CIMMYT Report on Wheat Improvement

1983

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Directors' Introduction

Byrd C. Curtis and Arthur Klatt

The CIMMYT Wheat Program strives to increase the production of bread wheat, durum wheat, triticale, and barley in developing countries by helping to improve the productivity of the resources used by the millions of Third World farmers who grow these crops. In working toward this long-term goal, the Program relies on a close collegial relationship with literally thousands of scientists in national crop improvement programs around the world. Our approach is to provide several "intermediate" products and services:

- improved germplasm,
- training for national crop improvement program scientists,
- effective, practical research procedures,
- consultation with national programs on research problems, and
- research information.

Cooperating national programs build on the work done by the Program, often refining and improving the germplasm contained in our international nurseries to better meet the needs of local farmers. The Wheat Program relies on the research and extension efforts of national programs both to implement and to multiply the impact of its work.

CIMMYT has its headquarters at El Batan, 40 km northeast of Mexico City in the state of Mexico. Much of the wheat breeding work is carried out at three primary locations in Mexico: during the summer cycle (May through October) at two high-elevation sites in central Mexico, El Batan and Toluca, and during the winter cycle (November through April) at the low-elevation Yaqui Valley Agricultural Experiment Station, near Ciudad Obregon in the state of Sonora in northwestern Mexico. A number of other sites in Mexico are used to screen germplasm for resistance and tolerance to specific diseases and stresses.

Dr. Byrd Curtis (left), Director of the wheat program and Dr. Arthur Klatt (right), Associate Director.

The World Wheat Situation

In 1983, world wheat production once more achieved record levels. The 496 million metric tons (MT) harvested constitutes a 3 percent increase over the 1982 harvest. Sharp increases in production by Australia (146 percent) and the developing countries of Asia (13 percent) were responsible for this improvement. Production in the rest of the world either decreased or remained at roughly the same level as in 1982.

Production in Europe was virtually unchanged (down a mere 100,000 tons from the 73.7 MT produced in 1982), as was that of Canada (down less than 1 percent from the 1982 level of 26.8 MT). The United States registered a significant decrease in production, down from 75.3 to 65.9 MT, due to government policies designed to reduce output by encouraging reductions in the area planted to wheat. Yields, however, were the highest ever.

Australia compensated for the decrease in US production by more than doubling its output, from 8.9 MT in 1982 to 21.9 MT in 1983. The 1982 crop was damaged by a severe drought, while that of 1983 benefitted from excellent planting and growing conditions (although excessive moisture during harvest damaged about a quarter of the crop).

Eastern Europe and the USSR had a combined production decrease of 5 million tons, all of which was attributed to a poor harvest (estimated at 80 MT) in the USSR. The countries of Eastern Europe produced slightly more wheat than in 1982 (29.7 MT in 1983 compared to 29.4 MT in 1982).

Asia stands out among the regions of the developing world for its strong 13 percent increase in wheat production, from 150.3 MT to 169.5 MT. China, India, Pakistan, and Bangladesh all recorded significant increases, but the most spectacular was that of China, which went from 68.4 MT in 1982 to 81.4 MT in 1983, a 19 percent increase. This gives China the distinction of producing more wheat than any other country in the world, for the first time. Fortuitous rains, combined with producer incentives and the increased use of fertilizer and other inputs, were responsible for this historic event.

In the rest of the developing world, the 1983 harvests were somewhat disappointing. Of the Latin American countries, only Brazil harvested more wheat in 1983 (2.2 MT) than in 1982 (1.8 MT), and this is still considerably below the 4.3 MT level of domestic consumption. Argentina experienced an 18 percent decrease in production, to 12.3 MT, due to a decline in the area sown to wheat. Mexico's production fell from 4.5 MT to 3.5 MT. In Africa, a 1.2 MT decrease, from the 1982 level of 10 MT, was principally the result of drought in Morocco, Tunisia and South Africa.

The consumption of wheat in developing countries is still increasing rapidly, especially in areas where wheat is not a traditional crop. About 100 MT were traded worldwide in 1983, of which about 52 percent, up from 47 percent a year earlier, went to developing countries. About 24 MT of wheat found their way to tropical countries (between 23°N and 23°S latitudes), where wheat is grown on a small scale, if at all. Wheat imports constitute an important expenditure of foreign currency for many of these countries, and interest in finding ways to produce wheat domestically is high.

A Shifting Emphasis

In attempting to increase wheat production in developing countries, the CIMMYT Wheat Program first focused on improving yields in traditional wheat-growing areas (irrigated and well watered). These areas account for about 70 percent of the Third World wheat lands. High-yielding, broadly adapted, and disease-resistant semidwarf materials were rapidly developed that performed well in diverse environments. Today, the key traits of high yield potential, photoperiod insensitivity, semidwarf growth habit, and resistance to the three rusts are incorporated across the Program's entire germplasm base.

Despite these advances, the consumption of wheat in the developing world continues to exceed the domestically produced supply. The better wheat lands are now generally devoted to high-yielding varieties, and it is on marginal lands and in areas where wheat is not a traditional crop (such as the tropics) that the most significant production gains can now be made. Consequently, the CIMMYT wheat program is shifting its emphasis to these areas.

The production constraints that characterize marginal wheat environments are highly diverse and tend to be more regional or site-specific in nature and extent. The Wheat Program's germplasm development strategy is therefore changing to accommodate these realities. We are now in the process of building on the broad adaptation that is the hallmark of CIMMYT wheats, with the objective of producing subsets of broadly adapted germplasm that possess resistances and tolerances to specific diseases and environmental stresses. In the context of this effort, our international network of cooperating scientists and national programs will play a vital role, since materials will be evaluated in the regions and locations for which they are intended.

Crop Program Highlights

Bread wheat—The Veery sibs continue to outperform nearly all other CIMMYT lines and locally grown commercial varieties in most parts of the world. No fewer than 11 varieties based on the Veery cross have been released around the world since 1980. Progress continues to be made toward developing lines tolerant to acid soils with high levels of free aluminum. Yields of up to 4 tons per hectare have been obtained with these aluminum-tolerant materials.

Durum wheat—Yields are now on a par with the best bread wheats, but stem rust, septoria and fusarium diseases limit production in many of the world's durum wheat-producing areas. Several new lines showing resistance to one or more of these diseases were identified in 1983. In addition, plans are being made to start a cooperative shuttle breeding program with Ethiopia, where especially virulent races of stem rust occur.

Triticale—Progress in total yield and endosperm development (test weight) was made in 1983. Lines yielding over 20 percent more than the best checks were found, and others were identified having test weights as much as 15 percent higher than the check varieties. In addition, triticale's considerable tolerance to high levels of free aluminum was confirmed.

Barley—Diseases remain the principal problem, especially scald, leaf rust, net blotch and, in the Andean region, race 24 of stripe rust and barley yellow dwarf. Considerable progress has been made toward incorporating scald and leaf rust resistances across the entire CIMMYT barley germplasm base. New sources of resistance to stripe rust race 24 were found, and several simple and inexpensive techniques for producing spores of *Rynchosporium secalis*, as well as greenhouse screening for resistance to several diseases, were successfully introduced in 1983.

New Programs

In 1983, the government of Peru invited CIMMYT to participate in a bilateral research program sponsored jointly by the World Bank and the Peruvian National Institute of Agricultural Research and Extension. The objective of the program is to improve small grain production in the country. This bilateral effort is comprehensive in nature, and includes research aimed at improving agricultural practices, developing new varieties, promoting the application of modern technology, and training. The Wheat Program continues to welcome the opportunity to take part in major in-country programs such as this.

Staff Changes

In 1983, a number of staff changes were made in order to strengthen the CIMMYT Wheat Program, both at headquarters in Mexico and in our regional and bilateral programs.

- Dr. David Saunders was added to the South and Southeast Asia regional program to provide assistance in developing management techniques for some of the nontraditional wheat-growing areas. He was replaced at headquarters by Dr. Joel Ransom, a former CIMMYT postdoctoral fellow.
- Dr. Reynaldo Villareal, a former CIMMYT postdoctoral fellow, joined the wheat program staff at headquarters.
- Dr. Walter Nelson, a breeder-pathologist, returned to headquarters from the CIMMYT-ICARDA cooperative program. He was replaced in Syria by Dr. Guillermo Ortiz F., a former CIMMYT postdoctoral fellow.
- Dr. Mengu Guler, an agronomist, joined Dr. Larry Butler, a breeder-pathologist, in Bangladesh.
- Dr. Gregorio Vázquez, head of the durum wheat program since 1977, took responsibility for CIMMYT's bilateral program in Peru. He was replaced at headquarters by Dr. Pedro Brajcich, a former CIMMYT postdoctoral fellow.
- Dr. Gerbrand Kingma returned to headquarters to lead the training program in cereal improvement. He was replaced as CIMMYT regional wheat program leader in Eastern and Southern Africa by Dr. Enrique Torres.
- Dr. Hubert Hers, a computer programmer, was added to the staff at headquarters to help with the computerization of the wheat program's extensive data base.
- Dr. Christoph Mann, a former CIMMYT postdoctoral fellow, joined the South and Southeast Asia regional program as a breeder-pathologist.

In addition to these changes in the regular staff, seven new postdoctoral fellows joined the CIMMYT wheat program in 1983, and four associate scientists worked with the senior staff on various projects.

Farmers' fields in the Peruvian Andes, where CIMMYT is participating in a new bilateral program.

CIMMYT-INIA Cooperation

Once again, 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. CIMMYT operates the summer cycle-nurseries at El Batan and Toluca, but benefits 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 the *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 help supply superior varieties to the farmers of Mexico.

Bread Wheat

S. Rajaram, C. E. Mann, R. Villareal, W. Nelson and G. Ortiz-Ferrara

Introduction

Genetic diversity and variability in germplasm are necessary elements in wheat breeding. While many kinds of genetic variability are not immediately useable because of limitations of space and resources, it is highly desirable to maintain this diversity to safeguard against environmental stresses, pests and pathogens which may arise in the future. Consequently, one of the current objectives of the CIMMYT wheat program is to avoid the narrowing of variability in both pathological and agronomic characters in the course of attempting to breed for high yield.

It appears that the yield potential of bread wheat germplasm has steadily increased during the 1960s and 1970s in certain high-yielding environments. Whether this increase will continue in the 1980s is not clear at this point. However, there is ample opportunity to increase yield potential in less productive environments, such as those with acid soils and insufficient moisture. This, too, is a current objective of the CIMMYT wheat program. The third objective is to stabilize yield in highly productive areas, for which germplasm with a high yield potential already exists.

High and stable yield potential in most environments is an ideal long-term goal for a large international breeding program such as CIMMYT's bread wheat program. This has been the objective since CIMMYT's inception, and some success has been achieved, as very widely adapted lines with increased stability have been produced. Further progress will depend on producing materials adapted to the differing conditions in the various wheat-producing regions of the world.

For the past seven years, attempts have been made to assemble genetic characteristics that would enhance the acceptability of new materials in these regions, taking advantage of agro-ecological similarities that allow them to be grouped into the following broad agro-ecological units:

- Irrigated areas with only a few disease problems, such as rusts. These include the countries of India, Pakistan, Sudan, Zimbabwe, Egypt and Mexico.
- Dryland areas of the world in which rainfall is sufficient for growing wheat. These fall into two categories:
  a) Lowland areas in North Africa and the Southern Cone countries of South America, with rusts and septorias as the main pathological constraints.
  b) Highland areas of the Andes, Central America (including Mexico) and East Africa. A multitude of diseases, such as rusts, septorias, fusariums, bacteria and barley yellow dwarf (BYD), pose a continual threat.
- Droughty areas where rainfall is too limited to support good wheat growth. These areas include the Middle East, central India and the high plateau of Mexico.
- Tropical lowland regions between 23°N and 23°S latitudes and below 1500 meters elevation. Here, *Helminthosporium* spp. and *Puccinia recondita* (leaf rust) are the main disease-causing organisms. Fusarium head scab could also be present in certain hot and humid tropical areas. High temperature is a critical physiological stress limiting wheat yield in these areas.
- Areas with acid soils and toxic levels of aluminum. These are found in Brazil and the central African highlands.

The CIMMYT bread wheat program strives, in collaboration with the national wheat programs, to remove production constraints in these agro-ecological units by breeding widely adapted, high-yielding semidwarfs which incorporate specific genetic characters, such as resistance to diseases, and tolerance to high levels of free aluminum and to drought. The

Dr. S. Rajaram (second from right), head of the bread wheat breeding program, with Dr. R. Villareal (third from right) and Dr. W. Nelson (left) in the winter cycle crossing blocks at CIANO.

current philosophy, objectives and breeding methodologies of the program reflect this goal.

Breeding and Screening Environments

Diversity of environments is a very important factor in breeding for wide adaptation and yield stability. It is the use of diverse environments for selection that has permitted the production of widely adapted wheat germplasm in Mexico.

The two principal locations, both in Mexico, used in selecting germplasm and advancing segregating generations are the Yaqui Valley Agricultural Experiment Station of the Northwestern Agricultural Research Center (CIANO) (39 meters elevation, 27°N latitude) near Ciudad Obregon, Sonora, and the Toluca Experiment Station (2640 meters elevation, 18°N latitude). The former is a high-yielding environment, the latter lower yielding, and they differ widely in rainfall, temperature regimes, soil type, disease spectra, and day length. In addition, a number of other sites within Mexico are used because of the different selection opportunities they offer: the El Batan Experiment Station (2249 meters elevation, 19°N latitude), the Fuerte Valley Agricultural Experiment Station (Los Mochis) (40 meters elevation, 26°N latitude); the Rio Bravo Agricultural Experiment Station (30 meters elevation, 25°N latitude), the Poza Rica Experiment Station (60 meters elevation, 21°N latitude), the Santiago Izcuintla Agricultural Experiment Station (40 meters elevation, 22°N latitude) and the Tarascan Mountains Agricultural Experiment Station (Patzcuaro) (2180 meters elevation, 18°N latitude). These are used to varying degrees and, in some cases, in cooperation with the National Agricultural Research Institute (INIA). CIMMYT also relies on about 100 additional locations around the world to gather genetic information for the crossing program.

In 1983, temperatures in the Cd. Obregon area were slightly higher than the long-term average (Figure 1). This may have caused a slight yield reduction; the average yield for the surrounding Yaqui Valley was 4.7 tons per hectare in 1983, compared with 5.1 tons per hectare in 1982. Performance in yield trials was also slightly lower in 1983 than in 1982.

The 1983 summer season at the Toluca Experiment Station was characterized by a complete lack of stripe rust, for the first time in 15 years. However, there were severe epidemics of septoria, fusarium and leaf rust diseases, which permitted good selection for resistance. About 1000 mm of rainfall fell during the 1983 wheat-growing season. The El Batan location had above-normal rainfall, which helped to produce good epidemics of leaf and stem rust.

Breeding Methodology and Results

A simplified flow diagram is presented in Figure 2 explaining the movement of basic germplasm and segregating materials. Crosses are made at both CIANO and Toluca and segregating materials are grown alternately at both locations. Yield trials are conducted at CIANO to identify germplasm with wide adaptation, high yield and resistance to leaf and stem rusts. Yield trials at Toluca identify materials suitable for rainfed, highland conditions, and the El Batan yield trials are used to identify germplasm for lower rainfall conditions.

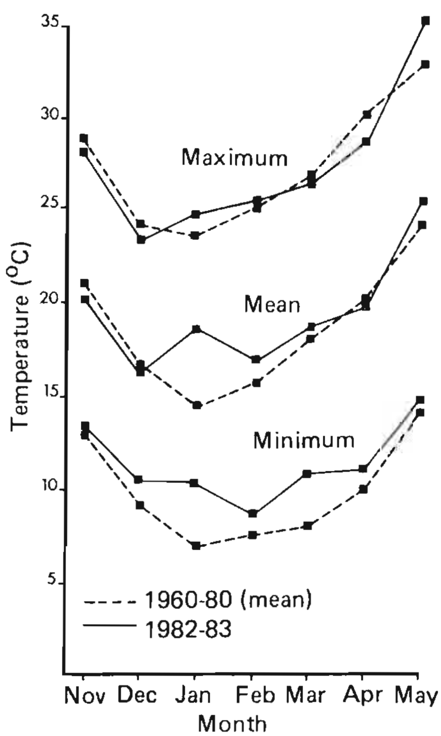


Figure 1. Comparison of mean monthly air temperatures during the wheat growing season for the period 1960-80 and 1982-83 at CIANO near Ciudad Obregon, Sonora, Mexico.

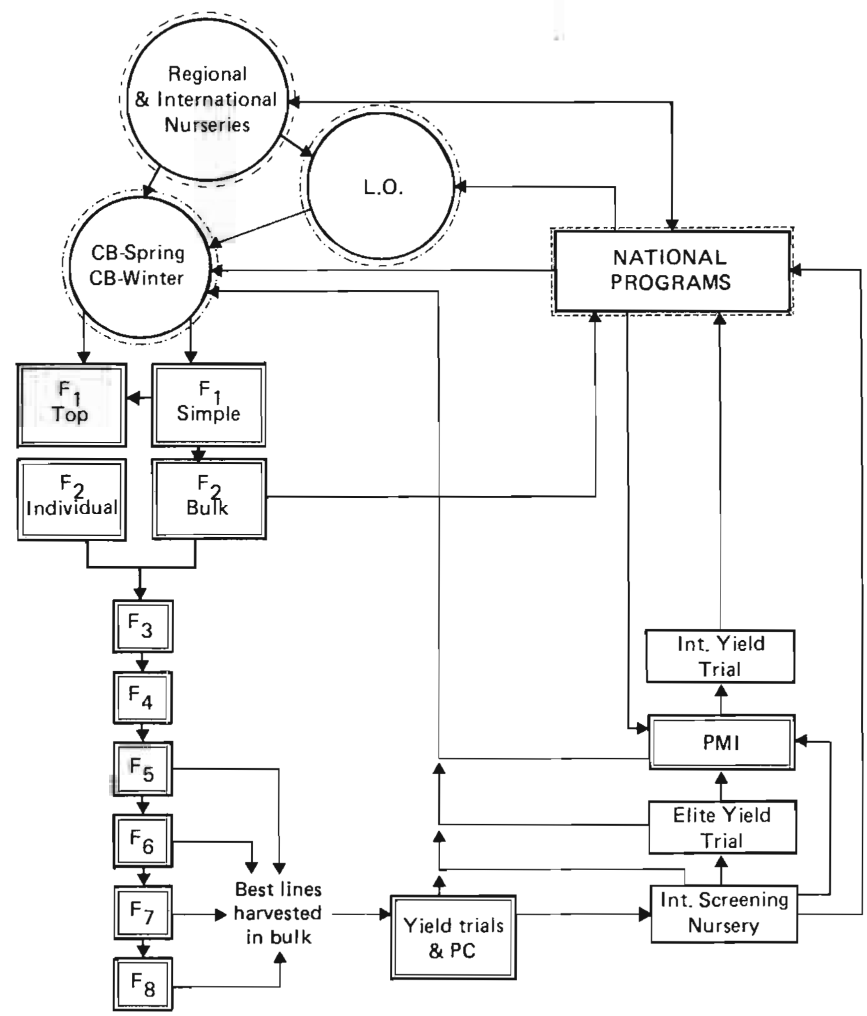
Yield Potential—The process of developing spring wheat germplasm for international use is a dynamic one. The genetic variability for high yield, wide adaptation, yield stability, disease resistance and agronomic and quality characters is exploited through crosses with advanced lines and subsequent selection. More than 1000 advanced lines were evaluated for yield potential at CIANO in 1983. Table 1 presents 25 lines that produced as much as or more than Ures 81, a well-adapted, high-yielding line under CIANO conditions. Some of these 25 lines will be tested internationally in 1984 to determine their yield stability and adaptability.

Table 2 presents the yield of 16 established and 3 advanced lines under 1) optimum fertility and well-watered conditions (5 irrigations) and 2) low fertility and limited water conditions (2 irrigations); both received an additional 171 mm of rainfall throughout the season. The experiment was disease free, permitting entries to differ only in response to water availability and fertility level. The highest-yielding entry in the fully irrigated and fertilized trial was the variety Nacozari 76, but it ranked 14th under the reduced water and fertilizer regime. The top-yielding entry under suboptimal conditions was Veery 8, and it ranked sixth under optimal conditions. CIANO 79 ranked eighth and seventh, respectively, under optimal and suboptimal conditions, so it should be considered the most stable, i.e., with relatively high yield in both environments. The advanced line Hahn"S" received fourth and sixth ranking, respectively, and should also be considered relatively stable. However, yield stability alone is not sufficient. This characteristic has to be combined with high yield potential to gain wide acceptance.

Wide adaptation—A central objective of CIMMYT's wheat program is widely adapted germplasm because narrowly adapted materials are of limited use vis-a-vis the developing world as a whole. Wide adaptation is defined as the ability of a genotype to produce high yields in diverse environments.

Various widely adapted materials, such as Siete Cerros, Anza, Pavon 76, and Nacozari 76, have become commercial varieties. In the early 1980s, several varieties developed from the cross Veery were released by national programs and their performance indicated wide adaptation. During the last four years, a Veery selection was the top performer in international trials [International Spring Wheat Yield Nurseries (ISWYN) 15, 16, 17 and 18].

In Figures 3, 4 and 5, Veery 5 (= Seri 82) is compared with Anza (a widely grown variety), Pavon 76 (also widely grown) and local checks (selected, locally grown varieties), respectively, in 42 different locations. In all three graphs, the yield of Veery 5 is plotted as a percent of these varieties at all 42 locations. At 38, 34 and 29 locations,



- Nurseries for use in CIMMYT crossing program
- CIMMYT breeding nurseries
- CIMMYT international nurseries
- National, CIMMYT regional, and other international programs

CB = Crossing block
L.O. = Observation lines
PMI = International multiplication plot
PC = Small multiplication plot

Figure 2. Movement of germplasm in CIMMYT's bread wheat program.

Key to test locations for Figures 3-5.

1. Brazil (Sao Paulo)
2. Bolivia (Santa Cruz)
3. Spain (CRIDA-10)
4. South Africa
5. Argentina (La Dulce)
6. Argentina (M. Juárez)
7. Norway
8. Romania
9. Argentina (Pergamino)
10. Portugal
11. Israel
12. Portugal
13. Ecuador
14. Canada (Alberta)
15. Japan
16. Bolivia (San Benito)
17. Cyperus
18. Tanzania
19. Burma
20. Syria
21. Sudan
22. Chile (Caultin)
23. USA (Washington)
24. Turkey
25. Canada (Manitoba)
26. Afghanistan
27. Pakistan
28. England
29. USA (Montana)
30. Canada (Saskatchewan)
31. Senegal
32. Mexico (Sonora)
33. Spain (Seville)
34. Greece
35. Chile (Chillan)
36. Tunisia
37. Yugoslavia
38. USA (ARS)
39. Egypt
40. Spain (El Encinal)
41. Zimbabwe
42. Kenya
43. Bolivia (Cochabamba)

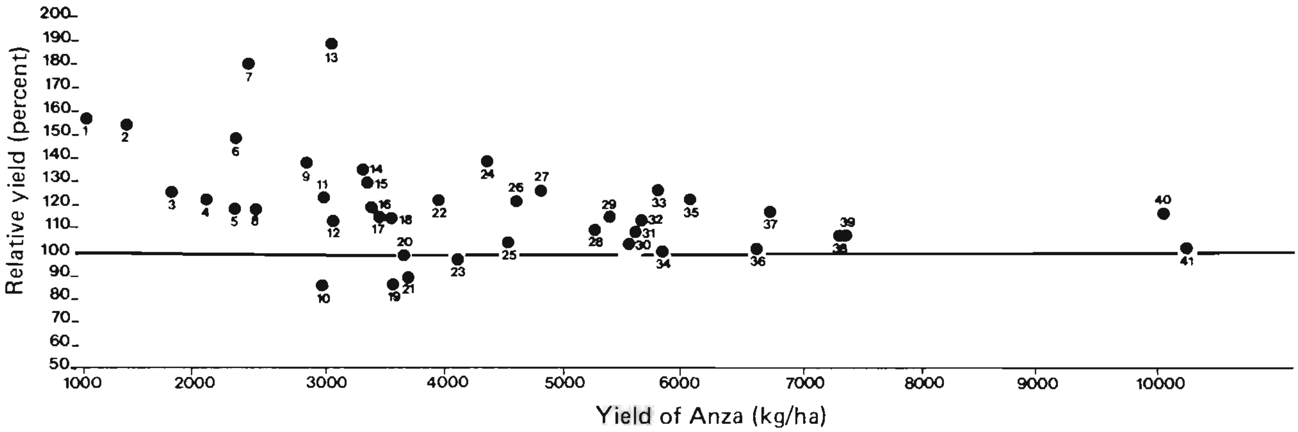


Figure 3. Yield of Veery 5 (Seri 82) as percent of Anza at 42 locations in the 18th ISWYN. Mean yield across locations: Anza: 4263 kg/ha, Veery 5: 4982 kg/ha (17°/o greater than Anza). Key to numbered locations on page 12.

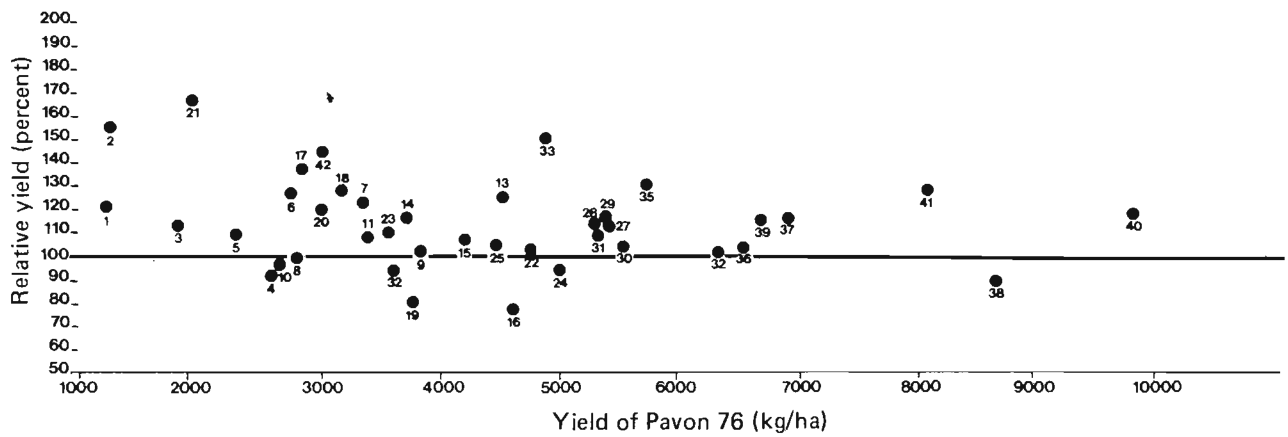


Figure 4. Yield of Veery 5 (Seri 82) as percent of Pavon 76 at 42 locations in the 18th ISWYN. Mean yield across locations: Pavon 76: 4484 kg/ha, Veery 5: 4982 kg/ha (11°/o greater than Pavon 76). Key to numbered locations on page 12.

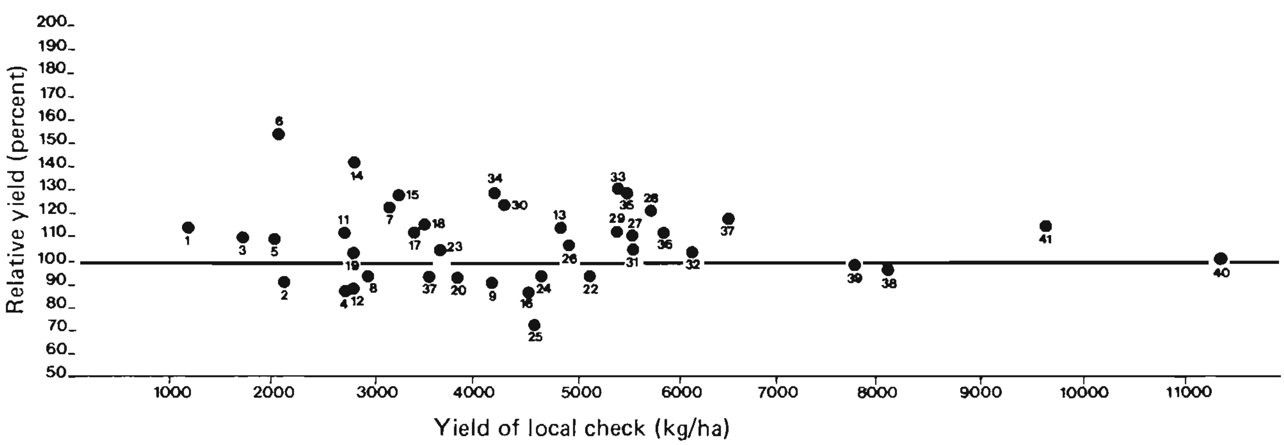


Figure 5. Yield of Veery 5 (Seri 82) as percent of the local check at 42 locations in the 18th ISWYN. Mean yield across locations: Local check: 4614 kg/ha, Veery 5: 4982 kg/ha (8°/o greater than local check). Key to numbered locations on page 12.

Veery 5 yielded more than Anza, Pavon 76 and the local checks, respectively. Averaged over all 42 locations, Veery 5 produced 17, 11, and 8 percent more than Anza, Pavon 76, and the local checks, respectively. The countries where Veery 5 yielded more than the local checks are Brazil, Spain (three locations), Argentina (two locations), Canada (two locations), Israel, Burma, Norway, Japan, Cyprus, Tanzania, the United States (three locations), Greece, Ecuador, Afghanistan, Pakistan, Chile, Senegal, England, Tunisia, Mexico, Yugoslavia, Egypt, and Zimbabwe. The locations in these countries are at different latitudes and elevations, and include both irrigated and rainfed regions. From these figures it can be concluded that Veery 5 is widely adapted and that its performance in the 18th ISWYN was better than Anza, Pavon 76 and locally adapted varieties.

In Figures 6, 7 and 8, the yield performance of Veery 3 (= Genaro 81) is compared with that of Anza, Pavon 76, and local check varieties, respectively, at the 42 locations of the 18th ISWYN. Veery 3 yielded more at 32, 27 and 22 locations than Anza, Pavon 76 and the locally adapted checks, respectively. These yields represent average increases of 13, 8 and 5 percent over Anza, Pavon 76 and the local checks, respectively. The countries where Veery 3 produced more than the local checks are Argentina (three locations), Bolivia, Sudan, South Africa, Canada (two locations), Israel, Burma, Japan, Tanzania, Greece, Afghanistan, Spain (two locations), Chile, Senegal, England, Mexico, and Zimbabwe. Some of these locations are the same as those in which Veery 5 also gave a better yield performance.

Based on these data it can be concluded that both Veery 3 (= Genaro 81) and Veery 5 (= Seri 82) are widely adapted, although to different degrees. It should be noted that even in the higher latitudes these lines gave a satisfactory performance compared with locally adapted varieties.

Variety releases—National programs have released 40 varieties since 1980 (Table 3), an average of 10 varieties per year. These varieties stem from many different crosses and consequently contain considerable genetic variation.

Disease resistance—In the dryland areas of world where rainfall is sufficient to support normal wheat growth the major diseases are rusts, septorias, fusariums, BYD and bacteria. CIMMYT's Toluca Experiment Station, supplemented by Patzcuaro, is a very good location to screen for high yield and resistance to these diseases. Since the whole disease complex cannot be attacked at the same time, high priority is placed on the problems of stripe rust, leaf rust, *Septoria tritici*, and *Fusarium nivale*.

Table 4 lists 16 varieties and advanced lines that have shown excellent resistance to *Septoria tritici* at Toluca and Patzcuaro. These lines have been used in crossing, and advanced progenies will be available in 1987. By that time, it is hoped that all of CIMMYT's bread wheats will carry some degree of genetic protection against *Septoria tritici*. (The assistance of Dr. Zahir Eyal in locating better sources of resistance to Middle Eastern populations of *Septoria tritici* is acknowledged).

Table 5 compares 17 advanced lines under heavy disease pressure from septoria, stripe rust, leaf rust, fusarium and bacteria at Toluca. The yield potential varied between

Key to test locations for Figures 6-8.

1. Brazil (Sao Paulo)
2. Bolivia (Santa Cruz)
3. Spain (CRIDA-10)
4. South Africa
5. Argentina (La Dulce)
6. Argentina (M. Juárez)
7. Norway
8. Romania
9. Argentina (Pergamino)
10. Portugal
11. Israel
12. Portugal
13. Ecuador
14. Canada (Alberta)
15. Japan
16. Bolivia (San Benito)
17. Cyperus
18. Tanzania
19. Burma
20. Syria
21. Sudan
22. Chile (Caultin)
23. USA (Washington)
24. Turkey
25. Canada (Manitoba)
26. Afghanistan
27. Pakistan
28. England
29. USA (Montana)
30. Canada (Saskatchewan)
31. Senegal
32. Mexico (Sonora)
33. Spain (Seville)
34. Greece
35. Chile (Chillan)
36. Tunisia
37. Yugoslavia
38. USA (ARS)
39. Egypt
40. Spain (El Encinal)
41. Zimbabwe
42. Kenya
43. Bolivia (Cochabamba)

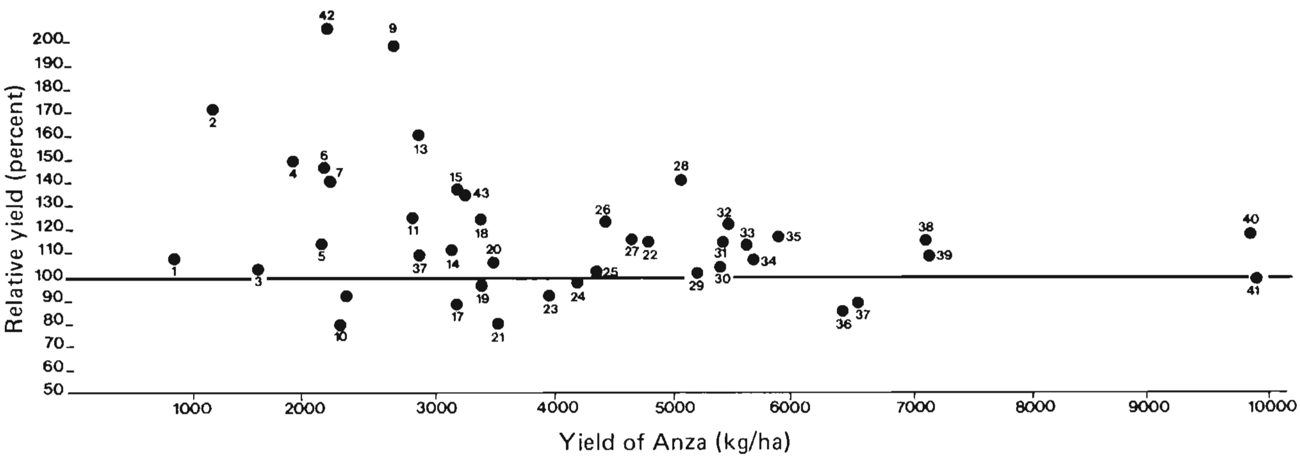


Figure 6. Yield of Veery 3 (Genaro 81) as percent of Anza at 42 locations in the 18th ISWYN. Mean yield across locations: Anza: 4263 kg/ha, Veery 3: 4826 kg/ha (13% greater than Anza). Key to numbered locations on page 14.

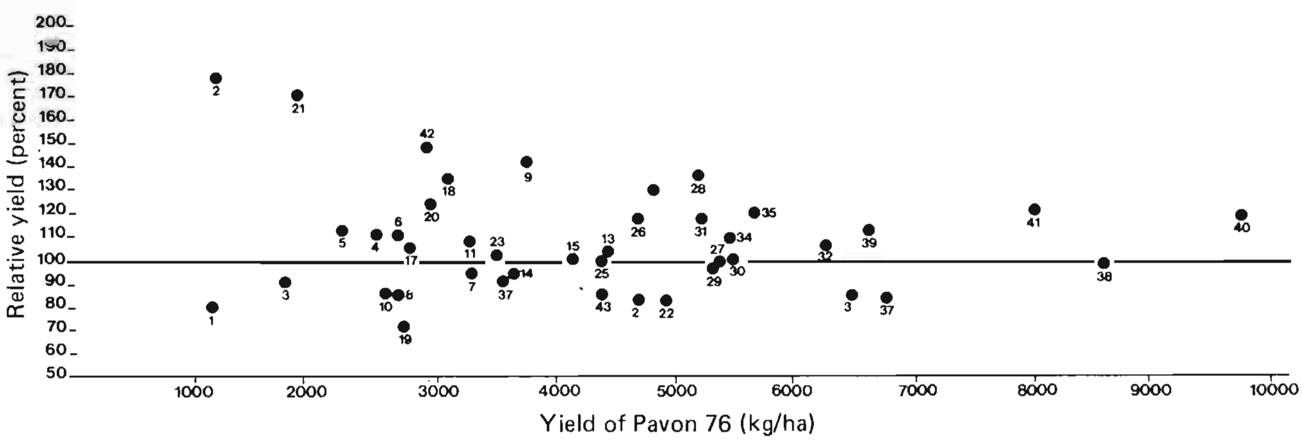


Figure 7. Yield of Veery 3 (Genaro 81) as percent of Pavon 76 at 42 locations in the 18th ISWYN. Mean yield across locations: Pavon 76: 4484 kg/ha, Veery 3: 4826 kg/ha (8% greater than Pavon 76). Key to numbered locations on page 14.

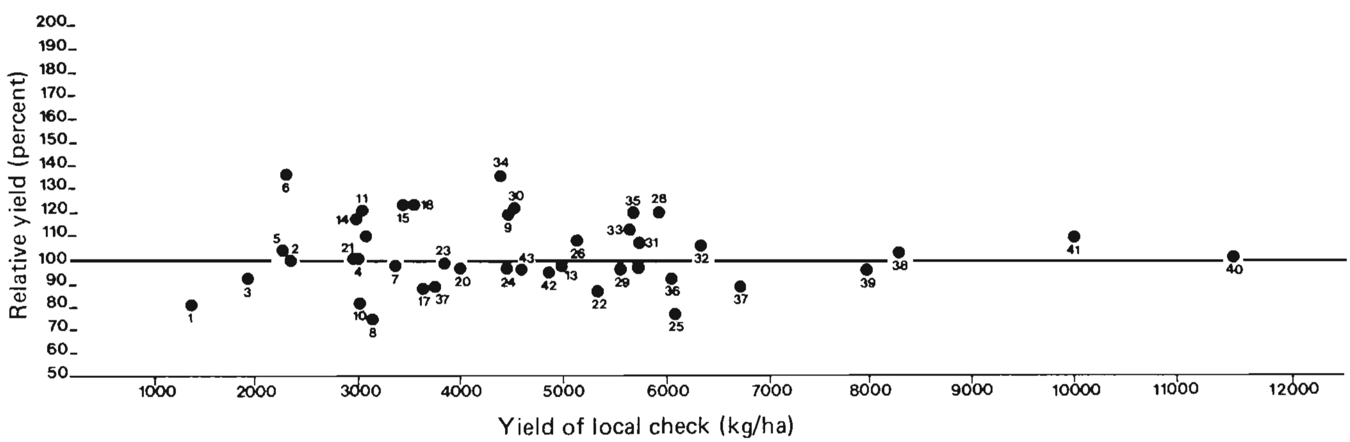


Figure 8. Yield of Veery 3 (Genaro 81) as percent of local check at 42 locations in the 18th ISWYN. Mean yield across locations: Local check: 4614 kg/ha, Veery 3: 4826 kg/ha (5% greater than local check). Key to numbered locations on page 14.

5571 kg/ha and 6768 kg/ha. Careful manipulation of genes for yield potential, disease resistance, and maturity could push this potential to 7500 kg/ha under highland production conditions. More than 600 advanced lines have been identified as having resistance to the disease complex prevalent at Toluca, and these will be yield-tested in 1984. This situation, in which plant type, disease resistance, quality characteristics, and maturity can be blended together to construct a highly productive genotype for well-watered, rainfed environments both in the highlands and the lowlands, will be monitored carefully.

Drought tolerance—Thirty-seven percent of the total area of all developing countries consists of semiarid environments in which available moisture constitutes the primary constraint on wheat production. The Middle East and North Africa region constitutes about 59 percent of this semiarid area, with the largest part located in Turkey. In South and East Asia, the largest semiarid areas are located in central India and China. Argentina and Mexico rank first among the Latin American countries in semiarid area.

Drought tolerance is a relative concept, defined as the ability of one genotype to be more productive than other genotypes in semiarid environments. Since the pattern of moisture availability is different from one semiarid environment to another, the drought tolerance of a variety must be location specific. The pyramiding of other traits, such as high and stable yield potential onto drought tolerance may provide flexibility and plasticity of response.

One of the objectives from the outset of the CIMMYT wheat program has been to produce germplasm that gives a good response under both droughty and high-yielding production conditions. To achieve this goal, a breeding program is used in which spring x winter wheat crosses are subjected alternately to reduced moisture and optimum irrigation at CIANO during the winter season. During the summer cycle, selected progenies are planted in highland locations at El Batan and Zacatecas, both of which have very low rainfall. The drought breeding program of CIMMYT is a cooperative venture between CIMMYT and INIA, as the selections at Zacatecas are made by INIA staff.

In addition to segregating populations, all the regular, advanced lines developed under good conditions will be tested at El Batan and Zacatecas. Table 6 shows the performance of 12 advanced lines at CIANO (with two irrigations) and at El Batan (rainfed conditions). These advanced lines were grown under the good conditions of CIANO and the somewhat less favorable conditions at Toluca. Some of these, such as Veery"S" and Flycatcher"S", were selected for high yield in well-watered environments. Despite their origins, however, it appears from Table 6 that these lines will perform well under both moisture regimes. In 1984, they will be subjected to international yield testing to obtain additional data on stability.

Wheats for tropical regions—Tropical wheats are defined as genotypes having the ability to give acceptable yields under tropical conditions. To do so, these genotypes must have *Helminthosporium* spp. and leaf rust resistance, as well as tolerance to high temperatures in both the juvenile and adult stages. Areas to which tropical wheat should be adapted are between latitudes 23°N and 23°S and below 1500 meters elevation. As the first step in the breeding program, CIMMYT's objective is to develop wheats for the South Asia region (Thailand, the Philippines, and Sri Lanka) and the Cerrados region of Brazil. Extension to other areas will come later.

Resistance to *Helminthosporium* spp. is tested at CIMMYT's Poza Rica Station and Santiago Ixcuintla; natural epidemics are recurrent in theses sites. Both locations are in the Mexican tropics. (At Santiago Ixcuintla, the experiments are conducted cooperatively with INIA.) Sixteen varieties and advanced lines that were found to be more resistant to *Helminthosporium* spp. than BH 1146 (a resistant check from Brazil) in Poza Rica are presented in Table 7. These lines will be utilized in the 1984 crossing block.

Heat tolerance is evaluated at CIANO by planting advanced lines in mid-January when temperatures are higher, and performance is evaluated in late April. In 1983, more than 200 advanced lines were identified as heat tolerant and these will be re-evaluated in 1984 to confirm their tolerance. Heat tolerance screening criteria include the following:

- Longer leaf retention
- High tillering capacity
- Acceptable spike fertility
- Relatively high 1000 grain weight
- High hectoliter test weight
- Relatively high yield

This breeding effort is designed to blend the genetic traits of heat tolerance, resistance to *Helminthosporium* spp. and leaf rust, resistance to sprouting, earliness, and other agronomic and quality traits so as to permit relatively high yields in the tropical belt.

Tolerance to toxic levels of aluminum—Among the soils adversely affected by mineral toxicities and/or deficiencies are the highly leached, acidic oxisols and ultisols, which are characterized by toxic levels of soluble aluminum and manganese. Aluminum toxicity is quite a severe problem in many areas of Brazil where the soil pH is below 5.0. In addition, wheat seems to be more susceptible to diseases when grown in acid soils.

The aluminum tolerance breeding program is a joint venture between CIMMYT and various Brazilian wheat-breeding institutes, such as the Brazilian Agency for Agricultural Research (EMBRAPA) at Passo Fundo, the Federation of Brazilian Wheat and Soybean Cooperatives (FECOTRIGO) at Cruz Alta, the Organization of Cooperatives of the State of Parana (OCEPAR) at Cascavel and the Agronomy Institute of Parana (IAPAR) at Londrina; the program would not be possible without their cooperation. Crosses are made in Mexico between aluminum-tolerant varieties from Brazil and high-yielding materials from CIMMYT. Progenies are evaluated under field conditions in Brazil for their tolerance to high aluminum levels; they are also evaluated in the aluminum toxicity laboratory at El Batan for resistance at the seedling stage and for agronomic type at the CIANO and Toluca stations.

In 1983, advanced lines were identified that yielded more than four tons per hectare in the acid soils of the Patzcuaro area of Mexico, compared to 1.5 tons per hectare for the variety Anahuac 75, which has little tolerance to aluminum. These lines, some of which have also performed well in Brazil (e.g. Thornbird"S"), are listed below:

- Thornbird"S" = IAS63/ALD//GTO/LV
- MRNG/4/NAD/TOR//PCH/3/BLT/MES/5/PAT 72195*2/ZP"S"//ALD"S"/EMU"S"
  CM57616-A-3Y-1Y-1M-2Y-2M-OY
- Aldan"S"/PF70354
  CM53524-10M-1Y-1Y-1Y-103F-OY
- Canastero"S"
  CM58446-A-1Y-1Y-4M-4Y-1M-OY

Table 8 compares six aluminum-tolerant advanced lines that in 1983 produced more than four tons per hectare in Toluca under a very high incidence of *Septoria tritici* and barley yellow dwarf virus (BYDV). All six lines are derived from the cross PF7619/DOVE"S"//CEP7670, which was made by FECOTRIGO in Brazil and selected by CIMMYT.

During the next five years, it is anticipated that the yield potential of aluminum-tolerant materials will be increased to six tons per hectare by combining scattered genes for yield potential with tolerance to high levels of free aluminum and resistance to the major pathogens that occur in acid-soil environments.

Screening for aluminum tolerance in Brazil. CIMMYT and several Brazilian institutions are cooperating to develop high-yielding, aluminum tolerant lines of wheat.

Slow rusting—Slow rusting is defined as the phenomenon in which the rate of rust development is slower and the ultimate disease intensity is less than would be expected in a fully susceptible variety. This type of host-parasite interaction, characterized by a susceptible host reaction, can be traced back to the variety Kalyan/Bluebird. The slow-rusting character appears to have been stable for at least eight years in the Yaqui Valley, Mexico, and CIMMYT breeds for this kind of resistance in all of its advanced lines. A partial list of slow-rusting advanced lines that have shown this characteristic for five years is presented in Table 9. Despite this progress, the program remains interested in other types of resistance as well.

Conclusions and Breeding Plans

- More than 40 varieties of bread wheats have been released since 1980, indicating that acceptability of CIMMYT germplasm has remained at the same high level as in 1960s and 1970s. The wide adaptability and high yield potential of the Veery lines could be further exploited by crossing to increase their stability in diverse environments.

- Various advanced lines of bread wheat were identified as high-yielding, better than Ures 81 (= Veery 2), and these will be internationally tested to ascertain their breath of adaptability and stability of yield.

- While the yield potential of wheats may be leveling off in high-yielding environments, there is ample opportunity to increase yield substantially in low-yielding, stressful environments, such as acid-soil areas having high levels of free aluminum. This has been demonstrated by the production of the Thornbird lines, which yield twice as much as Maringa at Passo Fundo, in the Brazilian state of Rio Grande do Sul. This line also has established a record yield of four tons per hectare, compared with 1.5 tons per hectare for the recommended variety Anahuac 75, in the acid soils around Patzcuaro, Mexico. It is expected that the yield of aluminum-tolerant lines will be further increased by adding genes for yield potential and for resistance to *Fusarium* spp., BYDV, *Septoria* spp., bacteria and rusts.

- It also should be possible to increase the yield potential of wheats in droughty environments by carefully combining drought tolerance with those characteristics giving high yield performance. Spring x winter wheat germplasm will continue to be screened at CIANO (under two and five irrigations) alternating with screening at El Batan and in Zacatecas, Mexico, locations characterized by low rainfall. The objective is to select those genotypes combining high yield potential in high-yielding environments with the capacity to respond well in low-yielding, droughty environments.

- Two years of research designed to identify lines suitable for tropical conditions have been completed. Capacity for high yield under elevated temperatures, coupled with earliness and resistance to *Helminthosporium* spp. and leaf rust, should result in lines adapted to this environment. Considerable progress has been made toward this goal.

- Also in the next three years, it is likely that resistance to *Septoria tritici* and the slow rusting type of resistance to leaf rust will be incorporated into most of our advanced lines.

- Studies on biomass, harvest index, and yield potential may help to find materials for new crosses that could result in further advances in yield. In a comparison of 13 varieties and advanced lines with respect to biomass, yield, harvest index, days to maturity and plant height, it was found that biomass did not necessarily correlate with harvest index, but did correlate positively with yield (Table 10). This suggests that further yield gains can be achieved through manipulation of these traits.

High levels of salt in the soil cause damage to wheat in many parts of the world, as seen here near Lahore, Pakistan.

- Leaf area index and leaf duration are other physiological characters to be investigated for genetic manipulation. Incorporation of genes for a mid-level vernalization requirement in CIMMYT's widely adapted spring wheats should further increase the yield potential of these varieties in spring wheat-growing areas such as the Mediterranean Basin.
- Screening of advanced lines for salt tolerance will continue, both in the laboratory and in the field near Mexicali, Mexico. In addition, durum wheats will be crossed with bread wheats in an effort to transfer the Karnal bunt resistance of durums to bread wheat.

Table 1. Advanced lines of bread wheat yielding equal to or better than Ures 81 at CIANO in 1982-83

Cross and pedigree	Yield (kg/ha)	Yield (°/o of Ures 81*)
TTR"S"/BOW"S" CM58857-2M-1Y-1M-2Y-0M	6869	110
KVZ/3/TOB/CTFN//BB/4/BLO"S" CM33028-I-1M-3Y-1M-1Y-2Y-0M	6891	109
BB/NOR//CN067/7C/4/GLL/AUST II61.157//CN067/NO/3/PVN"S" CM56615-8Y-2Y-2M-3Y-0M	6439	107
TI/TOB//ALD"S" CM33217-Q-4M-1Y-0M-136B-0Y	6639	106
BUC"S"/PVN"S" CM52359-2M-3Y-1Y-2M-1Y-0M	6276	106
FLN/ACC//ANA SWM4578-56M-3Y-3M-2Y-1M	6922	106
SAP"S"/MON"S" CM40392-17M-1Y-0M-101M-0Y	6578	105
LIRA"S" CM43903-H-4Y-1M-1Y-3M-2Y-0B	6650	104
PVN"S"/SIS"S" CM49894-37Y-3Y-4M-3Y-1M-3Y-0M	5944	104
PAT 10/ALD"S"//PAT72300/3/PVN"S" CM49922-1M-2Y-1M-3Y-0M	5739	104
BUC"S"/FLK"S" CM50070-24Y-1M-2Y-0M	6811	104
KEA"S"/BUC"S" CM67354-11Y-1M-3Y-0M	6352	104
HORK"S"/YMH//CAL/BB CM38212-I-7Y-2M-1Y-3M-2Y-0M	6811	103
ALD"S"/4/BB/GLL//CNO67/7C/3/KVZ/TI CM53450-3Y-2Y-2M-1Y-0M	6117	103
BNQ"S"/HORK"S"//PVN"S"/MN72156 CM57988-D-3Y-3Y-2M-1Y-0M	6180	103
KEA"S"/BUC"S" CM67354-14Y-2M-3Y-0M	6282	103
MYNA"S" SWM4589-7Y-18M-1Y-0M-56B-0Y	6748	103
F3.71/TRM SWM5704-10Y-1M-3Y-1M-1Y-0B	6244	103
ANA/HUAC"S"/4/65.116//MCD/ CAMA/3/NAC CM57206-P-1Y-2Y-1M-3Y-0M	6061	101
ALD"S"/PVN"S" CM49901-15Y-2Y-3M-3Y-1M-1Y-0M	6761	100
BUC"S"/PVN"S" CM58766-18Y-3M-5Y-2M-0Y	6922	100
KEA"S"/TOW"S" CM58975-2Y-3M-1Y-3M-2Y-0M	7017	100
MON"S"/IMU CM61942-5Y-1M-1Y-1M-0Y	6976	100
MON"S"/3/KAL/BB//ALD"S" CM62133-4Y-1M-2Y-1M-0Y	6556	100
ND/VG9144//KAL/BB/3/YACO"S" CM62661-D-1M-1Y-4M-1Y-0M	6737	100

* Percent of Ures 81 for the respective yield trial

Table 2. Yield of some varieties grown under optimal and suboptimal conditions* at CIANO in 1982-83

Name of variety or line	Optimal conditions Yield (kg/ha)	Rank	Suboptimal conditions Yield (kg/ha)	Rank
NACOZARI 76	6883	1	4611	14
GLENNSON 81	6835	2	4874	10
TORIM 73	6772	3	4515	17
HAHN"S" CM33682-L-1Y-1Y-4M-4Y-100B-502Y-0M	6691	4	5169	6
PAVON 76	6606	5	5117	8
VEE 8 CM33027-F-12M-1Y-1M-1Y-1M-0Y	6589	6	5722	1
YECORA 70	6565	7	4122	18
CIANO 79	6487	8	5163	7
GENARO 81	6459	9	5648	2
SIETE CERROS	6439	10	4850	11
TONICHI 81	6306	11	5272	4
ZARAGOZA 75	6156	12	4933	9
JUPATECO 73	6109	13	5198	5
INIA 66	6098	14	4519	16
URES 81	6080	15	5630	3
PITIC 62	5987	16	4759	12
PENJAMO 62	5976	17	4543	15
SONORA 64	5813	18	3611	19
BOW"S" CM33203-K-9M-24Y-1M-1Y-1M-1Y-0M	5761	19	4713	13
L.S.D.	926		875	
C.V.	9%		10%	
S.D.	542		512	

* Optimal conditions: 5 irrigations and 150 kg of nitrogen and 80 kg of phosphorus per hectare.
Suboptimal conditions: 2 irrigations and 50 kg of nitrogen and 40 kg of phosphorus per hectare.
Both treatments received and additional 171 mm of rainfall.

Table 3. Bread wheat varieties released since 1980 from CIMMYT-developed germplasm

Variety name	Cross and pedigree	Released Year	Released Country
PAVAO	BB/CAL II30877-62M-3Y-1M-2Y-0M	1982	Brazil
SALAMBO 80	PATO//CC/INIA CM1021-14BJ-4BJ	1980	Tunisia
CHASQUI INIA	CC/INIA//TOB/8156/3/CNO67 CM4264-23Y-2M-0Y	1982	Chile
HUEQUEN INIA	TZPP/PL//7C=BJY=NAC76 CM5287-J-1Y-2M-2Y-3M-0Y	1982	Chile
TANIT 80	TZPP/PL//7C=BJY=NAC76 CM5287-J-1Y-2M-2Y-3M-0Y	1980	Tunisia
GAVILAN	VCM//CNO"S"/7C/3/KAL/ BB=PVN76 CM8399-D-4M-3Y-1M-1Y-1M-0Y	1982	Peru
TOTORA IBTA 80	PVN76	1981	Bolivia
VICTORIA	PVN76"S" CM8399-D-4M-3Y-0M	1982	Chile
PILANCHU IBTA 80	PVN76"S" CM8399-D-4M-3Y-1M-0M(1-14)	1981	Bolivia
HARTOG	PVN76"S" CM8399-D-4M-4Y-2M-2Y-0M	1983	Australia
SHAM 2	7C//TOB/CNO"S"/3/KAL CM8865-D-4M-1Y-1M-2Y-0M	1983	Syria
HUASTECO M81	HOP/RON//KAL=HORK"S" CM8874-K-1M-1Y-1M-1Y-0M	1981	Mexico
VOGA	NAPO/CAL//ZBZ CM8935-D-5M-3Y-3M-2Y-0M	1982	Portugal
MAHONE F81	TOB/BMAN//BB/3/CDL/4/ SX=NIP"S" CM8972-9M-1M-1Y-0M(1-53B)	1981	Mexico

Table 3. (Cont'd)

Variety name	Cross and pedigree	Released Year	Country
MULEGE F81	NIP"S" CM8972-9M-1M-5Y-0M	1981	Mexico
ALONDRA 4546(ML)	D6301/NAI60//WRM/3/CNO*2/ CHR=ALD"S" CM11683	1980	Brazil
ICA SUSATA	ALD"S" CM11683	1982	Columbia
KLEIN ATALAYA	NO/BB//CC/WE CM12263	1981	Argentina
ALMANSOR	E4870/C306//M5892/666.5/3/ BB//CAL/INIA CM22099	1982	Portugal
KLEIN CARTUCHO	JUP/3/PJ/WRT//CAL CM28224	1982	Argentina
TUCUMAN	CAL/3/BB/5/KLPE/RAF//PJ/3/ CNO/4/NP876/BB CM28224	1982	Argentina
CRISTINA	BUCKY/MAYA"S"/4/BB/ HD832.5.5/ON/3/CNO/PJ CM31678-R-4Y-2M-21Y-0M	1983	Peru
GLENNSON M81	KVZ/BUHO"S"//KAL/BB=VEE 1 CM33027-F-8M-1Y-8M-1Y-2M-0Y	1981	Mexico
URES T81	VEE 2 CM33027-F-12M-1Y-4M-2Y-2M-0Y	1981	Mexico
GENARO F81	VEE 3 CM33027-F-12M-1Y-6M-0Y	1981	Mexico
CORDILLERA	VEE 3	1982	Paraguay
GAMTOOS	VEE 3	1983	S. Africa
LIMA 1	VEE 3	1982	Portugal
MILLALEAU INIA	VEE 3	1982	Chile
SERIC	VEE 4 CM33027-F-15M-500Y-0M	1983	Zambia

Table 3. (Cont'd)

Variety name	Cross and pedigree	Released Year	Released Country
VIRI	VEE 5	1983	Tanzania
PAKISTAN 81	VEE 5 "S" CM33027-F-15M-500Y-0M	1981	Pakistan
SERI 82	VEE 5 "S" CM33027-F-15M-500Y-0M-87B-0Y	1982	Mexico
LOERI	VEE 5 "S" CM33027	1982	Zambia
GUASAVE F81	KVZ//KAL/BB/3/BON CM33202-E-1M-2Y-0M	1981	Mexico
SARHAD 83	AU//KAL/BB/3/WOP"S"=BOW"S" CM33203	1983	Pakistan
VICTORIA M81	YR RESEL(B)/TRF"S"//RSK/ TRM=VUL"S" CM36064-A-1M-5Y-0M	1981	Mexico
SONOITA F81	TRM//KAL/BB=MOR"S" CM37130-15Y-1M-3Y-0M	1981	Mexico
ICTA SARA 82	TAST/4/TP//CNO/NO/3/ CNO"S"/7C/5/JUP CM38089-G-1Y-4M-1Y-3M-1Y-0M	1982	Guatemala
TONICHI S81	CAR 422/ANA SWM4610-2Y-20M-1Y-0M	1981	Mexico

Table 4. Comparison of spring wheat lines with resistance to *Septoria tritici* at Toluca in 1983.

Name and cross	Septoria score[1] Fl. lf[2]	Septoria score[1] Milk[3]	Maturity (days)	Height (cm)
BOBWHITE"S" CM33203-K-9M-9Y-4M-4Y-1M-0Y	18	44	142	90
ICTA SARA 82 CM38088-G-1Y-4M-1Y-3M-1Y-0M	23	43	142	100
GOV/AZ//MUS"S" CM41257-I-8M-3Y-1M-1Y-2M-1Y-0B	24	55	140	95

Table 4. (Cont'd)

Name and cross	Septoria score[1] Fl. lf[2]	Milk[3]	Maturity (days)	Height (cm)
MRNG/ALDAN"S" CM46961-12M-1Y-1M-4Y-1PTZ-0Y	23	56	134	95
PF 70354/MUS"S" CM47091-7M-1Y-3F-1Y-0Y	24	54	133	95
ALD"S"/PVN"S" CM49901-14Y-2Y-7M-1Y-0M	43	55	137	105
ALD"S"/MN72130 CM50361-8Y-3M-1Y-4Y-1M-0Y-0PTZ	23	54	140	85
IAS58/4/KAL/BB//CJ"S"/3/ALD"S" CM50464-12Y-6F-2Y-7M-2Y-0Z-0Y	22	53	140	100
ALD"S"/AZ CM51821-3Y-1Y-3M-4Y-0M	33	53	132	90
CEP 80111 CM55517-B-1F-703Y-4F-0Y-0A-0Y	22	55	133	100
CANASTERO"S" CM58446-A-1Y-3Y-3M-1Y-0M	13	52	140	100
H567.71/3*P.ATR CMH77.308-1Y-4B-1Y-5B-1Y-3B-0Y-2PTZ-0Y	22	54	130	90
P.ATR*2/H567.71 CMH78.421-3Y-3B-1Y-1B-0Y-1PTZ-0Y	27	56	134	85
PF 71131	18	45	133	130
THORNBIRD"S" F11915-A-502M-1Y-3F-701F-4F-0Y	25	53	128	100
MY54/3/N10B/Y50//K.LINE/4/CD/5/CJ"S"/6/PAT49 B13981-H-1Z-1A-1A-0A-2PTZ-0Y	32	45	142	105

1. First digit indicates disease intensity on the Saari and Prescott 0-9 scale (0 = no infection); second digit indicates disease severity on a 0-9 scale.
2. Flag leaf stage (Zadoks growth stage 39).
3. Late milk-early dough stage (Zadoks 77-83).

Table 5. Comparison of the highest-yielding advanced lines of bread wheat with Tesia 79 under heavy pressure from septoria, stripe rust, leaf rust, fusarium, and bacteria at Toluca in 1983.

Cross and pedigree	Yield (kg/ha)	Yield (% of Tesia 79)
TAN"S"/PEW"S" CM64642-5Y-1M-1Y-2M-0Y	6768	166
TAN"S"/IMU CM64636-3M-1Y-4M-1Y-1M-0Y	6252	154
VEE"S"/TSI CM58943-4Y-1M-4Y-3M-1Y-1M-0Y	6041	149
F35.70/MO//NAC CM43367-E-3Y-1M-3Y-4M-1Y-0B	6016	148
ANA/MAYA//TAN"S" CM60350-D-5Y-1M-4Y-3M-1Y-1M-0Y	5895	145
LOV23/BJY"S"/3/BB/NOR//CNO"S"/7C CM60338-H-1Y-1M-3Y-3M-2Y-1M-0Y	5860	144
LOV23/BJY"S"/3/BB/NOR//CNO"S"/7C CM60338-H-1Y-1M-3Y-3M-3Y-1M-0Y	5809	143
LOV23/BJY"S"/3/BB/NOR//CNO"S"/7C CM60338-H-1Y-1M-3Y-3M-5Y-1M-0Y	5739	141
LOV23/BJY"S"/3/BB/NOR//CNO"S"/7C CM60338-H-1Y-1M-4Y-1M-2Y-1M-0Y	5725	141
GJO"S"/PVN"S"//ALDAN"S"/FLK"S" CM60456-A-1Y-1M-1Y-1M-1Y-2M-0Y	5730	141
SPRW"S"/PVN"S"//VEE"S" CM64491-6Y-1M-5Y-1M-0Y	5728	141
MON"S"/VEE"S" CM64241-3M-1Y-2M-1Y-2M-0Y	5690	140
GJO"S"/PVN"S"//ALDAN"S"/FLK"S" CM60456-A-1Y-1M-1Y-1M-1Y-3M-0Y	5633	138
KEA"S"/TOW"S" CM58975-2Y-3M-1Y-12M-3Y-1M-0Y	5574	137
CAL/CHKW//PEW"S"/3/ALDAN"S" CM60179-AA-3Y-1M-1Y-2M-1Y-1M-0Y	5557	137
F35.70/M0//NAC CM43367-E-3Y-1M-3Y-6M-1Y-2M-0Y	5553	137
LOV23/BJY"S"/3/BB/NOR//CNO"S"/7C CM60338-H-1Y-1M-3Y-3M-2Y-2M-0Y	5571	137

Table 6. Performance of the best advanced lines of bread wheat grown under reduced moisture (two irrigations) at CIANO in 1982-83 and rainfed conditions at El Batan in 1983.

Name and pedigree	Yield at CIANO (kg/ha)	Yield at CIANO (°/o of Ures 81)	Yield at El Batan (kg/ha)	Yield at El Batan (°/o of Genaro 81)
VEE"S" CM33027-F-15M-4Y-4M-3Y-2M-1Y-0M	5976	118	5480	119
TYRANT"S" CM40610-25Y-3M-3Y-1M-2Y-0B	5672	118	5113	111
VEE"S" CM33027-F-12M-1Y-12M-1Y-2M-0Y	5835	115	4707	102
VEE"S" CM33027-F-15M-500Y-0M-75B-0Y	5806	115	5360	116
FLYCATCHER"S" CM43598-II-8Y-1M-5Y-2M-2Y-0B	5335	111	5447	118
MAYA/MON"S"//KVZ/TRM CM44083-N-2Y-2M-1Y-1M-1Y-1M-0Y	5333	110	6133	133
VEE"S" CM33027-F-15M-500Y-0M-98B-0Y	5430	107	5533	120
PAT10/ALD"S"//PAT72300/3/PVN"S" CM49922-1M-2Y-1Y-1M-3Y-0M	5739	104	4280	94
TAN"S" CM30697-2M-8Y-7M-1Y-1B-0Y	5220	103	5147	112
VEE"S" CM33027-F-15M-500Y-0M-66B-0Y	5198	103	5567	121
BB/ON//CN067"S"/N0/3/PVN"S" CM46718-28M-1Y-1M-3Y-0M	5446	101	4973	108
AZ//CHR/DD.05P/3/F12.71/BLO"S" CM48326-A-3M-1Y-1M-2Y-1Y-0M	5437	101	5013	109

Table 7. Spring wheat lines with acceptable *Helminthosporium sativum* resistance at Poza Rica in 1982-83.

Name and pedigree	*H. sativum* score*	Number and pedigree	*H. sativum* score*
JUP/ALD"S" CM36867-18Y-17M-3Y-0M-1PTZ-0Y	4	ND/VG9144//KAL/BB/3/YACO"S" CM62661-D-1M-1Y-4M-1Y-0M	4
BON/YR/3/F35.70//KAL/BB CM41860-A-5M-2Y-3M-1Y-1M-1Y-0B-0PTZ	4	KEA"S"/4/KAL/BB//CJ"S"/3/ALD"S" CM64617-8Y-1M-1Y-0M	4
JUP/MUS"S"/4/CNO"S"/7C//CNO67/INIA/3/TOB CM43601-K-3Y-3M-6Y-5M-0Y	4	KEA"S"/4/KAL/BB//CJ"S"/3/ALD"S" CM64617-14Y-1M-6Y-0M	4
MAD"S"/BJY"S" CM49640-3M-1Y-1Y-3M-1Y-1M-0Y	3	KVZ/HD2009 SWM2894-1M-1Y-1M-2Y-0M-0MM	4
MON"S"/MN72131 CM52721-4Y-2Y-6M-1Y-1M-0Y	4	PF69129	3
ALD"S"/MAD"S"//ALDAN"S"/PF70354 CM58253-H-1Y-1Y-2M-2Y-1M-2Y-0M	4	PF71131	3
BOW"S"/NAC CM61755-10Y-5M-1Y-1M-0Y	4	PF7339	4
MON"S"/3/KAL/BB//ALD"S" CM62133-4Y-1M-2Y-1M-0Y	4	BH1146 (Resistant check)	5
		SERI 82 (Susceptible check)	9

* 0-9 scale, 0 = no infection.

Table 8. Comparison of high-yielding, aluminum-tolerant lines of bread wheat at Toluca in 1983.

Name and pedigree	Yield (kg/ha)	Yield (0/o of Tesia 79)
PF7619/DOVE"S"//CEP7670 B25813-A-1M-1Y-1M-6Y-2M-0Y	5166	145
PF7619/DOVE"S"//CEP7670 B25813-A-1M-1Y-1M-3Y-3M-0Y	4989	140
PF7619-DOVE"S"//CEP7670 B25813-A-1M-1Y-1M-3Y-1M-0Y	4890	138
PF7619/DOVE"S"//CEP7670 B25813-A-1M-1Y-4M-1Y-2M-0Y	4816	136
PF7619/DOVE"S"//CEP7670 B25813-A-1M-1Y-3M-1Y-1M-0Y	4779	135
PF7619/DOVE"S"//CEP7670 B25813-A-1M-1Y-1M-2Y-4M-0Y	4713	133
PF7619/DOVE"S"//CEP7670 B25813-A-1M-1Y-3M-3Y-1M-0Y	4695	132

Table 9. Bread wheat lines showing the slow rusting characteristic for leaf rust for the past five years at CIANO.

Name and pedigree	Name and pedigree
KATHADIN"S" CM5484-F-5Y-4M-3Y-3M-1Y-0M	TZPP//IRN46/CN067/3/CHR/4/EMU"S" CM42384-9M-1Y-2M-4Y-0M
MONCHO"S" CM8288-A-3M-6Y-5M-1Y-0M	HD1944/CAL//TRM CM46250-2M-1Y-4M-2Y-0Y-3PTZ-0Y
PAVON"S" CM8399-D-4M-3Y-1M-0Y(1-126B)-0Y	PVN"S"//MN691465/MN691015 CM46690-35Y-5M-2Y-1Y-2M-0Y
TANAGER"S" CM30697	PJ/CAL//EMU"S" CM49852-10Y-1M-1Y-1Y-2M-1Y-0M
VEERY"S" CM33027	ALD"S"/PVN"S" CM49901-9Y-1Y-1M-3Y-0M
KINGLET"S" CM33089-W-3M-7Y-3Y-0M	4777*2//FKN/GB/3/PVN"S" CM49912-37M-4Y-4Y-1M-1Y-0M
SWIFT"S" CM33232-C-5M-1Y-10M-0Y	CN067"S"/SON64//CN067"S"/INIA"S"/3/PVN CM49918-3M-3Y-1Y-1M-5Y-0M
JUNCO"S" CM33483-C-7M-1Y-0M-5B-0Y	BJY"S"/PRT CM50323-12Y-1M-1Y-0Y
MINIVET"S" CM37705-G-2Y-3M-1Y-0M-47Y-0M	MON"S"/TOW"S" CM56723-2Y-1Y-4M-2Y-0M
PFAU"S" CM38212-I-7Y-2M-1Y-3M-1Y-0M	SPINETAIL"S" CM58478-B-2Y-1Y-1M-1Y-0M
YD"S"//KAL/BB/3/HORK"S"/MO CM38558-A-7Y-14M-2Y-0M	PF70354/VEE"S" CM65063-3Y-0Z-0Y
MAYA/NAC76 CM39424-10M-3Y-2M-1Y-2M-1Y-0B	CAR422/ANA SWM4601-2Y-20M-1Y-0M71B-0Y
TYRANT"S" CM40610-25Y-4M-1Y-1M-1Y-0B	F3.71/TRM SWM5704-10Y-1M-3Y-1M-1Y-0B
BAYA"S" CM42374-1Y-1M-2Y-2M-1Y-0B	

Table 10. Biomass, yield, harvest index, maturity and plant height of certain wheat varieties and advanced lines at CIANO in 1982-83.

Variety or advanced line	Biomass (ton/ha)*	Yield (kg/ha)**	Harvest index	Maturity (days)	Height (cm)
CASTAN	14.73	6104	0.41	126	100
CIANO 79	14.50	6469	0.45	126	85
URES 81	14.33	6565	0.46	126	90
MARCOS JUAREZ INTA	14.17	4850	0.34	120	95
TYRANT"S" CM40610-25Y-4M-1Y-1M-1Y-0B	13.87	5935	0.43	123	100
VEE 8 CM33027-F-12M-1Y-1M-1Y-1M-0Y	13.87	6689	0.48	123	85
GLENNSON 81	13.80	6317	0.46	123	90
GENARO 81	13.57	6724	0.50	123	90
NACOZARI 76	13.40	5969	0.44	122	90
SIETE CERROS	13.07	5570	0.43	121	90
PAVON 76	12.37	5767	0.47	121	95
ANZA	12.30	5491	0.45	122	85
VEE 5 "S" CM33027-F-15M-500Y-0M-87B-0Y	11.83	5994	0.51	121	85

* L.S.D. (5%) = 1.59 ton/ha; C.V. = 8.13%
** L.S.D. (5%) = 570 kg/ha; C.V. = 7%

Durum Wheat

P. Brajcich G., G. Vázquez G., and W.H. Pfeiffer

Introduction

The importance of durum wheat (*Triticum turgidum*, $2n=28$) as a major foodstuff for the countries of sub-Saharan and East Africa, the Middle and Near East, the Indian subcontinent and the Andean region is well known. Durum wheat is also recognized as a major crop in Canada, the USA, Argentina, Chile and Southern and Eastern Europe.

Worldwide, the area planted with durum wheat covers approximately 30 million hectares, with about 11 million hectares in developing countries. Production of only about 10 million metric tons in the Third World countries, principally the rainfed production areas of North Africa, the Middle East, Argentina and Chile, clearly reflects a low average yield. That these yields are not intrinsic to the crop, which is considered well adapted to dry areas, is shown by yields of up to 12 tons per hectare in certain international trials and up to 10 tons per hectare in farmers' fields in the Yaqui Valley in the Mexican state of Sonora. Indeed, under irrigated, high-input conditions with good management, CIMMYT's best durum wheats can produce as much or more than the Center's best bread wheats. Consequently, it appears that the low yields in the developing world are due to environmental conditions (especially moisture stress), poor management, and the use of varieties susceptible to one or more diseases.

Another factor, distinct from productivity per se, which must be considered in improving durum wheat is its dual economic role. In developing countries it is used mainly for local, wheat-based products, such as the flat, unleavened chapatis in India, cuscous in the Middle East and North Africa, bulgur in Turkey and mote in the Andean countries. In the developed countries, durum wheat is primarily an industrial crop used for semolina products, and consequently must meet high quality standards with respect to gluten strength along with protein and carotene content.

History of the program—The CIMMYT durum wheat program has come a long way from when it was initiated. In the beginning the major objectives were to introduce dwarfing genes, to eliminate day-length sensitivity (especially in materials from the USA and Canada), to overcome sterility and to incorporate disease resistance. The historic series from Barrigon Yaqui (the first modern variety planted in Mexico), to Oviachic 65 [the first durum wheat carrying dwarfing genes (Rht1) from Norin 10], to the widely adapted and distributed varieties, such as Jori 69, Cocorit 71, Mexicali 75 and Yavaros 79, demonstrates not only steady improvement in terms of yield potential, agronomic type and disease resistance, but also successful breeding for wider adaptation and better quality. A measure of the program's success is that to date 48 durum wheat varieties carrying CIMMYT-developed germplasm have been released by 15 countries around the world.

Current Objectives

Although steady progress has been made, so much so that the best durum wheats are now competitive with high-yielding bread wheats under good management, there is still considerable room for improvement. The need is for a combination of disease resistance and good agronomic type in high-yielding, widely adapted varieties. Thus, the CIMMYT breeding program is oriented toward the improvement of yield potential, adaptation, disease resistance and such agronomic characteristics as grain quality, earliness, cold tolerance, resistance to lodging and better head type. Special emphasis is being placed on better resistance to stem rust, septoria and

Dr. P. Brajcich (left) and Dr. G. Vázquez (right) of the durum wheat breeding program.

fusarium, characteristics that need further improvement since the incidence of these diseases is still high in many durum wheat production areas.

Building up the Germplasm Pool

The main source of new crosses is still the spring crossing block (CB). As Table 1 shows, the spring CB is made up of 25 different groups of lines, each line being outstanding for its group characteristic. In contrast to the spring CB, the 107 lines of the winter CB are arranged by country. Materials from Austria, Bulgaria, Germany, Great Britain, France, Italy, Morocco, Peru, Rumania, the Soviet Union, Yugoslavia, and especially Turkey are used to improve quality, cold and drought tolerance and resistance to stripe rust, septoria, fusarium and powdery mildew. It should be mentioned that the winter CB can be grown at the Toluca Experiment Station, in central Mexico, under natural conditions, whereas at the Yaqui Valley Agricultural Experiment Station (CIANO), near Ciudad Obregon in northwestern Mexico, artificial vernalization in the greenhouse, transplanting and supplemental light in the field nursery are necessary.

To produce additional lines with specific characteristics (e.g. high yield potential or resistance to specific diseases) or to develop these characteristics to a greater degree, a total of 3731 single crosses, 2978 top crosses and 270 spring x winter durum wheat crosses were made in the 1983 growing season at the CIANO, El Batan and Toluca experiment stations. In addition to these 6979 crosses, 100 interspecific crosses between bread wheat and durum wheat were made for the purpose of improving resistance to septoria and fusarium and tolerance to high levels of free aluminum. For the latter purpose, progenitors from Brazil and aluminium-tolerant lines from the bread wheat program were used.

In a move toward greater efficiency, the number of crosses was reduced; only the F_1 reserve (the F_1s that exhibited good performance during the previous cycle) were crossed. Generally, six heads were used for each single cross and ten for each top cross.

Selection and Evaluation

The breeding and testing sites in Mexico used by CIMMYT provide a broad spectrum of conditions under which selection and evaluation of segregating material and advanced lines can be carried out efficiently. Of the seven sites listed in Table 2, the most important are the CIANO station, where yield potential can be evaluated under irrigated, high-input conditions, and the El Batan and Toluca stations, where conditions are usually favorable for disease resistance screening.

To supplement the information obtained in Mexico, the durum wheat program also sends seed of segregating material and advanced lines to other countries around the world for evaluation. In 1983, 354 nurseries were sent to 59 countries where they were grown under a variety of environmental conditions (Table 3).

A large quantity of segregating materials was evaluated in the 1983 cycle. Table 4 presents data on the number of plants selected in different generations and the selection pressure placed on lines by grading the seed quality of individual plants. Of 85,723 individual plants harvested, only 21.4 percent (18,374 plants) were finally selected and planted.

The testing of promising advanced lines for yield potential is done primarily at the CIANO station, using a randomized block design with three replications. Commercial varieties of bread wheat, durum wheat and triticale are included as checks. In addition, all advanced lines are grown in small multiplication plots (PCs) to produce seed for the international nurseries.

The classical pedigree breeding method still meets the needs of the durum wheat program. Reserve seed of outstanding segregating lines and populations is planted again in the following cycle to improve selection efficiency and to avoid loosing variability due to increasing homozygosity.

Yield Performance

Considerable progress has been made in improving yield potential since the release of Yavaros 79 (Karim 79 in Tunisia, Helvio in Portugal and Nuno in Spain) in Mexico in 1979. Since this variety is the most recently released, it is considered to be the most appropriate reference point for measuring progress in yield potential, and was used as the check variety in all yield trials in Mexico in 1983.

Table 5 presents the data for the 25 promising durum wheat lines that were selected for inclusion in the 15th International Durum Screening Nursery (IDSN). These lines were selected for yield potential at the CIANO station and for disease resistance at CIANO, el Batan, and Toluca. All have yields one standard deviation or more above their respective trial means and at last ten percent above that of Yavaros 79. Exceptionally high yields, both in absolute terms (above 8 tons per hectare) and in comparison with the check variety, were observed in Carcomun"S", Dack "S"-Teal"S" x Mal"S" and Yav"S"-Snipe"S" x Coli"S". In addition, the 12 top-yielding lines in this table produced an average of 23 percent more than Yavaros 79 (range: 17 to 38 percent).

These superior yields are not restricted to the lines in Table 5. Twenty-eight additional lines also met the yield criteria mentioned above, and 140 of the advanced lines that were included in the PCs had an average yield of 6962 kilograms per hectare (Table 6).

These data demonstrate a significant general improvement in yield potential. This is especially important because improving yield is one of the highest priorities of the CIMMYT durum wheat program.

Results from the international nurseries were also encouraging. Under irrigated, well-managed conditions, yields of up to 11.6 tons per hectare and 12.1 tons per hectare were obtained in the 11th Elite Durum Yield Trials (EDYT) and the 13th International Durum Yield Trials (IDYT), respectively (Table 7). Under rainfed conditions, with lower fertility levels, yields were also satisfactory (Table 8). The cross Erpel"S"-Ruso"S" produced 69 percent more than the local check with low rainfall (210 mm) at Laxia, Cypress. Under these rainfed conditions, these outstanding lines displayed an average superiority of 30 percent over the local check varieties.

These data indicate the degree of plasticity in these advanced lines. It is significant that despite their having been selected under high-input conditions, they performed better than the local checks under conditions of low rainfall and fertility.

Yield components—One reason for this plasticity is the nature of the yield components in durum wheat. Both 1000-kernel weight and test weight are at very high levels, as is documented in Tables 6 and 9. The average 1000-kernel weight of 140 high-yielding lines was 56.7 grams, and in the case of the line Rok"S"-Snipe"S" x Sco"S", it was as high as 77.9 grams. The average test weight for these same lines was 82.9 grams. The high levels of both components suggests the possibility that high yields are being maintained under stressful conditions by compensation between the components. Since yield components are fixed at different stages of plant development, expression of only one component to its maximum leads to high yields even when the others are maintained at average levels because of unfavorable conditions.

Other yield components are also showing improvement. Head fertility is now high, with three to four kernels per spikelet and up to 30 spikelets per head, which results in more than 100 kernels per head. With the selection for high tillering capacity in all segregating generations, a high number of heads per square meter has been reached.

Further improvement in yield may well be possible by manipulation of the yield components. Crossing materials should be selected on the basis of maximum values for yield, test weight, 1000-kernel weight and fertility. Ultimately, all these characteristics should be incorporated into lines with lax or semilax, large spikes.

Disease Resistance

Artificial inoculation of leaf and stem rusts resulted in good epidemics at the CIANO and El Batan stations. At Toluca good levels of infection with septoria, fusarium, leaf rust and barley yellow dwarf virus (BYDV) occurred. At El Batan and Toluca, stripe rust was not present. To compensate for these irregularities in disease incidence, artificial innoculation should be used more in the future.

The increasing number of lines showing satisfactory resistance indicates an improvement in disease resistance in durum wheat. This is especially notable in Toluca where in the past only three parental lines (Huitle, Ruffous and Pochard) could be found which produced uninfected seed. In the 1983 cycle, under a high incidence of scab and septoria, several crosses were found with healthy grain (Table 10). After further testing, these apparently resistant lines will be used heavily in new crosses.

The dense, compact spike of the durum wheats favors the growth of septoria and scab. Consequently, selecting for types with lax spikes, long necks and reduced foliage should result in further improvement in resistance. Other sources of resistance may be found in germplasm from the Mediterranean coast. Another promising approach is attempting to incorporate into durum wheat the translocated 1B/1R chromosome which is found in some bread wheats (e.g., the Veerys, Bobwhites and Alondras).

Special emphasis is being put on improving resistance to stem rust. Aggressive races of stem rust occur in Ethiopia, one of the centers of origin of durum wheat, so all lines showing a good level of resistance at Debre Zeit, Ethiopia, are heavily used in crosses. In order to advance this part of the durum program, plans are being made to start a cooperative program with Dr. Tesfaya Tesemma, in which resistant parents and segregating populations will be exchanged. The objective is to incorporate genes for resistance from Ethiopia and Mexico into lines with a good agronomic type, high yield potential and wide adaptation.

Disease data from the international nurseries reported in previous years and from the 11th EDYT, 13th IDYT and 13th IDSN still show high coefficients of infection for stem rust, *Septoria tritici*, *Septoria nodorum*, powdery mildew and BYDV. These diseases will be the subjects of special emphasis in the future.

Various investigators have contributed to the CIMMYT durum wheat program by sending special resistant materials or by publishing the results of their own research. These include Dr. Z. Eyal, of Israel, and Dr. A. Mahmouri, of Tunisia, who sent lines resistant to *Septoria tritici*; Drs. G. Varughese and S. Fuentes, who sent promising lines from Portugal; Dr. M. Kholi, of Chile, who sent new material with good resistance to stem and leaf rusts, and to fusarium; and Dr. C. Qualset, of Davis, California, USA, and Dr. A. Comeau, of Canada, who published reports on resistance to BYDV.

Earliness

Cooperators often express the opinion that durum wheat should mature earlier to allow the crop to fit better into crop rotations, to escape diseases and to avoid drought stress and frost damage at the end of the season.

Consequently, earliness is one of the most important characters selected, and a large number of crosses is made for this purpose.

Table 11 shows a number of lines with both higher yields than Mexicali 75 and at least two days' earlier maturity. These data indicate that selection for earliness is effective in durum wheat, and that yields can be maintained at a high level or even increased.

Drought tolerance

At the CIANO station three yield trials were conducted under reduced irrigation. A postseeding irrigation (equivalent to approximately 100 mm of rain) and 177 mm of rainfall were the total water input. Table 12 presents six advanced lines that produced more than the checks, Yavaros 79 and Mexicali 75, under these conditions. That drought stress existed is demonstrated by the low yields of the two checks. These trials show that genes for drought tolerance have not been lost in the advanced lines, despite their having been selected under full irrigation.

Agronomic Type

Due to the two distinct economic roles of durum wheat, both semidwarf and medium-tall to tall lines are maintained. The former are better suited for the favorable growing conditions in areas where durum wheat is used for commercially processed products; the latter are better for low-input conditions and marginal areas, where it is grown primarily for local consumption.

In both plant types, selection continues for the following agronomic characteristics:

- Long heads with widely spaced spikelets to help reduce the incidence of head-rotting diseases
- Reduced foliage, smaller leaves, stiff straw, long neck, closed crown and synchronous tillering
- Solid stems to eliminate sawfly damage
- Cold tolerance
- Early and short grain-filling period

Quality

Grain quality in durum wheat is becoming increasingly important in developing countries. The CIMMYT durum wheat program is responding to this as shown by Tables 6 and 13, which document the quality level attained. This has been achieved by applying heavy selection pressure, as shown in Table 4: an average of 78.6 percent of the plants harvested are discarded on the basis of grain quality factors, such as appearance, type, color, plumpness, and the presence of yellow berry and black point. In addition, the seed of all F_3 and F_4 plants selected at CIANO are analyzed for pigment content, and only those with a carotene content of 5 parts per million or more are retained for further selection. Progenitors and advanced lines are also evaluated for seed type, semolina yield, pigment content, gluten characteristics, protein content, and spaghetti processing qualities.

To improve quality, lines from Italy, the USA and Canada are included in the crossing blocks. Crosses with winter lines may also contribute to further progress in quality.

Protein levels of about 10 percent, as reported in Tables 6 and 13, are somewhat low. It is suspected that this is due to poor fertility conditions at CIANO in the 1983 cycle, when the nurseries had to be planted on sandy soils outside the station.

Medium-tall (left) and semidwarf (right) durum wheat lines. Both types are maintained in the CIMMYT breeding program.

Future of the Program

Further improvement of durum wheat should be possible by increasing yield potential and by maintaining these potentials in farmers' fields, i.e., stabilizing the yields of broadly adapted genotypes. To achieve this, aggressive use will be made of spring x winter crosses, interspecific crosses with bread wheat to transfer the 1B/1R translocation present in the Veery, Bobwhite and Alondra bread wheats, and materials from the germplasm improvement and wide crosses programs. In addition, crosses between durum wheat and triticale are being watched for useful durum phenotypes.

Crosses between durum wheats and *Triticum monococcum*, *T. dicoccoides*, *T. carthlicum* and *T. polonicum* also might give better drought tolerance, improved quality and higher yield. Some lines of these species have very high 1000-kernel weights, very long spikes and extremely high fertility. In addition, both better disease resistance and new sources of resistance seem to appear in crosses with *Aegilops* spp. and *Agropyron* spp. These interspecific crosses promise an influx of new genetic material which seems to have potential.

Some of these crosses are also expected to have better salt tolerance. This characteristic will be of increasing importance as durum wheat production moves onto more marginal land with high levels of salt and as the quality of irrigation water decreases. In 1984, screening for salt tolerance will be done both at the seedling stage in petri dishes and at later stages in the field at the Agricultural Experiment Station at Guaymas, in northwestern Mexico, where high salt levels in the soil and in the irrigation water are a severe production constraint.

The bulked, spring x winter F_2 and the mid-tall to tall segregating populations will be selected under reduced irrigation and low fertility conditions at the CIANO station. This will help to identify germplasm suitable for areas of low inputs and low rainfall. The resulting advanced lines will be tested for yield at the CIANO and El Batan stations and for drought tolerance in field experiments in the dry area around Huamantla, in central Mexico.

Individual plants maturing at the same time as or earlier than Mexicali 75 will be selected. After seed quality grading, selected plants and lines will be distributed in separate nurseries to help to satisfy the requirements of many cooperators.

Analysis of the data from the international durum wheat nurseries indicates that durum wheat has a higher yield potential than bread wheat and triticale under favorable soil fertility, but is not competitive at high elevations and under high humidity or when septoria, fusarium and stem rust cause serious yield reductions. Lines producing healthy seed at Toluca will be used in crosses to increase disease resistance by pyramiding genes for resistance.

In addition, breeding for resistance to leaf and stem rusts, septoria, fusarium, powdery mildew, BYDV and helminthosporium will continue. For the next season a shuttle breeding system with Ethiopia is planned. This will help to broaden the genetic base for resistance to stem rust and other diseases, such as septoria and BYD.

Interspecific crossing is the most promising approach for improving durum wheat's tolerance to low soil pH and high free aluminum levels. Consequently crosses are being made with tolerant bread wheats from Brazil and from the CIMMYT bread wheat program.

Table 1. Crossing Block 1983: Classification and number of lines within groups.

Group	Outstanding characteristic	Number of lines
I	Commercial varieties	37
II	High yield	27
III	Three rust resistance	11
IV	Stem rust resistance	10
V	Leaf rust resistance	12
VI	Stripe rust resistance	16
VII	Septoria resistance	27
VIII	Powdery mildew resistance	11
IX	Helminthoporium resistance	8
X	BYDV resistance	17
XI	Fusarium resistance	18
XII	Good quality	16
XIII	High pigment content	15
XIV	High protein content	11
XV	High test weight and 1000 - kernel weight	11
XVI	High 1000 - kernel weight	13
XVII	High test weight	20
XVIII	Solid stem	8
XIX	Good fertility	3
XX	Large spike	7
XXI	Reduced foliage	7
XXII	Stiff straw	4
XXIII	Earliness	13
XXIV	Drought tolerance	6
XXV	Dwarf mutants	4
	Total	332

Table 2. Mexican locations for disease screening in the 1982-83 season.

Locations	Elevation (m)	Latitude	Leaf rust	Stem rust	Stripe rust	Septoria	Fusarium	*Xanthomonas translucens*
CIANO	39	27°N	x	x				x
Los Mochis	40	26°N	x	x				
Rio Bravo	30	26°N	x	x				
El Batan	2249	19°N	x	x	x		x	x
Toluca	2640	19°N	x	x	x	x	x	x
Patzcuaro	2043	20°N				x	x	
El Refugio	1500	21°N						x

x = disease present

Table 3. Distribution of the CIMMYT international durum wheat nurseries in 1983-84.

Region	Number of countries	Number of nurseries								
		F_2 irrigated	F_2 dryland	F_2 cold tol.*	F_2 stem rust	15th IDYN	13th EDYT	15th IDSN	Crossing block	Total
Africa	12	4	8	4	6	11	6	19	5	63
Asia	11	0	4	3	0	3	4	12	6	32
Central America	1	0	0	0	0	0	0	1	1	2
Europe	12	7	11	17	3	12	14	15	8	87
Middle East	11	2	7	3	3	10	7	18	4	54
North America	3	3	7	2	4	7	7	23	5	58
Oceania	2	0	0	0	0	3	3	4	0	10
South America	7	2	6	5	2	8	4	18	3	48
Totals	59	18	43	34	18	54	45	110	32	354

IDYN = International Durum Yield Nursery
EDYT = Elite Durum Yield Trial
IDSN = International Durum Screening Nursery
* tolerance

Table 4. Selection pressure in the winter 1982-83 (CIANO), summer 1983 (El Batan and Toluca) and winter 1983-84 (CIANO) growing cycles.

Cross or generation	Plants selected (winter 1982-83)	Selections retained and planted (summer 1983)	o/o plants selected	Plants selected (summer 1983)	Selections retained and planted (winter 1983-84)	o/o plants selected
F_1 top	7059	2002	28.67	11555	2142	18.54
F_1 double	419	95	22.67			
F_2 bulk	3403	875	25.71	4796	1248	26.02
F_2 bulk				2797	688	24.60
F_2 individual	13085	2525	19.30	8336	1870	22.43
F_3	14047	2512	17.88	5772	1165	20.18
F_4	2970	816	27.47	5000	834	16.68
F_5	1679	503	29.96	1784	374	20.96
F_6	777	334	42.99	1456	213	14.63
F_7	343	123	35.86	445	55	12.36
Totals	43,782	9,785	22.35	41,941	8,589	20.48

Table 5. High-yielding* durum wheat lines included in the 15th International Durum Screening Nursery.

	CIANO					El Batan			Toluca	
Cross and pedigree	Yield (o/o of Yavaros 79)	Days to heading	Plant height (cm)	Days to matur.	Bacteria	Stem rust	Leaf rust	Bacteria	Septoria	Fusarium
ESSAIP x S15-CR"S"{YAV"S" [(PLC"S"-CR"S" x RABI"S"/CII)KIF"S"]} CD 4213-A-4M-2Y-1M-0Y	138	89	100	136	10	0	30MS–S	–	74	1–5
[(CLR-KUTxSTAT"S"/TEAL"S") D67.3-GTA"S"] RUFF"S"-FG"S" x TROB"S" CD 44829-H-2Y-1M-1Y-0M	130	88	90	136	10	0	20MS–S	–	86	5
DACK"S"-RABI"S"xSNIP"S"/YAV"S" CD 40705-A-1M-1Y-1M-0Y	121	88	95	131	30	10MS–S	20MR	–	63	1–5
(56.3-56.112xCH67/FG"S")RU"S" CD 34604-D-1Y-2M-1Y-0M	121	87	95	131	20	30MS-S	5MR	50	63	4
DACK"S"-TEAL"S"xMAL"S" CD 39998-4B-1Y-1M-0Y	119	89	105	135	20	0	10MRMS	–	32	4
{TEAL"S"-AFN [GTA"S"(ZB-LKX 60.120/G11"S")] SAPI"S"}YAV"S" CD 40509-A-1M-3Y-1M-0Y	118	87	95	131	20	0	10MR	–	T	3
GGO VZ385-GS"S"xMEXI75 CD40150-14B-1Y-2M-0Y	117	79	–	–	20	0	10MRMS	–	76	1–5
SNIPE"S"-FG"S" ICD 74117-1L-1AP-0AP	117	88	90	135	10	0	20MRMS	–	73	5
BU"S" CD 28146-D-4M-1Y-3Y-0M	117	82	90	136	60	10MS-S	20MS-S	60	77	5

Table 5. (Cont'd)

Cross and pedigree	CIANO: Yield (o/o of Yavaros 79)	CIANO: Days to heading	CIANO: Plant height (cm)	CIANO: Days to matur.	CIANO: Bacteria	El Batan: Stem rust	El Batan: Leaf rust	El Batan: Bacteria	Toluca: Septoria	Toluca: Fusarium
[(ZB-MHMD M'RARIxS15-Cr"S"/ MEXI"S")SNIPE"S"] ROK"S" CD 27757-B-1M-2Y-2Y-0M	116	86	90	135	10	10MS-S	5MS-S	20	75	5
SCAR"S"-GDO VZ579xMEXI75 CD 26118-5B-1Y-6Y-0M 25Y-0B	115	80	90	127	40	TMR	10MRMS	30	74	5
PLC"S"-CR"S"xMEXI"S"/DOM"S"x DACK"S"-KIWI"S" CD 27748-B-2M-2Y-1Y-0M	114	87	90	134	20	TMR	5MR-MS	40	77	1–5
{TEAL"S"-AFN [GTA"S"(ZB-LKX 60.120-G11)] EID"S"}CHI"S" CD 40555-E-2M-1Y-1M-0Y	114	88	105	137	20	0	30MR-R	–	75	T
YAV"S"(MNG"S"*8156/JAR"S"* OLN)(20350/CNO"S"*8156* TOB"S"*CNO) GUIL"S"-SCAR"S" CD 35608-A-1M-2Y-1M-0Y	114	91	85	136	10	0	5MR	–	T	T
STIL"S"-YAV"S" CD 34039-7Y-1M-1Y-1M-0Y	114	85	100	137	20	5S-MS	30MRMS	20	T	1–3
YAV"S"-SNIPE"S"xCOLI"S" CD 43740-B-3Y-1M-2Y-0M	114	83	85	126	20	10S-MS	30MSMR	–	22	3
PIN"S"-MEMO"S"(S15-CR"S"/ CIT"S"-AA"S"xFG"S") CD 27313-F-1M-1Y-1Y-0M- 14Y-0B	113	77	–	–	30	TMR	10MS-S	60	76	5
CARC"S" CD 24831-E-3Y-5M-1Y-0Y	112	85	85	129	30	TMR	30MS-S	40	63	5
CAS"S"-FG"S"xTROB"S" CD 40559-C-2M-1Y-5M-0Y	112	103	105	143	10	0	10MRMS	–	76	5
SULA"S" CD 40159-3B-2Y-1M-0Y	111	81	95	125	40	0	TMR	–	54	5
DACK"S"-RABI"S"xSNIPE"S"/YAV"S" CD 40705-A-1M-1Y-2M-0Y	111	88	95	131	20	5MR-MS	20MS-S	–	22	T
GUIL"S" CM14646-C-1Y-1M-1Y-4AU-0Y	110	85	95	135	20	TMSS	10MRMS	40	86	T–2
GFN-AA"S"xGTA"S"-PG"S"/BOY"S" CD 25241-A-2Y-3M-1Y-1Y-0M	110	86	85	136	20	TMR	TMR-R	40	54	1–5
REN"S"xDACK"S"-TEAL"S" CD 38837-9B-2Y-1M-0Y	110	81	80	132	20	0	5MR-MS	–	65	5
YAV"S"/WLS-65150xD67.2(FG"S"- PAL x MEXI"S"/RABI"S" CD 25732-1M-1Y-2Y-3M-1Y 1M-0Y	110	85	85	131	20	0	10MRMS	30	T	T–3

Disease reactions: M = moderately, 0 = no reaction, R = resistant, S = susceptible, T = trace. Numbers are percentages except fusarium, which is scored on a 0 (no reaction) to 9 scale.

– = not determined.

* At least one standard deviation above trial mean and ten percent above the check.

Table 6. Agronomic and quality characters of the 140 highest-yielding durum wheat lines in the 1982-83 small multiplication plots at CIANO.

Character	Range Minimum	Range Maximum	Average	Standard deviation
Yield (kg/ha)	5716	8324	6962	580
Days to flowering	77	107	86.6	5.7
Days to maturity	123	143	132.8	4.4
Plant height (cm)	80	135	94.7	9.6
1000 - kernel weight (g)	44	78	56.7	5.1
Test weight (kg/hl)	79	85	82.9	1.2
Pigment content (ppm)	2.7	9.0	4.8	1.1
Protein content (%)	7.7	11.7	9.7	0.8

Table 7. Top-yielding lines from international nurseries at different locations under irrigated conditions in 1982-83.

Nursery, cross, and pedigree	Location and country	Yield (kg/ha)	Yield (% of local check)
13th IDYN. WAHA"S" CM17904-B-3M-1Y	Cordoba Spain	12110	104
11th EDYT. ROK"S" CD1895-12Y-1Y-8B-0Y	Harare Zimbabwe	11600	129
13th IDYN. ROK"S" CD1895-12Y-0Y-2E-3B-0Y	Sonora Mexico	8084	116
13th IDYN. ERPEL"S"-RUSO"S" CD0437-13M-3Y-0M	Beni Suef Egypt	7904	100
11th EDYT. CHEN"S" CD20626-5M-2Y-1M-0Y	Sonora Mexico	7762	112
11th EDYT. ERPEL"S"-GS"S" x BOY"S" CD25043-A-1Y-3M-0Y	Sohag Egypt	7700	124
11th EDYT. FOJA"S" CD17305-A-5M-4Y-1M-0Y	Guanajuato Mexico	7524	101
13th IDYN. BOY"S" CD4404-B-9Y-3M-0Y	Santiago Chile	7236	125
13th IDYN. CYUS"S"-SINCAPE9 x YEL"S"/ CFN-FG"S" x PTL"S" CM19981-I-3Y-3M-2Y-3M-1Y-0Y	Macedonia Yugoslavia	7110	116

IDYN = International Durum Yield Nursery
EDYT = Elite Durum Yield Trial

Table 8. Top-yielding lines from international nurseries at different locations under rainfed conditions in 1982-83.

Nursery, cross and pedigree	Location and country	Precip-itation (mm)	Yield (kg/ha)	Yield (% of local check)
11th EDYT. ERPEL"S"-RUSO"S" CD10437-13M-1Y-1M-1Y-0M	Laxia Cyprus	210	3798	169
11th EDYT. CHI"S" CD1314-A-1Y-2Y	Jordan	284	2995	152
11th EDYT. ROK"S" CD1895-12Y-0Y-2E-3B-0Y	Aleppo Syria	338	4894	118
13th IDYN. ERPEL"S"-RUSO"S" CD10437-13M-3Y-0M	Aleppo Syria	338	4433	150
11th EDYT. ERPEL"S"-GS"S" x BOY"S" CD25043-A-1Y-3M-0Y	Madrid Spain	367	4408	159
13th IDYN. WAHA"S" CM17904-B-3M-1Y	Madrid Spain	367	3499	103
13th IDYN. CYUS"S"-SINCAPE9 x Yel"S"/ CFN-FG"S" x PTL"S" CM19981-I-3Y-3M-2Y-3M-1Y-0Y	Punjab Pakistan	383	5555	101
13th IDYN. CYUS"S"-SINCAPE9 x YEL"S"/ CFN-FG"S" x PTL"S" CM19981-I-3Y-3M-2Y-3M-1Y-0Y	Constantine Algeria	392	5042	108
11th EDYT. ROK"S" CD1895-12Y-1Y-8B-0Y	R.D. Sde-Gats Israel	426	7461	110

EDYT = Elite Durum Yield Trial
IDYN = International Durum Yield Nursery

Table 9. Yield and yield components of selected durum wheat lines at CIANO in 1982-83.

Cross and pedigree	Yield (kg/ha)	Yield (% of Yavaros 79)	Test weight (kg/hl)	1000-kernel weight (g)
YAV"S"-CNDO CD38974-4M-1Y-3M-1Y-0M	6599	103.5	84.4	60.4
DACKS"S"-TEAL"S"xMAL"S" CD39998-4B-1Y-1M-0Y	8244	129.3	84.5	62.5
SULA"S" CD40159-3B-2Y-1M-0Y	7021	110.1	84.8	60.6
(RUFF"S"-MEXI"S"xSNIPE"S"/ PAL"S")CHI"S" CD40553-D-3M-2Y-1M-2Y-0M	6744	105.7	84.8	59.1
GUIL"S"-SHWA"S" x REN"S" CD42790-3Y-1M-1Y-0M	7037	110.3	84.0	70.2
ROK"S"-SNIPE"S" x SCO"S" CD43717-B-1Y-1M-2Y-0M	7108	111.4	82.0	77.9
RUFF"S"-FG"S" x TROP"S"/ YAV"S" CD43930-E-1Y-2M-1Y-0M	6577	103.1	85.6	59.2
(ATO"S" x SBA81-PLC"S"/68111-RGB x WARD)FG"S"-PALES x MEXI"S"/RUFF"S"-FG"S" CD34934-D-3Y-4M-1Y-1M-1Y-0M	6794	106.5	84.4	58.8
YAVAROS 79	6378	100.0	83.2	52.6

Table 10. Progenitors and advanced lines producing healthy seed at Toluca in 1983.

Cross and pedigree*
7175-71110
BUC CANDISUR
INRAT 69
NJORO 231
TEHUACAN 60
DUN"S" F4LAM-2Y-1Y-0Y
ROK"S" CD1895-12Y-0Y-2E-6B-0Y
IBIS"S"-USA1548 x SBA81 CD13510-F-2Y-5M-0Y
TERN CD17835
DACK"S"-YEL"S" CD18057-4Y-3M-2Y-2M-1Y-1M-0Y
(DACK"S"/CFN5-FG"S" x PTL"S")YEL"S" CD19752-A-4Y-1M-0Y
CYUS"S"-SINCAPE9 x YEL"S"/CFN-FG"S" x PTL"S" CD19981-I-3Y-3M-2Y-3M-1Y-0Y
CHUR"S" CD20124-11M-3Y-2M-1Y-0Y
GA"S" CD22344-A-8M-1Y-1M-1Y-2Y-1M-0Y
YAV"S"/WLLS-65150 x D67.2(FG"S"-PALES x MEXI"S"/RABI"S") CD25732 (2 sister lines)
S15-CR"S" x SHWA"S" CD25749-7B-1Y-2Y-2M-0Y
FUUT"S" CD26593-3B-2Y-1Y-0M
ALG86-RU"S" CD33417-1B-3Y-1M-0Y

Cross and pedigree*
STIL"S"-YAV"S" CD34039-7Y-1M-1Y-1M-0Y
CALI"S" CD34934-D-3Y-4M-1Y-1M-1Y-0M
YEL"S"-BAR"S"/GR"S"-AFN"S" x CR"S" (DOM"S" x CR"S"(2)-GS"S"/SCO"S")TEZ"S" CD38350 (2 sister lines)
STN"S" CD38397 (3 sister lines)
DACK"S"-RABI"S" x OLOR"S"/DACK"S"-RABI"S" x GOO"S" CD38422-B-1M-2Y-1M-0Y
YAV"S"-CNDO CD38974-4M-1Y-3M-1Y-0M
ENTE"S"-MEXI"S" x CTA"S"/CNDO CD40478 (2 sister lines)
BDR-MEMO"S" x YAV"S" CD40501-F-1M-1Y-2M-1Y-1M-0Y
TCHO"S" CD40553 (2 sister lines)
DACK"S"-RABI"S" x SNIP"S"/YAV"S" CD40705 (3 sister lines)
YAV"S" (2)-SCAR"S" CD40775-A-2M-2Y-2M-0Y
YAV"S"-TEZ"S" CD42270-10Y-1M-2Y-2M-1Y-0M
GUIL"S"-SHWA"S" x REN"S" CD42790-3Y-2M-1Y-0M
YAV"S"-SHWA"S" x REN"S" CD42798-14Y-1M-1Y-0M
SNIPE"S" x TEAL"S"-D6811/YAV"S" CD43677-I-1Y-1M-1Y-1M-0Y
SNIPE"S"-EDM x YAV79 CD43705-M-2Y-4M-1Y-0M

Table 10. (Cont'd)

Cross and pedigree*
JO"S"-CR"S" x SNIPE"S"/YAV"S" CD43715-C-1Y-2M-3Y-1M-0Y
YAV"S"-FG"S" x ROH"S" CD43739-C-3Y-2M-1Y-2M-0Y
RUFF"S"-GTA"S" x YAV"S"/SWAN"S" CD44255-C-2Y-1M-1Y-1M-0Y
(SBA81-CR"S" x CIT"S"/CHI"S")PAL"S" CD44257-G-1Y-2M-1Y-2M-1Y-0M
CHTO"S"-GUIL"S" CD45729-1M-1Y-1M-1Y-0M
GEDIZ"S"-FG"S" x GTA"S"/CNDO CD45987-2B-1Y-1M-0Y
YAV"S"-CTA"S" CD46191-7B-1Y-2M-2Y-0M
YEL"S"-P66.270 x YAV79 CD46829-2B-1Y-1M-1Y-0M
YAV79/KHP-GGO x RUFF"S" CD47213-7B-3Y-1M-2Y-0M
TERN"S"-YAV"S" x GRA"S" CD47474 (4 sister lines)
(STIL"S"/PG"S"-GGOVZ380 x S15-CR"S")TUB"S" CD47665 (2 sister lines)
RUFF"S"-FG"S" x FG"S"-CR"S"/YAV79 CD48054 (7 sister lines)
MTTE"S"-TAD"S"(KIF"S" x RSS-BD1419/MEXI"S"-CP) CD48250-C-2M-2Y-1M-0Y
DV24-COO"S" x FG"S"/CHI"S" CD48590 (5 sister lines)
YAV79-APO"S" CD48705 (3 sister lines)
{[(DACK"S"/CFN5-FG"S" x PTL"S")YEL"S"] RTTE -LDS}TUB"S" CD49313 (3 sister lines)
PLC"S"-RD3.6 x STW63/ENTE"S"-MEXI"S" CD49375-1Y-2M-1Y-0M
(EIP/GS"S"-TC60 x MEXI75)CFN5-FG"S" x PTL"S" CD49555-5Y-2M-1Y-0M
FUUT"S"-APO"S" CD49561-7Y-1M-1Y-0M
YAV79 x ALONDRA"S"-ALBE"S"/RUFF"S"-FG"S" CD50765-B-2Y-1M-3Y-0M
CHTO"S"-YAV"S" x GOO"S"-CIT71 CD50869-A-1Y-2M-3Y-0M

* Number of sister lines in parentheses.

Table 11. Yields of early maturing lines at CIANO in 1982-83.

Cross and pedigree	Yield (kg/ha)	Yield (°/o of Yavaros 79)	Yield (°/o of Mexicali 75)	Heading (days)	Maturity (days)
CARC"S" CD24831-E-3Y-5M-1Y-0Y	8229	129.0	140.1	85	129
SCAR"S"-GDO VZ579 x MEXI75 CD26118-5B-1Y-6Y-0M-25Y-0B	7152	112.1	121.8	80	127
SAPI"S"-YAV"S" CD38823-6B-2Y-1M-0Y	7432	116.5	126.6	85	127
SULA"S" CD40159-3B-2Y-1M-0Y	7021	110.1	119.6	81	125
SULA"S" CD40159-7B-1Y-1M-0Y	7905	123.9	134.6	84	124
(ATO"S" x AA"S"-PLC"S"/68111 x RGB-WARD)FG"S"-PAL x MEXI"S"/ RUFF"S"-FG"S" CD34934-I-3Y-1M-1Y-2M-0Y	6999	109.7	119.2	80	126
YAV"S"-SNIPE"S" x COLI"S" CD43740-B-3Y-1M-2Y-0M	8078	126.7	137.6	83	126
YAVAROS 79	6378	100.0	108.6	85	132
MEXICALI 75	5871	92.1	100.0	76	131

Table 12. Yield under reduced irrigation* at CIANO in 1982-83.

	Yield					Plant
Cross and pedigree	(kg/ha)	(°/o of Yavaros 79)	(°/o of Mexicali 75)	Heading** (days)	Maturity** (days)	height** (cm)
GIA"S" CD28222-D-1M-2Y-2Y-0M	6191	104.6	125.5	80	125	105
D25-REN"S"/DYCA"S" x RUFF"S"-FG"S" CD35059-C-2Y-2M-1Y-0M	6238	105.4	126.4	84	126	100
(CR"S"-AA"S" x MEXI"S"/JNK) CR"S"-TGBB x PG"S"-RALLE"S" CD35264-A-1Y-1M-0Y	6658	112.5	135.0	81	125	120
65150-LDS x YAV"S" CD36614-4Y-1M-2Y-1M-0Y	6376	107.7	129.3	87	126	105
STIL"S"-MEXI75 CD42644-4Y-1M-1Y-0M	6349	107.3	128.7	81	134	100
(ATO"S" x AA"S"-PLC"S"/68111 x RGB-WARD)FG"S"-PAL x MEXI"S"/RUFF"S"-FG"S" CD34934-D-3Y-4M-1Y-1M-0M	6794	114.8	137.8	85	126	115
YAVAROS 79	5918	100.0	120.0	85	132	95
MEXICALI 75	4932	83.3	100.0	66	130	100

* Total water input was one irrigation (= approximately 100 mm of rain) and 177 mm of rainfall.
** Heading, maturity and plant height were measured under full irrigation.

Table 13. Industrial quality parameters of selected lines from CIANO in 1982-83.

Cross and pedigree	Yield (kg/ha)	Pigment content (ppm)	Protein content (%)	Gluten consistency	Color	Yellow berry
FG"S"-DOM"S" CM18548-1Y-1Y-1Y-4M-0Y	6802	6.4	10.4	F	6	10
WIN"S" CM18577-11Y-6M-2Y-0Y-15B-0Y	6662	7.0	9.4	F	7	10
CHEN"S" CD20626-5M-2Y-1M-0Y	6561	7.8	10.3	F	6	10
(QFN-G11"S" x GTA"S"/IBIS"S") BOYS"S" CD23128-5Y-5M-1Y-2Y-1M-0Y	6531	6.6	9.7	F	6	10
AUK"S" CD25126-A-1Y-3M-1Y-1Y-0M	6639	5.1	8.5	F	5	10
ROK"S"-GUIL"S" CD42494-5Y-2M-1Y-0M	8224	8.1	9.2	F	6	10
(SHWA"S" x MAGH72-YAV"S"/ ROK"S")GUIL"S" CD44101-B-2Y-2M-1Y-0M	7100	9.0	8.8	F	10	10
STIL"S"-MEXI"S" CD42644-4Y-1M-1Y-0M	6349	7.2	9.8	1/2F	4	5
YAVAROS 79	6378	4.6	10.1	1/2F	5	5
MEXICALI 75	5918	6.4	10.5	F	6	10

Gluten consistency: F = strong, 1/2 F = medium, S = soft.
Color: Scale of 1–10, ten the best.
Yellow berry: Percentage of grains affected.

Triticale

B. Skovmand and P. Fox

Objectives

The primary objective of the CIMMYT triticale program is to produce widely adapted varieties with high yield potential and improved endosperm development. Industrial quality has previously been considered a secondary objective but now should perhaps be raised to a primary objective. Secondary objectives include better disease resistance, a shorter plant type, earlier maturity, greater genetic variability, increased drought tolerance, better resistance to sprouting and improved tolerance to high levels of free aluminum. One of the newer objectives of the program is to seek salt-tolerant materials.

Mexican Breeding Cycles

The 1982-83 winter cycle in the Yaqui Valley, site of the Yaqui Valley Agricultural Experiment Station (CIANO), in northwestern Mexico, was abnormal because of several rains during the growing cycle. Furthermore, the yield trials were located in an area where the water table was within one meter of the surface. This combination of conditions made drought screening ineffective. At the Toluca Experiment Station, the summer cycle was normal, with only a light frost. This caused only slight damage to some of the late-planted materials and had little impact on the overall program.

International Nurseries

A total of 199 lines were selected from the 1063 lines evaluated for yield potential and endosperm development. The selected lines were included in the 15th International Triticale Screening Nursery (ITSN), and were sent to more than 100 locations around the world.

The 14th International Triticale Yield Nursery (ITYN), consisting of 40 entries, was also sent to more than 100 locations worldwide. The ITYN was changed to a split plot design with substituted and complete triticales grown separately as main plots, because the two types differ mainly in height and maturity and thus should not be tested in a completely randomized design. Substituted triticales are those having at least one rye chromosome replaced by a D-genome chromosome from hexaploid wheat, whereas complete triticales have a complete set of rye chromosomes.

Variety Releases

The National Institute of Agricultural Research (INIA) of Mexico released two varieties of triticale during 1983. The line Chiva "S" (X-24551-8Y-3M-1Y-0M), a substituted triticale, was released for irrigated areas under the name "Alamos 83". This is a mid-term variety that during the last four cycles has outyielded Cananea 79 and Caborca 79 by about 6 percent and has an improved test weight. Its quality for use in cookie making is excellent. For dry, highland areas, the line Juanillo 159 was released under the name "Eronga 83". This complete triticale has a mid-late maturity and a high yield potential. It is the first release for these areas in Mexico.

Changes in the Breeding System

During the summer cycle of 1981, the triticale program was changed from a pure pedigree system to a modified bulk system, as described in the 1982 annual report. One of the reasons for the change was to avoid heavy selection pressure on the early, segregating populations. In Table 1, the test weights of F_2 bulks grown at Toluca, and derived from crosses of substituted x substituted (S x S), complete x complete (C x C), and substituted x complete (S x C) triticales are compared. There was no significant difference between the S x S and C x C crosses, but the means for the C x S crosses were significantly different from the other two types.

The second reason for changing the breeding system was to get yield and test weight evaluations on segregating populations in the F_4 rather than the

Dr. B. Skovmand (left) and Dr. P. Fox (right) of the triticale program.

F_6 and F_7 generations. During 1983, 153 F_4 bulk populations grown at the Toluca and El Batan Experiment Stations were evaluated, and 75 of these were accepted based on the superiority of their yields and test weights as compared to the check, Alamos 83.

Improving Agronomic Characteristics

Yield and adaptation—Table 2 shows the newer advanced triticale lines with both higher yields and higher test weights in comparison with the variety Alamos 83. Some of these lines outyielded the check by more than 20 percent and two lines had both a 10 percent or more better yield and a 5 percent higher test weight.

One of the objectives of the program has been to obtain short triticales combining good yield potential and improved test weight. Table 3 lists five advanced lines that combine these characteristics.

In the tropics, triticale is best adapted to highland conditions. For this reason, the principal site for selection has been changed from CIANO, in the lowlands of Sonora, Mexico, to the highland stations at Toluca and El Batan. Table 4 shows lines that performed well at these highland sites, among which are some lines that produced almost 30 percent more than the checks and others that had a 15 percent higher test weight.

Earliness—Table 5 compares the performance of early maturing triticales with the early wheat variety Sonalika, showing lines that performed favorably with respect to earliness and yield.

Test weight—It is now easier to obtain lines with good test weights at CIANO, so more emphasis is being placed on improving this characteristic at Toluca and El Batan. In 1983, Dingo (X41047-A-1Y-2M-1Y-2Y-1M-1Y-0B) and Zebra 79 (B2672-7191-0Y) both produced grain with a test weight over 70 kilograms per hectoliter at Toluca, and Dingo "S" (X41047-A-1Y-2M-1Y-2Y-2M-0Y), Zebra 79 and the cross PRT"S"-YO"R" x PND"S" (X52202-2Y-4M-1Y-2M-0Y) showed test weights greater than 75 kilograms per hectoliter at El Batan.

Disease resistance—Two problems that have been investigated are resistance to Karnal bunt and to *Helminthosporium sativum*. Lines that have shown resistance to *H. sativum* in the greenhouse and at the Poza Rica Experiment Station are listed below:

- Dingo"S" (X41047-A-1Y-2M-1Y-2Y-0M)
- IA-ADX"S" (X31714-B-1Y-1M-1Y-0M)
- Durum wheat-Balbo x DF"S" (X49812-2Y-2Y-5M-1Y-0M-0Y)

For Karnal bunt, triticales have the same level of resistance as wheat to artificial inoculation but have shown a low level of infection in the field. This may indicate some useful morphological, "field" resistance.

Aluminum tolerance—In 1983, the triticale program initiated preliminary laboratory screening of hexaploid lines for their tolerance to toxic levels of free aluminum. Wheat seedlings have been screened for several years using 1.7 millimoles (46 parts per million) of soluble aluminum in a nutrient solution. At this concentration most triticales survive; thus the screening level for triticale was raised to 2.96 millimoles (80 parts per million).

In 1983, seedlings from sixty-eight populations of hexaploid triticale underwent preliminary screening at this higher concentration of aluminum, with the following results: 40 populations were wholly intolerant, 18 had a 1 to 10 percent survival rate, 5 had an 11 to 20 percent survival rate, and 5 populations displayed a survival rate of greater than 20 percent. Lines that appeared tolerant are now being grown in CIMMYT's greenhouses and will undergo both field and laboratory testing in 1984. It is expected that these lines will perform well in acid soils that have a high free aluminum level.

Premature sprouting—It appears that the high selection pressure placed on endosperm development has fortuitously resulted in decreased alpha-amylase activity (an indirect measure of the tendency toward premature sprouting), as indicated by the Hagberg Falling Number technique. When about 5000 lines were checked for their falling numbers five years ago, no variation was found: all lines had the minimum value of 60 seconds and sprouting was a problem with all of them at Toluca, where there are almost daily rains during the growing cycle. Now some differences exist.

Taking advantage of this variation, selection for sprouting resistance has been initiated. Screening was begun in 1982 employing a rather simple technique observed in Brazil: spikes are selected in the field at complete maturity, submerged in water for about 18 hours and then placed in a humidity chamber for about 72 hours. Resistance is estimated by counting the germinated and dormant grains.

In 1983, about 200, F_2 populations were subjected to this treatment, and twenty-five populations that had less than 20 percent sprouting after the treatment were selected. These twenty-five populations will be planted in January, 1984, at Toluca, so that they will ripen in July during the period of daily rains.

Summary
Marked improvements in yield were obtained in 1983. Three lines produced over 20 percent more than the check at the lowland site, CIANO, and two yielded nearly 30 percent more at the highland sites. Endosperm development also improved, with test weights reaching as much as 15 percent more than the check variety. Combining high values for these two characteristics in the same line remains a problem, but a number of lines now have both test weights and yields that exceed the check variety by 10 percent at the highland sites.

Progress is also being made in other problem areas:

- Some resistance to helminthosporium and Karnal bunt has being found.
- Several lines are now as early as the early wheat variety Sonalika and have comparable yields.
- Triticale is proving to be quite tolerant to high levels of free aluminum in the soil: even with an aluminum concentration of 80 parts per million some triticale populations had a survival rate of more than 20 percent in the seedling test.
- Selection against premature sprouting is beginning.

The principal site for selection was changed in 1983 from the lowland CIANO station to the highland stations at Toluca and El Batan, since triticale is best adapted to highland conditions in the tropics.

Table 1. A comparison of test weights among three types of crosses at Toluca in 1983.

Type of cross	Test weight (kg/hl) Minimum	Maximum	Mean	Number of populations
Substituted x substituted	56.6	71.5	65.29	373
Complete x complete	58.0	74.4	65.02	139
Substituted x complete	52.2	67.8	61.50	383

Table 2. Highest yielding advanced lines compared with Alamos 83 at CIANO in 1982-83.

Cross and pedigree	Yield (% of Alamos 83)	Test weight (% of Alamos 83)
PTR"S"-PND"S" X39599-7Y-1M-1Y-2Y-0M	124	100
ECHIDNA"S" X34824-501M-500Y-501B-503Y-507Y-0M	122	101
PND"S"-YE x MPE"R" X59862-3M-2Y-1M-0Y	122	100
(CORM"S"-D67.3 x GTA"S"/SPY)GPR X65163-7Y-1M-0Y	117	100
IRA^2 x MSF"R"-IRA/PND"S"-ABN"S" x LLAMA"S" X62433-J-1M-1Y-2M-0Y	116	103
LMG"S"-FS477 X61094-22Y-3M-0Y	115	103
CASTOR"S" x M2A-ARM"S" X44621-4Y-2Y-1M-1Y-1M-0Y	114	104
CIN-FS579 x FS1897/TRR"S" X52471-11Y-1M-1Y-6M-0Y	112	104
PTR"S" x M2A-IRA/RAM"S" x IRA-CAL X53782-D-2Y-3M-1Y-0B	112	106

Table 2. (Cont'd)

Cross and pedigree	Yield (%o of Alamos 83)	Test weight (%o of Alamos 83)
*FARO"S" B2264-0Y-103	111	103
TESMO"S" X39860-7Y-2M-3Y-2Y-1M-0Y	111	100
*NUTRIA B2709-0Y-18	111	101
OCTOBULK31-CIN"R" x CABORCA 79 X52650-19Y-1M-3Y-1M-0Y	110	106
GPR"S"-PTR"S"/BURA x M2A-IA X62033-E-1M-2Y-2M-0Y	108	103
PTR"S"/RM"S"-IRA x FS477 X48675-7Y-3Y-3M-1Y-5M-0Y	108	103
PTR"S"-M2A^2 X44650-12M-1Y-1Y-2M-2Y-1M-0Y	108	102
PND"S"-IRA^2 x MPE"R"-PTR"S" X50973-B-12Y-1Y-1M-1Y-4M-0Y	107	104
FS381-FS477 x TORO"S"/M2A-M1A X61270-B-1M-1Y-2M-0Y	106	107

* Complete type triticale

Table 3. Dwarf triticale advanced lines included in the 15th International Triticale Screening Nursery giving their height, test weight and yield from CIANO, El Batan, and Toluca in relation to the check variety Alamos 83.

Cross and pedigree	Height (cm)			Test weight (kg/hl)			Yield (kg/ha)		
	CIANO	El Batan	Toluca	CIANO	El Batan	Toluca	CIANO	El Batan	Toluca
ALAMOS 83	100%	100%	100%	100%	100%	100%	100%	100%	100%
ALAMOS 83 (absolute values)	(106)	(107.5)	(115)	(73.4)	(68.1)	(63.5)	(5664)	(4903)	(4939)
QUOKKA"S" X39253-30Y-1M-2Y-502Y-502M-505Y-500B-0Y	68	67	61	99	102	99	102	101	56
QUOKKA"S" X39253-30Y-1M-3Y-501Y-502M-500Y-500B-0Y	68	62	56	97	101	102	97	98	67
BTO"S"-PTR"S" X49509-3Y-2Y-1M-2Y-2M-0Y	80	80	82	104	102	103	107	96	75
BTO"S"-PTR"S" X49509-3Y-2Y-1M-2Y-1M-0Y	80	76	78	105	104	106	103	123	82
PTR"S" x CML-FS1377/IA x CIN-FS658 X51038-D-4Y-3Y-5M-1Y-1M-0Y	85	95	86	100	105	103	88	130	106

* All data are averages from seven (CIANO) or two (El Batan and Toluca) experiments and are expressed as percent of Alamos 83 at the same site.

Table 4. Performance of certain advanced lines with good yield and test weight (given as percent of Cananea 79) compared with the check varieties Cananea 79 and Alamos 83 at El Batan and Toluca in 1983.

Cross and pedigree	Yield		Test weight	
	Batan	Toluca	Batan	Toluca
ECHIDNA"S" x PND"S"-RM"S" X61079-4M-1Y-1M-0Y	104	118	110	114
PND"S"-ABN"S" x IGA-IRA X47171-F-4M-7Y-1Y-2M-3Y-2M-0Y	104	104	112	112
M2A-CASTOR"S" x M2A-PTR"S" X50444-G-6Y-3Y-1M-1Y-2M-0Y	125	105	111	108
NUTRIA 401	107	165	107	110
PANCHE 312	104	164	112	114
DINGO"S" X41047-A-1Y-2M-1Y-2Y-2M-0Y	106	118	115	115
PND"S"-MPE"S" x GPR"S"-YAK"S" X50408-B-5Y-2Y-1M-1Y-0B	107	105	109	104
WHALE"S" X33470-C-1Y-3M-2Y-2M-0Y	106	134	109	113
CIVET"S" B2658	124	104	112	108
FS1018-PND"S" X56733-1YP-3MP-0Y	105	112	114	115
ALAMOS 83	77	87	105	105
CANANEA 79 (percent)*	100	100	100	100
(kg/ha or kg/hl)	(6160)	(4847)	(64.7)	(59.4)

* Averaged over 11 experiments.

Table 5. Characteristics of advanced triticale lines with early maturity compared with the early wheat Sonalika* at CIANO in 1982-83 (expressed as percent of Sonalika).

Cross and pedigree	Yield	Test weight	Height	Days to flowering
JUPPA"S"-MPE"R" x GPR-CML"S" X63507-901M-1YP-1MP-0Y	110	92	111	102
LMG"S"-SPD"S"(BGL"S"-MUS"S" x FS477/BTA"S") X63773-D-1YP-1MP-0Y	118	91	88	94
RAT"S" x MSF"S"-IRA X61178-4MP-1Y-1MP-0Y	112	93	100	95
BCM"S"(INIA-TK x H616.71/FS477) X58617-4YP-2MP-0Y	104	91	100	94
[(IA-M2A x Pi62/BGL"S")INIA-TK x H616.71/FS477] PND"S"-CASTOR"S" x MPE"S" X61834-G-1MP-1Y-2MP-0Y	102	92	105	101
SONALIKA	100	100	100	100

* Sonalika was sprayed with fungicide to control rust.

Table 6. Crosses with superior resistance to sprouting.

Cross and pedigree
TED"S"-PFT 7888 X66668-0M
PND RYE/UM-IRA x CASTOR"S" CT589-0M
GIRAF"S" x PND"R"-LNC CT1358-0M
TAPIR"S" x PND"R"-RM CT1833-0M
DF99 x TJ-BGL/OCTONAV x M_2A-BGL B8217-0M
HARE"S"-YOGUI"S" x JLO B8232-0M
JLO-PTR"S" x $(IRA\text{-}BGL)^2$ B8402-0M
MERINO"S"-JLO/BGL-CIN x IRA-BGL B8413-0M
M2A-BGL x JLO {[FURY-7C x WRC31//MTZ x 4C8825(ERA-CNO x GALLO)] DRIRA-MA} B8415-0M
JL0 x DRIRA-CINVEM/MERI"S"-JLO B8419-0M
BTA"S" x MERINO"S"-MUS"S" CT3954-0M

Barley

H. Vivar, P. A. Burnett, and J. Neuhaus-Steinmetz

Introduction

This report is written to cover the 16 month period starting on September 1, 1982 when new personnel took over the program.

Program objectives and progress—The susceptibility of CIMMYT's barley germplasm to various diseases is the main problem confronting the program. This susceptibility is to the prevalent barley diseases of Mexico, leaf rust (*Puccinia hordei*), scald (*Rhynchosporium secalis*) and net blotch (*Helminthosporium teres*), and to race 24 of stripe rust (*P. striiformis* f. sp. *hordei*) in the Andean region. Nurseries sent to this region were almost completely destroyed by the latter. A similar picture has emerged for scald in Ethiopia and powdery mildew in North Africa.

To correct this situation, breeding for disease resistance has become the major goal of the program, and disease screening has been markedly increased. In addition, the incorporation of resistance to leaf rust and scald across the whole germplasm base of the program is urgently needed. To this base, resistance to additional diseases will be added in the near future.

Already considerable progress has been made. There is a large number of lines in early generations, up to F_5, planted in the winter 1983-84 cycle at the Yaqui Valley Agricultural Experiment Station (CIANO), in northwestern Mexico, that carry resistance to both leaf rust and scald. This is largely the result of the earlier developmental work of a post-doctoral fellow, who made extensive crosses and created a good epidemic of scald in the F_2 during the summer of 1982. The best F_5 lines came from this F_2 nursery, and they have since been screened for leaf rust resistance at CIANO in the winter 1982-83 cycle and for scald resistance at the Toluca Experiment Station in the summer of 1983. Unfortunately, this F_2 nursery was the only one in which selection for scald could be carried out.

Breeding for stripe rust resistance is still in its infancy. The most advanced material planted at CIANO in the 1983-84 cycle is the top-crossed F_1, the bulked F_2 and the individually harvested F_2. The main difficulty in incorporating resistance to race 24 is its complete absence in the virulence spectrum in Mexico. The shuttle breeding system with the Andean region has failed to provide resistant selections due mainly to the following factors:

- the difficulty CIMMYT germplasm has growing in the problematic soils of the region,
- the presence of leaf rust as a recent, but major, problem, and
- the presence of barley yellow dwarf virus (BYDV) which is endemic in the region.

It is now believed, however, that by combining appropriate tolerances and resistances we will be able to take full advantage of this shuttle system.

A large number of barley lines introduced from Europe is currently being evaluated for resistance. European germplasm has not been utilized to any great degree by the CIMMYT program. We expect to gain some powdery mildew resistance and some additional sources of stripe and leaf rust resistance.

Organizational changes—There has been a metamorphosis during the period that this report covers, resulting in full integration of the pathology and breeding components of the program. In spite of increased activities, the program is almost self-sufficient in its general pathology requirements. All of the following activities are performed by the program staff: culturing inoculum in the laboratory, inoculating rust and scald, disease scoring, inoculating seedlings in the greenhouse and testing new screening techniques. The staff has been trained in these new activities and its members are keen to make the disease screening program successful. The extent and success of these changes is a major accomplishment of the program.

Data management—One team member has been heavily involved in the development of a new computerized system for storing data and printing books for the crossing block (CB), miscellaneous and

Dr. H. Vivar (left) and Dr. P. Burnett (right) of the barley program.

observation lines (LOs). This system will provide a more efficient way to store and retrieve data. The development of an F_1 book in which disease and agronomic data from the parental lines will be continually updated will enhance and facilitate the effectiveness of top crosses, which we currently favor for rapidly combining resistances to several diseases. The system being developed will also provide the mechanism to obtain printed lists of lines with different, specified traits, such as earliness, leaf rust resistance and scald resistance.

In order to broaden the data base, extensive disease and agronomic notes have been collected for most nurseries. In some cases, this is the first time such data have been recorded. In addition, all germplasm in the program is being classified for resistance to scald, leaf rust, net blotch, powdery mildew, spot blotch, stripe rust and scab.

Winter Cycle 1982-1983: CIANO, Northwestern Mexico

Leaf rust—A severe epidemic of leaf rust was established in the area planted except for the experiments, small multiplication plots (PCs) and international multiplication plots (PMIs). The production of fresh leaf rust spores in the greenhouse at the El Batan Experiment Station played a key role in the success of this artificial epidemic. Spores collected from susceptible seedlings were sent by air to Cd. Obregon, near CIANO, and applied to susceptible borders or "spreader" plants that were regularly distributed throughout the planted area. As the season progressed, these borders and some susceptible lines produced large amounts of inoculum which was harvested and used to inoculate the whole barley area several times. The material included in the nurseries was scored for incidence and severity of rust infection three different times. These nurseries included the normal crossing block (CBN), resistance crossing block (CBR), quality crossing block (CBQ), miscellaneous nursery and LO. Taking several scores one week apart appears to be an efficient method for identifying slow-rusting genotypes.

Table 1 lists the lines included in the 1983-84 CB that appeared to be slow rusting during the 1982-83 season at CIANO. These lines also had scores of less than 20MS at all other testing sites scored for leaf rust in Mexico. Varieties like Vada and its derivatives Georgie and Lofa Abed, that reportedly have partial resistance to leaf rust, are in this group. The slow rusting characteristic is being maintained in the program, but its incorporation into new lines is not being actively monitored. Attempts are being made to spread the genes by keeping a pool of slow-rusting parents and crossing these widely with other lines.

The resistance sources for leaf rust are not limited to slow rusting types but instead are a combination of this type with major gene resistance (the Pa series). Table 2 lists lines included in the 1983-84 CB that had the low scores typical of single gene resistance; Estate (Pa3) and Triumph (Pa9) are among them.

The races of barley leaf rust present in Mexico were identified by the United States Department of Agriculture (USDA) Rust Laboratory in Minnesota from samples collected at different locations in Mexico. Race 19 was predominant but races 8 and 12 were also present. The reactions of barley leaf rust differentials planted at five sites in Mexico are presented in Table 3. A more complete picture of the virulence of leaf rust in Mexico will come from the samples collected during the 1983 cycle at El Batan. Three major genes, Pa, Pa4 and Pa5, are not effective against the races present in Mexico.

Selection pressure—Leaf rust resistance, degree of head shattering and straw strength were the most important selection criteria. The severe epidemic of leaf rust made it possible to select resistant material; large numbers of susceptible lines were discarded in all segregating generations. An idea of the size of the reduction that took place is given by the number of selections made in the F_4, F_5, and F_6 generations (Table 4).

A small but vigorous group of lines survived the severe 1983 leaf rust epidemic. The best populations were in the F_3 generation, which provided a large number of selections.

From these F_3 populations, selections were made by Drs. Mohamed Mekni and Manuel Navarro, from the International Center for Agricultural Research in Dry Areas (ICARDA) and the Mexican National Institute of Agricultural Research (INIA), respectively, and were forwarded to them after harvesting.

The early maturing materials were planted in late December, almost 50 days later than the first planting date, and were also subjected to a severe leaf rust epidemic and heavy selection pressure.

Barley stripe mosaic virus—BSMV is present in Mexico, and some CIMMYT lines showed symptoms of infection in the seedling stage, but the number of lines contaminated in the nurseries was low. However, seed stock planted by the agronomy program to increase seed for the training program was highly contaminated and the harvested seed had to be discarded. Porvenir, a scald-susceptible check variety, which was planted every 100 entries throughout all the segregating populations, had to be eliminated because of BSMV. This virus is seed-and pollen-transmitted, and can be transferred mechanically. Constant vigilance will be necessary to keep the program free of BSMV. Chile has refused to accept CIMMYT germplasm without a specific declaration that the seed is guaranted free of BSMV and bacteria. In order to satisfy quarantine regulations, Dr. Tom Carroll, of Montana State University, USA, is currently testing 100 lines from the CB to ensure that symptomless carriers are not present.

Dr. Manuel Navarro and Ing. Enrique Riojas, national barley coordinator and barley breeder, respectively, from INIA, and Dr. Santiago Delgado from the Mexican quarantine office have been contacted to make them aware of the problem of BSMV-contaminated seed coming from the Mexican national seed producing organization. A student is working on BSMV for his masters thesis project at the Colegio de Postgraduados, Chapingo, under the direction of Dr. Rafael Rodriguez and Dr. Peter Burnett, of CIMMYT.

Stripe rust—The main disease problem in the Andean region is stripe rust race 24, which was introduced from Europe in 1976 and spread rapidly. CIMMYT barley germplasm is extremely susceptible to this disease, so a large number of crosses was made in 1983 to combine resistance to race 24 with other desired characters.

Several sources of resistance were identified at the San Benito Experiment Station in Cochabamba, Bolivia, in 1982. These were included in the fourth Latin American Disease and Observation Nursery (VEOLA), which is the source of the highly resistant lines listed in Table 5. Unfortunately, several of these lines are susceptible to leaf rust and scald.

Yield Potential—In general, the 1983 results confirmed the yield levels previously reported by the program. The highest-yielding genotype produced 6.9 tons per hectare, and early barleys (maturing in 90 days), produced up to 5 tons per hectare. An experiment for evaluating the yield of hull-less barley was discarded because of poor stand establishment due to low germination. Poor germination due to broken or damaged embryos continues to be the main problem for naked barleys in our program.

The yield of CIMMYT germplasm under disease-free conditions at CIANO is comparable to the best material coming from North America and INIA; however, straw strength and disease resistance need to be improved.

Yield losses—An experiment designed to measure yield losses due to leaf and stem rust failed to produced valid plot yields because of flooding. However, the 1000-kernel weight of infected plants of the line susceptible to leaf rust was significantly lower than those of either susceptible plants sprayed with a fungicide or resistant lines.

Winter Cycle 1982-83: Toluca Experiment Station, Central Mexico

Crosses—The Winter Barley Crossing Block (CBWB) and winter LO were planted on November 24, 1982. The spring CB, the spring x spring simple F_1 and the spring x winter F_1 were planted 20 days later to coordinate development for crossing purposes.

A frost that occured in March did not affect to any extent the viability of the crossed seed. Only minor damage was detected when samples were tested for viability. Seedlings that resulted from the viability tests were transplanted into pots in the greenhouse and their reactions to scald and leaf rust recorded. These disease scores are now being utilized for making top crosses at CIANO.

Leaf rust and scald—Extreme drought and low temperatures during the cycle were not conducive to the development of scald and leaf rust. Inoculations with chopped, scald-infected straw and an aqueous spore suspension produced in the laboratory, plus additional sprinkler irrigation resulted in only a mild scald epidemic. Inoculation with fresh spores collected at CIANO produced a late, mild, leaf rust epidemic.

There were no previous disease records on the winter nurseries. This lack of information was responsible for the poor performance of the spring x winter F_1 and F_2 nurseries in the 1982-83 cycles at CIANO; their extreme susceptibility to leaf rust made selection impossible.

In an attempt to correct this, disease scores were taken on the winter material in Toluca to provide a preliminary classification, but more accurate data were required. To provide this, winter lines were artificially vernalized and transplanted to the field in El Batan in the summer 1983 cycle. In Tables 6 and 7, lines resistant to scald and leaf rust from the CBWB are presented.

Russian wheat aphid—This pest (*Diuraphis noxia*) caused severe damage in all nurseries either from its toxin or from the viruses it transmitted. To estimate the severity of its effects, no insecticide was applied in the 1982-83 cycle. Symptoms were scored several times during the season, the two planting dates serving as repetitions. Barberrouse, a French variety, appeared to be resistant whereas Benton and Benton 4D were the most susceptible. All three cultivars are reported to be resistant to BYDV.

Because of the effects of *D. noxia* on the barley nurseries, Toluca will probably have to be eliminated as a winter locality for BYDV resistance testing. It is likely that the same complication will occur in winter plantings at El Batan.

Bacteria—A severe epidemic of bacteria (*Xanthomonas translucens*) developed in all barley nurseries. Lines were scored, and some very susceptible materials were eliminated from the CB. Resistance was also recorded and selections made in the simple F_1. At the moment, bacterial diseases are not considered a major problem in barley, so there is currently limited interest in breeding for resistance.

Summer Cycle 1983: El Batan Experiment Station, Central Mexico

Strategy—Planting dates were sequenced to ensure a spread of selection and disease inoculation times. This meant that the optimum time to inoculate the F_2s was different from that for the F_3s and that the optimum period for selection was spread out rather than all coming in a critically short period. Sequential planting also proved to be a very efficient way of handling segregating material and germplasm that differ in maturity.

Scald epidemic—To ensure good development of scald, susceptible borders were included every 30 double rows, a considerable increase in frequency over previous years. Unfortunately these borders had to be eliminated because they were contaminated with BSMV. A few lines in the CB, LO and miscellaneous group were also discarded because of contamination with BSMV.

Two inoculation methods were used. In the first, chopped straw from scald-infected barley, stored from the previous year, was spread between the rows throughout the field at early tillering. In the second, a suspension of spores in water, extracted from laboratory cultures of diverse isolates, was sprayed over the materials. This was done after rain, late in the day, and was repeated several times. The use of Ultra-low Volume Applicators (ULVA) facilitated uniform coverage of large fields with relatively low volumes of water and inoculum. No special attention was paid to spore concentration because of the frequency of inoculations. The techniques complemented each other and, as a result, a severe epidemic developed on the whole seven hectares planted with barley. Scald scores were taken several times and an accurate evaluation of resistance was possible for most nurseries.

It is essential that cultivars resistant to scald in countries other than Mexico be incorporated in the program. Ethiopia and the southern region of Chile are "hot spots" for scald resistance. Lines resistant in these localities and in Mexico are of particular interest (Tables 8 and 9). However, material showing susceptibility in Mexico but having resistance in Ethiopia will not be discarded.

Scald resistance—The reaction of differential lines to scald at three sites in Mexico is presented on Table 10. The data for the off-station site La Lagunilla is incomplete because winter lines were not planted in this location. Some genes and gene combinations, such as Rh4, present in Magnum and Trebi, and $Rh^{2}4$ Rh2 from Modoc are ineffective against races present in El Batan and Toluca. The recessive genes rh6-rh7 from Jet and rh8 from Nigrinudum were ineffective against races present in Toluca but effective in El Batan and La Lagunilla.

Virulent races present at La Lagunilla under natural conditions were unable to infect any of the twelve lines found to be resistant in Holetta, Ethiopia, but the races present in El Batan and Toluca infected two and three of these lines, respectively (Table 9). The rh8 gene from Nigrinudum is ineffective in Mexico and Chile and will not be used in crossing for these regions. However, rh6-rh7 from Jet, although ineffective in Toluca, provides a good level of resistance in Chile (Table 8). We believe that combining many isolates of scald from many locations within Mexico is important in screening for scald resistance.

Scald yield losses—To evaluate potential yield losses due to scald, a field study was conducted at El Batan. The barley line and three varieties (all resistant to leaf rust) used are listed in Table 11. These were sown in small plots (two, five-meter rows each) with four replicates and were either sprayed with fungicide (protected) or inoculated with scald. The amount of clean grain from each plot and 1000-kernel weights are shown in Table 11. The yield reduction in both the variety Varunda and the line RM1508-Por x Api-CM67 was 39 percent in plots inoculated with scald as compared with those sprayed with fungicide. There was essentially no difference in the yield of the resistant variety Carrizo in the inoculated and protected plots. There was a decrease in the yield of the scald-resistant variety Koru in the unprotected plots but this was thought to be caused by the presence of net blotch.

Yield reduction of this magnitude in scald-inoculated plots demonstrates the importance of this disease in Mexico. It should be stressed that the incidence of scald in this trial, even though the plots were inoculated, was similar to the level that we observed in many farmers' fields in the high plateau. The 16 percent yield increase obtained by spraying Koru suggests that losses caused by net blotch in this area should also be investigated. In addition, these losses highlight the need for breeding for resistance to foliar diseases in barley.

Leaf rust—During 1983, no attempt was made to inoculate leaf rust in the nurseries at Toluca and El Batan, in order to survey the natural virulence spectrum. In the future, leaf rust and scald will be inoculated at both stations.

The lack of leaf rust at El Batan resulted in a greater number of selections being made from the top-crossed F_1, the individually crossed F_2 and the bulked F_2 populations. The number of lines planted at CIANO in the 1983-84 cycle was 1452 from the individually crossed F_2 and 8139 from the individually crossed F_3 populations.

Leaf rust yield losses—To evaluate possible losses due to leaf rust, a field study was conducted at El Batan. The lines and varieties used were:

- 1101.2 MZP x CEL (6-row; leaf rust-resistant),
- BALKAN HOR 991 (6-row; moderately resistant to leaf rust), and
- KENYA 54 (2-row; leaf rust-susceptible).

These were sown in small plots (two, five-meter rows each) with four replicates and were either sprayed with fungicide (protected) or inoculated with rust.

Rust development was slow and late but Kenya 54 did eventually (just prior to senescence) give a score of 60-70S. The results of this trial were further confused because the leaf rust-resistant line used is very susceptible to stem rust and fusarium. In addition, it showed some symptoms of scald in the unsprayed plots. Consequently, even though the leaf rust-inoculated plots of the rust-resistant line showed no leaf rust they yielded 24 percent less than the sprayed check, whereas the inoculated plots of the moderately resistant line (Balkan Hor 991) and the susceptible line (Kenya 54) yielded 16 percent and 34 percent, respectively, less than the sprayed controls. The symptoms these last two lines showed were mainly of leaf rust with only trace amounts of other foliar diseases. It is thought, therefore, that these losses are attributable to leaf rust.

The incidence of leaf rust in these trials was generally higher than that naturally occurring in farmers' fields in the high plateau. However, in some years leaf rust can be severe in this area and the potential losses shown by this experiment emphasize the need for resistant lines and varieties.

Segregating populations—The percentage of bulk-harvested F_2 populations susceptible to scald and leaf rust was larger than it was in the top-crossed F_2s derived from the individually harvested F_1s. The superior resistance of these F_1 nurseries in comparision with the bulk-harvested F_2 populations indicates that the latter were derived from crosses between parents selected without regard for leaf rust and scald resistance. To avoid a similar situation in the future, only the 274 simple F_1s (out of 735) having parents resistant to leaf rust or scald were included in the bulk-harvested F_2s for 1983-84. The simple F_1s that did not have both leaf rust and scald resistance in their parentage were top-crossed widely to produce seed that does have these characters.

A total of 1068 top-crossed F_1s were planted at CIANO in the 1983-84 cycle. Of top crosses made for the Andean region (290 populations), some were sent for planting in Quito, Ecuador, and the rest were planted at CIANO. Fifty to seventy-five percent of the parentage of these populations comes from the Andean region, a factor believed to be important for normal plant development in the difficult soils of this part of the world. Figure 1 illustrates the consequences of these soil problems.

Greenhouse screening—Lines were screened as seedlings for resistance to powdery mildew, net blotch, spot blotch and scald in the greenhouse using the rag-doll technique. In this method seeds of the lines to be tested are placed on a sheet of paper towelling approximately 10 centimeters deep and as wide as is needed for the number of seeds to be tested. The seeds are placed approximately 1.5 centimeters apart and a dilute flour and water paste is applied to stick the seeds to the towelling. The towelling and seeds are then covered with a sheet of water-resistant paper (e.g., wax-coated paper) and then the two sheets are rolled. These rolls, secured with an elastic band, are then stood on end, seeds uppermost, in distilled water. Inoculation is done at the two leaf stage by inverting the roll and immersing it in a water suspension of 20,000 spores per milliliter. A variation of this system is to place the seeds 1 centimeter below the top of a paper towel-lined glassine bag which is opened at the bottom. These bags are then placed in racks, seeds uppermost, in trays that are partially filled with distilled water. Any line found to be resistant in the first test is checked by repeating the proceedure.

This technique was used to test the nurseries listed below for resistance to the following diseases:

- Net blotch: spring and winter CB, spring and winter LO, and PCs.
- Powdery mildew: spring CB, LO, and miscellaneous.
- Scald: bulk-harvested F_2.
- Spot blotch: CB.

Figure 1. Santa Catalina Agricultural Experiment Station, Quito, Ecuador. F_2 population with 50% of its parentage from the Andean region (right) compared to F_2 materials with no Andean germplasm in its parentage (left) growing in acid soils.

This technique worked well for all diseases except scald, in as much as seedling resistance matched, or nearly matched, that found in adult plants in the field (Tables 12 and 13). In the case of scald, the system failed, probably because the inoculum was inviable from having been in culture too long.

A good correlation exists between seedling and adult plant resistance for net blotch, mildew and scald. However, seedling reaction should not be used as the only method to identify resistance. We feel that a combination of resistance screening in the greenhouse and the field will prove extremely valuable to the program.

Early barleys—To test the idea that early barleys do not need to be resistant to leaf rust because their rapid maturation enables them to escape infection, an experiment with 48 lines ranging in maturity from 90 to 110 days was planted at El Batan in 1983. A split plot design was used; three replicates were inoculated with leaf rust and three were sprayed with fungicide. No leaf rust epidemic was produced in spite of several inoculations. This experiment is being repeated at CIANO in the 1983-84 season, where it has been planted late to favor rust development.

This experiment did, however, confirm the yield potential previously reported for early lines from the program. The yields of lines with maturation times of 85 to 100 days at CIANO (under irrigation) and El Batan (rainfed) are shown in Table 14.

The possibility of promoting some of these lines as varieties in Mexico became evident this year, when drought in the high plateau delayed planting until July. The production training program planted some early lines in farmers' fields as late as July 2 and harvested 2.5 tons per hectare in 90 days. Thus, a short season cultivar offers farmers the alternative of planting late or being able to replant a crop and still harvest before frost.

Summer Cycle 1983: Toluca Experiment Station, Central Mexico

Scald epidemic—A severe epidemic of scald was induced by a combination of two techniques: 1) chopped, scald-infected straw, stored from the previous season, was applied between rows at the seedling stage, and 2) a spore suspension in water was applied with an ULVA several times, after the daily rain. Spores were obtained using a simple technique developed by Dr. L. J. Piening of Alberta, Canada (Barley Newsletter, no. 23). With this method, scald-infected leaves are placed in a plastic bag, wet paper tissues are added to supply humidity and the bag is sealed and stored for 24 hours at 15-20°C. One liter of distilled water is then added to the bag after removing the paper tissues and the contents are shaken for a few seconds and decanted to a beaker. Spore production with this method was not high compared to culturing techniques, but no attempt was made to quantify the concentration because repeated applications were made.

This spore production technique is efficient, does not require sophisticated equipment and is easy to use. It also offers the advantage of being able to incorporate new collections, and possibly new races of scald collected from different locations, into the screening program almost immediately. In addition, a preliminary test showed that it gave good sporulation with net blotch. We believe that this technique could be used with a variety of diseases in cereal crops, and that trainees should be exposed to it and encouraged to use it in their national programs because of its low cost.

Toluca proved to be an excellent location for barley screening. In 1983, the nurseries were increased to 2.4 hectares from 1 hectare in 1982, and in the future we would like to increase further the testing at this station.

Selection pressure—Scald resistance and straw strength were the main selection criteria at Toluca. The F_4 produced a much larger number of selected plants than the F_5 or F_6 generations. This was due principally to the greater susceptibility of the latter to scald. Lines of the F_4 that were resistant to both scald and leaf rust and appeared homogeneous were harvested in bulk to be tested for yield at CIANO in the 1983-84 cycle.

In the absence of a leaf rust epidemic, more than the usual number of plants was selected in each scald-resistant line in order to decrease the chances of unwittingly discarding any useful leaf rust resistance. To avoid having to do this in the future, the Toluca barley trials will be inoculated with leaf rust.

Barley yellow dwarf—The reaction of a June planting of F_2s and of susceptible oat lines indicated that by planting late during the summer, Toluca may provide a site for barley yellow dwarf (BYD) selection in Mexico. The symptoms that developed were clearly identifiable and pre-selection for resistance was made in a few F_2 populations. BYD is one of the major diseases of barley in the Andean region and in areas of North Africa but a reliable field screening site has not been available in Mexico. Any means to eliminate susceptible plants in early generations will help in efforts to breed BYDV-resistant germplasm.

The classification of CB entries (Table 15) as either tolerant or resistant to BYDV was made from data obtained by Dr. Comeau in Quebec, Drs. Shaller and Qualset in California, Dr. McEwan in New Zealand and M.C. Conxita Royo in Spain. These scores were compiled from data taken on different nurseries over a number of years. A few entries were resistant at more than one location suggesting resistance to one or more BYDV strains.

Multiple disease resistance—Some entries of the CB are currently classified as resistant to more than one disease. In Table 16, lines resistant to BYDV and stripe rust race 24 are presented. In Table 17, varieties and lines resistant to stripe rust race 24 and net blotch in three locations in Mexico are presented.

Summer Cycle 1983: Off-station Nurseries

Of the four different localities in Mexico at which nurseries were planted for disease observation, La Lagunilla, located 100 kilometers northeast of El Batan, was the most useful. Disease scores of net blotch, scald and leaf rust complement those obtained by artificial inoculation at the CIANO, El Batan and Toluca stations. A powdery mildew epidemic initiated by artificial inoculation in susceptible borders expanded into the nurseries, but unfortunately heavy rains stopped it before full development.

A large proportion of the barley lines screened at this site was resistant to powdery mildew, indicating a narrow virulence spectrum in Mexico.

An epidemic of net blotch in the high plateau showed that the commercial Mexican varieties are susceptible. The CIMMYT barley program has a large number of resistant lines and these are being crossed with Mexican varieties.

The net blotch organism, *H. teres* was found to be producing both netting and spotting at this site. In addition, lesions caused by *Septoria nodorum* were found.

The pathology group planted barley nurseries at the Bajio Agricultural Experiment Station, near El Refugio, in central Mexico, and this site will continue to be used. However, experiments at the Tarascan Mountains Agricultural Experiment Station, near Patzcuaro, in west-central Mexico, provided very little information despite two inoculations with net blotch. This, in addition to its distance from El Batan, is causing a re-evaluation of its usefulness as a testing site for barley.

The Huamantla area, in central Mexico, was dropped as a location for barley observation because of almost complete crop failure in 1982 due to drought. This area may be used as a dryland testing site when CIMMYT's drought tolerant material is a little farther advanced.

International Trials

In order to broaden the basis of its testing, the CIMMYT barley program distributes nurseries containing its most promising lines to cooperators around the world for evaluation under a wide range of conditions. The International Barley Observation Nursery (IBON) consists of the highest-yielding lines of CIMMYT germplasm. The International Barley Yield Nursery (IBYT) includes high-yielding CIMMYT lines plus new entries from any national program that wishes to submit them. These new entries are grown in observation plots at CIANO prior to being entered into the IBYT.

Some modifications of the international trials were made in 1983. Early maturing lines were included in a new nursery named the International Early Barley Observation Nursery (IEBON), and the CBN and CBR were combined into one nursery to be known simply as the CB. The CBQ was eliminated and its components tranferred to the miscellaneous group.

New Releases

Kenya—A candidate for release in Kenya in 1983 as a variety is MPYT 169-2Y. This line is a direct introduction from Turkey that was reselected at CIANO in 1975 and 1976. The line was distributed as entry 41 in the 1977-78 miscellaneous group.

Thailand—Entries 47 and 118 from the second IBON, are being considered for release. These are SD 729-POR (CMB72-204-12Y-1B-0Y) and APAM-DWARF 21(B2-71A-3B-1Y-1B-0Y).

USA—A selection by Dr. Mathias Kolding from segregating populations at CIANO is being promoted as a candidate for release in Oregon. The line is designated FB 75334-3 or (M-3), and can be traced back to cross M66-85/CELAYA.

New Materials

A number of lines have been requested from various barley programs around the world. These have been included in the LO and reports of their reactions to diseases in Mexico are being sent back to collaborators.

Part of the World Collection of Barleys (11,087 entries) sent to CIMMYT in 1976 is being screened for leaf rust resistance in 1983 and 1984. Some lines have been discarded because they were contaminated with BSMV. Leaf rust scores on the material will be sent to Beltsville, Maryland.

Table 1. Lines that showed slow rusting to leaf rust at CIANO in 1982-83.

Line or variety and pedigree	Disease readings* 1	2	3
PI352696			
GAW12.1 22K NAA	1MS	5MS	5MS
BREA"S"-MZQ x DS-APRO			
CMB75A-1413-A-3B-1Y-1B-1Y-1B-0Y	5MS	20MS	20MS
CI3909.2 x M66.151-MANKER/TM-GAS			
CMB76A-382-0AP-2AP-1B-0Y	10MS	10MS	20MS
MZQ-GVA/BCO'MR-MZQ x P71318-M66.85			
CMB77A-282-1B-2Y-1B-1Y-1B-0Y	5MS	20MS	–
TOHN"S"			
CMB79A-1049-C-1Y-1B-0Y	5MS	5M	10M
ZAUZ"S"			
CMB79-1240-D-3Y-1B-2Y-1B-0Y	5S	5MS	20MS
MOU3553			
PI402031	1S	5MS	5MR
11012.2-MZQ x CPL			
CMB77-202-500Y-500B-500Y-0B	00	5MS	10MR
AIA-F3 BULK HIP x H251			
CMB79A-1638-A-500B-2Y-1B-0Y	15S	5MS	–
CFL-XC2240			
OSK-2Y	5MS	5MS	10M
PYE"S"			
CMB78-440-500Y-500B-500Y-0B	5MR	20M	10MR
LB IRAN	1R	1R	10M
MOU59-MOU1 x MOCH			
DII-599-21B	1R	20MS	10MS
CHE			
CI9185	1R	5MR	20MR

Table 1. (Cont'd)

Line or variety and pedigree	Disease readings* 1	2	3
API-CM67 x CM67-GVA CMB75A-131-11Y-1B-1Y-1B-1Y-0B	10S	10MS	10MR
RM150G-POR x API-CM67 CMB75A-1152-5R-1Y-2R-2Y-2B-0Y	5R	20MS	10MR
API-CM67 x EMIR CMB76-64-3Y-1B-1Y-1B-3Y-0B	10MS	10MR	20MS
NOPAL/API-CM67 x MZQ CMB76-288-16Y-1B-1Y-1B-2Y-0B	00	1MR	5MS
FOA"S" CMB77-1476-N-1Y-2B-2Y-1B-1Y-0B	10MS	10MS	20MS
CITA"S" CMB78-500-7Y-1B-1Y-1B-0Y	5S	5MS	5M
HECHO"S" CMB78-916-C-1Y-2B-1Y-500B-1Y-1B-0Y	1MR	10MR	10MS
TOHN"S" CMB79A-1049-B-500B-1Y-0B	1R	1MS	10MS
RANTO"S" CMB79A-1147-A-500B-1Y-1B-0Y	00	5MR	10R
AIA-F3 BULK HIP x H251 CMB79A-1638-A-1Y-1B-0Y	1MR	5MR	10MR
CARINA	10MS	10MS	20MS
GEORGIE	20M	20M	–
HASSAN	5MS	10MR	20MR
HOSTA	00	10MS	20MS
LOGRA	1MS	10MR	20MR
LOFA ABED	1MR	10M	20M

Table 1. (Cont'd)

Line or variety and pedigree	Disease readings* 1	2	3
SUWON20			
09315	00	1R	10R
CI03568	5M	5MR	30MR
ST2.D x MD-BR/ASSE			
CM.B. 4. B. B.	1S	5MR	10MR
ASSE-1206 x N-GERDA			
6402/6006-2-1Y-1B-0Y	5MS	5MR	10MR
RIHANE"S"			
2L-1AP-4AP-1B-0Y	00	1R	20MR
CM67(CER-KI x PRO-TOL I/TL)			
XV-4473-1B-1C-1B-2C-0R	00	5MR	10MR
BEACON-CEL x AVT-ATHS			
ICB307-5L-2AP-0AP-3KE-1Y-0B	15MR	20MR	20MR
LAGUNA	1MR	1R	10MR
CM67-CENTENO x 8855.13			
CMH76A-1018-1B-0Y	5M	10M	10MR
BREA"S"/API-CM67 x II266.L2966.69			
CMB78-70-1Y-1B-1Y-1B-2Y-0B	1S	1S	5MS
API-CM67 x ASSE			
CMB74A-964-1B-1Y-1B-0Y	1MS	5R	10R
BAMBA-CEL/MINN611 x APM-IB65			
CMB74A-1449-B-500R-500Y-500R-0Y	5S	10MS	–
APM-1865 x 70.22429			
CMB75-43-4Y-1B-500Y-0B	15MS	20MR	30MR
API-CM67 x PUE			
CMB75-106-1Y-1B-1Y-1B-2Y-0B	1R	5MS	5R
BREA"S"-CFL			
CMB75-514-500Y-501B-0Y	00	5MR	10MR

Table 1. (Cont'd)

Line or variety and pedigree	Disease readings* 1	2	3
MALA ABED	1S	10MS	10MS
VADA	1M	10MS	5M
TETRA KREUZUNG 1066/5094-1Y-1B-0Y	1MR	5R	10MR
MENUET	1MS	20M	20MS
EMIR-SHABHT x CM67/NGR CMB77-1029-1Y-1B-2Y-2B-1Y-0B	00	10MS	10MR
HOSO"S" CMB78-115-B-1Y-1B-1Y-500B-2Y-0B	1MS	5M	20MS
GSI CI12253	00	00	10MS
EMIR	5MS	5MS	20MS
ORGE4	10MS	20MS	20MS
ORGE1	5MR	20MR	–

* Disease reaction scores according to modified Cobb scale; readings taken at three different times; – = no reading taken

Table 2. Lines with single-gene resistance to leaf rust at CIANO in 1982-83.

Line or variety and pedigree	Disease readings* 1	2	3
API-CM67 x MZQ CMB73A-367-10B-1Y-0B	1MS	1R	1R
JITO"S" CMB79A-1167-B-1Y-1B-0Y	1R	1MS	1M
JRE"S" CMB79A-1184-C-501B-1Y-1B-0Y	1R	1R	5MR
SGDO"S" CMB79-54-4Y-1B-2Y-1B-0Y	00	00	00
SGDO"S" CMB79-54-500B-1Y-1B-0Y	00	00	1R
P. DULCE"S" CMB79A-23-501H-1Y-1B-0Y	1M	1MR	–

Table 2. (Cont'd)

Line or variety and pedigree	Disease readings* 1	2	3
CYPRUSBA	00	1R	1R
CC89	1MR	5MR	5MR
EGYPT20	1R	1R	1R
GIZA119	00	00	00
LIGNEE527 MONTPELLIER	00	1R	1R
LIGNEE640 MONTPELLIER	00	00	00
PRECOZ22	00	00	00
TUNIS	00	00	00
SEL9 AULA DEI	00	00	1R
3309	00	1R	1R
CFR40-4229	00	00	1R
12201-ATHS CYB-34-3A-0A-0A	1S	00	5MR
SHIKKI SHIRAZU(2)-ATTIKI CYB83-0A-0A-8AP-7AP-0AP	1S	1R	5R
GIZA-SHIGA HAKKOKU CR372/4/2-2Y-0B	00	00	00
DEIR ALLA105	00	00	00
PERU	00	1MR	1MR
3309-ATTIKI	1MR	1MR	5MR
MARI-ATHS CYB-4-2A-3A-1A-0A	5MR	1MR	1MR
SAIDA	00	1R	5R
CR270 2.3	00	00	00
CR366 13.1	00	1R	00

Table 2. (Cont'd)

Line or variety and pedigree	Disease readings* 1	2	3
CR366			
13.2	00	00	00
POR-EB1053 x CM67			
CMB72-230-A-501Y-500B-500Y-0B	00	00	1R
M7G-ATHS			
CMB74A-58-2B-2Y-1B-500Y-0B	00	00	1MR
CP-BRA			
CMB74A-10B-3B-1Y-1B-1Y-0B	1R	1R	00
MANKER-ATHS			
CMB74A-333-500B-0Y-501B-0Y	1MR	1MR	1R
CM67-CENTENO x CAM			
CMB75A-1041-2H-2Y-2B-4Y-1B-0Y	00	5MR	5R
COME"S"			
CMB79A-1077-A-501B-2Y-1B-0Y	1MR	1MS	–
ABACUS	00	5R	5R
RAMONA	1MS	10MR	1MR
ROLAND	00	1R	1R
GUDA"S"			
CMB79-376-1Y-1B-1Y-1B-0Y	5MR	1MR	5MR
ARIMAR	00	1R	1R
ESTATE			
DIV. 12259	00	00	00
CROSS270.2.3			
CI4977 x LINE58	00	00	00
TRIUMF	00	1R	–
NADJA	5MR	5MR	–
LG BOLIVIA	1MS	1MS	1MS

* Disease reaction scores according to modified Cobb scale; readings taken at three different times; – = reading not taken.

Table 3. Reaction of barley leaf rust differentials at five Mexican locations during 1982-83.

Differential variety	Resistance gene	Location				
		Patzcuaro	Toluca	Yaqui*	Refugio	Lagunilla
ODERBRUCKER	Pa	80S	TR	–	60S	80S
PERUVIAN	Pa2	R	–	10MR	TS	TMS
RICARDO	Pa2 +?	R	TR	–	TMS	TR
ESTATE	Pa3	–	–	0	TS	R
GOLD	Pa4	20S	–	60S	TMR	TR
LECHTALER	Pa4	80S	–	–	40S	–
MAGNIF 102	Pa5	–	–	–	–	20S
QUINN	Pa5(+Pa2)	R	TR	–	0	R
BOLIVIA	Pa6(+Pa2)	R	–	–	0	R
CEBADA CAPA	Pa7	–	R	–	0	R
EGYPT 4	Pa8	–	–	–	TS	5MR
ABYSSINIAN	Pa9	R	–	–	0	R
TRIUMPH	Pa9	–	–	R	TMR	R

Disease reaction scores according to modified Cobb scale.
* Artificial inoculation
– = no reading taken.

Table 4. Number of lines selected from segregating populations subjected to leaf rust epidemic at CIANO in 1982-83.

Generation	Total number of lines	Number of lines selected	Percent selected
F_4	2082	301	14.4
F_5	876	94	10.7
F_6	361	121	33.5

Table 5. Lines from the 4th Disease and Observation Nursery in Latin America resistant to stripe rust in the Andean region in 1982.

Line or variety and pedigree	Reaction*
PI382798 GAW42.1 14K N GONDAR	00
PI382934 GAW75.5 36K S ADIGRAT	10MS
PI383116 GAW129.1 76K E AMBO	5MS
PI383148 GAW144.3 168K SE AA	5MS
NB2905	10MS
MCU33-FZA x TIB/PI356456 DII-3958-34D	10MS
SMF7 75.36	5MR
DS4886	10MS
LB IRAN	00
CI9650	20MS
BEN 4D	5MR
DS4931	20S
F7 70077 E-II-PP-73-335-25E-2E-1E-3E-2E	10R

Table 5. (Cont'd)

Line or variety and pedigree	Reaction*
BREA"S"-DL70 x MOZDOSKY/NOPAL"S" CMB78-1018-G-1Y-1B-1Y-1B-0Y	10MR
UNA1614	1MS
JET	5MR
NIGRINUDUM	5MR
DOR	00
EMIR	10MR
TRIUMF	00
NADJA	1MR
GAL-PI6384	00
BIGO	5MS
DS4850	00
UNA8270	00
CI3909.2 502Y-500B-501Y-0B	1S
PM5-BEN DII-4118-6D	10MS
DOR/PB-GAL x FUN ESC-II-PP-70-110-3E-3E-8E-1E	1MR
CI3577-124 x CN336/BA-KI E-II-68-222-327-3E-70-74-3E	00
GAL x KI-CI2376(2) II-17060-3E-2E-2E	20MS
CI12823-CI585 x CI9805.16D II-14656-18PV-1T	00
CI12155-ARAMIR II-7915-1PI-1V	00
CI2325-CI12225 x BOY(2)-SURB(3) II-15263-1PT-1V	00

Line or variety and pedigree	Reaction*
DZ02.278	10MS
EH8B FYE L.G.C.	10MS
FOMA-PI14116.2D x CI12225.2D II-15107-1PV-3V	00
ERC14B	00
CI2325-CI12225 x BOY(2)-SURB(3) II-15263-3PT-3V	00
BOY-MCU3048.1D x CI1463.3D II-14127-1PI-5V	00
PI14116.13D-CI12225 x CI12917.37D II-15156-1PV-1PV-1V	00
(CI2375-CI12225 x CAN-MCU29/TIB) CI12225.23D II-14845-3V	00
BOY(2)-SURB(3) x CI12225.2D II-15199-1PV-5V	00
ROW906.73	00
PROCTOR-PRIOR x GOSPICK E-II-69-117-5E-2E-7E	00
ESC. II. 72.83.3E.7E.5E.1E	00
CI14064	1R
CI14100	1R
ESC. II. 72.607.14E.9E.6E	00
UNA8271	00
DC"S" II-17641-1E-1E	00
CI3909.2	00
PI382372 GAW102.7 245K NE JIMMA	5MR
ABED LOFA-ABN DII-2831-2D-24D	00

Table 5. (Cont'd)

Line or variety and pedigree	Reaction*
CI361.16D x MCU3021-MOCH II-14052-6PV-9V	00
CI1240-FOMA x CI6238.15D II-15099-2PT-5V	00
CI10622-CI5824 II-11720-11V-1B	00
CI10622-CI5824 II-11720-11V-2B	00
CI10622-CI5824 II-11720-11V-3B	00
PI382720 GAW24.3 142K N AA	00
KOB CI3948	1MS
BREA"S"-BEN CMB75-522-4Y-500B-0Y-500B-0Y-500B-501Y-0B	5MS
BEN	00
ABN CI2376	00
DUCHICELA	5MS
BOY-MOCH x BOY-MCU3048.1D II-14963-1PI-2V	00
CI12225.12D x MCU3021-MOCH II-14089-1PI-3V	00
PI14116.2D-CI12172 x CI12225.23D	00
MCU3021.5D-BEN x MCU3021-MOCH/CI1361.16D II-15822-7V	00
ERECTOIDES23-GAL E-II-69-95-3E-1E-1E	1MS
UNA80	00
TAL	5MR
TERAN78	1MS

* Modified Cobb scale

Table 6. Winter barley cultivars resistant to *R. secalis* at two Mexican locations in 1982-83.

Line or variety and pedigree	Reaction*	
	El Batan	Toluca
LAKELAND** CI-734	R	2
ILL 62.19	R	T
WISC.W.-GLABRON	R	0
ALASKA	R	2
MOULIN	R	0
ALPHA	R	T
FOHELZANHEZHOLD	R	T
FB 73 607D35	R	0
FB 74 506.08	R	T
AGER	R	T
HENRY	R	T
MAURY	R	T
DOMINA	R	2
VICTORIA	R	2
SCHUYLER	R	2
PENRAD	R	0

Table 6. (Cont'd)

Line or variety and pedigree	Reaction* El Batan	Reaction* Toluca	Line or variety and pedigree	Reaction* El Batan	Reaction* Toluca
OMUGI-BORD. RANQ L.2	R	T	FORRAJERA DE INVIERNO	T	T
OMUGI-BORD. RANQ L.4	R	T	FB 73.108	R	–
MS 2878 AK 28 89.1	R	0	WY 6005.18	R	0
B 3176	R	1	F1 HJ17-MARIS OTTER F7 HJ33-221-4R-3	R	0
HB 855-467 x ALPHA F5 HJ56-202.15	R	0	COSSAK	R	0

* Scales: El Batan-- R = resistant, T = trace; Toluca--0-9, T = trace; – = no data.
** Resistant to scald (3) in Carillanca, Chile

Table 7. Winter barley cultivars resistant to *P. hordei* at two Mexican locations in 1982-83

Line or variety and pedigree	Reaction* El Batan	Reaction* Toluca	Line or variety and pedigree	Reaction* El Batan	Reaction* Toluca
HURON	5MR	5M	SARUTONG	5S	MR
CASBON	5S	5S	ALPINE CI 9578	5MR	5M
MONROE	0	TM	FORRAJERA KLEIN	–	TR
BORD. DANQ-JONGU B641-F7-14-70	10M	5M	MARIS MINK	TR	5MS
LA ESTANZUELA 757-RIKA	–	TMR	BP.21 LAKELAND WB 5.51	TR	TMR
QUINN	TR	TR	CLAUDIA	–	TMR
EMIR"S"-ANCA N 8582-1692	–	5S	HENRY	0	TM
MLN 140-FELDA 7117-1606-12	TR	5MR	MAURY CI 15692	TR	TM
MILN 140.41 x 9845-7007 8445-7186	TR	5MR	DOMINA	TS	5MS
ARMELLE	5R	10MS	JEFFERSON	15MS	TR

* Modified Cobb scale; – = no data.

Table 8. Materials resistant to scald in Mexico and Chile and to stripe rust in the Andean countries in 1983.

	Scald				Stripe rust		
	MEXICO			CHILE	CHILE	ECU	BOL
Line or variety and pedigree	Bat	Lag	Tol	Car	Car	Quito	Coch
PI 382798	–	R	MR	2	R	–	–
PI 382934	R	R	R	0	–	10MS	10MS
PI 383116	R	R	R	1	R	5MS	–
PI 383148	R	R	R	0	MR	5MS	–
NB 2905	R	R	R	0	R	10MS	–
MCU33-FZA x TIB/PI 356456							
DII-3958-34D	R	R	MS	1	R	10MS	–
SM F7							
75.36	R	R	MR	1	–	5MR	–
DS 4886	R	R	MR	0	R	10MS	–
L.B. IRAN	–	R	R	2	R	R	–
CI 9650	R	T	R	5	R	20MS	–
BEN. 4D	R	R	R	4	R	5MS	TR
DS 4931	R	R	R	2	R	20S	–
F7 70077							
E-II-PP-73-335-25E-2E-1E-3E-2E	R	R	R	–	–	–	*
BREA"S"-DL70 x MOZDOSKY/NOPAL							
CMB78-1018-G-1Y-1B-1Y-1B-0Y	MS	R	MR	3	–	10MR	0
UNA 1614	R	R	R	0	R**	–	TMS
JET	R	R	S	2	–	5MR	5MR
NIGRIDUDUM	R	R	S	7	–	5MR	TMS

Bat = El Batan　Car = Carillanca　Coch = Cochabamba
Lag = La Lagunilla　Ecu = Ecuador
Tol = Toluca　Bol = Bolivia
Rust reactions scored according to modified Cobb scale.
Scald reactions: Mexico-- T = trace, R = resistant, S = susceptible, M = moderately; Chile-- 0–9 scale
— = no data taken.
* La Platina (Chile)
** Score lower than 20MR-MS in Cochabamba, Bolivia

Table 9. Scald reaction at three Mexican locations of material resistant to scald at Holetta, Ethiopia, in 1983.

Line or variety and pedigree	Reaction*		
	Batan	Lagunilla	Toluca
CON"S" CMB74A-967-6M-2Y-1B-1Y-1B	MR	0	MR
PI 383195 GAW151.2 175K SE AA	R	–	–
EH165 F3-3-8H	R	R	R
76.12.3 1B-1Y-0B	R	R	R
USDA 11122	R	R	MR
LITTLE BEN CI4686	R	R	MS
EH163 F3-45-3H-3-3	R	R	R
PERU	S	R	MS
I1258 L2171 7Y-0B	VS	R	VS
GOB"S" CMB78-1176-B-3Y-1B-1Y-1B-0Y	R	R	R
BREA-BENTON CMB75-522-4Y-500B-0Y-500B-0Y-500B-501Y-0B	R	R	MR
DUCHICELA	R	R	MR

* M = moderately, V = very, R = resistant, S = susceptible, 0 = no reaction. – = no data taken.

Table 10. Reactions of differential barley lines to scald at three Mexican locations during 1983.

Differential variety	Resistance gene	Reaction*		
		El Batan**	Toluca**	Lagunilla
ARMELLE	Rh	R	R	R
ATLAS	Rh2	R	R	R
ATLAS 46	Rh3	R	R	R
WISCONSIN WINTER x GLABRON	Rh3	R	R	–
MAGNUM	Rh4	TR	MS	–
TREBI	Rh4	MS	–	–
OSIRIS	Rh4 Rh10	R	R	R
MODOC	$Rh^2 4$ Rh^2	MS	S	–
JET	rh6-rh7	R	S	R
NIGRINUDUM	rh8	R	S	R
KITCHIN	Rh9	R	R	R
HUDSON	Rh	R	R	–

* T= trace, R = resistant, S = susceptible, M = moderately, – = no data taken
** Artificial inoculation

Table 11. Plot weights and 1000-kernel weights of four barley lines inoculated with scald or sprayed with fungicide at El Batan in 1983.

Line or variety	Scald susceptibility	Type	Sprayed		Scald - inoculated	
			Plot weight (g)	1000-kernel wt (g)	Plot weight (g)	1000-kernel wt (g)
KORU	resistant	2 - row	3731	43.50	3140*	37.72*
CARRIZO	resistant	6 - row	2145	41.98	2164	41.30
VARUNDA	susceptible	2 - row	2841	44.73	1722**	34.95**
RM1508-POR x API-CM67	susceptible	6 - row	3115	39.83	1903**	34.10**

wt = weight
* Significant at the 5% level
** Significant at the 1% level

Table 12. Lines resistant to net blotch at El Refugio, La Lagunilla and in the greenhouse.

Line or variety and pedigree	Reaction* GH	Ref	Lag
BREA"S"-DL70 CMB75-526-1B-1Y-1B-1Y-1B-0Y	2	4	–
ARUPO"S" CMB79-1312-F-3Y-1B-1Y-2B-1Y-0B	2	–	–
BURK(2)-APRO x 11016.2/BREA"S" CMB75A-190-500Y-501B-0Y-500B-0Y	2	2	T
EH163 F3-45-3H-3-3	2	1	T
EH11 F3.A.1.B.L.	2	3	–
KC CI1296	2	3	T
EH11 FB/NYT-1979.F3.A.1.B.L.	2	3	T
CM67(CER-KI x PRO-TOLI/TP) XV-4473-1B-1C-1B-2C-0R	2	4	–
ARIMAR	2	1	T
ESTATE DIV. 12259	2	2	T
GSI CI12253	2	1	0
CROSS270.2.3 CI4977 x LINE5B	2	2	T
DS4850	2	3	T
CI14064	2	–	T
CI14100	2	–	T
ESC. II. 72.607. 14E. 9E.6E	2	2	T
UNA8271	2	T	T
UNA8465	2	4	T
DC"S" II-17641-1E-1E	1	4	T
K8755	2	T	T
CI3909.2	2	4	T
PI382372 GAW102.7 245K NE JIMMA	2	3	T
M6-ROBUR. 35.6.3	2	3	–
MD-ATL x CM.B.4.2.1.B.B.	1	1	–
COSMO"S" CMB74A-1304-A-1B-3Y-1B-1Y-1B-0Y	1	1	–
TB-CHZO CMB75A-377-1B-500Y-0B-500Y-0B	1	4	T
NANCHE"S" CMB77-1240-B-500Y-501B-501Y-0B-501B-0Y	1	1	–
HUIZ/DWG1-API(3) x 5107 CMB78-62-2Y-1B-1Y-1B-2Y-0B	1	1	R
AMAPA"S" CMB78-276-2Y-1B-1Y-1B-3Y-0B	2	4	T
GALT-11012.2 x CH-DU CMB78-552-1Y-1B-1Y-1B-0Y	1	3	T
NOHA"S" CMB78-884-F-2Y-2B-1Y-1B-2Y-0B	2	4	TS

Table 12. (Cont'd)

Line or variety and pedigree	Reaction* GH	Ref	Lag
11012.2-TERN x ASSE-NACKTA/SI CMB78-961-F-500Y-500B-500Y-503B-0Y	2	4	R
CI5791	2	3	T
CEDRO"S" CMB77-1267-B-1Y-1B-1Y-1B-1Y-1B-0Y	2	1	R
CM72	2	2	–
MANKER x API-CM67 CMB75-277-500Y-0B-500Y-0B	1	1	T
DS4887	2	3	T
PI382720 GAW24.3 142K N AA	2	3	T
KOB CI394B	2	2	T

GH = greenhouse, Ref = El Refugio, Lag = La Lagunilla.
– = no data taken.
* Scale: Greenhouse, 0-5; El Refugio, 0-9; La Lagunilla, 0 = no infection, T = trace, R = resistant, S = susceptible.

Table 13. Lines resistant to powdery mildew in Lagunilla and in the CIMMYT greenhouse (seedling test) in 1983.

Line or variety and pedigree
ARUPO"S" CMB79-1312-F-3Y-1B-2Y-1B-1Y-0B
ARUPO"S" CMB79-1312-F-1Y-1B-2Y-1B-1Y-0B
ARUPO"S" CMB79-1312-F-1Y-1B-1Y-1B-1Y-0B
ARUPO"S" CMB79-1312-F-3Y-1B-1Y-2B-1Y-0B
ASSE-NACKTA 3699/3002-1B-1Y-1B-0B
ARAMIR
NACKTA-CVA CMB74A-1180-500M-500Y-500B-0Y
135-ARAMIR x ROBIN-ZEPHYR/ASSE-566.30.1.2
MASURKA
NOHA"S" CMB78-884-F-2Y-2B-1Y-1B-3Y-0B
AS
AS46
AS57
C63
MASSEY1980 HERRELS
OSR
WD CI1021
PO/KI-BA(3) x MC
REMO"S" XV9054-5R-3C-3R-ORV-1Y-1B-0Y

Table 13. (Cont'd)

Line or variety and pedigree
GAS-ORE"S" CMB75-303-1Y-2B-1Y-1B-3Y-0B
RHODES"S" CMB78A-569-1B-1Y-500B-500Y-500B-0Y
RILLO"S" CMB79-1375-C-3Y-500B-502Y-500B-0Y
ALGER-UNION 385.2.2
WI2269
P. DULCE"S" CMB79A-23-501H-1Y-1B-0Y
BFL"S" CMB79A-1267-B-500B-1Y-1B-0Y
AVT-TOL I x COMPLEX CROSS TA76-77-F2-1701-1AP-2AP
KORU
PYE"S" CMB78-440-500Y-500B-501Y-501B-0Y
PYE"S" CMB78-440-500Y-500B-500Y-500B-0Y
GLDA"S" CMB79-376-1Y-1B-2Y-0P
DS4886
NIGRINUDUM
CHE CI9185
LIGNEE527 MONTPELLIER
LIGNEE640 (MONTPELLIER)

Line or variety and pedigree
SUWON20 09315
CI03568
ASSE-1206 x N-GERDA 6402/6006-2-1Y-1B-0Y
RIHANE"S" 2L-1AP-4AP-1B-0Y
API-CM67 x EMIR CMB76-64-3Y-1B-1Y-1B-3Y-0B
RANTO"S" CMB79A-1147-A-500B-1Y-1B-0Y
N. ACC4000.301.80
CARINA
HOSTA
LOGRA
RAMONA
ROLAND
MENUET
GLDA"S" CMB79-376-1Y-1B-1Y-1B-0Y
GSI CI12253
EMIR
TRIUMF
NADJA
GAL x KI-CI2376(2) II-17060-3E-2E-2E
CI12155-ARAMIR II-7915-1PI-1V

Table 13. (Cont'd)

Line or variety and pedigree
CI120622-CI5824 II-11720-11V-1B
CI10622-CI5824 II-11720-11V-2B
TAL
FOMA-PI14116.2D x CI12225.2D II-15107-1PV-3V
UNA8271
NACKTA-HJA A33 CMB76A-261-1B-1Y-1B-1Y-1B-0Y
FRESNO"S" CMB77A-454-1B-500Y-500B-501Y-502B-0Y
NACKTA 501Y-502B-500Y-0B
FRESNO"S" CMB77A-454-1B-500Y-500B-501Y-500B-0Y
M6-ROBUR.35.6.3
MD-ATL x CM.B.4.2.1.B.B.
ROBUR-142 x ASTRIX-SUTTER332.1
563 x SCOTIA-STEPTOE901
ORGE4
ORGE1
MARIS CANON
UC566

Table 14. Yield of some early barley lines at El Batan (rainfed) and at CIANO (irrigated) in 1982-83.

	Yield (t/ha)		Days to maturity	
Line	El Batan	CIANO	El Batan	CIANO
MARI/COHO//Row 134.73 CMB 79-7Z-5Y-3B-2Y-2B-1Y-0B-1B	3.9	2.6	85	95
MONA/MZQ//DL71 CMB 77-383-37-1B-2Y-1B-3Y-0B	4.7	–	90	90
APAM/RL//BCO. MR/GVA CMB 75-38-16Y-1M-1Y-2B-1Y-0B	4.1	4.1	90	95
MONA/BEN//IMPALA/2/CI12173 CMB 79-588-8Y-2B-2Y-1B-1Y-0B	4.3	3.7	100	100
MONA/GWY 63//B1 CMB 77-302-4Y-3B-2Y-1B-1Y-0B	5.0	–	90	95

Table 15. Lines in the 1983-84 crossing block resistant* to BYDV at various locations.

Line and pedigree	Location**
H251 500Y-500B-500Y-0B	New Zealand
PI382696 GAW12.1 22K NAA	New Zealand
CEN x 2762-BC CMB77A-462-1B-3Y-2B-1Y-1B-0Y	Spain
BEN. 4D	New Zealand
UNA1614	California
DOR	California
MCU33-FZA x TIB/PI356456 DII-3958-27D	Quebec
CEN x 2762-BC CMB77A-462-1B-3Y-2B-1Y-1Y-0Y	Spain
CI2325-CI12225 x BOY(2)-SURB(3) II-15263-3PT-3V	California
BOY-MCU3048.1D x CI1463.3D II-14127-1PI-5V	California
PI14116.13D-CI12225 x CI12917.37D II-15156-1PV-1PV-1V	California
(CI2375-CI12225 x CAN-MCU29/TIB) CI12225.23D II-14845-3V	California
BOY(2)-SURB(3) x CI12225.2D II-15199-1PV-5V	California
ROW906.73	California
PROCTOR-PRIOR x GOSPICK E-II-69-117-5E-2E-7E	California
ESC.II. 72. 83. 3E. 7E. 5E. 1E	California
CEDRO"S" CMB77-1267-B-1Y-1B-1Y-1B-1Y-1B-0Y	New Zealand
CM72	California, New Zealand
MANKER x API-CM67 CMB75-277-500Y-0B-500Y-0B	Quebec
SUTTER	Quebec, California
PROMESA	California, Quebec
79W40762	California, Quebec, Spain
79W41762	California, Quebec, Spain

Table 15. (Cont'd)

Line and pedigree	Location**
79AN-MN I23-NV-1B-0Y	Quebec
M66.85-ATHS/API-CM67 x DS-APRO CMB75A-1617-A-7B-500Y-500B-0Y	Quebec
API-CM67 x AGER CMB76-408-27Y-1B-4Y-1B-1Y-0B	Quebec
U. SASK HARVEY143-BAL16/BCO. MR-AVT x CEL CMB76A-1007-D-1B-2Y-1B-1Y-2B-0Y	New Zealand
U. SASK HARVEY144-BAHTIM10 x CEL-CI3909.2 CMB76A-1008-B-5B-2Y-1B-1Y-3B-0Y	New Zealand
YOA"S" CMB77-125-1Y-1B-1Y-2B-1Y-0B	New Zealand
BREA"S"-SUTTER x F3 BULK HIP CMB79A-1062-C-501B-1Y-1B	New Zealand
OJL"S" CMB79A-1362-B-501B-1Y-1B	New Zealand
OJL"S" CMB79A-1362-B-501B-3Y-1B	New Zealand
P. STO"S" CMB79A-1524-D-500B-1Y-1B	New Zealand
POCHE"S" CMB79A-1536-A-2Y-1B	New Zealand
YORI"S" CMB77A-402-1B-1Y-4B-3Y-1B-0Y	Spain
PI2325-MAF102 x COSSACK CMB78-452-2Y-1B-1Y-1B-1Y-0B	Spain
KOB CI3948	New Zealand
BREA"S"-BEN CMB75-522-4Y-500B-0Y-500B-0Y- 500B-501Y-0B	Quebec, New Zealand
BEN	New Zealand, California
ABN CI2376	New Zealand
DUCHICELA	New Zealand
60 BARBEROUSSE	Spain

* based on one to four readings
** Quebec, Canada; Lerida, Spain; California, USA.

Table 16. Germplasm resistant to BYDV at various locations and to stripe rust race 24 in the Andean region.

Line or variety and pedigree	BYDV Location*	Stripe rust Reaction**	Stripe rust Location
BEN 4D	New Zealand	5MR	Ecuador, Chile Bolivia
UNA1614	California	1MS	Chile, Bolivia
DOR	California	R	Chile, Bolivia
CI2325-CI12225 x BOY(2)-SURB(3) II-15263-3PT-3V	California	R	Bolivia
BOY-MCU3048.1D x CI1463.3D II-14127-1PI-5V	California	R	Bolivia
PI14116.13D-CI12225 x CI12917.37D II-15156-1PV-1PV-1V	California	R	Bolivia
(CI2375-CI12225 x CAN-MCU29/TIB) CI12225.23D II-14845-3V	California	R	Bolivia
BOY(2)-SURB(3) x CI12225.2D II-15199-1PV-5V	California	R	Chile, Bolivia
ROW906.73	California	R	Bolivia
PROCTOR-PRIOR x GOSPICK E-II-69-117-5E-2E-7E	California	R	Bolivia
ESC. II. 72.83.3E.7E.5E.1E	California	R	Bolivia
KOB CI3948	New Zealand	1MS	Chile, Bolivia
BREA"S"-BEN CMB75-522-4Y-500B-0Y-500B-0Y-500B-501Y-0B	New Zealand, Quebec	5MS	Ecuador
BEN	New Zealand, California	R	Chile, Bolivia
ABN CI2376	New Zealand	R	Chile, Bolivia
DUCHICELA	New Zealand	5MS	Chile, Bolivia

* California, USA; Quebec, Canada.
** Modified Cobb Scale.

Table 17. Materials resistant to stripe rust race 24 in the Andean region and to net blotch in Mexico.

Line or variety and pedigree	Net blotch*			Stripe rust	
	Lagunilla	Refugio	Greenhouse	Reaction**	Test location
CI 14064	T	–	2	TR	Bolivia
CI 14100	T	–	2	TR	Bolivia
ESC 1172.607 14E-9E-6E	T	2	2	R	Chile
UNA 8271	T	T	2	0	Peru
DC"S" II-17641-1E-1E	T	4	1	R	Chile
CI 3009.2	4	T	2	R	Chile
PI 382372 GAW 102.7 245K NE JIMMA	3	T	2	5MR	Ecuador
ABED LOFA-ABN DII-2831-2D-24D	T	5	2	R	Chile

* Scale: Lagunilla and Refugio, 0-9, T = trace; greenhouse, 0-5.
** Modified Cobb scale.
— = data not taken.

Pathology and Disease Surveillance

J. M. Prescott, G. Bekele and P. A. Burnett

Introduction

Conservative estimates of damage or loss due to small grain cereal diseases average 10-15 percent of total crop production worldwide and losses of 100 percent for specific diseases in specific locations are possible under epidemic conditions. There are more than 40 species of fungi, bacteria and viruses that attack wheat and triticale. CIMMYT is interested in all of them, especially those that cause major problems in yield stability.

In Mexico, CIMMYT has active research programs on leaf, stem and stripe rusts, septoria glume and leaf blotches, helminthosporium leaf spots and root rots, Karnal bunt, loose smut, head scab, fusarium leaf blight, bacterial leaf blight, and barley yellow dwarf. Through cooperative programs with national cereal improvement projects and universities, similar and/or additional research activities are conducted. In addition, the world-wide Disease Surveillance Project is operated from CIMMYT's Mexican base. The activities in Mexico include:

- basic research on the causal agents of the major diseases.
- multiplication, collection, storage and reinoculation of the major diseases to assist our breeders in screening newly developed germplasm.
- disease monitoring and surveillance.
- working with the international nurseries program to control seed-borne diseases and to screen advanced lines for resistance.
- training young scientists from developing countries.

The Rusts

Leaf, stem and stripe rusts are cereal diseases of major economic importance on a worldwide basis. In 1981-82 the 15th International Bread Wheat Screening Nursery (IBWSN) was sent to 147 cooperators in 82 countries. The 206 advanced lines and checks in the nursery had been chosen from among CIMMYT's best materials in a high-yield environment with severe selection pressure for rust resistance. Data from sites with adequate rust screening levels were received from 27, 23, and 23 locations for leaf, stem and stripe rusts, respectively. There were numerous resistant lines with coefficients of infection as low as 1.0 (on a scale of 0-100) for each of the rusts. Detailed information about these entries are available from CIMMYT upon request. Ten lines with low coefficients of infection for leaf, stem, and stripe rust are presented in Table 1.

Many of the rust "hot spots" that were used to screen the IBWSN material in 1982 are located in South America, the highlands of East Africa, and the Middle East. It is of interest to note that 14 percent of the entries had a coefficient of infection of 1.0 or less for stem rust. This clearly reflects the intensive and long-term effort of CIMMYT to incorporate resistance to this disease into bread wheat.

In 1983, a major effort was initiated to increase the level of virulence of the rusts in our bulked field inoculum, in order to improve further the selection pressure on segregating generations. The method employed involved growing the 20 lines most commonly used in the crossing blocks of each crop improvement program in the greenhouse, inoculating these plants with bulked rust spore collections from many parts of Mexico and collecting spores separately from any rust pustules that developed. These "special urediospores" were then reinoculated onto the same line on which they were produced to multiply these low frequency virulence types. Following multiplication, the special urediospores were mechanically mixed with our field-collected urediospores to make up a new bulk inoculum. It is felt that if we continue to follow this procedure and add new biotypes obtained from surveys and

Dr. J.M. Prescott (left) and Dr. G. Bekele (right) of the pathology program.

greenhouse virulence analyses, the level of rust resistance in our germplasm will improve.

Septoria Glume and Leaf Blotch

Several years ago, a decision was taken to incorporate resistance to septoria glume and leaf blotches into all material in all crop improvement programs. The probability of success for this broad, sweeping endeavour is quite high due to the 1) availability of good levels of resistance in the germplasm, 2) severe selection pressure on the germplasm at the Toluca Experiment Station with artificially created epidemics, and 3) strong selection pressure on the selected material at the Tarascan Mountains Agricultural Experiment station, near Patzcuaro in west-central Mexico, under natural conditions.

At the Toluca station, excellent infection levels of both glume and leaf blotches are artificially produced by 1) spreading large quantities of infected straw from the previous crop over the research plots about one month after planting and 2) spray inoculation at the mid-joint growth stage with laboratory-produced inoculum containing special or new virulence types collected around Mexico. In this way a pathogen population that includes the same virulence genes as in the previous year's tests, along with potentially new virulence genes found at other locations in Mexico, is insured.

The 12th International Septoria Observation Nursery (ISEPTON) contained 180 varieties or advanced lines selected for their resistance to both *Septoria tritici* and *S. nodorum* at the Toluca and Patzcuaro stations. Sixty sets of this nursery were sent to cooperators in 42 countries. Reports have been received from 37 cooperators but only 17 locations were summarized. The other locations had little or no disease. Entries with an average score of 5.0 or less on the 0-9 scale, indicating that the disease was found only on the lower half of the plant, are listed in Table 2.

Helminthosporium Leaf Spot Diseases

These diseases are often severe in the warmer, more humid lowlands of the world. The two organisms most often involved are *Cochliobolus sativum* (syn. *Helminthosporium sativum*) and *Pyrenophora trichostoma* (syn. *H. tritici-repentis*) causing spot blotch and tan spot, respectively.

CIMMYT has developed a two phase system to select for resistance to these diseases. The first phase consists of greenhouse seedling tests in which large quantities of material from segregating populations and advanced lines can be rapidly screened for resistance. This procedure is used to reduce the amount of material to be tested further or to preselect material for field testing. The second phase involves growing the preselected lines in the field at the Poza Rica Experiment Station, located in a warm, humid, coastal area near Veracruz on the Gulf of Mexico, where foliar diseases are always severe.

Of a total of 7200 segregating populations and advanced lines that have been tested, 43 advanced lines of bread wheat and 59 lines from crosses between bread wheat and *Elymus giganteus*, *Agropyron distichum* and *Agropyron elongatum* have been identified as having good levels of resistance. Seed of these lines is available from CIMMYT on request.

Scab

Head scab is caused by several species of the genus *Fusarium* and is one of the most prevalent disease problems in southern China, Korea, Zambia, Brazil, Paraguay, Argentina, and the Pacific Northwest of the United States. In the Mexican highlands, at Toluca, Patzcuaro, and to a lesser extent at the El Batan Experiment Station near Mexico City, head scab occurs naturally on wheat. When wheat grown at these locations is artificially inoculated, adequate screening for scab resistance is nearly assured.

In the 1983 summer crop cycle, over 3000 advanced lines from the wheat and triticale programs were screened for resistance to scab at Toluca. In addition, segregating populations of bread wheat, created for scab resistance, were also tested. Three different methods of inoculation were used to determine the one most efficient for screening a large amount of material: 1) spray inoculation with a water suspension of conidia, 2) specific point inoculation utilizing a small piece of cotton soaked in a conidial suspension, and 3) scattering infected, nonviable wheat seed on the soil surface of plots containing the test material. At Patzcuaro, 1000 advanced lines identified as being resistant at Toluca in previous tests, and 21 highly resistant lines from China were also planted for retesting in this environment. Only the spray inoculation method was used at this location.

Scab development at both locations was excellent and maximum disease development was achieved 42 days after inoculation. In the experiments at both locations, including the different methods of inoculation, there was no difference in the disease level attained. Disease scoring utilized a 0-5 scale where 0 was immune; 1, highly resistant; 2, tolerant; 3, moderately susceptible; 4, susceptible and 5, very susceptible; 0-2 were acceptable scores and 3-5 unacceptable.

It was possible to select highly resistant and tolerant material at both locations. At Toluca, 564 advanced lines were selected; at Patzcuaro, only 198 lines were selected. It is interesting to note that all 198 lines selected at Patzcuaro were also selected at Toluca. The 21 lines from China were highly resistant at both locations. The 198 lines selected at both locations plus the 21 lines from China were included in the Third International Scab Screening Nursery (ISSN) and are available to interested cooperators upon request.

Karnal Bunt

Karnal bunt of wheat was first reported by Mitra at the Botanical Research Station in Karnal, Haryana, India, in 1930. There were only infrequent reports of its occurrence in northwest India between 1930 and 1968. In the mid 1960s, India initiated a major campaign to increase wheat production by means of improved crop management, utilizing more fertilizer, planting high-yielding varieties, increasing irrigation, etc. The incidence of Karnal bunt also began to increase about this time, probably due to the altered agronomic practices and field environment. However, even though the disease has increased, India's wheat production has increased from about ten million tons in 1965 to over forty million tons in 1983. Karnal bunt is now present in most parts of northwest and north central India, the Punjab area of Pakistan, and southern Nepal.

Karnal bunt was first reported in Mexico in 1971 in the Yaqui Valley area of the northwestern state of Sonora. The disease was rarely reported during the period 1971-1981 but began to increase in 1982 and became fairly widespread in the Yaqui and Mayo Valleys in the state of Sonora in 1983. Research on Karnal bunt in Mexico has been under way as a joint effort by the National Institute of Agricultural Research (INIA) and CIMMYT since 1979. The higher levels of Karnal bunt in 1983 plus the increased interest by North American scientists brought the Agricultural Research Service of the U.S. Department of Agriculture (USDA-ARS) into the cooperative research project and resulted in the initiation of a special project by the USDA-ARS at Frederick, Maryland. There are also several research projects under way in both India and Pakistan.

The pathogen—There is some controversy over the proper scientific name of the organism causing Karnal bunt. Some researchers know it as *Tilletia indica* and some know it as *Neovossia indica*. This should be settled soon as the present situation will lead to confusion in the literature. The morphology of the fungus is constant: The teliospores are spherical to oval, with articulations; they measure 22-49 microns in diameter, with about 35 microns the average. A thin, hyaline membrane surrounds the spores and this epispore persists even when the spores are mature. There are also sterile cells present in teliospore samples.

Germination—Freshly harvested teliospores do not germinate well; there appears to be a dormancy period of one to six months. Even after this, teliospore germination is often only 10-40 percent. Upon germination, a short (less than 2 mm long) promycelium is formed, which then produces a tuft of primary sporidia at its distal end. These primary sporidia, in turn, produce secondary sporidia. The primary and secondary sporidia, plus mycelial fragments, are the infectious units. Since the promycelium stage is essential, it is likely that only those teliospores on or very near the soil surface contribute to disease establishment. Germination is favored by a pH between 5.5 and 8.5 and occurs under both light and dark conditions, but appears to be enhanced by light.

Infection—Infection occurs by direct penetration of the ovary wall or by first passing through the lemma and then progressing onward to the ovary wall. The disease is confined to the ovary wall and later the endosperm; it does not attack the embryo. For infection to occur, cloudy days with high humidity, free water and dew periods longer than 12 hours appear necessary, so that the infectious units do not dry out.

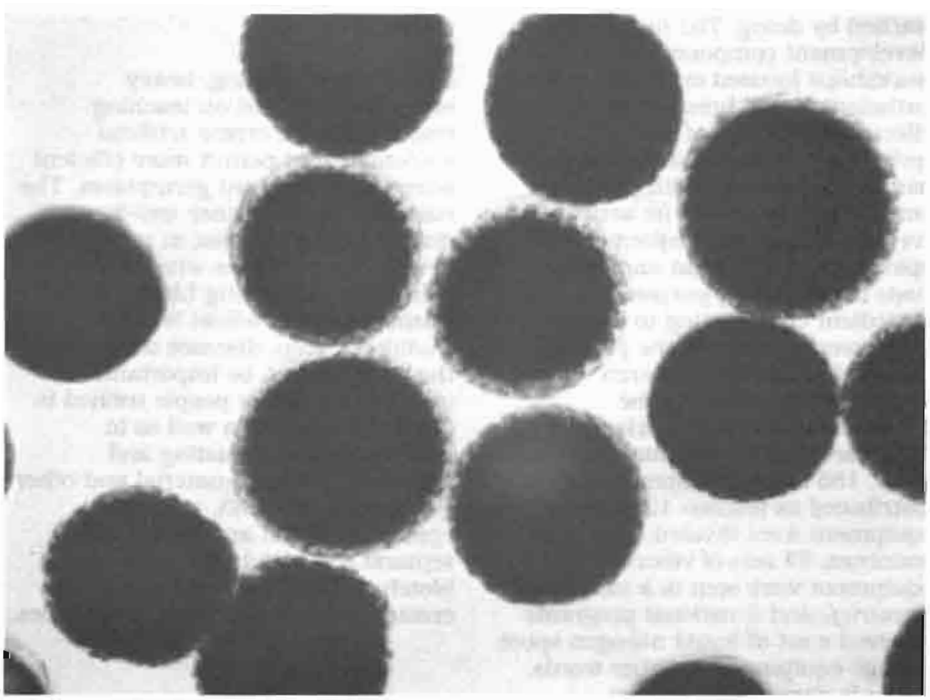
Chemical control—The cooperative program here in Mexico is mainly investigating two approaches to control: genetic resistance and chemical control.

Thirty-one chemicals (systemics, heavy metals, and organic compounds recommended for bunts and smuts) were screened in the laboratory for efficacy as seed treatments for control of *Neovossia indica*. Of these, 16 effectively inhibited teliospore germination, including Botran, Ceresan, copper carbonate, copper sulfate, Demosan, Dithane, Du-Ter, Granox, Guardsan 389, Maneb 80, Panogen, Sibutol, Terrazan F, Terrazan 75PH, Trigan S and Thylate 75. Longevity of the effect of the chemicals was also determined by testing the germination of teliospores at 24 hours, one week, one month, two months, four months and six months after chemical application. To determine whether a treatment influenced seed germination, seed germination tests were conducted at the same time. Chemicals that showed effective inhibition of *N. indica* teliospore germination are being retested at a range of application rates. Preliminary data indicate that Botran, Ceresan, Manzate, Panogen and Terrazan 75PH are effective over a wide range of application rates.

A number of systemic fungicides were included in the laboratory tests to determine which chemicals had potential for Karnal bunt control and consequently should be included in field evaluations. However, the laboratory tests utilized were not reliable because systemic fungicides often affect the fungus during the penetration and establishment phase rather than germination. Field tests were conducted to determine which of the following chemicals, applied in the forms indicated, were effective: Baycor-Baytan (dust and slurry), Baytan-Baysas (dust and slurry), Bayleton (dust and slurry), Benomyl (dust and slurry), Etaconazole (dust), Furmecyclox (dust and slurry), Imazalil (liquid), Nuarimol (dust and slurry) and Propiconazol (liquid). To be effective as a seed treatment, these compounds must remain in the plant for at least two months or until flowering has been completed. Unfortunately, no Karnal bunt developed, even in the checks, so evaluation was not possible and the experiment must be repeated.

Genetic resistance—During the greenhouse screening for genetic resistance conducted in the summer of 1983, 35 lines of bread wheat, durum wheat, and triticale were found to have no infection. This represents slightly less than 1 percent of the material tested. These lines are currently being retested in the greenhouse with both the boot injection and the spray inoculation techniques. Many of these apparently resistant lines have either TZPP or Alondra in their parentage, so in the 1984 summer cycle we will test all lines of CIMMYT germplasm that have these parents in their background. Also, the entire aluminium tolerance screening nursery, the 1B/1R genome collection and the CIMMYT rye collection is being screened using the injection and spray inoculation techniques. A search for resistance in the USDA world collection of material resistant to other bunts and smuts is being carried out with the boot injection technique alone.

In the 1983 winter cycle, a cooperative field evaluation for Karnal bunt resistance involving the National Institute of Agricultural Research, the USDA-ARS and CIMMYT was conducted at the Yaqui Valley Agricultural Experiment Station (CIANO). In this, 6343 varieties and lines (Table 3) were planted in 1-meter, double-row plots in an area that had a relatively high incidence of Karnal bunt the previous season. Ten heads of each of these lines were inoculated using the boot injection technique when the plants were at the mid boot stage. The inoculum concentration used was 10,000 sporidia per milliliter. Overhead sprinkler irrigation was used to provide optimum environmental conditions for infection and disease development. When mature, the inoculated heads were harvested, threshed and individually examined for the presence of Karnal bunt. Approximately 1700 lines had no Karnal bunt infection. Unfortunately, for several days during the peak inoculation period, the inoculum concentration was reduced due to a logistical problem. We feel that this may have increased the number of escapes and misclassification was possible. This probably explains the high number of apparently resistant lines. Whatever the reason, this "resistant" material has been placed in a special Karnal Bunt Screening Nursery (KBSN), and will be retested in the 1984-85 cycle in the greenhouse, in the field under natural infection conditions in India, Pakistan, and Nepal, and in the field under artificially inoculated conditions in Mexico. Specific information on these "resistant" lines as well as seed is available from CIMMYT on request.



Spores of *Neovossia indica*, the pathogen that causes Karnal bunt of wheat.

Protection of International Nurseries—In 1983, a set of regulations governing the movement of wheat and triticale germplasm from Mexico to the USA and Canada was developed by the receiving countries. Included in these regulations were recommendations for chemical treatment that, if followed by CIMMYT and if no Karnal bunt were detected, would allow for a review in 1984, possibly leading to a relaxation of the regulations for 1984 seed shipments. These recommendations are:

- All material destined for international distribution should be grown in an isolated field.
- The soil in this field should be treated with pentachloronitrobenzene (PCNB).
- Plants producing seed for shipment should be given multiple applications of Manzate 200.
- Duplicate nurseries should be grown in a Karnal bunt-free area.

CIMMYT agreed to these conditions, especially if in so doing, a relaxation of the regulations governing seed shipments to the USA and Canada could be achieved. All germplasm destined for international distribution by CIMMYT was grown in a separate field at the CIANO station. This field is approximately 2.5 kilometers from the field where the artificial inoculation was conducted. PCNB was applied in the irrigation water, and all exposed ridges and a 5-meter strip around the field were hand sprayed. The area involved was approximately 18 hectares. Manzate 200 was applied by aircraft to the crop in this field six times beginning when the earliest material was starting to head and continuing at 4- to 5-day intervals. Duplicate plantings were made near Hermosillo, Sonora, Mexico, in an area where Karnal bunt has never been reported.

At harvest, the material in the field was randomly sampled by staff of the Plant Protection and Quarantine office of the Animal and Plant Health Inspection Service (APHIS-PPQ). The samples were sent to the APHIS-PPQ headquarters in the USA, where they were subjected to strict visual examination and to the centrifuge wash procedure. No Karnal bunt was found. A review of the Karnal bunt situation in Mexico by the APHIS-PPQ staff resulted in the relaxation of the regulations governing seed shipments to the USA and Canada. For 1984 we have been notified that since no Karnal bunt was found in the material destined for international distribution by CIMMYT, seed would be accepted for normal field growing in the USA and Canada, provided that it was certified disease free and that the recipient held a valid permit issued after November 1983, by the APHIS-PPQ or Canadian authorities. Research at CIMMYT will continue to insure that the Karnal bunt issue does not hinder seed exchange in the future.

Training

In-country and regional training—This aspect of training addresses three interrelated problems: 1) the level of scientific competence of pathologists in developing countries, 2) the lack of uniform disease testing and 3) the lack of cooperation between pathologists and breeders in many of these countries. In an attempt to remedy these problems, CIMMYT and the Institute for Phytopathological Research (IPO) jointly proposed a series of disease methodology workshops to the Dutch Ministry of Foreign Affairs. Funding was approved in 1976 to support eleven workshops to be held in developing countries around the world; eight of these were major, two-week training sessions, and three were "mini" or short-term (3-5 days) workshops. The locations and dates of these workshops are listed below (asterisk indicates mini-workshop):

New Delhi, India
  January-February, 1976
Islamabad, Pakistan
  February, 1976
Ankara/Izmir, Turkey
  April-May, 1978
Njoro, Kenya
  September, 1978
Aleppo, Syria
  April, 1979
Santiago, Chile
  December, 1979
*Joydebpur, Bangladesh
  February-March, 1980
*Bhairahwa, Nepal
  March, 1980
*Islamabad, Pakistan
  March, 1981
Elvas, Portugal
  April-May, 1981
Beijing, China
  May, 1983

These workshops were attended by a total of 288 participants from 40 developing countries. CIMMYT and IPO scientific staff were involved as organizers and as instructors, giving lectures and conducting field exercises in which participants learned by doing. The manpower development component of the workshops focused on training plant pathologists and breeders in the effective utilization of modern techniques of field and laboratory pathology research, with particular emphasis on methods for artificially creating severe and uniform epidemics of leaf, stem and stripe rusts for screening purposes. A key ingredient contributing to the success of the workshops was the pathology field and laboratory research equipment provided by the government of the Netherlands to each participating national program. In all, 185 sets of equipment were distributed as follows: 123 sets of field equipment were divided among 40 countries, 57 sets of laboratory equipment were sent to a total of 38 countries, and 5 national programs received a set of liquid nitrogen spore storage equipment. In other words, not only were the workshop participants taught how to apply modern plant pathology techniques to carry out effective screening programs, but they were also given the equipment necessary to accomplish the task.

This series of workshops was completed in 1983 with the final workshop held in Beijing, China. CIMMYT would like to continue this series, but cannot do so until further funding is found. We feel that this type of short, intensive, special subject training is a very cost-effective means of strengthening national crop improvement programs.

In-service training—In 1983, 28 trainees from 18 developing nations participated in CIMMYT's in-service cereal improvement training programs held in Mexico. The basic concept underlying our in-service cereal improvement training remains that of a team approach to identifying and solving problems, with strong emphasis on field activities. Cereal improvement trainees learn CIMMYT's methodologies by working in daily contact with crop and pathology program personnel. Many of the skills developed during the training period will be applied in the national programs following the trainee's return.

In pathology training, heavy emphasis is placed on teaching trainees how to create artificial epidemics that permit more efficient selection of resistant germplasm. The rusts and several other well-known diseases are important in most developing countries where wheat cultivation has a long history. In most countries where wheat is not a traditional crop, diseases other than the rusts tend to be important, creating a need for people trained in disease diagnosis as well as in techniques for evaluating and screening parental material and other germplasm. In 1983, artificial epidemics of leaf and stem rusts, septoria leaf blotch, tan spot, spot blotch, Karnal bunt and scald were created in the experimental nurseries.

Using these, the trainees learned how to identify and evaluate various disease reactions. These skills will help them to evaluate better the germplasm developed by their own national programs and the international nurseries received from CIMMYT and other organizations.

Visiting scientists—The CIMMYT nurseries at CIANO, Toluca, and El Batan, plus the many research activities, are a big attraction to wheat scientists around the world. By financing short-term visits of several wheat scientists each year, most of whom come from the developing world, CIMMYT encourages personal interaction among wheat researchers and establishes a strong network of cooperators.

While visiting the program in Mexico, these scientists have a unique opportunity to exchange ideas among themselves and with our staff, to discuss research results, and generally to strengthen the personal and professional bonds that hold the international network of wheat scientists together. In 1983, CIMMYT's pathology program was visited by numerous wheat scientists interested in the rusts, septoria glume and leaf blotches, bacterial diseases, scab and loose smut.

Disease Surveillance

CIMMYT's Disease Surveillance Program (DSP) was initiated in 1976 with financial support provided by the government of the Netherlands. This support continued until the end of 1982, at which time CIMMYT included the DSP in its core-funded activities as an on-going project.

The DSP is concerned with those pathology-related factors that affect wheat production on a worldwide basis. The overall goal of the DSP is to help maximize yield per unit area and to minimize shortfalls caused by diseases. Disease monitoring is an integral part of the program because disease-causing organisms are capable of rather rapid changes in virulence spectra, which, in turn, can reduce the stability of crop production.

Summary of the disease situation—In the 1982-83 crop season, diseases did not reach epidemic proportions in any part of the DSP region. This is not to say that diseases did not occur and cause some loss, but only that there were no major epidemics causing widespread damage. There were several locally severe or "hot spot" areas noted by several countries, but overall, production losses attributable to diseases were lower than normal. This was possibly due to below-normal moisture early in the season in many countries,which did not allow diseases to begin an early build up, and to the more wide-spread use of resistant varieties.

The area covered by the DSP is geographically extensive and ecologically diverse, stretching from Morocco in the west to the Philippines in the east, and from southern Europe in the north, to the southern tip of Africa in the south. In terms of area and total production, wheat and barley are the principal cereal crops. Varieties grown in the DSP area vary from local selections of land race populations to highly improved dwarf or semidwarf types. These improved varieties are capable of withstanding a wide range of environmental conditions, from harsh, cold, continental climates (where winter habit wheat and barley prevail), to the warmer, more humid, semitropical climates (where spring habit, early-maturing wheats are grown only during the coolest parts of the year).

The disease-monitoring activites of the DSP continue to depend on the Regional Disease Trap Nursery (RDTN). In the fall of 1982, 200 sets of the RDTN were prepared and distributed from CIMMYT's headquarters in Mexico to 56 countries for growing in the 1982-83 crop cycle. The nursery comprised 143 bread wheat, 25 durum wheat, 30 barley and 2 triticale varieties and/or advanced lines. These materials include the main commercial varieties grown in the RDTN countries and a number of varieties with single or multiple resistance genes, which are used to classify the virulence of the different pathogens present in the region.

A summary of the leaf rust reactions on the lines with single gene resistances in the RDTN in 1983 is presented in Table 4. It can be seen that the leaf rust populations in Bangladesh were the most virulent, while those in Jordan were the least. While the data are not complete, they are still quite useful and when coupled with similar data from several years, become a valuable data base in which changes in pathogen virulence can be easily detected and information necessary for effective gene deployment extracted.

Similarly, Tables 5 and 6, summarizing the stem rust and stripe rust reactions, respectively, on lines with single gene resistances indicate the importance of each disease in selected countries. These data also contribute to a long term data base documenting the virulence spectra of these diseases.

As our data base becomes more complete, we expect that it will contribute to better management of our germplasm development activities, which will yield valuable advanced material for use by the developing nations of the world.

Table 1. Spring wheat lines from the 15th International Bread Wheat Screening Nursery with coefficients of infection of 1.0 or less (on a scale of 0-100) for leaf, stem, and stripe rust.

Name and pedigree	
BEZ-ZA75 x CAN"S" CM43297-G-3Y-1M-1Y-1M-2Y-1M-0Y	BOW"S" CM33203-K-9M-2Y-1M-1Y-1M-0Y
BOW"S" CM33203-K-9M-24Y-0M-15Y-0B	HAHN"S" CM33682-L-1Y-1Y-4M-4Y-100B-502Y-0M
BOW"S" CM33203-K-10M-7Y-3M-2Y-1M-0Y	KVZ x CN067-PJ62 SWM1285-2Y-3M-1Y-0M
BOW"S" CM33203-K-9M-2Y-1M-1Y-2M-0Y	CMT-M073 x TRM 73 CM43381-D-1Y-4M-1Y-1M-1Y-0B
BOW"S" CM33203-K-10M-7Y-3M-1Y-2M-0Y	CMT-M073 x TRM 73 CM43381-D-1Y-4M-4Y-2M-2Y-0B

Table 2. Materials with a score of 5.0 or less on the 0-9 scale from the 12th International Septoria Observation Nursery.

Name and pedigree	Reaction *S. tritici*	Reaction *S. nodorum*
CNT.8 (RESISTANT CHECK)	4.0	2.5
SUNBIRD"S" CM34630-D-5M-5Y-3M-1Y-0M-3PTZ-0Y	3.3	4.0
SUNBIRD"S" CM34630-D-5M-5Y-3M-1Y-0M-2PTZ-0Y	3.3	5.0
SUNBIRD"S" CM34630-D-5M-5Y-6M-3Y-2M-0Y-1PTZ-0Y	3.7	4.0
C.3228/65	4.0	2.0
ALONDRA"S" CM11683-A-1Y-1M-3Y-11M-0Y-0PTZ-0Y-1PTZ-0Y	4.3	4.0
PF.70100 -2PTZ-0Y	4.3	5.0
CEP.7779	4.3	4.0
PF. 69175	4.3	2.5
[(MY54/B10-Y54 x K LINE) CDZ] CJ71"S"-PAT49 B13981-H-1Z-1Z-1A-1A-0A-2PTZ-0Y	4.7	5.0
BOBWHITE"S" CM33203-N-1M-1Y-1M-1Y-0M-74Y-0B-1PTZ-0Y	4.7	4.0
COQUENA x KAL-BB CM15133-26BJ-3AL-1AL-0AL-1B-0H-0PTZ	5.0	5.0
NS.13-09=GABO 56-BKA2	5.0	5.0
CAR853-COC x VEERY"S" CM47556-EE-1M-1Y-2M-1Y-0Y-1PTZ-0Y	5.0	5.0
PF. 70226	5.0	5.0

Table 3. Germplasm screened for Karnal bunt resistance in 1983.

Germplasm source	Number of lines
Bread wheat	
CIMMYT crossing block	327
Advanced lines [small plots (PC)]	1145
Miscellaneous nursery	313
Karnal bunt (KB) resistance test, 1981-82, re-evaluation	185
KB resistance test, 1981-82, CIANO	46
KB resistance test, 1983, grennhouse	15
Hessian fly resistant lines	51
World bunt and smut resistance collection	1000
Total	3082
Durum and other tetraploid wheats	
CIMMYT crossing block	340
Advanced lines (PC)	584
Miscellaneous nursery	402
International Durum Screening Nursery (IDSN)	306
KB resistance test, 1981-82, reevaluation	142
KB resistance test, 1983, greenhouse	10
Triticum carthlicum lines	75
Total	1859

Germplasm source	Number of lines
Triticale	
CIMMYT crossing block	235
International Triticale Screening Nursery (ITSN)	208
Miscellaneous nursery	252
KB resistance test, 1983, greenhouse	10
Total	705
Rye	
World Rye Collection (WRC)	140
CIMMYT observation lines (LO)	84
Lines from Turkey and Poland	72
Total	206
Others	
Aegilops species	291
Wild *Triticum* species	79
Interspecific hybrids	31
Total	401
Grand total	6343

Table 4. Summary of leaf rust reactions on the lines with single-gene resistances in the Regional Disease Trap Nursery (RDTN) in 1983.

	Leaf rust resistance genes																					
Country	1	2A	2B	2C	3	9	10	12	13	14A	14B	15	16	17	18	19	20	21	22	23	24	25
Bangladesh	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	S
Pakistan	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	S	S	S	R	S
Nepal	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	S	R	S	S	S	R	S
Egypt	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	R	R	S	S	S	R	R
Mexico	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	R	R	R	S	S	R	S
Yugoslavia	S	S	S	S	S	S	S	S	S	—	—	—	S	S	R	R	S	R	—	—	R	R
Kenya	S	S	S	S	S	S	S	S	R	S	S	R	S	S	R	R	R	R	R	R	R	R
Mozambique	S	S	S	S	S	R	S	S	S	S	S	R	S	S	R	R	R	S	S	S	R	S
Bulgaria	S	S	S	S	S	R	S	S	S	S	S	R	S	S	R	R	R	S	S	S	R	R
Romania	S	S	S	S	S	R	S	S	S	S	S	R	S	S	R	R	R	S	S	R	R	R
France	S	S	S	S	S	R	S	S	S	R	S	R	S	S	R	R	R	R	S	R	R	S
Morocco	S	S	S	S	S	R	S	S	R	S	S	R	S	S	R	S	R	S	S	S	S	S
China	S	S	R	S	S	S	S	S	S	S	S	R	S	S	S	R	R	R	R	R	R	R
Yemen Arab Republic	S	R	S	S	S	S	R	R	S	S	S	S	R	R	R	S	R	S	S	S	R	S
Israel	S	R	R	S	S	R	S	—	R	R	R	R	S	R	R	R	R	R	S	S	R	R
Italy	R	S	S	S	S	S	S	S	R	S	S	S	S	S	S	S	R	S	S	S	R	R
Rwanda	R	S	S	S	S	R	S	S	S	S	S	R	S	S	R	R	R	R	R	S	R	R
Ethiopia	R	S	S	S	S	R	S	R	R	S	S	S	S	R	R	R	R	S	S	S	R	S
Netherlands	R	S	R	S	R	S	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Thailand	R	R	S	S	S	R	S	R	S	S	S	R	S	S	R	R	S	R	S	S	R	S
Iran	R	R	S	R	S	R	S	S	S	R	S	R	S	S	S	R	R	R	R	R	R	R
South Africa	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Saudi Arabia	R	R	R	R	R	S	S	R	R	R	S	R	S	R	R	R	R	R	R	R	R	R
Chile	R	R	R	R	R	R	S	R	R	S	R	R	S	R	R	R	R	R	R	R	R	R
Jordan	R	R	R	R	R	—	R	R	R	R	R	S	R	R	R	R	—	—	—	—	—	—
Switzerland	—	—	—	—	—	—	—	—	—	—	—	R	—	S	—	—	—	—	—	—	—	—
Lesotho	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	S
Spain	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	S
Zambia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
Tanzania	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R

S = susceptible, R = resistant, — = no data

Table 5. Summary of stem rust reactions on the lines with single-gene resistances in the Regional Disease Trap Nursery (RDTN) in 1983.

	Stem rust resistance genes																					
Country	5	7B	8	9A	9D	9E	12	13	14	15	16	22	25	26	27	29	30	36	37	TT3	GT+	TC
Portugal	S	R	R	S	R	R	S	S	R	S	S	S	R	R	R	R	S	S	R	S	R	R
Italy	R	S	S	R	R	S	R	S	S	S	R	S	R	S	R	S	S	R	S	S	R	S
Czechoslovakia	S	S	S	S	S	R	S	S	S	S	S	S	R	R	R	S	S	S	S	S	R	S
Hungary	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	S	S	S	S	S	R	R
Bulgaria	S	R	R	R	R	S	R	S	S	S	R	R	R	R	R	R	S	S	R	S	R	S
Yugoslavia	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
Israel	S	S	S	S	S	—	S	S	R	—	S	S	R	R	S	S	S	S	S	S	R	S
Saudi Arabia	S	S	S	S	S	S	S	S	S	S	S	R	R	R	S	S	R	R	S	S	R	R
Yemen Arab Republic	S	S	S	S	S	S	S	S	S	S	S	S	R	S	S	S	S	S	S	S	S	S
Iran	S	S	S	S	S	S	S	R	S	S	S	R	R	S	S	S	S	S	S	S	R	R

Table 5. (Cont'd)

Country	Stem rust resistance genes																					
	5	7B	8	9A	9D	9E	12	13	14	15	16	22	25	26	27	29	30	36	37	TT3	GT+	TC
Bangladesh	S	S	S	S	S	R	S	R	S	S	S	S	R	R	S	R	S	S	S	S	S	S
Nepal	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R
Egypt	S	R	S	R	R	S	S	S	S	S	S	S	R	S	S	S	S	S	S	S	S	S
Ethiopia	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	S	S	S	S	S	R	R
Kenya	S	S	S	S	S	S	S	S	S	S	S	S	R	R	R	S	S	S	S	S	S	S
Rwanda	S	S	S	S	S	S	S	R	S	S	S	R	S	R	S	S	R	R	R	R	R	S
Zambia	S	R	S	S	S	R	S	R	S	S	S	S	R	R	S	S	S	S	S	S	S	S
Lesotho	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	S	R
South Africa	R	S	S	S	S	S	S	S	S	S	S	S	R	S	R	S	S	S	S	S	S	S
Mexico	S	S	S	S	S	R	S	S	R	S	S	R	R	R	R	S	R	R	R	S	R	S

S = susceptible, R = resistant, — = no data

Table 6. Summary of stripe rust reactions on the lines with single-gene resistances in the Regional Disease Trap Nursery (RDTN) in 1983.

Country	Stripe rust resistance genes																
	1	2	3	4	5	6	7	8	9	10	SU	KAL	MXP	SOL	AV	TSS	EM
Netherlands	S	R	S	R	R	S	R	R	R	R	S	S	S	R	R	S	R
France	S	R	R	R	R	R	S	R	S	R	R	S	R	R	R	S	—
Spain	S	R	S	R	R	S	S	R	R	R	R	S	S	S	R	S	—
Portugal	S	S	R	S	R	S	S	R	R	R	R	S	S	S	R	S	R
Italy	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R
Switzerland	S	S	S	S	R	R	S	R	S	R	S	R	R	R	R	S	R
Czechoslovakia	S	S	S	R	R	R	R	R	R	S	R	S	S	R	R	S	R
Bulgaria	S	S	S	S	S	R	R	S	S	S	S	R	R	R	R	S	R
Yugoslavia	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R
Turkey	S	R	R	R	S	R	S	S	R	S	R	S	S	S	R	S	R
Israel	R	R	R	—	R	S	S	—	R	R	R	R	R	S	R	S	R
Saudi Arabia	R	R	R	R	R	R	R	R	R	R	R	S	S	R	R	S	R
Yemen Arab Republic	R	R	R	R	R	S	S	R	R	R	R	S	S	R	R	S	R
Iran	R	R	R	R	R	S	S	R	R	R	S	R	R	R	R	S	R
Pakistan	S	S	S	R	R	S	S	R	R	S	S	S	S	S	S	S	R
Nepal	R	R	R	R	R	R	R	R	R	R	R	S	S	R	R	S	R
Egypt	R	R	R	S	R	S	R	R	R	S	R	S	S	S	S	S	R
Ethiopia	—	S	—	—	—	—	—	—	—	—	—	R	S	S	R	S	—
Kenya	S	S	R	R	S	S	S	S	R	S	R	S	S	S	S	S	R
Rwanda	R	R	R	R	R	S	S	S	R	S	S	S	S	S	S	S	R
Ecuador	R	R	R	R	R	S	S	R	R	R	R	S	S	S	S	S	R
China	R	R	R	R	R	S	S	R	R	R	R	R	R	R	R	S	R

S = susceptible, R = resistant, — = no data

Wide Crosses

A. Mujeeb-Kazi

Introduction

Present emphasis in the CIMMYT wheat wide cross program centers on intergeneric hybridization to improve bread wheat (*Triticum aestivum*), but some efforts are being made to hybridize durum wheat (*Triticum turgidum*) with alien genera. The specific objectives of the program are the incorporation of resistance to three diseases, *Helminthosporium sativum* (known to cause seed decay, root rot and leaf spots), *Fusarium graminareum* (the pathogen of head blight and leaf spot) and *Neovossia indica* (syn. *Tilletia indica*) (the causal agent of Karnal bunt), and tolerances to salt, aluminum and copper stresses.

Of the approximately 325 species in the tribe Triticeae, about 250 are perennial and many are important forage grasses. In addition, they form a vast genetic reservoir for improvement of cereals. The alien genera that constitute the sources of genetic variability for the program's applied objectives include *Aegilops* (*Ae.*), *Agropyron* (*A.*), *Elymus* (*E.*), *Haynaldia* (*Ha.*), *Hordeum* (*H.*) and *Secale* (*S.*).

Until recently, the success rate in hybridizing wheat with related species was alarmingly low, primarily because of problems associated with crossability barriers and poor embryo development. These barriers have now been lowered so that intergeneric hybrids can be produced almost at will. This has been accomplished using pre- and/or postpollination techniques, together with manipulation of the media for embryo culture, which probably have influenced one or more of the following: pollen tube growth, gynoecium longevity, micropylar barriers, delivery of male gametes, initiation and continuation of seed development and development of the embryo. In addition to these special techniques, use has been made of factors such as 1) cross direction, 2) varietal choice, 3) ploidy level of the related parent, 4) presence or absence of recombination in the F_1, 5) production of fertile amphiploids from the F_1, 6) cytological variations in the backcross (BC) progenies, and 7) restoration of self-fertility by continued backcrossing of the wheat/alien species hybrid to wheat.

Dr. A. Mujeeb-Kazi, head of the wheat wide crosses program.

CIMMYT currently maintains 80 intergeneric hybrid combinations with wheat, a majority of which are both new and perennial. The procedure for advancing these hybrids toward meeting CIMMYT's applied agricultural goals was reported in the CIMMYT 1982 Wheat Annual Report. The salient aspects of our research efforts in 1983 are reported here.

Maintenance of Hybrids

Approximately 80 intergeneric hybrids have been produced in this program since 1980 and those that exhibit a perennial tendency are maintained by vegetative cloning under greenhouse conditions at the El Batán Experiment Station in México. Cloning of each hybrid is done in January and June in order to maintain at least three potted F_1 plants of each combination for continuous production of backcross I (BCI) seed and two potted F_1 plants for colchicine treatment aimed at producing fertile amphiploids. The hybrid combinations with *Agropyron*, *Elymus* and *Haynaldia* are all perennials, while those with *Aegilops* are all annuals.

New Intergeneric Hybrids

Production of new F_1 intergeneric hybrids is an integral part of the program and essentially serves to broaden the germplasm base available to facilitate alien genetic transfers to *T. aestivum* and *T. turgidum*. Advancing only a limited number of hybrids for particular objectives may be subject to failure at an advanced stage. By increasing the number of F_1 hybrid combinations each year, this risk is reduced. With alien species, whether they have a promising plant type or not, there is no guarantee that the finished product of hybridization with wheat will have agricultural utility. The constraints are numerous and the risks well demonstrated by the limited success of numerous researchers worldwide over the entire course of this century.

The most favorable situation for wide crossing exists when the alien species with desirable characteristics is a diploid ($2n=2x=14$), is amenable to chromosome banding, hybridizes with wheat and its chromosomes pair (recombine) with those of wheat, permitting intrachromosomal genetic transfers. Unfortunately, this has not yet been the situation, so work continues with large numbers of hybrid progeny, using the manipulative procedures that each particular hybrid requires and using cytology to measure progress.

The hybrids produced in 1983 are listed in Table 1. Several of these are new while others were reproduced so that a germplasm base would be readily available and commercially grown wheat varieties could be utilized in the hybridization where feasible.

Two major considerations dominated our thinking in producing these hybrids. First, using *T. turgidum* varieties as the female parents permits diversification of the germplasm when the *T. turgidum* /alien species F_1 is crossed with commercial bread wheat lines that otherwise cannot be directly hybridized with the alien species because of the absence of the homozygous, recessive, crossability genes in most *T. aestivum* varieties. In addition, such durum/alien//bread wheat crosses increase the chances of inducing translocations between the D genome and alien chromosomes via centric break-and-fusion processes (Figure 1). Another advantage is that backcrossing the *T. turgidum*/alien species hybrid to *T. turgidum* varieties provides an opportunity to incorporate alien genes into *T. turgidum*.

The second consideration was that in the majority of F_1 hybrids produced and cytologically analyzed, there is no evidence of recombination between the wheat and alien chromosomes. This eliminates the possibility of direct gene transfer in the F_1 and slows the realization of research objectives. A means of overcoming this difficulty is crossing alien species with existing stocks of *T. aestivum* and *T. turgidum* that either lack a chromosome 5B (mono-5B) or carry the PhPh mutant, both of which permit direct recombination between the wheat and alien chromosomes. However, F_1 hybrids with the 5B chromosome missing are difficult to exploit readily in a backcrossing program, and the crossable PhPh mutation is present only in poor agronomic backgrounds. Despite these limitations, and in absence of ideally crossable wheat germplasm, F_1 hybrids were produced (Table 1) between some alien species and either the monosomic 5B stock or the PhPh mutant of *T. aestivum* cv. Chinese Spring, or the PhPh mutant of *T. turgidum* cv. Capelli.

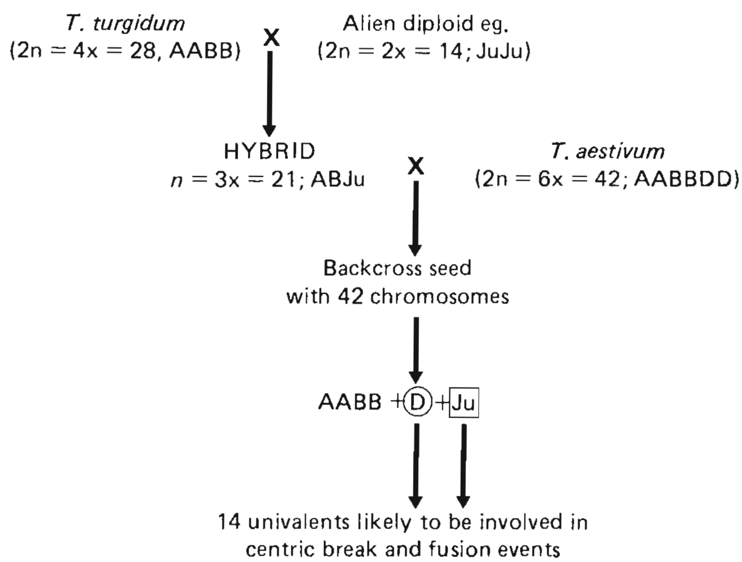


Figure 1. Scheme to show centric break and fusion events in *T. turgidum*/alien diploid (JuJu)//*T. aestivum* hybrids.

Advancement of the F_1 Hybrids from 1982

The F_1 hybrids produced in 1982 (*T. aestivum*/alien species) were advanced by crossing with elite CIMMYT *T. aestivum* and some *T. turgidum* lines and varieties. In backcrosses with *T. aestivum*, seed set ranged from 0 to 3 kernels per spike in 21 of the 23 hybrids advanced. No BCI seed was set for the *T. aestivum/A. campestre* combination and the *T. aestivum/E.angustus* hybrid continues to be vegetative (Table 2). Almost all BCI progenies included some plants with a complete chromosome complement (i.e., the somatic chromosome number of the F_1 plus the gametic chromosome number of the wheat parent) and aneuploids, presumably derived from loss or gain of chromosomes on the maternal (F_1) side (Table 2). Seed set when the F_1 hybrid was pollinated by *T. turgidum* was low and embryo culture was necessary to ensure survival of the BCI progeny.

First and second backcross generations (BCI and BCII) are produced using the procedures indicated by the following pedigrees (*T. aestivum* varieties other than Pavon 76 and Ciano 79 may also be used):

- BCI—(1) Chinese Spring/alien// Chinese Spring (seed stored for academic interest and distribution), (2) Chinese Spring/alien//Pavon 76 (seed kept for our use) or (3) Pavon 76/alien//Ciano 79 (seed kept for our priority use).

- BCII—(1) Chinese Spring/alien//2 * Pavon 76, (2) Pavon 76/alien/2 * Pavon 76 or (3) as described below, Chinese Spring/Alien//Pavon 76/3/Ciano 79.

In those cases in which *T. aestivum* cv. Chinese Spring is the female parent of the F_1 hybrids, a new system is being tried which, it is hoped, will more quickly result in agronomically suitable plant types. In this system a leading CIMMYT wheat line is used as the BCI wheat parent. To produce the BCII, a wheat line different from that used in the BCI is employed instead of using the same line a second time. This modification is similar to the F_1 top cross used in conventional wheat breeding. Elimination of the alien chromosomes might be a problem with this system, but our experience has been that complete elimination does not occur by the BCII stage. This will have to be confirmed cytologically in material produced by this new procedure.

Based on plant performance and cytological data, certain BCI combinations have been chosen for rapid advance. These are listed in Table 3, along with their desirable characteristics and the gene transfer methodology being used.

Field Performance of Some Hybrids and Progenitors

Advanced progenies derived from some intergeneric hybrids have been field-tested at the Yaqui Valley Agricultural Experiment Station (CIANO) and the CIMMYT experiment stations at Poza Rica, Toluca, and El Batan. These are listed in Table 4. Those most advanced are derived from bread wheat combined with *Elymus giganteus* ($2n=4x=28$), *Agropyron distichum* ($2n=4x=28$), and *A. elongatum* ($2n=10x=70$). Several lines possess alien chromosomes and those that have the euploid chromosome number of 42 may contain alien substitution products (*E. giganteus*) or have incorporated alien genes (*A. distichum*).

Promising advanced lines have been selected for resistance to *Helminthosporium sativum* and *Fusarium graminareum*, and their cytology indicates the presence of alien chromosomes. These are primarily selections from the crosses involving *E. giganteus*, *A. distichum* and *A. elongatum*, although other hybrid combinations and materials are being studied as well. The status of each of these is highlighted in the following:

T. aestivum/E. giganteus—*Elymus giganteus* has 14 pairs of chromosomes (Figure 2). Thus it has the potential to form 14 addition lines of wheat, each carrying a different *E. giganteus* chromosome. Five chromosome addition lines have been definitely identified and eight more tentatively so. The remaining chromosome is spontaneously substituted. Once the particular resistances or tolerances of these lines are determined, procedures will be initiated to promote subtle gene transfers by means of small reciprocal translocations.

Figure 2. Fourteen C-banded chromosomes of *E. giganteus* **photographed from its F_1 hybrid with** *T. aestivum* **($n=5x=35$).**

The chromosome addition lines that have been selected have excellent plant type, are early maturing in some cases, possess stem and leaf rust resistance and have good grain appearance. The plants selected at Poza Rica and Toluca for *Helminthosporium sativum* and scab resistance also have this chromosome history. The eight tentative addition lines will be verified with the aid of biochemical techniques (electrophoretic isozyme analysis) by collaborators at the Plant Breeding Institute (PBI) in Cambridge, England.

T. aestivum/A. distichum—In this combination there exists the potential for direct gene transfer via recombination in the F_1. Consequently, after the BCII, further advance was made by selfing at each additional generation. Selection was oriented toward superior plant type, earliness, and rust resistance. The principal objective in making the combination was to improve salt tolerance, but fortuitously, the lines selected are resistant to *H. sativum* and *F. graminareum*. Material with this improved tolerance will be ready for distribution to our collaborators after the 1983-84 cycle at CIANO. Since the *A. distichum* chromosomes are not amenable to chromosome banding techniques, isozyme analysis may have to be utilized to detect the incorporation of alien chromosome material.

T. aestivum/A. elongatum—The advanced progenies maintain a high number (2-19) of alien chromosomes and still have a grassy habit. They do exhibit resistance to *H. sativum*, but it may take another two or three backcrosses to substantially improve the plant type. *Agropyron elongatum* is also an excellent source of salt tolerance, but its high chromosome number ($2n=10x=70$), which results in gene dilution, may limit its practical usefulness. The same limitation may apply for *H. sativum* resistance. This will be assessed along with the production and advancement of other intergeneric hybrids.

Other hybrid combinations—All the progenies of other hybrid combinations in Table 4 are in early stages and require additional crossing, field observation, and manipulation. *Agropyron scythicum* and *Elymus canadensis* are sources of *H. sativum* resistance; *A. podperae* performed questionably for plant phenotype during segregation; *A. fibrosum* is an excellent source of Karnal bunt and helminthosporium resistance; *A. junceum* is ideal for salt tolerance; and the *Hordeum vulgare* combination with wheat is being assessed as a possible, but doubtful, source of alien transfers. It is believed that since the wheat phenotype is dominant at all stages of development, barley genes will not be expressed. If this is disproved, transfer of barley yellow dwarf (BYD) resistance could be expedited.

Among the 65 progenitors screened in Poza Rica for *H. sativum* resistance, the following were given a score of 1 to 3 on a scale of 0 (resistant) to 10 (susceptible): *Secale anatolicum* (2), *S. cereale* cv. Prolific (2) and tetraploid *S. cereale* in wheat cytoplasm (1). Some *Aegilops squarrosa* synthetics were satisfactory in the first two scorings, but susceptibility to leaf rust complicated the final assessment. It may be worthwhile to screen several *Ae. squarrosa* accessions since the D genome could be readily exploited. We have identified one highly resistant accession from PBI, which is currently being used there to develop a synthetic wheat.

Range Grass Nursery

Attempts were initiated to establish a range grass nursery at El Batan, comprising species of *Agropyron*, *Elymus* and their interspecific hybrids. The germplasm source for all entries is Dr. D. Dewey of the U.S. Department of Agriculture (USDA) Crops Research Laboratory, Logan, Utah. If the species flower, despite the mild winter with long days at El Batan, we intend to make future hybrids at CIMMYT, instead of conducting our summer cycle hybrid production al Logan.

The 135 entries of range grasses range from diploids ($2n=2x=14$) to complex polyploids like *E. angustus* ($2n=12x=84$) and are all perennial types. Five plants of each of the species and hybrids have been checked cytologically and then planted in the field at El Batan. In addition to these species, five clones each of all the perennial F_1 hybrids produced at CIMMYT have been planted to permit better assessment of their phenotypes and more convenient mass production of BCI seed during the June to October crop cycle.

Special Research Areas

Mono-5B chromosome—An attempt is being made to transfer the mono-5B chromosome stock from *T. aestivum* cv. Chinese Spring to three CIMMYT wheats with satisfactory crossability associated with the Kr genes. The wheats selected are Ciano 79, Nacozari 76, and Pavon 76. Second generation backcross seed has been produced and the mono-5B chromosome was detected by N-banding in the 41-chromosome plants. The goal is to advance to the fifth backcross generation and to remake some hybrids that appear promising but have not exhibited any recombination between the wheat and alien chromosomes in the F_1.

We are cognizant of the fact that advancing the F_1 hybrids lacking 5B by backcrossing may be difficult, but it is a challenge worth accepting on a limited scale. As insurance, we have already hybridized Chinese Spring mono-5B with some *Aegilops* and *Agropyron* species, but the results are too preliminary to present at this stage.

Copper efficiency—The copper efficiency gene on chromosome 5R of *Secale cereale* cv. Imperial has attracted our attention since its incorporation into *Triticum aestivum* would have a significant impact on wheat production in those soils where copper deficiency problems exist. Applying copper to the soil or to the seed in a dressing are solutions in current use, but a genetic solution is definitely preferable in the long term. Wheat can grow in copper-deficient soils, but it is sterile. Independent tests have indicated that the presence of rye chromosome 5R (specifically the 5RL arm) overcomes the sterility problem. We are now initiating the process of incorporating the 5RL chromosome arm into some of CIMMYT's elite wheat lines.

IB/IR translocation—Approximately 45 percent of the CIMMYT bread wheat program's advanced lines that are in the crossing block (CB) and small multiplication plots (PC) have the IB/IR translocation which is located on the IRS chromosome arm, derived in all cases from Petkus rye. This chromosome is easily identified using routine chromosome banding or somatic cytology. Considering the narrowness of the IRS germplasm source, we have initiated efforts to incorporate into CIMMYT wheat the IRS chromosome arm from other sources that exist either as IB/IR or ID/IR translocations or as IR substitutions for the 1A, 1B or 1D chromosomes of wheat. In the last case the translocation will need to be engineered.

Service Cytology

Using routine chromosome N-banding procedures, a large number of *T. aestivum* lines were analyzed to identify those with the IB/IR translocation. Those homozygous for this translocation are tabulated in Table 5. The IB/IR source in these lines is Petkus rye, via the varieties Kavkaz, Aurora and Weique-Red Mace, and their derivatives.

Collaborative Programs

Table 6 lists the programs outside of CIMMYT with which the wheat wide cross program has an active and mutually beneficial collaboration, and the particular groups involved. Specific advances are highlighted below:

England, Cambridge—The development of a monosomic series in wheat is in the BCIII stage. With respect to salt tolerance transfer, a hybrid between *A. junceum* ($2n=2x=14$) and 5B-deficient wheat has been produced that exhibits a high degree of chromosome pairing. In the course of screening various *Aegilops* species for resistance to *Helminthosporium sativum* at CIMMYT, a highly resistant accession of *Ae. squarrosa* was found. A synthetic hybrid will be developed from this at P.B.I.

Wales, Bangor—Under controlled screening conditions, a number of alien species have been identified as excellent sources of salt tolerance. Three of interest are *A. elongatum* ($2n = 10x = 70$), *E. sabulosus* ($2n = 4x = 28$), and *A. junceum* ($2n = 2x = 14$). The last is to be utilized in our program. It has been hybridized at the PBI with the 5B-deficient Chinese Spring wheat and at CIMMYT with euploid *T. aestivum* cv. Chinese Spring.

USA, Missouri—Mathematical studies of chromosome pairing enable the researcher to make an appropriate choice of methodology for obtaining alien genetic transfers. To this end, all the meiotic data from intergeneric hybrids generated in CIMMYT is analyzed with the aid of a computer program at the University of Missouri at Columbia, and the results utilized for project development. In addition, *Aegilops* species are being screened by Dr. G. Kimber for tolerance to high levels of free aluminum in the soil. When the study is completed, the data should serve to further CIMMYT's objective of using aluminum-tolerant, alien germplasm for wheat improvement.

USA, Colorado—Glennson 81, Pavon 76, and Chinese Spring are important *T. aestivum* varieties in the wide cross program. Their ability to respond satisfactorily in tissue culture has been demonstrated, and in the second stage, work with F_1 hybrids and advanced BC lines is to be initiated. The variety Chris also responded well in tissue culture. A few of its regenerants were salt tolerant and the first generation regenerant (R-1) plants showed some aneuploidy. The R-2 field-grown plants (lines) showed no morphological variability. CIMMYT's contribution to this joint project includes cytological studies and field planting of regenerants from tissue culture.

USA, Utah: Dr. Dewey—CIMMYT spring wheats were planted at Evans Farm and crosses were made by CIMMYT personnel using the species of *Agropyron* and *Elymus* that Dr. Dewey maintains. All embryo culturing was done in the USDA laboratory at Logan, Utah, after which hybrids were brought to El Batan in sterile media vials. In addition, the grass nursery has provided seed of all species accessions for the last three years, and valuable cytogenetic data was made available.

USA, Utah: Dr. Carman—This project aims at transferring the apomictic characteristic of *Agropyron scabrum* to *T. aestivum*. CIMMYT will assist with the crossing and the cytology when and if these are needed.

Perspectives

The goal of a wide cross program is to transfer desirable characteristics from related species to a crop plant. To accomplish this, small pieces (ideally) of alien chromosomes should be inserted into closely related chromosomes; however, insertions of alien genetic material into less closely related chromosomes can be equally valuable. The benefits breeders have derived from alien species through this introgression of alien genetic material are best exemplified by the current CIMMYT IB/IR wheat lines. Several lines with this translocation have been released around the world because of their wide adaptation, yield stability, tolerance to high levels of free aluminum and resistance to *Septoria tritici*. Some other significant wheat improvements made in other laboratories utilizing translocations are listed in Table 7. Alien transfers have also been successfully made for resistance to stripe rust and wheat streak mosaic. There have, however, been only a limited number of alien species involved in the above-mentioned studies. Considering the extent of the germplasm available, the prospects for future success are extremely good. For this to occur, a large number of alien genera need to be combined with wheat, and hybrid advancement must be based on critical field studies, controlled testing and cytogenetic analyses.

There will always be an argument about whether the resistance genes from alien species will have a sufficiently long-lasting effect to justify the effort involved in successfully transferring them to wheat. We believe that alien genes for disease resistance undoubtedly function in the same way as the other resistance genes in wheat, so that when the pathogen mutates, the resistance is likely to break down. Thus, the more resistance genes available, the more prolonged the resistance will be. The perennial grasses have been more strongly selected for disease and insect resistance than the cultivated annuals because they cannot escape disease and insects by dying after seed set. Thus, it is expected that their resistances may offer more durability.

More specifically, there are two areas in which wide crosses have great potential. The first is stress tolerance, where, in the absence of a mutable pathogen, alien transfers can be expected to have a long-lasting effect. The second is in some specific circumstances in which there is a total lack of genetic variability in wheat, so that any improvement has to come from alien introgression. This may be the case for Karnal bunt. If this is true, seeking to build in genetic resistance through conventional breeding would not be very logical, and screening *T. aestivum* lines and varieties to identify resistance would be an unrewarding endeavor. Despite the mutability of the pathogen, which will shorten the useful life of the resistance genes, the effort must be made to transfer alien genes to wheat.

CIMMYT views wide crosses as a long-term, risky project, after having fully understood the difficulties and limitations of the program. It is definitely an area which needs thorough investigation, but we do not seek or promise, with this radical approach, the high productivity and rapid variety turnover which is normally expected from conventional breeding programs. Over the last four years we have made hybrids that are unique, encountered research constraints that could never have been imagined, developed fruitful international collaboration in basic areas, and promoted the practical motivation that emanates from our breeding program. We are convinced that the prospective for this futuristic, risky project is to provide dividends during the next decade.

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Curtis, B.C., S. Rajaram, and A. Mujeeb-Kazi. 1983. Production and cytology of hybrids of *Triticum aestivum* L. varieties with several *Agropyron* and *Elymus* species. Agronomy Abstracts 1983: 74.

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Mujeeb-Kazi, A. and M. Bernard. Intergeneric hybridization to induce alien genetic transfers into *Triticum aestivum*. Pakistan J. Bot. In press.

Mujeeb-Kazi, A., M. Bernard, G.T. Bekele, and M.L. Miranda. 1983. Incorporation of alien genetic information from *Elymus giganteus* into *Triticum aestivum*. Pages 223-231 in S. Sakamoto, ed. Sixth International Wheat Genetics Symposium. Kyoto, Japan.

Mujeeb-Kazi, A. and R. Rodríguez. 1983. Cytogenetics of a *Hordeum vulgare* x *Triticum turgidum* hybrid and its backcross progeny with *T. turgidum*. J. Heredity 74:109-113.

Mujeeb-Kazi, A. and R. Rodríguez. 1983. Meiotic instability in *Hordeum vulgare* x *Triticum aestivum* hybrids. J. Heredity 74:292-296.

Rajaram, S., C.E. Mann, G. Ortiz-Ferrara and A. Mujeeb-Kazi. 1983. Adaptation, stability and high yield potential of certain IB/IR CIMMYT wheats. Pages 613-621 in S. Sakamoto, ed. Sixth International Wheat Genetics Symposium. Kyoto, Japan.

Table 1. Intergeneric hybrids produced in 1983 and maintained in the greenhouses at El Batan, Mexico.

Hybrid combination*	Chromosome number and ploidy level
T. turgidum cv. Cocorit/*A. acutum*	n = 5x = 35
/*A. campestre*	n = 6x = 42
/*A. intermedium*	n = 5x = 35
/*A. junceum*	n = 4x = 28
/*A. pulcherrimum*	n = 5x = 35
T. turgidum cv. Mexicali/*A. intermedium*	n = 5x = 35
/*A. junceum*	n = 4x = 28
/*A. podperae*	n = 5x = 35
/*A. pulcherrimum*	n = 5x = 35
/*A. varnense*	n = 5x = 35
T. turgidum cv. Yavaros/*A. acutum*	n = 5x = 35
/*A. intermedium*	n = 5x = 35
/*A. varnense*	n = 5x = 35
T. turgidum cv. Capelli (Ph Ph)/*A. acutum*	n = 5x = 35
/*A. intermedium*	n = 5x = 35
/*A. varnense*	n = 5x = 35
T. aestivum cv. Chinese Spring (mono 5B)/*A. campestre*	n = 7x = 49
T. aestivum cv. Chinese Spring (PhPh)/*A. acutum*	n = 6x = 42
/*A. caespitosum*	n = 5x = 35
/*A. intermedium*	n = 6x = 42
/*A. trichophorum*	n = 6x = 42
/*A. varnense*	n = 6x = 42
T. aestivum cv. Chinese Spring (mono 5B)/*Ha. villosa*	n = 4x = 28

**T. = Triticum, A. = Agropyron, Ha. = Haynaldia.*

Table 2. Backcross seed set and cytological data of F_1 hybrids and backcrosses produced in 1982 and advanced in 1983.

Alien species[1] as pollen parent with *T. aestivum*	F_1 somatic chromosome number	Number of backcross I seeds obtained	BCI somatic chromosome number range	Number of backcross II plants obtained	Number of BCI F_1 plants obtained
A. acutum	42	20	45 - 63	33	22
A. caespitosum	35	3	56	6	–
A. campestre	49	0[2]			
A. curvifolium	35	13	53 - 56	96	80
A. gentryi	42	2	61 - 63	4	3
A. intermedium	42	16	60 - 63	22	–
A. junceum (2x)	28	45	42 - 50	216	63

Table 2. (Cont'd)

Alien species[1] as pollen parent with *T. aestivum*	F_1 somatic chromosome number	Number of backcross I seeds obtained	BCI somatic chromosome number range	Number of backcross II plants obtained	Number of BCI F_1 plants obtained
A. junceum (4x)	35	41	44 - 56	62	15
A. junceum (spp. *mediterraneum*)	42	9	44 - 72	—	—
A. podperae	42	5	60 - 63	16	—
A. pulcherrimum	42	30	52 - 63	132	212
A. rechingeri	35	10	56 - 57	20	23
A. repens	42	3	61 - 63	12	—
A. repens-A. desertorum (C-3)	35 to 56 + t[3]	21	51 - 57	62	27
A. scirpeum	35	14	40 - 56	274	83
A. scythicum	35	12	41 - 56	3	—
A. stipifolium	35	1	54	14	4
A. trichophorum	42	29	49 - 63	43	80
A. varnense	42	44	48 - 63	78	18
E. angustus	63	0[4]			
E. cinereus	35	1	56	11	18
E. giganteus	35	5	56	9	—
E. triticoides	35	2	56	5	9

Blanks = data not obtainable. Dash = plants not produced.
1. *A.* = *Agropyron*, *E.* = *Elymus.*
2. Flowered but failed to set seed
3. Telocentric chromosome.
4. Remained vegetative.

Table 3. Backcross I (intergeneric hybrid/wheat) combinations selected for rapid advance.

Alien species[1] involved	Characteristic to be incorporated into wheat	Gene transfer methodology
A. junceum[2]	Salt tolerance	Addition line, induced transfer
A. junceum[3]	Salt tolerance	Natural recombination
A. scirpeum[3]	Salt tolerance	Synthetic genome induction
A. curvifolium[3]	Salt tolerance	Synthetic genome induction
A. elongatum[4]	Salt tolerance, *Helminthosporium* resistance	Natural recombination
Ae. crassa[3]	Karnal bunt resistance	Induced transfer
Ae. cylindrica[3]	Karnal bunt resistance	Induced transfer
Ae. variabilis[3]	Karnal bunt resistance	Induced translocation
S. cereale[2]	Improved copper efficiency	Induced translocation

1. *A.* = *Agropyron*, *Ae.* = *Aegilops*, *S.* = *Secale.*
2. $2n = 2x = 14$
3. $2n = 4x = 28$
4. $2n = 10x = 70$

Table 4. Intergeneric hybrid progenies observed under field conditions in Mexico.

Intergeneric combinations from which field progenies were derived[1]	Chromosome number range	Location and number of lines observed			
		CIANO	Poza Rica[2]	El Batan	Toluca
T. aestivum/E. giganteus	41 to 48 +t[3]	2323	60[4]	3023	495[5]
T. aestivum/A. distichum	40 to 50	1267	104[4]	3466	486[5]
T. aestivum/A. elongatum	44 to 61	46	23[4]	335	
T. aestivum/A. junceum	44 to 63			77	
T. aestivum/H. vulgare	42 to 47			162	
T. aestivum/A. podperae	46 to 63			6	
T. aestivum/A. scythicum	42 to 52			12	
E. canadensis/T. aestivum	44 to 50			34	
A. fibrosum/T. turgidum	56			2	
T. turgidum/A. distichum	56			9	
T. turgidum/A. elongatum//T. turgidum	X			39	
Miscellaneous	X	206			
Progenitors	14 to 42		65[4]		

X = data not yet obtained.
Blanks = not planted at that location.
1. *T.* = *Triticum*, *E.* = *Elymus*, *A.* = *Agropyron*, *H.* = *Hordeum*.
2. The second planting, comprised of 1836 lines, was discarded.
3. Telocentric chromosome.
4. Selections made for *Helminthosporium sativum* resistance.
5. Selections made for *Fusarium graminareum* resistance.

Table 5. Some CIMMYT *Triticum aestivum* L. materials containing the IB/IR translocation from Petkus rye. Translocation sources are the varieties Aurora, Kavkaz, Weique-Red Mace and derivatives.

Variety or cross	Number of lines
SNB"S"	5
LIRA"S"	10
TES-MUS"S"	1
ALD"S"-MN 72130	1
MON"S"-KVZ	1
KEA"S"	7
KVZ x BB-CHA/TRM	1
CHAT"S"	3
KAL-BB x ALD"S"	1
GOV-AZ x MUS"S"	1
KVZ-JUP x HD2206/SIS"S"	1
MAYA-MON"S" x KVZ-TRM	1
MUS"S"-PTM x MAYA-ALD"S"	1
GOF"S"-ALD"S"	1
KVZ-CGN	1
KVZ-CN067 x PJ	1
PF70354-MUS"S"	3
(IAS58-IAS55 x ALD"S"/MRNG) ALD"S"-IAS58.103A x ALD"S"	1
IAS63-ALD"S" x GTO-LV	3
KVZ-K4500L.6.A.4	1
KVZ-7C	1
JUP-ALD"S"	1
ALD"S" x ERA(3)-SN64/ALD"S"	1
(KVZ/TOB-CTFN x BB)BLO"S"	2
KVZ-J8216.67 x SIS"S"	1
ASP"S"-BJY"S" x ALD"S"	1
KVZ-HD2009	1
CRT-ALD"S"	4
TOB"S"/CN067-JAR x KVZ	1
CVA"S"	2
GHK"S"	1
GSV	1
KLT"S"	1
MAD"S"	2
PAM"S"	1
PHO"S"	1

Table 6. CIMMYT wide crosses program collaborators.

Location	Investigator	Objectives
England Cambridge	Dr. Colin Law	Monosomic series in Glennson 81 Salt tolerance transfer *Helminthosporium sativum* resistance transfer
Wales, Bangor	Dr. Garreth Jones	Salt tolerance screening
USA, Missouri	Dr. Gordon Kimber	Mathematics of chromosome pairing *Aegilops* spp. as source of stress tolerance
USA, Colorado	Dr. Murray Nabors	Tissue culture for alien transfers associated with salt tolerance and inducing recombination
USA, Utah	Dr. Douglas Dewey	Range grass cytogenetics Hybrid production
USA, Utah	Dr. John Carman	Apomictic gene transfer from *Agropyron scabrum*

Table 7. Resistances incorporated into wheat through translocation from alien species.

Disease or pest	Alien species*	Translocated wheat chromosome
Stem rust	*A. elongatum*	6A
Leaf rust	*A. intermedium*	7A
	Ae. umbellulata	6B
Leaf rust and powdery mildew	*S. cereale*	4A
Green bug	*S. cereale*	1A

* *A. = Agropyron, Ae. = Aegilops, S. = Secale*

Germplasm Development

R. Rodriguez R.

Introduction

The role of basic germplasm development in the wheat program at CIMMYT is to develop materials of bread wheat, durum wheat, triticale and rye with special characteristics, such as high protein content or large grain. These are then improved with respect to yield and plant type and made available to the breeding programs, which use them to develop new CIMMYT lines. Significant advances were made in 1983, especially in bread and durum wheats.

Bread Wheat

The principal emphasis in this part of the program in 1983 was on combining broad disease resistance and tolerance to high levels of free aluminum, developing isogenic lines for leaf rust resistance, transferring the solid stem character from durum to bread wheat, and improving certain components of yield. It appears that attempting to increase bread wheat protein content will be futile, so this project is receiving less attention than in previous years.

Protein content—In 1983, the effort put into this project was considerably reduced for two reasons:

- The material has been improved sufficiently that it can now be handled in conventional improvement programs.
- Although some lines show a certain degree of improvement, in general it has been found that the quantity of protein produced is no greater than that inconventional varieties.

The material tested in the 1981-82 cycle produced less protein than commercial varieties, as can be seen in the report for 1982. During the 1982-83 cycle, there were four field trials for productivity, in which 92 high protein lines were studied. Tables 1 and 2 show that in general the results for 1982-83 are similar to those observed in 1981-82. Nevertheless, in Table 2 there are two lines, CAL-NH x CMH73A.497/Her.77 and CMH73A.497-Her.77[2], which produced more protein per hectare than the check varieties, Ciano 79 and Ciano 67. Further observation is necessary to determine whether the differences are stable and actually significant.

Another interesting aspect is loaf volume. Many of the tested lines had a greater volume than the checks, particularly the line CMH73A.497-Her.77[2] (Table 2). This gave a loaf volume of 1015 cubic centimeters, which is very high compared with the 715 cubic centimeters of Ciano 79 and the 860 cubic centimeters of Ciano 67.

Disease resistance in aluminum-tolerant germplasm—The development of germplasm resistant to diseases and tolerant of high free aluminum levels is one of the main projects in the program. It is known that many Brazilian varieties have low yields but are tolerant of high aluminum levels and resistant to the diseases most common in Brazil. From such varieties, isogenic lines in which height and earliness have been modified have been developed. These are now being tested for yield and, through nurseries sent to appropriate parts of the world, for the aluminum tolerance and disease resistance characteristic of the original varieties. To date, the information we have received from these nurseries is incomplete. However, some positive results are being received from cooperators.

The present work is focused on crossing the better isogenic lines in an attempt to obtain material which combines good tolerance to aluminum with resistance to the greatest possible number of diseases. It is hoped that during the 1983-84 cycle, uniform lines will be available for pathological studies and to determine the degree to which we are reaching our objectives.

Ing. R. Rodriguez (right), head of the germplasm development program, with a visiting scientist.

Leaf rust resistance—The single genes Lr9, Lr19, Lr20, Lr21 and Lr24 are being utilized to develop isogenic lines which will be used to form multilines of Yecora 70 and Nacozari 76. Some of these genes are also being incorporated into the new varieties, such as Ciano 79, Genaro 81, Glennson 81, and Seri 82. In addition, some crosses are being made to combine several of these genes so as to increase protection against leaf rust.

At the same time, testing continues on the advanced isogenic lines coming from Yecora 70, Jupateco 73, Cajeme 71, Inia 66, Tanori 71, Sonalika, and others, into which have been incorporated Lr9, Lr19 and Lr24. These genes have been demonstrated to be effective under the conditions at the Yaqui Valley Agricultural Experiment Station (CIANO) and the El Batan Experiment Station (Figure 1). Many of the tested lines yielded more than their recurrent parents; however, in the 1982-83 cycle, 139 lines were tested in seven yield trials and some produced as much as the commercial varieties, but none were superior as can be seen in Table 3, which presents the results of one of these seven trials.

In 1983 the best lines with Lr9, Lr19 and Lr24 were included in the international nurseries to observe performance and to determine their effectiveness under a variety of conditions. The information received to date is reported in Table 4.

Insect resistance—For several years work has been conducted to develop a bread wheat with a solid stem and a good agronomic type. At present, there are lines in existence which combine these characteristics; nevertheless, it is necessary to introduce the solid stem characteristic into a broader and more diversified range of germplasm.

It has been observed that the solid stem character in durum wheat is superior to that in bread wheat. Consequently, interspecific crosses are being made to see if there is a possibility of transferring the durum type of solid stem to bread wheat.

Yield components—During the 1982-83 cycle, a yield trial was planted with lines having modifications of one or more components of yield, such as number of grains per spikelet, number of spikelets per spike, number of grains and spikelets per spike and size of grain. These materials had poor grains and poor agronomic type (Table 5), but they were considered good enough to initiate trials which will give us a preliminary idea of their yield potential.

At present, the project is being directed toward improving filling, size and weight of grain, as well as increasing tillering (Figure 2). To this end, crosses are being made with a diversity of materials such as those noted in the following:

- High-yielding lines and varieties from the conventional bread wheat improvement program
- Germplasm which is unrelated to existing CIMMYT germplasm
- Other species, including triticale

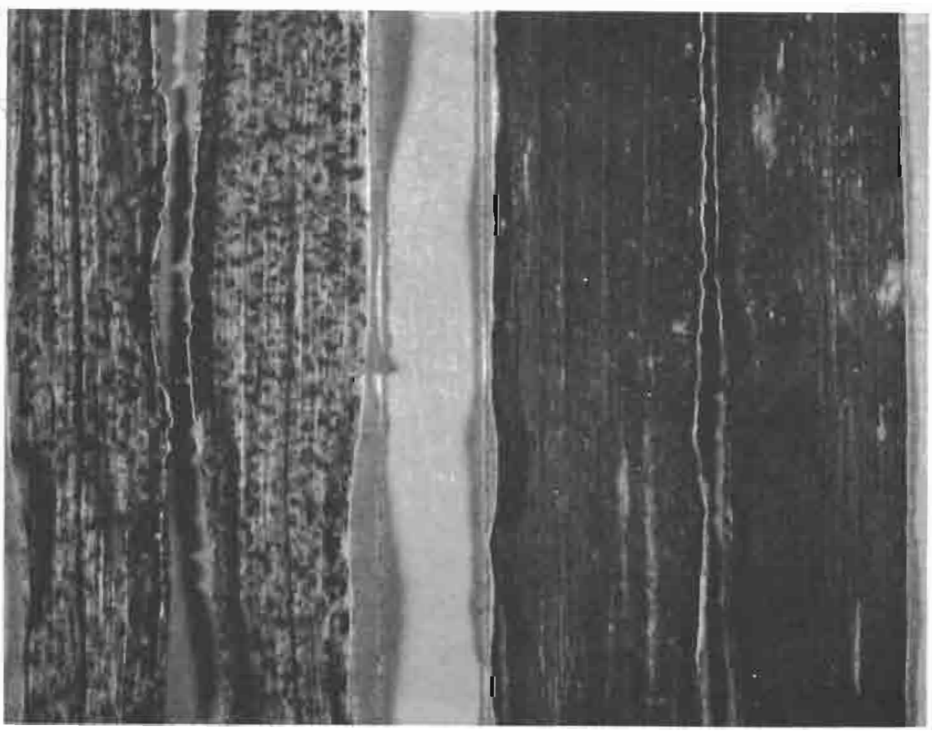


Figure 1. Effect of Lr19 incorporated into Yecora 70. Note the number of leaf pustules in Yecora 70 (left) and their absence in Yecora 70 + Lr19 (right).

Durum Wheat

In durum wheat the approach is similar to that in bread wheat: at first efforts are made to improve single characteristics and later, if necessary, they are worked with in combination. Bread wheats have frequently been used as a source of characteristics for improving the durums; this has been the case with dwarfing, solid stem, yield components and early maturity, which are some of the principal characteristics being manipulated in this part of the program.

Dwarfing—It has been reported in previous years that various triple dwarf, isogenic lines of Cocorit 71, Mexicali 75, Tehuacan 60, and others are now in advanced generations. There has been a satisfactory recovery of the durum wheat phenotype in this material and currently little time is dedicated to improving this characteristic.

Solid Stem—There are two sources of genes for the development of durum wheat with solid stems, one in durum wheat itself and another in bread wheat. Lines with solid stem have been selected from the material currently available and used to make new crosses in order to diversify somewhat the germplasm which carries this characteristic. Some of the lines with better agronomic type and a solid stem come from the cross CMH82.694; new crosses are being made with these.

Yield Components—Increased number of spikelets per spike was transferred from bread wheat to durum, while increased number of grains per spikelet originated separately in both bread and durum wheats. Currently, various lines of durum wheat show improvement in these characteristics, although fertility and grain filling in these lines are very poor. In general, the development of durum wheats with a larger number of spikelets per spike and grains per spikelet is less advanced than in the bread wheats. On the other hand, lines with large grains with acceptable fullness and a good agricultural type have been produced, making it possible to include these in yield trials in the next cycle.

Earliness—Early maturation is a characteristic of great importance that the basic germplasm development program is seeking to improve by means of interspecific crosses. For the most part, durum wheats are being crossed with early bread wheats, such as Sonora 64, Sonalika and some lines derived from CMH73A.497 (earlier than Sonalika). Various lines derived from CMH73A.497 x Mex.75^{2}, are earlier than Mexicali 75, which is one of the earliest varieties among the durum wheats. As expected, grain production is very poor in the earliest lines. At present the principal objective of this effort is to maintain earliness while increasing yield. This is being pursued by simple crossing and backcrossing with the higher-yielding varieties in the conventional durum wheat improvement program.

Triticale

At the present time, most of the work related to the improvement of triticale is based on crosses of triticale with bread wheat. From our experience with these crosses, it is clear that it is possible to transfer genes in both directions. When Beagle was crossed with a dwarf, early maturing, beardless wheat, lines were recovered that were phenotypically triticales, but with a short stem, beardless spike and earlier maturation than Beagle. Similarly, wheat types with a larger spike than the wheat parent were recovered. In crosses of triticale with Nacazori 76 (susceptible to leaf rust), triticales were obtained with a more uniform short stem than in conventional triticales, along with wheat phenotypes resistant to leaf rust. Triticale x Norteio 67 (susceptible to leaf rust) has yielded lines with very large spikes, resistance to leaf rust and a phenotype intermediate between triticale and wheat. In crosses with Super X, wheat phenotypes were obtained with a pubescent peduncle like the hexaploid triticales. Grain filling and vitreousness has improved considerably in lines with a plant height between 70 and 90 centimeters, particularly in material which contains CMH74A.888. The crosses CMH80.1022 and CMH81.1148 produced triticales with 36 to 40 spikelets per spike, a height of 70 to 90 centimeters, earlier maturity than Beagle and a more uniform grain size with fewer shrivelled grains than Beagle. Triticales derived from triticale x wheat crosses have demonstrated greater uniformity in characteristics such as height, earliness and grain filling.

In the 1983-84 cycle, some of the wheats and triticales derived from triticale x wheat crosses will be tested for yield. In addition, the triticales will be tested for their milling and bread-making qualities and for premature sprouting. The wheat types will be observed for their tolerance to high aluminum levels and for their disease resistance.

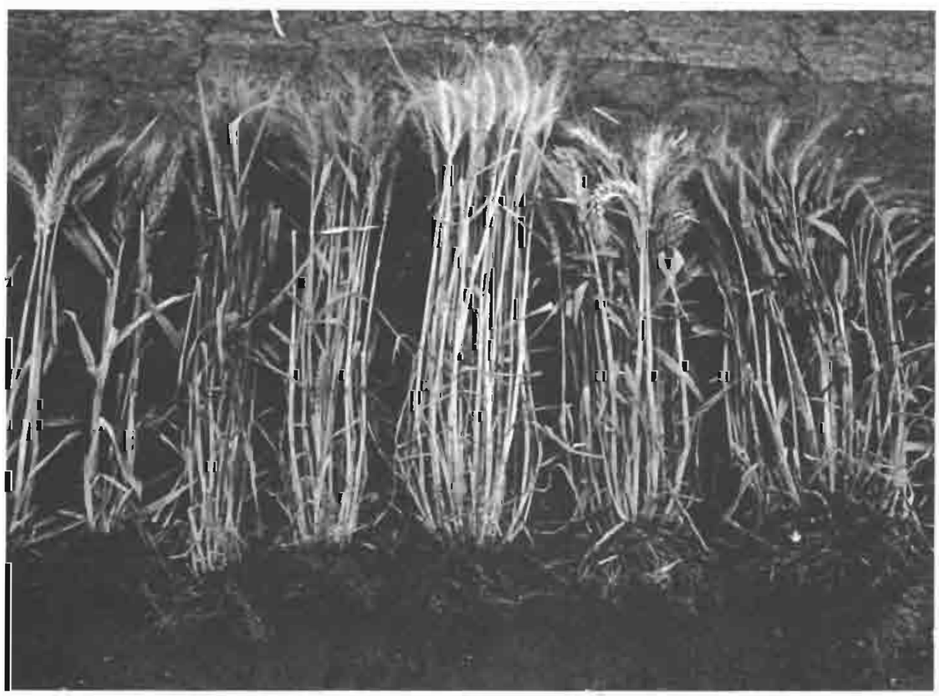


Figure 2. Variation in tillering. Many large-spiked wheats have few stems (plants on the left) but the number of stems can be increased to different degrees (plants on the right).

Rye

The principal goal of the work with rye is to develop ryes which will be appropiate for the formation of new and better triticales. For several seasons, a small program of individual selection has been maintained in populations of about 20 varieties. These varieties were grown side by side and open pollinated for various generations, making them very heterogeneous. From these heterogenous populations, individual plants were selected. Their progenies were planted in isolation and selected repeatedly for characteristics such as height, earliness, disease resistance, fertility, spike type, grain type, etc. The objective is to develop homozygous lines for each of these characteristics.

Snoopy is the variety that has been selected for the greatest number of generations; currently some of its lines are being used as the principal sources of dwarfing and earliness in crosses intended to improve the characteristics of all tall, late-maturing rye varieties. From these crosses, more than 100 lines have been obtained, which are gradually approaching an acceptable level of homozygosity.

International Nurseries

During 1983, four international nurseries were prepared and sent to different locations as determined by requests and the appropriateness of the location for observing the material. The nurseries and the number of each sent are as follows:

Yield components in bread wheat	50
Yield components in durum wheat	20
Resistance to leaf rust	43
Aluminum tolerance and disease resistance	34
Total	147

Table 1. Performance of germplasm with high protein content included in experiment no. 1 at CIANO in 1982-83.

Variety or cross and pedigree	Yield (kg/ha)	Protein content (kg/ha)	Protein content (%)	Loaf volume (cc)	Days to flowering	Plant height (cm)
TESIA 79	6250	521	11.8	635	76	70
CMH75A.66-CNO.79 CMH79A.21-1B-5Y-1B-0Y	5722	564	12.7	780	74	85
CMH75A.66-CNO.79 CMH79A.21-5B-1Y-3B-0Y	5708	516	11.8	700	70	80
CMH75A.66-CNO. 79 CMH79A.21-5B-4Y-7B-0Y	5708	526	12.6	690	70	75
CMH75A.66-CNO. 79 CMH79A.21-5B-1Y-1B-0Y	5556	506	11.8	665	70	75
CMH75A.66-CNO. 79 CMH80.15-3Y-1B-0Y	5542	450	12.2	710	72	85
CMH75A.66-CNO. 79 CMH79A.21-5B-4Y-3B-0Y	5292	493	12.8	660	68	80
CMH75A.66-CNO. 79 CMH79A.21-5B-1Y-4B-2Y-0B	5222*	501	12.2	710	70	75
CMH75A.66-CNO. 79 CMH80.15-3Y-5B-4Y-0B	5028	487	12.4	720	68	70
CMH75A.66-HER.77 x CMH75A.66 CMH80.127-1Y-1B-0Y	4833	461	12.9	840	76	80
CMH75A.66-HER.77 x CMH75A.66 CMH80.127-2Y-1B-0Y	4833	521	14.5	865	72	80
CMH75A.66-CNO. 79 CMH79A.21-5B-4Y-1B-3Y-0Y	4819**	471	13.0	695	70	75
CMH75A.66/RON.2-FND x SX CMH80.37-1Y-3B-0Y	4639	449	12.9	750	75	80
CMH75A.66-HER.77 CMH79.14-4Y-1B-2Y-3B-0Y	4625	532	15.0	930	70	75

Table 1. (Cont'd)

Variety or cross and pedigree	Yield (kg/ha)	Protein content (kg/ha)	Protein content (%)	Loaf volume (cc)	Days to flowering	Plant height (cm)
CMH75A.66-CNO. 79 x CMH75A.66 CMH80A.78-1B-7Y-0B	4472	458	13.9	850	75	75
CMH75A.66 CMH75A.66-8B-1Y-4B-1Y-0B	4444	502	15.7	865	73	75
CMH75A.66 CMH75A.66-8B-1Y-4B-1Y-5B-0Y-5B-0Y	4444	479	15.3	980	73	70
CIANO 67	4236	420	12.9	865	66	75
CMH75A.66 CMH75A.66-8B-1Y-4B-1Y-5B-3Y-1B-0Y	4208	466	15.3	855	75	75
CMH75A.66-HER.77 x CMH75A.66 CMH80.127-2Y-5B-0Y	4111	430	14.5	855	76	85
CMH75A.66-CMH76.173 CMH79A.87-1B-1Y-1B-0Y	4069	429	14.6	750	73	70
CMH75A.66-CMH76.217 CMH80.82-1Y-3B-0Y	4014	393	15.2	775	70	75
CMH75A.66-CMH76.217 CMH80.82-1Y-1B-0Y	3931	378	15.4	760	68	75
CMH75A.66-CMH76.217 CMH80.82-4Y-1B-0Y	3000	343	16.2	850	68	70
RON2-FND[4] CMH78A.30-1B-1Y-1B-1Y-1B-2Y-0B	2292	230	14.4	805	68	75

** L.S.D. 0.01 = 1490kg/ha for yield

* L.S.D. 0.05 = 1100kg/ha for yield

Table 2. Performance of germplasm with high protein content included in experiment no. 4 at CIANO in 1982-83.

Variety or cross and pedigree	Yield (kg/ha)	Protein content (kg/ha)	Protein content (%)	Loaf volume (cc)	Days to flowering	Plant height (cm)
CIANO 79	7306	520	9.7	715	80	80
CAL-NH x CMH73A.497/HER. 77 CMH79.196-6Y-3B-4Y-1B-0Y	6097	628	13.1	865	70	75
CMH73A.497-HER.77[2] CMH78A.217-8B-3Y-4B-1Y-3B-0Y	6028**	540	12.6	1015	72	75
CMH73A.497-HER.77[2] CMH78A.217-8B-3Y-4B-1Y-4B-1Y-0B	5583	511	12.8	880	74	75
CMH73A.497-HER.77[2] CMH78A.217-8B-3Y-4B-1Y-5B-2Y-0B	5569	504	12.5	920	74	75
CMH76.173-TESIA 79[2] CMH80.153-5Y-4B-0Y	5528	482	12.1	695	75	75
CMH73A.497-HER.77[2] CMH78A.217-8B-1Y-4B-1Y-5B-0Y	5472	492	12.8	890	73	75
CIMMYT SEL. (KLEPPER)	5417	519	12.7	760	72	80
CMH73A.497-HER.77[2] CMH78A.217-8B-1Y-4B-1Y-2B-0Y	5167	465	12.7	895	73	75
NH/CI13449//CC-INIA/CNO-7C	5167	422	11.7	675	86	80
CIMMYT SEL. (KLEPPER)	5097	506	13.3	825	73	80
CIMMYT SEL. (KLEPPER)	5097	489	12.9	875	76	80
(RON2-FND x H567.71/CNO.67) HER.77 (RON2-FND x H567.71/CNO.67) CMH79A.149-3B-1Y-3B-0Y	5042	504	13.3	820	74	65

Table 2. (Cont'd)

Variety or cross and pedigree	Yield (kg/ha)	Protein content (kg/ha)	(%)	Loaf volume (cc)	Days to flowering	Plant height (cm)
CMH76.173-NAC.76 CMH78A.117-2B-7Y-1B-3Y-3B-0Y	4958	472	12.8	570	74	70
CMH73A.497-ZA.75^{2} CMH79A.126-1B-1Y-1B-4Y-0B	4917	405	11.9	760	77	70
CMH73A.497 x CNO.67-SX^{2} CMH79A.130-4B-2Y-1B-3Y-0B	4833	453	13.0	865	70	75
CMH76.207-CMH76A.912^{2} CMH79A.173-4B-4Y-1B-0Y	4597	412	11.9	760	70	65
CIMMYT SEL. (KLEPPER)	4597	503	15.0	920	74	90
CIANO 67	4528	461	13.2	860	68	75
CIMMYT SEL. (KLEPPER)	4417	423	13.4	840	72	75
CMH76.217-CNO.79 CMH79A.105-9B-3Y-2B-0Y	4097	348	12.6	860	70	60
CMH76.217-CMH76.207 CMH78A.141-17B-1Y-1B-3Y-1B-0Y	3625	370	14.7	740	70	65
CMH73A.497-H570.71 x CMH73A.497 CMH76.173-4Y-3B-6Y-7B-0Y	3236	332	14.6	840	66	65
CMH73A.497-H570.71 x CMH73A.497 CMH76.173-4Y-1B-2Y-1B-1Y-3B-1Y-4B-0Y	2694	269	14.5	800	66	80
CMH73A.497-H570.71 x CMH73A.497 CMH76.173-4Y-3B-6Y-1B-0Y	2472	249	14.4	825	68	65

** L.S.D. 0.01 = 121 kg/ha for yield
* L.S.D. 0.05 = 894kg/ha for yield

Table 3. Performance of 22 lines resistant to *Puccinia recondita* and three checks at CIANO in 1982-83.

Variety or cross and pedigree	Yield (kg/ha)	Reaction to leaf rust*	Days to flowering	Plant height (cm)
GLENNSON	6528	30R-MR	84	90
NACOZARI 76	6472	60S	77	85
RL6010-INIA66^6 CMH79.728-1Y-7B-1Y-3B-0Y	6125	0	72	80
RL6010-INIA66^4 CMH78.616-6Y-7B-1Y-1B-1Y-1B-0Y	5931	0	74	80
RL6040-INIA66^3 CMH78A.672-1B-3Y-2B-1Y-5B-0Y	5917	0	74	85
RL6010-INIA66^4 CMH78.616-6Y-2B-3Y-10B-0Y	5903	TR	74	80
RL6040-INIA66^3 CMH78A.672-3B-1Y-1B-2Y-0B	5653	0	75	80
RL6040-INIA66^3 CMH78A.672-1B-3Y-2B-0Y	5653*	0	75	80
RL6010-INIA66^6 CMH79A.707-6B-2Y-2B-0Y	5500	0	72	80
AGENT - INIA66^3 CMH78A.680-6B-5Y-3B-1Y-1B-0Y	5500	TR	72	70
RL6010-INIA66^5 CMH79.726-1Y-1B-2Y-3B-0Y	5472	0	75	85
RL6010-INIA66^5 CMH78A.666-4B-3Y-1B-2Y-5B-0Y	5472	0	70	85
RL6010-INIA66^6 CMH79.728-1Y-7B-1Y-1B-0Y	5458	0	74	75

Table 3. (Cont'd)

Variety or cross and pedigree	Yield (kg/ha)	Reaction to leaf rust*	Days to flowering	Plant height (cm)
RL6010-INIA66^6 CMH79.728-6Y-4B-1Y-2B-1Y-0B	5403	0	70	85
RL6010-INIA66^5 CMH78A.666-1B-3Y-1B-1Y-1B-2Y-0B	5375	0	73	80
RL6010-INIA66^6 CMH79A.707-6B-4Y-2B-0Y	5361	0	72	80
RL6010-INIA66^6 CMH79.729-1Y-7B-1Y-1B-0Y	5306**	0	70	80
AGENT-INIA66^3 CMH79A.717-8B-2Y-1B-0Y	5236	0	70	75
INIA 66	5236	60S	73	75
RL6040-INIA66^4 CMH79.738-3Y-6B-3Y-0Y	5222	TMR	74	85
RL6040-INIA66^4 CMH79.738-3Y-6B-3Y-1B-0Y	5167	0	75	85
RL6040-INIA66^4 CMH79.738-3Y-6B-3Y-4B-0Y	4917	0	74	85
RL6010-INIA66^6 CMH79.729-3Y-4B-0Y	4764	TR	74	80
AGENT-INIA66^6 CMH80-552-1Y-1B-2Y-0B	4750	0/50S	72	80
RL6010-INIA66^4 CMH78-616-6Y-2B-3Y-5B-0Y	4697	TMR	74	85

*Leaf rust reaction = modified Cobb scale
L.S.D. 0.01 = 1280kg/ha for yield
L.S.D. 0.05 = 945kg/ha for yield

Table 4. Reaction *to leaf rust of lines carrying resistance genes in eight locations.

Gene (line or variety)	USA	Ecuador	Portugal	China	Egypt (a)	Egypt (b)	Bangladesh (c)	Bangladesh (d)	Pakistan	Thailand
Lr9 (RL6010)	TR-MR	0	0	0	0	MR-S	0	0	R	0
Lr19 (Agatha)	TR-MR	0	0	0	0	MS-S	0	0	R	0
Lr24 (Agent)	TMR	0	0	0	0	MS-S	0	0	R	0

*Modified Cobb scale.
a. Sakha Agricultural Research Station
b. Gemmeiza Research Station
c. Jessone Experiment Station
d. Joydebpur Experiment Station

Table 5. Some yield components of large spike lines at CIANO in 1982-83.

Variety or cross and pedigree	Yield (kg/ha)	Days to flowering	Plant height (cm)
AGENT-CMH76.1084^2 CMH79.750-2Y-4B-2Y-1B-2Y-0B	6750	87	95
CIANO 79	6500	80	85
ERA-SX^2 CMH78.792-2Y-1B-1Y-1B-0Y	6056	79	80
CMH76A.912-CMH76A.769 CMH78A.818-1B-3Y-1B-2Y-0B	6028	76	80
PEC-CMH76.1084^2 CMH79.708-3Y-1B-3Y-1B-1Y-0B	5611	76	75
CMH76A.912-CMH76A.769 CMH78A.818-1B-3Y-1B-3Y-0B	5556*	79	85
CMH74.638 x FURY-KAL^2/PVN"S" CMH78.790-1Y-2B-2Y-1B-1Y-0B	5528	77	80
CMH76A.769-CNO79^2 CMH79A.800-1B-4Y-2B-0Y	5444	80	100
CMH74.638 x FURY-KAL^2/PVN"S" CMH78.790-1Y-2B-2Y-1B-2Y-0B	5417	77	80
CMH76.1330-CMH77A.917 CMH79A.1384-3B-5Y-4B-1Y-0Y	5417	77	90

Table 5. (Cont'd)

Variety or cross and pedigree	Yield (kg/ha)	Days to flowering	Plant height (cm)
CMH74A.630-SX CMH77A.788-1B-15Y-1B-2Y-1B-0Y	5389	80	90
CMH76A.912-CMH76A.769 CMH78A.818-1B-3Y-1B-1Y-4B-0Y	5389	79	85
CMH74A.630-MAYA"S" x CMH74A.630 CMH76A.912-7B-2Y-4B-0Y-3B-0Y	5333	80	90
CMH74A.630-SX CMH77A.788-1B-15Y-5B-1Y-1B-0Y	5250	80	100
CMH76A.912-CMH76A.769 CMH78A.818-1B-3Y-1B-2Y-1B-0Y	5194**	77	80
CMH74A.630-SX CMH77A.788-1B-15Y-5B-1Y-4B-0Y	5111	80	100
ALONDRA 1-CMH77A.917 CMH79.215-1Y-3B-2Y-1B-6Y-0B	5056	72	75
CMH76.1084-CMH72A.429 CMH78A.860-1B-3Y-1B-1Y-1B-0Y	4944	79	75
ALONDRA"S"-CMH76.951 CMH78.353-7Y-1B-1Y-4Y-2B-0Y	4889	86	55
CMH74A.630-HERMOSILLO 77^2 CMH78.798-3Y-1B-1Y-1B-1Y-1B-0Y	4833	72	85
ALONDRA"S"-CMH76.951 CMH78.353-7Y-1B-1Y-4B-2Y-0B	4806	86	60
PEC-CMH76.1084^2 CMH79.708-3Y-1B-3Y-1B-3Y-0B	4778	79	75
CMH76A.912-CMH76A.769 CMH78A.818-1B-3Y-1B-1Y-1B-0Y	4722	79	80
ALONDRA 1-CMH77A.917 CMH79.215-1Y-5B-1Y-5B-0Y	4417	80	80
CMH77A.917-CMH75A.142 x CMH77A.917 CMH79A.955-7B-6Y-3B-0Y	4111	88	85

** L.S.D. 0.01 = 1624kg/ha for yield
* L.S.D. 0.05 = 1199kg/ha for yield

Germplasm Bank

H.A. Sencer

Introduction
The CIMMYT wheat germplasm bank became operational in October, 1981, when the construction of its building was completed. The majority of the installations was completed in 1982 and the seed drying room became operational at the end of 1983.

In 1982 and 1983 priority was given to the elimination of unnecesary and/or duplicated entries, and to updating the seed increase, rejuvenation and evaluation of the base collection. Elimination of unnecessary and/or duplicated entries left the bank's base collection at 20,183 entries, and its active collection at 3,013 entries by the end of 1983.

Seed Introductions
During 1983, 9035 new entries were added to the base and active collections of the bank, as shown in Table 1. Entries of primitive cultivars, commercial varieties, wild species and other special lines, which were included in the observation lines and miscellaneous nurseries of the breeding programs and/or received from other sources, were included in the active collection.

Seed Increase and Rejuvenation
Over 10,000 entries were sown at the Yaqui Valley Agricultural Experiment Station (CIANO) during the winter season of 1982-83, as shown in Table 1. Some parts of the nursery suffered from standing water due to poor levelling. The entries which showed low or no germination because of this problem were sown again during the 1983-84 winter season at CIANO.

Seed Storage
Fifty grams of seed for each of the 8947 entries that were harvested at the CIANO experiment station were placed in the short-term storage room (active collection) as shown in Table 1. The first group of seed, comprising 3371 entries, was placed in the drying room in December, to be transferred to the medium-term storage room (base collection) upon termination of drying.

Seed Distribution
In response to requests, 3998 samples were distributed in 1983 (Table 1). Most of these involved a considerable amount of information retrieval and large quantities of seed were requested.

Evaluation
The morphological and agronomic characteristics of the entries sown for seed increase and/or rejuvenation purposes at CIANO during the winter season of 1982-83 were recorded. In addition, the leaf rust reactions of the barley entries in the same nursery were recorded jointly with the pathology program. The first disease evaluation nurseries of bread wheat (318 entries) and durum wheat (210 entries), originating from the third International Bread Wheat Screening Nursery (IBWSN) and the fourth International Durum Screening Nursery (IDSN), respectively, were sent to cooperators in 1983. In addition, quality data for the entries originating from the 4th through 14th IBWSN were received during the year.

Information Bank
To finalize the elimination of duplication in the base collection, each nursery was compared with an average of four other nurseries. About 700 nursery comparisons were made (without the aid of the computer) in 1983. Thousands of entries were compared with one another as to their origins, pedigrees and/or names. A listing of all land races, commercial varieties and special lines of bread wheat, durum wheat, triticale and barley was also prepared as part of this operation.

The introduction, storage, distribution and seed increase/evaluation books were prepared manually. The preparation of introduction books for the six independent inventories (bread wheat, durum wheat, triticale, barley, germplasm development and

Dr. H. A. Sencer, curator of the wheat germplasm bank.

CIMMYT wheat introductions) included refining the introduction data (i.e., correction and completion, separation of descriptors, etc.).

Every individual seed request involved some sort of information retrieval (depending on the nature of the request) and was associated with a standard distribution list, which contains a required minimum amount of information. Producing these lists often involved a complete search of the inventories of individual crops, and in some cases retrieval of evaluation data. In 1983, the most unusual operation of this nature was the retrieval of Karnal bunt reactions obtained from the field inoculations during the 1981-82 cycle; this data search resulted in a 50 percent decrease in the number of entries to be tested in 1983.

As a first step toward computerization of the germplasm bank data base, the introduction data for a part of the bread wheat inventory (third through eighth IBWSN) and the durum wheat inventory (fourth IDSN) were entered into the computer. The field books for the disease evaluation nurseries were reproduced by computer.

Future Plans

In 1983, as in previous years, the principal emphasis was on re-organizing and up-dating the seed collection itself. This phase will end in 1984, when the rejuvenated and increased seed from the 1983 cycle is dried, tested for germination, and stored.

The next phase is the development of an automated data bank containing information on the agronomic, pathological, quality and other characteristics, as well as introduction and storage data, for each entry. This will provide the breeders, cooperators and other users with ready access to the whole collection.

Table 1. Summary of CIMMYT's wheat germplasm bank activities in 1983.

Type or source of material	Activities (number of entries)			
	Seed introduction	Seed increase, rejuvenation, evaluation	Additions to active collection	Seed distribution
Bread wheat	2590	2958	2759	2344
Durum wheat	1482	1357	1269	80
Triticale	809	2451	1954	278
Barley	389	2955	2397	–
Germplasm development	222	222	84	–
CIMMYT wheat introductions	3813	547	484	1157
Total	9305	10,490	8947	3859

Training

H.M. Hepworth, E. Knapp, and G. Kingma

Introduction

CIMMYT training programs are designed to strengthen and support the research capabilities of cooperating countries. During 1983, in-service training programs were carried out in cereal improvement (breeding and pathology), production agronomy, cereal technology and experiment station management. In addition the postdoctoral and visiting scientist programs were unusually active.

Several events of special interest occurred during the year:

- The addition of Dr. Gerbrand (Gerry) Kingma to the wheat training program will bring special expertise in the area of cereal improvement.
- Our first two trainees from Zimbabwe participated in the program.
- Recognizing the importance of high quality seed, CIMMYT training programs (both wheat and maize) devoted a full week to a concentrated program, "Seed Week." Dr. Johnson E. Douglas and Mr. Josef Cortés from the International Center for Tropical Agriculture (CIAT) seed unit very ably conducted this course.

Training at CIMMYT is not a simulated experience. It is a real-life situation with hands-on, learning-by-doing experience using the field as the training center. CIMMYT emphasizes the team approach to identifying and solving problems. The young scientists from cooperating countries work closely with senior CIMMYT staff, thus developing their expertise and confidence. As part of the training program, each participant is provided a number of text books, manuals and other publications related to their various fields of interest. Upon returning home, the trainees have a basic library for future reference.

The number of trainees from countries where wheat is not a traditional crop continues to increase. These countries are becoming more aware of their potential for wheat production and are anxious to get research programs underway.

Postdoctoral Program

In 1983 postdoctoral fellows from Germany (2) the Netherlands (1), India (1), Australia (1), the United Kingdom (1), Afghanistan (1) and the USA (1) were working in the CIMMYT wheat program. They are integrated into the program staff and participate as staff members.

Visiting Scientists

Senior scientists from many countries came to visit the CIMMYT wheat program in 1983:

Latin America	43
Africa	11
East Asia	30
Mediterranean region	10
Other	44
Total scientists	138
Total countries	34

These scientists usually come for two to three weeks, but some with special interests or expertise may remain longer. While at CIMMYT these visitors share their knowledge and experience with CIMMYT scientists and with our training groups. This is done through informal, person-to-person contact and through seminars and group discussions. CIMMYT believes that this unique opportunity for personal, as well as more formal, exchange of ideas and information is of great value.

Of course many of the visiting scientists select germplasm from the extensive CIMMYT nurseries for use in their own programs. They also bring germplasm from their programs for use at CIMMYT. The counterpart of the visiting scientist effort is that many CIMMYT staff members, especially those in regional or bilateral programs, travel to cooperating countries each year. This provides personal contact with many more cooperating scientists. In addition, CIMMYT staff can in this way better evaluate the performance of the germplasm sent to these cooperators as well as offer closer support to their programs.

Dr. E. Knapp (left), wheat production training officer, and Dr. H. Hepworth (right), head of the wheat training program.

Predoctoral Programs
A very limited number of young scientists are sponsored by CIMMYT to do research toward the Ph.D. degree. These scientists work on problems that are of special interest to CIMMYT and have potential for very broad application. Currently two young scientists are involved in these programs in wheat.

Wheat Production Training
It is a well-demonstrated fact that there is a sizeable gap between the potential yields and the actual yields farmers are receiving. This fact clearly indicates the urgent need for many more production agronomists.

The goal of the wheat production training program is to develop production agronomy specialists for national programs. These specialists are trained in the essential skills required to design, test and deliver to farmers technologies which will increase production and net farm income, thus reducing the yield gap. The essential skills are organized into three categories: 1) diagnosis of problems, 2) experimentation to determine possible solutions and 3) analysis of results to provide the basis for developing recomendations.

Experiments and demonstrations conducted in farmer's fields by the trainees themselves are the core of this program—the field is the classroom. But in addition, production agronomists must realize that a great many socio-economic factors also influence a farmer's decisions and his crop production operation. Therefore, the CIMMYT production training effort includes a strong socio-economic component (surveys, farmer interviews, on-farm research to design a technology suited to actual conditions, data analysis, and the preparation of alternative production technologies) presented in close cooperation with our colleagues from the economics program. Lectures and field trips supplement the practical agronomy (land preparation, seeding, weeding, fertilizing and harvest) learned in the field.

A special session of two weeks' duration is devoted to the study of irrigation principles and practices, again combined with practical field experience. In 1983, an irrigation specialist with wide experience was employed as a consultant to observe and monitor this phase of the training. His suggestions for improving the course will be incorporated into the program.

Dr. G. Kingma (right), wheat improvement training officer, in the field with wheat improvement trainees.

The number and the home areas of the trainees who participated in the production training program in 1983 are listed below:

Latin America	7
Sub-Saharan Africa	3
East Asia	7
Mediterranean region	4
Other (Norway)	1
Total trainees	22

Many of the group (88 percent) indicated that they had worked directly with farmers. Therefore, CIMMYT believes that the production training program is dealing with the proper target group, whose members should become key people in production programs in their home countries.

Cereal Improvement Training
Trainees from 18 countries participated in the 30-week cereal improvement training program in 1983. Their areas of origin and number are listed below:

Latin America	7
Africa	8
East Asia	10
Mediterranean region	3
Total trainees	28

These young plant breeders and pathologists worked directly with senior CIMMYT scientists in the on-going crop improvement research programs. The methodology and skills acquired can be applied in their own national programs. All phases of crop improvement are covered, including crossing, selection, disease inoculation and scoring, harvesting, nursery management and grain quality evaluation. An important phase of this training is learning how to create artificial epidemics by artificial inoculation to enhance selection of disease-resistant materials. Recent epidemics in some countries, resulting in great losses, clearly indicate the value of resistant materials. In nontraditional wheat areas, diseases other than the well-known rusts are of major importance. Consequently, disease identification and diagnosis, critical skills for these areas, are also taught.

Before the end of the program, most of the cereal improvement trainees select improved genetic materials to take or send to their national programs. Later, CIMMYT senior staff try to visit these young scientists in their home countries at regular intervals to consult with them about germplasm and to offer advice and support.

Cereal Technology

Scientists from five countries, Bangladesh (1), Burundi (1), Korea (2), Pakistan (1) and Tunisia (1) spent two months at CIMMYT working in the cereal quality laboratory. Here they learned to evaluate wheat varieties for baking and nutritional qualities and to operate the laboratory equipment. They also learned about the relationships between the quality laboratory and field breeding programs and about laboratory management procedures.

Experiment Station Management

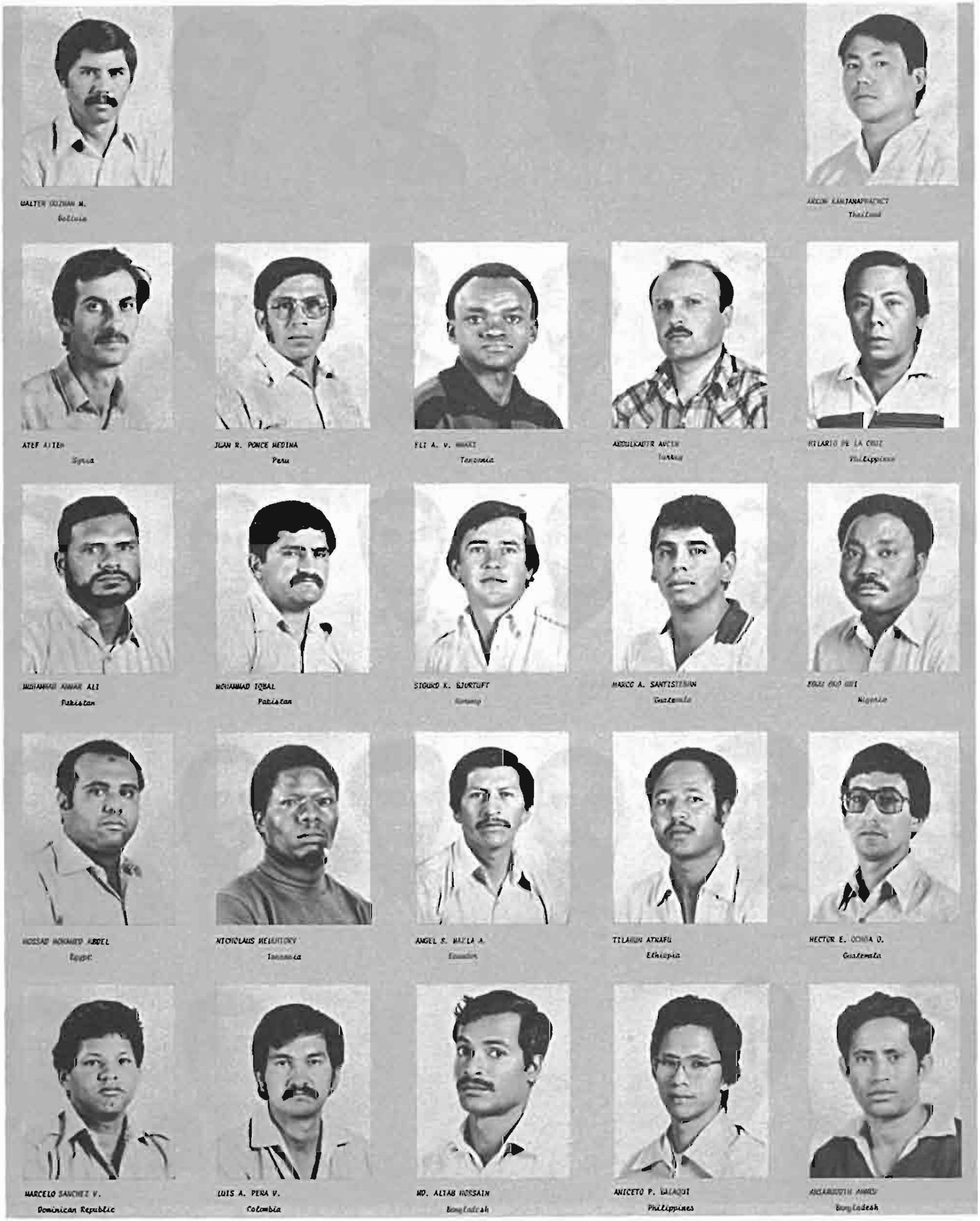
This program is conducted by the CIMMYT experiment station management group. It is designed to provide the trainees with the skills needed to improve research conditions at their home-country stations. Improved station operation results in better research and more confidence in results obtained. The course includes training in the proper operation and maintenance of machinery, tillage practices, seeding operations, etc. Scientists from Kenya (1), Peru (3) and Thailand (1) participated in this 18-week program.

Training Outside of Mexico

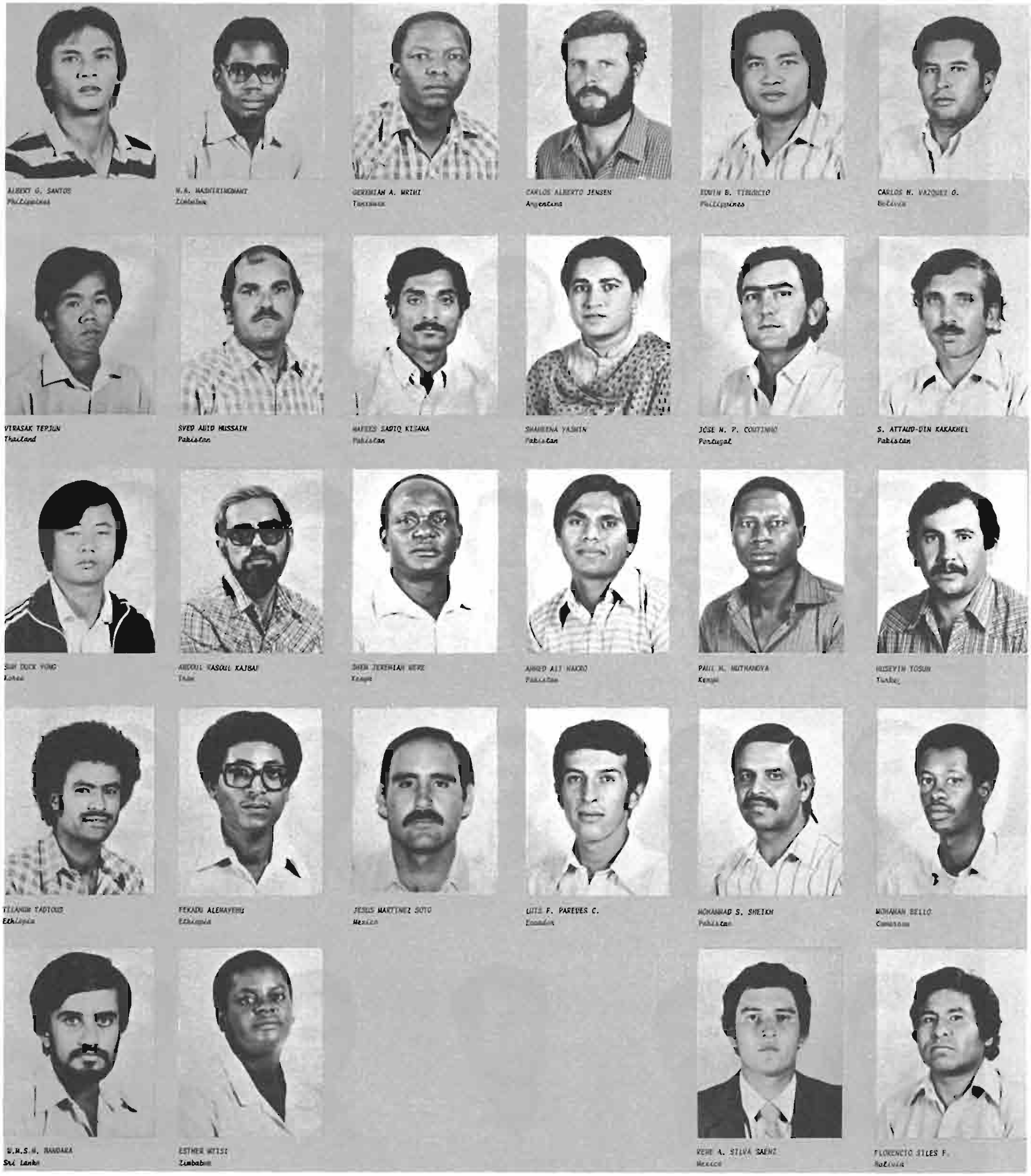
The CIMMYT wheat training program provided assistance to several training exercises outside of Mexico in 1983, in an effort to support programs in regions or cooperating countries where CIMMYT staff are stationed, e.g., Latin America and Pakistan. CIMMYT staff also responded to requests for assistance in training programs sponsored by other organizations, such as the World Bank.

The Future

CIMMYT believes that well-trained young scientists are the key to the future for national programs. Training at CIMMYT is projected to continue at least at the present level and whenever possible to be increased. Serious consideration is being given to the means and methods of giving more assistance to regional and in-country training efforts.



1983 Wheat Production Trainees



1983 Cereal Improvement Trainees


YOUSSEF AMMARI
Tunisia


PRIVAT BAGONA
Burundi


SUK SONG HYEON
Korea


SHAHEENA YASMIN
Pakistan


KHANDAKER MAJIDUL
Bangladesh


PARK SANG LAE
Korea

1983 Cereal Technology Trainees

Agronomy

J. Ransom

The agronomy program continues to emphasize research on management and production problems, and to provide training opportunities for new staff members, visiting scientists and in-service trainees in the production training course. Experiments are also conducted to resolve problems and to make recommendations relative to the breeders' nurseries. Moreover, because of an increase in the number of staff members in the agronomy program during 1983, a number of experiments were conducted to help develop useful screening procedures for the breeding programs. This work also included the evaluation of the performance of the most promising advanced material in several sub-optimal environments.

Fertilizer Studies

At all three experiment stations (El Batan, Toluca and the Yaqui Valley Agricultural Experiment Station [CIANO]), long-term fertility trials have been conducted for the past three years. The major objective of this work is to determine appropriate fertilizer rates for the breeders' nurseries, and to monitor the decline in soil productivity when no fertilizer is applied.

The results at El Batan were similar to those obtained in 1982 (Table 1). There was no yield increase with the application of phosphorus regardless of the amount of nitrogen applied. There was, however, a 20 percent increase in yield over the non-fertilized check when nitrogen was applied at 50 kilograms per hectare (kg/ha) or more; additions of more than 50 kg/ha of nitrogen did not significantly affect yield. These data suggest that between 50 and 100 kg/ha of nitrogen is sufficient to obtain optimum yields at El Batan, and the utility of applying phosphorus appears doubtful.

At the Toluca station, after three years of continuous cropping with wheat, there was no consistant response to the addition of fertilizer (Table 2). The probable reason for the lack of response is the high natural fertility of the Toluca soil coupled with the low nutrient demand of the crop (3 tons per hectare [t/ha] yield potential).

At the CIANO station, there was a significant yield increase over the non-fertilized check with the application of 60 kg/ha of nitrogen. However, additional inputs of nitrogen did not influence yield, nor did phosphorus at any level (Table 3). Given the high yield potential for the area (at least 6 t/ha), the yields obtained in this study are obviously low, even at the highest fertilizer levels. In the future, more emphasis will be placed on eliminating environmental and soil factors which might be limiting yield, so that the fertilizer needs of a wheat crop under high yield potential conditions can be better understood.

The influence of different levels of nitrogen fertilization on seedling emergence was also observed at the CIANO station (Table 4). Emergence was reduced by as much as 35 percent in areas of high nitrogen fertilization, and the response was similar whether the plots had been fertilized with urea or ammonium sulfate. One possible explanation for the negative effect of nitrogen is that frequent rains early in the season kept the surface of the soil wet for several weeks after planting, sealing it and reducing the movement of oxygen into the soil. Under these anerobic conditions, toxic levels of nitrites may have developed. Excess salt cannot be considered the cause, as it's effects would be less pronounced in wet than in dry years.

An experiment was also conducted to determine if micronutrients, sulfur and subsoiling could be used to increase the productivity of the soils at the CIANO station. Micronutrients were applied to all the main treatments, each of which consisted of a factorial combination of plus or minus sulfur and plus or minus subsoiling. This experiment was repeated in three different experimental blocks.

Yield was not significantly influenced by addition of sulfur, subsoiling or the combination of these two factors. Furthermore, micronutrients applied at rates of 50 kg/ha, and high levels of phosphorus (400 kg/ha) did not increase yields. These data, along with those of previous years, when micronutrients were applied to the soil and to the foliage, suggest that micronutrients are present in sufficient quantities to be non-limiting to the wheat crop, at least at our current yield level.

Dr. J. Ransom, wheat agronomy program.

Weed Control Studies

The herbicides which are currently recommended for the experiment stations are adequately controlling all weeds with the exception of *Cyperus esculentus* (yellow nutsedge) at the Toluca and El Batan stations. The dry weather after emergence at Toluca appeared to decrease the effectiveness of all herbicides applied, particularly with regard to *Cyperus*. For this reason, an experiment was conducted to determine the effect of the time of application of bentazon on *Cyperus* control, and to evaluate cultivation as an alternative control method.

Compared with the untreated control, tilling produced no significant reduction in the final number of plants of *Cyperus* (Table 5). Furthermore, bentazon applied 19 days after emergence appeared to promote *Cyperus* growth rather than retard it, possibly by reducing competition from broadleaf weeds. Applying bentazon three times, at 19, 34 and 47 days after emergence gave excellent control. The increase in control at the later dates may be related to growth stage, or to the environment at the time of application. At the later dates, *Cyperus* growth was more rapid as the soil was moist and the temperatures higher. Others have reported that the best control of *Cyperus* with bentazon is achieved when the plants are actively growing.

Wheat yield did not differ regardless of treatment, indicating that *Cyperus* in Toluca is not competing with wheat at the population level encountered this year. Nevertheless, since *Cyperus esculentus* is a perennial weed, a continuous control program is extremely important, since populations can build up quickly and become competitive if not kept in check.

One of the most important weeds in the area around Patzcuaro, Michoacán, is *Sicyos* sp. This species belongs to the cucumber family and because of its climbing habit, can cause lodging and yield losses of greater than 90 percent. Application of 2,4-D, the most commonly used herbicide in the region, does not control this weed. An experiment was conducted in conjunction with scientists from the National Institute of Agricultural Research (INIA) to determine the chemicals and application rates that might be used to control this troublesome weed.

Several chemicals appear to be effective against *Sicyos* at rates which are not toxic to wheat (Table 6). However, even at rates as high as 8 kg/ha, 2,4-D did not give control. Picloram was also ineffective and very toxic to wheat. The best herbicide was bromoxynil, though it was unavailable in the market this past season. Dicamba plus 2,4-D or MCPA appear to be acceptable combinations. Dicamba alone was active against *Sicyos* but did not control *Brassica campestris*, so combinations with a phenoxy type herbicide are needed. Chlortoluron with Chlorsulfuron also gave good control, but some crop toxicity was noted in areas of high soil moisture. Follow-up experiments are planned for the coming year.

Seedling Emergence

An experiment using the most promising advanced lines from the bread wheat, durum wheat, triticale and barley breeding programs was conducted to determine the influence of seeding depth and seed source on seedling emergence. Depths of seeding ranged from 3 to 12 centimeters (cm) and spacing was at 3-cm intervals. Seed was produced at the El Batan and CIANO stations. El Batan seed was typically 25 percent smaller than seed produced at CIANO. The data were transformed to a percentage of the emergence at the 3-cm depth for each species. This was done in order to compare the effect of sowing depth without any influence from other factors that might lower seedling emergence at all seeding depths (e.g., poor germination due to dormancy).

Averaged over all lines and seed sources, the effect of seeding depth on emergence of the four species was similar, except for bread wheat which performed better than all others at the greatest depth (Figure 1). The high overall emergence rate of the bread wheats was due to consistently good emergence of all varieties tested.

In barley, significant differences among lines in emergence ability did occur, but there was no significant

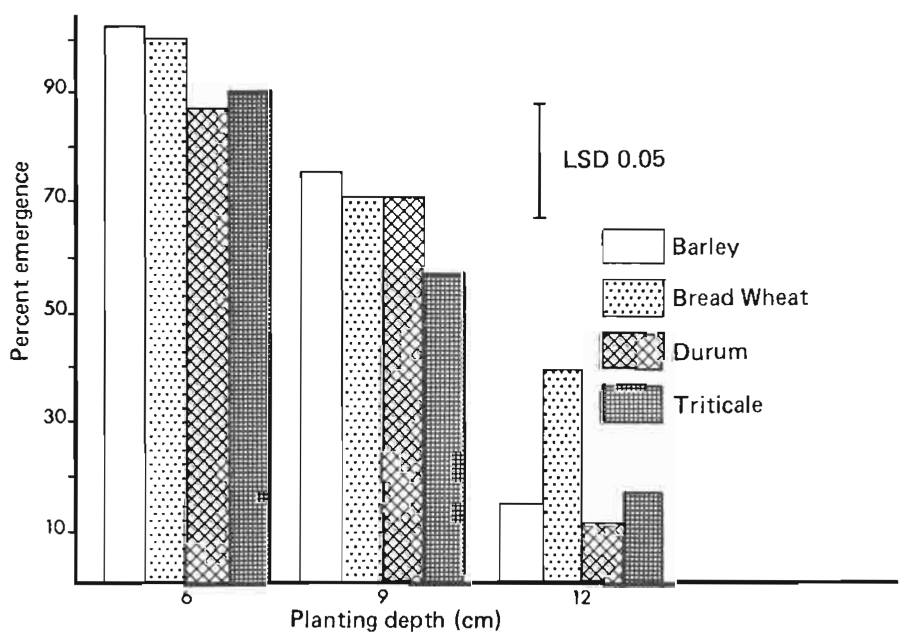


Figure 1. Seedling emergence of barley, bread wheat, durum wheat, and triticale at three planting depths. Percent emergence based on the emergence of each species at the 3-cm depth taken as 100%. Different genotypes and seed sources at each depth and for each species averaged.

response to seed source within the lines. The tallest barley, about 100 cm, had the same average germination percentage as the shorter types. Furthermore, there was no significant correlation between coleoptile length and emergence percentage.

There were no statistically significant differences in emergence percentage among the bread wheat lines, although some variability was evident. Three selections from the same cross (all Veerys) responded similarly, having excellent emergence with seed from CIANO and only average emergence from El Batan seed.

The bread wheats had the shortest coleoptiles. Moreover, there was a significant correlation between emergence and coleoptile length. This correlation appears to be largely a result of the two extreme points (Figure 2). These data suggest that a longer coleoptile might be important in bread wheat, although only 25 percent of the variability in emergence between genotypes can be explained by the length of the coleoptile.

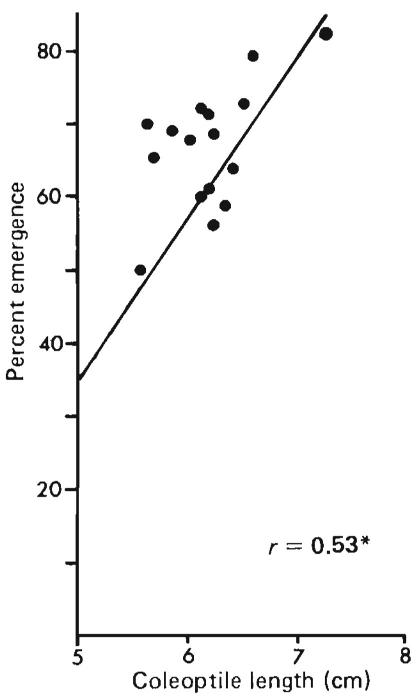


Figure 2. Correlation between coleoptile length and seedling emergence in bread wheat. Each point represents a genotype, percent emergence is the average between CIANO and El Batan seed. * = significant at the 0.05 level.

A large amount of variability was observed among the durum wheat lines. Durum wheat coleoptiles were longer than those of bread wheat and the thousand-grain weight, as much as 75 grams, was the highest of the four species. However, there was no significant correlation between any of the characters measured and emergence.

Considerable variability was evident among triticale lines and there was a significant seed source response. Emergence of five of the triticale lines was severely affected by seed source; El Batan seed performed poorly compared with seed produced at CIANO. Seed type has been a serious concern in the triticale program, and these data suggest that more work needs to be done in this area. However, there are several lines that performed quite well regardless of seed source, indicating that progress has been made toward improving triticale seed.

Four genotypes were complete triticales and six were substituted. There was variation in both groups, but the completes emerged much better on the average than the substituted triticales and there was a significant difference between the groups (Figure 3). There were also significant differences between the groups in plant height and coleoptile length, suggesting a relationship between these characters and emergence ability. Nevertheless, an examination of the correlation coefficients for the triticale lines shows that there is no significant correlation between coleoptile length and percent emergence.

Conditions of Seed Production

In conjunction with a study on the stability of advanced lines, seed from Glennson 81 (bread wheat) and Caborca (triticale) was harvested from several weed free agronomic environments that differed in the amount of nitrogen and water stress. These were planted to determine if conditions of seed production, resulting in differences in seed size and protein content, might affect yield. In this experiment yield did not vary regardless of seed production conditions for both species, indicating that seed size and protein content, at least within the range used in this study, are not important to overall yield providing there is good germination. Furthermore, reports of poor stands in triticale due to poor seed probably are due to other factors, such as diseases on the seed, rather than the size of seed sown.

Bread Wheat Yield Potential

There is a general belief that modern bread wheats have a higher genetic yield potential than older cultivars, as well as a greater yield stability. However, in normal practice agronomic and climatic conditions rarely allow full expression of the genetic yield potential. In order to evaluate progress achieved in yield potential of CIMMYT bread wheats, two trials were conducted, one at the CIANO station during the 1982-83 winter cycle, and the other at the El Batan station during the 1983 summer cycle. Eight bread wheat cultivars (representing over twenty years of breeding advances), the modern durum wheat cultivar Yavaros and the modern triticale Caborca were grown under near optimal conditions at each site. High nitrogen levels (200 kg/ha at CIANO, 150 kg/ha at El Batan) were used, with a second, lower level (75 kg/ha) at CIANO. Plants in both trials were supported to prevent lodging. Phosphorus fertilizer was also used; there was no indication of other mineral element limitations. Irrigations were scheduled to eliminate moisture stress throughout plant development. The trial was sprayed with insecticide (Metasystox), fungicide (Bayleton) and herbicides (Iloxan, Basagran, Chlorsulfuron) to ensure that pests, diseases and weeds did not limit yield.

Average grain yield of the eight bread wheats under high fertility conditions at CIANO was 6.32 t/ha (Table 7), with yields ranging from 5.56 to 7.26 t/ha. The two newest bread wheat cultivars, Genaro 81 and Ciano 79, produced an average of 0.57 t/ha more than the third-ranked, older cultivar, Siete Cerros. Other older cultivars showed a progressive yield decline down to M. J. Inta, a variety poorly adapted to CIANO conditions (Table 7). The modern durum wheat and triticale cultivars were broadly comparable to the modern bread wheats in yield. All the modern cultivars possessed higher above-ground biomass at maturity. In addition there was an indication of a shift in partitioning favoring the grain sink, as shown by the higher harvest index, as compared with the taller, older cultivars, Nainari 60 and M. J. Inta (Table 7).

Stability of yield regardless of nitrogen level was also a feature of the data for CIANO. Those cultivars showing high yield with high nitrogen were also the best producers at the lower, 75 kg/ha, nitrogen level (Table 8).

At El Batan, a mainly rainfed site generally considered less favorable than CIANO for high yields, the average yield under irrigation and high fertility was 5.98 t/ha, only 0.34 t/ha lower than at CIANO (Table 9). At this site the two modern bread wheats appeared among the top three best producers.

Analysis of yield components at the two sites revealed no historical trend in number of grain-bearing spikes, but there was a tendency for the more modern cultivars to have more grains per spike and, therefore, more grains per square meter. This, coupled with an only partially compensatory decrease in thousand-grain weight gave the higher yields.

Evidence suggests that some of the gain in yield potential achieved by Genaro 81 and Ciano 79 is attributable to a longer growth period, not to higher assimilation rates or partitioning efficiencies. For yield production per day, two mid-1960s cultivars, Sonalika and Siete Cerros, were the most efficient at CIANO and El Batan, respectively (Table 10). In above ground biomass production, Genaro 81 was clearly superior to the older cultivars at El Batan, as was Ciano 79 at CIANO. However, at both sites the modern durum cultivar Yavaros showed higher grain yield per day than any of the bread wheats tested.

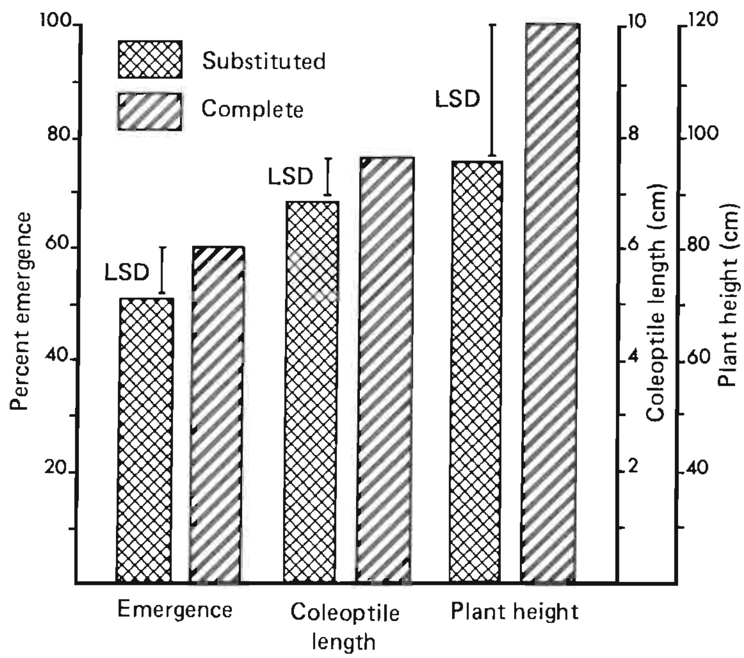


Figure 3. Comparison of complete and substituted triticales for seedling emergence, coleoptile length and plant height. Results from different genotypes and planting depths were averaged.

Triticale Yield Potential

This trial was designed to compare the yield potential of the highest-yielding CIMMYT triticale germplasm (six complete and six substituted types) under near-optimal agronomic conditions at the CIANO station. It is known that in certain specific environments (e.g., highland areas and acid soils) complete triticales generally outperform substituted types. However, under normal production conditions at high-yielding sites such as in the CIANO station area, there is little evidence of differences between types.

The trial was grown during the winter cycle at CIANO with 200 kg/ha of nitrogen and support against lodging. Other mineral elements were not limiting. A preventative program of insect, disease and weed control was employed.

The average yield, at 7.26 t/ha, was about 25 percent above average station yields for these cultivars in 1982-83. No significant differences in yield, biomass or harvest index could be detected either between or within the two groups (Table 11). It appears that high yields can result from a number of different yield component strategies. For example, the highest-yielding substituted type, Lemming "S", produced a large number of grain-bearing spikes, an average number of grains per spike and a low thousand-grain weight while Eronga 83, the highest-yielding complete type was near or above average in all these components (Table 11).

The trial is being repeated with additional lines at CIANO during the 1983-84 winter cycle to confirm these results.

Stem Length and Lodging Control

Modern CIMMYT wheats and triticales are designed to yield well under a wide range of environmental conditions. They are not specifically bred for performance in very high-input situations and lodging remains a potential problem at nitrogen levels above 150 kg/ha. One approach to reducing the incidence of lodging in high-input cereal production, especially in Europe, is the use of chemical straw shortener-stiffeners. Two such chemicals, the growth retardant Chlormequat (CCC) and the ethylene generator, Ethephon, were used at various rates and with various timings on five lines growing under high nitrogen (150 kg/ha) at the CIANO station in the 1982-83 winter cycle. Stem lengths were measured separately for the main shoots and for tillers and were ranked on the basis of stem length for 40 plants per plot during mid grain filling. No lodging was observed during the trial.

As expected, the later applications of both chemicals were more effective in reducing stem length in all the lines studied (Table 12). Generally Ethephon reduced stem lengths more than Chlormequat with an application at late booting (Zadoks growth stage 47) of 200 grams per hectare (g/ha) being most effective; main stem length was reduced by an average of 16.2 percent (Table 12) and the most advanced tiller by 19.3 percent (data not shown). The early (Zadoks stage 30) applications of both chemicals did not affect stem length since little stem extension occurred shortly after treatment.

Although overall stem length reductions were greater when Chlormequat and Ethephon were applied at late booting it is likely that applications at Zadoks stage 32, for Chlormequat at least, will be more effective in reducing lodging. It is often the lower internodes, elongating at that time, which need strengthening and shortening since, if they fail well before maturity, light interception and gas exchange will be impaired, with disease and harvesting problems to follow.

In conclusion, modern CIMMYT wheat lines that have dwarfing genes from Norin 10 are still capable of being shortened by Chlormequat and Ethephon, although not to the same extent as taller types. However, before any recommendation can be made on the use of such chemicals for lodging control, tests under the very high fertility conditions likely to induce lodging are necessary, along with yield data.

Gametocide Trial

The gametocide RH-0007 was tested at the El Batan station during the 1983 summer cycle for its ability to induce male sterility in bread wheat. The gametocide was applied in continuous logarithmic dilution strips together with the surfactant SG-98 on four bread wheat cultivars Genaro, Sonalika, Pavon and Alondra. The "male sterile" plants were sown between six rows of "male fertile" plants, two rows being sown at the same time as the male steriles; two, seven days later; and the remaining two, twelve days after the male steriles. The gametocide was applied at rates of 0.7 to 2.8 kilograms of active ingredient per hectare (kg.a.i./ha) at three times: 1) when mean shoot spike development had reached the double ridge stage, 2) when mean shoot flag leaf lengths were 5-10 millimeters (mm) and 3) seven days after treatment 2, when mean shoot flag leaf lengths had reached 73 mm for Genaro, 185 mm for Sonalika, 165 mm for Pavon and 173 mm for Alondra (overall mean of 150 mm).

Generally the gametocide caused stunting, reduced the synchrony of shoot production and delayed spike development, especially with high doses at the earliest application time. However, mature spike numbers were not affected by time of application. Percent selfing (determined by bagging some spikes) was extremely low at all three times of application and across the entire dosage range employed (Table 13), averaging only 0.8 percent and differing little among cultivars. However, selfing was lowest at the second application time (flag leaf 5-10 mm long). At this time doses down to 1 kg a.i./ha gave zero selfing (Table 13), but this application rate was not high, averaging only 575 milligrams per spike.

Recomendations from this trial:

- For minimal self-fertility in bagged spikes, a dose of 0.75-1.25 kg a.i./ha, applied when the mean flag leaf length is 5-10 mm, should be used.
- For maximal seed set from cross-fertilization with an acceptably low level of selfing a dosage of 0.75-1.25 kg a.i./ha when the mean shoot spike development is at the double ridge stage should be used (Table 14).
- Since there is a relatively wide range of effective treatment times (averaging 13 days between the first and last times of application in this trial) the gametocide could be used on populations segregating for spike development (ontogenetic rate).

Aphid Control

Insecticide spraying trials were conducted at the CIANO and El Batan stations to determine the amount of yield loss due to aphids and to determine the type of spraying program needed to eliminate these losses. Treatments consisted of spraying Metasystox at 0.56 kg a.i./ha 1) at the three leaf stage, 2) only when aphids were observed and 3) at the three leaf stage plus every three weeks thereafter. An unsprayed control plot was also included.

At CIANO there was no significant difference in yield regardless of the treatment. The aphids were naturally controlled by predators in early February, thus limiting the damage. It is quite unlikely that similar levels of natural predators develop every year.

At El Batan, where aphid attacks were accompanied by symptoms of the Orange Free State virus complex, there was a significant yield response to insecticide applications (Table 15). Only the plots with continuous spray treatment (three-leaf stage plus every three weeks) yielded significantly more than the control. However, all sprayed treatments had statistically similar yields. These data indicate that yield reductions due to aphids were only minor, and that a single application of a systemic insecticide was sufficient to limit yield losses. Considering the amount of streaking caused by the virus complex, it is somewhat surprizing that yield reductions were only minor.

Triticale Grain Growth

Work on triticale grain growth and maturation continued at both El Batan and CIANO. This work emphasized the identification of variability in the relationship between dry matter accumulation and moisture content, particularly in early triticales. Shrivelling is considered to be more of a problem in these than in later types, especially when water stress occurs during grain filling.

Grain-filling characteristics of 10 early lines were studied at CIANO, and 29, mostly early types from the triticale program crossing block, were used at El Batan. Six bread wheats of similar maturation time and two ryes were included for comparison. Considerable variation in grain-filling characteristics was seen, especially at El Batan. However, only five triticale lines showed grain-filling and maturation characteristics close to those of the bread wheats studied, and they were mainly lines of later maturity. An additional eight triticales were classified as intermediate, while the rest had grain growth patterns very different from bread wheat. These genotypes were generally characterized by a fast, early increase in water content, a high peak water level, and an early decline from this level which was associated with a stoppage of dry matter accumulation.

Work is continuing at CIANO with a similar range of lines both with and without water stress during grain filling. The objective is to determine how water stress affects grain growth, maturity and quality in types with a requirement for high grain water content during development.

Selection for Stress Tolerance

Several reports in the literature have stated that the ability of a wheat plant to fill its grain following post-anthesis desiccation of the leaves relates well to the plant's ability to tolerate drought and attacks of septoria. Experiments were conducted to evaluate the usefulness of artificial, post-anthesis desiccation as a screening method for drought tolerance at CIANO and for septoria resistance at Toluca.

At CIANO there was a significant correlation ($r = 0.55$) between the percent reduction in thousand-grain weight for lines grown under conditions of drought (first supplementary irrigation only) and percent reduction in thousand-grain weight for lines desiccated after anthesis by paraquat. Since the principle yield component affected by terminal drought and post-anthesis desiccation is thousand-grain weight, these data suggest this technique could be useful in selecting drought-tolerant genotypes.

At Toluca there was no significant correlation between the percent reduction in thousand-grain weight after post-anthesis desiccation with paraquat and the percent reduction in thousand-grain weight in plots inoculated with septoria ($r = 0.11$). This poor correlation can be partially explained by differences in the susceptibility of the lines: septoria-resistant genotypes would have a smaller reduction in thousand-grain weight than would susceptible genotypes since the former would be less affected by the disease.

No further work on the use of post-anthesis desiccation with paraquat is planned since the technique, even under the best conditions, can only identify some of the best lines. Furthermore, the technique requires a great deal of time in marking plots for anthesis dates and spraying.

Table 1. Grain yield (t/ha) as influenced by levels of applied nitrogen and phosphorous, El Batan, 1983.

Phosphorus applied (kg/ha)	Nitrogen applied (kg/ha) 0	50	100	150	$\bar{x}$
0	3.41	3.96	4.15	3.97	3.87
40	3.28	3.84	4.11	4.06	3.82
80	3.31	4.13	4.19	4.21	3.96
$\bar{x}$	3.34	3.98	4.15	4.08	

$LSD_{0.05}$ = 0.23 t/ha for levels of nitrogen

Phosphorous and nitrogen x phosphorus interaction were not significant sources of variation.

Table 2. Grain yield (t/ha) as influenced by levels of applied nitrogen and phosphorous, Toluca, 1983.

Phosphorus applied (kg/ha)	Nitrogen applied (kg/ha) 0	50	100	150	$\bar{x}$
0	2.41	3.46	3.15	2.76	2.94
50	3.09	2.75	2.95	2.53	2.83
100	3.00	3.05	2.75	2.87	2.91
$\bar{x}$	2.83	3.09	2.95	2.72	

$LSD_{0.05}$ = 0.85 t/ha for nitrogen x phosphorus interaction.

Table 3. Grain yield (t/ha) as influenced by levels of applied nitrogen and phosphorous, CIANO, 1982-83.

Phosphorus applied (kg/ha)	Nitrogen applied (kg/ha) 0	60	120	180	$\bar{x}$
0	4.28	4.59	4.54	4.52	4.48
40	4.08	4.51	4.71	4.57	4.47
80	4.13	4.63	4.75	4.62	4.53
$\bar{x}$	4.16	4.58	4.67	4.57	

$LSD_{0.05}$ = 0.11 for nitrogen levels.

Phosphorus and phosphorus x nitrogen treatment effects were not significant at the 5°/o level.

Table 4. Effect of different levels of applied nitrogen on the emergence of wheat (cv. Seri), CIANO, 1982-83.

Nitrogen level (kg/ha)	Stand density (plants/m^2)
0	64
60	63
120	52
180	42

Table 5. Influence of chemical and cultivation treatments on wheat (cv. Tesia) yield and on final stand of *Cyperus esculentus*, Toluca, 1983.

Treatment	Treatment time*	*Cyperus* stand density (Plants/m^2)**	Wheat yield (t/ha)***
None (control)		25	3.8
Cultivation	19	42	4.0
Cultivation	34	22	3.8
Cultivation	19 +34	33	3.7
Bentazon (1.5 1/ha)	19	60	3.9
Bentazon (1.5 1/ha)	19 +34	15	3.7
Bentazon (1.5 1/ha)	34	17	3.7
Bentazon (1.5 1/ha)	19 +34 +47	3	3.6

* Days after wheat emergence.
** $LSD_{0.05} = 29$
*** Not statistically different.

Table 6. Herbicide screening for activity against *Sicyos* sp. and application rates giving acceptable control, Patzcuaro, Michoacan, 1983.

Chemical*	Lowest rate giving acceptable control	Comments
Dicamba	0.25 kg/ha	*Brassica* not controlled
Dicamba + 2, 4-D (0.5 kg/ha)	0.25 kg/ha	Good *Brassica* control
Dicamba + MCPA (0.5 kg/ha)	0.25 kg/ha	Similar to dicamba + 2, 4-D
Dicamba + Bromoxynil (0.3 kg/ha)	all dicamba rates	Bromoxynil very active
Bromoxynil	0.13 kg/ha	No phytotoxicity up to 1 kg/ha
Bromoxynil + 2, 4-D (0.5 kg/ha)	0.25 kg/ha	Little improvement over Bromoxynil alone
2, 4-D	No control up to 8 kg/ha	
Chlortoluron + Chlorsulfuron (20 g/ha)	1 kg/ha	Some phytotoxicity
Picloram (22.9 g/l) + 2, 4-D (339.5 g/l)	No control up to 3 l/ha	High phytotoxicity

* The first chemical listed in a mixture was applied at rates which varied logarithmically, the second was applied at a constant rate as indicated.

Table 7. Bread wheat yield potential and yield components with 200 kg/ha of nitrogen*, CIANO, 1982-83.

Cultivar	Yield (t/ha)	Biomass** (t/ha)	Harvest index	Spikes/m^2	Grains/m^2	Grains/ spike	1000-grain weight (g)
GENARO 81	7.26	15.60	41.1	434	18,551	43	34.44
CIANO 79	6.97	15.75	39.0	385	17,182	45	36.02
SIETE CERROS 66	6.54	13.53	42.7	327	16,498	51	34.94
SONALIKA	6.44	11.58	49.5	330	10,732	33	52.76
YECORA 70	6.11	12.33	43.7	394	14,065	36	38.24
NACOZARI 76	5.88	13.13	39.6	345	14,913	43	34.93
NAINARI 60	5.83	14.62	35.3	409	12,889	32	39.83
M.J. INTA	5.56	13.87	35.3	475	12,627	27	38.72
YAVAROS (Durum)	7.12	15.28	41.4	389	13,964	36	44.91
CABORCA (Triticale)	6.76	15.60	38.5	375	16,617	44	35.87
LSD $_{0.05}$	0.64	1.68	4.5	43	1,702	6	2.83

* Phosphorus was also applied.

** Above-ground dry matter.

Table 8. Bread wheat yield potential and yield components with 75 kg/ha of nitrogen*, CIANO, 1982-83.

Cultivar	Yield (t/ha)	Biomass** (t/ha)	Harvest index	Spikes/m^2	Grains/m^2	Grains/ spike	1000-grain weight (g)
GENARO 81	4.96	10.51	41.1	313	11,973	39	36.84
CIANO 79	4.79	10.26	39.0	273	11,348	42	37.17
SONALIKA	4.56	9.61	49.5	280	8,534	30	47.51
SIETE CERROS 66	4.49	9.28	42.7	236	11,495	49	34.13
NACOZARI 76	4.32	8.89	39.6	245	9,857	41	38.35
M.J.INTA	4.13	10.72	35.3	330	8,577	27	42.82
NAINARI 60	3.95	10.30	35.3	335	9,168	28	38.10
YECORA 70	3.90	7.28	43.7	315	8,054	26	43.50
YAVAROS (Durum)	4.57	10.07	41.4	290	9,112	32	44.43
CABORCA (Triticale)	5.01	10.91	38.5	296	11,949	41	36.92
$LSD_{0.05}$	0.64	1.68	4.5	43	1,702	6	2.83

* Phosphorus also applied
** Above-ground dry matter

Table 9. Bread wheat yield potential and yield components with 150 kg/ha of nitrogen*, El Batan, 1983.

Cultivar	Yield (t/ha)	Biomass** (t/ha)	Harvest index	Spikes/m^2	Grains/m^2	Grains/ spike	1000-grain weight (g)
SIETE CERROS	7.27	15.74	40.6	661	21,168	32	30.22
GENARO 81	7.22	17.36	36.6	724	20,935	30	30.35
CIANO 79	6.66	13.95	42.0	546	17,556	32	33.38
NAINARI 60	6.47	15.34	37.1	567	16,099	29	35.38
SONALIKA	5.60	12.71	38.8	599	10,335	17	47.76
NACOZARI 76	5.46	12.40	38.7	619	16,328	27	29.65
M.J. INTA	4.77	13.61	30.8	713	11,864	17	35.43
YECORA 70	4.39	9.25	41.8	617	9,945	16	39.25
YAVAROS (Durum)	8.14	17.12	41.8	604	17,436	30	33.65
CABORCA (Triticale)	6.63	15.18	38.4	488	18,078	37	39.63
$LSD_{0.05}$	1.00	2.34	N.S.	113	2,600	5	2.67

* Phosphorus also applied.
** Above-ground dry matter.

Table 10. Grain yield and above-ground biomass production per day for bread wheat genotypes grown under optimal agronomic conditions at CIANO in 1982-83 and El Batan in 1983.

Location and cultivar	Grain yield (kg/day/ha)	Biomass (kg/day/ha)
CIANO		
SONALIKA	56.5	101.6
CIANO 79	55.8	126.0
SIETE CERROS 66	55.0	113.7
GENARO 81	52.6	113.0
YECORA 70	50.1	101.1
NACOZARI 76	49.4	110.3
M.J.INTA	46.3	115.6
NAINARI 60	45.2	113.3
YAVAROS (durum)	58.8	126.3
CABORCA (triticale)	56.3	130.0
EL BATAN		
SIETE CERROS 66	60.6	131.2
GENARO 81	58.2	140.0
CIANO 79	55.5	116.3
NAINARI 60	50.5	119.8
SONALIKA	50.5	114.5
NACOZARI 76	50.1	113.8
YECORA 70	37.5	79.1
M.J.INTA	35.1	100.0
YAVAROS (durum)	68.9	145.1
CABORCA (triticale)	58.7	134.3

Table 11. Triticale yield potential and yield components, CIANO, 1983.

Cultivar or line	Yield (t/ha)	Biomass* (t/ha)	Harvest index	Spikes/m^2	Grains/m^2	Grains/ spike	1000-grain weight (g)
COMPLETE TYPES							
ERONGA 83	8.26	17.28	42.3	314	16,140	52	45.10
SIKA"S" B-2683	7.51	15.22	43.6	303	16,760	56	39.60
ELK 37 B507	7.29	15.49	41.6	299	16,840	56	38.34
MERINO"S"-JUANILLO B-2736	7.27	14.43	46.3	277	15,070	55	42.75
CIVET"S"	6.90	15.02	40.5	350	17,840	50	35.00
IRA-BGL x DRIRA-KANG B-2658	6.72	14.70	40.3	357	16,680	47	35.61
MEAN	7.33	15.36	42.4	317	16,472	53	39.40
SUBSTITUTED TYPES							
LEMMING"S" X33208-I-500Y-500M-500Y-503B-503Y-0Y	7.77	16.80	40.8	397	18,600	47	36.73
CML"S"-KAL x IA-IRA X39651-1Y-1M-2Y-1Y-0M	7.47	14.78	44.6	363	18,970	53	34.65
TESMO X39860-2Y-7M-1Y-0Y	7.27	14.81	43.4	329	16,270	50	39.40
TESMO X39860-7Y-2M-3Y-2Y-0H	7.07	14.72	42.7	353	17,740	51	35.07
PTR"S"-CASTOR"S" X31731-24Y-9M-0Y	6.86	14.42	42.0	317	14,010	44	43.77
CABORCA	6.63	15.09	38.7	377	14,420	38	41.32
MEAN	7.18	15.10	42.0	356	16,668	47	38.38
$LSD_{0.05}$	N.S.	N.S.	N.S.	54	2,635	9	5.30

*Above-ground biomass

Table 12. Effect of Chlormequat and Ethephon on main shoot stem lengths as a percentage decrease (–) or increase (+) of the untreated control.

Treatment and dosage	Zadoks growth Stage	Cultivar YAQUI 50 (o/o)	GENARO 81 (o/o)	TESIA 79 (o/o)	CANANEA 79 (o/o)	YAVAROS 79 (o/o)	Mean (o/o)
Chlormequat							
2 kg/ha	30	-8.1	-1.1	-1.0	-0.6	+1.3	-1.9
2 kg/ha	32	-11.8	-1.0	-0.6	-0.6	-10.6	-4.9
2 kg/ha	47	-11.3	-2.3	-3.6	-8.7	-5.1	-6.2
4 kg/ha	30	-13.4	-1.5	-0.8	-3.9	-2.2	-4.4
4 kg/ha	32	-6.7	-7.2	-1.7	-6.4	-10.8	-6.6
4 kg/ha	47	-3.9	-6.1	-8.6	-10.0	-5.0	-6.7
Ethephon							
100 g/ha	32	-11.1	-5.6	-0.7	-8.9	+0.6	-5.1
100 g/ha	47	-17.1	-14.1	-10.3	-10.1	-5.5	-11.4
200 g/ha	30	-14.8	-0.1	+0.1	-1.2	+2.5	-2.7
200 g/ha	32	-14.6	-4.5	-10.6	-6.5	-6.4	-8.5
200 g/ha	47	-24.5	-21.5	-12.4	-15.1	-7.3	-16.2
Untreated control (cm)		130	80	72	93	69	89

Table 13. Percentages of normal seed set for bagged spikes, averaged across four cultivars for a range of dosages of the gametocide RH-0007 applied at three times.

Application time	Dosage* (kg active ingredient/ha) 2.60	2.24	1.95	1.66	1.40	1.21	1.01	0.87	0.75
1) Double ridge stage	0.9	1.0	1.5	0.6	0.9	1.2	2.6	3.9	4.3
2) 5-10-mm flag leaf stage	0	0	0	0	0	0	0	0.2	0.3
3) 7 days after treatment 2 (mean flag leaf length 150 mm)	0.8	0	0	0.2	0	0.4	0.7	1.4	0.6

* Mean dosage for each meter of plot.

Table 14. Weight of seed per spike (in milligrams) resulting from cross fertilization of spikes treated with the gametocide RH-0007 at a range of dosages applied at three times, averaged across four cultivars.

Application time	Dosage* (kg active ingredient/ha)					Mean
	2.00	1.60	1.25	1.00	0.80	
1) Double ridge stage	335	507	496	602	880	575
2) 5-10 mm flag leaf stage	106	77	77	109	260	129
3) 7 days after treatment 2 (mean flag leaf length 150 mm)	32	27	55	128	279	151
Mean	158	204	209	279	473	

* Mean dosage for each 1.5 meters of plot.

Table 15. Yield, averaged over genotypes, as influenced by insecticide applications (Metasystox at 0.56 kg a.i./ha), El Batan, 1983.

Time of application	Yield (t/ha)*
Control (no application)	5.29 b
Three-leaf stage	5.41 b
On incidence of aphids	5.42 ab
Three-leaf stage +every 3 weeks	5.69 a

* Means followed by the same letter are not significantly different at the 5% level using the Duncan's Multiple Range test.

Milling and Baking Laboratory

A. Amaya C.

Introduction

The principal objectives of the milling and baking laboratory are the following:

- To evaluate and screen early generation (F_3 and F_4) lines for good grain type
- To evaluate those early generation lines with good grain type for additional characteristics such as gluten strength, protein content, alpha-amylase activity and pigment content (durum wheat only)
- To evaluate advanced lines for test weight, rheological characteristics, gluten strength, protein content, and milling and baking qualities.

These data are integrated by the breeders with information on yield, disease resistance, agronomic characteristics and other factors to make the crosses and selections which produce higher-yielding, better-adapted bread and durum wheats and triticales.

In addition to fulfilling its principal objectives, the laboratory also provides training for personnel from national programs and seeks ways to improve its procedures and methods.

Bread Wheat

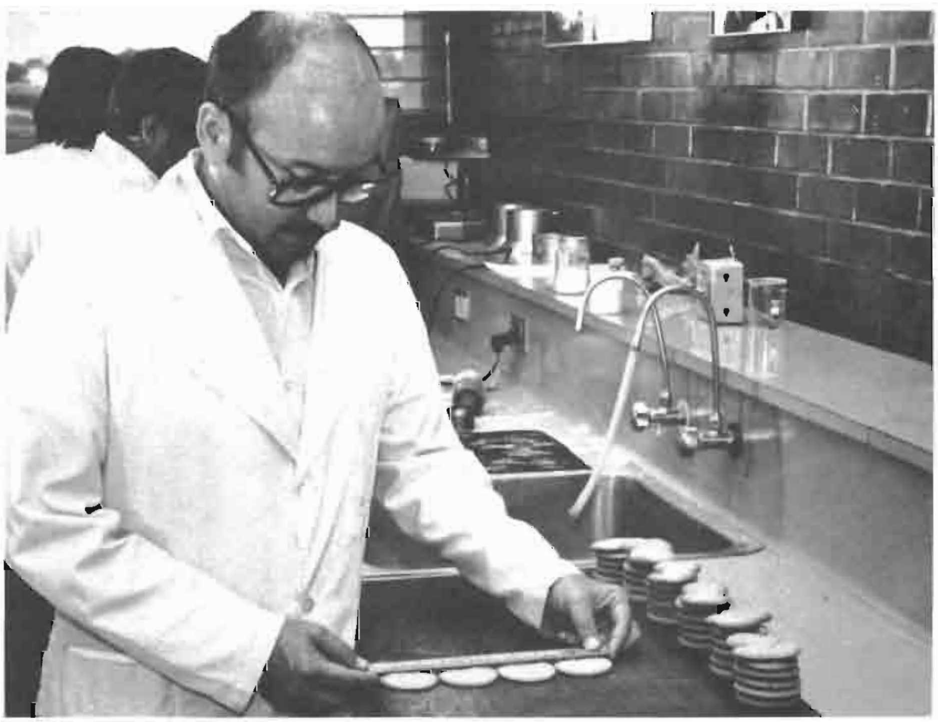
During 1983, a total of 3825 F_4 bread wheat selections were evaluated for gluten strength, using the Zeleny micro-sedimentation test. This is now used in our laboratory instead of the micro-Pelshenke test (see CIMMYT Report on Wheat Improvement, 1982) but the results are transformed into their micro-Pelshenke equivalents because the breeders are more familiar with the latter. The correlation between the results given by the two tests is 0.96. It was observed that a good proportion of lines had sedimentation values greater than 40 cubic centimeters (cc), indicating strong gluten, but also that a good proportion had values corresponding to weak gluten, indicating that the desired variability in gluten strength is being maintained in segregating material.

Among the advanced materials, the following nurseries were evaluated:

- Drought yield trials
- 14th International Septoria Observation Nursery (ISEPTON)
- Spring Crossing Block (CB), winter 1982-83
- Spring Crossing Block (CB), summer 1983
- Second Drought Tolerance Screening Nursery (DSN)
- 17th International Bread Wheat Screening Nursery (IBWSN)
- 19th International Spring Wheat Yield Nursery (ISWYN)
- Fourth Elite Spring Wheat Yield Nursery (ESWYT)
- Miscellaneous nursery
- Small multiplication plots (PC), summer 1983

All of this material was evaluated for its milling and baking qualities, gluten properties and protein content; in addition, mixograms and alveograms were prepared. The material harvested at the Toluca Experiment Station was also evaluated for alpha-amylase activity by means of the falling number test. In the latter, values ranged from 250 to more than 1000 seconds, indicating that good variability for resistance to premature spouting is found in the germplasm. From the material included in the 17th IBWSN and miscellaneous nursery, lines with desirable milling and baking characteristics were selected for inclusion in the crossing block.

Comparisons made between data obtained from material in the spring crossing block, grown with irrigation and harvested in the winter of 1982-83, and the same material grown under rainfed conditions and harvested in the summer of 1983,



Dr. A. Amaya, head of the wheat milling and baking laboratory.

showed a very good correlation. This means that the data obtained in the laboratory from material grown under irrigation can be used for selecting materials for areas in which wheat is grown under rainfed conditions.

Durum Wheat

From segregating materials of the F_3 and F_4 generations, 7315 individual plants were screened for carotene content. Only about 20 percent of them were discarded because of pigment values lower than 5 parts per million (ppm). This material had been previously selected for good seed type, with more than 50 percent of the plants originally selected in the field being discarded due to high levels of yellow berry, black point, and other undesirable seed characteristics.

The advanced materials evaluated in 1983 included the 15th International Durum Screening Nursery (IDSN), with 260 entries, and the Durum Spring Crossing Block, with 332 advanced lines and varieties. Both of these were harvested in the 1982-83 winter season. In the crossing block most of the lines had acceptable test weights. This characteristic and the absence of yellow berry are very important in durum wheat for obtaining a high semolina yield. In addition, 63 percent of the lines had pigment contents higher than 5 ppm, and only 7.5 percent had gluten characteristics that were undesirable for the preparation of macaroni and spaghetti with good cooking quality. Of the 260 lines included in the 15th IDSN, all had a test weight equal to or higher than 80 kilograms per hectoliter and only 25 percent had pigment values lower than 5 ppm, the minimum for producing pasta of acceptable color. Only 31 of the lines had weak gluten that will produce spaghetti with poor cooking characteristics.

Triticale

The increase in the number of triticale varieties being released around the world reflects the interest in cultivating triticale commercially. One of the main factors that will influence the commercial acceptability of triticale is its industrial quality. Therefore, CIMMYT breeders place special importance on the improvement of the milling and baking qualities of the high-yielding triticales.

In 1983, 694 triticales from the F_3 and F_4 generations, 63 primary triticales and 225 miscellaneous triticales, all grown during the 1982-83 crop cycle, were evaluated for alpha-amylase activity using the falling number (FN) test, and for gluten strength with the Zeleny micro-sedimentation test. Although most of the lines showed the high alpha-amylase activity (FN values in the range of 60-150 seconds) associated with premature germination, some lines had the preferable low activity levels (FN equal to or greater than 200 seconds). Most of the triticales had weak gluten (sedimentation values less than 24 cc); only a few showed gluten of better strength (28 cc or more).

In addition, the more advanced materials in the CB and in the 15th International Triticale Screening Nursery (ITSN), grown under favorable environmental conditions in 1982-83, were evaluated for physical, chemical and baking characteristics. It was found that great variability for the parameters evaluated existed among the lines tested. It is important to note that 76 percent of the triticale lines included in the 15th ITSN had a test weight of at least 75 kilograms per hectoliter, reflecting the marked improvement in grain type that has been achieved. It was also observed that more than 50 percent of the lines in both the CB and ITSN had FN values of at least 150 seconds, indicating that the alpha-amylase activity of the advanced materials is also decreasing. Although some lines showed improved gluten strength and good baking quality, it is necessary to put more effort into improving these characteristics. Taking this into account, the breeders have been using as progenitors those triticale lines showing good gluten strength and baking quality to improve the industrial quality of high-yielding triticales.

At present the laboratory is studying the possibility of incorporating new techniques which would facilitate the identification of triticales with good industrial quality.

Basic Germplasm Development

Quality characteristics were evaluated on 421 lines from the basic germplasm development program. Protein values of 14.4 percent were obtained in some lines with weak gluten, and several lines with strong gluten yielded flour with protein contents between 15.0 and 16.2 percent. The latter produced loaves with a volume between 850 and 930 cc, the highest among all the materials evaluated in the laboratory in 1983.

Training

During 1983, six trainees spent three months in the laboratory learning the techniques used in the evaluation of the breeding material, learning how to operate the equipment and, in some cases, learning how to maintain the machinery. The trainees were Yuseff Ammari, from Tunisia; Privat Babona, from Burundi; Shakeena Yasmin, from Pakistan; Khandaker Majidul, from Bangladesh; and Suk Song Hyeon and Park Sang Lae, from Korea. Also, Dr. Onanong Navikul and Dr. Suchon Nimmannitaya, from Thailand, and Dr. Maria Teresa de Palomo, from El Salvador, spent two weeks each in the laboratory as visiting scientists.

International Nurseries

M. Alcalá S.

Introduction

In the summer of 1983, CIMMYT distributed 1895 bread wheat, durum wheat, triticale, barley and germplasm development nurseries (sets of seed to be planted for various types of evaluation), to 239 cooperators in 91 countries. Tables 1 and 2 show the distribution details. These nurseries are distributed only upon request.

Cooperators who grow CIMMYT nurseries are asked to return performance data to CIMMYT for compilation, analysis, and subsequent worldwide distribution to other cooperators and interested parties. In addition, cooperators are free to use the germplasm they receive in any way that suits their needs. Options include crossing with local varieties or even moving an entry directly into seed multiplication for eventual release as a variety. CIMMYT requests only that the origin of the germplasm be acknowledged.

Nursery Categories

Five categories of nurseries are included in this program:

Crossing blocks—Potential parental lines are selected for use in crossing programs, and entries in each crossing block are arranged according to their previously identified genetic superiority for one or more traits. Varieties and lines are grouped for their high yield and/or wide adaptation, disease resistance, adaptation to certain regions, tolerance of high levels of free aluminum, agronomic characters, and milling and baking qualities. As many as 500 lines may be included in a crossing block.

Early generation F_2 (segregating populations)—The F_2 materials are second generation sister plants from the same cross, but they usually have widely different genotypes and characteristics. From these segregating populations, CIMMYT plant breeders select individual plants having desirable characteristics. Nurseries are compiled and sent to cooperators according to the local climatic conditions, soils, moisture availability, disease spectrum and cultural practices.

Screening nurseries—Lines that have performed well according to various criteria in Mexico may be entered into a screening nursery. The lines in these nurseries are evaluated for agronomic type, adaptation to local conditions and disease resistance, but not for yield. Screening nurseries serve three purposes:

- They introduce new genetic variability, which may be used directly, reselected and released as a variety, or used in crosses.
- They provide a means of assessing new advanced lines.
- They provide information on performance over a broad range of climatic and disease conditions.

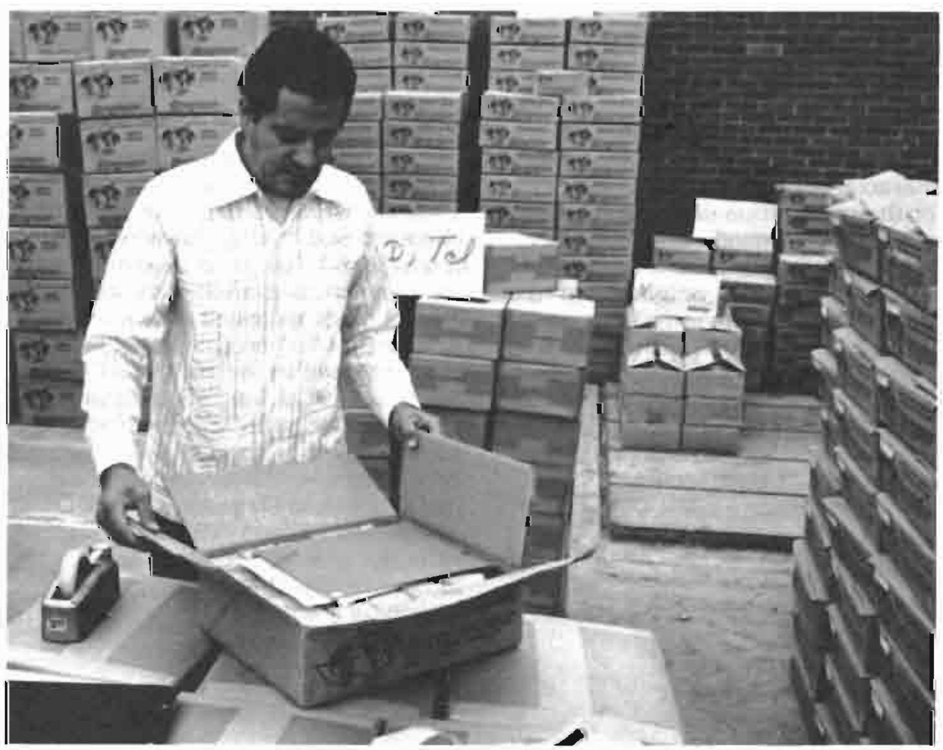
Yield nurseries—Entries in the yield nurseries (or trials) may come from national programs or from the CIMMYT program. They are usually advanced materials (from F_5 to F_7) or varieties already released commercially. The national program "nominations" are first grown and evaluated in Mexico for possible inclusion in a yield nursery.

Yield nurseries serve four purposes:

- They provide an assessment of the performance of advanced lines over a wide range of conditions.
- They permit comparison of performance characteristics of varieties from many sources at each trial location.
- They provide sources of genetic variability that a cooperator may use directly or in crosses.
- They generate information on the principles of adaptation.

Disease nurseries—These nurseries are sent to locations where particular diseases are likely to occur. Their purpose is to provide a means of identifying and evaluating potential sources of disease resistance. Agronomic evaluation receives less emphasis.

Yield components—These nurseries from the germplasm development program are sent to locations where the yield components, such as numbers of spikes per plant, spikelets per spike, grains per spike, as well as grain characteristics and biomass, can be evaluated individually under different environmental conditions. The resulting data provide information about the stability of the various components, which serves to guide further efforts at improvement.



Dr. M. Alcalá, head of the international nurseries program.

Table 1. Bread wheat, durum wheat, triticale, barley and germplasm development nurseries distributed by the International Nurseries Program in the summer of 1983.

Recipient country	Bread Wheat	Durum Wheat	Triti-cale	Barley	G.D.*
Latin America	**249**	**95**	**95**	**70**	**41**
Argentina	38	19	11	3	6
Bolivia	14	6	4	1	1
Brazil	49	3	20	5	12
Chile	21	8	8	8	6
Colombia	5	–	2	2	2
Costa Rica	3	–	1	1	–
Dominican Republic	1	–	4	–	–
Ecuador	12	1	3	4	1
Guatemala	9	2	4	1	1
Guyana	2	–	1	0	1
Mexico	53	45	29	24	7
Paraguay	15	1	3	2	2
Peru	22	10	5	19	2
Uruguay	5	–	–	–	–
Africa	**146**	**63**	**57**	**79**	**19**
Algeria	11	9	2	4	–
Burundi	2	–	–	–	1
Cameroon	5	1	2	2	1
Congo	2	–	–	–	–
Egypt	11	8	4	8	4
Ethiopia	7	9	4	6	2
Ghana	–	–	1	–	–
Kenya	12	5	5	12	1
Libya	3	4	–	4	–
Malawi	6	–	1	1	–
Morocco	6	6	4	8	–
Mozambique	4	–	–	1	–
Niger	1	1	1	1	–
Nigeria	4	1	2	2	–
Rwanda	5	–	2	4	1
Senegal	2	–	–	–	–
South Africa	16	9	10	12	5
Sudan	7	–	1	–	1
Tanzania	12	1	4	2	–
Tunisia	6	8	2	6	–
Uganda	3	–	1	–	–
Upper Volta	1	–	1	–	–
Zaire	2	–	1	–	–
Zambia	12	–	6	–	3
Zimbabwe	6	1	3	6	–
Middle East	**81**	**54**	**26**	**37**	**8**
Cyprus	3	4	2	3	1
Iran	2	1	–	1	–
Iraq	1	2	1	3	–
Israel	13	7	2	8	5
Jordan	4	6	2	3	–
Lebanon	1	1	–	–	–
Qatar	2	1	1	2	–
Saudi Arabia	3	1	3	–	–
Syria	23	13	6	7	1
Turkey	22	16	9	8	–
Yemen	7	2	–	2	1

Recipient country	Bread Wheat	Durum Wheat	Triti-cale	Barley	G.D.*
East Asia	**154**	**31**	**43**	**78**	**25**
Afghanistan	3	2	1	1	–
Bangladesh	14	1	1	6	1
Burma	4	–	1	3	1
Bhutan	2	–	1	2	–
China	57	5	9	23	6
India	4	2	1	4	3
Indonesia	3	2	1	2	–
Japan	1	–	–	–	–
Korea, South	4	1	4	7	–
Nepal	6	3	3	3	1
Pakistan	27	8	10	10	10
Philippines	7	2	2	3	–
Sri-Lanka	4	1	1	2	–
Taiwan	2	–	2	3	1
Thailand	16	4	6	9	2
Oceania	**15**	**10**	**14**	**2**	**2**
Australia	8	3	6	–	2
New Zealand	7	7	8	2	–
Europe	**109**	**87**	**85**	**74**	**26**
Austria	–	6	–	1	–
Belgium	–	–	–	–	1
Bulgaria	–	7	2	–	1
Czechoslovakia	4	–	–	–	1
England	2	–	1	5	1
France	8	4	9	8	3
Germany, East	2	–	2	4	2
Germany, West	1	6	3	3	–
Greece	7	7	6	6	3
Hungary	2	3	3	–	2
Ireland	5	–	–	–	–
Italy	7	17	6	8	2
Netherlands	–	–	2	–	–
Norway	3	–	3	3	1
Poland	7	1	9	4	2
Portugal	9	5	4	3	–
Romania	3	1	2	10	2
Russia	6	–	3	–	1
Spain	33	23	18	12	1
Sweden	4	–	4	–	1
Switzerland	–	–	3	–	–
Yugoslavia	6	7	5	7	2
North America	**9**	**1**	**3**	**3**	**4**
Canada	2	1	3	1	1
U.S.A.	7	–	–	2	3
TOTAL COUNTRIES	**85**	**59**	**76**	**66**	**51**
TOTAL NURSERIES	**763**	**341**	**323**	**343**	**125**

TOTAL NUMBER OF COUNTRIES TO WHICH GERMPLASM WAS SENT = 91

* Germplasm development
– = nursery not sent

Table 2. Number of entries in each of the 1983-84 nurseries.

Nursery	Entries
Bread Wheat	
F_2, Scab Resistance	36
F_2, Bulk-harvested	460
F_2, Helminthosporium Resistance	72
F_2, Aluminum Tolerance	127
F_2, Spring x Winter	151
Earliness Screening Nursery	189
Scab Screening Nursery	79
2nd Drought Tolerance Screening Nursery (DSN)	92
2nd Helminthosporium Resistance Screening Nursery	132
2nd Aluminum Tolerance Screening Nursery	72
17th International Bread Wheat Screening Nursery (IBWSN)	207
20th International Spring Wheat Yield Nursery (ISWYN) (1*)	49
20th ISWYN (6*)	49
5th Elite Selection Wheat Yield Trial (ESWYT) (1*)	29
5th ESWYT (6*)	29
14th International Septoria Observation Nursery (ISEPTON)	112
Durum Wheat	
F_2, Irrigated	289
F_2, Dryland	256
F_2, Cold Tolerance	126
F_2, Stem Rust Resistance	165
15th International Durum Yield Nursery (IDYN) (1*)	29
15th IDYN (6*)	29
15th Elite Durum Yield Trial (EDYT) (1*)	29
15th EDYT (6*)	29
15th International Durum Screening Nursery (IDSN)	306
Crossing Block	332

Table 2. (Cont'd)

Nursery	Entries
Triticale	
F_2, Spring x Winter	101
F_2, Bulk-harvested	234
F_2, Earliness	62
15th International Triticale Yield Nursery (ITYN) (1*)	49
15th ITYN (6*)	49
15th International Triticale Screening Nursery (ITSN)	207
Winter Crossing Block	44
Barley	
F_2, Spring	263
F_2, Spring x Winter	56
F_2, Andean Region	46
6th International Barley Yield Nursery (IBYN) (1*)	24
6th IBYN (6*)	24
2nd International Naked Barley Yield Nursery (INBYN) (1*)	24
2nd INBYN (6*)	24
1st International Early Barley Observation Nursery (IEBON)	17
11th International Barley Observation Nursery (IBON)	150
Crossing Block	458
2nd Barley Yellow Dwarf Virus Screening Nursery	41
Germplasm Development	
Yield Components (bread wheat)	27
Yield Components (durum wheat)	17
Leaf Rust Resistance Germplasm	163
Aluminum-Tolerant and Rust-Resistant Material	168

1* – In 1 single envelope for machine planting
6* – In 6 individual packets for hand planting

Andean Region

H.J. Dubin and P.C. Wall

Introduction

Over the last decade or so the number of hectares planted with wheat has declined in the Andean countries and productivity has stagnated. This decline in area has been basically due to negative political and economic policies relating to wheat in the forms of import subsides, unrealistic price policies, and lack of reliable marketing systems for local wheat.

The CIMMYT Andean regional wheat program concentrates on four countries, Ecuador, site of the base program, Colombia, Peru and Bolivia. CIMMYT regional staff input into the base program is somewhat greater than it is in the other three countries.

Regional personnel do not conduct their own research program, but are involved in the planning, execution and analysis of research in the four countries. All results quoted here are therefore the result of a team effort involving the CIMMYT staff, but with the primary responsibility for the conduct of the trials generally lying with the national researchers.

Variety Releases

In 1983 Colombia released ICA-Susata (Alondra"S") bread wheat for use in the drier areas of highland Colombia. The national program is also multiplying a Pavon"S" (CM8399-D-4M-3Y-1M-1Y-1M-0Y) for release in 1984.

INIAP-Altar (= Tob"S" x Desc-Fr), released in 1982, is now available to farmers in Ecuador and one large farmer is also selling seed privately. This variety has shown excellent resistance to the three rusts as well as to powdery mildew and *Xanthomonas translucens* in South America.

INIAP-Maná (= M_2A-IA) triticale should be released in 1984 and V. 14 (= Buey-Beagle), a complete triticale, is being multiplied for possible release. It is anticipated that the immediate use of triticale in Ecuador will be for concentrates and direct human consumption at the farm level.

Drought

Bolivia suffered an extremely severe drought in 1983 that destroyed most of the small grain crop as well as seed production. An emergency seed production project was designed with Interamerican Development Bank funding.

Pathology

As noted later in this report, barley yellow dwarf (BYD) continues to be a major factor in wheat production in Ecuador and other Andean areas. Richard Lister (Purdue University, USA) kindly tested wheat, barley and oat collections from Peru with Enzyme-Linked Immunosorbent Assay (ELISA) and the results indicated a predominance of PAV, a nonspecific strain of barley yellow dwarf virus (BYDV). This is consistent with previous data on germplasm from Ecuador.

As in previous years, the data from the Latin American Rust Nursery (ELAR) do not indicate any significant change in the virulence spectrum of *Puccinia striiformis* f. sp. *tritici* on wheat or of f. sp. *hordei* on barley. Race 24 and its variants 24-Mazurca and 24-Varunda were present. Stripe rust has recently been reported on barley variety I-5 in Bolivia, Chile and Ecuador.

Field observations, confirmed by microscopic examination, indicate that the spot form of *Helminthosporium teres* continues to be important on barley in the savannah of Bogota, Colombia. We have also observed this disease in Peru but not in Ecuador or Bolivia yet.

In 1983 *Sclerotium rolfsii* was observed for the first time infecting wheat germplasm nurseries in Santa Cruz, Bolivia. Concurrently, infestation of wheat by *Schizaphis graminum* was common in the same nursery.

Disease and Observation Nursery in Latin America (VEOLA)—Data are presented in Tables 1-5 from the third and fourth VEOLA for wheat, the third and fourth VEOLA for

Dr. H.J. Dubin (left), CIMMYT wheat scientist, Dr. Byrd Curtis (center), Director of the wheat program, and Dr. P.C. Wall (right), CIMMYT wheat scientist examining an on-farm trial in Cochabamba, Bolivia.

triticale, and the third VEOLA for barley. The primary aims of the VEOLA are to obtain disease resistance data from as many sites as possible and at the same time to provide the best disease-resistant materials to the national breeding programs in the Andean region for their own use. The source of the entries generally is CIMMYT, but Andean materials are also included after preliminary testing in the region.

Table 1 shows 21 of the best bread wheat lines in the third wheat VEOLA with combined resistances to stripe rust (leaf and head), leaf rust, and stem rust. Crosses such as Bucky x Tob-Cno"S" and Tob"S"/Cno"S"-Jar x Kvz, have consistently shown good disease resistance in the Andean countries. Tobari"S" provides good resistance to the three rusts in this area and is a parent of many well-adapted crosses. Data from the fourth wheat VEOLA provide information on the three rusts and powdery mildew; Table 2 shows six lines with excellent resistance to these diseases. As noted in Tables 3 and 4, triticales possess a high degree of resistance to the three rusts in this area and in general are more disease-resistant than bread wheats.

Lines of barley with good resistance to stripe rust (*P. striiformis* f. sp. *hordei*) and stem rust are listed in Table 5. These data were gleaned from the third barley VEOLA. VEOLA data indicate good levels of stripe rust resistance in Andean barleys but leaf rust resistance is lacking; thus leaf rust has become an increasingly important disease.

Agronomy

The CIMMYT agronomy effort in the Andean region is directed primarily toward stimulating and helping with on-farm research on small-grain cereals. The following principles underlie the type of research that is advocated for these crops in this region:

- The primary objective of the research should be to develop recommendations for groups of farmers or for a geographical area.
- The research should concentrate on the factor or factors most limiting to yield and economic benefit, taking into account interactions between factors.
- Interactions with other crops in the rotation are considered where necessary, but farming systems research, as such, is not advocated.
- The research is generally carried out under farm conditions, and only experimental variables are set at levels other than those in use by the farmer.

Soil fertility is the main limitation to yield in all the traditional cereal areas of the Andean highlands. The soils are generally characterized by low phosphorus availability and high levels of potassium. Other factors that are of almost universal importance in the region are the needs for disease-resistant varieties with high yield potential, nitrogen fertilizer and good weed control. However, adoption of new varieties and chemical weed control with 2,4-D is well advanced; farmers in many areas of the highlands change varieties as soon as seed of new varieties is available locally. In Ecuador it is estimated that over 90 percent of the wheat area is seeded with varieties released since 1969. Acceptance of new barley varieties has been very fast following the stripe rust epidemic of 1976.

In Ecuador the 1983 growing season was extremely wet, which led to marked increases of leaf and spike diseases (mainly *Septoria* spp. and *Fusarium* spp.) in the on-farm trials. This, together with periodic waterlogged conditions and poor stands, led to lower yields and weaker responses to fertilizer than those experienced in previous years. Tables 6 and 7 show results from verification trials conducted in 1982 and 1983 which include two bread wheat varieties common to both years. The trials included three fertilizer levels—0-0-0, the level most commonly used by small and medium-sized producers; 80-160-0, the fertilizer rate found in previous years to be the most economically beneficial; and 80-80-0, which had previously shown marginal rates of return almost as high as 80-160-0, but which is less capital intensive. The trials were conducted by the National Institute of Agricultural Research (INIAP) Production Investigation Program in the Cayambe area of Ecuador; all factors except the experimental variables were set according to common farmers' practices.

The detrimental effect of excess moisture in 1983 is evident from the average yields in the two seasons, 1966 kilograms per hectare in 1982 (Table 6) and 947 kilograms per hectare in 1983 (Table 7). In both seasons there was an economically significant response to fertilizer application, with 80-80-0 having a higher marginal rate of return than 80-160-0. Even though 80-80-0 was more cost effective overall in 1983, it was not so with the variety Atacazo 69 nor with INIAP-Altar at one of the four sites where, although the yield increase paid the costs, a 40 percent return on capital was not achieved.

At low yield levels, (e.g., in 1983 and without fertilizer) there was no significant difference in yields between varieties, but under conditions more favorable for yield, (e.g., in 1982 and fertilized) the new wheat variety INIAP-Altar produced significantly more than the older variety Atacazo 69. The presence of a significant site x fertilizer interaction in both seasons reflects the presence of a single site with a markedly stronger response to fertilizer than was the case at the other sites. This suggests that recommendation domains might need further refining, but since the same fertilizer application rate proved economical over the whole range of sites, this is not a high priority.

In an effort to understand inconsistencies in the results of on-farm trials, studies on barley yellow dwarf virus (BYDV) were initiated in the Cayambe area in 1980. Initial results showed average yield losses of approximately 20 percent attributable to the virus. In the 1983 season, two of the four replications of each of five fertilizer level trials were treated with a systemic insecticide (carbofuran) at seeding and then sprayed with Thiometon (another systemic insecticide) every two weeks, from four weeks after seeding until flowering to control the aphid vectors of BYDV. Results for five fertilizer levels, averaged over five sites, are shown in Figure 1. At each site, the data from two wheat varieties, INIAP-Altar and INIAP-Tungurahua, were averaged as there was no evidence that they differed in response to either fertilizer or insecticide. The number of aphids per stem was not great, seldom reaching more than five. Thus, the effects are probably due to BYDV, which was confirmed in the plots, rather than to direct effects of the aphids.

Overall, the lack of aphid control in the treatments shown in Figure 1 reduced yields by 24 percent, which was highly significant (P less than 0.01). There was a tendency for yield to be reduced more at high fertilizer levels (26 percent reduction at 160-40 N-P) than at low levels (11 percent reduction at 0-0 N-P). It should be noted that only the 40 kilograms per hectare phosphorus level is illustrated in Figure 1 because, in this wet year, there was no significant response to higher applied phosphorus levels except in combination with 160 kilograms per hectare of nitrogen.

Given these yield losses due to BYDV, the cereal breeding program has put high priority on selection of BYDV-resistant material. Concurrently, the production investigation program will study the timing and economics of insecticide applications to limit the effects of BYDV.

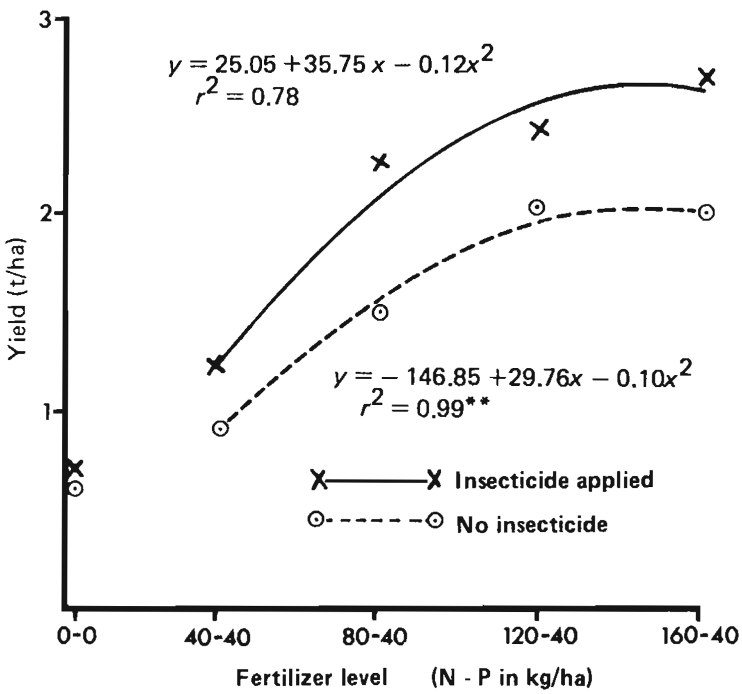


Figure 1. Yields of wheat with and without aphid control at five fertilizer levels. Each point represents the mean of two varieties averaged over five sites.

Table 1. Bread wheat lines from the third VEOLA with outstanding resistance* to stripe rust (leaf and head), leaf rust, and stem rust.

Entry number	Variety or cross and pedigree	Entry number	Variety or cross and pedigree
11	ALTAR"S" E-II-67-3965-1E-2E-9E	117	BUCKY x TOB66-CNO"S" E-II-72-8691-1E-1E-1E
21	BUCKY x TOB-CNO"S" E-II-72-8691-1E-1E-2E	118	BUCKY x TOB66-CNO"S" E-II-72-8691-1E-2E-1E
22	BUCKY x TOB-CNO"S" E-II-72-8691-1E-1E-3E	134	VEERY"S" CM-33027-F-1M-11Y-0M
23	BUCKY x TOB-CNO"S" E-II-72-8691-1E-1E-4E	138	AU x KAL-BB/BON CM-33802-E-1M-2Y-0M
32	T. AEST x KAL-BB/ON-CNO(6) CM-3305-B-11M-5Y-0M	140	KT/BB-FN x U-BZA EC-147
37	PJ62-WRT x CAL 26972-2M-300Y-300M-0Y	165	TOB"S"/CHA-JAR x KVZ CM-20707-A-1Y-8M-1Y-0Y-4PTZ
38	TOB"S"/CHA-JAR x KVZ CM-20707-A-1Y-8M-1Y-0Y-1PTZ	185	7C-NAD x TOB"S"-8156 CM-14960-27M-501Y-501M-0Y-2KE-2K
41	TOB"S"/CHA-JAR x KVZ CM-20707-A-1Y-8M-1Y-0Y-4PTZ	191	TOB"S"/CNO-JAR x KVZ CM-20707-A-1Y-8M-0Y-1PTZ
65	TOB"S"/CHA-JAR x KVZ CM-20707-A-1Y-8M-1Y-0Y-2PTZ	192	TOB"S"/CNO-JAR x KVZ CM-20707-A-1Y-8M-1Y-0Y-2PTZ
72	BUCKY x TOB-CNO"S" E-II-72-8691-6E-1E-2E	193	CC-CHB70 x BB-NOR67 CM-11860-E-1Y-2M-1Y-6M-2Y-0Y-3PTZ
86	BOBWHITE"S" CM-33208-N-1M-2Y-0M	196	BOBWHITE"S" CM-33203-N-1M-2Y-0M
88	VIREO"S" CM-28235-1Y-1Y-0M	203	AU-TOB x GRAJO CM-30833-N-2Y-2M-2Y-2M-0Y
90	VEERY"S" CM-33027-F-15M-500Y-0M	204	AU-TOB x GRAJO CM-30833-N-2Y-2M-3Y-1M-0Y
107	VAR# 1212-ISN68-69 x CNO-7C E-II-74-11728-6E-2E	207	BOBWHITE"S" CM-33203-F-4M-8Y-1M-0Y

Table 1. (Cont'd)

Entry number	Variety or cross and pedigree
213	KVZ x CNO-PJ62 SWM-1285-2Y-3M-1Y-0M
216	BON x KAL-BB CM-21432-2M-1Y-7Y-1Y-1M-0Y
224	KVZ-K4500-L.A4 SWO-176-3M-1Y-10Y-2Y-1M-0Y
231	KAL x KAL-BB/KAL-BB x MDS CM-38344-H-4Y-1M-3Y-0M
232	BOGRIN-JUP73 x HORK"S" CM-41266-0-13M-3Y-0M
242	(BB-CNO x INIA-SOTY/SPARROW"S") PAVON"S" CM-37705-K-5Y-3Y-1M-0M
259	(PAK F46313/TOB-CFN x BB)B.MAN-ON x CAL-MAYA"S" = ANI"S" CM-26346-A-17Y-1M-2Y-1M-1Y-0B
262	BOBWHITE"S" CM-33203-K-12M-14Y-1M-0Y
284	TOB"S"/CHA-JAR x KVZ CM-20707-A-1Y-8M-1Y-0Y-1PTZ

* Mean average coefficient of infection (ACI) for the four diseases no greater than 2. Data calculated from fourteen sites in South America, North America, and Africa. Not all diseases were present at all sites.

Table 2. Bread wheat lines from the fourth VEOLA with outstanding resistance* to stripe rust (leaf and head), leaf rust, stem rust, and powdery mildew.

Entry number	Variety or cross and pedigree
4	ALTAR
10	BUCKY x TOB-CNO"S"
27	JUP77-ALONDRA"S" CM36867-18Y-2M-0Y
28	KVZ-K4500-L-A4 SWO-176-3M-1Y-10Y-2Y-2M-0Y
31	KT59AE-NAR-59 x PCH T 3123-2T-2P-1P-1P
451	C-78048 = KAVKAZ-TORIM73 SWM-3879-7Y-3M-1Y

* Mean average coefficient of infection (ACI) less than 3 for the five diseases. Data included from thirteen sites in South America, North America, and Africa. Not all diseases were present at every site.

Table 3. Triticale lines from the third VEOLA with outstanding resistance* to stripe rust (leaf and head), leaf rust, and stem rust.

Entry number	Variety or cross and pedigree
299	M2A-IA X12665-11Y-6Y-5M
302	M2A-HEXA SEL. (from bulk) X12797-6Y-1Y-2M
305	BEAGLE"R"
323	M2A(2)-346 X8504-C-2Y-2M-100M-103B-104Y-6Y-2M-0Y
330	M2A-IRA X12581-18Y-1Y-6M-0Y
338	M2A(2) X8504-C-2Y-100M-103B-109Y-1M-2Y-5M-0Y
339	M2A-CML X8534-D-3Y-2M-0Y-102B-14Y-0M-100M-0Y
345	M2A-MIA X27947-22M-9Y-0M
350	TEJON-IRA X13895-B-100Y-100B-102Y-104Y-4M-1Y-0M
351	TEJON-IRA X13895-B-100Y-100B-102Y-114Y-4M-6Y-0M
352	M2A-FS 722 X12845-12Y-7Y-2M-1Y-0M
353	M2A-FS X12845-5Y-4Y-2Y-0M

* Mean average coefficient of infection (ACI) for the four diseases less than 2. Data calculated from fourteen sites in South America, North America, and Africa. Not all diseases were present at all sites.

Table 4. Triticale lines from the fourth VEOLA with outstanding resistance* to stripe rust (leaf and head), leaf rust, stem rust, and powdery mildew.

Entry number	Variety or cross and pedigree
48	M2A-IA X12665-14Y-1Y-6M
50	BE-BGL"S" X16216-100B-100Y-1M-1Y-1M-0Y
53	M2A-IA X12665-11Y-6Y-5M
54	CIN-M2A(2) X15401-15Y-2Y-2M-0Y
55	M2A(2) X8504-C-2Y-2M-100M-103B-101Y
56	IRA-M2A x IIA(2)/M2A-STR X26181-E-3Y-11M-1Y-0M
57	M2A X12593-B-1Y-1Y-4M
58	IA-MIA x CAL X14920-2N-0M
59	M2A-IRA110 X8516-E-1Y-1M-0Y
60	M2A-CML X8534-D-3Y-2M-0Y-102B-114Y-0M-100M-0Y
61	M2A x OCTO-HEXA X2803-B-1Y-5M-3Y-0M
65	M2A-CANADA X8208-G-1Y-2M-3Y-0Y

* Mean average coefficient of infection (ACI) less than 2 for all five diseases. Data calculated from thirteen sites in South America, North America, and Africa. Not all diseases were present at all sites.

Table 5. Barley lines from the third VEOLA with high resistance* to stripe rust (leaf) and stem rust.

Entry number	Variety or cross and pedigree
19	GALERAS x PI 6384 E-II-69-32-4E-4E
22	GALERAS x PI 6384 E-II-69-32-4E-4E
33	GALERAS x PI 6384 E-II-69-32-5E-2E
34	NIGRINUDUM-SEA OF AZOF E-II-69-58-2E-3E-3E
35	CHEVALIER-NIGRINUDUM E-II-69-31-1E-1E-2E
54	GRIGNON
56	UNA 8479
62	UNA 8483
63	UNA 8484
71	UNA 8269
72	UNA 8270
73	UNA 8271
74	UNA 8308
75	UNA 8310
76	UNA 8465
78	TERAN 78
89	(OG/FUN-CN48 x FUN) KI x BENTON
95	PI 6384-CAPUCHONA E-II-69-69-1E-1E
96	GALERAS-PROCTOR E-II-69-36-4E-2E-1E-1E
103	CN7-DC23/MOR x KI-CI 2376 II-17648-2E-3E-2E

* Mean average coefficient of infection (ACI) for the two diseases less than 5. Data calculated from five sites in South America and Africa. Not all diseases present at all sites.

Table 6. Yield of two bread wheat varieties and one bread wheat advanced line at three fertilizer levels. Means of three sites near Cayambe, Ecuador, 1982.

Fertilizer applied (N-P-K)	Grain yield (kg/ha at 14°/o moisture)			
	Atacazo 69	INIAP Altar 82	Alondra "S"[1]	Mean
0-80-0	1031	1379	1335	1248
80-80-0	2019	2699	2221	2313
80-160-0	1968	2861	2183	2337
Mean	1673	2313	1630	1966
Significance[2]:				
Varieties	**			
Fertilizer	***			
Var x Fert	*			
Site x Var	**			
Site x Fert	**			
C.V.	14.1°/o			

1. Advanced line.
2. *, **, *** = significant at the 5°/o, 1°/o and 0.1°/o levels, respectively.

Table 7. Yields of two bread wheat and one triticale variety at three fertilizer levels. Means of four sites near Cayambe, Ecuador, in 1983.

Fertilizer applied (N-P-K)	Grain yield (kg/ha at 14°/o moisture)			
	Atacazo 69	INIAP Altar 82	INIAP Maná[1]	Mean
0-0-0	414	450	418	427
80-80-0	950	1160	1101	1070
80-160-0	1269	1399	1358	1342
Mean	878	1003	959	947
Significance[2]:				
Varieties	*			
Fertilizers	***			
Var x Fert	N.S.			
Site x Var	10			
C.V.	22.7°/o			

1. Triticale
2. 10, *, **, ***, N.S. = significant at the 10°/o, 5°/o, 1°/o and 0.1°/o levels, and not significant, respectively.

Southern Cone Region

M.M. Kohli and M.A. McMahon

Introduction

The CIMMYT Southern Cone regional wheat program is now in its fifth year. Although there have been some changes in strategy, its basic objectives remain the same:

- Cooperate with the national agricultural research programs in Argentina, Brazil, Chile, Paraguay and Uruguay in the development of their wheat research programs
- Provide training, both formal and informal, to research personnel in these countries
- Assist in the development of locally adapted germplasm
- Help develop agronomic recommendations based on up-to-date technology that will work under farm conditions to produce an economic return

After a record wheat year in 1982, the Southern Cone region experienced a small decline in production during 1983. A major share of this change can be attributed to Argentina alone. Wheat production in 1982, which was approximately 43 percent higher than the 1974-76 average, was the result of the combination of a 15 percent increase in area and an 11 percent increase in yield over the base period (Table 1). In 1983, the area seeded to wheat in the Southern Cone region was reduced to approximately the same level as during the 1974-76 period, but yield was a significant 31.6 percent above the base period, resulting in an increase in wheat production of 23.2 percent. Thus the importance of higher yields obtained through the use of high-yielding varieties and better agronomic practices can be more easily appreciated in 1983 than in the preceding year.

The changes in area, production and yield of wheat in the Southern Cone region over a 20-year period are shown in Figure 1. On an individual country basis, improvement in the yield of wheat can be observed in Table 2. Taking 1961-65 as the base period, the increase in the yield of wheat among the countries of the region ranges between 10.3 and 43.9 percent. It is notable that most of the increase came between the 1974-76 and 1981-83 periods. It is also noteworthy that the smallest overall gain in yield over the last two decades has been in the largest wheat-producing country of the region, Argentina. There are probably several reasons for this small increase but one that stands out clearly is the lack of use of fertilizers to counteract the continuous depletion of natural soil fertility. Probably due to reduced fertility, Argentina has not been able to take full advantage of its new, high-yielding wheat varieties. There is serious concern about this situation at all levels of the new government and solutions may be forthcoming as early as 1984.

Crop Status

Argentina—The reduction of approximately one half million hectares in the area planted with wheat during 1983 was due to heavy rains in the south at the time of seeding. In addition, severe drought throughout the crop cycle in the north and the northwest caused reductions in yield. These two factors together caused a loss of over three million tons of wheat production. In addition, the widespread lack of fertilization was made evident by those few fields that had been fertilized or that had accumulated natural soil fertility through well-managed rotations with pasture. The lack of balanced fertilization, especially with respect to the nitrogen-phosphorus ratio is critically limiting production. The use of high-yielding wheat varieties is widespread throughout the country and the adoption of recently released varieties like Buck Pucara, Chasico INTA and Las Rosas INTA has diversified the improved germplasm base. This helped to keep the 1983 crop relatively free of disease and insect problems.

Dr. M.M. Kohli (second from left) with Brazilian national program researchers.

Brazil—The poor performance of the wheat crop during 1982 was the major reason behind the more than 30 percent reduction in the area seeded to wheat in 1983 (Table 1). Most Brazilian farmers have always considered wheat to be a high-risk crop and have sought favorable government policies to support production increases. However, in the past few years the government policy of reducing subsidies on the production and marketing of wheat has left farmers less interested in its cultivation. They seem to prefer a single crop of soybeans over a continuous wheat-soybean rotation, which also causes severe root-rot problems for the wheat crop. The long-term studies done at the National Wheat Center of the Brazilian Agency for Agricultural Research (EMBRAPA) recommended a wheat seeding every four years in southern Brazil to avoid damage caused by a complex of micro-organisms in the soil. However, an acceptable alternative to wheat for the winter months is still being sought by EMBRAPA.

The southern part of Brazil was dry in 1983, which prevented damage due to diseases or insect pests except in some localized areas where scab infections appeared with the late rains. Little damage was caused by helminthosporium spot blotch in the states of Parana and Matto Grosso do Sul.

The establishment of a regional wheat program by EMBRAPA for the central Brazilian Cerrados is likely to increase the wheat area under both irrigated and rainfed conditions. The new CIMMYT germplasm with additional disease resistance will fit very well in this area.

Chile—A 69 percent increase in wheat production over the preceeding year was the response to governmental policies establishing a price floor for national wheat production and supporting a private marketing system. Production also increased due to excellent crop conditions in all parts of the country except the south, where a prolonged drought seriously affected the spring-sown crop. The winter wheat crop, planted about three months earlier, suffered much less. There was a complete absence of diseases and insect pests. An additional stimulus was the national wheat production contest, discussed in more detail in the agronomy section of this report.

As a result of the increased interest in wheat production, demand for certified, improved seed overwhelmed supplies of certain varieties. In addition, fertilizer was unavailable in some parts of the country, making it difficult to take full advantage of the recommended technology.

The projection for the 1984-85 season is that wheat will be sown on 600,000 ha, and, if economic conditions remain favorable, on 750,000 ha within a few years. If yields can be maintained at their present levels this would result in Chile's producing 80 percent if its needs, thus reducing imports to 400,000 tons. However, it is widely believed that Chile can become completely self-sufficient in wheat. Without increasing the historical wheat area of 750,000 ha, this would require raising average yield by 500 kg/ha. Existing data indicate that this is a feasible goal.

Paraguay—The continuing impact of the national wheat campaign combined with a favorable price policy has produced excellent results over the past eight years. The government's target, to increase the area under wheat from 70,000 ha in 1982 to 100,000 ha in 1983, was not realized due to excessive rains during sowing time. However, the favorable weather conditions that accompanied the crop throughout its

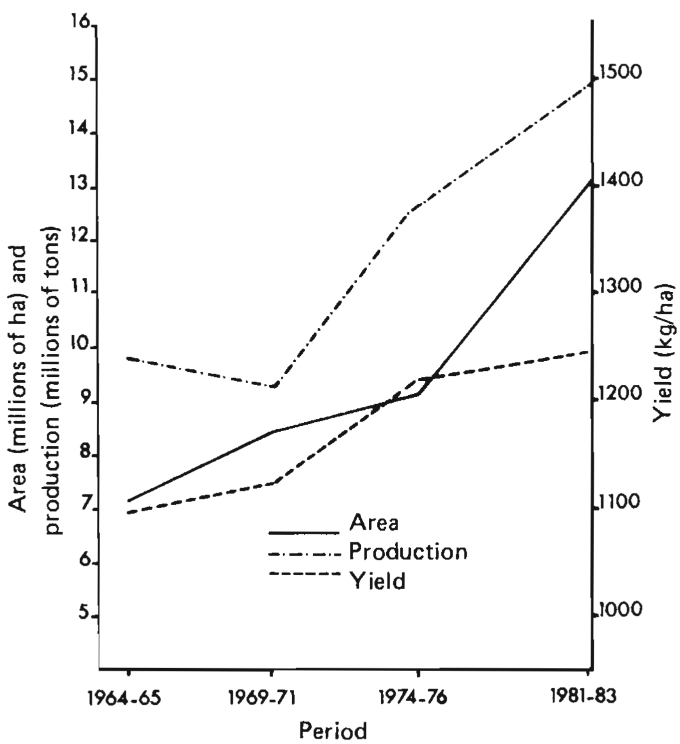


Figure 1. Area, production and yield of wheat over a two-decade period in the Southern Cone region. Data are averages for the period indicated.

development were primarily responsible for an all-time high average yield of 1426 kg/ha. Paraguay achieved a new national wheat production record of 107,000 tons during 1983.

Along with the increasing wheat production, Paraguay is also making strong efforts to increase the diversity of germplasm in its wheat area. The area planted with newly released wheat varieties is increasing slowly. To speed up change to new varieties, the Ministry of Agriculture and Animal Husbandry asked for CIMMYT's assistance in importing 60 tons of seed of a Veery selection from the Chilean National Institute of Agricultural Research (INIA). This new variety, named Cordillera 3, had a good yield record in experimental trials and gave excellent results in farmers' fields during 1982. In well-managed fields of Cordillera 3, yields up to 3600 kg/ha were obtained in 1983 and enough seed was harvested to plant more than 10,000 ha in 1984.

Uruguay—For the first time in many years, Uruguay experienced excellent weather conditions at planting time; most of the fields were sown in the recommended period and under optimum conditions. Weather conditions remained favorable throughout the development of the crop. Since no serious diseases or insect pests affected the crop, average yield reached a record high of 1500 kg/ha. This is 45 percent higher than the average yield during the 1961-65 period, which attests to the excellent research work done by the national program in developing new high-yielding varieties and a good production technology package.

Johnson grass and wild oats are becoming an increasingly important problem in Uruguay. Despite the availability of information on methods of control, the number of infested fields is increasing. Although this is confined to low-fertility fields at present, the amount of seed being dispersed into neighboring, more fertile fields could become a real problem in the future.

Germplasm Development

Bread wheat—As in previous years, newer germplasm derived from spring x winter and Brazilian x CIMMYT crosses predominated in the advanced yield trials all over the Southern Cone region. Among these, the performance of the Veery selections was outstanding. The average results of the 18th International Spring Wheat Yield Nursery (ISWYN) from South American locations give excellent testimony to the performance of the Veery selections in general (Figure 2). Excluding the local check, four of the five top places were occupied by a Veery "S". Veery 3 and Veery 5 are adapted widely in this region, and their yield performance, when compared to Anza and Pavon 76, which are already being grown under different names, is clearly superior (Table 3).

On an individual country basis, most of the newer selections produce significantly more than the commercially grown improved varieties. A selection of lines from each country is presented in Tables 4-7 and their yields given as a percent of the best local check. While in most countries the yields were averaged from more than one region, in the case of Brazil (Table 5), only the southern Parana region was included. This region is a transition zone between the areas of the state of Rio Grande do Sul with acid soils containing toxic amounts of free aluminum and the parts of the state of Parana with neutral soils, and suffers from most of the problems present in both regions. The predominance in Table 5 of newer germplasm derived from Brazilian x CIMMYT crosses is indicative of the progress being made in the cooperative effort of CIMMYT and Brazil to develop wheats tolerant of high levels of free aluminum. Over a three-year period, some selections, like PF 79765, PF 79791 and PF 8016, have produced 54 to 77 percent more than Maringa in the Passo Fundo area. Some of these lines will be ready for release after 1984. In the nonacid soils of Parana and the state of Matto Grosso do Sul,

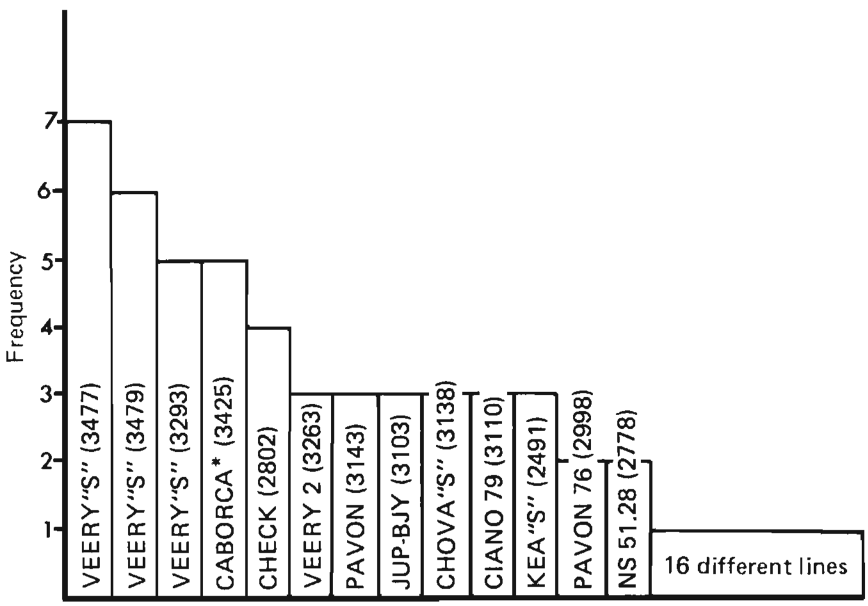


Figure 2. Relative performance of the best lines in the 18th International Spring Wheat Yield Nursery (ISWYN) at 13 locations in South America, as measured by the frequency of appearance among the five highest-yielding entries. Numbers in parentheses are the average yield (kg/ha) for 10 locations in the Southern Cone Region. *triticale.

the wheat varieties Anahuac and Cocoraque maintain their dominance. During 1981-83, the average yield of Cocoraque in the areas of Parana without aluminum problems was 12 percent higher than a group of checks. Two newer lines of interest for this area are IOC 803 (Kea "S") and IAC 28.

In an effort to create a greater array of varieties in their increasing wheat area, Paraguay is using Mexico and Chile for seed multiplication purposes. A new line from Minnesota, USA, Aepoglom-II 64.27, has performed well for several years and is in the seed multiplication stage, in preparation for release in 1984.

The warmer areas of the region, which suffer every year from drought and severe infections of spot blotch, are likely to benefit from the new CIMMYT nurseries directed at these problems. A number of selected lines from the 16th International Bread Wheat Screening Nursery (IBWSN) are presented in Table 8.

Durum wheat—The increasing wheat area in Chile brought new attention to the durum wheats. A group of 10 high-yielding lines from CIMMYT were sown at the SNA Experimental Station near Santiago; the yields of the five best lines are presented in Table 9.

The Chilean national wheat program, which had reduced its research on durum wheat substantally, started testing a large number of lines in yield trials at several locations. Some of the outstanding lines and their pedigrees are:

Stw 63-GII x AA "S"
A 13979-3p-2p-3p

Cr "S"-Gs "S" x Pg "S"
CD 9661-3p-2p-1p

ME-L75 x Qfn^2
CMH 77A-699-5B-1Y-1B

Para-Pg "S" x Mgh"S"
D 10506-2p-1p-1P-1P

S 15-Cr "S"
D 33312-8Y-4M-2Y-0M

In Argentina, durum wheats have been losing area to bread wheats in the southern part of the Pampas region, in spite of the release of the new variety B. Candisur.

The national durum wheat breeding programs are continuing their efforts to increase yield. CIMMYT germplasm fits extremely well into the durum areas of both Argentina and Chile. A group of high-yielding, stem rust-resistant lines selected in both countries is presented in Table 10.

Triticale—Brazil took the lead in the Southern Cone region in setting up an official price structure and a commercial policy for the production of triticale. The official policy, set for an initial period of three years, mandates that all triticale production will be marketed at wheat quality standards and price. This was a very important step in starting the large scale commercial production of triticale in Brazil. During the first year seed multiplication of PFT 766 and TCEP 77138, both Panda selections, was sufficient to produce in 1984 over 250 tons of seed, enough to sow approximately 2500 ha.

The demonstration fields of variety PFT 766, set up by EMBRAPA, received very favorable comments from the farmers. The crop produced a good stand, had excellent spike fertility and was completely free of diseases. The weak straw of variety PFT 766 could have resulted in lodging in some places due to the very heavy heads. The estimated yield in most fields ranged between 2500 and 3500 kg/ha, compared with wheat yields of 1700-3000 kg/ha.

In general, the newer lines from crosses involving Beagle and Tejon perform much better in Brazil than the older Maya II-Arm crosses. Some newer selections from Panda crosses, with good seed type, have also been selected in the Brazilian program. Seed shrivelling and low test weight remain problems of constant concern for the triticale programs of the region. In addition, their extreme susceptibility to helminthosporium spot blotch and head scab are production-limiting factors in an area like Brazil where these diseases attack in epidemic form. Local screening programs have been quite effective in identifying sources of resistance to these diseases, and to preharvest sprouting, which is a common problem. Some of the outstanding selections are given in Table 11.

Drought resistance nursery—This new bread wheat nursery from CIMMYT was planted at three locations in the region, Marcos Juarez, Argentina; Hidango, Chile; and Caacupe, Paraguay. While Hidango and Caacupe suffered only minor drought, Marcos Juarez suffered from severe and prolonged drought starting at the tillering stage. At Marcos Juarez, late rains caused heavy secondary tillering in most varieties, thereby masking the effect of the drought on yield. A number of lines from the drought nursery were selected for further testing at all three locations. They are listed below:

63.189.66.7-Hys"S"x Fury
SWM 6739-16Y-2Y-1Y-2Y

63.189.66.7-Hys"S"x Fury
SWM 6739-16Y-2Y-1Y-3Y

63.189.66.7-Hys"S"x Fury
SWM 6739-16Y-2Y-1Y-4Y

Veery "S"
CM 33027-F-15M-4Y-4M-3Y-2M-1Y-0M

Southern Cone Advanced Lines Nursery (LACOS)—The third wheat screening nursery organized under the auspices of the joint Interamerican Institute of Agricultural Sciences (IICA), Interamerican Development Bank (BID), and the Southern Cone regional program and coordinated by the INIA-CIMMYT wheat program in Chile, comprised the best 274 entries from the 19 programs in the region. Forty sets of the nursery were distributed within the region and to cooperators outside the region, the latter to generate complementary disease and agronomic data. Twenty-one reports have been received at this writing and are awaiting analysis.

The utility of materials entered in the LACOS nursery increases yearly. Several selections from the previous LACOS nurseries are in advanced yield trials at several locations in the region. In addition, various programs of the region have started using advanced lines selected from the LACOS as disease-resistant parents. A recent communication, from Dr. Alan Roelfs, of the United States Department of Agriculture (USDA) Cereal Rust Laboratory, St. Paul, Minnesota, USA, relates that the material from the LACOS combines some of the best sources of resistance to stem and leaf rusts. This may be due to the wide diversity of conditions under which these materials are selected and tested.

New Releases

A list of wheat varieties released in the region during 1983, is given in Table 12. It is significant that of the approximately 103 wheat varieties released in this region over the past five years, approximately 41 are direct introductions or reselections from CIMMYT germplasm.

Disease Screening

As mentioned earlier, 1983 was a fairly disease-free year. However, artificial inoculations for screening for disease resistance were extremely successful at several locations. In other locations, weather conditions were helpful in developing natural epidemics of particular diseases. Both kinds of location were used to screen for resistance.

Leaf and stem rust epidemics were light all over the region in spite of repeated inoculations. Argentina is a special case due to the ineffectiveness of the Lr 24 and Sonora 64 genes against the local leaf and stem rusts, respectively. At the National Institute of Agricultural Technology (INTA) experiment station at Parana, Argentina, both leaf and stem rusts were severe in the breeding nurseries. A surprisingly severe leaf rust infection was observed on the variety Precoz Parana INTA, which carries the Lr 9 gene for resistance. The newly released varieties La Paz INTA and Victoria INTA were also susceptible to leaf rust. This apparent change in virulence spectrum merits serious concern, since the area planted with these varieties is still on the increase. In addition, it poses a danger to other improved germplasm. The high levels of leaf rust infection on all the Veery selections may slow down their acceptance to some extent.

The susceptibility to stem rust of lines carrying the Sonora 64 resistance gene, like Marcos Juarez INTA and Nambu, has been causing serious concern. In spite of the generally low rust levels, several CIMMYT lines, like Nacozari 76, Pavon 76 and Ciano 79, and their crosses were heavily infected with stem rust. A trace of stem rust on Genaro 81 at Parana, Argentina, needs to be watched carefully due to the extensive area in the region planted with this variety.

Two dry years in a row have prevented the development of stripe rust in Chile. However, the breeding programs are well aware of its potential threat.

The following list presents the rust genes that are still effective over the whole Southern Cone region:

Stem Rust:
Sr genes 22, 24, 26, 27, Tt1 and Gt

Leaf Rust:
Lr genes 12, 17, 18, 19, 20 and possibly 9

Stripe Rust:
Yr genes 4, 7, 8 and 10

Spot blotch caused by *Helminthosporium sativum* was much less serious in 1983 than in 1982. However, artificial infections in Londrina and Palotina, Parana, Brazil, were extremely successful in helping to identify resistant material. A group of outstanding lines selected from the 16th IBWSN and the Helminthosporium Screening Nursery are given in Table 13.

A large-scale program involving several sources of resistance to spot blotch has been started by the Agronomy Institute of Parana (IAPAR) and the Organization of Cooperatives of the State of Parana (OCEPAR) of Brazil. For the immediate future, a combination of partial resistance and fungicides seems to be the only practical control method.

Another disease that is alarming to the farmers and wheat breeders of the region is scab. A short rainy period at flowering time was sufficient to cause moderate to severe levels of scab in the nurseries at Cruz Alta, Brazil. At La Estanzuela, Uruguay, an artificially inoculated scab infection was sufficiently severe to identify even minor levels of resistance in the materials. The sources of resistance that could withstand this severe infection are: Pel 73101, Pel 73151, Encruzilhada, Abura and Nyu Bay. Four CIMMYT advanced lines noted for low scab infection under natural conditions are derived from the two following crosses:

4777 (2) x FKN-Gb/Pvn
CM 49912-37M-1Y-1/2M

Cmt-Yr x Mon "S"
CM 43403-A-2Y-1M-1Y-1M-1Y-0B-4/87M-0Y

Another group of scab-resistant lines sent from CIMMYT, Mexico, were inoculated artificially in Passo Fundo, Brazil, and La Estanzuela, Uruguay. The lines that showed resistance in Brazil are listed in Table 14.

Ing. Martha Diaz of La Estanzuela, Uruguay, created an epidemic of septoria leaf blotch in the 13th International Septoria Observation Nursery (ISEPTON). Those entries with low septoria scores and good agronomic type are listed in Table 15.

Although the newer CIMMYT germplasm carries excellent resistance to leaf blotch, there is much less material which is resistant to the glume blotch caused by *Septoria nodorum*. Brazil and Paraguay suffer from this disease regularly, and Chile suffered a serious epidemic in its central coast region during 1982. Therefore serious efforts to screen for glume blotch should be started soon.

Bacterial blight caused by *Pseudomonas syringe*, first observed at the INTA experiment station at Pergamino, Argentina, during 1982, was extremely severe in 1983. The symptoms are: plants with a dull, glassy look; brown necrosis on the glumes; and, in the case of severe infection, complete spike sterility leading to premature drying. Bacterial blight was especially severe on the late-planted international nurseries where considerable variation in resistance was observed. Entries from the 19th ISWYN having low levels of bacterial infection are listed in Table 16.

The incidence of barley yellow dwarf in Chile and other countries of the region was extremely low during 1983.

Agronomy

In 1983, field work was mostly concentrated in Argentina and Chile, but contact was maintained with the programs in Brazil, Paraguay and Uruguay. This was done by visiting the various countries at opportune times during the crop cycle, participating in field trips and discussing future research projects.

Argentina

Argentina's wheat-growing area is expanding into regions outside of the traditional Pampa Humeda area. One of these is the Chaco Salteño region in the province of Salta in northwest Argentina. This is an irrigated area with very high yield potential. Farmers are already harvesting 4000 kg/ha with very little technical input. In September 1983, program staff participated in a three-day trip through the region, accompanied by researchers from INTA. Discussions were held with farmers and farm advisors. Various suggestions were made about raising wheat productivity in the area and these are now being tested by several farmers.

Soil fertility—Increases in wheat yields in Argentina over the past decade have been mainly due to higher-yielding germplasm and its ever-increasing diffusion. Argentina has now roughly 95 percent of its wheat area sown to semidwarf varieties. However, it appeared that these wheats were not expressing their full potential under farm conditions because of low soil fertility.

As a result, four years ago INTA organized a large fertilizer research program in wheat. This was centered at the Pergamino and Marcos Juarez experiment stations, but the Balcarce experiment station also conducted a fertilizer research program in the southwestern part of the province of Buenos Aires. These programs have produced spectacular results and have shown that the use of fertilizer on wheat is economically feasible in the Pampa Humeda of Argentina.

The government is now embarking on an ambitious program to increase fertilizer use on wheat in 1984. Since Argentina produces very little nitrogen fertilizer, the government is facilitating its importation through economic incentives. Internal distribution will be in the hands of farming cooperatives. At the moment it is thought that about 100,000 tons of nutrients (mostly nitrogen) will be used on the 1984 crop. If a 10:1 response ratio is assumed, and this is quite feasible, then this fertilizer campaign could add an extra one million tons of wheat to national production.

Fertilizer recommendations will be an important part of this program. It is now widely accepted in Argentina that for wheat, soil analysis is an inadequate basis for recommending nitrogen. Instead, this recommendation should be based on a combination of agronomic data, such as the yield potential of the area, the number years of continuous cropping, the previous crop, the length of the fallow period and the amount of stored soil moisture. On the other hand, soil analysis is a useful tool in predicting phosphorus response. Soil phosphorus levels (determined by the Bray 1 method) have been divided into three classes with respect to crop response: more than 15 parts per million (ppm), adequate; 7-15 ppm, deficient; less than 7 ppm, very deficient. Recommendations made on this basis were tested in the field in 1983 and worked very well.

In 1983, INTA put out sixteen demonstration plots in the Pergamino area based on their fertilizer recommendations; the results are presented in Table 17. Plot size was either 6 or 10 meters by 100 meters. The recommendations were made on the basis of a nitrogen to wheat price ratio (Pn:Pw) of 9:1, since this was the price situation at sowing time.

The data (Table 17) are very useful in that all the parameters which influence crop response showed a wide range of variation, including soil phosphorus and nitrogen, years of continuous cropping, preceding crop, rainfall and variety. Even with a Pn:Pw of 9, a dry year and highly varied conditions, the recommendations worked extremely well. In all but two sites, a response efficiency of 9 or greater was obtained. In most cases, the safety margin was very large: the average response efficiency of 15.7:1 is much greater than the 10:1 ratio necessary to ensure the success of the program.

To give an idea of how wheat in the Pampa Humeda responds to fertilizer application over a wide range of levels, data from Pergamino are presented in Tables 18 and 19. Table 18 shows data from 1982-83, a wet year, and Table 19 shows data from 1983-84, a dry year. These are presented as response efficiency data (kilograms of grain produced per kilogram of nutrient applied) with various combinations of nitrogen and phosphorus fertilizer. When the two tables are compared, it is clear that fertilizer use efficiency, as expected, increases greatly in a wet year. However, they also show that even in a dry year (Table 19) there is a wide range of nutrient doses that can be applied without risk of losing money if the price relationship is right. The best combinations of nitrogen and phosphorus for a Pn:Pw of 9 are enclosed with a dotted line.

Another interesting observation is that the response to nitrogen decreases very rapidly in a dry year, whereas nitrogen applied alone in a wet year gives a good response. The opposite is true for phosphorus: in the dry year, phosphorus gave greater efficiency. While none of these responses may be economic, these data should be kept in mind when planning future work involving soil moisture and fertilizer, especially in drier areas. It is obvious that on these deep soils, phosphorus plays a key role in moisture use. This is probably achieved by phosphorus' promoting faster root growth, which results in deeper penetration into the reserve soil moisture and a greater root volume.

It is important to stress the effect of fertilizer use on the efficiency of water use. Water is very often a limiting factor in wheat production in Argentina, so its efficient use is extremely important. Average water use efficiency data (kilograms of grain produced per millimeter of water used) for seven sites for 1983 are presented in Table 20. These data show that water use efficiency (WUE) increases dramatically with fertilizer application. The WUE ranges from 4.69 for the check (0-0-0) to 8.79 for an application of 120-80-0. This alone is justification for a fertilizer program in Argentina, because under present conditions of low fertilizer use, water use efficiency in wheat production is very low.

Chile

Over the past five years, INIA, with the collaboration of CIMMYT's Southern Cone regional agronomy program, has been conducting a series of on-farm trials in various parts of Chile with the following objectives:

- Determine the factors limiting wheat yields under farm conditions;
- Improve existing recommendations;
- Orient research in areas where present knowledge is inadequate.

The results of these trials have been published in previous reports, but since the program is now in its fifth year, it is appropriate to summarize and evaluate these advances, to present problems that still exist, and to look at future directions.

Over the past twenty years, there has been a revolutionary increase in potential wheat yields around the world. This has been achieved by developing wheat varieties that have a higher harvest index (grain to straw ratio), are shorter and are more resistant to lodging. When these characteristics are combined with better production practices, large increases in yield per hectare result. Since 1965 wheat yields per hectare have increased at a rate of 2.6 percent per year worldwide. However, the rate of increase in Chile has been only 0.9 percent annually, despite the availability of improved germplasm.

Yields in farmers' fields are normally determined by the following three factors, of which the first two are within the technical purview of INIA:

- genetics (varieties used),
- environmental and management variables, and
- economics (input and output price relationships).

Since its inception INIA has had a large wheat breeding program which has produced spectacular results in terms of the number of varieties available and recommended for use. Parallel to this, the other disciplines have been working on recommenda-

Dr. M.A. McMahon (right) with a member of the national program at Quilamapu, Chile.

tions for herbicides, fertilizers, fungicides, management, etc. However, these recommendations are usually brought together from the various disciplines and presented to the farmer without prior testing of the whole package. This lack of verification is probably the weakest link in the chain that goes from research to on-farm application.

If the package were verified before being presented to the farmer, a number of problems could be avoided. For example, when two varieties that are very similar under experiment station conditions are released, testing in farmers' fields might well show that one produces significantly more than the other, or that one or both have defects that did not show up under station conditions. A well organized and supported production program would detect these differences and make more appropriate and effective recommendations.

A second weakness is that the production programs are not setting priorities on the recommendations. For example, nitrogen, phosphorus and herbicide may all be needed to reach maximum yields, but, not all farmers may be able to apply all the factors. Therefore, it is important to know which factor is the most limiting or what combination will give an economic return, but at a lower level of yield.

Both of these problems reflect inadequate emphasis on production research under actual farm conditions. Developing a production program that does work in farmers' fields should help to solve these problems, and, in addition, should be able to

- detect problems which could be the basis for future research projects,
- discover inefficiencies in farmers' practices, such as sowing or applying herbicides too late, and suggest how to eliminate them, and
- familiarize production personnel with all aspects of wheat production in their area.

Although this kind of research involves contact with farmers, it is not extension. It is verification—the point at which station-generated technology is tested against reality. It can then be modified as need be and, in the extension phase, presented to the farmer as technology appropriate to and useful under his conditions.

INIA and CIMMYT have been carrying out this type of program in the areas of influence of three experiment stations, La Platina, Quilamapu and Carillanca. There is one professional level person working on this project at each station. The objectives have been met in most areas; these accomplishments are summarized in the following for the La Platina and Quilamapu stations.

La Platina—The program has concentrated on the coastal wheat-growing area of the Fifth and Six Regions. Its accomplishments are as follows:

- Potential wheat production in the area was determined to be three times actual yields.
- Such yields were found to be attainable only with the use of better germplasm.
- A program to distribute improved seed to small farmers for testing under their own conditions resulted in the increased use of improved varieties and increased demand for new varieties.
- Priorities were set for the recommendations; nitrogen was shown to be the most important element in increasing wheat yields in the area.
- Potassium was shown to be a possible limiting factor in production in the area.
- A strategy is being developed to use no-tillage methods in the area.

Quilamapu—The area of influence of this station was divided into three zones, each with its own objectives. The accomplishments are as follows:

- **Secano Interior**
  - — Superior varieties were identified and seed was distributed to farmers.
  - — Small groups of farmers were organized to multiply the seed of these varieties, for which demand is high.
  - — Priorities were set for the recommendations and a new potential yield for wheat in the area was determined.
  - — Work is starting on an improved wheat-pasture rotation using naturalized *Medicago* species. The first year's results are very encouraging.
- **Chanco**
  - — Superior varieties, not even known in the region three years ago, have been identified and multiplied in cooperation with local authorities and farmers. Their use is now widespread.
  - — An innovation, sowing spring varieties in July, has been introduced so that ryegrass and wild oats can be controlled mechanically prior to sowing. About 100 ha were sown under this system this year.
  - — Work is starting on the use of naturalized species of *Medicago* in the wheat-pasture rotation.
  - — Priorities are being set up in the production package for the area; nitrogen has been recognized as the main limiting factor.

- **Precordillera**

  — The variety Andifen was successfully promoted.

  — Farmers were convinced of the importance of sowing earlier.

  — Lack of seed was the production bottleneck last year. Therefore, various farmers who had sown certified seed were contacted and asked to sell their harvest as seed. The results of this will hopefully be reflected in the 1984 production.

The future—There will be a big upsurge in wheat production in Chile in the next five years. Although production declined over the past seven years, INIA has maintained research programs in wheat and has made some notable advances. These advances have not been reflected in production because the farmers were applying very little technology. As a result, there is a need for a group of production agronomists to work at each station verifying recommendations and helping farmers put them into use. Ideally this would be a team of three agronomists per station, with appropriate transportion which would allow them to move around the area to work directly with farmers. The methodology used would be the same as that which has given such good results in the La Platina and Quilamapu regions.

Wheat production contest—To stimulate wheat production, the Ministry of Agriculture sponsored a national wheat production contest, organized by INIA with the assistance of CIMMYT, and under the auspices of the Interamerican Institute of Agricultural Sciences (IICA), COPAGRO, and 14 commercial firms. The 171 participating farmers were enrolled in the extension groups sponsored by INIA. Their results (Table 21) were judged on the basis of two criteria:

- the yield on a one-hectare plot with no limit on inputs, and
- the production of a commercial field of at least five hectares, taking into account both yield and costs.

First prize, won by Detlev Moeller of Los Angeles, was a trip to CIMMYT in Mexico. There were also many other prizes for various categories, the total value of which was $62,000 US.

The 171 participants obtained an average yield of 5328 kg/ha, compared with the 1983 national average of 2100 kg/ha. This is excellent testimony to the value of the research and technology transfer acccomplished in Chile in recent years.

Training, Seminars and Workshops

Seven wheat scientist from Southern Cone national programs visited CIMMYT headquarters in Mexico to participate in training courses, exchange programs or other activities. These visits serve to develop a common understanding of regional problems as they relate to production and germplasm development, as well as to renew or establish direct contact between the national programs and CIMMYT headquarters.

During 1983, with the help of EMBRAPA and in cooperation with the IICA-BID Southern Cone project, CIMMYT organized a workshop on leaf spotting diseases of wheat. Twenty participants from 14 institutions in Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay spent one week learning the theorical and practical aspects of working with leaf spotting diseases. Because of the time constraits, only diseases caused by four fungi, *Septoria tritici*, *S. nodorum*, *Helminthosporium sativum* and *H. tritici-repentis* were treated in detail. The objectives of the workshop, to teach the participants techniques for generating artificial epidemics and for uniformly evaluating the results, were met. To promote the use of these techniques, CIMMYT has subsequently supplied some basic equipment and materials to pathology laboratories in the region. Dr. A. L. Scharen, of the USDA and Montana State University, Bozeman, USA, participated actively in the organization of the course, as well as assisting in the purchase of laboratory materials and providing scientific information.

Later in the year, the CIMMYT regional staff assisted INTA and Oregon State University (OSU), USA, in the organization of a wheat seminar. The objective of the seminar was to analyse wheat germplasm development and commercial production problems in Argentina. The contribution of the OSU group was to supply information about new developments and production techniques.

Table 1. Wheat area and production in the Southern Cone region in 1982 and 1983.

Country	Area (1000 ha)		Yield (kg/ha)		Production (1000 tons)	
	1982	1983	1982	1983	1982	1983
Argentina	7320	6832	2067	1713	15130	11700
Brazil	2829	1922	654	1183	1849	2273
Chile	374	471	1630	2100	586	988
Paraguay	70	75	986	1426	69	107
Uruguay	234	300	1353	1500	316	450
Percent increase over 1961-65 period	55.7	38.3	21.2	43.5	85.6	60.5
Percent increase over 1974-75 period	14.6	1.7	11.1	31.6	42.5	23.2

Source: FAO Monthly Bulletin of Statistics, March, 1984, except for Chile and Paraguay, which are based on local data.

Table 2. Changes in wheat yields in the Southern Cone Region from 1961 to 1983.

Country	Yield (kg/ha)			
	1961-65	1969-71	1974-76	1981-83
Argentina	1534	1334 (-13.0)	1603 (+4.5)	1692 (+10.3)
Brazil	707	939 (+32.8)	879 (+24.3)	996 (+40.9)
Chile	1437	1759 (+22.4)	1437 (0)	1772 (+23.3)
Paraguay	814	800 (-1.8)	1033 (+26.9)	1171 (+43.9)
Uruguay	1027	1009 (-1.8)	1067 (+3.9)	1388 (+35.2)

Figures in parentheses indicate percent change over 1961-65.

Table 3. Performance of Veery 3 and Veery 5 selections in the Southern Cone region as compared with Anza and Pavon 76 as local checks.

Location	Yield (kg/ha)				Percent of Anza		Percent of Pavon 76	
	Anza	Pavon 76	Veery 3	Veery 5	Veery 3	Veery 5	Veery 3	Veery 5
Argentina								
La Dulce	2210	2361	2511	2424	114	110	106	103
CV = 8.0								
Pergamino	2833	3888	5555	3977	196	140	143	102
CV = 17.1								
M. Juárez	2278	2822	3189	3611	140	159	113	128
CV = 14.8								
Brazil								
Londrina	717	1500	2283	2317	318	323	152	154
CV = 13.6								
Cruz Alta	130	344	911	607	701	467	265	176
CV = 32.2								
Campinas	983	1283	1067	1543	109	157	83	120
CV = 15.4								
Chile								
Carillanca	3933	4822	4444	4883	113	124	92	101
CV = 10.9								
Quilamapu	6021	5799	7077	7514	118	125	122	130
CV = 10.0								
La Platina	4944	5791	6437	6409	130	130	111	111
Paraguay								
Caacupe	579	1371	1315	1483	227	256	96	108
CV = 23.1								
Average*	2722	3293	3764	3796	138	139	114	115

* Locations with CV over 25 not included in the average.
Data from the 18th International Spring Wheat Yield Nursery (ISWYN).

Table 4. Outstanding bread wheat selections from Argentina in 1983.

Line, cross and pedigree	Yield as percent of Marcos Juarez INTA	Chaqueño INTA	Victoria INTA
KVZ-BON {[(21931-CH53 x AN/GB56)PJ62] SOTY} YR RESEL(B) CM 33729-A-1M-2Y-1M-3Y-0M (= LAJ 2514)	130	111	
KTZ M12-PATO(B)/B.MAN-7C x CDL CM 24166-L-7M-1Y-3Y-0YA-0P-1BV (= V 00001)	151	128	
KVZ [CAL-CNO x SON64(CNO x NAD-CHRIS"S") SON-REN x BB] SWM 2888-0Y-2BV-1BV-1BV-1BV(= V 00014)	150	127	
KVZ x CNO - PJ62 SWM 1285-2Y-3M-1Y-0M-1J-0J(= LAJ 2484)	149	126	
BB-KAL x ALD"S"/Y 50_e-KAL^3 x EMU"S" CM 38795-H-12Y-9Y-1M-0M-1J-0J(= LAJ 2528)	134	118	
JUP-ALD"S" CM 36867-18Y-17M-3Y-0M-1J-0J(= LAJ 2519)	131		126
(TH^6-KF x LEE^6-KF/CAL)ALD"S" SWM 3410-8Y-4M-1Y-2M-1Y-0M-1P-0P (= LAP 1144)	121		116
BOBWHITE"S" CM 33203-K-9M-33Y-1M-500Y-0M-1J-0J (= LAJ 2532)	131		127
ALD"S"/CAL x BB-CNO CM 32595-4Y-1M-1Y-2M-1Y-0M-1P-0P (= LAP 1146)	112		108
CNO"S"-GII x BON CM 25732-81Y-0Y-0P-1P-3T-1T(= PAR 80/5134)	113		109

Source: National Institute of Agricultural Technology, (INTA), 1983.

Table 5. Performance of new wheat germplasm in the acid soils of the southern Parana region, Brazil.

Variety, line or cross	Yield (kg/ha) 1981	1982	1983	Average yield as percent of Maringa
PF 6968^2-HADDEN (= CEP 7778)	2140	1680	2480	141
PAT 19-ALD x GTO-LV (= CEP 7951)	2740	1730	1600	113
MARINGA-ALDAN (= OC 8123)	2040	1790	1480	114
MARINGA-ALDAN (= OC 8125)	2170	1420	1420	108
MARINGA-ALDAN (= OC 8145)		1560	1580	107
PF 70124-CNT10 (= PF 7815)	2270	1400	1690	118
THORNBIRD"S" (= PF 79765)		2620	1680	115
THORNBIRD"S" (= PF 79780)		2740	1610	113
THORNBIRD"S" (= PF 79782)		2820	1680	118
PF72640-PF732 x PF7065-ALD"S" (= PF79791)		2850	1700	119
SULINO	2270	1860	1850	126

Source: Agronomy Institute of Parana (IAPAR), Brazil, 1983.

Table 6. Outstanding bread wheat selections from Chile in 1983.

Line and pedigree	Yield as percent of		
	Millaleu	Aurifen	Onda
CIANO 79	106	114	
HD 2162	105	113	
7C-PVN CM 36569-8Y-1M-1Y-2M-5Y-0M	105	113	
VEERY"S" CM 33027-F-12M-1Y-1M-1Y-1M-0Y	105	113	
HORK"S"	106	114	
BOBWHITE"S"-Q 10.097 CM 33203-H-11M-5Y-0M	164		107
BUCKBUCK"S"-Q10.102 CM 31678-R-4Y-2M-24Y-1M-0Y	102		105
VEERY 5 "S" (=SERI 82) CM 33027-F-15M-500Y-0M-87B-0Y	108		111
VEERY"S" CM 33027-F-5M-500Y-0M-107B-0Y	112		115
VEERY"S" CM 33027-F-15M-500Y-0M-126B-0Y	104		107

Source: National Institute of Agricultural Research (INIA), 1983.

Table 7. Outstanding, high-yielding bread wheat lines from Paraguay in 1983

Line or cross and pedigree	Yield as percent of Cordillera 3	Yield as percent of Itapua 25
LIRA"S" CM 43903-H-2Y-1M-3Y-2M-2Y-0B	105	135
VEERY"S" CM 33027-F-12M-1Y-1M-1Y-2M-2Y-0M	113	145
VEERY"S" CM 33027-F-12M-1Y-2M-1Y-1M-0Y	109	140
VEERY"S" CM 33027-F-12M-1Y-3M-0Y	107	137
LIRA"S" CM 43903-H-2Y-1M-6Y-2M-1Y-0B	106	136
KI LUC^4-Y53 x IFLE 9996 C 5849	106	137
JUP"S"-EMU"S" CM 36869-1Y-5M-1Y-0M	102	132

Source: Ministry of Agriculture, Paraguay, 1983.

Table 8. Outstanding entries from the 16th International Bread Wheat Screening Nursery (IBWSN) selected at several locations in the Southern Cone region.

Line or cross and pedigree
GENARO 81
F3.71-TRM SWM 5704-10Y-1M-13Y-3M-2Y-2M-0Y
F3.71-TRM SWM 5704-10Y-1M-3Y-3M-2Y-3M-0Y
PVN"S" (PATO(R)-CAL/7 x BB-CNO 67) CM 32535-4M-1Y-1M-1Y-1M-0Y
VEE"S" CM 33027-F-15M-500Y-0M-76B-0Y
BOW"S" CM 33203-H-4M-1Y-0M-81B-0Y
BOW"S" CM 33203-K-9M-24Y-1M-1Y-1M-1Y-0M
[JUP(7C-PATO(B)/LR64-INIA66 x INIA66-BB)] ANA CM 37760-C-21Y-2M-1Y-3M-0Y
BJY"S"-JUP CM 40038-6M-4Y-2M-1Y-2M-1Y-0B
BJY"S"-JUP CM 40038-21M-1Y-2M-0Y-88M-0Y
SAP"S"-MON"S" CM 40392-17M-1Y-0M-175M-0Y
CROW"S" CM 40457-5M-3Y-1M-2Y-0M-154M-0Y
BON-YR/F35.70 x KAL-BB CM 41860-A-5M-2Y-3M-1Y-1M-1Y-0B
LIRA"S" CM 43903-H-2Y-1M-5Y-1M-1Y-1M-0Y
YR-PAM"S" CM 46091-16M-1Y-6M-2Y-1Y-2M-0Y
BLO"S" [HORK"S"(TP x CNO67-NO/BB-CNO67)] CM46919-7Y-1M-1Y-1Y-1M-0Y
BUC"S"-BJY"S" CM 49641-6M-1Y-3Y-2M-1Y-0M
BUC"S"-BJY"S" CM 49621-7Y-1M-2Y-3Y-0M
ALD"S"-PVN"S" CM49901-9Y-1Y-1M-3Y-0M
YD"S"-MN72131 CM 50310-1M-1Y-1Y-1M-1Y-0M
BUC"S"-EMU"S" CM 52324-22M-1Y-2Y-2M-2Y-0M
BUC"S"-PVN"S" CM 52359-2M-3Y-1Y-4M-0Y
BUC"S"-CHRC"S" CM 52421-26Y-1Y-1M-4Y-0M
(CGT-AZ x IAS55-ALD"S"/ALD"S"-NAFN) PJN"S"-PEL SP127 6.67 CM 58478-B-2Y-1Y-2M-1Y-0M
LOV23-BJY"S"/BB-NOR x CNO67"S"-7C CM 60338-H-1Y-1M-2Y-0M

Table 9. Yields of the five best durum wheat lines grown at the SNA Experiment Station near Santiago, Chile, in 1983.

Line and pedigree	Yield (kg/ha)
YAV"S"--SNIPE"S" x COLI"S" CD 43740-B-3Y-1M-2Y-0M	8440
SHWA"S"-REN"S" x YAV"S" CD 40159-7B-1Y-1M-0M	8040
SHWA"S"-YAV"S" CD 26406-3B-2Y-7B-0M-24Y-0B	7330
ROK"S" CD 1895-12Y-0Y-2E-3B-0Y	7160
ROK"S"-GUIL"S" CD 42494-5Y-2M-1Y-0M	7120
SNA 3 (check)	6910
QUILAFEN (check)	6340

Table 10. Durum wheat lines selected in both Argentina and Chile for high yield and stem rust resistance in 1983.

Line and pedigree
TROB"S" CM 9927-1S-2S-0Y
(QFN-GII"S" x GTA"S"/IBIS"S")BOY"S" CD 23128-5Y-5M-1Y-2Y-1M-0Y
(SOI179-PH158 x GTA"S"-SO195/JNK)YAV"S" CD 25126-A-1Y-3M-1Y-1Y-0M
SHWA"S"-YAV"S" (= CHEN"S") CD 26406-3B-2Y-9Y-0M-1Y-0B
SHWA"S"-YAV"S" (= CHEN"S") CD 26406-3B-2Y-9Y-0M-11Y-0B
SHWA"S"-FG"S" x ROK"S"-MEMO"S" CD32054-A-1Y-3Y-1M-0Y
YAV"S"-SNIPE"S"/MEXI"S"-P66.270 x GTA"S" CD 33863-1B-3Y-2M-0Y
SNIPE"S"-MAGH"S" ICD 74122-2L-1AP-0AP-1KE-0Y

Table 11. New triticale lines resistant to helminthosporium spot blotch, head scab and preharvest sprouting in Brazil in 1983.

Line	Cross and pedigree
TCEP 796	IA-M_1A X15633-21Y-1Y-1M-0Y-0A
TCEP 7889	TEDDY"S" X19649-A-9Y-1Y-1M-1Y-100B-0Y-0A
TCEP 8128	PANDA"S"-RM"S"
TCEP 8034	TEDDY"S" X19649-A-9Y-1Y-1M-1Y-101B-0Y-0A
PFT 7882	TEJON"S"-BGL"S" X16134-3Y-1Y-1M-1Y-1B-0B
PFT 7893	FS 3972 X48M-0N-Y
PFT 8117	
PFT 80110	M_2A-BGL X15490
PFT 8036	DELFIN 80
PFT 811	YE-M_1A X29306-3F-9F-4FS-1FS-0Y

Table 11. (Cont'd)

Line	Cross and pedigree	Line	Cross and pedigree
TOC 807	M_2A-BGL	ITOC 811	BGL"S"-M_2A X18701-6Y-3M-2Y-1M-0Y
TOC 813	M_2A-CML x RM X36517-864H-0Y-6T-0T	ITOC 814	CHT"S" X22473-102Y-100Y-6Y-0Y
TOC 815	TEJON-BGL"S" X16134-503PR-0T		

Table 12. Wheat varieties released in the Southern Cone Region in 1983.

Country	Name	Cross or line and pedigree	Institution
Argentina	LAS ROSAS INTA*	KIATL x INIA-BB(NP876-PJ62 x CAL/BB) CM 16716-Q-3M-2Y-2J-2J-0J	INTA
	TUC NORTEÑO*	CAL-BB {[(KAL x PET-RAF/PJ62)CNO] NP876-BB}	INTA
	B. PATACON	CAEREN 2.4.2 x RAP-BAPET 107.8	Buck Seeds
	NORKIN T 82*	PV18A-CNO"S" x MJ I	Northrup King Seeds
	COOPERACION BAHIA	(K.ANIV-ST x ROCA-K-ANIV)16/60B.MAN/ A85.69 x B NAM	ACA
Brazil	OCEPAR 6 = FLAMINGO	CJ-COTIPORA x PAT 7284 B 14263-05-0T-0L-28T-0L	OCEPAR
	CEP 7672	PLATIFEN-CNO"S" x GIRUA-PURPLE STRAW	FECOTRIGO
	CEP 7780	PF 6968^2-HADDEN	FECOTRIGO
	BR 8 (PF 75171)	IAS20-TP x PF 70100	EMBRAPA
	BR9 = CERRADO	BH 1146-IRN 595/71	EMBRAPA
	BR10 = FORMOSA*	ALONDRA"S"	EMBRAPA
	R BUTUI (SB 75129)*	BB-PATO x SON64-KL. REND	IPAGRO
Chile	SNA 12 = GRANEROS*	FLICKER"S" CM 8954-B-7M-1Y-1M-1Y-0M	SNA
	SNA 24 = PORVENIR*	EMU"S" CM 8327-C-9M-1Y-0M	SNA
	A.S. BAER (BT58-77)	H46-My64/MG-MIR808 x R-P	CAMPEX BAER
	PENECA BAER (BT62082)	H46-My64(PCH x MY-LEE/KTOL)77113-B-GOR-J672-E58	CAMPEX BAER

* Varieties of CIMMYT origin.

Table 13. Bread wheat lines resistant to *Helminthosporium sativum* in the Southern Cone region in 1983.

Line and pedigree	Line and pedigree
F3.71-TRM SWM 5704-10Y-1M-3Y-3M-2Y-2M-0Y	ANAHUAC"S"(65.116 x MCD-CAMA/NAC) CM 57206-2-1Y-1Y-1M-3Y-0M
F3.71-TRM SWM 5704-10Y-1M-3Y-3M-2Y-3M-0Y	CRT-ALD"S" II 14055-0M-19LD-25LD-1LD-0Y
[JUP(7C-PATO(B)/LR64-INIA66 x INIA66-BB)] ANA CM37760-C-21Y-2M-1Y-3M-0Y	F3.71-TRM SWM 5704-10Y-1M-3Y-3M-3Y-0B-1PTZ-0Y
BJY"S"-JUP CM 40038-6M-4Y-2M-1Y-2M-1Y-0B	KVZ x BB-CHA/TRM CM 30832-Z-3Y-1M-4Y-1M-0Y-1PTZ-0Y
BJY"S"-JUP CM 40038-21M-1Y-2M-0Y-81M-0Y	CMT-MO x TRM CM 43381-D-1Y-4M-3Y-3Y-4M-0B-13M-0Y
BJY"S"-JUP CM 40038-21M-1Y-2M-0Y-88M-0Y	LIRA"S" CM 43903-H-4Y-1M-2Y-1M-1Y-0B
SAP"S"-MON"S" CM 40392-17M-1Y-0M-101M-0Y	CAR 853-COC x VEE"S" CM 47556-Q-1M-2Y-6M-0Y-2PTZ-0Y
SAP"S"-MON"S" CM 40392-17M-1Y-0M-191M-0Y	ORE F1 158-FDL x KAL-BB/NAC CM 47634-I-2M-3Y-1M-2Y-1Y-1M-0Y
CROW"S" CM 40457-5M-3Y-1M-2Y-0M-154M-0Y	ORE F1 158-FDL x KAL-BB/NAC CM 47634-I-2M-3Y-1M-2Y-1Y-2M-0Y

Data from the 16th International Bread Wheat Screening Nursery (IBWSN) and the Helminthosporium Screening Nursery.

Table 14. Bread wheat lines resistant to scab in Brazil and Uruguay in 1983.

Line and pedigree	Line and pedigree
NAD x BB-INIA CM 7161-9M-1Y-8M-2Y-0Y	K6582-TOB K 6648
IAS 20-TP x PF 70100 PF 75171	COW"S"/NAD x BB-INIA A 1909-1P-2P-0Y
F3.71-TRM SWM 5740-10Y-1M-3Y-3M-3Y-0B-1PTZ-0Y	KI.ATL-SOREN H 1772-5P-2P-2P-1B-1P-0P-0Y-1B-0Y
PF 7673 0PTZ	

Table 15. Bread wheat lines with low septoria scores and good agronomic type from the 13th International Septoria Observation Nursery (ISEPTON) at La Estanzuela, Uruguay, in 1982.

Line and pedigree	Line and pedigree
SUNBIRD"S" CM 34630-D-5M-2Y-1M-1Y-0M-0PTZ	IAS 20^2-H567.71 CMH 77.205-1Y-1B-7Y-1B-1Y-1B-0Y-0PTZ
SUNBIRD"S" CM 34630-D-5M-2Y-1M-1Y-0M-2KE-0Y-0PTZ	P.ARTH^2-H567.71 CMH 78.421-3Y-3B-1Y-1B-0Y-1PTZ
VEERY"S" CM 33027-F-1M-9Y-0M-97Y-0B-0PTZ	CEP 7841
GOV-AZ67 x MUS"S" CM 41257-I-8M-1Y-1M-2Y-2M-0Y-0PTZ-1PTZ-0Y-0PTZ	BOBWHITE"S" CM 33203-K-9M-9Y-4M-4Y-0M-0PTZ
GOV-AZ67 x MUS"S" CM 41257-I-8M-1Y-1M-2Y-2M-0Y-0PTZ-2PTZ-0Y-0PTZ	CONDOR"S"-MUSALA"S" CM 39458-6M-2Y-2M-0Y
IAS 20-H567.71 CMH 76.480-13Y-5B-1Y-1B-1Y-1B-0Y-3PTZ-0Y	TOROPI

Table 16. Lines from the 19th International Spring Wheat Yield Nursery (ISWYN) with resistance to *Pseudomonas syringe* in 1983.

Line or variety and pedigree	Line or variety and pedigree
LIRA"S" CM 43903-H-4Y-1M-1Y-3M-3Y-0B	MARCOS JUAREZ INTA
	IA 7873 = MAYA 74"S"
VEERY"S" CM 33027-12M-1Y-1M-1Y-1M-0Y	QT 4083
DGA-BJY"S" CM 40610-25Y-4M-1Y-1M-1Y-0B	TUNGURAHUA E II-685512-7E-0E-6E
BJY-JUP"S" CM 40038-6M-4Y-2M-1Y-2M-1Y-0B	KVZ-CUT 75
	MN 73168
PARANA 2 2.71-74T-1T-1T-2T-0Y	MN 7357

Table 17. Results of demonstrations based on fertilizer recommendation at INTA, Pergamino, Argentina in 1983.

Site	Soil P level (ppm)	Soil N level (ppm)	Optimum economic dose(kg/ha) N	P_2O_5	Years of continuous cropping**	Preceding crop	Rainfall (mm)	Variety	Check yield (kg/ha)	OED* yield (kg/ha)	Difference in yields (OED* - check)	Response efficiency (kg grain/ kg nutrient)
Bragado (La Paz)	30.5	22	32	0	2	Wheat	270	–	1850	2600	750	23.4
Bragado (Don Adolfo)	11.3	22	38	16	6	Sunflower	270	–	1790	2750	960	17.8
Bragado (Macias)	5.1	22	48	40	10 +	Wheat	270	–	1080	2540	1460	16.6
9 de Julio (Obligado)	10.2	22	35	18	–	Triticale	141	Leones	1470	2400	930	17.5
9 de Julio (Del Fabro)	8.0	24	44	23	10 +	Sunflower	244	Victoria	2340	4190	1850	27.6
9 de Julio (Del Fabro)	8.0	24	44	23	10 +	Sunflower	244	Leones	3640	3830	190	2.8
9 de Julio (La Norumbega)	15.7	20	23	0	6	Soybeans	244	Leones	3430	4150	720	31.3
Venado Tuerto (La Chispita)	13.5	33	40	0	10 +	Soybeans	258	–	2250	2800	550	13.8
Chivilcoy	5.5	22	11	30	–	Soybeans	–	–	2050	2700	650	15.9
9 de Julio (Castro)	7.1	24	40	30	6	Maize	244	Leones	2980	3910	930	13.3
9 de Julio (Carrilla)	10.5	24	23	18	5	Wheat	244	Leones	2660	2840	180	4.4
Bragado (Quarteri)	7.7	24	48	28	9	Maize	270	–	1860	3030	1170	15.4
Pergamino (Guernico)	12.0	33	30	0	10 +	Soybeans	324	Victoria	1010	1280	270	9.0
Pergamino (Basualdo)	19.0	28	25	0	15	Soybeans	324	Victoria	1800	2530	730	29.2
Pergamino (M. Ocampo)	9.6	25	30	20	12	Soybeans	324	–	1330	1780	450	9.0
Chacabuco (Zubiri)	8.0	60	18	46	–	Soybeans	388	Victoria	2150	3220	1070	16.7
								Mean	2110	2990	880	15.7

* O.E.D. = optimum economic close
** 10 += more than 10
– = unknown
N = nitrogen
P = phosphorus

Table 18. Average fertilizer response efficiency (kg grain/kg nutrient) at 18 sites for various combinations of nitrogen and phosphorus in a wet season (1982-83), at Pergamino, Argentina.

Nitrogen (kg/ha)	Phosphorus (kg/ha) 0	20	40	60	80
0	–		3.08		1.30
30		20.08		14.58	
60	14.78		14.54		11.20
90		14.29		12.00	
120	9.84		10.94		9.13

Dotted line encloses economically efficient combinations at a nitrogen: wheat price ratio of 9.

Table 19. Average fertilizer response efficiency (kg grain/kg nutrient) at seven sites for various combinations of nitrogen and phosphorus, in a dry season (1983-84), at Pergamino, Argentina.

Nitrogen (kg/ha)	Phosphorus (kg/ha) 0	20	40	60	80
0	–		6.45		2.83
30		13.28		12.42	
60	8.54		10.94		9.96
90		10.54		10.84	
120	6.48		9.28		9.54

Dotted line encloses economically efficient combinations at a nitrogen: wheat price ratio of 9.

Table 20. Water use efficiency (kg grain/mm of water use) at seven sites for various combinations of nitrogen and phosphorus at INTA, Pergamino, Argentina, in 1983-84.

Nitrogen (kg/ha)	Phosphorus (kg/ha) 0	20	40	60	80
0	4.69		5.28		5.19
30		6.13		7.13	
60	5.70		7.06		7.70
90		7.17		8.21	
120	6.36		7.86		8.79

Table 21. Highest yields (kg/ha) in the 1983 Chilean wheat production contest.

	Irrigated		Rainfed	
Region	One-hectare plot	Commercial field	One-hectare plot	Commercial field
I	8740	8710	8350	8090
II	9600	8330	7810	7110
III	8480	8000	8250	7670

Source: National Institute of Agricultural Research (INIA), 1983.

Peru

G. Vásquez G.

For the 20-year period 1961-81, annual wheat production in the Andean countries, Columbia, Ecuador, Peru and Bolivia, averaged 319,000 metric tons, but in 1981 it barely reached 270,000 tons. Peru was the most productive with 117,000 tons, but wheat production in Peru has been falling off; the 1983 estimate came to only 100,000 tons. Similar, but a little less drastic, has been the decrease in barley production, which in 1970 was 170,000 tons and in 1980 had fallen to 130,000 tons.

In response to this situation, the Peruvian government set up the National Cereals Program (PNC) within the National Institute of Agricultural Research and Extension (INIPA) in 1983, with the purpose of conducting research, extension and training in the small grains which are, in order of national importance, wheat, barley, oats, triticale and rye. The main objectives of this program are:

- To improve agricultural practices;
- To develop widely adapted, improved varieties for the three, small grain growing zones, the coast, the mountains and the cold high plateau;
- To develop and promote appropriate technological changes;
- To prepare technical personnel at different levels to ensure the organizational continuity of the PNC;
- To increase the production of cereals, especially wheat, which is a basic grain in the Peruvian diet.

CIMMYT was invited to participate in this program by the Peruvian government. Its response was to ask Dr. G. Vásquez, an experienced small-grains breeder on the CIMMYT wheat program staff, to accept assignment to Peru, where he will assist the PNC reach its objectives by:

- Helping to identify agronomic practices which are limiting production and suggesting ways to improve them;
- Facilitating the exchange of germplasm and information between the PNC and CIMMYT, assisting in the evaluation of that material and helping Peruvian scientists select and develop material that will be useful in the program;
- Identifying young scientists who would profit from in-service training at CIMMYT, Mexico, helping to arrange for older researchers to go to CIMMYT as visiting scientists, and participating in in-country training efforts;
- Acting as a liason between CIMMYT and the PNC so that CIMMYT can provide a maximum of support and resources.

CIMMYT's participation in this program began in August, 1983. A full report covering the first 18 months will be published in the *1984 CIMMYT Report on Wheat Improvement*.

Rugged terrain is an important agricultural problem in Peru, solved here by terracing.

Dr. G. Vázquez, CIMMYT scientist with the bilateral program in Peru.

North and West Africa and the Iberian Peninsula Region

S. Fuentes F. and G. Varughese

Introduction

It has been three years since the North and West Africa and Iberian Peninsula regional wheat program came into existence. The program operates with two staff members, a breeder and a plant pathologist. One of the basic functions of this regional program is to act as liaison between the CIMMYT headquarters in Mexico and various national programs. This is achieved by periodic working visits to various national programs. During 1983, 346 days were spent visiting various programs in this region and headquarters.

The 1982-83 season was one of the most abnormal years on record for the North African and Iberian regions. In Portugal, southern Spain, Morocco and western Algeria, the crop cycle started under good conditions, but a severe three-month drought, beginning around the middle of December, resulted in the total loss of a good percentage of the crop. Tunisia and eastern Algeria had excessive rainfall during November and December. Many fields were unworkable until the end of January due to the water-logged soil. Hence, the crop in general was very late. This combination of factors resulted in an extremely poor harvest for the region.

Traveling Workshop and Training

The promotion of regional collaboration to achieve a better understanding of the common problems wheat and barley breeders face is one of the primary objectives of a regional program. Keeping this in mind, breeders from Tunisia, Algeria, Morocco, Spain and Portugal were invited to visit the Alentejo region in Portugal and the Extremadura and Andalucia regions in Spain during the week of 1-7 May 1983. Seventeen participants, plus the two CIMMYT resident staff and Mr. Walter Nelson of CIMMYT, participated in the workshop. The group visited Portugal's national plant breeding station at Elvas and the experiment stations of the Spanish National Institute of Agricultural Research (INIA) in Badajoz, Seville and Cordoba. The program was informal and most of the time the group was in the field. There were many open discussions among the participants. We hope to continue this kind of exchange visit on an annual basis, but rotating it among the different countries of the region.

Training is one of the key functions of CIMMYT. In 1983, the program identified four young people to take part in CIMMYT training courses. In addition, five scientists from the region went to CIMMYT as visiting scientists.

Germplasm Evaluation

Evaluation of CIMMYT germplasm for its adaptation to the region, identifying lines and varieties having adequate resistances and tolerances to the prevailing regional diseases and stresses, and transmitting this information to the breeders at the CIMMYT headquarters and to the various collaborators in the region are other important funcions of regional programs. In 1983, the North and West Africa and Iberian Peninsula Regional Program evaluated three screening nurseries and an observation nursery.

The most promising lines in the 16th International Bread Wheat Screening Nursery (IBWSN), the 14th International Durum Screening Nursery (IDSN) and the 14th International Triticale Screening Nursery (ITSN) are listed in Tables 1, 2 and 3 respectively. Among the bread wheats, the most promising crosses for the region were Veery, Neelkant, Hahn and Bobwhite. The combinations Dougga-Bluejay, Maya-Moncho, Alondra, Nacozari and Pavon also looked good. The three best durum crosses were Carcomun"S" (CD24831), Chen"S" (CD26406) and PIN"S"-MEMO"S" (S15-CR"S"/CIT"S"-AA"S"xFG"S") (CD27133). In case of triticale the Maya II-Armadillo cross and Juanillo continued to show promise for the region. In addition, the crosses Chiva and Pika and combinations with Merino also looked good.

Dr. G. Varughese, CIMMYT wheat scientist in the North and West Africa and Iberian Peninsula region.

Disease Resistance

The severe drought in the area did not allow the development of epidemics of any disease. Some powdery mildew on the lower leaves of commercial barleys in Portugal had no effect on yield. The widespread scorching, death of foliage and poor plant development was attributed to water stress.

At Elvas, Portugal, all screening nurseries were planted in mid-November at Casas Velhas, about 15 kilometers from the national plant breeding station, in an area with an abundance of dew and overhead irrigation facilities. As a result of weekly inoculations, starting at the late tillering stage, with spores of the three rusts and *Septoria tritici*, stripe rust developed strongly on the foliage and spikes during April and May, and stem rust and septoria leaf blotch were adequate toward crop maturity, the former especially affecting the durum wheats. Almost no leaf rust was recorded.

Tables 4 and 5 list the genotypes of bread and durum wheats, respectively, from CIMMYT's screening nurseries that were resistant to stripe rust and showed some resistance to stem rust and *Septoria tritici*. These data were recorded in the nurseries at Casas Velhas, Portugal, and Rinconada, Seville, Spain.

Information on the virulence patterns for the three rusts (Table 6) and *Septoria tritici* was obtained from the field reactions of the isogenic lines and test genotypes included in the 1982-83 Regional Disease Trap Nursery. In the case of *S. tritici*, the following materials were highly resistant (a score of 4.0 or less) at Elvas, Portugal: PF7748, IASSUL 20, Nova Prata (Brazilian), Buck Naposta (Argentinian), Wared (USA) and Trifon"S" (entry 44 of CIMMYT's 11th International Septoria Observation Nursery).

In addition to the winter planting, a summer nursery was attempted at Zafarraya, Malaga, Spain. The site is close to the Mediterranean on a plateau at 700 meters elevation and has frequent fogs, dew and irrigation from underground sources. The best selections from the Portuguese wheat programs and the differential rust nurseries were planted here. Toward the end of autumn, stem rust and leaf rust from natural sources developed intensively, with susceptible lines having scores of up to 90S. The effective genes and selected lines resistant to the rust at Elvas and Zafarraya are listed in Table 6.

Symptoms of barley yellow dwarf (BYD) were noticed in commercial crops and experimental nurseries at several locations throughout the region; this disease is often confused with drought effects. In general, the incidence of the disease was insufficient to allow good screening, but an exception was the epidemic observed in the nurseries at Lerida, Spain. The aphid vector *Rhopalosiphum padi*, abundant in the fruit orchards of the region, contributed to the heavy incidence of the disease. About 90 percent of the entries in the 16th IBWSN and 10th International Barley Observation Nursery (IBON) were susceptible, with scores of 4-9; only 10 percent had scores of 1-3. The most resistant materials are listed in Table 7.

Variety Releases

The nine new varieties approved for release during the 1982-83 crop cycle in Spain and Portugal are listed in Table 8. In addition, three bread wheats, Almansor (= E4870-C306 x M5392-666.5/BBxCC-INIA [CM22099]), a selection from a CIMMYT F_2, Voga (= NAPO-CDL x ZBZ [CM8935-D-5M-3Y-3M-2Y-0M]), and Lima I (= Veery 3) are in the final year of variety register trials in Portugal. Two durum wheats, Helvio (= Bittern"S" [CM9799-126M-1M-5Y-0Y]) and Celta (= Frigate"S" [CM17904-B-3M]) are also in the final year of variety register trials in Portugal. The bread wheat crosses Neelkant"S" and Bobwhite"S" are likely to be released in Spain during the coming year.

In Spain and Portugal triticale is an accepted crop. A Maya II-Arm"S" was released this year for cultivation in Portugal under the name Monsanto. In addition, two lines, Avis (= INIA-ARM"S" [X1648-9M-0M]) and Borba 1 (= BGL"S" x M2A-CIN [X15673-A-1Y-2Y-1M-0Y]) are in the final year of variety register trials in Portugal. Borba 1 is a Beagle type with an excellent yield potential and a good test weight. Tunisia this year planted about 2000 hectares of triticale, the variety being a selection of Maya II-Arm"S". Selections of the cross Juanillo looked extremely promising in Tunisia and are in the final phase of evaluation before release.

Table 1. Most promising bread wheat lines in the 16th International Bread Wheat Screening Nursery (IBWSN) in the North and West African and Iberian Peninsula region in 1982-83.

Entry number	Line and pedigree	Entry number	Line and pedigree
33	VEERY"S" CM33027-F-15M-4Y-4M-3Y-2M-1Y-0M	168	ALD"S"-PVN"S" CM49901-14Y-2Y-1M-1Y-0M
41	VEERY"S" CM33027-F-15M-500Y-0M-115B-0Y	171	4777^2 x FKN - GB/PVN"S" CM49912-37M-1Y-1Y-1M-2Y-0M
75	NEELKANT"S" CM40454-33Y-4M-4Y-1M-2Y-1M-0Y	172	4777^2 x FKN - GB/PVN"S" CM49912-37M-1Y-1Y-2M-1Y-0M
118	MAYA-MON"S" x KVZ-TRM CM44083-N-3Y-1M-1Y-1M-1Y-0B	196	BUC"S"-CHRC"S" CM52421-6M-3Y-2Y-3M-0Y
122	MUS"S"-PTM x MAYA-ALD"S" CM44740-A-3Y-1M-1Y-2M-1Y-2M-0Y	203	ALD"S" (BB-G11 x CNO67-7C/KVZ-TI) CM53450-3Y-2Y-2M-2Y-0M

Table 2. Most promising durum wheat lines in the 14th International Durum Wheat Screening Nursery (IDSN) in the North and West African and Iberian Peninsula region in 1982-83.

Entry number	Line and pedigree	Entry number	Line and pedigree
24	ATO"S" x AA"S"-PLC"S" CD1859-1Y-500B-0SK	144	SHWA"S"-YAV"S"(= CHEN"S") CD26406-3B-2Y-7Y-0M-24Y-0B
53	PLC"S" x SAH-PG"S"/MEXI75 CD16895-A-3M-2Y-3M-0Y	162	[SCA"S"(ZB-MOHM'RARI x S15-CR"S"/ MEXI"S"] FRIG"S" CD27276-A-2M-3Y-1Y-1M-0Y
84	SHWA"S"-MEXI75 x YAV"S" (= CARCOMUN"S") CD24831-A-1Y-3M-1Y-1Y-0M	163	PIN"S"-MEMO"S"(S15-CR"S"/CIT"S"-AA"S" x FG"S") CD27313-F-1M-1Y-1Y-0M-1Y-0B
85	SHWA"S"-MEXI75 x YAV"S"(= CARCOMUN"S") CD24831-A-1Y-3M-1Y-3Y-0M	164	PIN"S"-MEMO"S"(S15-CR"S"/CIT"S"-AA"S" x FG"S") CD27313-F-1M-1Y-1Y-0M-2Y-0B
94	QFN-AA"S" x GTA"S"-PG"S"/BOY"S" CD25241-A-2Y-3M-1Y-1Y-0M	165	PIN"S"-MEMO"S"(S15-CR"S"/CIT"S"-AA"S" x FG"S") CD27313-F-1M-1Y-1Y-0M-12Y-0B
135	SHWA"S"-YAV"S" (= CHEN"S") CD26406-3B-2Y-7Y-0M-8Y-0B	168	PIN"S"-MEMO"S"(S15-CR"S"/CIT"S"-AA"S" x FG"S") CD27313-F-1M-1Y-1Y-0M-21Y-0B
142	SHWA"S"-YAV"S" (= CHEN"S") CD26406-3B-2Y-7Y-0M-20Y-0B		
143	SHWA"S"-YAV"S"(= CHEN"S") CD26406-3B-2Y-7Y-0M-21Y-0B		

Table 3. Promising triticale lines in the 14th International Triticale Screening Nursery (ITSN) in the North and West African and Iberian Peninsula region in 1982-83.

Entry number	Line and pedigree
35	PTR"S"-MIA X34824-501M-500Y-506B-501Y-505Y-501M-500Y-0B
99	KLA"S"S x M2A-IRA/IRA-PND"S" X41059-E-1Y-2M-2Y-502Y-503M-0Y
100	CABORCA 79
101	BOA"S"
127	PTR"S"/RM"S"-IRA x FS477 X48675-7Y-3Y-2M-0Y
150	BEAGLE
162	M2A-BGL x RAM X52913-65Y-2M-3Y-0B
164	(GDO VZ471-BR"S" x PG"S"/WLOSZANOVSKIE) M2A(2) X53260-3Y-2M-1Y-0B
171	SERVAL"S" x M2A-CAL (BUEY-BGL"S" x M2A(2) /IA-IRA) ADX"S" X54032-B-1Y-2M-2Y-0B
191	(IRA-BGL)(2) B2686-2110
215	CIN-CNO x BGL/MERINO"S" B2700-292
238	MERINO"S"-JLO B2736-505
242	MERINO"S"-JLO B2736-2229
259	IRA-BGL/M2A-ARM"S" x BGL B3023-305

Table 4. Bread wheats from the 16th International Bread Wheat Screening Nursery (IBWSN) most resistant to stripe rust and stem rust (score 5MR-MS or less), and to *Septoria tritici* at Elvas, Portugal, and Seville, Spain, in 1983.

Row number	Variety or cross and pedigree	Septoria score*
2	ANZA	5
10	MYNA"S" SWM4589-7Y-18M-1Y-0M	5
36	VEERY"S" CM33027-F-15M-500Y-0M-76B-0Y	5
126	TES-PAM CM45984-9Y-2M-2Y-2Y-0M	5
146	BLO"S" [HORK"S"(TP x CNO67-NO/BB-CNO67)] CM46919-7Y-1M-1Y-1Y-1M-0Y	4
147	PF70357-ALD"S" CM47090-14M-1Y-1F-703Y-10F-705Y-3F-0Y	4
158	BUC"S"-BJY"S" CM49641-9Y-1M-2Y-3Y-0M	5
167	ALD"S"-PVN"S" CM49901-9Y-1Y-1M-3Y-0M	3
174	PAT-ALD"S" x PAT72300/PVN"S" CM49922-1M-2Y-3Y-1M-0Y	3
184	BUC"S"-BUL"S" CM50609-3Y-1M-3Y-0Y	5
185	BUC"S"-BUL"S" CM50609-3Y-1M-4Y-0Y	5
210	RPB 14.68-NAC x DOVE"S" CM53829-N-7M-4Y-2Y-1M-2Y-0M	5
212	PDGA 2 x KAL-BB(CAL x CNO67"S"-SON64/EMU"S") CM54017-M-2M-1Y-2Y-1M-2Y-0M	5
215	MAYA-PVN"S" CM55748-1Y-2Y-1M-2Y-0M	5
225	ANA-HUAC"S"(65.116 x MCD-CAMA/NAC) CM57206-P-1Y-1Y-1M-1Y-0M	5

* 0 - 9 scale, 0 = no infection.

Table 5. Durum wheats in the 14th International Durum Screening Nursery (IDSN) most resistant to stripe rust and stem rust (5MR-MS or less), and to *Septoria tritici* (score 5 or less, scale 0-9) at Elvas, Portugal, and Seville, Spain, in 1983.

Row number	Variety or cross and pedigree
1	FLAMINGO"S" D27582-8M-13Y-2M-0Y
38	MISRI"S"-MEXI"S" x SNIPE"S" CD10662-F-1M-1Y-2M-1Y-0M
123	MEMO"S"-GDO"S" CD26135-1B-1Y-1Y-4M-0Y
128	SHWA"S"-YAV"S" CD26406-1B-1Y-2Y-0M-1Y-0B
140	PIN
163	PIN"S"-MEMO"S"(S15-CRANE"S"/ CIT"S"-AA"S" x FG"S") CD27313-F-1M-1Y-1Y-0M-1Y-0B
165	PIN"S"-MEMO"S"(S15-CRANE"S"/ CIT"S"-AA"S" x FG"S") CD27313-F-1M-1Y-1Y-0M-12Y-0B
205	[MALA"S"(61.130-LDS x GS"S"-CR"S"/ GS"S"-MEXI"S")] ROK"S"-MEMO"S" CD32038-B-1Y-4Y-3M-0Y
217	SAPI"S"-RU"S" CD32843-2B-2Y-2M-0Y
219	SAPI"S"-RU"S" CD32843-2B-2Y-3M-0Y
222	ALGERIAN 86-RU"S" CD33417-1B-3Y-1M-0Y
266	OFN-MEMO"S"(DACK"S" x D67.2- GTA"S"/OYCA"S" x RUFF"S"- FG"S" CD35212-A-1Y-1M-3Y-0M
275	ALBE"S"-MEMO"S" CD35616-3B-2Y-1M-0Y

Table 6. Effective genes for resistance to stripe rust (*Puccinia striiformis*), stem rust (*P. graminis* f. sp. *tritici*) and leaf rust (*P. recondita*) contained in the isogenic lines of the 1982-83 Regional Disease Trap Nursery and in local differential nurseries. Field data recorded at Elvas, Portugal, (winter 1982-83) and Zafarraya, Spain, (summer 1983).

Elvas, Portugal	Zafarraya, Spain
Stripe rust	
2(Selpek), 3, 5, 8, 9, 10, Su92, and GIZA 155	No data
Stem rust	
Sr-9e, 14, 22, 24, 25, 26, 27, Tt-2 and Gt	Sr-8, 9b, 9d, 9e, 14, 22, 24, 25, 26, 27, Tt-2 and Gt
In both places the varieties LEEDS, SAMACA, AFRICA-MAYO, HOPPS, PATO"R", CHRIS, and most CIMMYT bread wheat germplasm.	
Leaf rust	
No data	Lr-13, 17, 19, and 20 TOB-B. MAN x BB/CDL (CM8972) KTZM12-UP301/B.MAN-7C x CDL (CM24160) BOBWHITE"S" (CM33203) CHIROCA-ANA (CM40111) KAL-BB x MON (CM40226) K4500.2-BJY"S" (CM40480) HD2205-ALD"S" (CM40629) CLEMENT-MO73 x TRM73 (CM43381)

Table 7. Genotypes in the 16th International Bread Wheat Screening Nursery (IBWSN) and 10th International Barley Observation Nursery (IBON) highly resistant to barley yellow dwarf virus in Lerida, Spain in 1983.

Entry number	Variety or line and pedigree	BYDV score[3]
16th IBWSN		
9	R37-GHL 121 x KAL-BB SWM4275-41M-1Y-4M-1Y-0M	Trace
11	F3.71-TORIM SWM5704-10Y-1M-3Y-1M-1Y-0B	Trace
55	MINIVET"S" CM37705-G-2Y-3M-1Y-0M-47Y-0B	Trace
42	BOBWHITE"S" CM33203-H-4M-1Y-0M-51B-0Y	1.0
88	PATO-ON x MAYA"S"/BB-RON x MAYA"S" CM40739-36M-1Y-1M-1Y-1M-0Y	1.0
162[1]	PJ-CAL x EMU"S" CM49852-10Y-1M-1Y-2Y-1M-0Y	1.0
198[1]	BUC"S"-CHRC"S" CM52421-26Y-1Y-1M-4Y-0M	1.0
199[1]	MON"S"-MN72131 CM52721-5Y-1Y-1M-2Y-0M	1.0
10th IBON		
39[1]	M66.85-CI12168(M66.95-M16.123 x GBS0252/API-CM67 x MONA) CMB77A-402-1B-1Y-4B-3Y-1B-0Y	1.0
72[1]	CQ-CER(3) x API(2)/PRO(2)-TOL 1(2) CEL-CI3909.2 CMB77A-1941-7H-2Y-3B-1Y-1B-0Y	1.0
176[2]	PI2235-MAF102 x COSSAK CMB78-452-2Y-1B-1Y-1B-1Y-0B	1.0
237[1]	79W41308	1.0

1. Excellent agronomic type.
2. Also highly resistant to powdery mildew.
3. 0 - 9 scale, 0 = no infection.

Table 8. New varieties approved for release in Spain and Portugal during 1982-83.

Variety name	Cross and pedigree	Country
Bread wheat		
DEGEBE	UP301 x SON64-PI62 JT 35-2L	Portugal
TEJO	(21931/CH53-AN x GB56)AN64 II20985-5H-2H-11H	Portugal
ALBARES	MYNA"S" SWM4589-7Y-8M-1Y-0M	Spain
ARGANDA	VEERY"S" CM33027-F-12M-1Y-6M-0Y	Spain
CARTHAYA	VEERY"S" CM33027-F-15M-500Y-0M-87B-0Y	Spain
Durum Wheat		
FAIA	P. AMAR-OVI x MEX DWARF	Portugal
CASTIÇO	(USAIIIC-GANSO x GRULLA"S"/ BY^{2}_{E}-TC x ZBV(FG"S") CM14403-G-3Y-6M-1Y	Portugal
Triticale		
MONSANTO	MAYA II-ARM"S" X2802-70N-3M-1N-2M-0Y	Portugal
Barley		
ENXARA	CM67-U.SASK1744 CMB72.45-19Y-2B-2Y-1B-1Y-0B	Portugal

Eastern and Southern African Region

E. Torres

Staff and Staff Changes

The Eastern and Southern African Regional wheat program has operated since 1979 with one senior scientist from CIMMYT and one Associate Expert supported by the Dutch government. The former is CIMMYT's representative in the region, and he is mainly responsible for linking the wheat breeding activities at headquarters in Mexico to the needs of the national wheat programs in eastern, central and southern Africa. The latter works with national scientists in the management of and selection from local and international nurseries planted by Kenya's National Plant Breeding Station (NPBS) at Njoro and other sites.

In 1983 there were new appointees to both positions. CIMMYT designated Dr. Enrique Torres, cereal pathologist, as its regional representative; he assumed the post in February. The Dutch government named Mr. Daniel Danial as Associate Expert, effective October 1.

Regional Operations

The regional activities of Dr. Torres began in February with a brief visit to cooperators in Malawi, Tanzania, Zambia, and Zimbabwe. This visit was arranged and guided by the previous CIMMYT representative, Dr. G. Kingma.

The regional office of CIMMYT joined the Tanzanian Agricultural Research Organization and the Canadian International Development Agency (CIDA) in sponsoring a regional wheat workshop which was held in Arusha, Tanzania, in June. Forty-five participants, representing Burundi, Ethiopia, Kenya, Madagascar, Malawi, Tanzania and Zambia, analyzed the constraints on wheat production in their respective countries. The proceedings, prepared by the secretariat of the local organizing committee, will be published by the regional office in early 1984.

A total of 14 national scientists from Burundi (1), Ethiopia (3), Kenya (4), Tanzania (4) and Zimbabwe (2) enrolled in the various training courses offered by the wheat program in Mexico, and returned to resume their duties in their home countries.

Several working visits to national wheat programs took place during 1983. A visit to Ethiopia in May permitted direct observation of the severe damage caused by a very intense stem rust epidemic on nurseries of local and introduced durum wheats at Debre Zeit. This event illustrated the need for closer contact between CIMMYT in Mexico and Ethiopia's durum wheat breeding program, and led to the scheduling of a later visit by the durum wheat breeder from Mexico, Dr. Pedro Brajcich. A second trip to Ethiopia coincided with Dr. Brajcich's visit and also with the appropriate time for identifying durum materials adapted to the heavy soils of central Ethiopia. Breeders from CIMMYT and Ethiopia arranged an exchange (shuttle) breeding program that will involve the station at Debre Zeit, Ethiopia, and the Yaqui Valley Agricultural Experiment Station (CIANO) in Mexico, as crossing and testing sites. A third trip to Debra Zeit was made in late October to make final selections.

Zimbabwe was revisited in September to participate in the selection of segregates at the Harare and Lowveld nurseries. Germplasm derived from CIMMYT material is of major importance to this country's effort to breed semidwarf varieties. Rusape, the newest variety, is a Veery "S". This visit included the Rattray Arnold Research Farm, owned and managed by the Seed Cooperative Company of Zimbabwe, a private farmers' association. This is another CIMMYT cooperator in Zimbabwe; its research thrust is closely coordinated with that of Ministry of Agriculture.

Zambia's breeding program for irrigated wheat was also visited. Irrigated wheat is a way for Zambia to increase its grain production to reduce escalating wheat imports and alleviate a chronic flour deficit. This large breeding program has already released two varieties derived from CIMMYT germplasm, Canary (= {[(My 54/N10-Y50xK.Line) CD] Buho} We-Gto x Kal-Bb) and Loerie (= Veery 5). In the pipeline are several selections from Chat"S"-Kavco (CM56774).

Activities in Kenya

During the main (rainfed) season, the NPBS's introduction section planted 9 groups of F_2 populations, 21 breeders' nurseries, and 5 pathology nurseries at Njoro, Molo and Eldoret. Individual plants were selected from the better F_2 populations, bulk-harvested within each population and planted as an F_3 under sprinkle irrigation in the off-season at Njoro.

The 21 breeders' nurseries included contributions from CIMMYT in Mexico (11), CIMMYT in South America (2), Zimbabwe (2), Ethiopia (1), the Netherlands (1), Pakistan (1), the Republic of South Africa (1), Tanzania (1) and Zambia (1). These nurseries developed under severe water stress and low disease incidence. In contrast, over 100 selections from the international nurseries that were planted in the off-season have developed well due to abundant rains in late November and early December. In these nurseries, stripe rust incidence is high in the spreader rows and the susceptible checks.

The objective of the five international pathology nurseries, which included the U.S. Department of Agriculture International Spring Wheat Rust Nursery, CIMMYT's Regional Disease Trap Nursery and its counterpart, the Latin American Rust Nursery (ELAR), is to monitor and describe changes in virulence patterns of cereal rust populations. Data from Molo, adequate for evaluating stripe rust, and from Njoro, mostly on stem rust, were returned to their respective nursery sources for compilation and analysis.

In addition to CIMMYT staff from Mexico, there were two visitors from the Pakistani wheat program. They participated in scoring disease incidence on Pakistani and other introduced nurseries and selected several hundred entries to be tested in Pakistan.

South and Southeast Asia Region

E.E. Saari

Introduction

The regional wheat program based in Thailand covers both South and Southeast Asia. The weather was favorable for the most part throughout South Asia and wheat production was at record levels. However, late rains in the Indian subcontinent caused spoilage of some of the late-harvested crop. In Southeast Asia, wheat is not a commercial crop in most countries, but several countries have increased the level of research activities on wheat.

Traditional Wheat-producing Areas

Pakistan—The weather was favorable and the rainfed crop was better than normal. A record crop of 12.4 million metric tons was produced and no serious disease outbreak was recorded. The CIMMYT wheat program staff based in Pakistan will present a detailed report on wheat production so only observations on diseases will be presented here.

This year diseases were not a problem but the crop remains vulnerable to attacks of leaf and stripe rust. The situation is less critical than in 1978 when the last rust epidemic occurred, but the improvement is only marginal. More varieties are available but with the exception of Pak 81, the resistance levels to leaf rust and stripe rust in the Punjab area continue to be inadequate.

There is a need to continue improving the strategy for rust resistance screening in the field. The levels of artificial inoculation and the race composition of the inoculum are not yet satisfactory for effective screening. Strengthening of the trained manpower and improvement of facilities are also required.

A number of secondary disease problems need short and long term attention. Loose smut is becoming a serious problem in farmers' fields. All of the local varieties are considered susceptible and the levels of infection observed are now significant. There is a need to initiate a longer term program for the incorporation of resistance. This will take several years, but good sources of resistance have been identified by the Cereal Disease Research Institute (CDRI), in Karachi. For the short term, treating certified seed for loose smut should be encouraged. If the crop starts out free of disease, then a considerable amount of time will be required to establish and build up infection levels.

Karnal bunt was restricted to India and Pakistan, but in the past few years it has spread to other parts of the world and has become a disease of increasing importance. Careful surveys should be conducted to determine the seriousness of the disease and its limits of distribution in Pakistan. An evaluation of the older Pakistani varieties for possible sources of resistance should also be undertaken.

In the rainfed areas of northern Punjab and in the areas around Islamabad, flag smut is a perennial problem. The release of varieties highly susceptible to this fungus has caused a serious increase in the disease. The infection levels observed are above tolerable limits, so a program to incorporate resistance should be started. Resistance to this disease is stable and it can be incorporated relatively easily. Australian varieties reported to possess resistance are Boka, Darkan, Eagle, Falcon, Kondut and Timgalen. The variety Dirk from Australia should also be tested for resistance since it was grown commercially in Pakistan in the 1960s.

India—The wheat crop was recorded at an estimated 42.5 million metric tons which is an increase of 4.5 million tons over the 1982 crop. The weather was favorable and disease problems were few.

It has been calculated that the average yields being obtained in different parts of India are still about half or less of the potential. One of the major contraints to higher yields has been the lack or inefficient use of

Dr. E.E. Saari (left), CIMMYT scientist in the South and Southeast Asia region.

fertilizer. The grassy weeds canary grass (*Phalaris minor*) and wild oats (*Avena fatua*) are also important factors in production in the northern irrigated areas.

A number of new varieties were released by the Central Varietal Release Committee in 1982-83; these are listed in Table 1. Promising candidates being considered for future release are PBW34, HD2329, WH283, WH331, Raj1972, HD2327 and CPAN1796.

This year was relatively disease free in India, but the three rust diseases remain important in any consideration of variety release. Resistance to one or more of them must be at acceptable levels in most regions of India.

Karnal bunt was not a problem this year, but the increase of the disease in the past few years remains a concern. Loose smut is on the increase and needs attention. Farmers' fields with infection levels in excess of 5 percent can be easily found. The incorporation of resistance needs to be part of the regular breeding program. The oat cyst nematode, *Heterodera avena*, is a problem in some areas and is spreading. Wheat varieties have been screened for resistance but so far only a few exhibit some resistance.

Sonalika is still the most widely grown wheat in the north. It is estimated that more than 50 percent of the wheat area in Uttar Pradesh, Bihar and West Bengal is sown to this variety. It is now susceptible to leaf rust, and in a favorable year losses could be substantial. Finding an adequate replacement for parts of India, as well as Nepal and Bangaldesh, is a pressing issue.

Nepal—Nepal had a favorable year and record wheat production. The situation was similar to that in northern India, which also had few disease problems and very favorable weather. The variety Sonalika, also referred to as RR-21, is still dominant especially in the plains area adjacent to India. Leaf rust and helminthosporium leaf spot are problems in this area. The variety UP262 is doing well and being accepted by the farmers.

Bangladesh—The situation in Bangladesh is similar to that in northeast India: Sonalika occupies about 70 percent of the wheat area. Its susceptibility to leaf rust and to helminthosporium leaf spot is a cause for concern, and variety diversification is important. The new cultivar Balaka is gradually being accepted and will relieve some of the pressure, but there is a need for additional varieties. There are several new, promising lines which could help in this respect when they become available in quantity.

Non-traditional Wheat Areas

Thailand—The CIMMYT South and Southeast Asia regional wheat program works closely with the national wheat program, which is a cooperative venture of the Thai Department of Agriculture, Kasetsart University, Chiang Mai University and other agencies. The wheat program organizes an annual meeting, promulgates a work plan, and coordinates trials and nurseries.

The best wheat, triticale and barley lines are initially screened and selected from germplasm received from ICARDA, CIMMYT and other sources. These selections are entered into the Thailand Observation Nursery (TON), which is distributed to numerous locations throughout Thailand. The main purposes of the nursery are to test the different environments in Thailand with respect to the possibility of wheat, triticale and/or barley cultivation, to obtain some information on cultivar adaptation, to introduce wheat as a crop into new areas and to gain experience in the management of the three crops.

The Thailand Yield Nursery (TYN) is a replicated yield trial which is sown at a limited number of locations where facilities and experienced people are available. The objective of the TYN is to assess the performance of the best selections from the TON. Inia 66 and Sonora 64 are used as the check varieties. These are fairly well adapted to Thai conditions, and there is a small area of commercial production of these two varieties in northern Thailand. A third variety, really a mixture of cultivars referred to as Colombia 118, is also grown to a limited extent.

Wheat production in Thailand is less than 1,000 tons at the present time, but imports are in excess of 150,000 tons. Imported wheat is made into white flour for bread, cakes, cookies and noodles. Local wheat production has been used primarily for specialty markets requiring the enzyme activity from germinating wheat seeds. Triticale grows well in Thailand and yields have been equal to or better than the best bread wheats. Overall plant development is impressive but grain filling is still a problem. Barley has done well and several lines have been selected and tested for commercial potential.

The Department of Agriculture, on the basis of cooperative tests with Kasetsart University and Chiang Mai University, officially released Inia 66 and Sonora 64 this year. This was partly to recognize previous research efforts and partly to establish a standard for future variety releases. The Department of Agriculture also released two barley varieties selected from CIMMYT material in the Second International Barley Observation Nursery. These had been evaluated and found to have good malting quality by the Boon Rawd Breweries of Thailand. In addition, there are several new lines which have been yielding more than the check varieties. The best bread wheats and triticales from the three programs in 1982-83 are listed in Table 2.

There are a number of diseases which must be carefully watched. *Helminthosporium sativum* attacks on wheat, triticale and barley are common, but in most situations not a limiting factor. Rice blast disease is capable of destroying the barley crop and is a potential problem. Seedling blight and root rot caused by *Sclerotium rolfsii* are widespread and are especially severe on barley.

Seed treatment with the fungicides Vitavax and Sicarol appear to give good control of *S. rolfsii*. Symptoms which appear to be barley yellow dwarf disease have also been observed, but confirmation of the presence of the virus has not been undertaken. Leaf rust is found on some of the older varieties but no rust has appeared on Inia 66 or Sonora 64. This indicates a rather primitive race structure, but the prospects are that leaf rust will be a major disease problem if the wheat area should increase. The few samples analyzed belong to race groups 17 and 13. Stem rust has been observed but it is not a problem at this time, although the warm temperatures throughout Thailand should favor this disease. Stripe rust has not been observed, but it has been reported once. This could well be an error as high temperatures normally are a limiting factor for this disease.

Several species of aphids (*Rhopalosiphum rufrabdominalis, R. maidis, R. padi, Schizaphis hypersiphonata, Histeroneura setaria, Sitobion* spp., *Melanaphis socchari* and *Aphis craccivora*) have been found on wheat, but *Rhopolospihum padi* seems to be the most common.

There is a possibility that nematodes may be important. In one trial in northern Thailand, root development of wheat was greatly retarded and the damage observed was similar to that caused by nematodes. Analysis of the soil indicated the presence of the nematode *Trichodorus* spp. at a concentration of 95 per 300 cubic centimeters of soil. This level is considered high enough to damage rice, so it is quite possible that it would also hurt wheat.

Burma—Wheat has been grown for about 100 years in some parts of Burma, and it is considered the principal crop by some farmers. The area sown is approximately 100,000 hectares, with a production of 120,000 tons. The main wheat-growing areas are the Sagaing and Mandalay Divisions in upper Burma, and Shan State in the eastern sector of the country. About 10 percent of the wheat area is irrigated, and a rice-wheat rotation is common. The remainder (90 percent) is rainfed and the crop must be produced on residual moisture since winter rainfall is not reliable.

The local wheat variety is called Monywa White, which is an old Indian variety also known as IP 4 or NP 4. This variety is favored in the Mandalay and Sagaing areas because of its drought tolerance and earliness. In Shan State, Lerma 50 and WC 4, a Canadian introduction, are reported to be the recommended varieties. Several semidwarf lines have been introduced from Pakistan, and a number of selections from recent CIMMYT nurseries look promising. The Pakistani varieties LU 26, Lyallpur 73, Blue Silver (= Sonalika) and Punjab 81 have been released for the Sagaing and Mandalay areas.

Leaf and stem rust are considered to be the most important disease problems. Stem rust epidemics occur periodically but the race structure appears to be independent of that on the Indian subcontinent. The leaf rust populations also appear to be different from those observed in Bangladesh and India, based on varietal response in the field.

The Philippines—The Philippines grew wheat before World War II but subsequently found it unprofitable compared with imports from Oceania and North America. Recently there has been a revival of interest in the possibility of wheat cultivation because of the current high level of imports, the need for crop diversification, and excess production of the basic staple, rice, during the past few years.

The Bureau of Plant Industry (BPI) has been conducting research on wheat varieties and agronomic evaluations throughout the country. Most of the experiments have been conducted in northern Luzon State. The Institute of Plant Breeding (IPB) at the University of the Philippines, Los Baños, has been working on variety development for a number of years.

The IPB has screened thousands of introductions and, in more recent years, has initiated a modest breeding program. Two wheat varieties from the IPB program were released by the

Dr. E.E. Saari (left) in Wheat Pilot Production Project fields in the Philippines.

Philippines Seed Board in 1980. The first was Trigo 1, also known as UPL-W1 or accession number 4073, which is a selection from lines received from Chile. The second variety was named Trigo 2 and is selection 11 from cross C85, with the pedigree Fiorello x F x A-188-67 (accession number 13089). The line C85-11 was also referred to as UPL-W2 before being named Trigo 2.

A National Wheat Pilot Project (NWPP) was started in the 1982-83 dry season to evaluate the potential for wheat production in the dry season (November or December to February or March), to verify the technology package, to evaluate the economic aspects of wheat cultivation and to re-introduce wheat to the northern areas of regions I, II and III of Luzon State. The Philippines Council of Agricultural Resources, Research and Development acted as coordinator for the sowing of 25 hectares of Trigo 1 and Trigo 2 in farmers' fields. The participating institutions included Central Luzon State University, the National Food Authority, Cagayan State University, Meralco Corporate Farm Management, and the Bureau of Plant Industry at Muñoz, Nueva Ecija and Cagayan Valley.

The results were variable, with yields varying from 0 to 1.5 tons per hectare. There were a number of management problems that need to be resolved in order to increase average yield and lower the cost of production. Lack of experience with the crop was a major factor; many farmers attempted to manage it as they would rice.

Several additional problems were identified that will require adjustments or additional research. One of these is the management of water-logged soils in the rice-wheat rotation. There is also a need to control weeds, particularly grass weeds like *Echinochloa colonum* and volunteer rice. Stand establishment was a major problem in heavy clays and soils subject to water logging. In several areas helminthosporium leaf spot, caused by *H. sativum*, became the limiting factor. Chemical control will be required since varieties with adequate resistance are not available. Seedling blight and root rot caused by *Sclerotium rolfsii* is an important factor limiting stand establishment and the number of tillers produced, especially in warm, moist soils. An effective seed treatment will be required. Leaf rust (*Puccinia recondita*) has been observed but is not yet a problem.

Some insects appear to be potentially troublesome. Stem borers, both *Sesamia* spp. and *Chilo* spp., were commonly observed. Several other insects, such as leaf miners, leaf rollers and aphids, have been recorded. Aphids present a special problem because of the possibility of barley yellow dwarf virus transmission.

In the dry season, a green crop is highly attractive to other species of animals, such as birds, rodents, rabbits, water buffalo, etc. Unless these can be controlled, they represent a major problem for the early on-farm trials.

The NWPP has developed plans to expand the on-farm trial area to 60 hectares, with some modifications in the package of recommendations. Experiments to resolve some of the difficulties encountered were outlined for the 1983-84 season. Current experiment station wheat yields have been approximately two to three tons per hectare, so there is room for improvement in the on-farm yields with better sowing techniques and disease control. The prospect for better-adapted varieties also looks good. Several selections from crosses made at the IPB appear to have better adaptation and higher yield than current varieties, and have good stability to environmental stress and some resistance to *Helminthosporium sativum*.

Sri Lanka—The Department of Agriculture has conducted wheat trials at the higher elevations since 1975. The indications were that wheat could be grown throughout the year at these elevations, but planting in the dry season, which normally starts in November or December, with harvest occurring in February or March, was the most realistic from a cropping standpoint.

Island-wide, on-farm feasibility trials were initiated in 1981-82. More than 3000 small plots were sown in all districts. The varieties Sonalika and Trigo 1 were provided in seed packets for sowing 1/200-acre or 1/8-acre plots. The yields from the 1982 harvest were variable due to an unprecedented drought in some regions of the island, but the results in nine districts were encouraging, with yields ranging from 0.8 to 3.7 tons per hectare with an average yield of 1.9 tons per hectare.

Based on these results, plans were developed to increase the number of demonstration plots to more than 10,000. The problem of marketing then became a limiting factor, and the planned expansion had to be reduced. There are no flour mills in the countryside in Sri Lanka; consequently all production must be either used for seed or sold to the one flour mill on the coast. Until a marketing strategy is developed, the potential expansion of wheat appears to be limited, unless local industries can be developed.

Indonesia—Wheat has become an important component of the diet of Indonesians. Current imports are at about 1.5 million tons per year. This level of importation has raised the question of whether it is possible to grow wheat economically in Indonesia.

Actually, wheat has been grown on a small scale at the higher elevations on the island of Java for many years. It was introduced by the Dutch and later by the Japanese during World War II. Local varieties remaining from these two eras are referred to as Pangalengan I, Omare Komigi, Oshio Komigi and Danchi Komigi. They are tall but reasonably well adapted at lower fertility levels.

The small quantity of locally grown wheat is consumed at the village level. It has been used primarily as a cereal groats extender for rice and maize. Another preparation involves pounding the wheat into a pasty flour, adding meat and spices, wrapping the mixture in a banana leaf and baking it. Wheat straw has been used for mushroom culture in some areas. Also, in some areas naked barley was reportedly grown before wheat was introduced, but this could not be verified.

In the mid-1970s a project was initiated to cultivate wheat at the higher elevations of central Java. The variety Jupateco 73 was grown by farmers, but the marketing system was not able to absorb the production and the project was discontinued. A program to introduce and select lines of wheat for possible use in Indonesia was again undertaken in the late 1970s and, in 1981, a large number of lines from the Philippines, Pakistan, India and the CIMMYT program were under evaluation.

Some of these are semidwarf introductions that looked promising at a number of locations where temperatures are moderate and some irrigation is available. The most promising semidwarf varieties that have been identified to date are SA75, Chenab 79, IWP72, HI784 (Swati), UP262, Punjab 81, Lyallpur 73, from Indian and Pakistani introductions. Trigo 1 from the Philippines looks good but it is a tall variety. A number of CIMMYT advanced lines and Jupateco 73 appear to have promise but will need additional yield testing.

The date for experimental wheat sowing on the islands of Java and Sumatra varies depending on the elevation and rainfall pattern at the different stations, which is determined by the location of the station in relation to the mountains. Sowing takes place mostly between March and June, with harvest about three or four months later.

Wheat cultivated in the rainy season is subject to many disease problems. Fusarium head scab and helminthosporium leaf spot are particularly severe during this period. Frequently the losses are complete, which makes wheat cultivation impractical. Growing wheat in the dry season reduces the scab and helminthosporium problems, but if the relative humidity is high and warm temperatures prevail (i.e. at lower elevations), helminthosporium can still be a major disease. Under these same conditions, and also with water-logged soils, *Sclerotium rolfsii* is a serious disease. Leaf rust was observed only on the varieties Pangalengan I and Donchi Komigi, suggesting a primitive race structure, the rust probably coming from infections on the local grasses. However, its presence suggests that leaf rust would probably be a disease of concern if the acreage of wheat were increased to a point where race variants would be favored.

The current plan is to continue the wheat introduction, screening and testing program. In 1984 the fourth Five Year Plan will begin and wheat research and production are to receive more attention.

Table 1. Wheat varieties released in India in 1982-83.

Cross number, name and pedigree	Area and conditions
HI784 (SWATI) NPO-TOB"S" x 8156/KAL-BB	Central zone. Late sowing, good fertility, irrigated.
CPAN1676 (ROHINI) BON x CNO-SON64/KAL-BB	Northern Plains zone. Normal sowing, irrigated, good fertility.
HD2281 HD2160-249	Northern Plains zone. Normal sowing, irrigated, good fertility.
DWL5023 (durum) CR"S" x LD"S" x GR"S"	Northern Plains zone. Normal sowing, irrigated, good fertility.
HUW37 (KAL x 5331) x HD1982	Northeastern Plains zone. Normal sowing, good fertility, irrigated.
LOK-1 S308-S331 (= Sonalika - Chotti Lerma)	Central zone. Late sowing, good fertility, irrigated.
HI617 (SUJATA) Selection from germplasm	Central zone. Normal sowing, good fertility, irrigated.
RAJ1555 (durum) COCORIT 71-RAJ 911	Central zone. Normal sowing.
HUW55 E4870-HD1982 x INIA66-HD2189	Northeastern Plains zone. Normal sowing, good fertility, irrigated.

Table 2. Promising bread wheat and triticale lines identified in yield trials in Thailand in 1982-83.

Trial location* and local number	Line or cross
CMU 2	NP887 - UP361
CMU 10	Y50E - KAL^3
CMU 26	BB - CNO x INIA-SOTY
CMU 30	CHL - INIA"S"
CMU 245	CHAT"S"
SW 2	TANORI 71
SW 7	MONCHO"S"
SW 9	TOB66 - CNO"S" x PI62/SKA
SW 13	JUANILLO 97
SW 15	JUANILLO 159 (= ERONGA 83)
1015^3	PI62 - FR x PI62 - MA/M x P
1510	NEPAL ADVANCED LINE NS73
UP 262	
BUCKBUCK"S"	
NACOZARI 76	

* Trial locations: CMU = Chiang Mai University; SW = Suwan Farm, Kasetsart University; others = Department of Agriculture

Pakistan

P.R. Hobbs

Introduction

The 1982-83 wheat crop set a new record for production in Pakistan. Official figures put wheat production at 12.34 million tons, exceeding the target of 12.20 million tons. This is a 6 percent increase over the previous year's record and a 47 percent increase since 1977 (Table 1). Favorable weather and policy measures on the supplies of quality seed, fertilizer and irrigation water, as well as price incentives played vital roles in achieving this record production.

Production Factors

Rainfall was very favorable for wheat production in 1982-83. In Islamabad 577 mm of rain fell from October to April compared with a 20-year average of 319 mm for the same period. Although September, October and the first half of November were drier than normal, rains started on November 15 and were evenly spread throughout the season. In many irrigated areas wheat was grown without irrigation. The above-average rains in April and May also benefited the crop by lowering temperatures and supplying ample moisture during the critical grain-filling period. This was important because many farmers are adopting a double cropping pattern with wheat being planted late, following rice or cotton. In a year with warm temperatures in the spring, this late-planted wheat will suffer during grain filling. More emphasis is needed on early maturing varieties for late planting in a double cropping system.

The heavy rain in mid-November did delay wheat planting in some areas, especially the Northwest Frontier Province (NWFP), and the above-average rain in May interfered with harvesting and threshing. However, better grain filling, due to lower temperatures and increased moisture, probably offset the losses.

Diseases were less important during 1982-83 than in other years. No major occurrence of leaf rust was observed and stripe rust, although heavy in northern Punjab and the NWFP, came late, affecting only the seed quality. Loose smut seemed to be on the increase and flag smut in northern Punjab and southern Kashmir caused significant losses.

Dr. P. Hobbs (second from right), CIMMYT wheat scientist, and Dr. S. Rajaram (left), head of the bread wheat breeding program, looking at salt-damaged wheat with a national program scientist.

The supply of improved seed to farmers was almost twice that available in 1977. However, the situation was better in the Punjab and Sind than in the NWFP, Azad Jammu Kashmir (AJK) and Baluchistan, where no seed industry exists. Good quality seed of recommended varieties helped increase production, since farmers' seed is often mixed and the varieties susceptible to diseases.

Fertilizer prices increased in 1982-83 owing to a gradual withdrawal of the subsidy. Consumption of fertilizer, however, increased to 712,000 tons of nutrients compared with 628,000 tons the previous year.

The increase in fertilizer use is mainly attributable to the increased availability of credit. The production credit supplied to farmers during 1982-83 was 3706 million rupees compared with 1105 million in 1977-78. The support price of wheat was raised to 64 rupees per 40 kilograms during 1982-83.

All the preceding factors resulted in increased yield. In addition, the area planted with wheat increased due to favorable rains in the Barani Tract and to more double cropping in the rice and cotton areas of the country.

Wheat Regions

Sind—Late planting is a common practice in the Sind since most of the wheat follows cotton or rice. Late rains, however, kept temperatures low at the end of the cycle. Pavon occupied 60 to 65 percent of the area followed by Sonalika with 15 percent. Seed availability was a problem. A number of fields were planted with seed of poor quality—mixtures and varieties susceptible to leaf rust, such as Pak 70. Rust was not a problem but smut incidence was high.

Punjab—The crop in the cotton belt was good, but planted late. Rust was not present, but smuts were. The major varieties were WL-711, BWP-79, Sandal, Yecora, Pari-73 and Sonalika. Punjab 81 and Pak 81 (= Veery "S") are being multiplied at the government seed farms.

In the rice belt, crop conditions were poorer than in the cotton belt, and weeds, principally *Chenopodium album*, *Phalaris minor* and *Avena fatua*, were a major problem. Waterlogging and salinity were other problems. The major varieties were Yecora (50 percent of the area), Pari-73 and Sonalika. Rust diseases were not a problem.

In the rainfed areas yields were well above normal. Lyallpur 73 (50 to 60 percent of the area) and local varieties were the major farmers' selections. Farmers were more reluctant to use fertilizers in this area. Flag smut was a problem.

Azad Jammu Kashmir—These rainfed areas have great potential for wheat production, but yields were restricted by the unavailability of improved varieties and lack of fertilizer use.

North West Frontier Province—The wheat crop in this province was good in both the irrigated and rainfed areas. The unavailability of improved varieties is a major constraint; Mexipak, highly susceptible to stripe rust, is still being grown by many farmers. Weeds were a serious problem especially the broadleaf types, which could have been easily controlled with 2,4-D, but it was not available.

Baluchistan—The irrigated areas, like the Sind, had few problems. Mostly local white wheat and barley varieties, susceptible to stripe rust, are grown in the uplands. The race of stripe rust in this upland region is different from that in Punjab and the NWFP because other improved varieties, including Mexipak, are resistant. Improved varieties are available but seed production is too low to meet farmers' needs. Yields were high because of favorable rains.

Breeding

Pakistan has developed a well-trained group of wheat breeders over the last 15 years. Evidence of this is that in 1982-83, five new varieties of bread wheat and one of barley were released (Table 2).

In 1982-83 the National Coordinated Wheat Program prepared 180 sets of the national uniform yield trials (Table 3) utilizing lines submitted by the provincial breeders. These were distributed throughout the country and results from 136 locations were returned. It is noteworthy that over a third of the entries were selected for early maturation or rainfed conditions, reflecting a change in institutional emphasis. Disease data was collected and used in the analysis.

Sixty-one international nurseries were sent to Pakistan in 1982-83. These included 29 bread wheat, 5 durum wheat, 13 triticale, 10 barley and 4 germplasm development nurseries. They were distributed among ten different provincial and national research stations within Pakistan. All the results except for the F_2 nurseries were returned to CIMMYT for analysis.

The management of all these nurseries was excellent at the Ayub Agricultural Research Institute (AARI), Faisalabad, the National Agricultural Research Centre (NARC), Islamabad, the Cereal Crops Research Institute (CCRI), Pirsabak, and the Agricultural Research Institute at Quetta, Baluchistan. Although the management was good at the Agricultural Research Institute at Tandojam, Sind, the program would benefit from more of its scientists attending the six-month training program at CIMMYT in Mexico. More emphasis is needed on inoculation of materials at some stations and the use of the available Oyjord planters would speed up planting and give more uniform stands at other stations. NARC planted all its yield nurseries by machine this year.

Pathology

The Cereal Disease Research Institute (CDRI) continued to assist breeders in the inoculation and evaluation of cereal diseases. The national wheat disease screening nursery was grown in many locations in Pakistan and also in Kenya, Thailand and Turkey. There is still a shortage of varieties with stripe rust resistance. Pak-81 (= Veery"S") was the only truly resistant variety available but the newly released Sarhad 83 will add to the list.

Laboratory and greenhouse studies are actively used to identify resistance genes for leaf and stripe rusts and the information is passed to the breeders. More emphasis is needed on good inoculation of breeders' material to help identify resistance sources.

Agronomy

Agronomic research in Pakistan is mainly restricted to experiment stations, is fragmented by discipline and is poorly coordinated among disciplines. Most agronomic research in farmers' fields is left to soil fertility institutions and extension services although recently research programs on adaptation have begun. The gap between farmers' and experiment station yields is high.

To provide some leadership in this area, on-farm research was started in 1982-83. An area was selected in the rainfed part of northern Punjab and an exploratory survey was conducted. Wheat is the major crop in this area. It is grown in the winter and spring, followed by a summer fodder crop and then the land is left fallow for a year before starting the biennial sequence again. Data were collected on cropping patterns, crop utilization, livestock, crop management and socioeconomic conditions. Several areas were identified for further research, and suitable experiments were designed and conducted during the wheat season.

With respect to fertilizer, it was found that both nitrogen and phosphorus were needed for high yields, and that there was a significant interaction of nitrogen and phosphorus. Taking the total average response to nitrogen and phosphorus as 100 percent, the part due to nitrogen was 68 percent, that due to phosphorus 8 percent and the residual due to the interaction of these two elements, 24 percent.

Average nitrogen response curves were linear from 0 to 120 kilograms of nitrogen per hectare (kg N/ha) with a slope of 15 kilograms of grain per kilogram of nitrogen. There were differences between locations, with two of the four sites showing linear responses up to 120 kg N/ha and two up to only 80 kg N/ha. Average phosphorus responses, on the other hand, reached a maximum at 40 kilograms of phosphate per hectare, with the best economic returns at this level. At some sites response to phosphorus was still economic up to 80 kilograms of phosphate per hectare but declined above this level. Fifty kilograms of potash gave significant and economic returns on two of the three sites tested.

Other factors leading to improved yields were weed control and the use of improved varieties. Weed control increased yields by 11 percent, on the average, over the eight sites where trials were conducted. Three improved varieties, Pak 81, Barani 83 and Junco "S" produced significantly more than the predominant variety Lyallpur 73 at all locations. These new varieties also offer better resistance to stripe rust.

At the end of the season, a crop assessment was made, including information on yields and management practices. The overall mean yield for the 100 fields sampled was 1.906 tons per hectare (t/ha) (range: 0.5 to 4.86 t/ha). This compares favorably with the official estimate for the variety Barani, 0.97 t/ha. The difference can be explained by the unusually high rainfall and by more farmers using modern technology in the area under study. Lyallpur 73 was the variety grown by 91 percent of the farmers sampled. Planting date varied from September 23 to December 10, with an average of November 2. Seeding rate was 96 kilograms per hectare. Twenty percent of the farmers used seed drills; fifty-two percent plowed with animals. Only 15 percent of the farmers weeded and 78 percent mixed mustard with the wheat for use as fodder during the season.

Among the 88 percent that used fertilizer, the average composition was 41-34-0 (nitrogen-phosphorus-potassium). Increased yield was correlated with increased fertilizer use. There was an increase in cropping intensity this year because of the favorable rains. Many farmers grew two crops (wheat and fodder) on all fields instead of allowing those cropped the year before to lie fallow.

Training

A three-week training course on weed science research was held from November 20 to December 8 at the National Agricultural Research Centre, Islamabad, in cooperation with the International Plant Protection Center of Oregon State University. Twenty-six participants attended, representing a wide array of commodity programs and disciplines. Participants' interest was extremely high: average scores improved from 41 to 78 percent between pretraining and post-training exams. The result was a group of well-trained, confident scientists in this new field of research in Pakistan. With the dramatic increase in weed populations coupled with rising costs of labor, herbicides are becoming economically feasible in Pakistan.

Eight trainees were sent to Mexico for short-term training at CIMMYT in 1982-83. Five were sent to study breeding and pathology, two to study agronomy, and one to study cereal technology. Noteworthy among these was the trainee from Sind, the first to be sent since 1971.

Dr. Naeem Hashmi, the national wheat coordinator, and Dr. Muhammad Aslam, the director of CDRI, visited the Yaqui Valley Agricultural Experiment Station (CIANO) at Ciudad Obregon, Mexico, from March 16 to April 6 as visiting scientists. Dr. M.A. Bajwa, Director of the Wheat Research Institute, AARI, Punjab, and Mr. Manuwar Hussain, Research Officer, CDRI, visited Kenya from August 25 to September 8 to evaluate materials in the regional disease nursery grown at Njoro. Mr. Bakht Roidar Khan was sponsored by CIMMYT to attend a cereal conference held in the United Kingdom in late June.

The annual travelling wheat seminar took its usual pilgrimage from Karachi to Peshawar from March 16 to 29. Thirty-five participants took part in the trip to evaluate the status of the crop. Wheat on experiment stations, in farmers' fields, in extension demonstrations and on seed farms was evaluated for yield, disease and agronomic factors. A trip to AJK was included in this year's itinerary to see this neglected area of Pakistan. A second tour was arranged to visit the upland wheat areas of Baluchistan from May 15 to 20. Fifteen participants went on this trip. The travelling wheat seminar brings together scientists from many disciplines and all provinces and leads to better understanding among them. Dr. Gene Saari, from the regional program in Asia, joined part of the tour.

Kaghan Summer Nursery

A concerted effort was made in 1983 to improve the productivity and usefulness of the summer wheat nursery in Kaghan. The station is used to advance generations in the off-season and to evaluate progenies for disease resistance. It is shared with other crop programs, so advanced planning and good management are essential. Assistance, in the form of equipment and advice on the organization of the trials and the station, was given at planting time. Weeds are usually a major constraint, but this year herbicides were used with good results. A measure of the success of this effort is that the seven different wheat programs that planted at the station in 1983 were all able to harvest good quality seed in time for inclusion in the October plantings in their provinces.

Table 1. Area, production and yield of wheat in Pakistan from 1977 to 1983.

Crop cycle	Area (thousands of ha)	Production: Tons (thousands)	Production: Percent of 1977-78	Yield (kg/ha)
1977-78	6360	8,367	100	1316
1978-79	6687	9,950	119	1488
1979-80	6924	10,857	130	1568
1980-81	6984	11,475	137	1643
1981-82	6981	11,631	139	1666
1982-83	7269	12,339	147	1697

Table 2. New varieties released in Pakistan in 1982-83.

Name	Previous designation	Line or cross, pedigree	Institution
Bread wheat			
SIND 81	P94	NORTEÑO x MEXIPAK	AEARC*
SARHAD 82	BOBWHITE	AU x KAL - BB/WOODPECKER"S" CM33203-K-9M-24Y-0M	CCRI
BARANI 83	K342	BB-GALLO/GTO-7C x BB-CNO CM32347-3M-1Y-1M-1Y-1K-0A	AARI
AARI 83	V79391	FURY x KAL-BB CM37138-42Y-1M-5Y-1M-4V-5Y-0A	AARI
PUNJAB 83	V79353	(ORE FI.158-FDL x MEXIFEN"S"-TIBA63^2)COC CM37987-I-1Y-5M-0Y	AARI
Barley			
JAU 83	CR368/4-1	(GIZA 117 x Bathim 52) CR 193/11 x FAO 78	AARI

* Atomic Energy Agricultural Research Center.

Table 3. National uniform yield trials for 1982-83.

Trial name	Number of entries	Number of seed sets dispatched	Number of results returned
Normal maturation	20	60	50
Early maturation	12	60	45
Rainfed	12	20	14
Durum and triticale	10	20	16
Barley	8	20	11
Total	62	180	136

Bangladesh

L. Butler and M. Mehmet Guler

Introduction

The officially proclaimed target of the Bangladeshi Extension Directorate for wheat in the 1982-83 season was 1.65 million acres. The actual production area was about 1.4 million acres, which should have yielded approximately 1.2 million tons of grain. The target figure was realistic and could perhaps have been attained had there not been a severe seed shortage. A severe drought during the rice season forced many farmers to consume their stored wheat seed, and the government was able to obtain only about 6000 tons of the needed 10,000 tons of seed on the international market. The 4000-ton shortfall would have planted an additional 80,000 acres.

On the other hand, growing conditions were good during the wheat season, so ample supplies of seed are available for the 1983-84 cycle. The official target for this cycle is 1.8 million acres, which should yield about 1.5 million tons. This should be easily attainable if good rains fall in October and November.

Breeding

A new program of variety development was fully implemented in 1983. Lines were evaluated and selected on the basis of their performance following two dates of planting, one favorable (November 15-20) and the other late (December 15-20). Each line was evaluated in this way at least once before it was allowed to advance to the national screening nursery (Bangladesh Screening Nursery) and to yield trials. The purpose of the new program is to provide a mechanism for systematically selecting germplasm capable of tolerating heat-accelerated maturation and also producing at least as much as Sonalika if planted late but producing more than Sonalika if planted on a favorable date. Sonalika is the predominant commercial variety but must be replaced because of its susceptibility to leaf rust. The newly released varieties Balaka, Kanchan, Ananda, Barkat and Akbar have demonstrated such flexibility. The new program has streamlined the process by which such germplasm is identified and tested.

Dr. L. Butler (right), CIMMYT wheat scientist in Bangladesh.

Nineteen lines from the 16th International Bread Wheat Screening Nursery (IBWSN) were selected in such a manner and have been advanced to the Bangladesh Screening Nursery.

Strong emphasis has been placed on the identification of plants resistant to *Helminthosporium sativum*, a pathogen causing an endemic and often severe leaf blotch disease. Entries in the CIMMYT Helminthosporium Screening Nursery were screened under natural infection at a regional agricultural research station: 15 lines with an average infection rating of 56, as opposed to a rating of 75 for Sonalika, were identified. In addition, a number of plants from several F_2 populations from CIMMYT, Mexico, segregating for *Helminthosporium* resistance, were selected and seed samples were returned to Mexico for advancement. These populations constitute the first step in a "shuttle" breeding effort between Bangladesh and CIMMYT that has the goal of accumulating resistance in material adapted to Bangladeshi conditions.

The first International Rice-Wheat Integrated Yield Trial, jointly distributed by IRRI and CIMMYT, was conducted at three locations in the 1982-83 cycle. The trial as initially planned was too heavily weighted towards late-maturing varieties which would be expected to yield well if favorable dates of planting were always available to the Bangladeshi farmer. This is usually not the case, so varieties and production estimates for late planting dates are needed. Consequently, the trial was planted on two dates, November 20 and December 19. Also, six entries previously evaluated and rejected in Bangladesh were replaced with lines developed in the national program. Significantly, four of these substituted lines plus the local check, Balaka, were consistently among the top performers at both dates of planting. Despite its limitations as first planned, the trial is a positive step towards the determination of the most productive combinations of varieties for use in the rice-wheat rotation.

Variety Releases

Four varieties, Ananda (Kal-Bb, CM26992-30M-300Y-300M-500M-0Y-0JO), Kanchan (UP 301-C306, II87-I-IP-5P-5Jo-0JO), Barkat (Jun"S", CM33483-C-7M-1Y-0M) and Akbar (Ron-Tob"S", CM7705-3M-1Y-2M-2Y-0Y) were released in February, 1983. Three are of direct CIMMYT origin. The introduction of these varieties into farmers' fields will be an important step towards the replacement of the leaf rust-susceptible variety Sonalika.

Extension

Much time usually elapses between the release of a new variety and its widespread use by the farmers, primarily because of the time needed to produce a sufficient quantity of certified seed. A cooperative program was initiated between the Agricultural Extension Directorate and the Wheat Centre of the Bangladesh Agricultural Research Institute (BARI), whereby the accelerated introduction of newly released varieties is accomplished through extension demonstrations. Kits composed of seed and fertilizer, each sufficient to plant one-tenth acre (400 square meters) of a variety, were prepared by the Wheat Centre and delivered to the regional headquarters of the extension directorate. They were then distributed to various extension field staff for planting in farmers' fields. Farmers were allowed to keep the entire quantity of grain harvested from the plots and encouraged to store it as seed.

Seventy-six such kits were prepared by the Wheat Centre for the 1982-83 season, the majority of which the contained the variety Balaka. The program was expanded in 1983 to 1028 kits containing the new varieties Kanchan, Ananda, Akbar and Barkat.

Pathology

Extensive surveys have revealed that the primary pathogen responsible for the leaf blotch disease affecting wheat is *Helminthosporium sativum*. Previously, *H. tritici-repentis* was thought to be the causal agent. This finding has important implications for the selection of sources of resistance.

Spores of leaf rust populations were collected from susceptible border rows infected naturally at the central research station at Joydebpur. These spores were successfully preserved by vacuum drying. The race composition of these collections will not be known until next season when they will be used to inoculate all relevant nurseries.

Agronomy

Dr. Mengu Guler, CIMMYT agronomist, joined the project in July. His expertise is very much needed to sort out the confusion in wheat agronomy research previously conducted in Bangladesh.

Training

In-service—In September and October of 1982, 100 subdistrict extension officers were given a three-day lecture series covering the botany, improvement, production, and quality characteristics of wheat.

In February a field day was held at Ishurdi Regional Agricultural Research Station with over 300 farmers and regional extension staff attending. Field days are very useful training sessions for both extension officers and farmers since both visual and "hands-on" observation of yield trials and new varieties is possible.

Three trainees were sent to Mexico to attend the six-month courses offered by CIMMYT. Two participated in the production agronomy course and one in cereal technology.

Postgraduate—Under the terms of the project, four doctoral and three masters candidates are eligible to receive scholarships. Much difficulty has been and continues to be experienced in obtaining the necessary government clearance for these nominees. Only Messrs. Abdur Razzaque (doctorate, breeding, Oregon State University), Abdus Samad (master of science, breeding, North Dakota State University) and Mohammed Badaruddin (doctorate, agronomy, North Dakota State University) were attending classes in 1983; furthermore, Mr. Razzaque returned to Bangladesh for personal reasons. However, Messrs. A.B.S. Hossain (doctorate, breeding, Kansas State University) and Kazi Benozir Alam (master of science, plant pathology and breeding, University of Missouri) have obtained clearance and will begin their studies in January, 1984.

Equipment and Facilities

The eagerly awaited plot combines and planters (four of each) were received in 1983; the planters were tested with success. All vehicles except one and some laboratory equipment, including compound and dissecting microscopes, balances and scales, test-weight apparatus and moisture meters, were also received.

No project funds were earmarked for facility improvement as such, but this need has become increasingly apparent. Certainly the general mandate of improving the research capability of the BARI Wheat Project should include critically needed construction. Project funds were used to renovate a room for the cool storage of seed at the central research station at Joydebpur and other projects of a similar nature are planned.

CIMMYT-ICARDA Cooperative Bread Wheat Improvement Program

G. Ortiz F.

Introduction

World wheat production averaged 450 million metric tons in the period 1980-81 (FAO Monthly Bulletin of Statistics, March 1982). About 10 percent of this total (approximately 44 million tons) was produced in the countries of the ICARDA region in Africa and Asia.

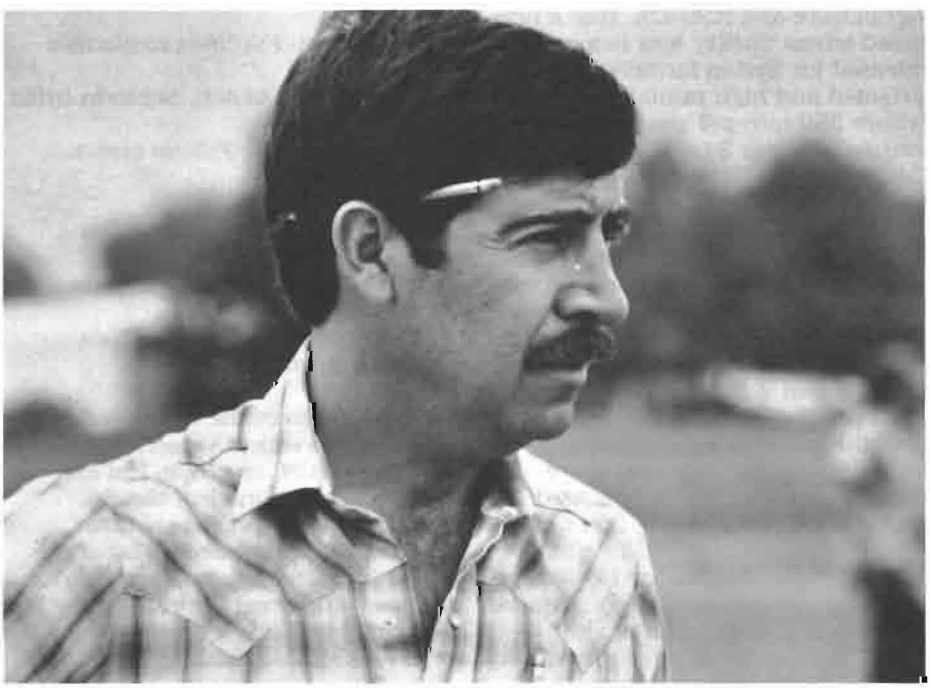
Bread wheat ranks first among the food crops in the Middle East and North African countries. This cereal provides the principal food for the majority of the population which, on the average, consumes in excess of 150 kilograms of wheat per capita per year. Total wheat imports in these countries have increased rapidly to meet consumption demands, averaging 15 million metric tons annually during the last five year period. Most of these imports are of bread wheat.

Over 90 percent of the bread wheat grown in the region is rainfed at precipitation levels of 250 to 650 millimeters per year; 50 percent of the area receives less than 400 mm. There are several reasons for the lack of improvement in wheat production in the lower rainfall areas. Diseases, insect pests, frost, heat, drought and other environmental factors in combination with the lack of good agronomic practices (poor land preparation, weeds, poor moisture conservation, sowing problems, poor crop stands, etc.) are the main problems. The CIMMYT-ICARDA cooperative bread wheat program has a special responsibility to develop suitable varieties for these lower rainfall zones.

Breeding

The program is a joint CIMMYT-ICARDA effort, with collaboration from ICARDA scientists in agronomy, pathology, entomology and grain quality; CIMMYT provides expertise in breeding. High-yielding varieties combined with improved agronomic practices offer the best hope for increases in production in the region.

Breeders are continuing to work towards the development of materials that will yield as much as possible given the limited rainfall of the region. In addition to drought tolerance, new materials are being selected for cold, heat and salt tolerance. Improved resistance to diseases is also an important aim. To this end, particular attention is being paid to the three rusts, septoria, bunt and bacterial blights. Insects are also a serious problem in many areas and materials are being screened for resistance to stem sawfly, Hessian fly, suni bug and aphids. Improvement of grain quality is also an objective.



Dr. G. Ortiz, CIMMYT wheat scientist who coordinates the CIMMYT-ICARDA cooperative bread wheat improvement program.

A wide germplasm base is maintained through the use of CIMMYT nurseries and segregating populations. In 1982-83, 883 F_2 populations were received, providing germplasm with potential for rainfed and irrigated areas, tolerance to high levels of free aluminum, resistance to *Helminthosporium* spp., and agronomic characters derived from spring x winter crosses.

A total of 10,769 entries in segregating populations of F_2 to F_8 generations were evaluated by the breeding program in 1982-83. All lines were grown under two management systems, one rainfed with a small amount of fertilizer, the other with supplementary irrigation and optimal amounts of fertilizer. It is believed that by growing segregating populations under both systems, selection can be made simultaneously for both high yield and yield stability.

Results from yield trials of new and advanced lines demonstrate the progress to date in improving yields relative to the widely grown variety Mexipak 65 and the improved check variety Golan (Table 1). Some lines are superior to the checks, especially in the more favorable, irrigated environments.

Yields at Tel Hadya this year were influenced by frost. Because of its timing, the frost caused more damage to the lines that matured early or in midseason than to the later lines like Mexipak and Golan. To avoid a selection bias toward late lines, the mean yield of each trial was used as the basis for selection and special attention was paid to frost damage and date of heading.

Stability of performance—Table 2 lists the six lines that were selected nine or more times at 20 locations in the Wheat Observation Nursery (WON) during 1982-83. These selected lines are from different sources, including ICARDA, CIMMYT, Turkey, and Egypt. The locations to which this nursery was sent, both inside and outside the ICARDA region, represent a wide range of environments and prevalent diseases so that the selection of an entry at a number of locations is a good measure of its stability. The outstanding lines in this nursery were promoted to the regional yield trial and many of them will be used as parents in the crossing block next year.

Regional yield trials—Table 3 gives the results from six years of regional wheat yield trials, comparing the two highest-yielding bread wheat lines with Mexipak 65 and the national check, a recommended, high-yielding variety with proven adaptation at that location. During the last five seasons there has been a tendency for the top two new lines to perform slightly better than both Mexipak 65 and the national check. During the last six years the top line has yielded an average of 271 kilograms per hectare (kg/ha), or 7 percent, more than the national check. This is a modest increase and indicates some improvement in the breadth of adaptation.

A summary of the highest-yielding lines in the regional wheat yield trial of 1982-83 is presented in Table 4. Grain yield and other agronomic data were compiled from 21 different locations including two at the Tel Hadya Research Station, one under rainfed conditions and the other with supplementary irrigation. The overall average yield of the entries, excluding the national checks, was 4057 kg/ha, with individual entry means ranging from 3619 to 4512 kg/ha. Experimental error at some of the locations was large and resulted in a relatively high global coefficient of variation (C.V. = 18 percent) for the combined analysis. Even though disease scores were reported by most cooperators, heavy infection was reported in only a limited number of locations.

Flk"S"/Hork"S" was the highest-yielding line and was among the top 10 entries at 16 out of 21 locations. This line was also superior to the national checks at 13 locations. However, it was susceptible to the rusts at several locations, especially leaf and stripe rusts. The second highest-yielding line, HD 2206/Hork"S", ranked among the top 10 entries at 14 locations and it was also superior to the national check at 13 locations. This line is moderately susceptible to leaf and stem rusts. Vee"S", which is a winter x spring cross, ranked third and combines high yield with good yield stability, midseason maturity and good disease resistance. Overall, it seems to be the most promising line in the trial.

Variety releases—Among the more important events of 1983 for the CIMMYT-ICARDA Cooperative Bread Wheat Improvement Program was the announcement from the collaborative research program between the Syrian Ministry of Agriculture and ICARDA, that a new bread wheat variety was being released for Syrian farmers in the irrigated and high rainfall areas (above 350 mm per year). This variety is Sham 2 (= 7C//Tob/ Cno"S"/3/Kal, CM 8865-D-4M-1Y-1M-2Y-OM).

Table 5 summarizes the performance of this new variety as compared with Mexipak 65, the present commercial variety, in field verification trials for these two zones during the last four years. Sham 2 clearly shows better yield performance. Its average yield over the last four years is 4812 kg/ha, or about 12 percent more than Mexipak 65, in the irrigated areas. For Zone A (above 350 mm rainfall), the average yield for four years was 3217 kg/ha, or 11 percent more than the check variety. Disease resistance, protein content and bread-making qualities of this variety are also better than Mexipak 65. In general, the maturity and plant height of both varieties is the same. Breeders' seed was produced in 1982-83 and about six tons of quality seed will be available next year.

Conclusions and future plans—Progress has been made in developing improved germplasm adapted to the Middle East and North Africa region. The bread wheat breeding program will continue to concentrate on the problems of the region using world-wide resources to identify and develop adapted germplasm. Special emphasis will be placed on the lower rainfall areas, making extensive use of winter x spring crosses and increased use of "shuttle" breeding using more locations inside and outside Syria.

Pathology

During the 1982-83 crop season, efforts to maintain and improve the disease resistance continued. A large amount of advanced and segregating material was screened for several diseases prevalent in the countries of the ICARDA region.

The priority diseases for resistance breeding in bread wheat are:

- Stripe rust, *Puccinia striiformis*
- Septoria leaf blotch, *Septoria tritici*
- Common bunt, *Tilletia caries*, *T. foetida*
- Leaf rust, *Puccinia recondita*
- Stem rust, *Puccinia graminis*
- Tan spot, *Helminthosporium tritici-repentis*

Information from the ICARDA Bread Wheat Observation Nurseries (ICARDA-WON) on stripe, leaf and stem rusts, septoria leaf blotch, common bunt, and tan spot was received and processed. A list of the top-performing bread wheat lines for leaf and stripe rust in this nursery is presented in Table 6. Data were received from Jordan, Yemen, Egypt, Pakistan, Bangladesh, Mexico, Portugal, Spain and Ecuador. Twenty-three entries out of 127 in this observation nursery showed a good overall stripe rust resistance, while 31 lines from the same nursery proved to have good leaf rust resistance.

Septoria leaf blotch is an important disease of bread wheat in the North African countries. Table 7 shows those lines having good levels of resistance in the septoria nursery planted at Afin, Syria, and ICARDA's wheat observation nursery planted at Elvas, Portugal.

Common bunt resistance is an important objective in the bread wheat program. In CIMMYT's screening effort, all material in the preliminary and advanced yield trials is grown in special bunt nurseries and artificially inoculated with a mixture of Syrian isolates. Those lines showing resistance are retested in the following season. If their resistance is confirmed, the lines are tested against a number of non-Syrian isolates in a well-isolated area, and lines having broadly based resistance are promoted to the crossing block.

During the 1982-83 crop season several crosses involving bunt resistant parents were screened and resistant segregants selected. Results are encouraging and efforts to screen resistant material in this fashion will continue. Crosses made to include resistance to other diseases will also be screened under heavy disease pressure during the next season.

Agronomy

Several management factors were examined in multilocation trials in farmers' fields in Syria. In fertilizer trials, it was clear that nitrogen is the most important nutrient in areas with moderate to high rainfall. Previous experiments had shown that while significant genotypic differences exist, these differences were often not uniformly expressed between seasons or among sites. Previous cropping history, climate, and soil type interact in a complex fashion with nitrogen uptake and utilization by the plant. Consequently, studies of genotypic differences in responsiveness to nitrogen continued.

For the third season, a plant ideotype experiment was conducted to determine if a single optimum balance of yield components exists for the local environment. Eight bread wheat varieties with contrasting yield component characteristics were tested at five population densities (approximately 50, 100, 200, 400, and 800 plants per square meter). The aim of this experiment was to determine which yield components, if any, were more consistently related to high yields under rainfed conditions at Tel Hadya. In theory, this information could help plant breeders select higher-yielding lines for rainfed conditions in the region.

In each season so far, the effects of weather (frost, for example) have been the most readily identifiable influence on grain yield. Frost during heading was not a problem in 1982-83 but winter temperatures were cold for longer than usual and heading was delayed. Under these circumstances there were not enough tillers at low population densities to compensate for the reduced numbers of plants, and there was,therefore, a larger effect from increasing plant density than in previous years. In addition, there was a tendency for lines with many tillers to give the highest yields.

Grain quality

A total of 3420 quality tests, mainly on bread wheat breeding lines, were run in 1982-83. In addition, studies were made of the effects of environment on quality.

From the data on environmental effects in Table 8, it is clear that in this region hardness is little affected by differences between years or among locations and is the most highly heritable of the quality characters. Kernel weight is also controlled more by genetic than environmental factors. Protein content and wheat meal fermentation time were the most affected by the environment. The wheat meal fermentation time test appeared to be affected more by differences between seasons than by differences in location, and is of little value in selection, unless the populations contain a very wide range of gluten strength.

Little is known about the quality characteristics of the Arabic flatbreads, called khobz. Studies were conducted to define these characters and to develop a scoring system to evaluate flour samples. Dough handling, dividing and sheeting properties; khobz colour and diameter; crumb and biting texture; layer separation; odor; taste and keeping quality were scored on a point system for routine and repeatable evaluation of entries.

The effect of suni bug damage on physical dough properties was studied. Physical dough characteristics were affected even when only 5 percent of the grain was damaged. Flours made from grain, 20 percent or more of which was damaged, were impossible to handle in khobz baking procedures and would not rise in the oven.

A test was developed to detect suni bug-damaged flour samples. A normal, wet gluten test is carried out on 10 grams of flour. After washing and drying, the gluten is stretched 5 centimeters along a ruler. The degree to which the gluten retracts after release (a measure of its elasticity) gives an indication of the presence and measure of the severity of suni bug damage. The presence of as little as 5 percent damaged wheat can be detected by this test, which is simple and needs only inexpensive and readily available equipment.

Entomology

Wheat stem sawfly, suni bug, and cereal aphid received special attention. The search for resistant germplasm is proving to be more successful with the sawfly than with the other two pests.

Wheat stem sawfly—Under light natural infestation at Suran and heavier artificial infestation in Tel Hadya, 79 bread wheat lines were screened for resistance to wheat stem sawfly. As in previous seasons the variety Fortuna and its derivatives were the best sources of resistance to this insect (Table 9). The consistency of this resistance was confirmed when the resistant line MT-777 (CI 9294/Fortuna), together with a local check (Golan) and a susceptible check (MP-112) were exposed to increasing levels of infestation. Even with the heaviest infestation (11 females per square meter) the proportion of stems infested in the resistant line was significantly smaller than in the local and susceptible checks (Figure 1).

Suni bug—As indicated by surveys, the suni bug is present in all bread wheat growing areas of Syria. The greatest damage was detected in the Aleppo and Idlib provinces where an average of 17 and 6 percent of the grain, respectively, was damaged. These levels of suni bug damage seriously affect the bread-making qualities of the flour (Figure 1). None of the 79 lines screened for suni bug damage was rated as resistant.

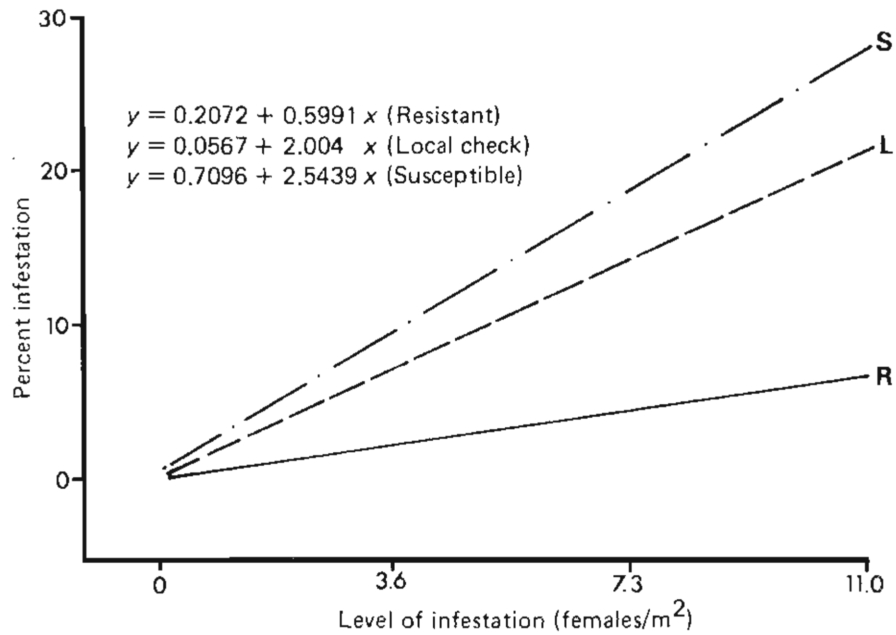


Figure 1. Regression of four levels of infestation with wheat stem sawfly on the percent infestation in three bread wheat varieties, in 1983. L, local check (Golan); R, resistant (mT-777, CI9294/Fortuna); S, susceptible (MP-122).

Table 1. Number of lines that gave significantly* better yields than the checks Mexipak 65 and Golan in the 1982-83 yield trials.

Location and trial	Average yield (kg/ha)	Number of lines tested	Number of lines yielding more than Mexipak 65	Golan
Tel Hadya - Rainfed				
New lines	3592	858	9	8
Advanced lines	4137	176	0	7
Tel Hadya - Irrigated				
New lines	4928	396	9	30
Advanced lines	5266	176	17	7
Terbol				
Advanced lines	5495	176	0	15

*P = 0.05%

Table 2. Lines selected nine or more times at 20 locations in the WON in 1982-83.

Entry number	Times selected	Cross and pedigree
34	11	BB/2*7C//Y50E/3*KAL CM 29014-7S-2AP-1AP-4AP-0AP
125	11	SAKHA 18//CNO"S"/CAL/4/SAKHA/3/ TZPP//SN64/NAPO S 2896-100-1S-3S-0S
71	9	7C/PVN"S" CM 36569-8Y-1M-1Y-2M-0Y
16	9	GV/ALD"S" L 882-1AP-0AP-2AP-0AP
65	9	SNB"S" CM 34630-D-3M-3Y-1M-1Y-0M
127	9	SAKHA 69

Table 3. Yield of the two highest-yielding bread wheat lines in the regional wheat yield trial compared with the bread wheat check varieties for the years 1978-83.

	Yield (kg/ha)						
	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	Average
Mexipak	3278	3510	4151	3577	4333	4277	3854
National check	3477	2830	4107	3629	4590	4403	3839
Top bread wheat line	3477	3180	4356	3926	4845	4876	4110
Second bread wheat line	3469	3140	4347	3679	4745	4729	4018
Number of locations	24	31	27	29	18	18	25

Table 4. Performance of the highest-yielding lines in the regional wheat yield trial in 1982-83.

Cross and pedigree	Yield (kg/ha)	CHK*	SEL**	Days to maturity	Protein content (percent)	1000-kernel weight (g)
FLK"S"/HORK"S" CM 39816-1S-1AP-0AP	4512	13	16	153	11.8	35.1
HD 2206/HORK"S" CM 39808-62M-1Y-1M-0Y	4444	13	14	152	11.7	33.3
VEE"S" CM 33027-F-9M-1Y-4M-500Y-500M-502Y-0M	4403	13	17	154	12.1	36.4
INIA/NAPO//3*CAL/3/CJ/4/KPK NCP 212-A-1K-3AP-0AP	4360	13	14	156	12.0	36.4
MEXIPAK 65 (bread wheat check)	4012	10	8	151	11.6	34.1
WAHA (durum check)	3832	4	6	151	12.8	41.0
Overall Mean	4057					
LSD 5%	292					
C.V.	18%					

Data are averages from 21 locations.

* Number of locations where the line was superior to the national check.

** Number of locations where the line was among the ten highest yielding entries.

Table 5. Summary of the performance of Sham 2 compared to Mexipak 65 in field verification trials in the irrigated zone and zone A (above 350mm rainfall) in Syria in 1979-1983.

Zone and variety	Yield (kg/ha) 1979-80	1980-81	1981-82	1982-83	Average	Percent of Mexipak 65	Diseases* LR	SR	StrR	ST
Irrigated zone										
SHAM 2	4257	5517	4082	5390	4812	112	3	5	1	2
MEXIPAK 65	3585	5026	3545	5073	4307	100	20	8	9	5
Zone A										
SHAM 2	3520	2999	3148	3202	3217	111				
MEXIPAK 65	3148	2740	2873	2830	2898	100				

*LR = leaf rust, SR = stem rust, StrR = stripe rust, ST = *Septoria tritici*; rusts are reported as average coefficient of infection, septoria on a 0 (no infection) to 9 (very heavy infection) scale.

Table 6. Entries in the Wheat Observation Nurseries (WON) showing resistance to stripe and leaf rusts in 1982-83.

Entry number	Cross and pedigree
8	P106.19//SOTY/IT*3 L 0489-1AP-0AP-6KE-0AP
28	TOB"S"/3/CNO67/JAR//KVZ CM 20707-A-1Y-8M-1Y-0M-0Ptz
58	BOW"S" CM 33203-F-4M-4Y-1M-1Y-0M
61	BOW"S" CM 33203-K-9M-2Y-1M-1Y-1M-0Y
64	G11/YR RESEL(B)/3/AU//KAL/BB CM 34603-A-1M-GY-4M-1Y-2M-0Y
66	SNB"S" CM 34630-D-5M-5Y-3M-1Y-0M
81	BCH"S"//Y50 E/KAL*3 CM 39761-9K-2AP-0AP-2AP-0AP

Table 7. Entries in the Wheat Observation Nursery (WON) showing resistance to *Septoria tritici* in Syria and Portugal in 1982-83.

Entry number	Cross and pedigree
2	INIA/NAPO//TOB/3/SPRW"S" L 0017-5S-4S-2AP-1AP-1AP-0AP
10	TOB/CNO"S"//PI 62/3/SKA L 0771-4L-2AP-0AP
30	NR/3/CNO"S"/PJ//G11 CM32125-2AP-2AP-0AP-1AP-0AP
102	CMN 72.428/MRC//FLR"S" CM 46869-2AP-0AP
117	Cross unknown-COC SWM 6493-2AP-0AP
129	SAKHA 91

Table 8. Influence of growing season, location and heritability of some quality factors in bread wheat.

Quality factor	Between seasons	Between locations
Kernel hardness	0.98	0.97
Protein content	0.64	0.72
Wheat meal fermentation time	0.21	0.47
1000-kernel weight	0.77	0.83

Data are average coefficients of correlation among test data from eight cultivars grown at six locations over two years.

Table 9. Bread wheat lines with high levels of resistance to wheat stem sawfly in six consecutive seasons, 1978-1983.

Line	Mean level of infestation
MT-777, CL 9294/FORTUNA	1.6
MT-773, CL 9294/FORTUNA	3.3
FORTUNA	3.4
SAWTANA	4.3
MT-778, CL 11490/FORTUNA	3.5
LIMPOPO	4.3
LEW	5.4
MP-112 (susceptible check, 1978-1982 mean)	25.0
GOLAN (local check, 1983)	9.3

Glossary

A.: *Agropyron.*

AARI: Ayub Agricultural Research Institute, Faisalabad, Pakistan.

ACI: average coefficient of infection, a measure of the severity of an infection. Used principally with rusts.

Ae.: *Aegilops.*

AEAC: Atomic Energy Agricultural Center, Pakistan.

a.i.: active ingredient.

AJK: Azad Jammu Kashmir, a state in Pakistan.

APHIS-PPQ: Plant Protection and Quarantine office of the Animal and Plant Health Inspection Service, U.S. Department of Agriculture.

BARI: Bangladesh Agricultural Research Institute.

BC: backcross, i.e., a cross between an F_1 and one of its parents; BCI, BCII, etc. refer to the first, second, etc. backcross generations, in which the progeny of the previous generation is again crossed with the same parent.

BID: Interamerican Development Bank (Banco Interamericano de Desarrollo).

BPI: Bureau of Plant Industry, the Philippines.

BSMV: barley stripe mosaic virus.

bulked: bulk-harvested.

bulk-harvested: a mixture of seed harvested from more than one plant, e.g., an entire line or population (vs. individually harvested). Also applied to mixtures of different races or collections of pathogen spores.

BYD: barley yellow dwarf, a viral disease of a large number of grasses including most cereals.

BYDV: barley yellow dwarf virus.

CB: crossing block.

CBN: normal crossing block.

CBQ: quality crossing block.

CBR: resistance crossing block.

CBWB: winter barley crossing block.

cc: cubic centimeters.

CCRI: Cereal Crop Research Institute, Pirsabak, Pakistan.

CDRI: Cereal Disease Research Institute, Pakistan.

CIANO: The Yaqui Valley Agricultural Experiment Station (Campo Agrícola Experimental Valle del Yaqui) of the Northwestern Agricultural Research Center (Centro de Investigaciones Agrícolas del Noroeste), administered by the National Institute of Agricultural Research (INIA); 39 meters elevation, 27°N latitude.

CIAT: International Center for Tropical Agriculture (Centro Internacional de Agricultura Tropical), Cali, Colombia.

CIDA: Canadian International Development Agency.

COOPAGRO: Agricultural Cooperative of the Western Region (Cooperativa Agropecuária Mista do Oeste), Brazil.

C.V.: coefficient of variation.

cv: cultivar.

DSN: Drought Tolerance Screening Nursery

DSP: Disease Surveillance Program.

E.: *Elymus*.

EDYT: Elite Durum Yield Trial.

ELAR: Latin American Rust Trial (Ensayo Latinoamericano de las Royas).

El Batan: experiment station and CIMMYT headquarters; 2249 meters elevation, 19°N latitude.

ELISA: enzyme-linked immunosorbent assay, a technique for identifying types of barley yellow dwarf virus.

EMBRAPA: Brazilian Agency for Agricultural Research (Empresa Brasileira de Pesquisa Agropecuaria).

El Refugio: the Bajio Agricultural Experiment Station (Campo Agrícola Experimental del Bajio), administered by the National Institute of Agricultural Research (INIA); 1500 meters elevation, 21°N latitude.

ESWYT: Elite Selection Wheat Yield Trial.

F: filial generation; F_1 refers to the progeny of a cross between any two plants; F_2, F_3, F_4, etc. refer to the successive generations.

FECOTRIGO: Federation of Brazilian Wheat and Soya Cooperatives (Federação das Cooperativas Brasilieras de Trigo e Soja).

FN: falling number, a measure of alpha-amylase activity.

g/ha: grams per hectare.

Guaymas: the Guaymas Agricultural Experiment Station (Campo Agrícola Experimental en Guaymas), administered by the National Institute of Agricultural Research (INIA).

H.: *Hordeum*.

Ha: *Haynaldia*.

ha: hectares.

hl: hectoliters.

IAPAR: Agronomy Institute of Parana (Instituto Agronómico do Paraná), Brazil.

IBON: International Barley Observation Nursery.

IBWSN: International Bread Wheat Screening Nursery.

IBYT: International Barley Yield Trial.

ICARDA: International Center for Agricultural Research in Dry Areas, Aleppo, Syria.

ICARDA-WON: a bread wheat observation nursery sent out by ICARDA.

IDSN: International Durum Screening Nursery.

IDYT: International Durum Yield Trial.

IEBON: International Early Barley Observation Nursery.

IICA: Interamerican Institute of Agricultural Sciences (Instituto Interamericano de Ciencias Agrícolas), Turrialba, Costa Rica.

INBYT: International Naked Barley Yield Trial.

individually harvested: seed collected separately from each plant (vs. bulk-harvested).

INIA: National Agricultural Research Institute (Mexico: Instituto Nacional de Investigaciones Agrícolas; Chile: Instituto Nacional de Investigaciones Agropecuarias; Spain: Instituto Nacional de Investigaciones Agronómicas).

INIAP: National Institute of Agricultural Research (Instituto Nacional de Investigaciones Agropecuarias), Ecuador.

INIPA: National Institute of Agricultural Research and Extension, (Instituto Nacional de Investigación y Promoción Agropecuaria), Peru.

INTA: National Institute of Agricultural Technology (Instituto Nacional de Tecnología Agropecuaria), Argentina.

IPB: Institute for Plant Breeding, the Philippines.

IPO: Research Institute for Plant Protection (Institut voor Plantenziektenkunding Onderzoek), the Netherlands.

ISEPTON: International Septoria Observation Nursery.

ISSN: International Scab Screening Nursery.

ISWYN: International Spring Wheat Yield Nursery.

ITSN: International Triticale Screening Nursery.

ITYN: International Triticale Yield Nursery.

KB: Karnal bunt.

KBSN: Karnal Bunt Screening Nursery.

kg: kilograms.

kg/ha: kilograms per hectare.

kg N/ha: kilograms of nitrogen per hectare.

l/ha: liters per hectare.

LACOS: Advanced Lines of the Southern Cone (Líneas Avanzadas del Cono Sur), a regional nursery for the Southern Cone region.

Lagunilla: an off-station site near La Lagunilla, Hidalgo, Mexico.

LO: observation lines (líneas de observación).

Los Mochis: the Fuerte Valley Agricultural Experiment Station (Campo Agrícola Experimental Valle del Fuerte), administered by the National Institute of Agricultural Research (INIA); 40 meters elevation, 26°N latitude.

LSD: least significant difference, a statistical measure of the importance of differences in data.

m: meters.

mm: millimeters.

mono-5B: a genetic stock of the Chinese Spring variety of bread wheat in which one member of the normally paired chromosome 5B is missing. In intergeneric hybrids lacking this chromosome, pairing is enhanced at meiosis.

NARC: National Agricultural Research Centre, Pakistan.

Navojoa: the Mayo Valley Agricultural Experiment Station (Campo Agrícola Experimental Valle del Mayo), administered by the National Institute of Agricultural Research (INIA).

NPBS: National Plant Breeding Station, Kenya.

nursery: a small amount of seed or a small number of plants of a line or variety used in an experimental plot.

NWFP: Northwest Frontier Province, Pakistan.

NWPP: National Wheat Pilot Project, the Philippines.

OCEPAR: Organization of Cooperatives of the State of Parana (Organização das Cooperativas do Estado do Paraná), Brazil.

OSU: Oregon State University, USA.

Patzcuaro: the Tarascan Mountains Agricultural Experiment Station (Campo Agrícola Experimental "Sierra Tarasca"), administered by the National Institute of Agricultural Research (INIA); 2043 meters elevation, 20°N latitude.

PAV: An isolate of barley yellow dwarf virus transmitted nonspecifically by *Rhopalosiphum padi* and *Sitobium avenae*.

PBI: Plant Breeding Institute, Cambridge, England.

PC: small seed multiplication plot (parcela chica).

PMI: plot for seed multiplication for international trials.

Pn:Pw: ratio of the price of nutrients (fertilizer) to the price of the wheat produced.

PNC: National Cereals Program (Programa Nacional de Cereales), a special program of the Peruvian National Institute of Agricultural Research and Extension (INIPA).

Poza Rica: the Poza Rica Experiment Station, administered by CIMMYT; 60 meters elevation, 21°N latitude.

ppm: parts per million.

R: regenerant from tissue culture; R-1, R-2, etc. refer to the first, second, etc. regenerant generations made by reculturing tissue from whole plants of the previous generation.

RDTN: Regional Disease Trap Nursery.

Rio Bravo: the Rio Bravo Agricultural Experiment Station (Campo Agrícola Experimental "Rio Bravo"), administered by the National Institute of Agricultural Research (INIA); 30 meters elevation, 26°N latitude.

S.: *Secale*.

Santiago Izcuintla: the Santiago Izcuintla Agricultural Experiment Station (Campo Agrícola Experimental "Santiago Izcuintla"), administered by the National Institute of Agricultural Research (INIA); 40 meters elevation, 22°N latitude.

SD: standard deviation.

stripe rust: synonym of yellow rust.

T.: *Triticum*.

t/ha: metric tons per hectare.

Toluca: the Toluca Experiment Station, administered by CIMMYT; 2640 meters elevation, 19°N latitude.

TON: Thailand Observation Nursery.

top cross: a cross between an F_1 and a variety or line genotypically different from either of the parental varieties or lines.

Triticum aestivum: bread wheat.

Triticum durum: a synonym of *T. turgidum* ; durum wheat.

Triticum turgidum: durum wheat.

TYN: Thailand Yield Nursery.

ULVA: ultra-low volume applicator.

USA: United States of America.

USDA: United States Department of Agriculture.

USDA-ARS: Agricultural Research Service of the U.S. Department of Agriculture.

VEOLA: Disease and Observation Nursery in Latin America (Vivero de Enfermedades y Observación en Latinoamérica).

WON: Wheat Observation Nursery.

WRC: World Rye Collection, a germplasm bank.

WUE: water use efficiency.

X.: *Xanthomonas.*

Z.: Zadok growth stage.

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