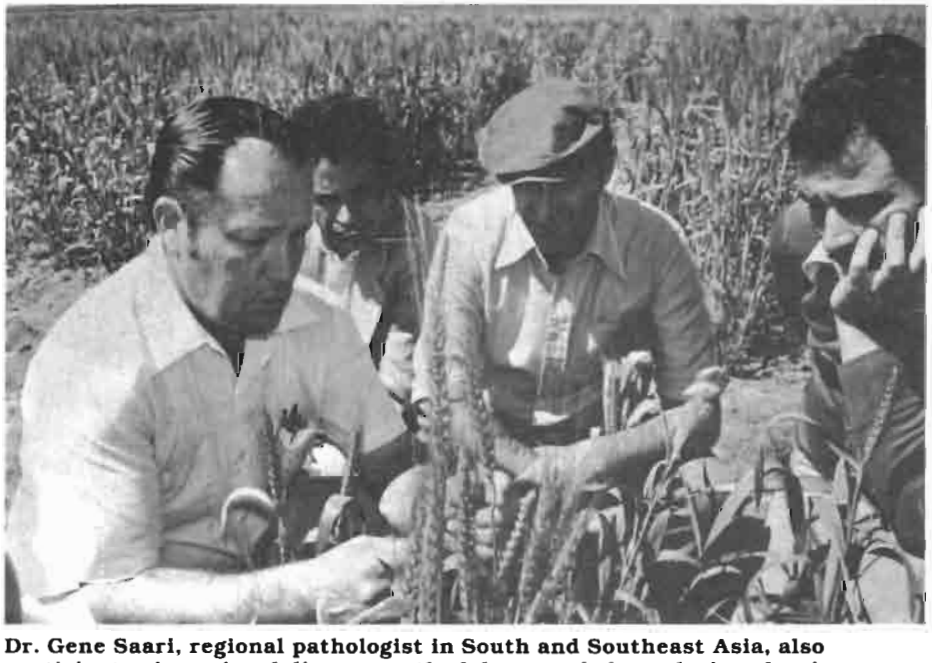
Introduction

CIMMYT staff posted in Thailand work throughout the South and Southeast Asia region. Maize is an important crop in this region, but wheat is also important, though primarily in South Asia. The regional wheat program responds to national program requests for consultation, evaluation, training, and assistance in developing germplasm with improved adaptation to local environmental conditions. The basing of a regional wheat program in Thailand reflects CIMMYT's desire to respond to the increasing interest in wheat cultivation in "non-traditional" areas.

In recent years, wheat consumption in Southeast Asia has increased at an annual rate of 10 to 12 percent; the average annual increase in Thailand from 1964 to 1980 has been 16.9 percent. World wheat trade is projected to be almost 100 million tons for 1982-83 (International Wheat Council, September 1982) and approximately one-third of that will be imported by countries in the Far East; Southeast Asia accounts for almost 20 percent of that figure, as shown in Table 1. Some average prices and shipping rates for US wheat exported to Asia over the last ten years are shown in Table 2.

A number of countries in Southeast Asia have attained, or are approaching, self-sufficiency in rice production. Even so, many countries still find themselves in a food deficit situation. For a number of reasons, these countries rely on wheat imports to fill the gap, and these imports consequently now represent a major expenditure of foreign exchange. Thailand's situation is unique in the area because it actually exports rice and maize; however, wheat is becoming increasingly important to the Thai diet.

Although various temperate crops, such as potatoes and grapes, are grown successfully in the tropics and subtropics, very little research has been done on wheat in these zones primarily because it is thought of as a crop for cooler climates. The variability that exists within the species can be exploited, however, and specific selection pressure can be used to increase



Dr. Gene Saari, regional pathologist in South and Southeast Asia, also participates in regional disease methodology workshops designed to improve the breeding of disease-resistant materials by national programs (photo: C.R. Dowswell).

the frequency of adaptation genes. Thailand offers a range of climatic conditions that allows for selection of varieties more suited to tropical and subtropical conditions.

Cropping Patterns

There are two situations in which wheat, triticale or barley might be incorporated into the cropping sequence. The first is after a late harvest of rice or some other rainy season crop. Some irrigation would be required, particularly for germination, and a couple of subsequent irrigations would greatly enhance prospects for a good yield. The advantage of wheat under these conditions is that three to four times the area can be sown to wheat as compared to rice with the same amount of water. Experiments with irrigated wheat in Thailand suggest sowing should occur between mid-November and early December, with maturation in 90 to 105 days. The best yields achieved have exceed 3.0 tons per hectare for two successive years; some results are provided in Table 3. These figures are based on small-plot yields.

The second situation involves the rainfed or upland areas, where sowing takes place as early as possible in October after kenaf, maize or upland rice has been harvested. This ensures enough moisture for germination and stand establishment; there would also be a reasonable probability of a rain or two during the early stages of plant growth. The crop would be strictly rainfed, with little chance of rain in December or January. Adapted varieties will have to be tolerant of heat, with a slightly extended maturity cycle (110 to 130 days); screening has begun for these characteristics and yields should exceed 1,200 kg/ha. Table 4 gives the current yields obtained from some on-farm trials, but the varieties used were not the best rainfed varieties. Unfortunately, seed for the newer varieties is still in short supply.

Wheat, triticale or barley could also be useful in a number of other situations. Barley could be planted under saline conditions, or in areas with shallow soils and minimal moisture-holding capacity. Even though yields are likely to be below average under such circumstances, 800 to 1,000 kg/ha in 60 to 70 days are possible. Advantage could also be taken of triticale's tolerance to low soil pH and to toxic levels of free aluminum.

Technical Considerations

Sowing a crop out of its normal area usually means less flexibility in terms of sowing date, seed rate, fertilization and other practices. A careful evaluation of these components will be required because different agronomic practices substantially affect yield. For example, broadcast versus drilled sowing has a pronounced effect in rainfed trials, as can be seen in Table 4. This may be a reflection of the effect of moisture, and possibly temperature, on seed germination. Earlier planting dates with a heat-tolerant variety should improve stand establishment (more useable moisture would also be available), which would in turn increase yields significantly.

Other considerations include new or different diseases or insects, such as the seedling blights that have been observed when planting in warm soils. These blights are caused by *Sclerotium rolfsii* and *Fusarium* spp., and require more research. Seed treatments to control these fungi may be necessary as a regular practice. Because very few crops are grown during the dry season, the wheat currently grown is invaded by rats, birds and cattle. Measures for their control may be required until large areas are established to dilute their effects.

Wheat, triticale and barley could be sown for forage or grazing purposes, but their exclusive use in this capacity endangers seed supplies. Seed storage is yet another important factor to consider, especially at the farm level, because small grains are quite sensitive to moisture.

Other Considerations

One of the major obstacles to establishing wheat as a commercial crop in the region is the current lack of a marketing system. The small amount of wheat grown in northern Thailand, near Mae Sai, is sold directly to the manufacterers of "bae-sae," a liquid glucose used in manufacturing candy.

Local development of milling and baking technology looks promising, particularly for whole wheat bread in the north. The future for domestic wheat production depends to some extent on how the product is used. One potential use is in the production of Chinese or yellow noodles, "ba-mi," a readily accepted substitute for rice. Manufacture is simple and can be done at home or on a small commercial scale, as it requires little equipment.

Conclusions

Wheat cultivation in Thailand and in other Southeast Asian countries is now technically feasible. Research and varietal improvement will no doubt increase current yield levels. Wheat may be useful either as a supplemental crop grown on otherwise fallow land, or as an alternative crop in very dry years. The sowing of wheat after kenaf and other upland crops should be explored; between 160,000 and 320,000 ha are sown to kenaf in northeast Thailand alone. The economic aspects of wheat, triticale and barley production must now be evaluated; an appropriate pricing policy and efficient marketing system must also be established. Programs to promote local markets and domestically produced wheat products should be supported. Many of the results of wheat research in Thailand will probably be applicable to other Southeast Asian countries.

Table 1. Estimated wheat and flour imports to the Far East and Southeast Asia for the 1982-83 trade year (Modified from IWC, 29 September, 1982)

	Millions of tons	
	1981-82	1982-83
Far East Asia		
Bangladesh	1.1	1.3
China	13.0	13.5
India	2.6	4.0
Japan	5.6	5.5
Korea, Rep. of	1.9	2.2
Pakistan	0.3	0.4
Sri Lanka	0.7	0.6
Others	0.4	0.4
Sub-total	25.6	27.9
Southeast Asia		
Indonesia	1.5	1.5
Korea, Dem. Rep.	0.4	0.4
Malaysia	0.5	0.5

Table 1. (continued)

	Millions of tons	
	1981-82	1982-83
Philippines	0.9	0.9
Singapore	0.2	0.4
Taiwan	0.6	0.7
Thailand	0.1	0.2
Vietnam, Soc. Rep.	0.4	1.0
Sub-total	4.6	5.6
Total	30.2	33.5
Trade: world total	99.3	100.0
Production: world total	460	464

Table 2. Wheat and wheat flour import equivalents to Thailand, 1973-1982, and average prices for each trading year and freight rates to India or Bangladesh

		Cost - US$/ton	
Year	Metric tons	Price 1/	Freight
1982	260,000*	163	45*
1981	219,700*	175	51
1980	143,842	173	40
1979	168,387	160	31
1978	127,744	128	27
1977	89,506	103	20
1976	136,368	133	25
1975	62,052	149	39
1974	96,985	180	46
1973	90,371	140	17

* Estimates

1/ FOB - Gulf Ports U.S.A. for hard red winter wheat, No. 2

Table 3. The top five breadwheat (BW) and triticale (Tcl) varieties in yield trials at different locations in Thailand under irrigated conditions in 1980-81 and 1981-82

Location and elevation	Year	Variety	Type	Rank	Yield (kg/ha)
Pak Chong 300 m	1981	Sonalika	BW	1	3974
		UP 262	BW	2	3592
		Beagle	Tcl	3	3146
		Mapache	Tcl	4	2858
		Anza	BW	5	2743
	1982	CMU 26	BW	1	3323
		CMU 24	BW	2	3314
		Juan.97	Tcl	3	3271
		IRA-DRI	Tcl	4	3241
		CMU 12	BW	5	3141
Chiang Mai 300 m	1981	Bacum	Tcl	1	4301
		Anza	BW	2	4166
		Rahum	Tcl	3	4155
		Pavon 76	BW	4	3483
		UP 262	BW	5	3894
	1982	CMU 26	BW	1	2512
		Inia 66	BW	2	2306
		Jupateco 73	BW	3	2178
		CMU 24	BW	4	2014
		CMU 285	BW	5	1952
Samoeng 820m	1981	UP 262	BW	1	3578
		Pavon 76	BW	2	3461
		Anza	BW	3	3276
		Inia 66	BW	4	3427
		Mapache	Tcl	5	3192
	1982	CMU 22	BW	1	4120
		CMU 20	BW	2	3930
		CMU 8	BW	3	3900
		1510	BW	4	3890
		Inia 66	BW	5	3791
Chiang Rai 400m	1982	Bacum	Tcl	1	3336
		CMU 300	BW	2	3243
		Pavon 76	BW	3	2942
		113	BW	4	2842
		CMU 30	BW	5	2771

Table 4. Preliminary results from on-farm rainfed wheat trials with the varieties Inia 66 and Sonora 64 sown on 29 October, 1982. (Adapted from B. Norman Rainfed Wheat Production in Chiang Rai, Third Wheat Workshop Proceedings, NADC, August 1982)

Site	Variety: Inia 66 Treatment: Water Balance (mm)[1/] Available	Used	Yield (kg/ha)
Ban Tham	391	331	1063
Ban Din Dam	304	300	800
Ban Mac Chedi	309	244	906

Site	Variety: Sonora 64 Treatment: Land Preparation	Yield (kg/ha)
Ban Chong	Disc - not levelled - broadcast	350
	- drilled	669
	Disc - levelled - broadcast	581
	- drilled	856
	Scarify - not levelled - broadcast	738
	- drilled	931
	Scarify - levelled - broadcast	1031
	- drilled	1469

[1/] Based on gypsum block measurements to one meter

Disease Surveillance

J.M. Prescott

Introduction

The CIMMYT disease surveillance program (DSP) is concerned with the phyto-pathological factors that affect wheat and barley production in the principal wheat and barley producing countries of Asia, Africa, the Middle East and southern Europe. The overall goal of the DSP is to help maximize yield per unit area and to minimize shortfalls caused by disease. Disease monitoring is an integral part of the program, because disease causing organisms are capable of rather rapid changes in virulence spectra; this, in turn, can reduce the stability of crop production.

The geographic area covered by the DSP is extensive and ecologically quite diverse. It stretches from Morocco in the west to the Philippines in the east and from southern Europe to southern Africa. The cultivars grown range from local selections of land race populations to highly improved dwarf and semidwarf types. These latter improved cultivars range from true winter-habit types that survive the harsh "steppe" conditions to the very short duration spring-habit cultivars that do well in the dry or humid semitropic areas where the crop is grown during the coolest months of the year.

Dr. Mike Prescott, regional pathologist and CIMMYT's in-country representative in Turkey, returned to Headquarters in late 1982 to assume new responsibilities (photo: J.L. Castillo).

Review of the Season

In general, and across the entire region, the cereal diseases affecting wheat and barley production did not reach epidemic proportions in 1982, except in a few localized areas and for a few "minor" diseases. The Regional Disease Trap Nursery (RDTN) was grown by 56 countries in the 1981-82 or 1982 crop cycle. Forty-six of these countries, representing 92 locations, returned nursery reports. Eight of these reports (representing 8 countries) indicated that no disease development occurred. Disease development on at least 10 percent of the nursery entries was reported by 38 countries (84 locations).

The rusts—Leaf rust of wheat, caused by *Puccinia recondita*, continues to be the most prevalent and widespread foliar disease in the DSP region. Of the 46 countries returning data; 30 reported the presence of this disease. The amount of leaf rust reported was, in general, higher than the previous two years, except in Zone IV (the North Africa countries).

Leaf rust of barley, caused by *P. hordei*, also was reported by 29 countries, but only 15 of these had significant levels of the disease.

Stripe rust of wheat and barley, caused by *P. striiformis*, was reported by 24 countries, but the disease reached significant levels of infection in only 15 of these countries. As is normally the case, the disease was confined to higher elevations and the more northerly latitudes.

Stem rust, caused by *P. graminis*, which attacks both wheat and barley, was reported by 23 countries, reaching significant levels of infection in only 18 of these.

Other foliar diseases—Septoria leaf blotch (*Septoria tritici*) and septoria glume blotch (*S. nodorum*) were reported by 12 countries, but reached significant levels of infection in only 6 of them; however, none of these countries indicated the extent of losses. Septoria leaf blotch of barley, caused by *S. passerinii*, was reported by 10 countries, but only Morocco indicated significant levels of the disease.

Powdery mildew, caused by *Erysiphe graminis*, was reported by 14 wheat-producing countries and 15 barley-producing countries. None of the reports indicated significant losses due to this disease.

Leaf-spotting diseases, caused by *Helminthosporium sativum* and *H. tritici repentis*, were reported by 14 bread wheat-producing countries and 16 barley-producing countries. However, none of these countries reported significant losses.

Flag smut, caused by *Urocystis agropyri*, continues to be a minor problem in several countries. However, this soil-borne disease has not spread to other countries, even those adjacent to the countries reporting the disease.

Spike diseases—Like last year, a few countries reported fusarium head scab (China, Turkey, France and Zambia). Severity was not reported and losses were apparently not significant. The smut and bunt diseases, caused by *Ustilago* spp. and *Tilletia* spp., continue to persist throughout the DSP region. Losses were estimated by several countries to be 1-3 percent of the total crop. Until wider usage of protective chemicals, better quality seed and greater resistance is achieved, losses of this magnitude will continue.

Viral diseases—Barley yellow dwarf virus (BYDV) again caused significant losses in both wheat and barley production in the countries of North Africa and the Iberian Peninsula. Turkey, Pakistan and India also reported BYDV, but not at significant levels. Turkey reported wheat streak mosaic virus (WSMV) and soil-borne mosaic virus (SBMV), but only in isolated areas.

Overall, viral diseases of small grain cereals were not of economic importance in the region, except for the instances just mentioned. It should be noted that the build-up of aphids in the small grain crop of Egypt continues to be of concern; however, no viral diseases were reported.

Summary of the disease situation—Thus, in the 1981-82 crop season, diseases generally did not reach epidemic proportions in the DSP region. However, some severe "hot spots" were noted by several countries for one or two diseases. Overall, production losses attributable to diseases were less than normal, possibly due to less than normal moisture early in the season in many countries and to the more widespread use of resistant varieties.

Nursery Results

The disease monitoring activities of the DSP continue to be accomplished via the distribution and analysis of the Regional Disease Trap Nursery (RDTN). In the fall of 1981, 150 sets of the RDTN were prepared and distributed from CIMMYT's regional office in Ankara, Turkey, to 56 countries for growing in the 1981-82 crop cycle. The nursery comprised 102 bread wheat, 20 durum wheat, 26 barley and 2 triticale varieties and/or advanced lines. These materials represent the main commercial cultivars grown in the RDTN countries,

plus a number of single or multiple resistance-gene cultivars to classify the virulence of the different pathogens present in the region. Ninety-two locations returned nursery data forms. However, the data from 8 locations was not used because no disease was reported.

Epidemiological zones—Based upon geographic characteristics and the virulence spectra of the diseases present, the DSP area can be divided into several different "epidemiological zones" (see Figure 1):

- **Zone I** represents south and southeast Asia, ie., the area south of the Himalayas and east of Afghanistan. The main wheat and barley growing countries of this area are Afghanistan, Pakistan, India, Nepal and Bangladesh. There is some north-to-south and south-to-north movement of disease in this area, especially in India and Pakistan, but the overall disease movement is from the western side to the eastern side of the area. There may be some "leakage" of disease from this area northwards and/or northeasterly into China, but the high mountains tend to function as a geological barrier.
- **Zone II** comprises the Middle East and Asia Minor. The diseases present in this area are both endemic and exodemic. There appear to be two exodemic sources: the Balkan pathway and the Great Rift Valley system of eastern Africa. Wheat and barley are cultivated extensively in this area and can be found growing throughout the year at the higher elevations of the Arabian Peninsula and in the northeast part of the zonein Turkey, Iraq and Iran. Egypt and the desert-type environments of this zone, where wheat is grown under irrigation, represent sub-zones where disease does not persist during the hot summer months between crops. There is question as to whether Bulgaria, Greece and Yugoslavia should be included in the region, as these countries provide the northern pathway for disease movement into the region.
- **Zone III** is represented primarily by East Africa and the Great Rift Valley system. For the present, all countries south of the Sahara are grouped into this zone, with the recognition that there are several sub-zones. Much more work is needed to define this zone and the sub-zones within it.
- **Zone IV** consists of the North African countries and parts of southern Europe, including the Iberian Penninsula (Spain and Portugal). Cereal diseases appear to be both endemic and exodemic in this zone. The diseases can survive in the mountains of Algeria and Morocco. They move mainly in a northerly direction, but there can be significant exchange between southern Europe.
- **Zone V** consists principly of southern Europe. From there the cereal diseases move either into Zone IV (North Africa) or

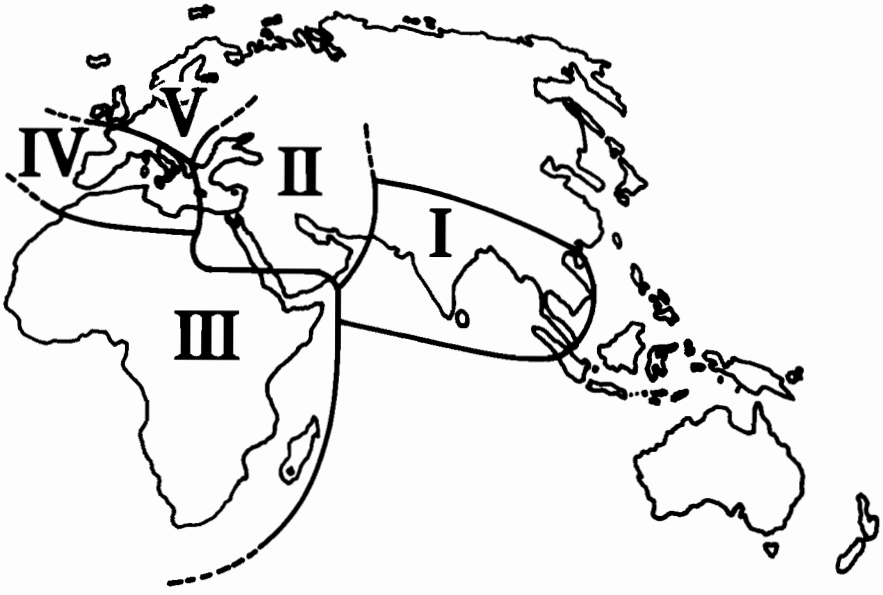


Figure 1. Major epidemiological zones for the wheat rusts.

into Zone II (the Middle East). Zone V can also be influenced by Zone IV. The principal sources of inoculum are found in northern Europe, including England, and North Africa.

Throughout the DSP region, diseases appear to move in a west-to-east fashion with some north-to-south or south-to-north movement within a given zone. However, much more work needs to be done before the zones can be clearly defined based solely on virulence patterns. The current method of defining zones by country is not satisfactory, since a country can actually be included in several virulence zones.

Bread wheat—In Table 1, the percent of susceptible bread wheat nursery entries is presented. Pakistan and Mexico reported the highest number of entries susceptible to leaf rust (80.4 percent) followed by Turkey, Bangladesh and Zimbabwe (76.5, 74.5 and 72.5 percent, respectively). In general, 30 of the 39 countries reported leaf rust on the bread wheat cultivars. Yellow rust (stripe rust) was reported by 24 countries, with the greatest virulence reported by the east African countries of Kenya (95.1 percent) and Zaire (87.3 percent). Stem rust (black rust) was reported by 23 countries, with the greatest virulence in Turkey (76.5 percent), Bulgaria (75.5 percent) and Ethiopia (73.5 percent). Septoria was reported by only 12 of the 39 countries and was severe only in Israel, France and Madagascar. Powdery mildew was reported by 14 of the countries with Bulgaria, England and Yugoslavia reporting the highest levels. Helminthosporium diseases were reported by 14 countries with Bangladesh, Morocco, Nepal and Zambia reporting the most severe levels of the disease.

Durum wheat—The percent virulence for the durum wheat entries of the RDTN is presented in Table 2. Leaf rust was the most widely reported disease (28 countries). Turkey had the broadest leaf rust virulence, followed by France, Mexico, Portugal and Spain. Stripe rust was reported by 18 countries, with Rwanda, Kenya and France having the broadest virulence. Stem rust was reported by 18 countries also, with Bulgaria, Kenya and Sudan experiencing the greatest virulence, followed by Czechoslovakia, Saudi Arabia and Turkey. Septoria diseases were reported by only 9 countries. Powdery Mildew was reported by 11 countries with Bulgaria and France having the most virulence. The helminthosporium diseases were reported by 11 countries also, with Morocco, Bulgaria and Zimbabwe having the most virulence.

Leaf rust (caused by *Puccinia recondita* on wheat and *P. hordei* on barley) was the most widely reported disease in 1982.

Barley—The disease situation on the barley entries of the RDTN is presented in Table 3. Leaf rust was the disease most often reported (23 countries), with Italy, Cyprus, Turkey, Spain and Portugal indicating the greatest virulence. Thirteen countries reported stripe rust, with England, Ecuador and Nepal reporting the most virulence. Stem rust was reported by 17 countries, with Kenya, Ethiopia, Sudan and Saudi Arabia indicated the widest virulence spectrum. Septoria diseases were reported by only 5 countries. Powdery mildew was reported by 15 countries, with England, Italy and Yugoslavia indicating the widest virulence. Helminthosporium diseases were reported by 15 countries, with Bangladesh and Morocco indicating the highest levels.

The data presented in these three tables also clearly indicate disease levels suitable for screening purposes. If more than 10 percent of the RDTN entries were susceptible in a given location, then the level of disease could be considered sufficient for screening in that location; if the level of susceptibility was more than 30 percent, then the disease in question could be said to be major problem in that location.

Table 1. Percent virulence on international disease trap nursery (IDTN) breadwheat entries in 1982[1/]

Country	No. of Locations	Diseases					
		LR[2/]	YR	SR	SEPT	PM	HELM
Afghanistan	2[a/]	54.9	13.7	-[b/]	1.0	-	9.8
Algeria	2	16.7	26.5	-	4.9	-	-
Bangladesh	3	74.5	-	1.0	-	-	98.0
Bulgaria	1	44.1	56.9	75.5	-	79.4	-
China	1	-	-	-	-	-	14.7
Cyprus	1	7.8	2.0	-	0.0	0.0	-
Czechoslovakia	1	-	4.9	43.1	-	-	-
Ecuador	1	29.4	65.7	0.0	4.9	-	-
England	2	-	69.6	-	-	78.4	-
Ethiopia	2	-	-	73.5	-	-	-
France	1	52.0	68.6	-	70.6	-	-
Greece	1	-	-	11.8	-	12.7	-
Iran	1	14.7	30.4	47.1	-	20.1	1.0
Israel	2	52.9	27.5	47.1	77.5	-	-
Italy	5	52.9	4.9	41.2	-	60.2	1.0
Jordan	1	13.7	-	3.9	-	12.7	-
Kenya	9	6.9	95.1	64.7	-	-	-
Madagascar	1	4.9	-	-	76.5	-	40.2
Malawi	2	55.9	5.9	18.6	0.0	2.0	24.5
Mexico	2	80.4	-	23.5	-	-	-
Morocco	1	36.3	-	23.5	22.5	1.0	81.4
Nepal	2	68.6	1.0	67.6	-	17.6	79.4
Netherlands	1	10.8	-	-	-	-	-
Pakistan	5	80.4	65.7	-	-	-	-
Portugal	2	39.2	27.5	42.2	8.8	58.8	0.0
Rwanda	1	-	67.6	-	-	-	-
Saudi Arabia	2	32.4	6.9	45.1	-	-	-
Spain	3	39.2	27.5	42.2	8.8	58.8	0.0
Sudan	1	-	-	41.2	-	-	-
Switzerland	1	24.5	-	-	-	-	-
Tanzania	2	2.9	5.9	-	-	-	-
Thailand	3	28.4	-	-	-	-	2.9
Tunisia	1	2.9	1.0	-	30.4	2.9	5.9
Turkey	5	76.5	56.9	76.5	39.2	65.7	1.0
Uganda	1	-	30.4	5.9	-	-	22.5
Yugoslavia	1	-	-	-	4.9	71.6	-
Zaire	1	14.7	87.3	41.2	-	-	-
Zambia	1	10.8	-	-	-	-	67.6
Zimbabwe	3	72.5	-	55.9	-	-	-

NOTES: [1/] Data from 102 cultivars
[2/] LR = Leaf or brown rust
YR - Stripe or yellow rust
SR = Stem or black rust
SEPT = Septoria Spp.
PM = Powdery mildew
HELM = Helminthosporium Spp.
[a/] Number of locations reporting disease
[b/] Disease not reported

Table 2. Percent virulence on international disease trap nursery (IDTN) durum wheat entries in 1982[2/]

Country	No. of Locations	Diseases					
		LR[2/]	YR	SR	SEPT	PM	HELM
Afghanistan	2[a/]	30.0	0.0	-[b/]	0.0	-	10.0
Algeria	2	45.0	80.0	-	40.0	-	-
Bangladesh	3	35.0	-	0.0	-	-	95.0
Bulgaria	1	50.0	20.0	100.0	-	85.0	-
China	1	-	-	-	-	-	10.0
Cyprus	1	25.0	0.0	-	5.0	-	-
Czechoslovakia	1	-	5.0	90.0	-	-	-
Ecuador	1	45.0	35.0	0.0	-	-	-
England	2	-	65.0	-	-	75.0	-
Ethiopia	2	-	-	90.0	-	-	-
France	1	70.0	80.0	-	-	80.0	-
Greece	1	-	-	0.0	-	0.0	-
Iran	1	5.0	55.0	15.0	-	40.0	-
Israel	2	15.0	60.0	25.0	55.0	-	-
Italy	5	65.0	0.0	75.0	-	35.0	0.0
Jordan	1	10.0	-	0.0	-	5.0	-
Kenya	9	5.0	90.0	100.0	-	-	-
Madagascar	1	10.0	-	-	70.0	-	75.0
Malawi	2	50.0	0.0	5.0	0.0	0.0	20.0
Mexico	2	70.0	-	20.0	-	-	-
Morocco	1	50.0	-	20.0	50.0	0.0	100.0
Nepal	2	60.0	10.0	55.0	-	35.0	75.0
Netherlands	1	10.0	-	-	-	-	-
Pakistan	5	35.0	25.0	-	-	-	-
Portugal	2	70.0	15.0	65.0	10.0	55.0	0.0
Rwanda	1	-	100.0	-	-	-	-
Saudi Arabia	2	60.0	10.0	85.0	-	-	-
Spain	3	70.0	15.0	65.0	10.0	55.0	0.0
Sudan	1	-	-	100.0	-	-	-
Switzerland	1	15.0	-	-	-	-	-
Tanzania	2	0.0	0.0	0.0	-	-	-
Thailand	3	40.0	-	-	-	-	5.0
Tunisia	1	0.0	0.0	-	30.0	0.0	45.0
Turkey	5	85.0	60.0	45.0	10.0	55.0	-
Uganda	1	-	5.0	0.0	-	-	40.0
Yugoslavia	1	-	-	-	0.0	65.0	-
Zaire	1	30.0	40.0	85.0	-	-	-
Zambia	1	5.0	-	-	-	-	80.0
Zimbabwe	3	45.0	-	30.0	-	-	-

NOTES: [1/] Data from 20 cultivars
[2/] LR = Leaf or brown rust
YR = Yellow or stripe rust
SR = Stem or black rust
SEPT = Septoria spp.
PM = Powdery mildew
HELM = Helminthosporium spp.
[a/] Number of locations reporting disease
[b/] Disease not reported

Table 3. Percent virulence on international disease trap nursery (IDTN) barley entries in 1982[1/]

Country	No. of Locations	Diseases					
		LR[2/]	YR	SR	SEPT	PM	HELM
Afghanistan	2[a/]	23.1	11.5	-[b/]	0.0	-	3.8
Algeria	2	3.8	0.0	-	0.0	-	-
Bangladesh	3	7.7	-	0.0	-	-	96.2
Bulgaria	1	19.2	0.0	57.7	-	7.7	-
China	1	-	-	-	-	-	-
Cyprus	1	96.2	-	-	-	3.8	3.8
Czechoslovakia	1	-	0.0	80.8	-	-	-
Ecuador	1	3.8	69.2	0.0	-	-	-
England	2	-	84.6	-	-	96.1	-
Ethiopia	2	-	-	100.0	-	-	-
France	1	0.0	0.0	-	-	3.8	-
Greece	1	-	-	0.0	-	61.5	-
Iran	1	0.0	0.0	0.0	-	3.8	50.0
Israel	2	34.6	3.8	11.5	0.0	-	-
Italy	5	100.0	0.0	30 8	-	80.8	23.1
Jordan	1	38.7	-	0.0	-	3.8	-
Kenya	9	0.0	11.5	100.0	-	-	-
Madagascar	1	0.0	-	-	3.8	-	19.2
Malawi	2	3.8	-	3.8	11.5	0.0	7.7
Mexico	2	26.9	-	57.7	-	-	-
Morocco	1	50.0	-	3.8	0.0	11.5	80.8
Nepal	2	0.0	65.4	26.9	-	11.5	0.0
Netherlands	1	46.2	-	-	-	-	-
Pakistan	5	7.7	38.7	-	-	-	-
Portugal	2	84.6	3.8	61.5	7.7	57.7	11.5
Rwanda	1	-	11.5	-	-	-	-
Saudi Arabia	2	30.8	0.0	92.3	-	-	-
Spain	3	84.6	3.8	61.5	7.7	57.7	11.5
Sudan	1	-	-	96.2	-	-	-
Switzerland	1	69.2	-	-	-	-	-
Tanzania	2	0.0	0.0	0.0	-	-	-
Thailand	3	3.8	-	-	-	-	0.0
Tunisia	1	19.2	0.0	-	3.8	11.5	7.7
Turkey	5	88.5	15.4	42.3	0.0	61.5	61.5
Uganda	1	-	3.8	0.0	-	-	3.8
Yugoslavia	1	-	-	-	0.0	76.9	11.5
Zaire	1	23.1	26.9	50.0	-	-	-
Zambia	1	0.0	-	-	-	-	61.5
Zibabwe	3	3.8	-	73.1	-	-	-

NOTES: 1/ Data from 26 barley cultivars
2/ LR = Leaf or brown rust
YR = Stripe or yellow rust
SR = Stem or black rust
SEPT = Septoria spp.
PM = Powdery mildew
HELM = Helminthosporium spp.
a/ Number of locations reporting disease
b/ Disease not reported

Pakistan

H.H. Hepworth and P. Hobbs

Introduction

Pakistan and CIMMYT work together in a number of ways, including the exchange of nursery materials and information, the training of promising young national staff (both in Mexico and in Pakistan) and the visiting scientist program, in which senior Pakistani scientists travel to Mexico with specific research objectives in mind. *In situ* wheat research and training are assisted by a CIMMYT agronomist stationed in Pakistan.

Following three successive years of record wheat crops, Pakistan set 12.3 million tons as a production target for 1982, which would have been a fourth record if achieved. However, a severe drought period at seeding produced below average emergence in many fields. In addition, heavy rains at harvest resulted in substantial losses in yields and a decrease in crop quality. Despite these adverse conditions, the crop was estimated at 11 million tons, close to the 1981 record harvest.

The area seeded to wheat remained at levels close to those prevailing in 1981: 4.9 million hectares of irrigated wheat and 1.6 million hectares rainfed. Fertilizer supplies, especially nitrogen, are improving because of increased domestic fertilizer production. Pakistan has in essence achieved self-sufficiency in wheat production, and was even able to export 50,000 tons in 1982. However, an annual production increase of 3 percent is required to meet rising demand spurred by population growth.

Barley remains a minor crop, seeded on 172,000 ha. Work is proceeding on the development and release of improved varieties. Triticale continues to show good yield potential and superior adaptation in certain areas, but none is yet grown commercially.

Variety Development

Most of the wheat varieties now grown in Pakistan are susceptible to leaf rust and/or stripe rust. Breeding programs are stressing disease resistance, and close cooperation with cereal

Each year, wheat scientists from all over Pakistan, along with several CIMMYT staff, tour the country's major research stations and wheat production areas (photo: H.M. Hepworth).

pathologists is bringing positive results; several resistant lines are nearing release. In addition, two recently released varieties are being multiplied for distribution:

- Pak 81 = Kvz-Buho x Kal-Bb = Veery No. 5 (CM33207-F-15M-500Y-0M)
- Punjab 81 = INIA/Son64-P4160E x Son64 (PK6841-2A-2A-1A-0A)

Sonalika has become susceptible and must be replaced, but no early maturing, disease-resistant, semidwarf variety is currently available for release. This problem deserves a high prority in future research efforts.

Work is underway to improve and strengthen the procedure for variety registration and release. The objective is to establish a standarized, controlled mechanism for the testing and release of new varieties, and for withdrawal of old ones. This system should also provide for the timely increase and distribution of clean, disease-resistant seed through supervised channels. The current lack of viable, clean, disease-free seed is a serious problem for farmers.

Production Problems

Short-season varieties—Increased mechanization is making greater cropping intensity both possible and attractive to farmers (usually wheat/rice or wheat/cotton). This underscores the need for improved short-season varieties like Sonalika.

Weed control—Weeds are now recognized as a serious constraint to wheat production. *Phalaris minor* currently infests thousands of hectares; in some cases, the crop is completely lost to this weed. Other weeds are causing major yield losses as well.

Research done by Pakistani scientists and by commercial chemical companies indicates that a variety of herbicides are effective against these weeds, and would be of considerable economic benefit to farmers. A very strong need exists to educate both researchers and farmers on weed control technologies. Herbicides alone, however, will not solve the problem. Clean seed, well-prepared seedbeds and timely seeding are also very important.

Soil and water management—Factors contributing to low yields in a number of areas include low plant populations, inefficient fertilization and heavy weed infestations. As mechanization increases, the opportunity exists to improve soil management and tillage practices; this would result in greater water conservation, improved weed control and better seedbed preparation. All of these will in turn contribute to higher emergence rates and increased plant populations, thereby leading to greater yield potential.

Bangladesh

L. Butler

During the last decade, Bangladesh has dramatically increased the level of domestic wheat production, from 89,000 tons to well over one million tons in 1982. This is an impressive accomplishment, particularly in light of the fact that wheat is not a traditional crop in Bangladesh. A dedicated staff of national crop improvement program scientists, as well as enterprising and motivated farmers, are the primary reasons for the success enjoyed to date.

In mid-1982, CIMMYT and Bangladesh entered into a 5-year cooperative research agreement with an overall goal of raising still further the country's wheat production. A CIMMYT breeder/pathologist (Dr. Larry Butler) has been stationed in Bangladesh for the duration of the project to engage in the following activities:

- Identify the key factors that still limit production in the country;
- Provide assistance to scientists of the Bangladesh Agricultural Research Institute (BARI) in developing methods and/or information to overcome production problems;
- Assist BARI scientists in developing varieties with better disease resistance and greater production potential;
- Identify promising young scientists for in-service training at CIMMYT, Mexico, and be involved in in-country training efforts;
- Act as liaison between BARI and CIMMYT, Mexico, in all matters that pertain to varietal improvement and agronomic practices for Bangladesh.

A full report on the first 18 months of work will be forthcoming in the *1983 CIMMYT Report on Wheat Improvement*.

Dr. Larry Butler (right), helping to evaluate the performance of CIMMYT materials at Ishordi, Bangladesh (photo: B.C. Curtis).

In 1982, Dr. Kazi M. Badrudozza was the Executive Vice-Chairman of the Bangladesh Agricultural Research Council and Director of BARI (photo: C.R. Dowswell).

Wheat cultivation in Bangladesh is part of a complex cropping system that includes rice and/or other winter pulses. Here, Dr. Sufi Ahmed, Coordinator of the Bangladesh National Wheat Improvement Program, examines a farmer's field (photo: C.R. Dowswell).

CIMMYT/ICARDA Cooperative Bread Wheat Program

W. Nelson

Introduction

The 1981-82 crop cycle marked the second year of the CIMMYT/ICARDA bread wheat program. Information stemming from five years of breeding at ICARDA and from CIMMYT's bilateral and regional programs in North Africa and Turkey provides a sound basis for wheat germplasm development for the ICARDA region. The facilities of both Centers are used to broaden the germplasm base of the winter-sown, spring bread wheat needed in the region.

At ICARDA, the program concentrates on the breeding problems that are specific to wheat-growing regions in North Africa and the Middle East. Selections are made from F_2 populations and advanced lines developed at CIMMYT, Mexico, as well as those developed at ICARDA. These selections are then further tested for regional adaptation, especially their tolerance to extreme temperatures and drought, and their resistance to such diseases as common bunt, septoria leaf blotch (*Septoria tritici*) and stripe rust.

The CIMMYT crossing program includes crosses planned especially for the ICARDA region. The F_1 seed is shared so that ICARDA can make top crosses for more specific adaptation to the diseases, insects and environmental conditions of the region. The CIMMYT breeder stationed at Aleppo visits the Mexico base program during both the Cuidad Obregon and Toluca cycles to assist in planning crosses and making selections, and to coordinate the two programs so as to eliminate undesired duplications.

Disease and Insect Resistance

Crossing and selection at ICARDA are designed to supplement the base program at CIMMYT. Common bunt, for example, is a continuous problem in the region's colder areas, primarily on small farms and during years when seeding is late. At CIMMYT, high soil temperatures at seeding prohibit infection for the screening of segregating populations; conditions at ICARDA, however, are ideal for infection. Resistance to common bunt can thus be added to CIMMYT germplasm, helping smaller farmers whose seed is seldom treated.

Dr. Walt Nelson, here examining wheat in Mexico, coordinates the CIMMYT/ICARDA cooperative bread wheat breeding program (photo: J.L. Castillo).

Similarly, sawfly resistance is needed in the region and screening can be done under natural or artificial conditions in Syria. Further screening for possible sources of resistance to aphids, suni pest and Hessian fly is also necessary. These insects are endemic to certain areas in the ICARDA region, making effective screening possible.

Over the past two years, more than 500 crosses were made for common bunt and sawfly resistance. The best resistance to sawfly is found in photosensitive parental material, primarily from the USA; winter wheat lines are the best source of common bunt resistance. To overcome these problems, top crosses to F_1s were made in 1982. Ten bunt-resistant spring wheat lines were promoted to the crossing block. Two lines with the solid stem character from Fortuna and with the genotype of Pavon "S" and Cajeme 71 from the CIMMYT germplasm development program were obtained. This new germplasm will be used to further improve the agronomic type of resistant lines.

The CIMMYT/ICARDA spring wheat program is assisted by ICARDA's cereal pathologists. The Key Location Disease Nursery (KLDN) is distributed by the ICARDA Cereal Pathology Program to regional locations known to have reliable epidemics. The bread wheat KLDN consists of advanced lines tested in yield trials, and its results help to identify lines with superior disease resistance.

Pathologists also produce artificial epidemics of stripe rust, septoria leaf blotch and common bunt to screen segregating populations and identify resistant parental material. ICARDA's Associate Entomologist provides assistance to the joint bread wheat program in screening for sawfly resistance under natural and artificial conditions.

Resistance to Cold, Heat and Drought

ICARDA is located at a latitude of 36° N, where it is cold enough to vernalize winter and facultative wheats. During the 1981-82 cycle, temperatures fell below 0°C for 40 days, resulting in severe leaf injury and winter kill on some lines. A freeze on April 1st (1981) caused extensive damage. A March 26th (1982) freeze of -5°C caused severe damage in the boot and early heading stage. The extent of the yield losses caused by the late freezes in both years were related to the growth stage of the crop. Early heading lines were more severely damaged, and selection for resistance to late frost is probably too closely associated with the actual growth stage to be of much use in identifying genetic variation.

Various techniques are used to select for tolerance to cold, heat and drought. Advanced lines and yield trials are seeded early to increase cold damage; a late seeding is made to increase the selection pressure for drought and heat tolerance. Segregating populations are grown in alternate generations under both rainfed and irrigated cycles. Cold tolerance selection pressure is better during the irrigated cycle, while heat and drought selection pressure increases in the rainfed cycle. Advanced lines are also screened for drought tolerance at other sites with rainfall of 250 mm or less.

Yield

In 1982, 770 advanced lines were tested in yield trials under both rainfed conditions and supplemental irrigation. Thirty-seven and 19 lines, respectively, showed significantly higher yields than the high-yielding checks Mexipak and Golan. The best of these lines were included in the regional Wheat Observation Nursery (WON), sent to cooperators throughout the region.

In the 1981-82 WON, 20 lines were selected at 6 or more of a total of 18 locations. The lines selected at seven or more locations are listed in Table 1. The first six of these were spring x winter crosses. All of them have one common parent in the winter background with the 1B/1R translocation. Winter wheat parents appear to bestow regional adaptability, and this gene pool will be probed further.

The best WON entries are tested in the Regional Wheat Yield Trial (RWYT) sent to regional cooperators. Over the last three years, the two top-yielding lines have shown a consistent advantage over Mexipak, as has the top-yielding line over the local check. These data are presented in Figure 1 for the two yield environments above and below 3.5 tons/ha.

Industrial Quality

The ICARDA Cereal Quality program has developed equipment and tests for assessing the quality of the bread, "kholbz", that is preferred in the region. Advanced bread wheat lines are subjected to these tests, as well as to standard quality testing for other types of bread. Additional information concerning bread wheat research at ICARDA can be found in the 1982 ICARDA Annual Report.

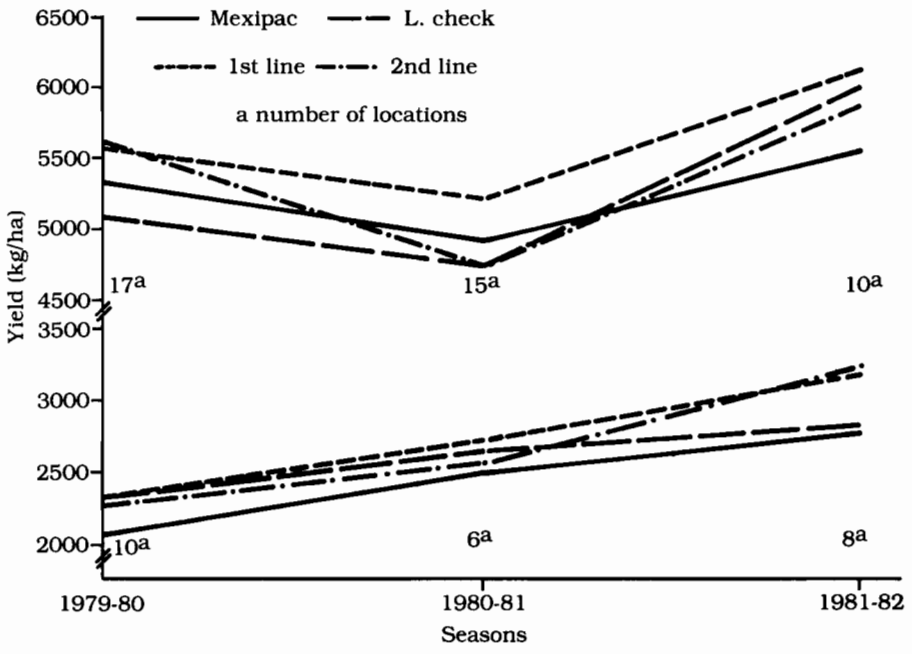


Figure 1. Comparison of two top yielding bread wheat lines for 3 years in the Regional Wheat Yield Trial (RWYT) with Mexipak and the national check in poor and favorable environments (mean location yield below or above 3500 kg/ha).

Table 1. Lines selected at 7 of the 18 locations of the Wheat Observation Nursery, 1981-82

Frequency of selection	Cross and pedigree
9	Au//Kal/Bb/3/Bon CM 33203-E-1M-2Y-0M
9	Kvz/4/Bb/Cno'S'//Jar/3/Cno/7C/CC/Tob SWM 2903-4L-6AP-0AP
8	Kal/Bb//Ald'S' CM 37217-16Y-1M-0Y-1Mn-0AP
8	WRM//Kal/Bb SWM 1445-8Y-2M-500Y-502M-500Y-506M-502Y-0M
7	Vee'S' CM 33027-F-9M-1Y-4M-500Y-500M-502Y-0M
7	RBS/Hork'S' SWM 2923-5L-1AP-0AP
7	2*MB//Inia'S'/Napo/5/N066/Bb/3/Cno//Nad/Chr'S'/4/7C CM 32973-2AP-3AP-0AP-1K-0AP

Glossary

ACI—Average Coefficient of Infection (rust)
ACWYT—African Cooperative Wheat Yield Trial
a.i.—Active ingredient
BYDV—Barley yellow dwarf virus
CB—Crossing block
cm^3—Cubic centimeter
CI—Coefficient of infection (rust)
CIANO—Centro de Investigaciones Agrícolas del Noroeste (Cd. Obregón, México)
CIMMYT—Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
cm—Centimeter
CRL—Cereal Rust Laboratory, USDA, St. Paul, Minnesota
CV—Coefficient of variation
EDYT—Elite Durum Yield Trial
ELAR—Ensayo Latinoamericano de las Royas
EMBRAPA—Empresa Brasileira de Pesquisa Agropecuaria (Brazilian Agency for Agricultural Research)
FAO—Food and Agriculture Organization of the United Nations
g—Gram
ha—Hectare
hl—Hectoliter
HYVs—High yielding varieties
IBON—International Barley Observation Nursery
IBWSN—International Bread Wheat Screening Nursery
IBYT—International Barley Yield Trial
IC—Index of quality
ICARDA—International Center for Agricultural Research in the Dry Areas (Aleppo, Syria)
IDRC—International Development Research Center (Ottawa, Canada)
IDSN—International Durum Screening Nursery
IDYN—International Durum Yield Nursery
INAT—Institut National Agricole Tunisienne
INIA—Instituto Nacional de Investigaciones Agrícolas (The Mexican National Institute of Agricultural Research)
INIAP—Instituto Nacional de Investigaciones Agropecuarias (Ecuador)
IPO—Institut Voor Plantenziektenkundig Onderzoek (Research Institute for Plant Protection, Netherlands)
ISEPTON—International Septoria Observation Nursery
ISWYN—International Spring Wheat Yield Nursery
ITSN—International Triticale Screening Nursery
ITYN—International Triticale Yield Nursery

kg—Kilogram
kg/ha—Kilograms per hectare
kg/hl—Kilograms per hectoliter
LR—Leaf rust
LSD—Least significant difference
m—Meter
m^2—Square meter
PC—Small plot multiplication for pure seed
PCM—Small seed increase plot
MPI—International multiplication plots
ppm—Parts per million
ppt—Parts per thousand
RDISN—Regional Disease and Insect Screening Nursery
RDTN—Regional Disease Trap Nursery
SNACWYT—Screening Nursery for the African Cooperative Wheat Yield Trial
SR—Stripe rust
t—Ton (= 1000 kg)
t/ha—Tons/hectare
USAID—United States Agency for International Development
USDA—United States Department of Agriculture
VEOLA—Vivero de Enfermedades y Observación en Latinoamerica
YR—Yellow rust
Y81-82—Yaqui, México, 1981-82

Cover design: Miguel Mellado E.

Layout: Miguel Mellado E.; Rafael De la Colina F.; Adriana Leal H.; José Manuel Fouilloux V.

Typesetting: Silvia Bistrain R.; Maricela A. de Ramos; Bertha Regalado M.; Patricia Martínez Ch.

Typing: Ma. Dolores Mir; Leticia González; Rosa Isela Magaña; Carmen Alatorre de Fernández

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Londres 40 Apartado Postal 6-641 06600 México, D.F., México