CIMMYT ANNUAL REPORT 1972
ON MAIZE AND WHEAT IMPROVEMENT

1972

Annual Report

Centro Internacional de Mejoramiento de Maíz y Trigo

International Maize and Wheat Improvement Center

Londres 40 Apartado Postal 6-641 México 6, D. F., México

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Introduction

The year 1972 was a period of continued progress for CIMMYT and its network of collaborators.

To summarize: significant scientific gains are described in this annual report for each branch of CIMMYT's crop research. In-service trainees at CIMMYT reached an all-time high for one year (82). CIMMYT staff scientists were in residence in nine countries outside Mexico to assist wheat and maize production programs. CIMMYT donors under leadership of the World Bank provided the Center with financing which totalled $6.4 million, more than in any previous year. This continued growth required a more careful program review, and CIMMYT responded by holding two program reviews and one administrative review during the year (see below).

In research, one significant breakthrough in 1972 came from the maize staff, which harvested a new opaque-2 line containing higher lysine levels and higher tryptophan levels combined with the hard endosperm (inner kernel) preferred by most of the world's maize eaters. This maize with higher quality protein was undergoing field trials in 16 countries of Asia, Africa, and Latin America at the end of 1972.

Other significant improvements for cereals are reported in the following pages: for example, for the bread wheats, progress in crossing winter-spring wheats; for the durums, which now are dwarfed and rapidly improving in yield potential; for triticale, the man-made wheat-rye cross, in which the problem of shrivelled grain was substantially solved in 1972; for barley, a program resumed in 1972 after an interval of 10 years; for short, lodging-resistant tropical maize lines, now reduced in height by more than one meter; and for cold-tolerant sorghum, which sets seed at elevations above 2,000 meters in the tropics. The CIMMYT scientists report each of these developments.

Training programs at CIMMYT are considered an index of progress because the trainees returning home strengthen the capacity of their governments to conduct local research under climatic conditions faced by local farmers. The number of in-service trainees at CIMMYT has increased each year during the last three years: 1970, 42 trainees from 18 countries; 1971, 67 trainees from 20 countries; and 1972, 82 trainees from 35 countries.

Pressure to accept a larger number of trainees continues to increase, but the CIMMYT scientific staff believes that the number of trainees should not exceed the number that can be given individual attention--which may already be close.

In 1972 CIMMYT stationed members of its scientific staff in two new national production programs (Zaire and Nepal), both for maize. These new assignments were in addition to earlier programs still continuing. The older programs are: for wheat production, in Algeria, Morocco, Tunisia, and Turkey; and for maize production, in Colombia, Egypt and Pakistan.

CIMMYT's financing, it now appears, has become more stable and more adequate after the organizing of the Consultative Group for International Agricultural Research in November 1971. This body consists of 27 members interested in supporting the international research centers. Members of the Group include governments, international agencies, and private foundations.

CIMMYT received assistance in 1972 from eight of these donors: from the Governments of Canada, Denmark, and the United States; from three international organizations--the Inter-American Development Bank, the U.N. Development Fund, and the World Bank; and from the Ford Foundation and Rockefeller Foundation. The financial support provided to CIMMYT over the past three years is summarized in the following table.

CIMMYT FINANCING FOR 1970-72 (US$)

	1970	1971	1972
General operations in Mexico	2,156,000	2,259,000	2,998,000
Capital plant investment in Mexico	2,540,000	1,947,000	975,000
Grants for projects specified by the donor	1,055,000	1,713,000	2,152,000
Miscellaneous income	110,000	256,000	322,000
Total financing	5,861,000	6,175,000	6,447,000

CIMMYT's new headquarters, 50 kilometers northeast of Mexico City, experienced its first full year of use during 1972. The buildings and laboratories proved both functional and attractive. New staff service units have been organized for building and grounds maintenance, for vehicle and machinery repairs, and for dormitory and food services, and these slowly gained experience during the year.

An important new element of the CIMMYT program in 1972 was the addition of an economic studies unit. By recommendation of the Trustees, the first thrust of the economic unit was a series of studies on the adoption of new technology for wheat and maize. These studies were in progress at the end of 1972 in four wheat-growing countries (India, Iran, Turkey and Tunisia) and in four maize-growing countries (Kenya, Mexico, El Salvador and Colombia). Preliminary findings are expected in mid-1973, and a comprehensive report in 1974.

A program review was requested in 1972 by the donors, and CIMMYT responded energetically (some staff think too energetically). CIMMYT invited an external panel composed of three scientists and one economist to review its program in March 1972. The Panel's thoughful report was made available to donors at International Centers Week in July 1972. To explore a different type of program review, the CIMMYT senior staff held a series of seminars in their own research plots and laboratories during September-December 1972. This review resulted in a program evaluation which will be available to donors at International Centers Week in 1973. In December 1972 CIMMYT invited still another external panel to review CIMMYT's administration. The report was made available to donors.

Although review of programs and administration proved a heavy burden to the senior staff in 1972. It is expected that a simpler procedure will develop whereby an annual review can be held and the findings distributed to the Consultative Group.

The number of senior staff at CIMMYT in 1972 remained at about 40, the same as in 1971.

Haldore Hanson
Director General
El Batán, México
June 1973

Dr. Joseph A. Rupert
1916-1972

In 1972 death came to an agricultural officer who had given distinguished service to the Rockefeller Foundation and to CIMMYT.

Dr. Joseph A. Rupert first arrived in Mexico in 1947 to assist N. E. Borlaug in wheat pathology.

The Rockefeller Foundation subsequently appointed Dr. Rupert head of its cooperative wheat improvement program in Colombia (1950-55) and director of its cooperative agricultural program in Chile (1955-68). The governments of both Colombia and Chile decorated Dr. Rupert for his services.

In 1968 the Rockefeller Foundation transferred Dr. Rupert to the University of California (Davis) to direct a new program for intercrossing spring and winter bread wheats, in collaboration with CIMMYT. This work was beginning to show important results last year, before Dr. Rupert died.

No one can replace Dr. Rupert. But CIMMYT is continuing the winter-spring crossing program by cooperative action among the University of Oregon, the Government of Turkey, and the wheat staff at CIMMYT.

WHEAT

Page

INTRODUCTION

The precariousness of the world food supply was brought sharply into focus by events in the last six months of 1972. It became clearly evident again that a poor harvest in a single large cereal-producing country can have worldwide impact on food grain stocks, food prices and shipping. What would happen if there were poor harvests in two of the large cereal-producing countries in the same year?

Although the 1972 world grain harvest has been estimated at 1.064 billion metric tons, the second largest crop on record, production declined by approximately 42 million tons from the previous year. Much of this decrease resulted from a poor wheat harvest in the USSR, caused by severe winter-killing and a severe drought in the spring wheat areas. The poor harvest resulted in Russia's contracting for 20 million tons of wheat in the international market as of October, 1972. Estimates indicate that these Russian purchases, as well as increased imports by several other countries, will increase wheat world trade during the 1972-73 year to about 67 million metric tons compared to 52 million tons for the previous year. With the increased demand for wheat grain, prices have risen sharply on the international market. On July 1, 1972, the cash price for No. 2 Red Winter wheat at United States Gulf ports was about US$55 per metric ton; by December 31 it was more than US$100 per ton. The heavy demand for freighters and shortage of shipping capacity also increased ocean freight rates by 40 percent during the same period. The poor harvest coincided with a growing shortage of fertilizers, especially phosphorous, on the international market and prices have increased 10 to 30 percent.

Fortunately, the poor harvest in the USSR coincided with a period when the total world grain stocks, including feed grains, were at a moderately high level, for example, July 1, 1972, 132 million metric tons. It is estimated that the stocks will fall to 117 million tons by July 1, 1973. The world grain situation, however, is much more critical for *food* grains than for feed grains.

The world wheat stocks in exporting nations stood at 49 million metric tons on July 1, 1972, and current estimates indicate they will fall to 34 million tons by July 1, 1973. The food grain situation in Asia is also further complicated by a shortage of rice, caused by military disruptions in Bangladesh, Vietnam, and Cambodia, by floods in the Philippines, by drought in India, and by unwise, short-sighted economic policies which restrict production in some other countries.

Fortunately, the 1972 wheat harvests from India to Morocco were good to excellent. India, Afghanistan, Pakistan, Iran, Iraq, Turkey, Jordan, Lebanon, Tunisia, Algeria and Morocco harvested record or near-record crops. Throughout the area the impact of the Green Revolution, especially on wheat production, continues to expand. The area sown to high-yielding varieties and the use of chemical fertilizers and other improved cultural practices continues to spread. Favorable weather throughout the India-Pakistan subcontinent, the Middle East, Near East and North Africa during the 1971-72 wheat crop season also contributed greatly to the excellent harvest.

Losses from diseases and insects were of little consequence anywhere in North Africa, the Near East and Middle East during the 1971-72 crop season. Moreover, several new high-yielding dwarf wheat varieties developed in these countries and carrying different types of disease resistance are beginning to reduce the area sown to the widely grown cross 8156 derivatives, for example, Kalyansona, Mexipak, 7 Cerros, etc., that were introduced directly from Mexico. This diversification of genotypes reduces, though it does not eliminate, the danger of widespread disease epidemics. Vigorous breeding programs must be maintained to provide a continuous flow of varieties with new sources of resistance to provide better protection against new races of the pathogens.

Despite the progress being made in increasing wheat production in many of the aforementioned countries, there is no room for complacency. One can easily imagine the famine and human suffering that would have resulted if adverse weather conditions such as the USSR suffered during 1972 had also simultaneously struck the India-Pakistan subcontinent. Indeed, it is largely because of the consecutive record-breaking wheat harvests culminating in a 1972 crop of 26.5 million metric tons (compared to a 1965 harvest of 12.4 million) that permitted India to stockpile more than 9 million tons of food grains, mainly wheat. This stockpile is now serving India well to offset the poor 1972 rice and sorghum harvests.

Moreover, in times of pending food crisis, such as the world now faces, one must take stock not only of the shortfalls in production, but also of the progress achieved in recent years. What would the world food grain situation be today without the achievements of the Green Revolution in the subcontinent of India and Pakistan? What would the plight of their people be today if these countries were still producing 15.5 million metric tons of wheat jointly as they did in 1965, instead of the 33 million tons they harvested in 1972?

It becomes ever more apparent that the developing nations must be aided in improving their agriculture so they can produce most of the food that they need. One of the greatest obstacles to achieving this goal is the lack of trained, well-motivated agricultural scientists. CIMMYT continues to provide practical training for many young scientists in the fields of agronomy, plant breeding, plant pathology, plant physiology and cereal technology. Within the past year funds for this purpose have been increased, and the number of trainees has been increased to the maximum that can be instructed effectively by the present staff.

CIMMYT continues to provide genetic materials, both segregating and advanced fixed lines, of bread wheat, durum wheat, triticale and barley to cooperators throughout the world. The CIMMYT gene pools of these crops are constantly being modified and broadened to increase the spectrum of disease and insect resistance in the material distributed. Wheat yield stability, to a large extent, *is* dependent upon the development and widespread use of disease-resistant varieties.

Increased yield stability in wheat production--as well as in all cereals--is a major need for all countries. Widespread disease epidemics can lead to famine. Better control of diseases is the most important factor contributing toward increased yield stability that can be manipulated by plant breeders. Are we giving this aspect of varietal improvement sufficient emphasis?

More effort must be on breeding for increased yield stability, especially as it relates to disease resistance. CIMMYT scientists believe that the present national yields of wheat in all the developing nations can be doubled with the currently available commercial varieties if adequate fertilizer is applied and if diseases are controlled. Wheat breeders must not be lured into placing undue stress on developing higher yielding varieties without improving the level and spectrum of disease resistance.

In-service trainees fill seed packets for distribution to some 60 countries with which CIMMYT exchanges materials.

From 1963 to 1972 the small CIMMYT wheat staff was heavily committed to assisting India and Pakistan, and more recently to many Near East, Middle East and North African countries, to increase their wheat production. During this period, there was little opportunity to continue directly assisting the Latin American countries with their wheat production problems, although CIMMYT did continue to supply them with genetic materials. CIMMYT wheat staff members visited several of these countries during 1972 with the aim of re-establishing closer cooperation. The countries visited include Guatemala, Ecuador, Peru, Brazil and Argentina. Tentative plans have been made to visit Colombia, Chile, Bolivia, Paraguay and Uruguay during 1973. Plans are also being made to establish a cooperative regional testing program to serve South American countries.

A shortage of chemical fertilizer continues to be one of the greatest obstacles to increasing cereal production in the developing nations. While top priorities and allocation of huge sums of monies are often devoted to dam and irrigation development projects, only low priorities and inadequate funds, if any at all, are allocated for developing an efficient fertilizer industry, even when the raw materials are available. The result of inadequate planning for fertilizer production capacity as well as for timely imports of fertilizers will make it difficult for several developing countries to attain their 1973 cereal production targets. Currently, the world demand for fertilizer has outgrown production capacity. Consequently, several countries, such as India and Pakistan, which are attempting to achieve and maintain self-sufficiency in cereal production, were "caught short" of fertilizer, especially phosphates, dur-

A CIANO staff member gestures to emphasize a point in his discussion of wheat breeding problems. Many visitors from around the world visit the CIANO station each year.

ing the fall 1972 wheat planting season. The CIMMYT wheat staff contends that higher priorities and a greater allocation of funds must be made for fertilizer plant construction if the developing countries are to meet food production needs.

MEXICO

The Resident CIMMYT Program Conducted in Collaboration with the National Program of Mexico

CIMMYT, like other international centers, cooperates very closely with the national program of the host country. All of the materials under development are made available to the *Instituto Nacional de Investigaciones Agrícolas* (INIA) for use in Mexico. Since many readers may not be fully aware of this relationship, it seems appropriate to provide an explanation.

CIMMYT has not released and will not release named commercial varieties. It only makes available materials at all stages of development to cooperating national programs. National programs use these materials directly for further selection or to incorporate them in their crossing programs. Any improved types may be named by the national programs and put into commercial production. Mexico is no exception. Certain of the present commercial varieties of Mexico have been developed in this way, but others have emanated directly from the national program activities. Thus, Mexican varieties are truly Mexican.

There is, however, a special relationship in Mexico between the national and international programs since the principal CIMMYT wheat nursery is grown on the CIANO station of the INIA system. This station, located in Sonora State in northwestern Mexico, is operated by INIA and receives direct assistance from the farmers of the region. Thus, all materials at all stages are directly available to CIANO and, hence, to INIA. One INIA scientist is employed as a liaison plant breeder between the two programs. INIA also operates several stations throughout the wheat growing areas of Mexico and, in this way, widespread testing is done within the national program. INIA also conducts a dynamic national breeding program involving many crosses for many crops, including bread wheat, durum wheat and barley, and INIA makes these materials available to CIMMYT. This relationship, as for other cooperating national programs, greatly assists the development of new germ plasm in CIMMYT materials. Thus, the Mexican National Program in wheat as a country program is included in this report immediately following the report on the CIMMYT Resident Program in Mexico.

THE BREAD WHEAT PROGRAM

In the past year nursery development was good at all three locations --CIANO, Toluca, and El Batan. Leaf rust developed early at CIANO and susceptible varieties were under heavy selection pressure. Leaf rust infection reduced Inia 66 yields about one ton/ha. Stem rust infection was at a sufficiently high level to permit effective selection. At Toluca, stripe rust began early and essentially destroyed Siete Cerros production. *Septoria tritici* was also much heavier than last year and it is now possible to select for resistance to prevalent strains of this disease.

In the past year 14 advanced lines were considered to have superior yields, disease resistance and agronomic characteristics. These are presented in Table W1.

The yield of the highest yielding check is shown below that of each genotype. Generally, yields of these outstanding lines were equal to or superior to the highest yielding check variety. In a few cases, lines were chosen primarily for outstanding disease resistance or other characteristics. The line 12300 x LR64 - 8156/Nor67 appears particularly promising.

The average yield and disease reactions for the CIMMYT Elite No. 1 and CIMMYT Elite No. 2 yield tests grown at 12 and 17 locations in different countries, respectively, are given in Tables W2 and W3. It is evident that the Bluebird series of varieties continue to show good yields and relatively low coefficients of infection. Moreover, the outstanding performance in grain yield and disease resistance of several other lines in these tests indicate they should be considered as potential candidates for varietal release in several national programs.

Table W4 presents data for Mexican varieties grown in the International Spring Wheat Yield Nursery for six consecutive seasons from 1964-65 to 1969-70 plus average coefficients of infection for stem rust, leaf rust and stripe rust. As expected, there has been a gradual erosion of resistance in those varieties grown widely on a commercial scale, resulting in a selection pressure for new virulent strains of the rusts. (One must ignore the 1965 results represented only by a few reporting locations where diseases were very prevalent). Among the varieties under study, Roque 66, Jaral 66 and Tobari 66 have shown a continuing high level of resistance. Azteca 67, which is a sister strain of Ciano 67, also has generally maintained better resistance than Ciano 67.

These data give strong evidence of the effects of selection pressure of widely grown commercial varieties such as Siete Cerros, Lerma Rojo 64A and Penjamo 62 on the rust pathogens.

The International Bread Wheat Screening Nursery (IBWSN) is grown in cooperating national programs worldwide. It consists of the best lines and varieties which entered yield tests in Mexico each year. The number varies from year to year, depending on the selection pressure in the nurseries. The results of the Third IBWSN (Series A) grown in 1969-70 are now available. Certain cross combinations have provided many sister strains showing acceptable disease resistance and high yields. Crosses appearing most often as promising disease resistance are shown in Table W5.

With the exception of four crosses, the variety Ciano 69 appears as a parent in all of the outstanding new crosses. Twenty-nine crosses had only one line with a reaction of less than 10S to all three rusts and, hence, were omitted from Table W5. With these lines included, the frequency of parental appearance in the crosses with five or more resistant lines is: Ciano 67, 85 lines; Bluebird, 39; Inia, 34; Tobari 66, 28; Sonora 64, 14; Corre Caminos, 14; Chris, 14; Son 64-Kl. Rend., 10; Lerma Rojo 64, 10; Tezanos Pinto Precoz, 8; Penjamo 62, 6; Calidad, 6; and Noroeste 66, 5.

We may further define this list with regard to parental composition. Ciano 67 is one of the parents of the Bluebird series and appears 124 times. Inia 66 is a sister of Noroeste 66. Hence, collectively the Son 64 x

TABLE W1. Characteristics of superior bread wheat lines in yield tests at CIANO, Sonora, Mexico (1971-72).

Genotype and pedigree	Yield kg/ha	Grain weight kg/hl	PK[b] min	Protein %	Alveogram P/G	Alveogram W	Sedimentation cc	Loaf vol cc	Rust reactions *P. gram. tritici*	Rust reactions *P. recondita*	Height
Yecora "s" 23584-26Y-2M-1Y-0M-302M	7 344 8 203 Cj [a]	81.3	120	12.7	5.8	380	51	. . .	0	10S	E·$_2$
Bb - Inia 66 26591-1T-7M-0M-55Y-0M	7 479 8 302 Coc	81.8	120	11.8	5.0	299	55	650	TR	20MR	E·$_2$
Chanate # 2 = Cno-Pj62xCno-7C 26665-22Y-300M-301Y-2M- 501Y-500M-0Y	8 291 7 911 7C	81.2	38	8.8	3.9	163	25	680	TR	10MS	E$_2$
12300 x LR64-8156/Nor67 30842-31R-2M-2Y-0M	8 156 7 459 7C	80.2	120	9.7	6.2	307	61	640	TR	TR	E$_1$
Cno - Inia66 x Bb 28339-17Y-1M-1Y-0M	6 355 7 049 Cj	82.2	120	11.7	3.1	513	69	845	TRMR	10MR	E$_2$
Chanate # 1 = Cno-Pj62xCno-7C 26665-22Y-300M-301Y-1M- 500Y-0M	8 224 8 276 Cj	81.9	53	9.3	3.3	169	31	675	TS	10MR	E$_1$
Kal - Bb 26703-30M-1Y-1M-3Y-0M	7 854 7 912 7C	81.3	120	10.4	6.3	262	39	655	0	5MR	E$_3$
Kal - Bb 26702-30M-1Y-1M-500Y-OM	7 797 8 276 7C	82.9	120	11.5	5.1	330	49	755	TR	5MS	E$_3$
Inia66 - RL4220 x 7C 35038-7Y-1M-0Y	7 359 7 843 7C	82.6	120	11.2	4.6	335	51	780	0	10MS	E·$_2$
Inia66-Bb/Inia66-Cno x Cal 34178-64Y-7M-0M-(6.50)-M	6 308 5 876 7C	83.2	93	9.8	7.7	221	35	740	10MR	20MS	E·$_2$
Son64-Kl. Rend x Nor67/Azt67 29187-3R-1M-1T-0R	8 061 7 373 Ti	81.8	120	11.9	7.6	499	43	810	10MR	5MR	E·$_2$
Inia "s" - Napo63 x Cno 25483-8M-4T-2M-3R-0M	6 863 7 311 Cj	81.9	120	10.0	5.6	386	44	710	. . .	. . .	. . .
Cno "s" - Jar66 25339-14M-1S-2R-3R-0M	6 905 6 696 Yr	82.8	115	10.9	5.3	376	49	755	TR	TR	. . .
7C - On x Inia66 - B. Man 28424-8Y-1M-1Y-0M	7 958 7 912 7C	81.5	111	11.9	8.3	321	39	650	TR	20MS	E·$_1$

[a] Highest yielding check variety in the same experiment and yield (kg/ha).

[b] PK = Pelshenke value.

LR 64 cross appears 39 times. Tobari 66, from the cross Tzpp x Son 64, is related to Calidad, from the cross Tzpp-Son64/LR64-Tzpp x AnE3. Therefore, Tzpp x Son 64 appears 31 times in the parentage. Sonora 64 is present in Ciano 67 (= Pi62 - Chris "S" x Son64), in the Bluebirds, in Inia 66, in Tobari 66, in Corre Caminos, in Son 64-Kl. Rend., in Calidad and in Noroeste 66. It is involved in the parentage of 234 of these lines. Chris is present in Ciano 67 and, hence, in the Bluebirds. So, it is involved in 138 of the lines. Sonora 64 - Klein Rendidor is represented by the Bluebirds and is present in 49 lines. Lerma Rojo 64 is present in Inia 66, Calidad, and Noroeste 66, so it appears in 45 lines. Tzpp appears in Tobari 66 and Calidad, or 41 lines. Penjamo 62 appears in the Bluebird series and is present in 45 lines. The relationships of these varieties is shown schematically in Fig. W1. Some 27 additional varieties appear in the parentage of crosses giving rise to one to four resistant lines.

It appears from this relationship that the outstanding CIMMYT materials are narrow-based genetically. To a degree this is true, but steps have been taken using a

TABLE W2. Average yield and reaction to rusts of the bread wheat genotypes in the CIMMYT Elite Selection Yield Trial #1 (1969-70).[a]

Genotypes and pedigree	Yield kg/ha	Coefficient of infection: Stem rust [b]	Coefficient of infection: Stripe rust [b]
Bb # 4 = Cajeme 71 23584-26Y-2M-3Y-2M-0Y	4 988	3.5	9.4
Inia 66 19008-83M-100Y-100M-100Y-100C	4 890	11.6	20.4
Bb # 3 = Saric 70 23584-26Y-2M-2Y-0M	4 759	2.0	10.5
Inia"s"-Napo63 = Tanori 71 22402-6M-4Y-1M-1Y-0M	4 735	7.0	11.3
Bb # 2 = Yecora 70 23584-26Y-2M-1Y-0M	4 718	8.2	16.1
Cno"s"-Inia"s"[2] 23959-13T-1M-5Y-0M	4 640	3.6	17.2
Bb # 1 = Nuri 70 23584-15Y-6M-0Y	4 629	14.6	15.1
Penjamo 72 7078-1R-6M-1R-1M	4 584	25.2	21.0
Bluebird # 7 23584-18M-10Y-3M-3Y	4 567	4.0	7.5
Kl. Rend. x Son64 x Inia"s" x Cno"s" 24970-29M-3Y-2M-0Y	4 560	0.48	13.7
No66"s" x Cno"s" 24941-23M-5Y-2M-0Y	4 526	3.8	20.4
23584 x Cno"s" 26592-1T-17M-0Y	4 479	0.16	14.6
Tob 66 x Cno"s" 24908-30M-3Y-3M-0Y	4 409	6.4	2.1
Tob x Cno"s" 25000-6M-2Y-0M	4 397	5.1	12.0
Bluebird # 5 23584-37Y-2M-2Y-0M	4 376	4.8	7.5
Sonora 64 8469-2Y-6C-4C-2Y-1C	4 308	24.8	28.4
Tob-Cno"s" 25000-68M-2Y-0Y	4 284	0.4	9.1
Son-Kl. Rend. Cno"s" x LR64[2]-Son64 27130-57M-0Y	4 222	2.0	13.1
Tob-Cno"s" 25000-13M-3Y-2M-0Y	4 221	0.16	15.6
Tobari 66 19021-4M-3Y-102M-100Y-101C	4 219	2.0	10.5
7 Cerros 8156-1M-2R-4M	4 200	35.6	24.8
Ciano 67 19957-18M-1Y-3M-9Y	4 191	5.1	28.1
Tob-cno"s" 25000-26M-1Y-0Y	4 138	1.1	10.2
23584-Cno"s" 26572-6Y-3M-0Y	4 013	0.4	24.8
Cno"s"?Inia"s"[2] 23959-52T-1M-3Y-0M	4 011	0.4	15.7

[a] Countries and number of locations where test was grown: U. S. A. (4 locations), Pakistan (1), U. A. R. (1), Tunisia (1), South Africa (1), Morocco (1), Ecuador (1), Mexico (2).

[b] Average values from 5 locations only: North Dakota, Egypt, Tunisia, South Africa and Mexico.

TABLE W3. Average yield and reaction to rusts of the bread wheat genotypes in the CIMMYT Elite Selection Trial #2 (1970-71).[a]

Genotype and pedigree	Yield kg/ha	Coefficient of infection	
		Stem rust[b]	Stripe rust[c]
Yecora "s" (R) 23584-26Y-2M-1Y-0M	4238	1.8	7.0
Yecora "s" (R) 23584-26Y-2M-1Y-0M	4200	0.8	12.0
Bluebird # 4 Reselec. 23584-26Y-2M-3Y-1M-0Y	4178	0.4	3.5
Yecora "s" 23584-26Y-2M-1Y-0M-89Y	4174	0.2	12.5
Inia-Cal x Inia"s"-CC	4140	0.2	25.0
Cno"s"-Inia 25717-11Y-3M-1Y-0M	4123	0.8	0.4
LR64-Son64^2 x Tob 27180-26M-4Y-3M-0Y	4100	0.1	2.7
Cal/Cno"s" x LR64^2-Son64 27169-48M-1Y-1M-0Y	4045	0	10.0
Bluebird # 4A (R) 23584-26Y-2M-3Y-2M-0Y-300M	4026	0.1	5.0
7 Cerros 8156-1M-2R-4M	4024	3.6	15.0
Inia 66 19008-83M-100Y-100M-100Y	3990	0.8	0.2
Saric 70 23584-26Y-2M-2Y-0Y	3978	0.2	5.0
Kal-Bb 26902-30M-1Y-1M-0Y	3947	0	39.5
Bluebird (R) 23584-102M-103Y-100M-0Y	3937	0.2	5.0
CC-Inia x Cno"s"-Son64 28084-1Y-4M-0Y	3929	0.8	10.0
Penjamo 62 7078-1R-6M-1R-1M	3873	21.6	4.0
Cpo-Cno(Son64 x Tzpp-Y54/Cno) 25820-16Y-1M-1Y-0Y	3865	6.8	0
Robin # 1 26787-300Y-300M-302Y-301M-0Y	3864	0.2	0.2
Bb - Inia 26591-1T-7M-0Y	3824	0.2	0
Tobari 66 19021-4M-3Y-102M-100Y-101C	3742	0.2	0.2
Inia-Bb 26478-32Y-9M-1Y-5M-0Y	3680	2.9	2.5
Cno^{2}Son64-Kl. Rend. 26529-3T-7M-4Y-4M-0Y	3626	0.2	0.4
Cno"s"-Son64 26529-3T-7M-4Y-4M-0Y	3581	0.4	2.0
Cno"s"-Son64 23582-50Y-3M-0Y	3581	0.4	2.0
Jar-Napo-Sharbati 28048-20Y-2Y-0Y	3572	0.2	0.2
Bb-Cno 26592-1T-16M-1Y-1M-0Y	3310	0.2	2.0

[a] Countries and number of locations where test was grown: U.S.A. (4 locations), U.S.S.R. (1), Morocco (2), Tunisia (2),
[b] Average values from 2 locations; U.S.A. and Iran.
[c] Average values from 2 locations; Iran and Tunisia.

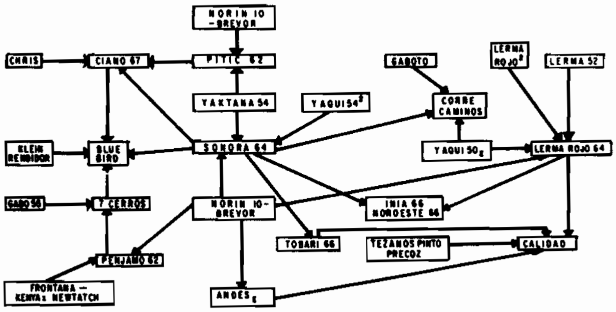


FIG. W1. Relationships of principal varieties appearing in the parentage of superior lines of the Third International Bread Wheat Screening Nursery.

system of top crosses and double crosses to greatly diversify and expand the varieties contributing to the gene pool. The new materials which have not yet reached the yield testing stage reflect this input. Nevertheless, it remains to be seen whether the new combinations can compete in yield with the materials currently in the yield nurseries.

The plant breeder dealing with improved varieties must recognize the superior germ plasm built up in a program and realize that new genes for yield, disease resistance and other characteristics must be added to the "hard core" base of improved germ plasm. This accounts for the very few times that a single cross of an improved variety x a native cultivar produces usable, high-yielding, disease-resistant and agronomically acceptable varieties. In other words, trying to improve land

TABLE W4. Average yields and coefficients of infection for the three rusts of the Mexican bread wheat varieties included in the First to the Sixth International Spring Wheat Yield Nursery (1965-70).[a]

Variety	Yield rank[b]	Yield, kg/ha						*Puccinia graminis tritici*						*Puccinia recondita*						*Puccinia striiformis*					
		1965	1966	1967	1968	1969	1970	1965	1966	1967	1968	1969	1970	1965	1966	1967	1968	1969	1970	1965	1966	1967	1968	1969	1970
Pitic 62	2	3526	3124	3500	3499	3032	3289	8.8	10.3	22.2	19.9	16.5	35.4	52.0	10.0	22.8	31.3	15.8	37.6	34.2	12.0	23.3	8.4	11.5	25.6
Nainari 60	7	3422	3145	3244	3214	2843	3041	13.2	10.3	10.3	15.0	16.0	38.7	7.0	5.1	20.7	7.4	4.2	19.8	53.5	19.8	31.6	25.4	21.0	41.3
Penjamo 62	3	3417	3263	3407	3474	3055	3273	6.0	7.8	8.7	13.6	10.1	23.8	10.4	4.6	15.7	8.1	8.3	12.8	52.5	12.0	17.5	11.1	16.3	20.5
Siete Carros	5	3321	2983	3203	3485	3016	3301	5.4	8.3	25.8	21.5	11.9	33.3	20.0	12.7	16.3	36.4	32.0	42.1	39.8	18.2	21.6	15.9	21.1	35.9
Lerma Rojo 64A	6	3253	3021	3461	3225	2917	3138	1.0	6.2	12.9	15.4	8.4	21.2	32.3	6.5	12.9	18.3	15.3	50.1	50.0	20.4	19.6	13.3	22.5	24.4
Sonora 64	15	2718	2400	2787	2973	2612	....	24.0	5.9	16.9	12.6	14.4	....	12.0	5.3	17.3	15.6	13.7	....	47.5	31.5	56.4	35.0	33.3	....
Roque 66	12	....	2940	2900	....	....	....	....	3.0	4.0	....	....	....	....	3.5	1.6	....	....	....	....	6.8	8.5	....	....	....
Jaral 66	13	....	2912	2912	2918	....	....	....	3.3	5.4	3.5	....	....	....	2.7	7.7	2.4	....	....	....	4.2	2.2	4.0	....	....
Bajio 66	17	....	2846	....	....	....	....	....	2.9	....	....	....	....	....	3.6	....	....	....	....	....	13.2	....	....	....	....
Super X	1	....	....	3374	3469	....	....	....	....	11.3	17.2	....	....	....	....	10.8	12.3	....	....	....	....	18.6	13.3	....	....
Inia 66	4	....	....	3355	3502	2937	3307	....	....	10.7	3.9	4.4	9.7	....	....	3.8	16.8	11.0	17.9	....	....	17.2	12.1	16.7	42.9
Noroeste 66	9	....	....	3199	3325	2853	....	....	....	1.7	3.2	4.2	....	....	....	3.5	8.4	3.8	....	....	....	17.7	22.3	20.5	....
Tobari 66	8	....	....	3178	3275	2849	3296	....	....	0.9	1.1	3.0	6.9	....	....	1.7	3.2	1.1	3.0	....	....	4.6	1.6	4.0	12.4
Ciano 67	11	....	....	3000	2972	2519	3212	....	....	0.5	5.6	7.4	11.4	....	....	6.9	4.8	2.0	11.0	....	....	9.6	8.2	11.3	18.1
Yaqui 50	14	....	....	2854	2941	....	....	....	....	11.4	5.4	....	....	....	....	12.6	15.9	....	....	....	....	8.6	8.2	....	....
Azteca 67	16	....	....	....	3273	....	....	....	....	....	3.3	....	....	....	....	....	2.2	....	....	....	....	....	2.4	....	....
Norteño 67	10	....	....	....	3268	2761	....	....	....	....	2.8	4.6	....	....	....	....	8.1	2.1	....	....	....	....	5.6	11.9	....

[a] Number of locations from which data were obtained differs for yield and for each one of the rusts. Nevertheless, the reporting countries (representing the major wheat krowing areas of the world) for the six ISWYN presented in the table are: Ist ISWYN (1964-65), 34 locations in 23 countries; 2nd ISWYN (1965-66), 50 locations in 28 countries; 3rd ISWYN (1966-67), 62 locations in 30 countries; 4th ISWYN (1967-68), 63 locations in 34 countries; 5th ISWYN (1968-69), 63 locations in 34 countries; and 6th ISWYN (1969-70), 63 locations in 37 countries.

[b] For average yields of 2 to 6 years.

races is a losing battle. *Land races must be used indirectly to improve the gene pool, but generally they will not directly produce superior commercial varieties.*

NATIONAL INSTITUTE OF AGRICULTURAL RESEARCH, CEREALS DEPARTMENT

Most of Mexico's wheat production is from irrigated areas using fertilizers. Although eight percent of the wheat acreage is sown under rainfed conditions, the yield per unit of area is so low that it contributes only two percent of total production.

The important wheat growing areas in Mexico are: (1) the Northwest, comprising the State and Territory of Baja California, Sonora and Sinaloa; (2) the states of Chihuahua and Coahuila; (3) a central region formed by the states of Guanajuato, Michoacán and Jalisco; and (4) small rainfed areas in the states of Oaxaca, Chiapas, Nuevo Leon, Michoacán and Chihuahua.

According to data in Table W6, the cultivated area for the past two years has decreased considerably because the price of wheat has remained constant for the past 14 years while production costs have increased. Meanwhile, prices for other crops, such as safflower and cotton, have increased, resulting in higher incomes per hectare. Thus, other crops have tended to displace wheat in the irrigated areas.

In 1972 the decrease in average yield was partly due to reduced tillering because of temperatures higher than normal in the early stages of plant development. Another factor contributing to lower yields was the severe leaf rust attack on the widely sown variety Inia F66.

For these reasons, total production has decreased notably since 1969. Meanwhile, wheat consumption has steadily increased, requiring importation of wheat to meet national demands in 1971 and 1972 for the first since 1956.

For 1973, the *Compañía Nacional de Subsistencias Populares* will improve somewhat the support price of wheat, which is now US$64 per ton for the Northwest and US$73.04 for the northern and central areas of Mexico.

New varieties are generally released every three to four years; in general, these varieties are superior to the ones they replace in yield, disease resistance and quality. Three new varieties were named and designated for release in 1972. They are: Roque F63 (= Ciano"s" x El Gaucho - Sonora 64, 11 23586 - 21M - 1T - 3M - 1R); Mochis F73 (=Son64 - Kl. Rend x Bb"s", 26502 - 8Y - 9M - 1T - 1M - 5S - 0M); and Toluca F73 (=Inia"s" - Napo x Ciano, 28036 - 11 1M - 1R - 2M - 1T - 0M). The yield, disease resistance and quality performance of these new varieties and several other promising lines is shown in Tables W7 and W8.

Contributed by Rodolfo Moreno Galvez, Cereals Department, National Institute of Agricultural Research, Ministry of Agriculture and Livestock, Mexico.

PATHOLOGY

Rusts

Worldwide, stem rust (*Puccinia graminis tritici*), leaf rust (*P. recondita*) and stripe rust (*P. striiformis*) are the most important diseases of wheat. They often limit both grain yield and grain quality.

In any successful breeding program, there must be a continuous effort to search for and to incorporate new sources of resistance into the gene pool through proper

TABLE W5. Spring wheat crosses with two or more lines in the Third International Bread Wheat Screening Nursery (Series A) and entries with reaction below 10S to the three rusts at all locations (1969-70).

Genotype and crosses	Number of lines	Entries resistant to 3 rusts
Cno "s" x Son 64 -- Kl. Rend/8156 II23584—	15	37, 43, 45, 47, 48, 51, 52 53, 55, 241, 242, 243, 244, 257, 258.
Corre Caminos — Inia "s" II23528—	7	23, 24, 25, 26, 27, 28, 29.
Bluebird — Ciano II26572—, II26573—, II26592	11	167, 170, 171, 172, 173, 174, 175, 176, 177, 181, 182.
Ciano — Chris II26520—, II26527.	10	116, 145, 149, 150, 151, 155, 156, 157, 158, 165.
Tobari 66 — Ciano "s" II24908—, II25000—.	13	83, 200, 204, 205, 206, 218, 219, 221, 222, 223, 224, 225, 225, 256.
Ciano — Penjamo 62 II25092—, II25093—.	6	229, 230, 231, 232, 233, 234.
Son64-Kl. Rend/Cno "s" x LR64 — Son64 II277139—.	5	98, 99, 100, 104, 105.
Inia66 — Bluebird II26478—.	5	92, 135, 137, 141, 142.
Noroeste 66 — Ciano "s" II9975—.	3	207, 208, 209.
Sonora 64 — Klein Rendidor II19975—.	2	10, 11.
Ciano "s" — Sonora 64 II23582—.	2	31, 33.
Ciano — Inia 66 II23597—, II25329—.	2	63, 127.
Ciano — Tobari 66 II25079—, II24989—.	2	86, 215.
Ciano "s" — Bajio 67 II27939—.	2	123, 124.
Corre Caminos — Ciano II25952—.	2	131, 132.
Ciano — Bluebird II26528—, II26529—.	2	161, 162.
Tobari 66 — NP. 832 II26896—.	2	191, 192.
Bajio 67 — Calidad II27455—.	2	194, 195
Ciano — Jaral 66 II27569—, II23949—	2	197, 250.
Inia "s" (Son 64A-Tzpp x Y54/Jn) II23817—.	2	246; 247

TABLE W6. Area, yield, production and consumption of wheat in Mexico from 1965 to 1972.

Year	Hectares	Yield kg/ha	Production tons	Actual consumption [a]
1965	820,000	2500	2,050,000	2,023,271
1966	720,000	2291	1,650,000	1,699,973
1967	856,000	2803	2,400,000	1,899,088
1968	754,031	2578	1,943,780	2,126,348
1969	806,668	2852	2,300,590	2,224,153
1970	757,052	2988	2,262,451	2,235,663
1971	643,094	2894	1,860,978	2,344,763
1972	689,793	2578	1,778,573	2,420,000

[a] Data from: Departamento de Planeación, Dirección General de Agricultura, S.A.G., Mexico.

manipulation of parents and keen selection of the segregant materials. This approach is used in CIMMYT's pathology research, and partly explains the success of the many Mexican cultivars that have been utilized as commercial varieties abroad in recent years.

CIMMYT pathologists, however, persist in broadening the gene pool for resistance to rusts and to some other diseases. Strong selection pressure is exerted, using both greenhouse and field conditions to identify resistant plants in the seedling stage or adult-plant stage.

During the past year, much information about the distribution of the virulence genes in *Puccinia graminis tritici* has been gathered. Table W9 shows the reaction of certain varieties with genes for specific resistance to isolates of *Puccinia graminis tritici* collected at CIANO in the 1971-72 season.

TABLE W7. Agronomic characteristics of new wheat varieties and promising lines sown at Mochis, Sinaloa and Roque, Guanajuato (1971-72).

Variety or line and pedigree	Yield, kg/ha Mochis	Yield, kg/ha Roque	Stem rust	Leaf rust	Stripe rust	Maturity days	Height cm
ROQUE F73							
Cno"s" x El Gau-Son64	5388	7704	TrR	20MR	TrMR	120	85
II23586-21M-1T-3M-1R							
MOCHIS F73							
Son64-Kl.Rend x Bb"s"	6496	5824	TrR	10MR	20MS	127	75
II26502-8Y-9M-1T-1M-5S-0M							
TOLUCA F73							
Inia"s"-Napo63 x Cno F67	6004	7166	TrR	10R	TrR	128	90
II28036-111M-1R-2M-1T-0M							
Bb"s" x Son64²	6165	6704	TrR	TrR	0	136	75
II27345-22M-1T-3M-2S-0M							
Nad.63-LR64A x Bb"s"	6260	6333	TrR	TrR	10MR	130	90
II30756-3S-1M-1T-0R							
12300-LR64A x 8156/Inia F68	6475	7361	10MS	10R	20S	128	100
II30842-5S-3M-2T-0R							
Yecora F70	5075	6555	TrR	80S	20S	128	80

TABLE W8. Bread-making characteristics of new wheat varieties and promising lines harvested at Roque, Guanajuato (1971-72).

Variety or line and pedigree	Test weight kg/hl	PK min	Flour yield %	Protein %	Alveogram W	Alveogram P/G	Mixing time min	Loaf vol cc
ROQUE F73								
Cno"s" x El Gau-Son64	77.6	+120	65	12.1	318	4.1	3.00	975
II23586-21M-1T-3M-1R								
MOCHIS F73								
Son64-Kl-Rend x Bb"s"	82.8	61	58	9.9	372	5.0	3.40	1005
II26502-8Y-9M-1T-1M-5S-0M								
TOLUCA F73								
Inia"s"-Napo63 x Cno F67	81.5	120	67	12.0	364	3.9	5.15	+1025
II28036-111M-1R-2M-1T-0M								
Bb"s" x TzPP-Son64²	82.8	52	65	10.2	296	3.5	3.30	860
II27345-22M-1T-3M-2S-0M								
Nad63-LR64A x Bb"s"	83.3	98	61	12.2	301	5.0	3.15	885
II30756-3S-1M-1T-0R								
12300-LR64A x 8156/Inia F68	84.0	120	67	8.4	306	6.2	3.30	805
II39842-5S-3M-2T-0R								
Yecora F70	83.5	91	61	9.1	308	5.8	5.00	890
Potam S70	82.9	80	63	8.1	122	1.4	4.00	625

It appears that no single gene provides very effective protection. Table W9 also indicates that the varieties Ciano 67, Inia 66, Tobari 66, Hopps and Lerma Rojo 64A almost certainly carry genes for adult-plant resistance since a high percentage of rust isolates attack them in the seedling stage. Interestingly, Cocorit 71 is highly resistant to all the isolates, while Jori 69 has become susceptible to certain isolates in the seedling stage. Although no susceptible reaction was seen in the field (1971-72), one isolate from the 1971-72 collections has produced susceptibility on adult Jori 69 in the greenhouse.

A genetic search in the adult stage involving varieties Ciano 67, Lerma Rojo 64A, Yaqui 50 and Hopps has demonstrated that complex gene action is responsible for providing resistance. The resistance of Ciano 67 and Lerma Rojo 64A was different from Hopps and Yaqui 50. There are indications that some of the genes in Yaqui 50 are identical to those in Hopps. The genetic complexity of the variety Hopps and its mode of segregation indicates that this variety carries a general type of resistance.

A separate genetic study involving the varieties Sonora 64, Inia 66, Norteño 67 and Noroeste 66 tested against races 12 and 113 of *P. graminis tritici* revealed that the latter three varieties carry two dominant and one recessive gene for resistance in the seedling stage. Two of the three genes were linked and also present in Sonora 64. In addition to these genes for seedling resistance, Inia 66, Noroeste 66 and Norteño 67 all carried adult-plant resistance of the postseedling type.

A similar study was conducted with some of the advanced durum lines. Durums, as a class, are very resistant in Mexico, but they are not resistant when moved abroad. The study involving durum lines Crane "S" (11 - 23055 - 56M - 3Y - 1M - 3Y - 1M - 0Y), Booby "S" (11 - 21203 - 5Y - 1Y - 2Y - 4M - 2Y - 100M), and Anhinga "S" (11 - 22234 - 9M - 2Y) suggests that the resistance to races 12 and 113 in the seedling stage depends on only two dominant genes and that these genes are common to all three varieties. Cocorit 71 is also highly resistant to these races, but observations suggest that the resistance is based on three genes. The

TABLE W9. Reaction of certain varieties with genes for specific resistance to 350 isolates of Puccinia graminis tritici **collected from CIANO, Sonora, Mexico.**

Variety or line	Isolates virulent on seedlings %	Adult plant reaction in the field
Line M (Sr 8)	93.9	90S
Line C (Sr 9c)	81.3	50S
Lee (Sr 11)	92.2	50S
Line G (Sr 7a)	76.6	60S
Line O (Sr 7b)	95.5	60S
Line F (Sr 10)	10.3	TS
Line S (Sr 13)	26.7	40MS
Rendwn (Sr 17)	12.0	TR
Line P (Sr 9a)	96.9	80S
Pitic 62	95.7	90S
Penjamo 62	96.8	50S
Ciano 67	92.8	TMR
Inia 66	52.1	TMR
LR 64A	54.8	10MR
Tobari 66	13.8	TR
Yecora 70	22.4	TR
Saric 70	8.6	TR
Cajeme 71	14.0	TR
Tanori 71	43.4	TR
Jori 69	16.5	TR
Cocorit 71	0	TR
Era	2.6	TR
Fletcher	2.6	TR
Hopps	92.2	TR

above findings show the need to strengthen stem rust resistance in durums. Based on three years of experience, the following durum lines should be used as sources of adult-plant resistance to *Puccinia graminis tritici:* CI-7196 (Russia), PI-182669 (Syria), PI-2190044 (Cyprus), CI-6828 (Tunisia), PI-191235 (Spain), PI-166445 (Turkey), PI-182671 (Lebanon), PI-223163 (Israel), PI-190933 (Spain), PI-191931 (Portugal) and PI-157951 (Italy).

A characterization of stem rust on ~~Triticale~~ was attempted by collecting spores of stem rust from triticale, wheat and rye, and inoculating them separately on seedlings of these hosts. Eleven of the 19 isolates from triticale produced a susceptible reaction on some lines of triticale and certain varieties of wheat and rye. The other eight isolates produced a resistant reaction on both triticale and rye, whereas in wheat the varietal reactions involved resistance as well as susceptibility. The behavior of three races of *Puccinia graminis tritici* collected from wheat and inoculated on lines of triticale and varieties of wheat and rye was similar to that encountered using isolates from triticale. In contrast, the isolates from rye differed in their virulence pattern from the races of *Puccinia graminis tritici* and *Puccinia graminis* isolates from triticale on all three hosts. Nine of 10 isolates from rye did not produce a susceptible reaction on any of the varieties of wheat and triticale but did produce a differential reaction on rye. The remaining isolate from rye acted like *Puccinia graminis secalis* when inoculated on varieties of rye, but like *Puccinia graminis tritici* when inoculated on the wheat varieties, and was capable of producing a susceptible reaction on the triticale lines as well. According to these results, probably the pathogen mostly responsible for stem rust of triticale belongs to *Puccinia graminis tritici* rather than *Puccinia graminis secalis.* However, the results indicate the existence of genetic recombinants of the fungi derived from the forms *Puccinia graminis tritici* and *Puccinia graminis secalis* which have the capacity to attack triticale, wheat and rye.

Results from a separate parallel study indicate that *Puccinia recondita tritici* is the pathogen responsible for leaf rust on triticale rather than *Puccinia recondita secalis.*

Leaf rust of wheat, caused by *Puccinia recondita tritici,* is very prevalent in the northern wheat belt of Mexico. There is a wide range of variability in virulence genes. In 1971-72, there was a shift of virulence, and for the first time the Bluebirds (Yecora 70, Cajeme 71 and Saric 70) became susceptible to a new strain of leaf rust, namely, race 77. There is no lack of resistance to this pathogen in the bread wheat program, but an exact knowledge of the genetic variability comparable to what is known for stem rust resistance is not available. The variety Tobari 66 has adult-plant resistance against leaf rust in addition to seedling resistance.

Like leaf rust, stripe rust, caused by *Puccinia striiformis,* has expanded its virulence range in the Valley of Toluca. For the first time, the Minnesota variety Era and the line Meng-8156 became susceptible to a new type of this fungus. It is not yet known whether the same race was responsible for virulence on both varieties or whether two different races were involved.

Stripe rust variability in regard to physiological races does not appear to be as great as for leaf rust and stem rust.

Results are available for lines entered in the International Spring Wheat Rust Nurseries grown in 1968, 1969 and 1970. Data for the better lines submitted from CIMMYT together with check varieties are shown in Tables W10, W11 and W12.

In the 1968 data (Table W10), all the lines show a low coefficient of infection for stem rust, leaf rust and stripe rust, although as expected, susceptibility of varying levels was shown at certain locations. Much of the resistance was derived from Tezanos Pinto Precoz and AndesE (dwarf). In the 1969 data (Table W11), genotypes are shown having a low coefficient of infection for stripe rust, which is increasing in importance many countries. In the 1970 data (Table W12), lines with a low coefficient for all these rusts are again presented. The coefficient for both stem rust and leaf rust is low as well as the highest recorded individual rating in all cases. For stripe rust, the coefficient is low but high susceptibility was recorded at one or two locations.

Septoria Research

Results from the Sixth International Bread Wheat Screening Nursery grown at Toluca in 1972 are reported in Table W13 for lines showing good combined resistance to stripe rust and *Septoria tritici.* Reaction to *Septoria tritici* in both summer nurseries at Toluca, State of Mexico, and in Patzcuaro, State of Michoacan, are recorded on a 0-9 scale with zero representing essentially no disease and nine representing complete susceptibility. Selection pressure was heavy for both stripe rust and *Septoria* so results can be considered quite indicative of the genetic resistance to prevalent strains. At the Toluca nursery an attempt was made to indicate reaction type for *Septoria.* The results often agree with results obtained in Algeria, Morocco, Tunisia

TABLE W10. CIMMYT varieties and advanced lines showing a high level of resistance to *Puccinia graminis tritici*,[a] *Puccinia reconidta*[b] **and** *Puccinia striiformis*.[c] **(Data from the International Spring Wheat Rust Nursery, 1968.)**

Lines or varieties and pedigrees	*Puccinia graminis tritici*		*Puccinia recondita*		*Puccinia striiformis*	
	Average coefficient of infection	Highest rating	Average coefficient of infection	Highest rating	Average coefficient of infection	Highest rating
Son64 x Tzpp-Y54 18888-103M-100Y-100M-100Y-101C-1Y	2.4	25S	1.6	30S	4.5	20MS
Son64 x Tzpp-Nai60 18889-3M-2Y-2M-1Y-1C-2Y	4.2	70MR-MS	0.4	5MS	4.0	20S
Son64 x An64A II-18918-70M-7Y-3M-2Y-1C	3.0	15MS	1.0	20S	4.6	30MS
Tzpp-Son64A 19021-4M-3Y-102M-1Y	2.4	40MR-MS	3.0	40MS	5.2	30MR-MS
Pi62-1153.526 x Son64 19957-12M-3t-5R-1R	1.6	5MS	0.4	5MS	9.1	60S
Tzpp-An$^{3}_{E}$ II-19025-5M-1R-3C-104T-100C	4.4	70MS-S	1.4	20MS	6.2	30MS-S
LR64A x Tzpp-An$^{3}_{E}$ II-19005-6M-5Y-3M-1Y-1C	3.1	70MR-S	5.2	65S	5.1	40MS-MR
HuaRojo^{2}/My54 x N10-B 8834-8Y-2C-1Y-101C	2.5	20S	3.9	50S	7.0	20S
Tzpp-Son64A 19021-4M-3Y-100M-2c	5.9	60S	2.4	30S	7.6	20S
LR64^{2}-Son64 II-19865-58M-100Y-104c	2.5	25S	4.2	65S	9.6	40S
Tobari 66 (check)	2.7	40MS	1.4	30MR	7.3	50S
Ciano 67 (check)	6.9	40S	3.8	40S	14.0	60MS-S
Inia 66 (check)	2.8	25S	12.0	65S	25.0	70S
Lerma Rojo 64A (check)	12.0	80S	8.3	65S	19.0	80S
Mentana (check)	50.0	100S	36.0	100S	11.0	50S

[a] Grown in 21 locations (11 countries) in North America and South America; 10 locations (5 countries) in Africa; 1 location in Asia; 2 locations (2 countries) in the Middle East; and 1 location in Australia.

[b] Grown in 16 location (8 countries) in North and South America; 2 locations (2 countries) in Europe; 8 locations (4 countries) in Africa; 1 location in Asia; 1 location in the Middle East; and 1 location in Australia.

[c] Grown in 4 locations (2 countries) in South America; 1 location in Europe; 1 location in the Middle East; 3 locations (3 countries in Asia); 3 locations (2 countries in Africa).

and Turkey. In certain lines there are very different reactions at the two locations, which may indicate a difference in physiological forms of *Septoria* at Toluca and Patzcuaro. It is also evident that the general level of readings is higher at Patzcuaro than at Toluca, possibly due to a difference in the time of reading or to the virtual absence of any other disease to interfere with the *Septoria* reaction at Patzcuaro.

Certain genotypes also have shown a high degree of resistance to this disease in several other countries, as shown in Table W14 with data from International Septoria Nursery No. 2. Although the disease incidence was rather low in the South American countries, the results from the United States, Mexico, Tunisia and Ethiopia allow a good classification of genotypes resistant under different environmental conditions, and assumedly also resistant to different physiological races of the fungus.

In the past year, the second Regional Disease and Insect Screening Nursery was grown under widely differing environmental conditions in many countries. Data were collected by Dr. E. E. Saari for resistance to *Septoria* among the entries from a wide variety of sources and based on several *Septoria*-infected nurseries. Of the 2,400 entries in this nursery, 310 varieties and lines had good resistance to *Septoria tritici*. These varieties are listed in Table W74, in the Appendix.

With this wide assortment of varieties or crosses from which to choose, the national programs in countries where *Septoria tritici* is a threat should immediately begin to incorporate many of these materials into their crossing programs. CIMMYT believes that very acceptable levels of resistance against this disease can be obtained for most environmental conditions in a limited time.

BREAD WHEAT INDUSTRIAL QUALITY

The CIMMYT Wheat Quality Laboratory is equipped to evaluate quality of bread wheat and within the past eight months evaluation of durum wheat has been

TABLE W11. CIMMYT varieties and advanced lines with a high level of resistance to *Puccinia striiformis* **(data from the International Spring Wheat Rust Nursery, Stripe Rust Section, 1969).**

Genotype and pedigree	*Puccinia striiformis* Average coefficient of infection	Highest rating
Son 64 x Tzpp - Nai60 18889-13M-3Y-7M-1Y	2.5	15MS
(Frocor x My54 - Bage) Frocor^2 P9916-9t-1b-2t-1b	0.8	30R
(Pi62 - St464) Tehuacan^2 D19329-28M-11Y	1.5	30R
(Pi - B.Yaqui) Tehuacan^2 D14571-3R-12T-2R-1R	1.3	10S
(Frocor/Kt48 x B.Tendre - 5H) 4777^2 x Lerma - Frocor P9897-8t-2b-1t-1b	2.5	25S
(YK54 x N10 - B/B.Yaqui) Tehuacan^3 D14497B-5M-9Y	2.2	10S
Kt - Fn x My48/Frocor II11996-4R-5M-1r	3.3	30MS
Tzpp - Son64 20877-4C-1R-8M	6.1	50MS
HuaRojo^2/Ny54 x N10 - B 8834-8Y-2C-1Y-101C	3.7	25S
Ciano"s"(check) 19957-18M-1Y-3M-7Y-2M-1Y	9.7	40S
Inia66(check) 19008-83M-100Y-100M-100Y-100C	20.0	70S
Barleta Benvenuto(check)	64.0	100S

initiated. The Laboratory is designed to evaluate both large and small samples, enabling breeders to give quality appropriate consideration early in the breeding program when only small samples are available.

When early generation quality screening is used along with agronomic and pathological selection, a higher percentage of the lines have desirable quality in the advanced generations.

The wheat quality evaluation of lines starts with the F_3 individual selections (seed from F_2 selected plants). First, the material is selected for grain type and all lines of bread wheat with good grain type are then evaluated for gluten strength by the Pelshenke test. This test has proven to be a very satisfactory screening method for separating strong-gluten and weak-gluten types and considerable advancement has been made in improving quality since the inception of its use.

During the 1971-72 season at CIANO, 19,000 individual plants were screened for seed type. Only those with plump, clean grain were evaluated with the Pelshenke test. Only lines with acceptable gluten strength in corresponding identificable grain type (hard or soft wheat types) were replanted at Toluca.

From the Toluca summer harvest, 13,518 individual plants in the F_3 and F_4 were screened for gluten strength. From these, 3,733 lines were classified as having weak gluten, 4,100 were intermediate and 5,685 had strong gluten. This tremendous variability in gluten strength results from the wide variation in germ plasm (parental types) that is constantly being incorporated into the crossing program.

Detailed quality characteristics of all varieties included in the parental crossing block is determined each season to aid planning of new crosses. This classification of parents in the crossing block is very important in an international program since it permits the orderly crossing and selection of lines suitable for differing country needs.

In evaluating the advanced material, including the rows cut in bulks of the F_4, F_5 and F_6 lines, the high-yielding materials from replicated yield tests and most of the lines in the crossing block, the samples are first checked for grain type and test weight. Lines with good grain and high test weight are selected for more complete quality evaluation. All breeding lines with a test weight of less than 80 kg/ha are discarded. In the last two years, most of the lines selected for good yield have test weights well above the established

TABLE W12. CIMMYT varieties and advanced lines showing a high level of resistance to *Puccinia graminis tritici*,[a] *Puccinia recondita*[b] **and** *Puccinia striiformis*[c] **(data from the International Spring Wheat Rust Nursery, Stripe Rust Section, 1970).**

Lines or varieties and pedigrees	*Puccinia graminis tritici* Average coefficient of infection	Highest rating	*Puccinia recondita* Average coefficcient of infection	Highest rating	*Puccinia striiformis* Average coefficient of infection	Highest rating
Son64 x Tzpp - Y54 18888-103M-100Y-100M-100Y-101C-1Y	0.3	TrMR	0.2	TrMR	1.3	20MR
HuaRojo^2/My54 x N10 B 8834-8Y-2C-1Y-101C	2.0	10S	1.7	5S	5.8	40S
Son64A x Tzpp - Nai60 18889-13M-3Y-7M-1Y	1.5	5S	1.4	5MS	8.3	70S
Tzpp - Son64A II-19021-4M-3Y-102M-2C	1.5	10MS	0.4	TrS	9.4	80S
Tobari 66 (check) VII-V163	1.9	5S	0.2	TrMS	6.4	50S
Ciano"s" (check) 19957-18M-1Y-3M-7Y-2M-1Y	5.4	30MR	2.0	5MS	11.5	70S
Inia 66 (check)	1.8	5VS	3.0	10MS	13.3	80S
Lerma Rojo 64 (check) IIC-V35	10.4	30S	0.4	TrS	15.5	80MS

[a] Grown in 2 locations (2 countries) in South America; 2 locations (Mexico) in North America; 1 location (Kenya) in Africa.

[b] Grown in 2 locations (Mexico) in North America; 1 location (Kenya) in Africa.

[c] Grown in 4 locations (2 countries) in North America; 5 locations (2 countries) in South America; 1 location (England) in Europe; and 1 location (Kenya) in Africa.

TABLE W13. Advanced lines in small multiplication plots showing a high level of resistance to Puccinia striiformis **and** Septoria tritici **as compared with Mexican commercial varieties (data from the Sixth International Bread Wheat Screening Nursery grown at the summer nurseries in Toluca, Mexico State, and Pátzcuaro, Michoacán State, 1972).**

Varieties or lines and pedigrees	Reaction to *P. striiformis* Toluca	Reaction to *Septoria tritici* (scale 0-9) Toluca	Pátzcuaro
Inia 66	30MS	5MR	7
Azteca 67	TR	4MR	6
Tobari 66	5MR	5MR	6
7 Cerros	90S	6S	5
Cajeme 71	TR	6S	4
Potam 70	10MS	8S	8
Lerma Rojo 64	30MR-MS	4MS	8
Yecora 70	5MR	8S	7
Tanori 71	60MS	6S	8
Nuri 70	5MR	6MS	8
Vicam 71	20MS	8S	8
Saric 70	TrR	5MR	5
Pitic 62	5R	4MS	4
Cocorit 71	TR	6MS	3MS
Penjamo 62	30MS	5MR	3MS
Jori 69	TR	3R	3MS
Sonora 64	60MS	7S	8
Inia"s"-Np63/LR64^2-Son64 x CC 32565-28M-1Y-0M	TR	5R	6
Bluebird # 4 23584-26Y-2M-3Y-2M-0Y-300M-0Y	TR	3MR	4
Bluebird # 4A "s" 23584-26Y-2M-3Y-1M-0Y-(1-2Y)-0Y	TR	3MR	4
Bluebird # 4A "s" 23584-26Y-2M-3Y-1M-0Y-104Y-0M	TR	2R	4
Cd 1 27105-21M-1Y-6M-0Y	10MR	5R	5
12300 x LR64-8156/Nor67 30842-58R-1M-4Y-0M	5R	3VR	2**
Cno "s"-Gallo 27829-19Y-1M-4Y-0M	TR	3MR	6
Cno "s"-Gallo 27829-19Y-2M-6Y-0M	TR	3R	6
Cha # 1 26665-22Y-300M-301Y-1M-500Y-0M	TR	4MR	7
Cno-Inia (Kl. Rend-Son64 x Inia/Cno) 35255-5Y-5M-0Y	5MR	4MR	5
CC-Inia"s" x Cal 30883-35M-3Y-1M-0Y	TR	4MR	7
(Kl. Pet-Raf x Pj62/Cno) Bb 30623-18M-1Y-2M-0Y	seg yellow	2VR	6
Bb - Cha 34330-500Y-500B-0Y	TR	4MR	6
Sr - TR256 CM 4041-1Y-0M	10MR	5MR	6
Pato (B) (Jar-Np/LR64 x Tzpp-An_E) CM 1020-15M-3Y-0M	10MR	4MR	7
Cal - Pj 62 CM 1079-4M-1Y-0M	TR	TR	5*
Cno "s"-Jar x Bb CM 1308-19M-1Y-0M	TR	4R	6
Fn-Md x K117A/Cofn^2 (Son64-Kl.Rend./Cno"s" x LR64^2-Son64) CM 2182-6M-1Y-0M	TR	4R	6
Tac-Bb/Tob"s"-8156 x Cno"s" CM 2230-20M-1Y-0M	TR	5MR	4
Pl/Inia-Cno x Cal II 34148-51Y-1M-3Y-0M	0	4VR	7
$Y50_E$ - Kal^3 II 35188-D-16Y-1M-1Y-0M	5MR	5MR	6
Tob x cc-Pato 27369-1R-4M-0Y	5MR	4MR	6
Inia"s"-Np63 x Cal^2 30656-5M-1Y-1M-1Y-0M	TR	2R	6
Inia"s"-Np63 x Cal^2 30656-15M-1Y-1M-0Y	TR	2R	3
Son64 x SK_E-An_E/St464-Bza) Gallo 30723-31-1Y-1M-2Y-0M	TR	4MR	3
Tob x CC-Pato 27369-1R-4M-0Y	TR	3R	6
Bonanza (Dekalb)	TR	3MR	8
Pato	TR	3R	4

TABLE W13. (continued)

Varieties or lines and pedigrees	Reaction to *P. striiformis* Toluca	Reaction to *Septoria tritici* (scale 0-9) Toluca	Pátzcuaro
LR-N10$_R$ x An^3_E	5R	5MR	6
Calidad	TR	4R	7
Pato(B) (Jar-Np/LR64 x Tzpp-An$_E$) CM 1020-13M-1Y-0M	0	5MR	7
Yr · No66 CM 4027-1Y-4M-0Y	TR	3MR	6
CC-Inia/Tob-Cfn x Bb CM 4265-16Y-10M-0Y	TR	3R	6
Tzpp^2-An x Cno"s"-No66 CM 4839-11Y-4M-0Y	5R	3R	7
Ji · Yr"s" CM 4985-21Y-1M-0Y	5R	4MR	6
Pi"s" x Cno-No66 CM 5030-32Y-1M-0Y	20MS	5MR	6
Tob^2 · 7C CM 5207-C-3Y-4M-0Y	5R	5MR	7
Tob · Sr^2 CM 5211-B-7Y-1M-0Y	TR	5MR	5
Tob-8156 x Bb/Yr CM 5363-G-1Y-5M-0Y	5R	5MR	6
Tob-8156 x CC-Inia/Yr CM 5367-E-5Y-1M-0Y	10R	5R	1*
Bb-Cno x Suwon-Bb CM 5567-A-1Y-4M-0Y	5R	4R	7
Bb-Cno/Cno"s"-No66 x Pi62 CM 5620-D-3Y-1M-0Y	10MS	5MR	5
Cal-Bb x Tob-Sr CM 5775-J-6Y-1M-0Y	10R	4MR	6
Tob-Cno"s" x Tob-8156/Cal x Bb-Cno CM 5816-D-4Y-2M-0Y	5R	5R	7
Tzpp · Tor CM 867-9M-IY-5M-0Y	5R	4R	5*
Pato(B) (Jar-Np/LR64 x Tzpp-An$_E$) CM 1020-15M-3Y-2M-0Y	5R	5MR	7
Cal · Sr CM 1069-25M-7Y-2M-0Y	5R	4R	5
Cal · Tor CM 1097-38M-1Y-4M-0Y	5MR	5MR	7
Cno"s" x Nad-Chris"s"/Son64-Kl.Rend x Bb CM 1221-25-M-1Y-3M-0Y	5R	5MR	6
Tob^2-Np x Inia"s"-Np CM 1299-12M-2Y-1M-0Y	5R	4R	6
(Fn-Nd x Kl.17A/Cfn^2) Son64-Kd.Rend/Cno"s" x LR64^2-Son64 CM 2182-5M-1Y-2M-0Y	10MR	5MR	5
Pato-7C/CC-8156 x Cno"s" CM 2264-7M-1Y-1M-0Y	5R	4R	7
(Inia"s"/Son64 x Tzpp-Y54) Czho 3.6G-1Y-3M-0Y	5R	5R	7
Vcm-Cno"s" x Cal/Nor-7C 35078-18Y-1M-1Y-2M-0Y	10MR	4MR	7
[(Kl.Pet-Raf x Pj62/Cno)Nor] Inia-Cno x Cal 34841-59Y-2M-1Y-3M-0Y	10MR	5R	8
Kal-Ska x Tob/Inia-Cno x Cal II 34925-5Y-2M-4Y-1M-0Y	40MS	5MR	7
(Cno x Son64-Kl.Rend/Son65)Cno"s"-Inia"s"^{2} 36764-2Y-2M-1Y-3M-0Y	30MR	5MR	8
Lfn x Cno"s"-No = KF$_4$-81 no pedigree	5MR	5MR	6
(Kl.Pet-Raf x Pj62/Cno)Bb 30623-18M-1Y-2M-1Y-4M-0Y	20MR	5MR	6
Inia"s"-Np63 x Cal^2 30656-5M-1Y-1M-1Y-1M-0Y	TR	3R	5
Inia"s"-Np63 x Cal^2 30656-5M-1Y-1M-1Y-3M-0Y	5R	4R	5
Cal-CC x Tob 30745-59M-1Y-1M-1Y-3M-0Y	10MR	4MR	...
Az67 x Nad-LR64/Bb 32053-7M-2Y-2M-1Y-3M-0Y	10R	3R	...
Ptm · Bb^2 32427-44M-1Y-3M-1Y-1M-0Y	40MS	5MR	...
Y50$_E$ · Kal^5 35188-5M(F$_1$)-39Y-0M-24M-0Y	6MS-MR	3R	...
Y50$_E$ · Kal^5 35188-5M(F$_1$)-31Y-0M-17M-0Y	30MR	5MR	...
Y50$_E$ · Kal^3 35188-5M(F$_1$)-31Y-0M-8M-0Y	30MR	4R	...

Asterisks inidicate outstanding agronomic characteristics.

minimum. This reflects the effectiveness of strong selection pressure on grain type in early generations.

Quality evaluation in the advanced material includes: milling quality, flour protein, ash determination, and mixogram, alveogram, sedimentation and baking tests. After all materials have been evaluated, the lines outstanding for quality are incorporated into a special section of the crossing block. This assures that these lines will be crossed with materials with good agronomic characteristics during the next generation (Table W15).

Considering the different types of quality required in different countries, the best material is selected according to its agronomic characteristics, reaction to diseases and yield. These lines are distributed to national programs around the world by CIMMYT through the International Spring Wheat Screening Nursery. When the seed is distributed, information on quality evaluation already obtained in Mexico is also included.

TABLE W14. Varieties and lines of wheat showing a high level of resistance to Septoria tritici **in eight countries (data from the International Septoria Nursery #2, 1971-72).**

Genotypes and origin	USA Oregon	México Pátzcuaro	Guatemala Labor Ovalle	Colombia Tibaitatá	Ecuador Sta. Catalina	Argentina Pergamino	Tunisia Mateur	Ethiopia Holetta
Tzpp - An_E (Mexico)	20[a]	2[b]	10[a]	1[b]	10[a]	5[b]	3[b]	50[a]
LR x N10-B/An_E (Mexico)	40	4	40	1	10	2	5	50
# 1959 (Portugal)	25	1	10	0	20	1	4	20
K4527 (Ethiopia)	30	3	20	1	10	1	2	30
Crespo 63 (Colombia)	30	3	10	0	15	3	3	40
K4539 (Ethiopia)	50	3	20	2	15	1	3	30
CI8155 - Nar59² (Ethiopia)	25	3	20	1	20	1	3	40
K4500 (Ethiopia)	30	1	20	0	10	1	3	20
150(Fr-Kad x Gb)² (Ethiopia)	40	3	20	2	10	2	3	30
K4496 (Ethiopia)	20	3	20	1	15	4	3	40
K4497 (Ethiopia)	30	4	10	1	30	3	3	40
Kenya Governor (Kenya)	35	6	25	1	20	3	4	40
Cedar (Kenya)	40	4	20	1	20	3	3	40
Pato (Argentina)	20	1	30	0	10	1	3	50
J925-67 (Brazil)	30	2	20	1	15	3	4	50
C26 (Brazil)	40	2	30	0	10	3	3	20
C331/64 (Brazil)	50	2	20	3	10	1	4	20
C3328/65 (Brazil)	50	1	10	0	15	3	2	10
C3312/65 (Brazil)	40	1	10	1	15	TR	2	20
S-2 (Brazil)	40	2	10	0	15	2	2	20
S-12 (Brazil)	50	1	10	1	20	1	3	25
Giruá-Purple Straw (Brazil)	60	1	10	0	5	1	3	30
Hiraki S2 (Brazil)	40	4	20	0	5	1	3	30
S-11 (Brazil)	30	1	0	1	20	1	2	30
Trintani² - Rulofen (Brazil)	50	1	20	1	20	0	2	30
Czhno - Kenya Farmer (Brazil)	50	3	20	0	10	0	2-3	30
Tzpp - An_E (Brazil)	40	3	30	1	10	3	5	30
Toropi (Mutant) (Brazil)	40	1	10	0	10	0	4	30
Pel A506-62 (Brazil)	60	1	5	1	15	1	5	30
Pel A506-64 (Brazil)	50	2	10	1	20	1	5	30
Tob - BMan x Bb (Mexico)	50	1	30	1	10	1	3	15
Buck Atlantico (Argentina)	40	1	20	1	15	TR	3-4	30
Buck Manantial (Argentina)	60	2	30	1	10	0	3	25
Gaboto (Argentina)	50	0	10	2	20	TR	5	20
Tezanos Pinto Precoz (Arg.)	30	1	30	1	20	TR	2-3	50
Rafael MAG (Argentina)	30	1	60	1	20	0	2-3	30
Fletcher (USA)	60	2	10	0	20	0	3-4	30
Toropi (Brazil)	50	1	10	1	20	0	2-3	30
Piamontes (INTA) (Argentina)	50	1	20	0	10	0	4	30
IAS20 = Iassul (Brazil)	60	1	20	0	15	TR	3-4	40
Pato - Ciano (Mexico)	50	4	20	1	10	TR	4-5	70
Tob - CC x Pato (Mexico)	40	2	10	0	10	3	6	70
Andes 56 (Colombia)	60	3	0	0	10	2	4	40
Tob66 - Calidad (Mexico)	50	2	30	0	5	1	4-3	60
Mara (Italy)	50	1	0	0	20	1	2-3	30

[a] Disease rating based on percentage.
[b] Disease rating based on 0-9 scale.

NUTRITIONAL IMPROVEMENT IN BREAD WHEATS

The nutritive value of bread wheats has been extensively studied in many laboratories, showing relatively low contents of protein and lysine in the grain.

To identify possible genes for high protein content and high lysine content in wheat genotypes, analytical screening has been performed in some materials selected from the breeding program. Up to now, the lysine variability occurring in CIMMYT wheat materials, unfortunately, has been very small.

TABLE W15. Bread wheat lines with outstanding industrial quality selected for the Sixth International Spring Wheat Screening Nursery and for the CIMMYT Crossing Block (1971-72).

Cross and pedigree	Grain type	Test weight kg/hl	PK min	Protein %	Alveogram P/G	Alveogram W	Sedimentation cc	Mixogram	Mixing time min	Loaf vol cc
CC - Inia"s" x Cal 30883-35M-3Y-1M-0Y	2	82.2	>120	11.6	3.1	240	50	7	4.35	910
(Kl.Pet - Raf x Pj62/Cno)Bb 30623-18M-1Y-2M-0Y	2	82.5	>120	11.2	5.1	336	56	6	4.00	950
Son64 - Pj62 21011-4P-2P	2	81.8	100	10.9	4.5	406	41.	6	3.52	855
Inia x Tob"s" - Napo/Cno - S10B3 CM5646-H-1Y-0M	2	79.4	>120	11.6	3.7	316	44	7	4.32	990
Cno"s" x Nad63-Chris"s"/Son64 -Kl.Rend x Bb CM1221-57M-3Y-0M	2	81.5	>120	12.1	4.0	514	58	7	5.32	880
Cno"s" - 8156B x CC - Inia CM1768-62M-1Y-0M	2	82.8	>120	12.4	4.5	401	54	6	3.17	925
Cno"s" - 8156B x CC - Inia CM1768-40M-1Y-0M	2	82.8	70	12.6	3.8	357	51	4	2.20	880
Inia - Bb x RR68 II34179-1Y-1M-7Y-0M	2B	82.8	>120	11.5	2.5	282	45	5	3.07	930
Bb - Calidad 30877-62M-3Y-1M-2Y-0M	2	82.9	>120	10.7	3.4	271	53	5	2.55	890
Tob - CC x Pato 27369-1R-4M-0Y	2	80.3	>120	11.0	4.5	249	39	7	4.00	900
Pato(B)(Jar-NP/LR64 x Tzpp - An,,)421 CM1020-13M-1Y-0M	2B	81.0	118	11.9	3.1	243	64	7	5.00	950
Bui - Gte CM1142-23M-5Y-0M	1	80.3	115	12.3	2.8	321	44	4	2.52	940
Gold Medal				12.5	3.7	340	37	5	2.30	850

Lines from the screening nursery that include high-yielding lines and varieties were evaluated for protein and lysine content. The protein content ranged from 9.0 percent to 16.0 percent with an average of 12.6 percent, and was without exception negatively correlated with grain yield. The lysine in protein ranged from 2.3 percent to 3.4 percent, indicating very little variability among lines and offering little possibility of improving the level of this essential amino acid by selection in currently available materials. Protein variability was again observed to be negatively correlated with the lysine content in the grain protein. Nevertheless, scientists at the University of Nebraska have reported finding several lines of wheat from the World Collection which combine high protein content and high lysine content. As sources of high protein content they reported NB-542437, SD-69103, C. I. 7337 and C. I. 6225. The wheat designated as P. I. 176217 (Nap Hal) had both a high protein level and a high lysine content.

Within the past two years several samples with genetic potential for high protein content, including Frondosa and the promising Nap Hal varieties, have been crossed to high-yielding CIMMYT lines and varieties in an attempt to improve the nutritional quality of the protein in the gene pool of the wheat breeding program. In addition, the line St. 464 x *Agropyron elongatum* has been widely used in the CIMMYT crossing program to transfer its high-protein and high-lysine characteristics into better genotypes. One of the most promising segregates from this effort, called Buitre, carries the improved protein of the Agropyron parent. However, this line requires further improvement for grain yield and fertility.

THE WINTER WHEAT-SPRING WHEAT CROSSING PROGRAM

There are few places in the world where wheat is grown commercially in which field temperatures and and photoperiodism are such that without the aid of artificial vernalization, winter and spring wheat varieties can be brought into flower at the same time. Consequently, this has restricted crossing between these two types. Most of the crossing between these two groups of wheats has been done in greenhouses, which has limited both the diversity of parents and the number of crosses.

In the early 1960's the late Dr. Joseph A. Rupert --while posted in central Chile where both winter and spring wheats can be made to flower simultanously under field conditions without vernalization--became interested in developing an aggressive crossing program to bring together and exploit many of the desirable genes that have been largely "isolated from one another by the winter habit mechanism". A small breeding program to achieve this objective was initiated in Chile. In 1968 when Dr. Rupert was transferred to the U. S. A., this program was supported by a Rockefeller Foundation grant at the University of California, Davis. The project was expanded and transferred to Oregon State University in the fall of 1971 to be tied more directly to the Rockefeller Foundation-supported Turkey-Oregon State-CIMMYT programs. The primary purpose of this breeding program is to develop winter wheat or semiwinter wheat varieties well adapted to the Anatolian Plateau, the Iranian Plateau and the highlands of Afghanistan, where the Mexican-type spring wheats are damaged by low winter temperatures. After the death of Dr. Rupert, Dr. M. M. Kohli assumed responsibility for CIMMYT's role in the cooperative effort at Oregon State University.

Two nursery sites were used in the 1971-72 crop season. One of these was at the Hyslop Farm near Corvallis, and the second was at the North Willamette

Research Station near Portland. Crop growth conditions were very satisfactory throughout the season.. Both winter and spring types survived well. Excessive precipitation throughout the early part of the season encouraged the development of *Septoria tritici* at Corvallis in particular. This provided ideal conditions for selection. With the cessation of rains and rising temperatures, *Septoria* development was arrested.

During the spring season stripe rust developed well and again provided a good opportunity for screening against this disease. Leaf and stem rust were essentially

Several entries from the second International Septoria Nursery showed a marked tolerance for *Septoria.* These are listed in Table W16.

In addition to those listed, Riebesel 47/51 from the Netherlands and several lines of *Triticum spelta* were also resistant.

TABLE W16. Entries in the International Septoria Nursery II showing good level of resistance to Septoria tritici **(Corvallis, Oregon, 1971-72).**

Variety or line	Origin	*Septoria* reaction Scale: 0-9
LR-Tzpp x An_{E} = Anza "s"	Mexico	2
# 1959	Portugal	2
K4496 L_{5} Az	Ethiopia	2
K4497 L_{14} B_{1}	Ethiopia	3
Pato	Argentina	2
Tzpp	Argentina	3
Rafaela MAG	Argentina	3
Nariño 59	Colombia	3

Resistance to stripe rust was present in a wide range of materials, both in the winter varieties and in the spring varieties. Certain winter types, such as Hyslop, Sel. 101 and Druchamp, combine well in crosses and have good agronomic type, drought resistance, winter hardiness and good soft wheat industrial quality characteristics. These were crossed intensively with other types. Certain other winter wheat lines have excellent combining ability: Weique - Red Mace; Jade - Jubilee x Gabo; and Suwon 92 - Roedel. These are particularly notable for the outstanding head type which they transfer.

After selections were made among these various populations, collections, and segregating materials, the selections were distributed to countries considered suitable. These included the Crossing Block (both spring and winter types), segregating materials from F_1 to F_8, CAR lines from Dr. Rupert's Chilean collection, and observation lines and sets comprising 36 promising high-yielding fixed lines. Various portions of this material were sent to 19 countries.

The CAR-line collection was submitted in totality to the U. S. National Repository at Fort Collins and to Beltsville in the U. S. A. It was suggested that it be entered as the Dr. Joseph A. Rupert collection.

The value of materials from this program was demonstrated in several nurseries throughout the world in the past season. Excellent genetic spring-type materials with enhanced drought resistance and good agronomic type were observed in several countries.

CIMMYT has decided to carry this work forward, insofar as making spring-winter crosses, at its Toluca Station during the winter season. The crossing program for improving the spring types will be an integral part of the spring wheat improvement program. Double and top crosses will also be made at CIANO. The winter improvement program will continue to be integrated with the winter program of Oregon State University and the Turkey centre for winter wheat work. No materials beyond F_1 will be grown in Mexico.

CIMMYT feels that a dynamic program in this field will result in many beneficial gene transfers from the winter to spring varieties and that disease resistance, in particular, can be transferred from the spring to the winter varieties.

HYBRID WHEAT RESEARCH

The hybrid wheat research program was suspended at the end of the 1971-72 crop season. This decision was made even though considerable progress had been achieved toward developing a usable commercial hybrid. The decision was largely made because of the difficulties of producing and utilizing a commercial hybrid in developing nations.

Research indicated that suitable fertility restorer lines could be developed that were capable of restoring fertility to male-sterile lines over a wide range of ecological conditions. Numerous experiments also indicated that hybrid vigor between certain lines frequently increased yields from 15 to 25 percent above the highest yielding parent. Despite these promising aspects of hybrid wheat research, serious economic obstacles are anticipated in producing and utilizing commercial hybrid seed, especially in developing nations. The small amount of pollen produced by wheat and its vulnerability to high temperatures and drying during dissemination makes F_1 hybrid seed production an economically hazardous commercial undertaking (because of low percentage of seed set), and certainly will result in high seed prices for farmers. Moreover, in the developing nations only a very small percentage of the farmers could afford to purchase new seed every year, and distribution problems would be formidable even if the crop were economically feasible. Weighing these factors, CIMMYT decided to utilize the funds formerly used in the hybrid program to develop new types of genetic stocks that will be help increase yield and disease resistance in the bread wheat and durum wheat programs and in the triticale program. The leader of the hybrid wheat program was assigned to develop the barley breeding program.

The best restorer lines and many male sterile lines from the hybrid wheat program have been labeled and stored at low temperatures where their viability can be maintained for many years and can be used in any future work by CIMMYT's staff or its collaborators.

Several effective fertility restorer lines ("R" lines) with good agronomic characteristics merit mention. Among these are: (1) Primeepi - Yaqui54 x H22.67A (two sister lines); and (2) Wn - Lerma Rojo642 x Inia F67 (three sister lines).

More than 100 male-sterile lines (androsterile "A" lines), phenotypically similar to their corresponding maintainer lines ("B" lines), were developed from a wide background of commercial varieties and breeding lines. The seed of these lines has also been stored at low temperature.

Indirect Benefit from the Hybrid Wheat Research Program

Because the dwarfing genes from Norin 10, which has been used widely in the Mexican breeding program since 1956, are recessive, they were difficult to handle in hybrid programs. Consequently, a search was made for other sources of dwarfing that would be useful in hybrid breeding programs, as well as in conventional varietal development. Two other sources of dwarfing have been isolated. The first is from a Rhodesian wheat designated A948-Al and the second is from a cross of Tom Thumb x Sonora 64. In the latter cross, there are apparently two dwarfing genes (excluding the Norin genes) that render the plants too short for practical use. Nevertheless, certain combinations of of Tordo and Topo which are being used currently by the conventional bread wheat breeding program.

In addition, the following promising dwarf genotypes were selected last summer at El Batan: S948-Al - Santa Elena^5 (= H567.71-85-0B); S948-Al - Ciano "s"^{2} x Ciano F67^3 (= H570.71-3Y-0B); Tom Thumb - Sonora 64 x Ciano "s"/Ciano F67^3 (= H296.70A-3B-1Y-0B); and S948-Al - Ciano "s"^{2} x Ciano F67^2 (2 sister lines, H310.70A-3B-1Y-0B and H310.70A-3B-2Y-0B).

These genotypes, under the conditions at CIANO, attain 50 cm height and posses acceptable grain quality. Some of them will be multiplied in the 1972-73 crop season.

Other interesting agronomic types of plants have been isolated from the hybrid wheat program. Among the most promising for future use in the conventional bread and durum breeding programs are:

1. Several lines of bread and durum wheats with erect leaves. These are currently under more detailed study by the physiology-agronomy section of CIMMYT, where search is underway for lines with erect leaves, which may reduce tiller mortality from competition caused by shading.

2. Many promising branched-spike forms of both durum and bread wheats.

The transfer of the branching characteristics present in *Triticum turgidum* to commercial bread wheats *(T. aestivum)* and to durums *(T. durum)* has been difficult to do. The branching trait is multigenic and recessive; when *T. turgidum* is crossed to durum the F_1 generation shows no ramification, while F_2 segregants with different degrees of branching are found. Homozygous types can be recovered in this type of cross. In crossing to bread wheats, no homozygous types have been obtained. Also, there is a high degree of sterility in the florets and poor development of the grain in the segregating populations.

Despite these problems, some improvement has been achieved in the last few years in obtaining ramified durums and bread wheats. The genotypes listed in Table W17 have a stable type of branching and acceptable grain quality.

The branched durum wheats listed in the table developed maximum ramification similar to that shown in Fig. W2; Fig. W3 corresponds to the intermediate branching found in the bread wheats.

These materials will be placed in preliminary yield tests during 1972-73. This type of wheat has potential for high yield since many of the spikes produce more than 200 grains. Nevertheless, additional field and laboratory tests will be necessary to determine its possibilities for commercial production.

DURUM IMPROVEMENT PROGRAM

Unlike the common wheats, durums are generally used in making special products, for example, pastas, crochers and couscous. They are, however, also used for making bread in certain countries. Pastas, such as macaroni, sphagetti and others, are the principal preparations in many countries. In North African countries the grain is used primarily for couscous, a product which resembles fluffy, broken cooked rice. In India, semolina is utilized in desserts and other local preparations. Some durum is used for chapatis in the durum growing areas.

Durum wheats are particularly important in the economy of Morocco, Algeria, Tunisia, Italy, Turkey, Syria, Transcaucasian USSR, Iraq, India, Argentina, Canada and the United States. The heaviest consumption of pasta products probably occurs in southern

TABLE W17. Bread wheat and durum wheat genotypes possessing a stable type of branching and good agronomic characteristics (1971-72).

Genotype	Type	Pedigree	Origin Batan, 1972
Rad #3 "S"(Rad #2 "S"/Nach-Tc60 x Nach)	Durum	H193.70-4Y-2B-1Y-0B	E-493
Rad #3 "S"(Rad #2 "S"/Nach-Tc60 x Nach)	Durum	H193.70-5Y-4B-0B	E-496
H844.66-M. Reo x Cno^2-Chris	Bread	H135.70-12Y-103B-1Y-0B	PH-115
H844.66-M. Reo x Cno^2-Chris	Bread	H135.70-12Y-103B-2Y-0B	PH-116
H844.66-M. Reo x Cno^2-Chris	Bread	H135.70-6Y-1B-1Y-0B	E-244
H844.66-M. Reo x Cno^2-Chris	Bread	H135.70-6Y-1B-2Y-0B	E-245
M. Reo - Noroeste 66^2	Bread	H155.70-2Y-10B-4Y-0B	E-271
M. Reo - Noroeste 66^2	Bread	H155.70-2Y-5B-3Y-0B	E-315
M. Reo - Noroeste 66^2	Bread	H155.70-2Y-5B-4Y-0B	E-316
M. Reo - Noroeste 66^2	Bread	H155.70-2Y-5B-5Y-0B	E-317
M. Reo - Noroeste 66^2	Bread	H155.70-2Y-5B-7Y-0B	E-319
M. Reo - Noroeste 66^2	Bread	H155.70-2Y-7B-2Y-0B	E-322
M. Reo - Noroeste 66^2	Bread	H155.70-2Y-9B-2Y-0B	E-331
M. Reo - No 66 x Co.Ca - Tob 66^2	Bread	H393.70A-2B-2Y-0B	E-193
M. Reo - No 66 x Co.Ca - Tob 66^2	Bread	H393.70A-11B-3Y-0B	E-213
(H844.66 - M. Reo) (Cno^2 - Chris)^2	Bread	H378.71-2Y-0B	E-95

Europe and western North Africa. The European markets absorb most of the durum wheat in international trade. Traditionally, the North African countries, as well as Argentina and North America, supply much of the needs. In Tunisia, Algeria and Morocco, durum is still the wheat species grown most extensively. However, the recent introduction of high-yielding dwarf varieties of bread wheat have made some inroads on the durum acreage. These countries, through increased production, are nearing self-sufficiency in wheat and soon they will be able to resume substantial exports to the countries of the European Economic Community. Thus, it becomes increasingly important in their case to develop improved durum varieties with high yield potential, good disease resistance and good industrial quality so they can again become important exporters. The export of durum wheat can become an important source of foreign exchange for Morocco, Algeria and Tunisia. Other countries of the eastern Mediterranean region, especially Turkey and Syria, could also profit from expanded production and trade in durum wheat.

When the CIMMYT durum program was expanded four years ago, the main objectives were to develop materials with (1) high yield and good yield stability, (2) a broad spectrum of disease and insect resistance and (3) good industrial quality. Since then superior dwarf lines have been developed. The best of these new varieties and lines yield similar to the dwarf bread wheats, even though these lines do not have fully acceptable quality. Although resistant to the rusts in Mexico, durum lines are generally susceptible to the prevalent races of stem rust and stripe rust in North Africa. Better *Septoria* and *Giberella* resistance is also required.

FIG. W3. Intermediate branching obtained in crosses with bread wheats.

FIG. W2. Maximum branching obtained in crosses with durum wheats.

Table W18 presents the average yields of several superior durum lines and the yield of the highest yielding bread or durum wheat check in the corresponding yield test for 1970-71 and 1971-72 at CIANO. Yields for 1971-72 are lower than for the previous season. Much of the difference can be attributed to the generally higher temperatures during the season, leading to a shorter growing period.

The results of the Second International Durum Yield Nursery (IDYN) presented in Table W19 indicate the good yield level and acceptable yield stability of the new Mexican durum varieties, Cocorit 71 and Jori 69, as well as several newer lines. The IDYN, although now only three years old, is already proving a valuable tool for improving durum wheat worldwide.

New Durum Varieties

In Mexico, Cocorit 71, from the cross RA_E-Tc^4 x Stw63/AA "s" (= Raspa del $Aguila_E$ - $Tehuacan^4$ x Stewart 63/Aninga, D-27617-18M-6Y-0M), was named and released by INIA and put into commercial production during 1972. This variety has very high yield potential and appears to be widely adapted to both irrigated and rainfed conditions in many countries where diseases are not limiting. In areas of high rainfall in North Africa, it still needs a higher degree of resistance to stem rust, *Septoria,* scab and mildew in

TABLE W18. Yields (kg/ha) and rank in respective yield tests (in parentheses) of best-yielding lines of durum wheats and of best bread wheat checks in two years of testing at CIANO, Sonora, Mexico.

Genotype and pedigree	1970-1971 Line	1970-1971 Check		1971-1972 Line	1971-1972 Check	
Crane "s" D-23055-33M-1R-3M-0Y-67Y-0M	9956 (1)	7 Cerros	8862	7115 (7)	Cajeme 71	6501
21563 x Gr "s" D-31543-12M-5Y-0M	8998 (5)	Cajeme 71	9149	6746 (4)	Cocorit 71	6501
Jo "s" x Cr"s" D-27591-5M-3Y-1M	8982 (1)	7 Cerros	8466	7396 (3)	Cojeme 71	6501
Cocorit "s" D-27617-18M-3Y-0M	8899 (4)	7 Cerros	9019	6678 (12)	Cajeme 71	6501
Gll "s"/BY_E^2-Tc x ZB-W D-25624-7M-2Y-1M-3Y-1M	8659 (2)	7 Cerros	8899	7526 (1)	Cajeme 71	6501
21563 x AA "s" D-27547-1M-1Y-4M-1Y-0M	8529 (2)	Cajeme 71	8654	6818 (3)	Cocorit 71	6501
Cocorit "s" D-27617-17M-3Y-4M	8341 (8)	7 Cerros	8466	6433 (14)	Cajeme 71	6501
Cocorit "s" D-27617-17M-6Y-1M-3Y-0M	8263 (15)	Cajeme 71	8701	6563 (7)	Cocorit 71	6704
Gll "s"/BY_E^2-Tc x ZB-W D-25624-7M-2Y-1M-5Y-1M	8076 (6)	7 Cerros	8899	6735 (9)	Cajeme 71	6501
Jo "s" x Cr "s" D-27591-5M-2Y-1M	8049 (6)	7 Cerros	8867	7396 (3)	Cajeme 71	6501
Gaviota "s" D-31725-3M-8Y-0M	7841 (13)	7 Cerros	8930	6725 (4)	Cocorit 71	6704
21563 x AA "s" D-27625-5M-2Y-2M-2Y-0M	7747 (6)	Cajeme 71	8555	7224 (1)	Cocorit 71	6501
AA "s" (CP_E^3-Gz x Tc^3/BY_E^2-Tc) D-31733-3M-4Y-0M	7549 (15)	7 Cerros	8930	6933 (1)	Cocorit 71	6704
21563 x AA "s" D-27625-5M-2Y-2M-1Y-0M	7497 (12)	Cajeme 71	8555	7157 (2)	Cocorit 71	6501
Jo "s" x Cr "s" D-27591-5M-2Y-2M-0Y	7195 (7)	7 Cerros	8466	6735 (10)	Cajeme 71	6501
21563 x AA "s" D-27547-4M-8Y-3M-1Y-0M	7138 (11)	Cajeme 71	8654	6652 (5)	Cocorit 71	6501

TABLE W19. Results of the Second International Durum Yield Nursery, 1970-1971 (average values from the number of locations indicated in parentheses).

Variety or cross	Origin	Yield kg/ha	Test weight kg/hl	Height cm	Disease reaction: Stem rust	Leaf rust	*Septoria* scale 0-9
		(25)	(18)	(25)	(9)	(10)	(6)
Cocorit 71	Mexico	4291	79.89	83.79	10.71[a]	21.71[a]	5
Anhinga "s"	Mexico	4015	81.35	100.56	10.80	19.40	4
Crane "s" (B)	Mexico	3920	78.45	104.52	32.33	15.40	6
By_E-Tace x Tc40 By_E^2-Tc x STW63/AA"s"	Mexico	3917	78.26	77.60	24.70	19.74	4
Jori C-69	Mexico	3871	80.18	79.27	13.76	13.40	6
66W-5101		3856	80.30	77.29	18.10	24.40	6
Brant "s"	Mexico	3835	78.51	75.98	24.26	18.10	6
Crane "s" (A)	Mexico	3808	79.85	77.38	14.95	25.60	6
Gerondo VZ.466	Italy	3802	79.93	87.46	24.10	2.80	4
Local Check		3786	80.13	109.67	26.64	20.52	4
B.Bal x By_E^2-Tc D.Buck x TM_E-Tc/Lak	Mexico	3785	77.29	82.45	31.15	2.85	4
Inia - 66	Mexico	3758	79.79	87.56	0.04	1.42	6
T.dic.V.Vernum x Grulla "s"	Mexico	3690	80.03	80.43	16.53	21.30	7
Garza "s"		3578	79.01	77.96	17.76	17.71	4
Capeiti	Italy	3578	80.97	105.49	35.95	26.36	2
61-130 x Leeds	USA	3564	80.17	84.98	7.55	22.40	2
My54-N10B x T.GL/Tc60 Lak-Be11 116_E-Tc60	Iran	3528	80.05	85.01	23.21	29.00	5
Gab-125	Italy	3489	78.93	104.24	24.41	21.96	3
Tehuacan 60	Mexico	3322	81.18	115.70	15.28	27.00	3
Leeds	USA	3306	81.40	121.16	14.58	22.20	2
Wells	USA	3246	79.35	125.31	14.88	21.40	2
64W 5102-948		3219	76.85	70.56	16.76	19.40	7
Oviachic C-65	Mexico	3212	77.98	76.80	29.44	21.60	6
Hercules	Canada	3119	80.33	120.15	15.62	23.00	4
S-9	India	3009	77.96	68.60	33.42	17.88	4

[a] Values represent coefficients of infection.
The 2nd IDYN was sent to: 6 countries (11 localities) in North America; 5 countries (6 localities in Europe); 7 countries (10 localities) in Africa; 7 countries (11 localities in the Near East; and 3 countries (5 localities) in Asia.

order to produce stable yields. In quality it is inferior to Jori 69, having a tendency to produce mottled or yellow-belly grains.

In Tunisia, two durum lines originating from the CIMMYT program were officially released. Amal 72 was derived from a line known as Brant "S" (D-24102-4R-4M-0Y), and Maghrebi 72 from the line GII "S"/Br 180-Lk x Gz-61-130 (D-26842-21Y-3M-0Y). Both of these lines have considerable promise for production in moderate-rainfall regions of Tunisia. Cocorit 71 is also under consideration for release in Tunisia and Algeria.

Diversifying the Durum Germ Plasm

To increase the genetic diversity of the breeding materials, the crossing program has been intensified. As parental materials, to intercross with the most outstanding breeding lines, CIMMYT is using durum varieties from the U.S. Department of Agriculture (USDA) collection, new durum varieties received from collaborating countries, and promising materials, principally land varieties, observed by CIMMYT scientists travelling in other countries and later supplied by national programs. Such materials are crossed to the best CIMMYT dwarf types available and segregating populations are then distributed to some 50 locations throughout the world. Under this system, segregates are selected under a wide array of climatic and disease conditions. Many of these selections are recirculated to the CIMMYT program in the regular interchange of materials; others are reincorporated into the crossing program. Some of the best may be incorporated in the international nurseries for more widespread testing. Hence, adapatation becames apparent and the more widely adapted types may eventually become varieties in different countries. This is an excellent method of developing and ensuring yield stability.

Disease Resistance

The various diseases of self-pollinated cereal crops are the principal hazard to production stability. Durum wheats are no exception.

In the CIMMYT breeding program, dwarf durum lines are put under strong selection pressure for resistance to stem rust and leaf rust at CIANO in northwestern Mexico and to stem rust, stripe rust and scab at Toluca in the Central Plateau. Only those lines showing acceptable resistance to prevalent races of the pathogens are selected. In Mexico, durum wheat production is relatively unimportant and the area sown to durums is small. Thus, the disease race spectrum is relatively narrow because of a lack of strong selection pressure on the pathogen which normally would produce races capable of attacking durum cultivars. In contrast, countries in the Mediterranean region have grown durums for centuries and the fungi have developed diverse virulent strains which represent a much different gene pool for pathogenicity than in Mexico. Although a few durum lines from the CIMMYT program have fair resistance, it is apparent that greater resistance must be provided, particularly for both stem rust and stripe rust.

Septoria is a major disease of the high-rainfall coastal areas of the Mediterranean region and the durum area of Argentina. In both regions, scab (*Giberella zeae*) and mildew (*Erysiphe graminis*) are also important. In the 1971 summer season at Toluca, *Septoria* became established in the wheat nursery from natural sources of inoculum. This increased in the past season and selection is now possible for local races of *Septoria tritici*. In addition, severe scab develops and selection pressure is high at Toluca for both of these diseases. Mildew is not normally present and screening for this disease cannot be done successfully in Mexico.

With the aforementioned selection pressures, it has been possible to identify varieties, originating mainly from Argentina, Italy and the United States, which carry a good level of resistance to most of these pathogens. Presently, the resistance sources are being rapidly integrated into the CIMMYT durum germ plasm. In Table W20, *Septoria* scores from four countries are shown for varieties included in the third International Durum Yield Nursery (IDYN). In the past year the world collection of durums has also been screened under field conditions in four countries.

Durum Quality

During the initial stages of the durum breeding program, emphasis was on increasing yield, broadening disease resistance and improving agronomic type. No equipment was available for conducting quality evalua-

TABLE W20. Durum varieties and lines possessing some resistance to Septoria **spp. in various countries (Third International Durum Yield Nursery, 1971-72).**

Genotypes	Origin	Reaction to *Septoria* (scale 0-9)				Stem rust	Loaf rust
		Argentina	Portugal	Morocco	Algeria		
I. Varieties resistant at 3 locations (reactions of 5 or less)							
61-130 x Leeds	(USA)	5	1	3	6	4.2[a]	30.9[a]
D-6647	(USA)	5	2	5	7	1.8	32.4
Inrat	(Tunisia)	5	2	5	7	16.8	33.9
Quilafen	(Chile)	5	3	5	8	16.8	36.4
Cocorit 71	(Mexico)	5	2	4	9	14.4	27.4
Parana 66/270	(Argentina)	5	2	7	4	1.6	0.51
II. Varieties resistant at 2 locations							
Gerardo	(Italy)	3	3	6	7	26.7	13.1
Capelti	(Italy)	5	2	7	8	13.0	38.5
T.Dicc. Vernum/G11 "s"	(Mexico)	6	2	2	8	40.0	32.9
Jori C 69	(Mexico)	8	4	5	7	18.4	33.9
Cocorit "s"	(Mexico)	8	2	4	8	12.7	22.8
Gs "s"-D.Buck x T.Me-Tc/Lk	(Mexico)	9	2	7	4	24.3	24.3
Local Check	...	2	4	5	9		

[a] Average coefficient of infection calculated from information of other locations where rusts were reported.

tions for durum wheat and pasta products until May 1972. Therefore, quality evaluation was initiated as a regular procedure on the 1971-72 crop.

Preliminary quality screening was performed on early generation lines. The early materials are screened for grain type, protein content and yellow pigment content of semolina.

Advanced lines are evaluated for grain type, hectoliter weight, semolina yield, moisture, protein content, macaroni processing, and brightness and cooking characteristics of the product.

When the durum quality evaluations were initiated this year, it was found that most durum lines in the CIMMYT program had poor quality characteristics. Therefore, all the crossing block material has been evaluated in the laboratory. Breeders can now select and utilize suitable progenitors with the desirable quality characteristics in their current crosses.

TRITICALE

The CIMMYT triticale program is currently financed under special project grants from the Canadian International Development Research Centre and the Canadian Development Agency. The program is organized as a cooperative research effort between CIMMYT and the Plant Science Department of the University of Manitoba, Canada.

Although triticales have been known since the Nineteenth Century, the first concentrated improvement effort in North America began in 1957 at the University of Manitoba. CIMMYT's interest dates from collaborative work with that institution under Rockefeller Foundation assistance. CIMMYT's research effort was greatly expanded in 1968 and again under the financial arrangements referred to above in 1971.

Basically, triticale had three major defects when CIMMYT began its research--it was partially sterile, it was too tall for heavy applications of fertilizer and its seed was shrunken. The first two problems have been essentially solved and notable improvements have been made in the third.

Yield Improvement

There has been a remarkable increase in the general yield level of the triticales dating from the incorporation of fertility from the Armadillo strain and dwarfing of the plant height. These improvements have now reached a point where the yields are approaching those of the superior bread and durum wheats. One of the problems in comparing the yields of the two crops (wheat and triticales) is the changing disease and environmental interactions on the wheat check varieties.

During the 1971-72 season at CIANO, the durum variety Cocorit 71 was the top yielder in all triticale experiments--about one ton above the triticale long-term check (6457 versus 5363 kg/ha). The two bread wheat check varieties, Inia 66 and Siete Cerros, were damaged by leaf rust. As a consequence, Yecora 70 has replaced Inia as a new bread wheat check for next year.

At Toluca, scab caused by *Giberella zeae* depressed the yields of the durum check varieties Cocorit 71 and Jori 69, and stripe rust caused very serious damage to Siete Cerros. The better triticale strains outyielded Inia, which remained the highest yielding wheat check in the triticale tests at Toluca. Tables W21 and W22 compare yields of triticale strains in several tests with durum and bread wheat checks at CIANO and Toluca, respectively.

TABLE W21. Summary of yield performance (kg/ha) of check varieties and top triticales in replicated yield tests grown at CIANO (Y71-72), Sonora, México.

Varieties	I	II	III	IV	V	VI	VII	Total	Average 7 tests
Inia 66 (Bread)	3370	4362	4116	4187	4675	4466	4133	29309	4187
Siete Cerros (Bread)	5029	4875	5129	4779	4841	4812	5237	34702	4957
Bread Wheats Average	4199	4618	4622	4483	4958	4639	4985	32005	4572
Jori 69 (Durum)	5466	5937	6404	5866	6604	6320	6300	42892	6128
Cocorit 71 (Durum)	6395	6479	6458	5966	6687	6633	6583	45201	6457
Durum Wheat Average	5930	6208	6431	5916	6645	6476	6441	44049	6292
Armadillo 105 "s"	5591	5625	5779	4800	5279	5083	5383	37540	5363
Top triticale	5354	5466	5712	5154	5508	5237	5250	37681	5388
Average of top 5 triticales in each test	5451	5314	5572	5050	5355	5144	4770		5237

TABLE W22. Summary of yield perfomance of triticale strains and of check bread wheat and durum varieties grown in six replicated yield tests at Toluca, and in two tests at El Batan, Mexico (summer 1972).

Variety	Experiments at Toluca (MV-72), kg/ha								Exps. at El Batán (BV-72), kg/ha		
	I	II	III	IV	V	XX	XX	Average	XX	XX	Average
Inia 66 (BW)	4479	4366	4820	4729	4324	4757	5212	4669	5027	5694	5360
7 Cerros (BW)	991	741	687	737	1108	941	1104	901	4506	4756	4631
Jori 69 (D)	1166	1383	1700	1237	1545	2012	2116	1594	1236	2041	1638
Cocorit 71 (D)	2112	2254	2550	2608	2754	3000	2625	2557	4423	4430	4426
Armadillo 105	4075	4500	4408	4325	4570	4116	3504	4214	6076	7073	6574
Average of top 5 triticales	4612	4450	4046	4008	5009	4906	4842	4553	6332	7174	6753

Disease Resistance

Genes for resistance to several of the major pathogens are present in the most promising CIMMYT triticale strains. In addition to the rust resistance reported elsewhere, three important leaf and root-rotting diseases attack bread and durum wheats in the El Batan and Toluca nurseries. *Septoria tritici,* which is particularly destructive of leaf tissue, generally affects triticale much less than wheat. This view is reinforced by observations made in Tunisia, Algeria and Brazil. Again at Toluca, scab *(Giberella zeae)* is less of a problem on triticales than on durum varieties. Root rots and head blight diseases have been prevalent at El Batan in the past three seasons and the most common isolate from diseased plants was *Coshliobolus sativus.* Although it cannot be attributed positively to resistance, many triticale lines are essentially free of infection.

Lodging Resistance

Considerable emphasis is being placed on incorporating better resistance to lodging. Two main approaches have been used. Dwarfness from the Mexican bread and durum varieties can be easily transferred to the triticale background, but it appears that certain linkage groups causing low fertility are associated with the dwarfing genes just as in the early work on dwarf wheats. This is particularly true as one approaches the three-gene dwarf condition. However, in the strain known as Cinnamon, the yield and fertility characteristics of Armadillo have been combined with a gene for dwarfing derived from Inia 66.

In the second approach, strong, heavy straw is being used to increase lodging resistance. In the Beaver strains used for this purpose, sterility does not appear to be associated with lodging resistance. But, improvement in lodging resistance with this approach is obtained in small increments.

Dr. F. Zillinsky, head of the CIMMYT triticale program, inspects a new short triticale strain.

Improved Grain Development

Three approaches are being made to improve seed type and select suitable gene combinations for further crossing work: (1) Visual selection of plants for superior seed development. (2) By mutation using irradiation and chemical means. This program is carried on in cooperation with Dr. Gustaffson of Svalof, Sweden. (3) Using the gravity table separator to screen populations for heavy, dense kernels.

During the past year considerable progress in improving seed type by the first method has been made. Some 6,000 lines, comprising more than a half million plants, were examined in the Navojoa, Sonora, nursery and superior seed types were selected. These were again grown in the Toluca nursery and proved to have inherited the better seed type characteristic. Selection again for good grain type was made on a single-plant basis. Also, new crosses were made between the progeny of the elite plants selected at Navojoa and crossing block strains.

In the mutation work, the M_2 and M_3 have been grown. Single plants have been selected but notable improvement has not yet been observed. The remainder of the population was bulk harvested and will be separated on the gravity table as a back-up measure.

The gravity table separator was put into operation after the harvest at Toluca. In the F_2 generation, plants with good agronomic traits were selected. After examining the seed type of populations exhibiting plants with good seed development, the remaining plants in the field were bulk harvested and the grain separated by the gravity table. Bulked lines of advanced material have also been separated in this fashion and are under small-plot increase at Navojoa in the 1972-73 season. CIMMYT feels that this new tool may be very effective in improving grain characteristics.

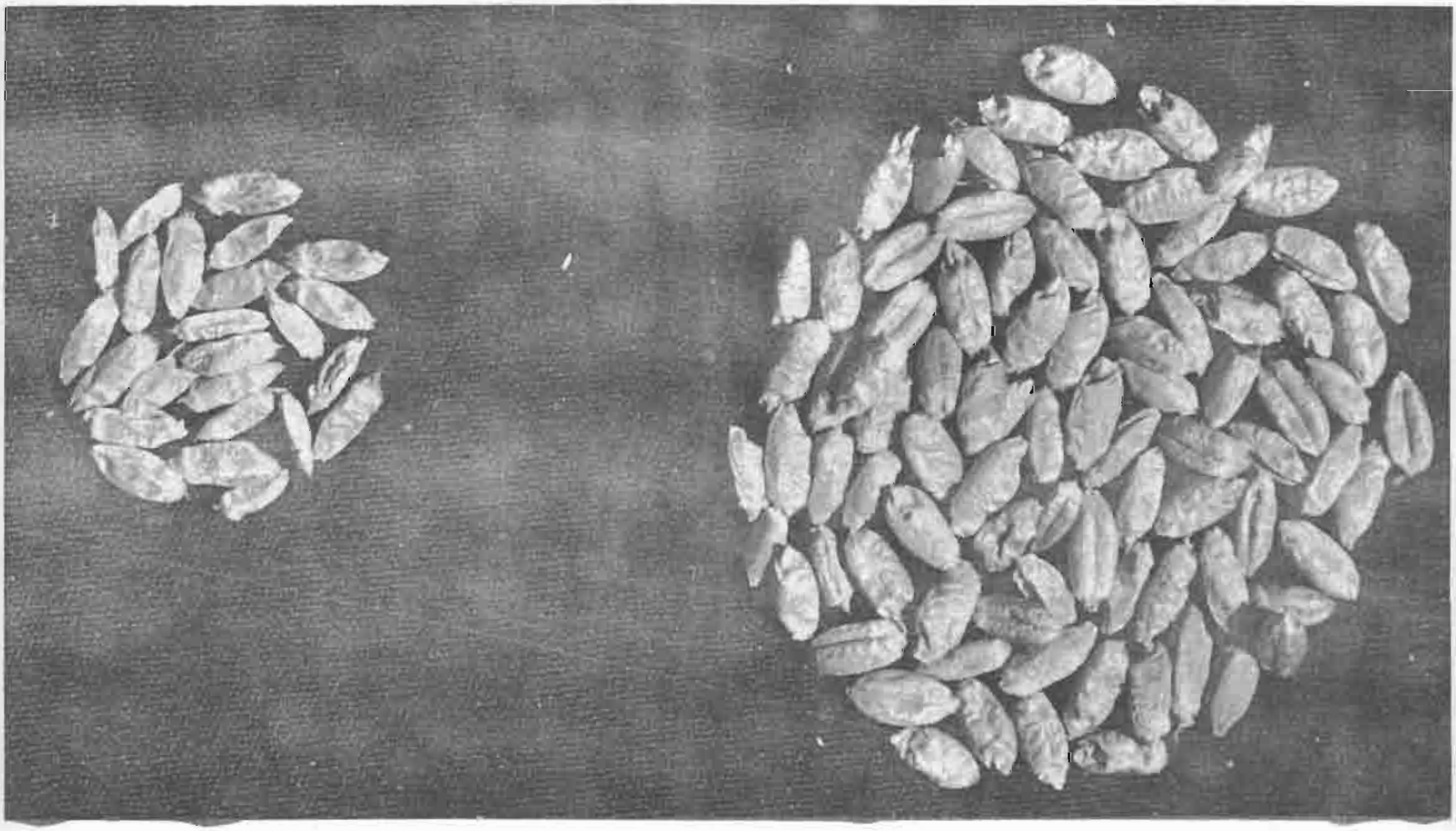
Frost Hardiness

There are now strong indications that the rye parent has contributed considerable frost hardiness to some of the spring triticale strains. Fairly high winter survival was observed in CIMMYT lines grown in England, Hungary and at centres in the states of Washington and Oregon in the U.S.A. From Hungary it was reported that strain PM-13 from the Third International Triticale Yield Nursery (ITYN) surpassed the Italian winter wheat check variety Libellula in frost hardiness in the 1971-72 season. In Ottawa and Winnipeg, Canada, bulked F_2 and F_3 populations from spring crosses segregated winter types at the rate of 0.05 to 2.00 percent when these were grown in the summer. Winter habit plants develop normally when fall sown at Toluca. This provides an opportunity to cross spring x winter triticales at this location.

An extensive program has been planned for the coming season for crossing winter x spring triticales and the broad introgression of winter ryes into the best triticale germ plasm.

Adaptation

Since triticale is a manmade crop of very recent origin, selection pressures to fit it to many ecological niches have not been involved as with other cereals.



Poor seed type has been one of the major obstacles to triticale production. Rapid advances are now being made toward a plump, well-filled kernel.

Thus, as a crop it has a relatively narrow genetic base which limits its adaptation to different latitudes, elevations, temperature extremes, day lengths and other factors. In essence, it is dependent on the limited variations currently present within its component genomes. By widening the germ plasm base and recombining these genes, triticales will achieve the ability to adapt broadly. This process is being hastened by the CIMMYT collaborative network of cooperative testing with widespread national programs. Selection for adapatation in many locations and reincorporation of these adapted types into the crossing programs is extremely advantageous.

Triticale lines developed early in the program appeared to have a specific narrow adaptation. In Mexico, for example, triticales were better adapted to the severe disease conditions of Toluca and El Batan than many of the wheat varieties. But, because of excessive height they were not adapted to the high-production areas of northwestern Mexico.

From this early development, tremendous changes have taken place. The major detriments to triticale as a crop mentioned earlier (infertility, lodging and poor seed development) are either solved or nearing solution, making decisive differences in its possibility for production. The continuous integration of new germ plasm is changing its adaptive potential very rapidly. There are now triticale varieties which compete closely with wheat check varieties in many locations. Others are generally adapted to rather broad regions and still others, of course, are ill-adapted in most locations. However, improvement has been rapid and consistent. The relative performance of the varieties entered in the first three International Triticale Yield Nursery (ITYN) trials illustrates this advance (Table W23).

In the first and second years of the ITYN, 16 varieties including checks were grown; in the third, there were 25. Weighted percentages of locations in which triticale varieties ranked among the five top yielders in the test, including the wheat checks, consistently ad-

TABLE W23. Relative yield rank of triticale genotypes in the First, Second and Third International Triticale Yield Nursery.

	1st ITYN, 1969-70 (38 locations)		2nd ITYN, 1970-71 (17 locations)		3rd ITYN, 1971-72 (26 locations)	
Genotype	No. of times entry among top 5	No. of times entry outyielded highest check	No. of times entry among top 5	No. of times entry outyielded highest check	No. of times entry among top 5	No. of times entry outyielded highest check
Armadillo 102	...	...	...	...	7	1
Armadillo 104	...	...	...	...	7	2
Armadillo 105	...	...	...	...	8	3
Armadillo 107	...	...	...	...	6	3
Armadillo 108	...	...	...	...	4	1
Armadillo 109	...	...	...	...	2	2
Armadillo 111	...	...	...	...	8	4
Armadillo 112	...	...	...	...	7	3
Armadillo 113	...	...	...	...	5	2
Armadillo 114	...	...	...	...	2	...
Armadillo 116	...	...	...	...	2	...
Armadillo 117	...	...	...	...	1	...
Armadillo 130	5	...	2	...	...	...
Armadillo 132	...	...	...	...	1	...
Armadillo 133	7	...	3	...	...	...
Armadillo 136	15	...	6	1	...	...
Armadillo 147	8	1	...	...	...	...
Armadillo 157	4	...	...	...	...	...
Armadillo 211	3	1	3	...	...	...
Armadillo 1524	9	1	...	...	...	...
PM - 4	...	...	0	0	...	...
PM - 13	...	...	0	0	1	1
PPV - 8	...	...	4	2	...	...
PPV - 13	...	...	6	1	...	...
PPV - 21	...	...	5	2	...	...
T - 909	...	...	8	2	...	...
Badger 118	...	...	...	...	5	4
Badger 119	...	...	...	...	6	4
Badger 121	...	...	...	...	3	1
Badger 122	...	...	...	...	6	3
Badger 123	...	...	...	...	6	3
Bronco PN90	11	1	4	1	...	...
Bruin 34	1	...	...	...	...	...
Bruin 46	3	1	...	...	...	...
Rosner	8	...	3	2	...	...
UM70 - HN470	...	...	...	...	2	1
Pitic 62 (Bread wheat)	32	12	12	4	10[c]	7
Inia 66 (Bread wheat)	...	...	9	6	...	...
Tobari 66 (Bread wheat)	25	6	...	...	7[c]	1
Albatross (Durum wheat)	20[a]	3	...	...	...	...
Jori 69 (Durum wheat)	...	...	8	1	7[c]	...
Local variety (Wheat)	27[a]	10	10[b]	2	12	4

[a] Albatross tested only at 35 sites and local variety at 34 sites.
[b] Local variety tested at 16 locations.
[c] Pitic 62, Tobari 66 and Jori 69 in 25 tests.

vanced from 11.3 percent in 1969-70, to 13.8 percent in 1970-71, and to 16.3 percent in 1971-72. A similar advance was made in the percentage of triticale varieties x locations in which the triticale varieties outyielded the highest check. It increased from less than one percent to nearly six percent in 1971-72. Table W23 shows that certain strains are widely adapted as indicated by the comparatively large number of locations in which they showed a high yield performance, while for others adaptation was narrow, and some were not in the top group at any location.

In data not presented, it appears that Armadillo 133, Armadillo 136 and Rosner were able to perform well under relatively cool and delayed maturity conditions. The line PPV21 seemed well adapted in all South American nurseries.

Based on these analyses, it should be possible to recombine the lines currently showing wide adaptability through new crosses and thereby further increase the adaptation of this crop.

Nutritional Improvement

In recent years there has been a growing awareness of the need to improve the nutritional value of cereal grains. In triticale as a crop it appears that high protein content is readily attainable.

Even though both chemical analyses and feeding trials (using different test animals and humans) have indicated that triticale protein has a slightly higher nutritional value than wheat protein, a higher lysine content must be achieved since lysine is still the limiting essential amino acid in triticale as it is in other cereal grains.

Chemical screening for protein and lysine content has been routinely performed during the past year on many advanced generation lines that have favorable agronomic characteristics. Similar tests were also conducted on the best lines entering the preliminary yield test and increase plots.

The protein content of 2,381 lines studied during 1972 ranged from 10.9 percent to 19.1 percent with an average of 13.4 percent. The earliest triticales evaluated in our program were generally higher in protein content, ranging from 11.0 percent to 21.0 percent, but these usually had severely shriveled kernels. With intensive selection for plumper kernels and higher grain yields, the grain type has improved but the protein content has gone down, approaching that generally found in wheat.

Lysine in the protein ranged from 2.6 percent to 3.9 percent with an average of 3.4 percent. However, despite the well-known inverse relationship between protein content and lysine content in the protein, some triticale strains possess both high protein content and high lysine content in the protein.

The screening method used in evaluating protein quality of seed from individual plants is the DBC (dye binding capacity) methods. Using this screening method for basic amino acids (lysine) will permit CIMMYT to search for improved protein quality in many segregates, regardless of grain type.

Early nutritional evaluation of triticale using the meadow vole as a test animal at Michigan State University established a wide range of protein efficiency ratios (PER) among different triticale lines. This wide variability indicated that the low PER values might be due to a high content of toxic compounds, such as resorcinols, in some lines. Chemical analysis has shown that the resorcinol content of triticale compared to its parental species (wheat and rye) is intermediate or closer to that usually present in wheat, which has not shown deleterious effects in wheat diets. Resorcinol values in CIMMYT triticale strains (over two years) ranged from 0.05 percent to 0.13 percent. Some of the triticale lines with the highest content of resorcinols were fed to voles and no correlation with the PER was observed. Among 550 triticale samples fed to voles in the CIMMYT Animal Nutrition Laboratory, we have not found a single toxic line.

The vole PER values obtained at CIMMYT are variable, but most of them are similar to those obtained with casein (2.4 to 3.2). Even though toxicity or presence of antimetabolic factors has been reported with some triticale strains, this possibility probably has been overestimated.

Primary Hexaploid Triticales

The low rate of recovery of haploid plants from embryo-cultured primary hexaploid triticale crosses coupled with the high mortality resulting from colchicine treatment has been a continuing handicap to broadening the genetic base of triticale. Up to 1971, a relatively few new primary hexaploids representing only a few crosses were available to the program. A few additional new types introduced later from the Universito of Manitoba augmented this number. Thus, much of the introduced variation has resulted indirectly from crossing hexaploid triticales x wheats and hexaploid triticales x ryes as well as from crossing hexaploid triticales with triticales.

During 1969-70 and 1970-71 the triticales under yield test at Navojoa, Sonora, showed a narrow range in grain yields. Such results strongly indicate the lack of genetic variability among the genotypes. Accordingly, it was mandatory that a concentrated effort be applied to the production of new primary triticales.

The techniques used, combined with new methods of handling transplanted plant and methods of colchicine treatment, has resulted in a 500 percent increase in the number of primary hexaploid triticales produced in the past year. The success achieved includes:

Number of crosses attempted	191
Number of crosses from which embryos developed	150
Number of embryos excised on nutrient media	1994
Number of haploid plants grown	193
Number of crosses represented with haploids	72
Number of new hexaploid triticale (to date)	30

This relatively high production of new hexaploids will undoubtedly increase the adaptability and the potential for better agronomic characteristics, higher grain yield and better grain type.

One of the problems in embryo work at CIMMYT is that crosses are made at CIANO in late March and early April. Thus, embryo transfers coincide with the beginning of the hot months and it is difficult to assure survival under these adverse conditions until the chromosomes can be doubled. In addition, because many crosses are made at the same time, facilities are overextended. To overcome this problem, the excised embryos are transplanted to nutrient agar and held at 2° C for up to 15 days. There appears to be no detrimental effect and the cold shock may help break the dormancy of certain crosses. This methods allows for an orderly processing of embryos and their transfer to El Batan. Another modification involves dipping

Dr. Zillinsky explains how new crosses are effected in the triticale program during an in-house program review by CIMMYT staff.

plants in a 100 ppm solution of indole acetic acid for one minute before transplanting to peat pots. This has resulted in better root development and less damage to the root apices.

The earlier method of doubling chromosomes was cumbersome and consisted of cutting the tillers, fitting a wax paper around the tiller and sealing the base with petroleum jelly. With this method, the colchicine often leaked down to the root and killed the plant.

A new method is now employed using capillary tubes drawn to a fine tip. The tip is inserted in the hollow of the stem and held in place with a wire loop. This system works well and the danger of colchicine entering the root is greatly reduced. Three or more tillers may be treated simultaneously, if desired.

Possible Uses of Triticale

Triticale will probably be used both for human consumption and for animal feed. In the food-deficit countries, with which CIMMYT is primarily concerned, it will undoubtedly be used largely as food. In the developed nations, the grain will largely be converted to animal proteins, except for small quantities which may be used for special foods or industrial purposes.

Triticale will probably be used in foods such as chapatis, tortillas, breads, pasta products, breakfast cereals and pancake flours. It may also eventually be used in the industrial preparation of enzymes, malts and in the brewing and malting industry.

Early reports from various laboratories in the developed nations indicated that it was impossible to make satisfactory bread from triticale flour. These same reports, however, indicated that acceptable bread could be made by mixing wheat and triticale flours in the correct proportions. During the past year Lorenz et al. at Colorado State University and Tsen at Kansas State University reported that it is possible to produce bread of acceptable quality with 100 percent triticale flour.

During 1972 preliminary baking studies were made on several advanced hexaploid triticale lines at the CIMMYT Wheat Quality Laboratory. The grain of these triticales was produced under irrigation in Sonora during the 1971-72 crop season. The samples were tempered at 14.5 percent moisture for 24 hours and milled in a Brabender Quadrumat Senior Mill.

The hectoliter weight of the triticale samples ranged from 65.6 kg to 70.2 kg compared to a hectoliter weight of 83.7 kg for the Inia wheat control. The flour yields of the triticale lines ranged from 51.7 percent to 59 percent compared with 83.7 percent for Inia. The low flour yields of the triticale lines resulted almost entirely from their low test weights.

More than half of the triticales studied had higher protein content than the wheat control. All triticale samples had extremely weak mixing properties. Considerable variation was observed in sedimentation value and the lines with the higher values produced the best loaves.

The baking tests followed the AACC method employing two fermentation times, 125 and 65 minutes. In general, both loaf volume and internal loaf characteristics improved with the shorter fermentation time and some made acceptable bread.

Tortilla- and Chapati-Making Characteristics

The same triticale flours that were used in the bread baking tests were used to make tortillas. The results were quite satisfactory. Tortillas made from wheat flour and triticale flour were very similar in general characteristics. There were no particular problems in making tortillas.

Triticale meal (*ata*) was used to make chapatis. The quality characteristics of the triticale and wheat chapatis were similar except that the color was darker in the chapatis.

PHYSIOLOGY AND AGRONOMY

Climate

The crop season of 1971-72 at CIANO was almost rainless, with March temperatures noticeably higher than average (Table W24). Also, exceptionally hot weather was recorded in the first week of April, with four successive daily maxima above 37°C (see Fig. W4). Compared to 1970-71, solar radiation levels were quite similar but temperatures from January to April averaged almost 2° C higher. Seeded from late November to early December and grown under optimal conditions of nitrogen and water, the variety Yecora yielded 10 percent less in 1971-72 (6.9 tons/ha) than in 1970-71 (7.7 tons/ha) over several trials. Probably this yield reduction was related to the higher temperatures in 1971-72 when flowering and maturity were hastened several days.

Wheat Physiology

Studies as outlined in last year's annual report have continued at CIANO. Table W25 reports some of the results of detailed genotype comparisons. The set of genotypes was chosen to illustrate genetic progress over the last 10 years. Gabo, Nainari 60 and Napo 63 represent important tall cultivars of the 1950's and early 1960's; ranked down the table are the newer wheats of progressively reduced stature and some of the latest varieties and lines, the triple dwarfs (for example,

TABLE W24. Climatic conditions during crop season at CIANO, Sonora, Mexico (27°20' N, 109°54' W, 40 m above sea level).

Month	Mean air temperature °C			Mean solar radiation cal/cm²/day		Total rainfall mm		
	70-71	71-72	12-yr avg	70-71	71-72	70-71	71-72	12-yr avg
November	20.2	19.4	20.5	346	346	0	3	6.6
December	16.5	15.5	16.4	269	284	6	4	19.5
January	13.7	15.2	15.0	331	297	0	6	15.9
February	14.6	16.4	15.8	409	405	0	0	7.3
March	18.0	19.9	17.7	535	523	0	0	2.2
April	19.7	21.6	21.1	602	602	0	0	0.4
May	24.0[a]	23.8[a]	24.6	596[a]	622[a]	0	0	0

[a] First half of May only.

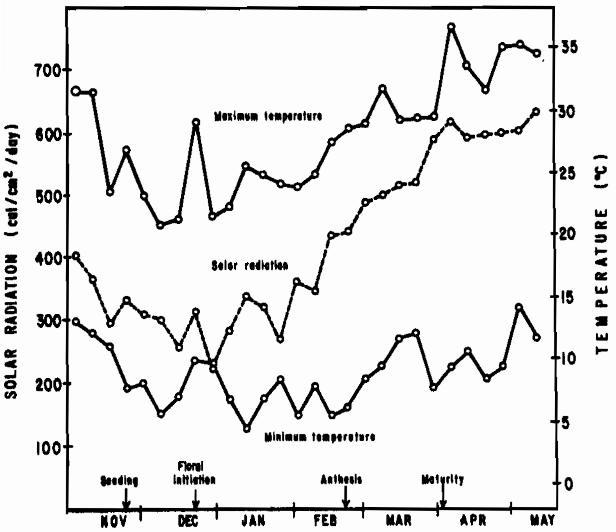


FIG. W4. Weekly means of daily maximum and minimum temperature and daily total solar radiation for the 1971-72 crop season at CIANO, Ciudad Obregon, Sonora, Mexico. The axis also shows the main stages of development of the variety Yecora 70 seeded on November 25, 1971.

Yecora 70). Grain yield/m² has increased approximately 25 percent in the 85-90 cm group compared to the 140 cm group. Relating this to total dry matter production and to harvest index (grain dry weight/total dry matter), we see no clear change in the former but a progressive increase in the latter from 0.33-0.34 to 0.40-0.44. Thus, increase in grain yield is entirely due to a more efficient distribution of dry matter, and this most likely bears a direct physiological relation to the reduction in stature. The following two genotypes in Table W25 are even shorter. Grain yield has not increased further, however, and this may indicate we are approaching a limit of progress in this direction.

Table W25 also includes some representative current varieties from other countries: Hira (India), Robin (Australia), Era (USA) and Kloka (Germany). Only Hira, a triple-dwarf variety closely related to the new Mexican varieties, yielded well. The low yield of the Australian varieties (Robin and Gabo) is probably also partly a stature-related phenomenon, while the two varieties from higher latitudes (Era and Kloka), although shorter, suffered because of their delayed date of anthesis under the shorter days of Mexico (see also Fig. W4). The last two columns of Table W25 show the key numerical components of yield, grain number and grain size, respectively. There is no good relationship between either of these parameters and grain yield for the genotypes chosen.

Time-of-seeding studies continued in an effort to understand climatic control of yield potential. Fig. W5 shows yield as a function of date of anthesis. The various crops had the same yield potential at anthesis in terms of grains/m², except for the earliest seeding date where this was approximately 10 percent lower. Note the response of grain yield to change in anthesis date and, hence, major change in the temperature and radiation environment of the postanthesis grain-filling period (see Fig. W5). The tendency of grain yield to decrease with anthesis occuring early February was entirely due to the decline in grain size, a well-known

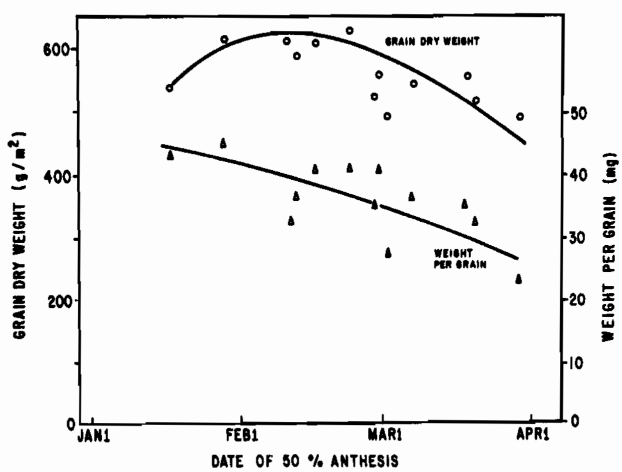


FIG. W5. Change in grain dry weight and weight per grain with date of anthesis. Results from four high-yielding varieties (Hira, Yecora 70, LR-N 10BxA3E (ww 15), and Cajeme 71) seeded at 4 dates (Nov 5, Nov 25, Dec 16, Jan 6); results of Hira from last date and WW 15 from last two dates excluded because of stem rust damage; trial B II, CIANO, 1971-72.

TABLE W25. Important growth and yield parameters at harvest for some of the bread wheat genotypes studied intensively.

Genotype	Height cm	Date of 50% anthesis	Grain yield (dry) g/m²	Total dry matter	Harvest index	Grain number x10³/m²	Mg per grain (dry)
Gabo	140	Feb 24	479	1 402	0.34	13.0	36.7
Nainari 60	140	Feb 28	501	1 489	0.33	13.5	37.3
Napo 63	140	Feb 18	484	1 424	0.34	13.9	34.8
Pitic 62	120	Feb 27	552	1 440	0.38	16.9	32.7
Penjamo 62	110	Feb 22	567	1 513	0.37	15.9	35.7
Inia 66	110	Feb 16	511	1 324	0.38	13.8	37.1
7 Cerros 66	105	Feb 29	586	1 492	0.39	16.9	34.7
Yecora 70	90	Feb 21	627	1 430	0.44	15.3	40.0
Cajeme 71	90	Feb 29	560	1 386	0.40	13.6	41.2
Vicam 71	85	Feb 28	602	1 490	0.40	19.3	31.3
Bluebird # 6 [a]	85	Feb 18	629	1 433	0.44	17.0	37.1
BbxInia [b]	85	Feb 21	610	1 383	0.44	16.1	38.0
Tordo [c]	70	Feb 27	511	1 272	0.40	14.4	35.6
Olesen	55	Feb 19	560	1 279	0.44	17.8	31.5
Hira	85	Feb 12	591	1 320	0.45	16.3	36.4
Robin	130	Feb 28	474	1 389	0.34	12.8	37.0
Era	110	Mar 21	378	1 415	0.27	13.2	28.6
Kloka	115	Mar 5	435	1 396	0.31	13.8	31.5
SE of mean			18	41	0.01	0.6	0.7

Seeding density: 100 kg/ha in 20-cm rows with 200 kg/ha N and 80 kg/ha P_2O_5; seeded November 24-25, 1971, at CIANO, Sonora, Mexico.
a Cno "S" x Son64 —Kl Rend/8156B. II 23584—?
b 265591-1T-7M-0Y
c Nai 60 x TT-Son64/LR64-Son64. H244-1Y-6B.

physiological effect of higher temperatures. The increase in solar radiation occurring during the period was insufficient to compensate for this concurrent temperature increase.

One specific aspect of plant morphology which may be important if yield potential is to be further increased is leaf angle. Theoretical computer simulations of wheat crop photosynthesis suggest advantages for erect leaves when both leaf area indices are high and sun angles are high (low latitudes and/or summer growing season). In addition, the current Mexican wheat varieties, when grown under high water and nitrogen, tend to be floppy or nonerect in leaf habit. Some erect-leaf lines selected from the bread and durum wheat programs were studied. Despite minimal selection on other desirable plant characteristics, several erect durum lines were as high yielding as Cocorit 71. A much wider range of selections will be tested in the next season, with special emphasis on their performance in narrower rows and at higher population densities.

A major alternative approach to the physiology of yield improvement is the study of yield-limiting factors operating when one of the best-yielding new varieties (Yecora 70) is grown free of disease and under optimal soil conditions (Fig. W6). Manipulations of the crop environment were similar to those reported last year. Fig. W7 summarizes results from shading treatments for the two seasons. Both these shading and additional thinning experiments strongly support the idea that early crop growth (in the first six weeks or up to the end of tillering) is not related to grain yield under the conditions represented by Fig. W6. The substantial tiller death due to light competition in the crop after nine weeks (Fig. W6) partly explains the insensitivity to early growth. Solar radiation levels and crop growth become particularly important in the second half of the crop cycle and not only during grain filling. The results in 1971-72 of treatments involving CO_2 fertilization, which presumably increases crop photosynthesis, support this conclusion regarding the periods when carbohydrate supply is important. In all these experiments, manipulation of crop carbohydrate supply in the so-called late vegetative-anthesis stage affected grains/m² whereas manipulation during grain filling affected grain size.

Considering only the postanthesis or grain-filling period, the size of the sink or demand for carbohydrate (as represented by the number of grains per m²) was varied largely by thinning and crowding treatments

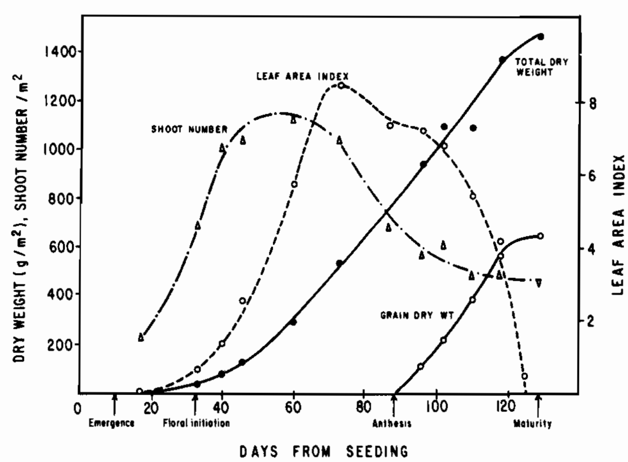
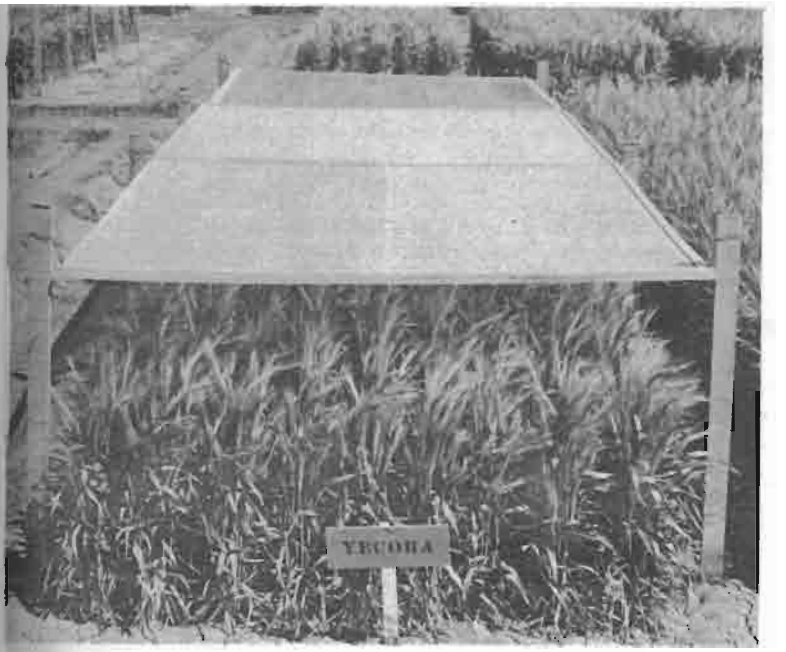


FIG. W6. Key parameters for control crop of Yecora 70, seeded Dec. 3 under optimal conditions; trial B XLIII, CIANO, 1971-72.



This wheat shading experiment by the CIMMYT physiology section is one of several experiments designed to evaluate the components of wheat yield.

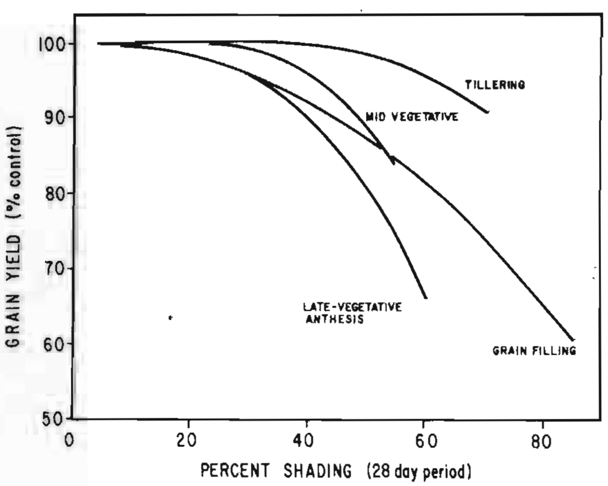


FIG. W7. Summary of the effects of shading on yield of the variety Yecora 70 grown under optimal conditions. Treatments involved a single continuous exposure for approximately one month to shades of various intensities during one of the four stages of development of the crop referred to; trials A XIII (1971-72) and B XIII (71-72) at CIANO.

(Fig. W8). The results were clearly different from those presented for the previous season --grain size declined at a greater rate as grains/m^2 increased. Hence, grain yield reached a maximum (720 g/m^2) not far above that of the yield of control crops and well below the 1000 g/m^2 recorded in 1970-71. Despite certain reservations about Fig. W8, sink size (grains/m^2) was a potential yield-limiting factor in 1971-72, but not to the extent observed in 1970-71. Grain removal treatments applied to individual ears in the crop support this conclusion.

The important question of whether yield is more limited in the postanthesis period by photosynthate

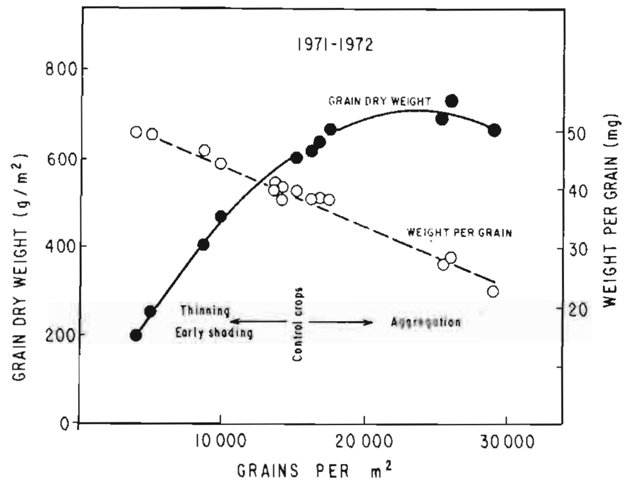


FIG. W8. Response of final grain size and final grain dry weight to changes in postanthesis sink size as indicated by grains/m^2; trials B XIII, B XXXIII, CIANO, 1971-72.

supply (source) than by sink size in the crop was examined in the several key genotypes as well as in the variety Yecora. Treatments, applied at anthesis, involved crop shading and thinning, and also leaf, grain and floret removal for shoots in undisturbed crops. Full interpretation of the results obtained is complex and must await further experiments. However, it has been possible to identify varietal differences in the sensitivity of grain size to apparent changes in the ratio of source to sink. For example, in the varieties Yecora and Olesen, individual grain weight increased more than 30 percent as a result of practically eliminating postanthesis light competition by removing all but one row of each plot at anthesis. At the other extreme, the response of the variety Kloka was less than 10 percent. Siete Cerros, Sonora, Cajeme and the line LR-N10B x An3_E were also relatively insensitive to source manipulation, whereas Cocorit and Tobari seemed moderately sensitive.

In summary, although no unequivocal guidelines for achieving further increases in yield potential have as yet emerged from the above physiology program, some useful points are evident. These presently relate specifically to the genotypes and experimental environment studied. There seems to be little relationship between early growth or vigour and grain yield; similarly, there is no relationship between tillering and yield. Other things being equal, there is no good relationship between length of the vegetative (pre-anthesis) period and yield potential at anthesis as measured, for example, by grain number/m^2. But yield potential appears to be determined by factors governing tiller survival, in particular, light levels in the last one-third of the vegetative phase; during this period erect leaves may be advantageous. Grain size depends on postanthesis events; other things equal, anthesis dates later than about February 15 will lead to smaller grains and lower yields because the detrimental effect of higher postanthesis air temperatures more than compensates the advantage of rising solar radiation levels.

All the above physiological studies were carried out with an optimal water supply. In addition, in the last season there was a preliminary experiment on drought simulation, testing the feasibility of identifying drought-resistant genotypes at CIANO (Table W26). It is interesting to find a statistically significant change in ranking of several of the genotypes as the intensity of the terminal postanthesis drought increased. Also, yield stability under such conditions was not clearly related to maturity of the genotype. Such studies will be expanded next season.

TABLE W26. Effect of simulated postanthesis drought on grain yield of nine genotypes (trial B XII, CIANO, Sonora).

Genotype	Date anthesis No stress Sown Dec 9	Grain yield (ton/ha)			
		No stress Sown Dec 9	Slight stress[a] Sown Nov 22	Mod stress[a] Sown Dec 9	Severe stress Sown Dec 21
Barley-Porvenir	Feb 22	4.83	4.34	3.31	2.68
%		100	90	68	56
Sonora 64	Feb 24	5.52	5.20	4.24	3.26
%		100	94	77	59
Ciano 67	Feb 25	5.78	5.18	4.42	3.78
%		100	90	76	65
Yecora 70	Mar 1	6.37	5.46	4.24	3.25
%		100	86	67	51
Cocorit 71	Mar 2	7.09	5.20	3.83	2.38
%		100	73	54	34
Pitic 62	Mar 4	5.12	4.16	3.17	2.22
%		100	81	62	43
Gabo	Mar 4	4.40	4.02	3.69	2.75
%		100	92	84	63
Nainari 60	Mar 5	4.68	4.03	3.24	2.74
%		100	86	69	59
Tcl Arm[b]	Mar 6	3.74	3.52	2.48	1.76
%		100	94	66	47

LSD between genotypes at different levels of drought = 0.58 t/ha.

Seeded at 100 kg/ha in 30-cm rows with 100 kg/ha N and 80 kg/ha P_2O_5.
[a] Last watering: full flooding for 3 hours on Feb. 10, 1972.
[b] X-308-27Y-2M-1Y-302B-0N-101B (triticale).

Wheat Agronomy

CIMMYT's wheat agronomy studies in Mexico seek to determine guidelines for managing the new varieties and promising lines being produced by the breeding program and in particular, to see whether existing recommendations should be changed as plant type, etc., change. At present, investigations are conducted under irrigated conditions at CIANO but there were no irrigation studies.

Results of the time-of-sowing trial with various genotypes (Fig. W5) confirm the results reported last year. Early November planting is best for the large genotypes, such as the variety Cajeme 71 and the line LR-N10B x $An3_E$ (WW 15). Early (Sonora 64 and Hira) and midseason (Yecora 70) types did somewhat better at a late-November planting even though, in contrast to the previous season, there was no frost damage to earlier plantings. Stem rust reduced yields of still later plantings (December 16 and January 6) of susceptible genotypes (Hira and WW 15).

Another nitrogen fertilizer study was conducted despite the difficulty of obtaining land of low soil N status and despite the limited transferability of the results of such experiments. However, this experiment, which included some old varieties as well as recent ones, did provide a useful resume of the yield progress during the last two decades (Table W27).

Lodging resistance of the newer genotypes has meant higher yields at higher optimal soil N levels. Additional improvements in yield potential, apart from lodging resistance with varieties such as Yecora 70 (see earlier discussion), are also evident at high soil N levels. At low soil N levels there appear to be no differences between genotypes in the yield and, therefore, in the efficiency with which they use limiting supplies of soil N.

TABLE W27. Summary of steps involved in the major pathway for yield improvement at CIANO over the last 20 years showing the interaction between N level and genotype under disease-free conditions.

Soil N	Variety	Lodging	Yield, t/ha
low	Yaqui 50	0	2
low	Nainari 60	0	2
low	Yecora 70	0	2
high	Yaqui 50	severe	4
high	Nainari 60	moderate	4.5
high	Nainari 60	0[a]	5.5
high	Yecora 70	0	6.7

[a] Lodging prevented by having crop grow through mesh.

An extensive seeding density spacing trial was conducted. Four bread wheat and four durum varieties were tested at all combinations of 40, 100 and 250 kg/ha seed and 15, 30 and 45 cm row spacing; extreme values were used to amplify variety x treatment interactions. Varieties were chosen for differences in tillering, maturity and, for one durum variety (6WW-5101), for leaf erectness. Overall trial mean yields for the three seeding densities were, respectively, 6.000, 6.13 and 6.03 tons/ha (LSD = 0.10 ton/ha); for the three spacings there were, respectively, 6.05, 6.20 and 5.90 tons/ha (LSD = 0.14 ton/ha). Variety x treatment interactions were small; durums were slightly more sensitive than bread wheats to changes in spacing. A slight, but significantly greater, positive response to increased seeding density did appear to be associated with the lower tillering varieties (Sonora 64 and Siete Cerros) and the erect durum variety.

The depth-of-cultivation trial of last season was repeated, but failed to show the previously reported advantage of deep chiseling (to 40 cm) during land preparation.

WHEAT TRAINING AND VISITORS

During 1972, approximately 740 visitors saw the plots at Ciudad Obregón or visited CIMMYT wheat nurseries at Toluca and El Batán. There were 9 short-term visitor-trainees, 12 senior scientists, 3 postdoctoral fellows and 39 in-service trainees in various phases of the wheat program activities. Training has emphasized the in-service and postdoctoral fellowships, and CIMMYT now provides opportunities for a limited number of visitor-trainees and senior scientists to work in the program.

In-Service Training

In-service training provides a means of developing young scientists for national research and production programs. In 1972, four courses were offered: wheat production, wheat breeding, wheat pathology and cereal chemistry.

The three principal aims of the program are:

1. To provide leadership for accelerated research and production programs. Trainees are treated as team members; they are shown the value of enthusiasm, hard work and sound judgment, all designed to develop confidence and an ability to lead others.

2. To broaden the outlook of the young scientist. While in Mexico, the trainee can see all types of agriculture, ranging from the traditional to the fully modern, progressive agriculture practiced in the irrigated areas of the Northwest. The latter represents the latest techniques in production and marketing. He discusses with colleagues from many countries their problems, methods of agriculture and different philosophies. He learns that he is not alone in the world but a member of a very large fraternity. He observes and learns how the different disciplines and factors of agricultural development are interrelated and how adjustments in one affect the others.

3. To broaden and develop his technical knowledge and abilities. The trainee scientist is given some formal lectures, but most of his time is devoted to field work alongside CIMMYT scientists in the various programs. When he has completed the course and passed through two crop seasons, he will know the morphology and development of the wheat plant, and has been exposed to genetics, plant pathology, plant nutrition, response to environment and cultural practices, and the utilization of the product and marketing procedures. He will have learned to identify in the field, and know how to prevent or minimize the losses from, the common pathological and physiological diseases of wheat and insect pests. He will have knowledge of how to establish the objectives, select a suitable design, manage, analyse and interpret field experiments leading to the development of a package of practices or recommendations for local conditions.

These aspects are part of the training of all in-service scientists. Beyond this, specialized courses prepare the scientist for activities in a particular field as a member of a research team.

In wheat breeding, the trainee gains experience in the operation of a breeding program designed to develop new improved varieties. He learns to identify and describe desirable agronomic, morphological, physiological, insect and disease resistance and marketing characteristics of wheat. He gains experience in working out breeding objectives, learns how to organize a breeding program, prepare seed for the nursery, lay out the land, manage a breeding nursery and keep records. He learns how to identify better parent material, various crossing methods and how to make selections in segregating populations. He also learns how varieties and lines are tested and evaluated, how to maintain purity and multiply seed, and how to determine and describe grain quality.

In the wheat production course, the scientist receives more training in production methods and experimental techniques. He receives field participant training in growing and operating production demonstrations, weed control, depth of seeding experiments, fertility and spacing experiments, and others designed to acquaint him with how a package of production practices is developed to suit a particular situation. He becomes acquainted with methods of approaching farmers to gain their acceptance of new techniques and how to organize and conduct production training courses in his own country.

The wheat pathology scientist has additional training in identifying diseases and biotypes of diseases in the field, greenhouse and laboratory. He learns how to create artificial epidemics of the more common diseases. He also works alongside his breeder colleagues during selection in the field.

Cereal chemistry scientists learn how to perform and interpret laboratory tests for evaluating wheat quality, both from the nutritional and industrial use standpoint. He is also taught how to organize and manage a wheat quality laboratory and train supporting technicians.

In all in-service training, the scientist learns by actually doing rather than through lectures alone. All operations are performed by the scientist.

Other Categories of Training

This heading includes the short-term visiting scientist, the senior scientist and the postdoctoral fellow. The orientation of individual programs depends on the scientist's previous experience, his technical knowledge and other criteria. Enthusiasm for research and production and the development of team spirit are emphasized. Invariabily, they work as integral parts of the CIMMYT team. In many cases, they are or will be team leaders in their own country and this new experience broadens

Dr. Borlaug gives a seminar in the wheat plots for young scientists from developing nations in the training program.

their appreciation of the possibilities of expanding programs, even with limited personnel. CIMMYT hopes that each will re-enter his field with renewed enthusiasm.

In the past year, CIMMYT has increased the number of visitor-trainees who come for several weeks to two months of practical experience in the wheat program. These may be scientists coming for a short period during harvest or scientists who are studying for or have recently completed a Ph.D. In the latter case, the scientist comes to CIMMYT before returning to his home country. These scientists already have enough technical background but gain much by seeing a program in action and selecting materials useful in their home programs.

In the postdoctoral program, a certain number of scientists are accepted whose field of work is related to CIMMYT activities. They are, of course, assumed to be fully capable of independent research. The postdoctoral fellows are accepted to develop new staff for CIMMYT and for other international organizations.

Such appointees generally serve for two years. Three member of the present resident staff were formerly postdoctoral fellows.

In-service trainees lay out their own experimental plots in the wheat production training program.

Dr. M. Quiñones discusses plant breeding problems of durum wheat with a group of trainees in the CIANO nursery.

Erisyphe graminis **is a common disease of barley.**

BARLEY

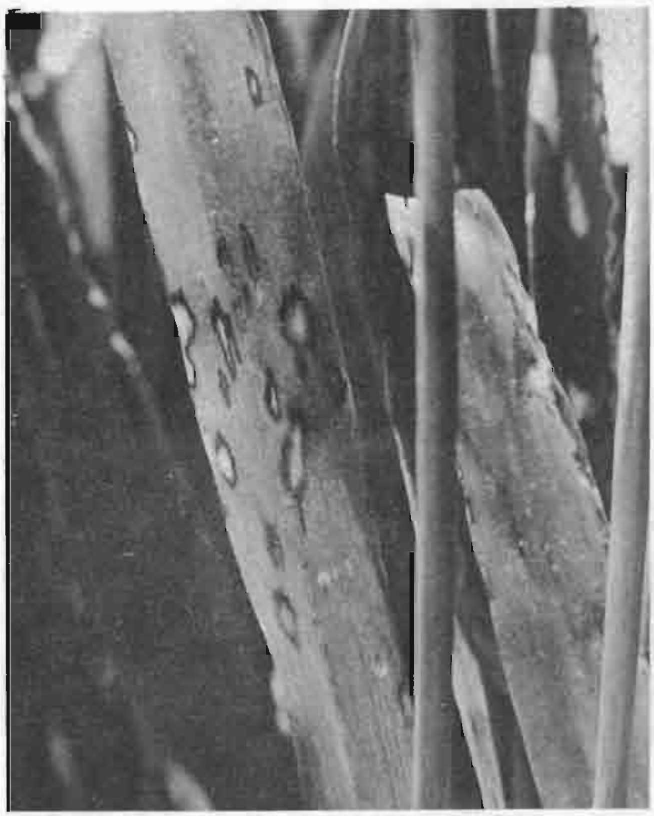
During the current year a barley program was initiated at CIMMYT. The program focuses on improving this crop as a natural complement to the wheat program. There are many areas adjacent to deserts or with a short frost-free period in the higher mountain regions of the Himalayas, Andes and other mountain chains where wheat does not successfully compete with barley production. In many of these areas barley has become a main food staple for human consumption. In still other areas, such as in South Korea, barley is grown as an alternate crop in rotation with rice. Present wheat varieties have a maturity period which extends into the time when paddy is transplanted. Hence, the shorter maturity period of barley has made it the favoured crop.

Considering these factors, CIMMYT decided to develop naked varieties which could be used directly as food. In addition, the recent discovery of the "hiproly" barley provided an opportunity to use this high-lysine type to improve the nutritional value of the crop.

In the past, most barley improvement has been done with hulled types. Hence, in developing highly nutritional, disease-free, high-yielding naked types, many hulled types will arise which may have direct use as animal feeds. The growing needs for animal protein in many countries can be reinforced by producing better feed varieties. This will be the second emphasis of the program. No attempt will be made to breed for malting types for brewing.

During the initial stages of the program, effort has been on bringing together superior germ plasm from many countries. CIMMYT thanks the many scientists nucleus for its improvement program.

More than 4,000 lines were received and these have been grown for observation in the past year. Notes were taken on different characteristics and many were selected on the basis of agronomic type, disease re-



Rhyncosporim **scald of barley is common in most barley-producing regions of the world.**

Note the sterility in the high-lysine "hiproly" barley being used in the CIMMYT crossing program.

sistance, and some were selected for nutritional possibilities. This preliminary screening resulted in the selection of 187 lines and varieties. These constitute a crossing block now being grown at CIANO. A total of 117 F_1 single crosses and 127 top and double crosses were produced in the current season and these also have been sown. In addition, 100 F_2 bulk populations and 25 F_2 top and double cross populations were selected from crosses made in the past two seasons. Segregating lines from crosses received from other countries which are now in F_3 to F_6 have been incorporated into the program.

Many additional varieties and lines have continued to come in which will be observed in future cycles and represent very valuable additions to the germ plasm base. Such characteristics as usable short dwarf materials, resistance to a wide spectrum of diseases and other desirable traits are present within the material, but in a very dispersed background. CIMMYT intends to bring together as quickly as possible the necessary array of genes to produce superior varieties through single, top and double crosses.

This physiological spotting of barley leaves is often confused with leaf diseases.

As stated earlier, the program is in its initial stages and sufficient material is not yet available for systematic distribution to cooperating national barley programs. Next year early segregating materials should be made available for selection in other countries.

Nutritional Improvement

In barley, as for maize, mutant recessive genes have been identified which favorably modify the amino acid balance of the protein and produce improved nutritional quality.

The high-protein and high-lysine barley mutant, Hiproly (CI.3947), was identified by Hagberg, Karlson and Munck in Sweden in 1969 while screening the Barley World Collection. This mutant gene (lys) increases the lysine content of the protein about 30 percent. Recently, another mutant, No. 1508, obtained from the variety Bomi, was found to increase the lysine in the protein by about 45 percent (Munck 1972). Toft-Vieuf in 1972 reported a third high-lysine barley, CI. 7115, with about 15 percent more lysine in the protein than normal barley controls. These mutants maintain a rather constant lysine content at different crude protein levels after various treatments of nitrogen fertilization. Munck and his group in Sweden and the Ris group in Denmark have kindly provided CIMMYT with seed of these superior-quality barleys. Therefore, CIMMYT's recently initiated barley breeding program has begun to incorporate materials of high protein quality. These lines have been crossed to varieties with acceptable agronomic type to incorporate the high-quality-protein character. The segregating materials from the crosses are being evaluated, using the dye-binding capacity (DBC) screening method to assess quality. The selected plants that were replanted will continue to be evaluated during the next segregating cycle.

The protein content of 80 lines included in the crossing block ranged from 12.8 percent to 18.3 percent with an average of 16.4 percent. The lysine content in the protein of the best materials was about 3.9 percent. In the segregating generations, 800 individual plants tested showed a very wide variability in the protein and lysine content of the grain.

NATIONAL PROGRAMS

The following section covers the progress in wheat, triticale and barley improvement in national programs where CIMMYT is involved.

These reports were prepared either by the national program coordinator of the country involved or jointly by the national program coordinator and a CIMMYT resident scientist.

These national programs reports are grouped by continents: Asia, Africa and South America.

INDIA

For the fifth successive year, wheat production increased to a new record level. The official estimate of the 1972 harvest was 26.45 million metric tons. This represents a 12.2 percent increase over last year's record of 23.247 million tons. The estimated total acreage rose to 19.162 million hectares, 6.6 percent above the previous year. The average yield continued to improve and is now 1,382 kg/ha. Fig. W9 shows the area, production, yield and imports for 1960 to 1972.

In general moisture at sowing was favorable in most wheat areas, except Peninsular India. Dry conditions continued there and in the central rainfed area until late in the crop season when rains in sections of central India produced a substantial recovery. In northern India,

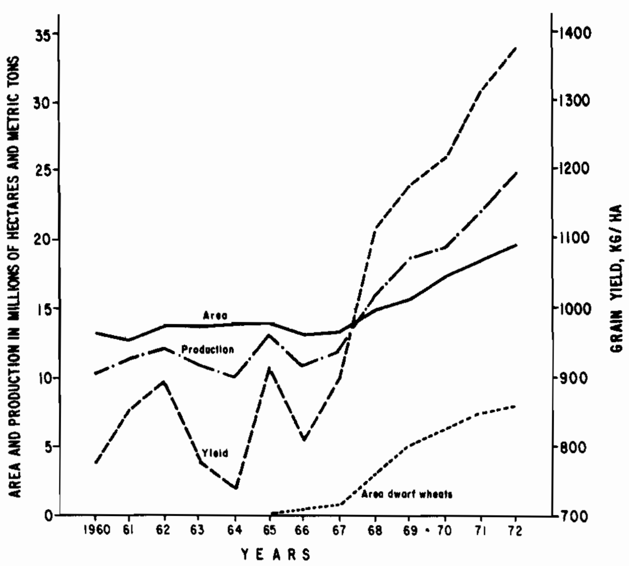


FIG. W9. Cultivated area, production and yield of wheat in India, 1960-72.

growing conditions were excellent up to grain filling. Then hot weather (4-5°C above normal) and a concurrent rapid development of leaf rust undoubtedly reduced the potential yield. This was aggravated by the adverse effects of late sowing in some areas which has been increasing in recent years due to late paddy harvest. Rice has become a major complementary summer crop in the normal wheat regions. This trend toward later sowing should not be continued if wheat production is to remain high. Early maturing, high-yielding rice varieties are needed to reverse this trend.

The significance of the Wheat Revolution can be appreciated because of the severe drought which occurred during the 1972 summer in much of the rice and sorghum areas. The increased wheat production provided an additional 5.1 million tons of wheat which, added to existing stocks of food grains, provided a stockpile of more than 9.0 million tons after the wheat harvest. Considering the shortage of food grains in the international market and the partial failure of the monsoon, the increase in wheat production undoubtedly reduced the suffering that such a drought would have caused in the past.

Wheat now accounts for about 25 percent of total grain production in India. Approximately half the present acreage is irrigated and high-yielding varieties occupy about 59 percent of this area. With more fertilizer and a continuing spread of the high-yielding dwarf varieties, there is still a tremendous potential for increasing production in both irrigated and rainfed areas. The Ludhiana district of Punjab averaged 3.3 tons/ha on 92,000 hectares this year. The average yield of the national demonstrations throughout the wheat production areas exceeded 3.0 tons/ha and the top yield in All-India Crop Competition was 7.6 tons/ha. Research has also shown that applications of 40 kg N/ha with 30 kg P_2O_5/ha give an average yield increase of 60 percent. These figures indicate the great potential when considering average national yield of 1.38 tons/ha. These projections ignore the other needs of levelling, drainage, irrigation and other factors which are still to be accomplished on a large scale. Production approaching 50 million tons is quite possible on somewhat less than present wheat acreage.

As in the past, the All-India Coordinated Wheat Improvement Program held its annual meeting in August to review the trials conducted in the past season and to plan the program activities for the coming year. The need to identify a rust resistant variety superior to or equal to Kalyansona was a major topic of discussion. The late attack of leaf rust in large areas of the Northwest and Northeast emphasized the need to further diversity the varieties.

Breeding Research

Breeding lines are evaluated in a coordinated system of yield nurseries. The country was divided into five major climatic zones and the trials are designed to sample the conditions existing within the zone. These zones are: Northwest Plains, Northeast Plains, Northern Hills, Central and Peninsular. Irrigated, rainfed and high- and medium-fertility trials are grown. These include lines and varieties which are suitable for the respective zones.

On a national basis, 41 trial combinations were conducted in which 490 varieties were evaluated under different arrays of environment, fertility and water supply. This was in addition to numerous station trials conducted on newer breeding lines. The trials are

TABLE W28. Varieties recommended for release in India in 1971-72.

Variety and pedigree	Area for release
BREAD WHEATS	
HS 1097-17 E 5165 (CJ60) x E4717 (S x Mt x Mq x Rw²)	Northern Hills, higher elevations.
NI 5439 RFPM-80 x NP710³	Peninsular, rainfed.
DURUM WHEATS	
Meghdoot (HI 7483) HI 6-23-HY23 x NP404	Central India, rainfed.

arranged in a continuous flow pattern and successful varieties advance to higher level trials each year. Both bread and durum varieties are included where applicable.

Last year the three varieties shown in Table W28 were considered superior to those presently grown in certain regions and recommended for release to the Central Varietal Release Committee. Table W28 also indicates the areas where these varieties are suited. HS 1097-17, which has been under test for several years, has consistently yielded higher at elevations above 5000 feet. NI 5439 has shown consistently high yield performance in Peninsular India. Its chief defect is leaf rust susceptibility. Meghdoot, a durum variety, outyields the presently widely grown NP 404 which entered into its parentage.

Several other varieties appeared sufficiently promising to be seriously considered. These varieties shown in Table W29 were submitted for District Level Trials. These are conducted on farm fields under Extension Service personnel. The data from coordinated program trials and district trials will be used to determine the relative merit of these varieties at the next annual meeting.

The coordinated project cooperates with several international, regional and national programs. Last year 15 different yield trials and screening nurseries were grown, including those from CIMMYT. Table W30 shows some of the most promising lines selected from CIMMYT's Fifth International Bread Wheat Screening Nursery. These are presently in the national yield trials. All selected lines are amber grained and have 2- or 3-gene dwarf stature.

TABLE W29. Most promising bread wheat and durum wheat lines being tested extensively for future release (India, 1971-72).

Genotype and pedigree	Area and conditions
BREAD WHEATS	
UP-310 K1. Pet.-Raf (LR-Son 64)[2]	Northwestern Plains Zone, high fertility, irrigated
W6-377 W6. 143-USA 225 x PV 18	(Same)
HD-1925 Son 64 A-LR 64 A	(Same)
HD-1949 E 5557 (Pi "s")-NP 852	(Same)
HD-1982 E 5557-HD 845	Northeast Plains Zone, high fertility, irrigated
HD-1999 Son 64-My 54 E x Son 64-P 4150 E3	(Same)
HB-102-101 NP 846-S 227	Northern Hills, lower elevation, high fertility, irrigated
DURUM WHEATS	
MACS-9 T. durum-T. polonicum (41 x 15)	Peninsular, rainfed
HD-4502 Pi "s"-By[2] x Tc-(Z-B-W)	Peninsular, high fertility, irrigated

The small-scale manufacture of threshers is common in many Villages of North India.

Agronomy and Physiology Research

Three trials which have given consistent results over the past years were grown under the project. They are: rate, time and method of N application, P_2O_5 rates and N rates under rainfed culture. Other trials which will continue for one or two additional years deal primarily with new varieties being developed, including the three-gene dwarf type in order to identify any changes in agronomic practice needed to produce maximum returns. Other interests include the maximization of wheat yields when wheat is sown late. The purpose of this research is to identify varieties and practices which can be used with late sowing to accommodate rotations with other late-maturing crops. This does not mitigate the need to continue searching for high-yielding, early maturing varieties of all summer crops which would permit maximum flexibility and yield in multiple cropping systems.

Another area is the fertility requirement for wheat sown after maize or rice crops. This reflects the widespread and growing interest in double and triple crop-

TABLE W30. Wheat genotypes from the Fifth International Bread Wheat Screening Nursery showing good yield potential in India (1971-72).

IBWSN Entry	Genotype	Pedigree
37	Inia 66-Bb	26478-32Y-9M-1Y-2M-0Y
44	Bb-Inia66	26591-1T-7M-0Y-301M-0M
46	NP 876-PJ 62 x Cno "s"-PJ 62	27983-21Y-1M-0Y
63	Cno "s"-Gallo	27829-19Y-2M-3Y-0M
64	Cno "s"-Gallo	27829-19Y-2M-6Y-0M
103	Tob "s"-Napo 63 x Cno-Son 64/Col-Ska	35058-26Y-0M
107	(Cno-Chris x On/Gallo) (Cno-S 64 x Cno-Inia)	35106-64Y-0M
112	Bb-Gallo	30810-1M-5Y-0M
114	Cno "s"-Gallo	27829-19Y-2M-1Y-0M
122	HD 832-Bb	27047-51M-2Y-2M-1Y-0M
123	HD 832-Bb	27047-51M-2Y-2M-4Y-0M
233	(LS-3.1-Pi62 x Inia/CC-Inia) Gallo	CM-1186-500M-0Y
251	Inia "s"-On x Inia-Bb	CM-1607-7M-0Y
257	Cno "s"-No 66 x CC-Inia 66	34167-91Y-6M-0Y
258	Cno "s"-No 66 x CC-Inia 66	34167-95Y-2M-0Y
268	Inia 66-RL 4220 x 7 Cerros	35038-7Y-1M-0Y
270	Tob "s"-Napo x Cno-Son 64/Cal-Ska	35058-26Y-3M-0Y
271	(Cal-Bb) [(Kl. Pet.-Raf x PJ 62/Cno) (NP 876-Bb)]	35063-23Y-1M-0Y
273	Bb-Gallo/Cno-Son 64 x Bb	35129-18Y-1M-0Y
279	(Son 64^2 x Tzpp-Y 54/An 64 A) Bb	34630-9Y-1M-0Y
287	PJ 62-Cal	30403-19M-2Y-1M-0Y
304	(Napo 63^2-Tob "s" x Inia "s"/Cno) (Kl. Pet.-Raf^2/Son 64 x Tzpp-Y 54)	32550-4M-1Y-1M-0Y
318	Cno "s"-Gallo	27829-19Y-3M-5Y-1M-0Y
319	Cno "s" Bb	27845-5Y-3M-4Y-3M-0Y
336	Ska-On	Exp.LV-V-1363-1Y-1M-0Y

ping. Rice, for example, as previously indicated, is becoming increasingly important as a rotational crop with wheat in northern India and, thus, has created several agronomic questions about the present variety and fertilizer use.

Physiology studies involving the yield components (light penetration, and dry matter production and distribution) and their relative contributions to yield are being pursued under both irrigated and rainfed culture. Varieties are also being studied for comparative photosynthetic activity and sink size.

Plant Pathology Research

The wheat disease survey, with its associated trap nurseries, was continued. Stem rust and yellow rusts were of minor importance except for a very isolated pocket of late-sown local (desi) varieties in northwestern Uttar Pradesh. Here stem rust was severe. This is a reminder of the potential hazards presented by this organism when susceptible varieties are used and climatic conditions are conducive to its development.

The yellow rust race capable of attacking Kalyansona was only rarely found outside a small area in the Punjab foothills where a few fields of this variety were damaged. Again, as for stem rust, a hazard does exist and the disease must be monitored.

The most serious wheat disease problem of the past years has been leaf rust. A race capable of attacking Kalyansona and NP 884 survived in the northern inoculum reservoir. This race was established early and built up rapidly in the entire Northern Plains wheat belt. Fig. W10-11 indicates the average degree of leaf rust development on a zonal basis. Kalyansona, although attacked at moderately severe levels, is not nearly as susceptible as the check durum variety, which

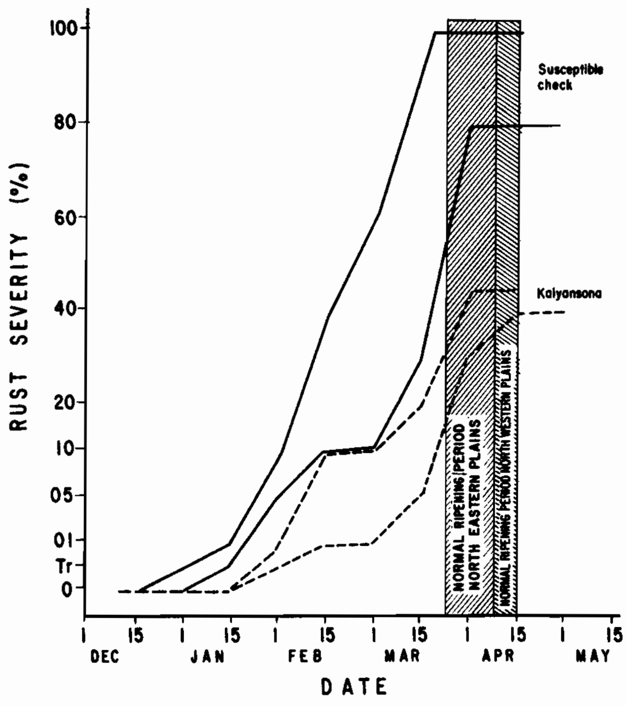


Fig. W10-11. Average leaf rust development in the Northwestern Plains and Northeastern Plains of India, 1971-72.

at one time was the principal durum variety of Peninsular India. This disease, coupled with hot, dry weather, reduced yields some and this was especially true for late-sown fields following the rice crop.

Kalyansona, with its resistance to loose smut, bunt and powdery mildew, exerts a strong influence on the incidence of these diseases. In North India, loose smut is no longer a major disease and powdery mildew remains insignificant. The importance of resistance genes in Kalyansona is very appreciable, considering the area sown to this variety.

The pathology program also does extensive testing and screening of breeding lines for resistance. CIMMYT lines are included. Those from the Fifth IBWSN which showed resistance to the three rusts are presented in Table W31.

Quality

The wheat germ plasm collection of the Indian Agricultural Research Institute will be screened for basic quality characters. The milling and baking industry, which is developing rapidly, requires varieties with acceptable bread-making qualities. Several varieties, such as Sharbati Sonora, UP301 and Hira, satisfy these requirements. Varieties suitable for both bread and *chapati* making need to be identified.

The protein level of most varieties increases with higher applications of N. In most varieties lysine content is inversely associated with protein content but some varieties are reported to maintain their lysine percentage as the protein percentage increases. The cereal chemists are interested in identifying such varieties in the interest of nutrition.

TABLE W31. Wheat genotypes from the Fifth International Bread Wheat Screening Nursery resistant to the three rusts in both winter and summer nurseries (India, 1971-72).

IBWSN Entry	Genotype	Pedigree
13	Tanori 71	25717-11Y-3M-1Y-0M
53	12300 x LR 64-8156/Nor 67	30842-58R-1M-4Y-0M
58	(Inia "s" x Napo 63 (Inia 64-Tzpp x Y54)	28844-8R-3M-3Y-0M
84	Bb-Inia	26591-1T-7M-0Y-55Y-0M
86	Bb-Inia	26591-1T-7M-0Y-113Y-0M
87	Bb-Inia	26591-1T-7M-0Y-115Y-0M
89	Bb-Inia	26591-1T-7M-0Y-208Y-0M
102	Cno-No x Gte	34134-20Y-0M
104	Cno "s"-No 66/C 273 x NP 875-E 853	34273-63Y-0M
124	Wren	28875-300Y-20M-2Y-0M
161	Ahome F 71	19957-18M-1Y-2M-1Y-6M
185	Tzpp	
202, 203	Pato	21974-4R-4M-2R-0Y-0P(-0Y)
217	Buitre	28867-300Y-300M-0Y
225	Tob "s" x 8156	22944-3Y-5M-0Y
236	Inia "s"-Napo 63 (Son 64-Kl. Rend/Cno x LR 64^2-Son 64)	CM811-68M-0Y
257	Cno "s"-No 66 x CC-Inia	34167-81Y-91Y-6M-0Y
263	CC-8156 x Cno "s"/Ska-Cal	35019-1Y-1M-0Y
268	Inia 66-RL 4220 x 7 Cerros	35038-7Y-1M-0Y
269	Nor-P1/Nor67 x Cno-Son 64	35052-28Y-1M-0Y
271	(Cal-Bb) (Kl. Pet-Raf x PJ 62/Cno) (NP 876-Bb)	35063-23Y-1M-0Y
275	Kal^2 (Fr-Th x Sk-Kt/Nar "s"-Fr^3)	35173-15Y-2M-0Y
276	Cno "s"-No 66/C 273 x NP 875-E 853	35273-10Y-4M-0Y
311	Cno-Son 64 x Bb	30505-71-7Y-1M-0Y
330	(Nar 59-101y/PJ 62-Gb x Tzpp-Knott No. 2) Cal	30409-44R-1M-3Y-1M-0Y

PAKISTAN

Several factors interacted to adversely affect wheat production during the 1971-72 crop season. These factors included the disturbance caused by the December war in the subcontinent, a shortage of canal water, below-normal winter rainfall, above-normal temperatures and a shortage of phosphorous fertilizer.

The wheat area for the 1971-72 crop cycle was 5.9 million hectares, 1.3 percent less than for the 1970-71 season. Most of the reduction in area occurred in the Punjab and Sind provinces. These reductions were partly offset by an increased wheat area in the Northwest Frontier Province.

Temperatures were above normal at sowing and during the first few weeks of seedling development. Seedling development was poor during the early stages, especially in the rainfed areas of the Northwest Frontier Province and in northern Punjab, but it recovered greatly following a series of rains during January and February. In the principal wheat producing areas of the Punjab and Sind, however, less than one-half inch of of precipitation fell throughout the season.

Despite the reduced acreage and adverse climatic effects, preliminary estimates indicate a national production of 7.1 million metric tons (Fig. W12), substantially above the 6.5 million tons of the previous year.

Increased fertilizer use was responsible for most of the production increase. During the 1971-72 wheat season, 181,587 metric tons of nutrients were applied compared with 146,497 tons during the previous season. Nevertheless, the total tonnage of fertilizer applied does not tell the whole story on fertilizer needs and utilization. Several hundred fertilizer experiments have been made throughout the wheat growing areas during the past nine years. The results indicate that the proper nitrogen-phosphorus ratio is about 2:1, or 1:1 in a few locations in the Northwest Frontier Province. The application ratio of N to P_2O_5 in 1970-71 was 7:1; it deteriorated to 8:1 in 1971-72. Repeatedly soil

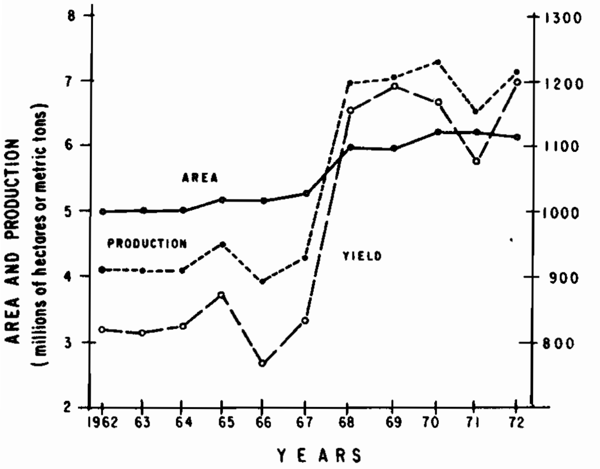


Fig. W12. Wheat production in West Pakistan from 1962 to 1972.

fertilizer tests have shown that 100 kg/ha of N applied without P_2O_5 increased yield only 400 to 600 kg/ha more than the check plot, whereas 60 kg of N with 40 kg of P_2O_5 increased grain yields 100 to 150 percent over the check plot. **The N:P_2O_5 imbalance is the greatest single factor presently, limiting wheat yields in Pakistan.**

Perhaps the fastest and easiest way to increase phosphate fertilizer consumption is by importing complex fertilizers such as diammonium phosphate and mono-ammonium phosphate for use as "starter" fertilizers. This would largely circumvent the large extension effort that will be required to correct the under-utilization of phosphate with the present fertilizer products such as urea and super-triple phosphate. In planning for the expansion of national fertilizer factories, production of fertilizers such as diammonium phosphate and mono-ammonium phosphate must be advocated.

Record wheat yields can be and are being obtained. During the reporting year competitions were held among farmers. The top yields ranged between 7.2 and 8.5 tons per hectare. The possibilities for high production are obviously excellent. Despite this, the general level of the yield curve for the country has flattened out much below the attainable peack. Al least part of this is due largely to two factors, namely (1) the under-utilization of phosphate fertilizer and (2) the inability of most small farmers to finance fertilizer purchases. Since small farmers cultivate more than 75 percent of the wheat acreage, remedial measures could have dramatic effects. Experimental research has established that an increase in fertilizer use from 30 to 90 kg/ha in a balanced 2:1 ratio of N to P_2O_5 can double yields with no other increase in inputs. The efficiency of irrigation water also rises, since under low levels of fertility two to three irrigations produce the same yields as five to six irrigations. Present practices involve applying three to four irrigations and less than 30 kg/ha fertilizer in the better wheat areas. Clearly, increasing fertilizer use, by whatever means, in this large sector of the farming community will again move the yield trend line rapidly upward.

In the rainfed areas, crops were marginally better in 1971-72 than in the previous year. Tall varieties still occupy 92 percent of the rainfed area. Under rainfed conditions, results from the use of improved technology coupled with improved varieties have shown good possibilities for a twofold to threefold increase in yield, but this has not yet been demonstrated commercially on a large scale. The accelerated wheat program is expanding its activities in these regions and in this area

Breeding Research

The breeding programs at all four main centres are expanding, both in magnitude and in the diversity of the genetic material with which they work. The number of new crosses and segregating lines tested has continued to increase. These nurseries have doubled in size in two years.

During the present year, the Kaghan summer nursery site finally became a reality after four to five years of struggle. An excellent summer breeding nursery was grown. This new facility will lead to a more rapid advance of generation material. Even more important, the various generations can be screened in Kaghan under heavy epidemics of all three rust species. This will enhance the disease resistance of lines being developed and eventually will result in the development of new Pakistani varieties with greater yield stability.

Eleven different international nurseries were grown collectively by the Pakistani research stations, some of them at as many as three stations. In the Eighth International Spring Wheat Yield Nursery, Chenab 70 ranked first in yield at the three stations. In the International Durum Yield Nursery, Cisne "S" outyielded all other lines and varieties. Among the triticales, PM 107, an Armadillo line, yielded 4.4 tons/ha compared to Chenab at 5.1 tons in the same test. It is heartening to see yields of this new crop approaching yields of the highest yielding Pakistani variety, Chenab 70.

Mexipak continued to be the dominant variety in commercial production. The newly developed varieties, Pakistan 20 from Tandojam, Chenab 70, Barani 70 and SA-42 from Lyallpur, and Khushal 60 from Tarnab are now being grown extensively. Khushal 69 is the leading variety in the major wheat area of the Northwest Frontier Province (N.W.F.P.). Collectively these new varieties are expected to occupy up to 60 percent of the improved variety acreage in the coming year. This diversification greatly reduces the rust hazard in the Mexipak monoculture.

Several new lines have been selected which appear promising and may form new varieties (see Table W32).

The first two varieties in Table W32 have performed well and are now under preliminary multiplication in the Sind. The line designated 114B-35 x Nad 63 is late-maturing and yielded up to 60 percent more than Mexipak or Chenab 70 with low levels of fertility and limited availability of water. At full irrigation and high fertility (120-60-0), it yielded 12 percent less. This variety should be very useful in dry land culture. The two sister lines of Khushal 69 (Zorawar 71 and Kalam 71) are performing well in tests at the research and farm level in the N.W.F.P.

At Quetta, research has continued to expand, particularly for cold-hardy wheats for the higher altitudes of northwestern Baluchistan. Selections were developed from several of the spring wheat varieties such as Mexipak and Sonalika (Blue Silver) which are much more cold tolerant than the original strains. This material can be of real value to researchers interested in semiwinter types with relatively low winter tolerance.

Interesting agronomic experiments were conducted at Lyallpur and Bahawalpur. Varieties were tested after a

TABLE W32. New promising lines in the Pakistani breeding programs.

Variety and pedigree	Developed at	Important characteristics
Dirk-TJ 558 x My 64-Son 64 PK1345-5T-3T-6T-0T	Tandojam	High yield, good quality
36896-Cj 54 x Y 54/5657 PK116-3T-1T-0T	Tandojam	Good yield, very good quality
Cno "s" x Son 64-Kl Rend/8156 = Bb "s" II23584-303M-0Y-IIa-1436	Lyallpur	High yield, good quality, triple dwarf
114B-35 x Nad 63	Lyallpur	Long duration, low irrigation requirement
Bb-Nor67 II27100 135M-1Y-1M-2Y-0M	Lyallpur	Good grain, high rust resistance
Zorawar 71 = (21931-Ch 53 x An/Y50)C271 PK937-14F-5K-1F	Tarnab	Good quality, high yield
Kalam 71 = (21931-Ch53xAn/Y50C271 PK937-17F-4K-2F-5K	Tarnab	High yield

pre-sowing irrigation and given only one irrigation 29 days after emergence. Certain genotypes under this limited irrigation regime produced a very good yield (up to 4.3 tons) on the research station. Another experiment attempted to determine whether spring wheat types could be clipped for forage. At 45 days after seeding, yield appeared to be little affected and about 2.3 tons of green forage was taken from each hectare. This is a period of very low forage availability and an alternative source of forage may be provided with little adverse effect on grain production.

Microplot yield and demonstration plots were grown throughout the country at the farm level. Average yields averaged between 3.1 and 4.1 tons per hectare for the Punjab and Sind; as expected, average yields were considerably lower in N.W.F.P., ranging from 2.5 to 2.9 tons per hectare.

Pathology

In Pakistan much of the pathology work is conducted by the Senior Plant Pathologist and his staff at Murree and at Rawalpindi. In addition, plant pathologists work with the breeders at some state centers. There is close cooperation between the pathology group and breeders at the various stations. The newly developed lines are screened against rusts, bunt and flag smut. The Cereal Diseases Centre at Murree screens many lines against individual races of stem and leaf rusts in the greenhouse and in the summer nursery. In the present year, 51 lines were selected with resistance to all prevalent races of stem and leaf rust in the country. These lines are under yield test and have entered the crossing program.

Quality

The two well-established cereal quality laboratories located at Tandojam, Sind and at Lyallpur in the Punjab, are now actively servicing the breeding programs of the research centres. Since several high-yielding varieties such as Pakistan 70, Chenab 70 and Khushal 69 have now provided diversification for production, part of the breeding emphasis has shifted to combining the grain quality of the older varieties with the superior yield and disease resistance of the introduced materials. Thus, cereal quality is now becoming a fully integrated partner in the wheat improvement at all levels of genotype development.

Coordination

After the formation of four provinces from the one original western province, overall coordination of the wheat program, which had been officially in operation since 1965, ceased to exist. Despite this, the research groups at the different stations in several provinces have continued to exchange materials, testing materials in a uniform grid of varietal tests and farm demonstrations. Through the assistance of the Ford Foundation, they have been able to conduct joint tours and meetings. It is understood that efforts are underway to reinstitute coordination at the national level under the auspices of the Agricultural Research Council. Such a move would greatly enhance and assure the continuing effectiveness of the wheat research programs.

AFGHANISTAN

During the past season (1971-72), the widespread drought in Afghanistan was broken. Rains were not heavy in the fall, but they were sufficient for germination. Through the remainder of the season abundant snowfall in the mountains and a good level of precipitation in the dry land wheat regions insured a good crop. In the Kinduz region, however, flooding occurred in the spring.

Because of the 1970-71 drought, seed supplies were extremely low. The Government imported about 6,000 tons of seed, mostly Mexipak, from Pakistan but germination was low for about two-thirds of it. Mexipak and Lerma Rojo were the varieties favoured by the farmers. In the Helmand Valley, yields of 6 tons per hectare were reported under irrigation and in many dry land areas, record yields were obtained.

The support price for wheat was set by the Government at US$62.50 per ton but the price in northern Afghanistan markets during the preharvest season rose to the equivalent of US$168.67 per ton. The Government set stringent laws to prevent hoarding during this period and, to a degree, farmers were reluctant to deliver grain to the markets for fear they would be accused of hoarding and would lose their grain as well as be arrested. Food supplies reached a critical low ebb in some of these deficit areas.

About 250,000 tons of wheat were imported under P. L. 480 from the United States and perhaps another

65,000 to 70,000 tons from the U.S.S.R., World Food Program and other sources. This marks a very major increase of imports over the 50,000 to 60,000 tons that have been fairly constant over the past few years. The import measures considerably alleviated the starvation which would otherwise have been widespread during 1971-72.

Fertilizer imports are expected to be increased during 1972-73 and sold by a fertilizer corporation through private retailers. A urea plant at Majar-i-Sharif is expected to be constructed with Russian participation in 1973 with a rated capacity of 70,000 tons per year. There is a small phosphate deposit in the country, but it is inaccessible and will be expensive to exploit. Thus, imports of phosphatic fertilizers must be continued for some years if the value of urea applicacion is to be effective.

Consideration is being given to setting up a semi-autonomous research institute which would coordinate and establish priorities in agricultural research. Such a move would have the great advantage of closer planning of the research and would provide mobility for research personnel. The extension service is still somewhat embryonic but, nonetheless, a considerable advance in the introduction of superior varieties is evident.

Afghanistan continues to have a large area under tenant agriculture. A variety of systems are used. One of the more common is a two-thirds crop share to the owner and a one-third share to the tenant with the owner supplying seed, fertilizer and water. In another system, labour is paid about one-eighth of the crop at harvest. Kuchis (nomadic people) are often hired for harvesting operations and receive about one-tenth of the crop they cut. In still other cases, farm labour is employed on a cash basis. In the Helmand Valley Project, the land is Government owned and Kuchis are being settled on tracts.

The research personnel are growing very creditable plots at many of the stations, often under very adverse conditions. The variety E_1-314 is being grown under widespread increase and two varieties (17778 and Ephrat) are considered particularly promising. These are likely to be released for farmer cultivation.

The research and extension programs are being assisted, as for several years, by the United States Agency for International Development. In the past year, additional help in wheat research has been provided by a scientist assigned by the Government of India.

Dr. G. Anderson (left), associate director of the CIMMYT wheat program, checks wheat plots in Pakistan.

IRAN

Wheat production in Iran reached 4.25 million tons in 1971-72, compared to 3.8 million tons in 1970-71 and a five-year average of 4.0 million tons. Much of this production increase is attributed to favourable rainfall, in contrast with the drought of last year. In addition, disease incidence was low in the highly productive areas of the Caspian Coast. Yellow rust and stem rust are normally prevalent and often serious in this region, but during the current crop year rusts were more destructive in certain areas of western Iran.

Iran is nearly self-sufficient in its wheat needs. However, because most of the wheat lands are rainfed, annual production varies with the available rainfall. Over the past five years, an average of about 300,000 tons were imported each year. It is anticipated that demands will steadily increase. Based on an annual consumption of 150 kilograms of wheat per person and a 2.5 percent population increase, it is expected that requirements will be 1.75 million tons above the present level by 1980 (Table W33).

This increasing need was sensed some years ago and research was intensified. Furthermore, an Impact Program aimed at augmenting production was initiated in 1968. Under this plan, selected farmers receive seeds of improved varieties, a fertilizer subsidy, a small cash loan for operations, and are assisted with a package of agronomic practices. Both the research efforts and the Impact Program have concentrated on the irrigated lands or on those with regular and adequate rainfall. Plans are now underway to expand research and production to areas of lower rainfall, which are largely winter wheat tracts. In such areas the emphasis will be on varietal imporvement, mechanization, cultural practices and crop rotations. Yields and resulting production can be greatly increased over immense areas through means such as the use of seed drills, water management, weed control and judicious use of moderate levels of fertilizers. In this area of about 2.5 to 3.0 million hectares, yields could be doubled.

TABLE W33. Projected wheat requirements for 1975 and 1980 for Iran.

Year	Population millions	Wheat consumption (millions of tons)	Seed requirements (millions of tons)
1970	29.0	4.35	0.5
1975	32.8	4.92	0.5
1980	37.8	5.56	0.5

As mentioned, the Impact Program was initiated in 1968. In 1971-72 there were 250,000 hectares under this plan. The semidwarf varieties Inia 66, Tobari 66 and Penjamo 62 occupied 120,000 hectares. Bezostaya from the USSR and the locally improved varieties Roshan and Ommid, which are adapted to the colder winter conditions of the Iranian Plateau, covered 130,000 hectares. Among the spring types, Inia 66 has been particularly successful. In the Grogan area southeast of the Caspian Sea, yields up to 6 tons per hectare have been common from this variety. Although these yields are very encouraging, yield tests have shown that some of the more recent dwarf varieties surpass Inia 66 (Table W34).

TABLE W34. Yield and resistance to mildew of recently introduced varieties in the Gorgan area of Iran, 1971-72.

Variety	Yield t/ha	% of Inia as check	Mildew resistance (0-9 scale)
Potam 70	5.23	136	3
Jaral 66	4.95	129	5
Chenab 70	4.75	124	7
Mexico 120	4.73	123	5
Cajeme 71	4.64	121	3
Nuri 70	3.08	80	7

In the Impact Program area of 250,000 hectares, it is reasonable to assume that production increased at least one ton per hectare this past year. Next year the area will increase to 350,000 hectares. Thus far, 46,000 tons of improved seeds and 88,000 tons of fertilizers have been distributed. It is estimated that a similar area will be sown to improved varieties through farmer-to-farmer seed sales, but, because of inadequate fertilizer use, yields will not equal those under the Program. Overall, it is felt that next year an additional 500,000 tons can be produced.

Research

Iran has an active and dynamic breeding program with activities at several stations throughout the wheat regions. Scientists are selecting and testing many crosses and lines to develop superior replacements for present varieties. In Table W35, several promising new lines are listed and their yields are compared with standard checks at different locations. These lines combine such characters as greater winter hardiness or superior disease resistance with yields equal to or better than the present varieties. Presently, they are in the advanced "on farm" trials and under multiplication for possible release.

In Table W36, data are presented for disease reactions of three lines in several countries.

In the past few years, utilization of high-yielding, disease-resistance germ plasm of both exotic and Iranian origin has been emphasized. Breeding of both winter and spring wheats has been integrated into the same program and it has now been decided to separate the two portions into more distinct groups since the two have somewhat differing objectives and materials.

Approximately 60 to 65 percent of Iran's wheat area is sown to winter and semiwinter wheat varieties. In the colder areas the dwarf Mexican spring wheats have been unsuitable. Thus, for these areas, local wheats, with an intrinsically lower production capacity (but greater winter hardiness), are grown on most of the acreage. Such local wheats are considered adapted to a wide range of sowing dates and more marginal conditions of moisture and fertility. It is necessary to exploit more fully exotic winter wheats for crossing with local

TABLE W35. Performance of some advanced lines at five locations in Iran.

Lines and pedigrees	1968 - 1969		1969 - 1970		1970 - 1971		1971 - 1972		Highest disease rating			
	Yield t/ha	% of check	Yield t/ha	% of check	Yield t/ha	% of check	Yield t/ha	% of check	Yellow rust	Leaf rust	Stem rust	Mildew (0-9)
KARAJ												
200H . Fn x Rsh 1-44-792	3.73	136[1]	3.67	86[1]	5.64	144[1]	6.10	113[2]	10S	TrMS—S	20S	...
FA x Th . Mt/OMMID 1-44-21863	4.11	125	3.50	110	5.29	140[1]	6.82	126[2]	20S	0	10S	...
Drc [[(Fn-K58xN/N10-B) Gb 55] (Son64xTzpp-54/Nai60)] 1-49-516	...	...	...	...	...	...	8.00	168[2]	0	0	0	...
GORGAN												
$P4160^{3}_{E}$. Nar 59 x LR64A* 7-45-516	4.36	116[3]	2.62	112[3]	3.61	129[3]	5.41	103[4]	0	0	0	...
Rsh [(Mt-KyxMy48) (LRx N10-B/An^{3}_{E})] [a] 5.46-137	4.20	165[3]	3.75	132[3]	3.98	126[3]	5.10	97[4]	0	0	0	3
AHVAZ												
(same as above)	...	...	3.12	125[5]	4.31	204[5]	4.70	106[4]	0	0	0	7
MOGHAN												
(same as above)	...	...	5.94	168[5]	4.92	125[5]	4.20	109[5]	25S	0	0	...
SHIRAZ												
Fr^{3}-McM x Mt-Y/Rsh 4-46-2240	...	...	...	...	4.27	107[6]	4.67	88	0	0	0	0

Check varieties: 1) OMMID, 2)Dayhin, 3) Akova, 4) Inia, 5) Sholeh and 6) Roshan.

[a] Being considered for release.

This is the summer nursery at Kelardasht, Iran.

varieties. This should result in greater winter hardiness and in additional resistance to such important diseases as mildew and those produced by *Helminthosporium* and *Septoria.*

Considerable information had been gathered on winter hardiness, disease resistance and plant type on some collections over past years. During the current year, 40 of the best local types were selected for inclusion in the crossing block. The program has also received the first regional crossing block from Turkey, selections from the International Winter Wheat Preliminary Nursery and materials from different cold regions of the world. Using these new materials will provide a much wider germ plasm base in the breeding program.

TURKEY

In the past two years, record wheat crops have been grown in Turkey. In 1971 the official estimate was 13.5 million tons and in 1972 it was 11.5 million tons, representing an average yield of 1,500 and 1,300 kg/ha, respectively. "Normal" production is about 10 million tons. Undoubtedly, new varieties, improved cultivation practices and greater fertilizer use contributed to these excellent crops. However, most wheat scientists attribute the increased production to favorable weather conditions.

Turkey sows about 8.5 million hectares of wheat each year. This represents a doubling of the acreage since the early 1950's. Additionally, there are approximately 2.5 million hectares of barley. Since a fallow-wheat rotation is most common, some additional 8.0 million hectares lie fallow each season. Fallow and wheat together occupy 70 percent of the total cultivated area, making wheat the dominant agricultural product and the economic indicator for Turkey.

There are two distinct wheat production areas. In the Central Anatolian Plateau rainfall is limited (less than 400 mm), winters are moderately cold and because there is little irrigation, winter wheats are grown under a wheat-fallow sequence. Along the coast, adequate rainfall, mild temperatures and, in some areas, the availability of irrigation allow growing fall-sown spring habit wheats. In this coastal area Mexican wheats have made a distinct contribution to total production.

TABLE W36. Disease reactions in several countries of three bread wheat lines now considered for release in Iran.

Lines and pedigrees	INDIA 1971-1972			EGYPT Sakha		TURKEY Izmir		TUNISIA Beja	NEPAL			IRAN[a]		
	Stripe rust	Leaf rust	Stem rust	Stripe rust	Leaf rust	Stripe rust	Leaf rust	Septoria scale 0-9	Stripe rust	Leaf rust	Stem rust	Stripe rust	Leaf rust	Stem rust
200 H-VLF x Rsh 1-45-14699	30S	100S	40S	TrMS	80S	20S	50S	5	0	40S	0	10S	TrMS-S	20S
FA x Th-Mt/ OMMID 1-44-21863	100S	60S	40S	0	80S	30S	50S	3	0	60S	10S	20S	TrR	20S
DAP [[(Fn-K 58 xN/N10-B) GB 55] (Son64xTzpp-Y54/Nai60)]	TrR	TrS	5MS	0	TrMS	TrS	0	4	0	30MR	0	0	0	0

[a] Highest reading in 1971-72.

Bread wheats account for 40 to 50 percent of the total area and durum and compactum wheats occupy 30 to 40 percent and 20 to 30 percent, respectively. Bread wheats are becoming increasingly popular.

Yields have remained about 1 ton/ha but this varies widely with climatic fluctuations. Although production has doubled since the 1950's, this is mostly due to expanded acreage. From 1961 to 1971, Turkey imported 4.781 million tons of wheat. This was necessitated by the more than 2.5 percent population growth and a very high annual (250 kg) per capita use. These factors made it essential that yields per hectare be raised if needs were to be met and, especially, if grazing lands now used for wheat were to be released for animal production.

In 1969 the Government of Turkey requested the assistance of the Rockefeller Foundation for intensifying its wheat research, aiming to increase yields as rapidly as possible. The Wheat Research and Training Project, which was subsequently formed, emphasized development of a multidiscipline, all-Turkey research system to produce varieties and develop cultural practices to increase yields. This is coupled with a dynamic extension program to carry information to farmers.

A comprehensive coordinated program has evolved. The wheat project has responsibility for breeding high-yielding, disease-resistant varieties of good quality. It must develop a suitable set of cultural practices to enhance and stabilize yields. It is also responsible for training extension personnel in these practices.

The wheat production project is headed by the Chief of the Field Crops Section in the Directorate of Agriculture, who also has the mandate for extension programs. Following the successful Mexican wheat introduction program of 1967-69, an intensive 25-province extension effort was initiated for winter wheat on the Central Plateau. Through demonstrations and adaptive research on farmers' field, it is expected that 1.0 million hectares will be grown under improved varieties and techniques in 1973. A target has been set to extend this area to 4.0 million by 1977. To reach this objective, an intensive training program was initiated in 1972.

Seed for the production program is supplied by the State Farm General Directorate. The state farms, collectively, have the capability of raising 120,000 tons with private farms can raise this figure rapidly. Unfortunately, seed sales have dropped due to difficulties in getting credit to the farmers.

The entire wheat production program--research, production and seed production--is coordinated by the Ministry of Agriculture through the General Directorate. In addition to the Rockefeller Foundation, the Ministry is assisted by personnel of the United States Agency for International Development, CIMMYT, Oregon State University and the Food and Agriculture Organization of the United Nations.

Varietal Improvement

As mentioned earlier, there are two distinct wheat regions. In the coastal areas where spring habit wheats are grown, Mexican wheats have become predominant since 1968, but some local bread and durum wheats and Italian wheats are also grown. In the palteau region, the principal wheat varieties include 220/39, 111/33 (*T. compactum),* 1593/51, 093/44, Akbasak 073/44 (*T. durum)* and Kunduru 1149 (*T. durum).* All of these varieties are tall and susceptible to the three rusts except 111/33 which has resistance to stripe rust. The variety 220/39 has very weak straw but good drought resistance and excellent quality. By comparsion, 1593/51 and 093/44 are higher yielding but of lower quality. Variety 111/33 is drought tolerant. The two durum varieties are similar in yield, but 073/44 is better in quality. Both are marginal in winter hardiness.

Bezostaya, introduced from the USSR is increasing rapidly because under good management it outyields the Turkish wheats. Given poor conditions of low moisture and fertility, it is inferior. Its red grain and lower flour yield are disadvantages. Another introduced variety, Wanser (USA), occupies a limited area. Its susceptibility to rusts and its lower yield than Bezostaya will limit its spread.

Three new varieties have been released from Eskesehir: (1) Yektay 406, selected from the Italian variety San Moreno; it has fair straw strenght and good yield but is somewhat lacking in winter hardiness. (2) Variety 4/11 from the cross Mentana x Yerli is recommended for low rainfall areas. Its yield is only fair and shattering is a problem. (3) Bolal, selected from the Nebraska cross Cheyenne x Kenya-Mentana, is recommended for the entire Plateau. It shows good yield and winter hardiness with fair straw strength, but is susceptible to all three rusts.

In the spring wheat area Penjamo 62 predominates, occupying 90 percent of the Mexican wheat acreage, which in turn is 50 to 60 percent of the spring wheat area. This older variety retains good yield, straw strength, *Septoria* tolerance and rust resistance. Lerma Rojo, because of *Septoria* susceptibility, has almost disappeared. Super X, Siete Cerros and Nadadores are still grown, but susceptibility to stripe rust and *Septoria* makes them of only regional value. Italian varieties are spreading slowly because of greater *Septoria* tolerance and later maturity. The Government is considering the Italian varieties Mara, Conte Marzotto, Libellula and Campodoro for multiplication and/or importation. Susceptibility to stem rust and stripe rust coupled with poor grain and bread quality will likely hinder their spread.

Spring Wheat Breeding

The main station at Izmir has developed an extensive breeding and selection program. Factors of paramount importance are grain yield, straw strength, *Septoria* tolerance and resistance to the rusts and to powdery mildew. Suitable varieties should also mature in late May or early June from early seeding. They should have a prolonged vegetative stage to avoid late frosts at heading and a short reproductive cycle to avoid the dessication of early summer. Pitic 62 and several Italian varieties have this characteristic, but all are rust susceptible.

The Izmir Centre is screening many introductions from Mexico, Lebanon, Chile, Algeria and other countries for reaction to *Septoria* and stem rust. In addition, approximately 1,200 crosses were made in 1972. The spring wheat materials are commonly grown at six centres, including Izmir, Adapzari, Samsun, Adana, Antalya and Diyarbakir. Thus lines adapted to a particular location can be selected and those with wide adaptation can be identified for multiplication or further crossing.

Izmir and one or two other stations grow preliminary yield trials. Advanced yield trials are distributed from these stations for testing at other centres, which are encouraged to enter their own selected materials. Some of the outstanding lines are shown in Table W37.

TABLE W37. Yield and disease information for outstanding bread wheat varieties and lines from the Turkish breeding programs in 1971-72.

Genotype and pedigree	Yield t/ha	Yield % of best check	Disease code [a]
Nuri 70	5.40	138	...
Inia"s" - Napo63	5.05	129	3
Gallo - Jar"s"	5.04	129	2
Cno"s" - Inia"s"	4.61	118	...
El Gau - Pi62/Son64 x SK_E-An_E	4.56	117	2
Napo - Tob"s" x SX 28071-7Y-3Y-0M	3.88	110	2
Tob66 - Cno"s" 25000-4M-1Y-1M-1Y-0M	4.60	130	3
Tob 66 - Cno"s" 25000-6M-2Y-0M	4.38	124	...
Bb - Inia x Cal[b] 27237-68M-1Y-0M	4.74	134	...
Ciqueña[b] 2106-6-2-0Y	4.57	129	2
Potam 70	4.68	136	1
Cajeme 71	4.34	126	1
Yecora 70	4.15	120	1
Bb - Nor 67[b] 27100-60M-1Y-0M	4.13	120	...
Ciqueña"s"[b] 21406-6-2-300Y-0M	5.87	119	2
Cno - Inia"s" 25329-6M-300Y-301M-0Y	5.25	106	...
Chanate[b] 26265-22Y-300Y-301Y-3M-0Y-52Y-0S	5.16	105	3
Chanate 26265-22Y-300M-301Y-2M-502Y-0S	5.06	109	...
Chanate 26265-22Y-300Y-301Y-2M-501Y-0S	4.84	104	..
Robin 26787-300Y-300M-302Y-2M-500Y-0S	5.00	108	...
Robin 26787-300Y-300M-302Y-2M-0Y-500Y-0S	5.80	125	...
Robin 26787-300Y-300M-302Y-3M-0Y	5.49	118	...
Robin 26787-300Y-300M-302Y-1M-0Y	4.95	107	...
Robin[b] 26787-300Y-300M-302Y-0M	4.93	108	...
Son64 [(WF51/Md x N-K117A) 6134 - Dirk] 1C11/1-0S	5.15	111	2
Cno"s" - Gallo 27829-13Y-3M-0Y	5.15	111	2
Pato (B)	4.86	106	2

[a] 1 = susceptible to stem rust; 2 = resistant or tolerant to Septoria; 3 = susceptible to stripe rust.
[b] Lines with good adaptation throughout the spring wheat area.

Yields are for 1971-72 and disease reactions are for the past two seasons. At Izmir, *Septoria* was heavy in 1970-71, and stem rust and stripe rust were severe in 1971-72. Lines of bread wheat combining good yield and resistance included selections from Cigueña, Robin, Ciano-Inia, and Ciano "s"-Calidad. Other lines with good *Septoria* resistance but only fair yield were derived from Sonora-Klein Rendidor, Inia-Ciano x Calidad, Calidad, Pato-Ciano, Jaral, Pato and Ciano-Inia "s"2. There is a real need and a strong possibility that one or more of these lines may be valuable in rectifying the potentially dangerous monoculture of Penjamo 62 by creating additional diversity.

As in North Africa, the improved durums have serious disease susceptibility defects in Turkey. Those with some *Septoria* tolerance in 1970-71 were susceptible to stripe rust and stem rust in 1971-72. The lines shown in Table W38 produced the best yields in the current year.

Preliminary multiplication of Cocorit 71 has been initiated for the Diyarbakir area where it has performed well in the past two years even though this is a winter region. Some of the Crane lines show promise, too.

During the 1972 summer, a Turkish screening nursery comprising the best breeding lines from all spring wheat stations was assembled and will be grown at all stations for disease and agronomic acceptability. It is planned that the better lines will enter a regional test in the following year.

Winter Wheat Breeding

Breeding for winter wheats is centered at Ankara and Eskesehir. Although active for many years, the main emphasis had been on improving native populations. Recently, a large-scale hybridization program was undertaken at both stations with a wide germ plasm base. The varieties for the Plateau should have: (a) shorter straw and better straw strength than existing varieties, with a range of maturities from medium-late for Thrace to very early in the

TABLE W38. Yield of outstanding durum wheat varieties and lines from the Turkish breeding program in 1971-72.

Genotype and pedigree	Yield t/ha	Yield % of best check[a]
Al "s" - AA"s" 27575-6M-5Y-2M-0Y	5.26	127
Al"s"/LD357 x Tc^2 - G11 27588-10M-1Y-2M-0Y	4.51	109
Cit"s" 27617-18M-3Y-0M	4.62	112
Gs - AA"s" 27664-9M-4Y-0M	4.54	110
Chap/GY^2_E - Tc x TAC_E - Tc^2 25665-6M-2Y-1M-0Y	4.73	115
G11/BR180 - Lak x 62-220-61-130 26842-21Y-3M-0Y	4.30	106
Al"s"/$LD357_E$-Tc x G11 27588-1M-1Y-4M-0Y	4.26	105
LD357E - Tc^2 x AA"s" 27534-1M-1Y-1M-0Y	4.11	102
Al"s"/$LD357_E$ - TM_E x ZB - W 27572-20M-3Y-1M-0Y	4.06	101
$LD357_E$ - Tc^2 x AA"s" 27534-12M-1Y-1M-0Y	4.52	100
$LD357_E$ - Tc^2 x AA"s" 27534-3M-1Y-2M-0Y	4.73	104
G11 x 60-115- RL 3601 26833-12Y-1M-2Y-2M-0Y	4.69	104
Cocorit 71	4.57	97
Jori 69	4.52	96

[a] Check variety was Penjamo 62.

Southeast, (b) good winter hardiness, (c) responsiveness to fertilizer and improved tillage and (d) resistance to stripe rust, stem rust, loose smut and bunt.

Many introductions have been made from worldwide sources. In the present year, 2,500 and 500 bread and durum wheat crosses were made at Ankara and Eskesehir, respectively. About 60 percent involved spring x winter crosses using Mexican and Chilean spring wheats. Plant type, disease resistance and earliness are being sought from the spring sources. The remaining crosses are winter x winter, employing Turkish wheats with various introductions. Top and double crosses are being used, too.

An extensive yield testing program has been initiated, using many lines. The Central Plateau tests are coordinated by the Ankara Station, those in the Southeast, by Diyarbakir Station, and so on. The best lines from these tests will be grown by the National Variety Trial. This Institute has final authority on release. They test the varieties submitted for three years, and then a decision is made to release or to discard them.

Since the new breeding approach is just underway, it will require two to three years for materials to enter these tests. The one exception is some of the early material developed by the late Dr. J. A. Rupert's spring-winter program which is now entering advanced trials. Lines currently in test are those developed in the earlier program. Some appear to outperform the commercial varieties, but all are generally tall and somewhat lacking in disease resistance. Results are shown in Table W39. Lines emanating from the cross M6402 appear promising if winter hardiness and stripe rust resistance are adequate.

In Thrace, Bezostaya and Etoile de Choisy performed well. Bezostaya, introduced in 1968, covers an estimated 60 percent of the wheat area and is expected to cover 80 percent in 1972-73. Etoile de Choisy has equal or greater yield but is a week later in maturity. It is now being grown for multiplication prior to release.

In southeastern Turkey, Pitic 62 and Penjamo 62 were superior in yield to Bezostaya in 1971-72, possibly due to the effect of hot dry winds on the late-maturing Bezostaya. Some lines under test are promising, but further tests are indicated. Cocorit 71 durum is being multiplied for release. Most of this area continues to be sown to local types because of a currently weak extension service. Plans have been formulated to remedy this shortcoming.

TABLE W39. Yields of outstanding lines of winter wheat in Turkey (1971-72).

Cross and pedigree	Yield t/ha	Yield % of best check
Rto-Pn x Pi 62 M6406-6-1A-101A-1A-0A	3.75	113
Ky Sel 2657/Fr x KAD-CB M6402-1-8A-10A-1A-0A	3.68	111
Ky Sel 2657/Fr x KAD-CB M6402-1-6A-101A-1A-0A	3.59	108
Ky Sel 2657/Fr x KAD-CB M6402-5-9A-5A-1A-0A	3.38	102
Ky Sel 2657/Fr x KAD-CB M6402-7-34A-1A-1A-0A	3.83	115
Ky Sel 2657/Fr x KAD-CB M6402-4-21A-3A-1A-0A	3.70	111
Fr-Tmq x Tx580 - 405/908 - Fn M6405-2-1A-101A-1A-0A	3.45	104
(Bowie-Qnh x FL "S"/093/44) N 604478- 4/11P246-10	4.00	120
(Bowie-Qnh x FL "S"/093/44) N 604478- 4/11P246-10	3.53	106
093/44 (Fn x K 58-N/Tmp) P206-40	3.88	117
093/44 (Fn x K 58-N/Tmp) P206-11	3.51	105
FL "S" (Fn x K58-N/Tmp) P211-6	3.79	114
Mql-Oro x Oro-Tmq 67	3.60	108
69-167	3.69	107
(Cj 54-36896 x Gb 56^2/Yalta) Mxp 65 PK2372-4A-11A-0A	3.38	113

Three new nurseries have been started in the past two years. In 1970-71 a regional yield trial comprising the best lines from Ankara and Eskesehir was grown at eight locations on the West and Central Plateau. This was repeated in the current year and the best lines from the trial, together with new lines from these stations and four from Ankara University, will be grown in 1972-73. The selected lines will advance to the National Trials the following year.

Two new international regional trials were initiated for the coming year: the International Winter Wheat Screening Nursery and the International Winter Durum Screening Nursery. These nurseries have the objective of exchanging and disseminating materials and obtaining agronomic and disease evaluations from several countries. Included are all the advanced lines of the Turkey program and introduced lines showing good adaptation. Nurseries were seeded at 14 locations in Turkey and one each in Algeria, Mexico, Iran, Roumania and Hungary. In succeeding years, both materials and

The search continues for adapted varieties of winter wheat for the Central Plateau of Turkey.

locations will be expanded. F_2 populations have been distributed to three countries and introductions were made from several winter wheat countries. The latter will be evaluated and "fed" into the breeding system to widen the germ plasm base of the Turkish program and other collaborating country programs.

Pathology Research

The diseases found in Turkey in 1972 include: stripe rust, leaf rust, stem rust, common bunt, dwarf bunt, loose smut, powdery mildew, *Septoria, Helminthosporium,* flag smut, *Cercosporella,* "take all" disease and snow mold. In the winter wheat area, stripe rust is the most important disease and under favourable conditions it can inflict severe losses. Stem rust, common bunt and loose smut are also important. In the spring wheat region, stripe rust and *Septoria* are most important and the cause of greatest loss. Loose smut is common and powdery mildew can cause serious damage in the Marmara-Black Seas coastal regions.

Due to the favourable environment for crop development in the spring of 1972, diseases were held in check. Late in the season, stem rust in the Aegean region and leaf rust in the eastern region reduced some yields.

The disease surveillance program undertaken in 1971, which includes trap nurseries, disease surveys and race and virulence identification for the rusts, was continued this year. The trap nursery comprised 60 varieties of wheat and barley. It was sown at 40 locations. During the past year the disease survey was conducted jointly by the Research Centre and the Plant Protection Directorate. About 6,000 fields were observed throughout Turkey. Records were made of disease incidence and samples were collected for identification. Race identification of stripe rust suggests that four races were prevalent. Hence, the virulence is narrow. At Izmir, an isolate of stripe rust was found which was virulent on Bezostaya. This was the first occurrence in the country and may have a serious effect on Bezostaya production for the future. Five races

Winter wheat varieties are tested for resistance to rust in greenhouses.

of stem rust were identified. This collaboration between the two aforementioned groups has greatly assisted the breeding and production program since there is a real shortage of trained pathologists in Turkey. The program will be enlarged to allow testing for bunt resistance and foot rots. *Septoria* research will also be intensified.

Artificial rust epidemics are now created routinely in the breeding nurseries. Methods for creating *Septoria* epidemics at Izmir are being studied. Quantities of *Septoria*-infected wheat straw were collected and stored for spreading on the nursery site and inoculum is being produced in the laboratory for spray applications. Screening for resistance to the various diseases was emphasized in the last season.

Because the prevalent diseases of Turkey are also of major importance in the Afro-Asian countries, the Regional Trap Nursery Program (RTN) was continued. Distribution was made to 86 centres in 30 countries through ALAD and FAO. This nursery is greatly assisting in disease monitoring and is expected to give advance warning of potential production hazards. Dr. R. W. Stubbs of the Netherlands tested the seedling and adult-plant response of the RTN varieties to selected isolates of stripe rust. Dr. M. Boskovic of Yugoslavia performed a similar test for leaf rust. All scientists of the region are deeply indebted to them. Screening these varieties to isolates of stem rust is being conducted at Ankara. These data, coupled with nursery reports from the different countries, map the virulence distribution of rusts in the region.

Tillage Research

Traditional soil management practices in Turkey fall into two categories--annual wheat and fallow-wheat rotations. Annual cropping is practiced in the coastal regions while the fallow-wheat system is followed in the transition zone (400 to 600 mm rainfall) and the plateau (400 mm or less rainfall) with some overlapping in the coastal-transitional. Annual cropping will likely be extended in the transitional zone with better soil management.

In the coastal regions, yields increased dramatically with the advent of Mexican wheats in 1967-68. Most of this increase has been due to better varieties, increased use of fertilizer, better planting dates and the use of grain drills. Although there is some improved soil management, large areas have poor seedbed preparation, resulting in reduced stands and lowered yields. The yield reductions probably average one ton per hectare.

Agronomic research to increase yields has been concentrated on the Central Plateau. Traditional cultural practices generally involve May or June moldboard plowing of land lying uncultivated from the last harvest. This land is generally under heavy grazing during the fallow period and produces much of the livestock feed. After plowing, the land is left bare until seedbed preparation, using a double disc in midsummer or late summer. Where other implements are lacking, a second plowing may be done. In either case the resulting seedbed is often cloddy, attributable to a 40 to 60 percent clay fraction, and is dry to a depth of 25 to 40 cm. Therefore, it is customary to wait for October rains to do a presowing cultivation. If the rain is light or late, germination may be much delayed. Then seedlings enter the winter in the 2- to 4-leaf stage with shallow roots and no tillers, making the seedlings vulnerable to winter killing. Such weak plants, if they survive the winter, must make their growth in the spring and early summer. They are very dependent on sufficient and timely rains. With good rains, yields range between 1.5 and 2.0 tons per hectare. Without good rains, yields may be less than one ton per hectare.

Soil management experiments were conducted by the Eskesehir Experiment Station from 1932 to 1950 and soil management systems were also studied at Ankara. Important results were obtained but many are outdated due to changed equipment and techniques. In these experiments little fertilizer was used, improved varieties were not available and deep-furrow drills had not been produced. These trials indicated that early plowing in the spring was superior to late plowing and that this should be followed by a secondary tillage to maintain moisture in the upper profile. These results are still valid.

The study of tillage methods was renewed in 1969 by the Oregon State University-USAID team in cooperation with Turkish research organizations. The trials were revised and extended in 1970 under the Wheat Project. The objectives were to test equipment and tillage systems which had been successfully used in other parts of the world, and to measure moisture conservation in the soil profile under the different systems. A second objective was to determine the maximum yield based on expected moisture supply. These data, coupled

Cheatgrass (Bromus tectorum) is a common weed on the Central Plateau of Turkey. This weed will become more serious under good tillage practices.

with soil testing, could then be used to determine N needs so that fertilization can be done according to expected moisture. In all experiments, detailed physical and chemical soil analyses were made by Dr. Sefik Yesilosoy of the Soil and Fertilizer Research Institute.

These research studies aim to establish a fallow system which conserves maximum moisture sufficiently close to the surface to allow September sowing with a deep-furrow drill. This would result in well-established plants independent of rainfall. When such conditions were achieved in the 1969-71 experiments, yields of 3.5 to 4.0 tons per hectare were recorded.

In the above experiments, the following results were obtained:

1. Fall tillage by chiseling 25 to 30 cm deep or subsoiling 50 cm deep did not excell no tillage in the fall.
2. Moldboard plowing and sweep plowing were similar except where cheatgrass (*Bromus tectorum)* was present, in which case the moldboard was better.
3. Sweep plow plus harrow and sweep plow plus rodweeder were superior to rodweeder alone.
4. In treatments where surface moisture was insufficient for early emergence but a good seedbed was present, the first significant rain germinated seed. This result shows that a good seedbed with little moisture at the surface but adequate moisture at 20 cm is superior to the traditional cloddy seedbed where moisture is 30 to 40 cm below the surface.

The offset disc was used for the first time in 1971. Both the moldboard and offset disc gave an extra 0.3 to 0.6 tons per hectare above the sweep plow alone. However, when the sweep plow-harrow combination was used for secondary tillage and for summer weed control, the results were superior. For summer weed control and maintenance of the soil mulch, the sweep plow-harrow combination appears best. Thus, a combination of moldboard plow, sweep and spike tooth drag harrow, used properly, are the only tillage implements required for good soil management in most of the Central Plateau.

Level of conserved moisture seems to be well correlated with yields. Based on this relationship, it should be possible, after a few years, to base N applications on the amount of water available in the profile during the spring before cropping.

Agronomic Research

In addition to soil management, other criteria must be established if benefits from additional moisture conservation are to be maximized. Information such as best sowing date, seeding rate, fertilizer rates and method of application, and other cultural practices are requisites to assembling a package of practices to fit the production system. In the fall of 1971 a series of agronomic trials were undertaken for this purpose.

These tests were:

Sowing Dates x Seeding Rates x Varieties. Fig. W13 shows that sowing date was considerably more important than seeding rate. At Ankara the early date of seeding gave 530 kg/ha more yield than the late seeding and 300 kg/ha more than the second date. At Altinova the corresponding figures were 950 and 420, respectively. The 60 kg/ha seeding rate was inferior to the other rates. Bezostaya and Wanser gave better response to early seeding than 1593/51, and 220/93 and Bezostaya responded less to increased seeding rate

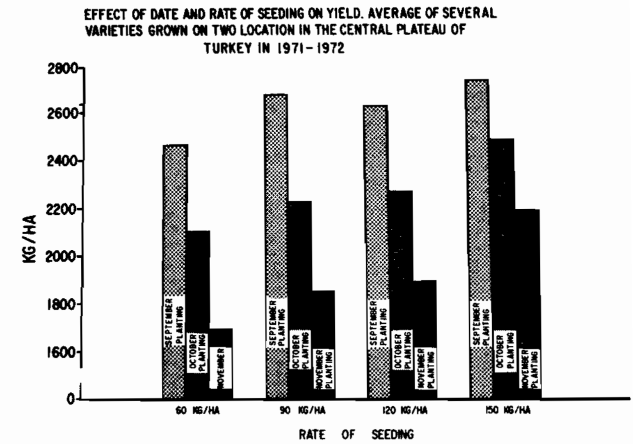


FIG. W13. Effect of date and rate of seeding on yield. Average of several varieties grown at two locations in the Central Plateau of Turkey in 1971-72.

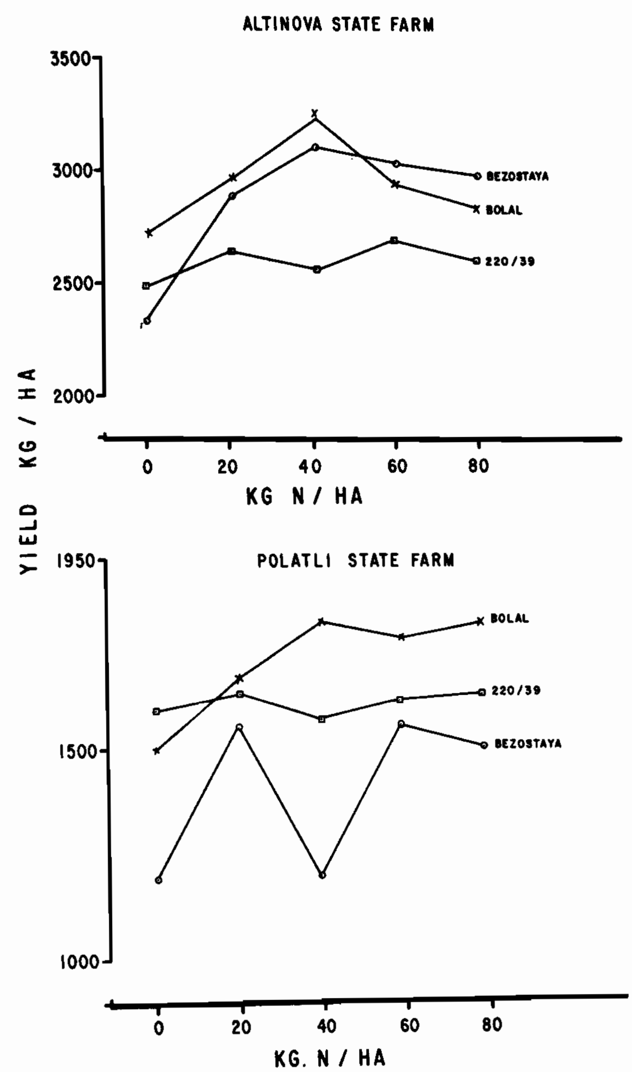


FIG. W14. Effect of nitrogen rates on yields of wheat varieties at two locations in the central plateau of Turkey, 1971-72.

than the others.

Nitrogen Rates x Varieties. The average yield shown in Fig. W14 indicates that 40 kg N/ha generally gave essentially maximum yields. The local tall variety gave less response to N than the other two varieties and lodged at rates of 60 kg and above. At Polatli no varieties responded and yields were generally low. Moisture from the preceding fallow provided sufficient N for a 1.5 to 2.0 ton per hectare yield.

Time and Rate of N Application. In these experiments no response to N beyond 40 kg/ha was observed. Split applications were slightly better than applying all N before sowing. This may be because of leaching due to a long wet spring. Average yields are shown in Fig. W15.

Drill Type x Fertilizer Placement x Rates of DAP. The data were inconclusive although there appeared to be some depressing effects of DAP application on emergence and seedling vigour.

Since the Wheat Project was initiated in 1970, the agronomic research phase has had excellent cooperation from the Soil and Fertilizer Research Institute, the Oregon State University-USAID group, the State Farms General Directorate and the General Directorate of Agriculture. The Wheat Project has farms and research stations. The Crops Section of the General Directorate and the OSU-USAID group use the information generated in adaptive trials on private farmers' land in cooperation with local extension personnel. The adaptive trials are also used in training for extension, and as personnel are developed, emphasis is given to establishing widespread farm demonstrations in the provinces. The Soil and Fertilizer Research Institute conducts soil analyses and moisture determinations for both the detailed and adaptive trials. The state farms provide land, necessary labour and housing facilities for staff in the field.

In the region from Morocco to Pakistan, about 35 million hectares of wheat and barley are grown annually under rainfed conditions. Generally, the region receives less than 500 mm of annual precipitation and uses a fallow-crops cycle. Since moisture is the most limiting factor, higher yields will be largely dependent on improved efficiency of water use. In developed countries water efficiency use is about 50 percent higher than in countries of the Middle East. This is reflected in 60 to 80 percent higher yields. With application of adequate technology, immediate success could be achieved. In some regions modifications can be made readily while in others a new package of practices will be

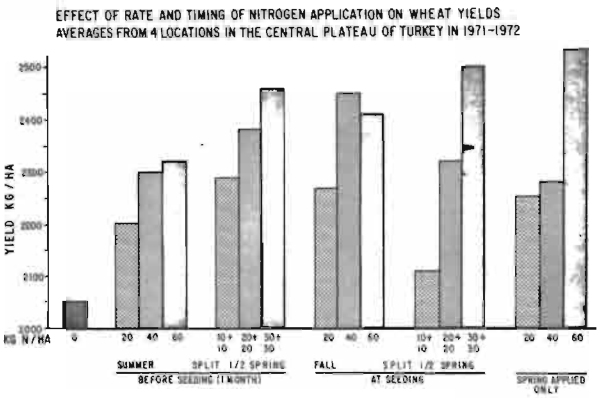


FIG. W15. Effect of rate and timing of nitrogen application on wheat yields averages from 4 locations in the central plateau on wheat yields (averages from 4 locations in the central plateau of Turkey in 1971-1972).

This shows the realtionship of plant development and root formation to planting date under dryland conditions in Turkey. Planting dates are shown; the photograph was made December 24, 1971.

required. The major successes thus far in the developing countries have been made in areas under irrigation or with adequate rainfall. Increased yields in low rainfall areas will come from improved varieties, suitable cultural techniques and judicious fertilizer use.

Quality

A well-equipped cereal quality laboratory has been established at Ankara to serve the breeding program. The Pelshenke test and other tests are being used for early generation material with bread-making for advanced lines. It is planned to extend the Pelshenke tests to all breeding centres and technicians are being trained in its operation. Plans also include tests for macaroni quality.

Training

There is still a shortage of well-trained scientists in all disciplines of the research program. To date 17 Turkish scientists have received training at CIMMYT under FAO, Rockefeller Foundation and USAID support, and four more are slated for 1973. Five Turkish scientists have been supported for master of science degree training abroad and have returned, and three more are on course for an M. S. degree in the United States. It is planned to send seven more to the United States in 1973. By 1975 their return should greatly improve the manpower situation.

In Turkey, a series of in-service training programs have been conducted by the Project. The Ministry of Agriculture has undertaken a preservice training program, whereby new graduates are stationed for one year at one of the Research Institutes. Following this year's service in which the project plays an important role, the young scientists are reassigned to extension, research and other organizations.

The Project has participated in a training program organized by the Agriculture Extension Service with assistance of the OSU-USAID team. Through USAID support, seven complete sets of tillage equipment (including tractors, tillage implements and vehicular transport) were imported for tillage demonstrations and adaptive trials on the Central Plateau. In the past year the extension staff has been trained through classroom and field work in the use of the equipment and implementation of the program. Equipment has been received, assembled by the trainees and the field program will begin in the spring of 1973.

In still another training activity, scientists from the branch stations have been temporarily transferred to the Ankara and Izmir Stations during crossing and selection. This has allowed them to work alongside the more experienced scientists and enabled them to get new ideas and approaches. Also, short courses have been given to scientists involved in the disease survey. This is followed by successive visits of the Ankara pathologists to operations in the field.

The Turkey program is characterized by an intense team spirit and interdisciplinary cooperation is very great.

LEBANON

The Arid Lands Agricultural Development Program (ALAD) of the Ford Foundation has assisted for several years in developing agricultural programs in Middle East countries. The headquarters of the organization is in Beirut. For the past several years, Dr. G. Kingma, a wheat breeder, has been assigned to assist the Lebanese Wheat Improvement Program. He has also acted as regional coordinator of wheat improvement work for the last two years on an international scale. Trials supplied by CIMMYT were dispatched in cooperation with Dr. A. Hafiz of FAO to several countries. These included the International Bread Wheat Screening Nursery, International Durum Wheat Screening Nursery, International Spring Wheat Yield Nursery, International Durum Yield Nursery, International Triticale Yield Nursery and the International Septoria Observation Nursery. In addition, the Regional Disease and Insect Screening Nursery, Regional Trap Nursery, Preliminary Observation Nursery and Regional Wheat Yield Trial, which comprise materials originating in the region, were distributed from Beirut to countries from India to Morocco. The work has entailed several international trips.

In the past year the ALAD group hosted a Regional Wheat Workshop attended by wheat scientists spanning the countries from India to Morocco and from Eastern Africa. The workshop's theme was the diseases and agronomic practices of vital interest to the whole region. Reports from all scientists indicated the value placed on such work sessions.

In Lebanon the major wheat area lies in the central Bekka Valley. This valley is characterized by a rapid change in rainfall, from a high level in the south to rapidly diminishing precipitation northward toward the Syrian plain. Rainfall in the present year was above average early in the season but later rainfed crops suffered damage from drought. Siete Cerros (Mexipak) remains the principal variety in the higher rainfall and irrigated areas. Stripe rust was widespread but because of its late appearance, damage was limited.

The better genotypes from the CIMMYT material include lines from these crosses: PV 18A-Cno 67; CC-Inia "S" x Cno-Chris; CC-Inia "S" x Cal; Bb-Nor 67; Bb-Nar 59; On-Bb and Cno "S"-Gallo. In yield tests Siete Cerros performed better than all other entries. Yecora "S" (R) and Cocorit 71 were also high yielding. These materials were grown under severe drought during the maturation period at the Tel Amara Station.

The results received from 22 locations for the Regional Wheat Variety Trial are presented in Table W40.

TABLE W40. Average yields of the 10 leading wheat varieties and lines in the Regional Wheat Yield Trial grown during 1971-72 at 22 locations.

Entry no.	Variety or line	Yield kg/ha
33	$My54_E$ -LR x H490[a]/LR64 x Tzpp-Y54	4524
35	[(Md-N/N x Th-K117A) Ind 38] Indus 66	4395
7	Chenab 70	4326
34	HD832-ON x Kal	4297
19	Zorawar	4274
21	Syrimex	4256
12	Mexipak 65	4255
18	Kalam 71	4167
15	Mexicani	4117
29	Cno "S"-Inia 66 = Tanori 71 "S"	4114

[a] H490 = Tacuari (Argentina).

Two new lines outyielded Chenab 70 by a small margin, but among the top 10 varieties there is less than one-half ton per hectare difference in yield.

In the first Preliminary Observation Nursery (PON), results were obtained from 10 centres. The average yields of the top 10 varieties are in Table W41.

Generally, the bread wheat varieties had acceptable resistance to the three rusts except for entry 84 which was susceptible to leaf rust and entry 161 with susceptibility to all three. Most of the lines listed were

Dr. E. Rodriguez visits wheat plots in Lebanon with Dr. G. Kingma (foreground) and Lebanese staff.

TABLE W41. Average yields of the 10 leading varieties or lines from the First Preliminary Observation Nursery grown during 1971-72 at 10 locations.

Entry no.	Variety or line and pedigree	Yield kg/ha
121	Son-Tzpp x Napo 63/Napo-Tob x 7C 35563-500Y	4.7
75	Mexipak 69	4.6
84	Kalyansona x FA0215-1-2 JIT45-3L	4.5
6	Inia 66-Bb 26478-7Y-8M-2Y-2M-0Y	4.5
99	Nor 67-7C 30367-1M-2Y	4.5
161	[(Md-N/N x Th-K117A) Indus 38] Indus 66 PK1115-2K-3F	4.4
50	Super X	4.3
55	Kal x Son64 JIT16-3L	4.3
182	Tanori 71	4.2
163	Roque "S"/G36896-Gb54 x Gb56	4.2

susceptible to *Septoria* but entries 55, 84 and 6 showed some tolerance.

In the PON, several durum and barley varieties were also included. Among the durums, Cocorit 71, Ganso and Crane "S" showed superiority. Among the barley varieties, WW Cilla, WW Wing, W1 2197, Giza 120 and Svalof-Hellas were rated superior.

The Regional Disease and Insect Screening Nursery (RDISN) was grown for the second time in 1971-72 and, together with the Regional Trap Nursery, is providing good information on the epidemiology and physiologic race specialization throughout the region. In addition, it is assisting in the spread of germ plasm. The RDISN is still undergoing some growing pains and several errors still creep in for parental origin. This appears to have resulted mostly from misclassification in certain contributing programs but there were also some errors in putting up seed. Steps are being taken to remedy these shortcomings.

This regional activity is considered to be of great importance in building up linkages between the national programs of the Eastern Hemisphere. Following the same pattern, a similar development is now taking place in Latin America and a truly global exchange of information will become possible.

MOROCCO

The Cereal Improvement Project of the Moroccan Ministry of Agriculture is provided technical assistance from CIMMYT, USAID and the Near East Foundation. Three CIMMYT scientists were employed during the crop period. Recently, Francis Bidinger resigned to begin studies toward the Ph.D., beginning in the fall of 1972. Administrative support to expatriate personnel is provided by USAID and the project is implemented through a committee of the Moroccan Ministry.

Weather conditions in the 1971-72 season were very favourable for wheat development. Total rainfall for the season was about normal and well distributed from November to March. During the first three weeks of April, dry weather stressed the crop some, but rains in late April and early May were adequate to bring the crop along nicely to maturity. These late rains, however, also contributed to late disease development.

Some lodging occurred due to high winds in the Sidi Kacem area. Temperatures during the season were average, although somewhat higher than normal in the April dry period, and light frosts occurred in the Marrakesh area in the winter months. Otherwise, it was a very successful year for wheat production.

Reports of fields yielding 3.5 to 4.0 tons per hectare were common. There was some delay in harvesting due to continued damp, cool nights which prevented mechanical harvesting in the mornings. The prices set for wheat and barley were the same as in the previous year--durum wheat, 47 dirhams/q (US$105.80 per metric ton); bread wheat, 43 dirhams (US$93.00 per ton); and barley, 27 dirhams (US$58.50 per ton). These remunerative prices encouraged fertilizer use.

Official figures for the 1971-72 cycle are not yet available but estimates indicate that the total production of bread wheat will be approximately 650,000 tons, which surpasses the previous high of 636,000 tons in 1969-70. For durum wheat, estimates indicate that total production will be below the record 1.975 million tons recorded for 1968. It is believed that wheat imports will rise from 350,000 to 500,000 tons during the 1972 season.

Breeding Research

Experimental material was sown at seven main stations throughout Morocco. These include Sidi Kacem (SK), Merchouch (MCH), Fes, Marrakesh (Menaca Sta) (MKM), Station Cotonniere Beni Mellal (SCBM), Sidi Allal Tazi (SAT) and Ellouizia. These, together with winter wheat testing centres at Targist, Meknes and Boulemann, represent the major wheat areas. Table W42 shows materials planted.

TABLE W42. Number of experimental genotypes sown in Morocco in the 1971-72 wheat season.

Species	Homozygous	Heterozygous	Totals	
Triticum aestivum	4,416	5,330	9,746	
Triticum durum	892	263	1,155	10,901
Triticale	155		155	
Hordeum vulgare	297		297	11,353

Sowing was completed between December 15 and December 31, the most desirable time, and germination and early growth were good up to heading in April when the dry period started. Late rains favoured the development of leaf rust, especially on the variety BT-908 which suffered yield losses from this disease and lodging. Maturity was hastened in the late period of growth by higher-than-normal temperatures.

In general, there were no serious epiphytotics of any of the major diseases, only isolated attacks of leaf rust and stem rust. Mildew was relatively severe at Rabat and Sidi Kacem, and barley was most affected. A low level of stripe rust (*Puccinia striiformis*) developed at Sidi Kacem, Merchouch and Menaca stations. Leaf firing was fairly common but not serious. The *Septoria* attack was lighter than in previous years, making it difficult to select for resistance at any of the stations. Hessian fly infestation was fairly heavy on early sown materials and sawfly was most severe on the late-sown varieties. A survey of the Hessian fly infestations made by Dr. R. L. Gallun of the USDA indicated that this pest probably exists in different racial forms than those in the United States.

Many wheat breeding lines have now been tested for two or more years. Most of these lines have good *Septoria* tolerance and yield above BT 908, the principal local commercial variety. In several cases, experimental lines outyielded Siete Cerros, which in a year with little disease (like 1971-72) is one of the highest yielding varieties. In Tables W43, W44, W45, W46, W47 and W48, the higher yielding materials are recorded. It should be noted that among the commercial Mexican varieties, Potam 70, Cajeme 71, Tanori 71 and Siete Cerros have shown good results over most locations. However, care must be taken to avoid sowing those which have no tolerance to *Septoria* blotch under conditions where this disease is normally present. Some of the newer durums also showed promise when cultivated in areas where *Septoria* is of low incidence while at other locations they appear to be outyielded by the more resistant bread wheats. Among the barleys, several gave yields above the check variety, but absolute yields are considerably below those of wheat. Triticale yields are still somewhat low, but they approach yields of the standard bread wheat check variety. The promising nutritional properties of this new species makes it of continuing interest to the Moroccan Program.

Action was taken this year to officially recommend the growing of Siete Cerros in southern Morocco (Marrakech, Souss Valley, etc.). Potam 70, Cajeme 71 and several lines selected in the Moroccan Program were included in the National Yield Trials and put under preliminary increase.

In the segregating F_4 through F_6 generations, 195 rows were harvested in bulk. All of these lines have demonstrated good tolerance to *Septoria* over three years, and they have been distributed to collaborators in other countries for testing under a wide range of disease and environmental hazards.

TABLE W43. Yields (kg/ha) and yield rank (in parentheses) of wheat genotypes with some resistance to Septoria **tested for several years in Morocco (results of 1971-72).**

Genotypes and pedigree	Septoria reaction scale 0-9[a]	Dryland locations				Irrigated locations			Grand Average
		Sk	Fes	Mch	Average	MKM	SCBM	Average	
LR64"S"-Hua rojo = HD1675 + S331"S"	3	3838 (7)	5566 (2)	4956 (2)	4783 (1)	5520 (5)	4614 (2)	5067 (3)	4896 (1)
Cno"S" - Inia² 23959-52T-1M-3Y-0M	8	3799 (8)	4939 (6)	4897 (4)	4545 (4)	6254 (1)	4249 (5)	5251 (2)	4827 (2)
Son64-Y50E x Gto/Inia"S" 23528-7M-1T-1M-8-0M	8	3709 (10)	4943 (5)	4827 (7)	4493 (6)	5687 (4)	4847 (1)	5267 (1)	4802 (3)
Ska/Tzpp-Son64 x Np63 30455-12M-0Mch	...	4139 (1)	4060 (14)	4609 (4)	4269 (12)	6012 (3)	3889 (11)	4950 (4)	4541 (4)
Son64-LR64=HD1799	5	4110 (3)	5220 (4)	4709 (8)	4680 (2)	4616 (18)	3684 (15)	4150 (6)	4467 (5)
CHECK VARIETY POTAM[b]									
Cno"S"-Gallo 27829-19Y-1M-4Y-0M	5	4478 (2)	3907 (12)	4944 (6)	4443 (7)	4100 (7)	....	..	4357 (6)
NpxTzpp-Son64/8156 (R) 28071-TM-3Y-1M-0Y	5	4237 (5)	4476 (3)	5289 (3)	4667 (3)	3350 (21)	....	....	4338 (7)
Cno - No66 26111-6M-7Y-3M-0Y	9	3476 (14)	4760 (3)	4726 (1)	4321 (10)	5383 (7)	2972 (24)	4177 (5)	4263 (8)
CHECK VARIETY SIETE CERROS & CAJEME 71[b]									
Cal "S" 22429-11M-1Y-1M-0Y	6	4055 (7)	4403 (3)	4402 (6)	4287 (11)	4825 (12)	3488 (19)	....	4234 (9)
Cno - Son64/Cno-Inia 30506-301M-0 Mch	8	4005 (8)	4251 (8)	4837 (3)	4364 (9)	4687 (16)	3333 (21)	....	4222 (10)
CHECK VARIETY YECORA 70[b]									
No66-Bb"S" 26481 22Y-1M-3Y-0M	...	3515 (11)	4572 (6)	4599 (5)	4229 (13)	4412 (20)	3543 (17)	3977 (7)	4128 (11)
CHECK VARIETY INIA 66[b]									
Cal-Cno"S" 27052-26M-2Y-2M-3Y-2M-0Y-300M	4	4237 (6)	4593 (2)	4716 (13)	4515 (5)	2716 (24)	....	....	4065 (12)
Bb 4 (R) Resel 23584-26Y-2M-3Y-1M-0Y	5	4255 (5)	3866 (1)	4556 (8)	4226 (14)	4387 (6)	3163 (17)	3775 (8)	4045 (13)
CHECK VARIETY NURI 70[b]									
Bb4A (B) 23584-26Y-2M-3Y-1M-0Y	...	4635 (2)	3768 (3)	4731 (4)	4378 (8)	3129 (20)	3226 (16)	3177 (9)	3897 (14)
Cno"S" - Gallo 27829-19Y-2M-0Y	5	3993 (10)	3409 (8)	4989 (3)	4130 (15)	3295 (19)	2965 (20)	3130 (10)	3730 (15)
CHECK VARIETIES TOBARI 66 & BT908[b]									

[a] Results of 1970-71.

[b] Yield position of check varieties.

TABLE W44. Yields (kg/ha) and rank (in parentheses) of wheat varieties and lines tested in Morocco for two or more years (results of 1971-72).

Variety or line	Septoria reaction scale 0-9[a]	Dryland locations: Sk	Fes	Mch	Average	Irrigated locations: MKM	SCBM	Average	Grand Average
Potam	7	3945 (4)	4833 (1)	4984 (1)	4589 (1)	4996 (2)	3068 (7)	4011 (5)	4365 (1)
Cajeme 71	4	4221 (1)	4548 (2)	4615 (2)	4462 (2)	4211 (6)	3638 (4)	3356 (8)	4246 (2)
Siete Cerros	9	3968 (3)	3944 (5)	4165 (6)	4022 (5)	5015 (1)	4113 (1)	4723 (1)	4241 (3)
Yecora 70	9	4048 (2)	4387 (3)	4595 (4)	4343 (3)	4448 (4)	3378 (5)	4041 (4)	4171 (4)
Inia 66	7	3673 (6)	4219 (4)	4611 (3)	4168 (4)	4118 (8)	3791 (2)	4133 (2)	4082 (5)
Nuri 70	5	3746 (5)	3724 (6)	3959 (7)	3810 (6)	4842 (3)	3256 (6)	4108 (3)	3905 (6)
Tobari	7	2979 (8)	3277 (8)	4363 (5)	3539 (7)	4193 (7)	3700 (3)	3806 (6)	3702 (7)
BT 908	3	3199 (7)	3446 (7)	3428 (8)	3358 (8)	4386 (5)	2604 (8)	3635 (7)	3412 (8)

[a] Results of 1970-71.

TABLE W45. Highest yielding lines (kg/ha) and yieding rank[a] (in parentheses) from the Bread Wheat Crossing Block grown in 5 or 6 locations (Morocco, 1971-72).

Cross or variety and pedigree	*Septoria* reaction[a] scale 0-9	Dryland locations: Meknes	Mch	Fes	Sk	Average	Irrigated locations: MKM	SCBM	Average	Grand average
12300xLR64A-8156/Nor67 30842-31R-2M-2Y-0M	5	4555 (4)	4999 (1)	. . .	3830 (12)	4461	5332 (6)	4097 (1)	4715 (1)	4559 (1)
Cal/Cno"s"xLR64^2-Son64 27169-48M-1Y-1M-0Y	4	4035 (7)	4244 (9)	4719 (6)	4355 (10)	4337	4688 (3)	3564 (3)	4626 (2)	4430 (2)
Cno-IniaxCal 27224-53M-1Y-3M-0Y	5	3595 (12)	3772 (12)	5510 (1)	5415 (6)	4346	5599 (4)	3439 (5)	4519 (4)	4404 (3)
NpxTzpp-Son64/8156 (R) 28071-7M-3Y-0M	3	3648 (11)	3644 (15)	4568 (7)	4612 (4)	4115	5866 (2)	3306 (8)	4586 (3)	4270 (5)
Cal-Cno"s"xCno-Son64 28567-15Y-4M-1Y-0M	3	4888 (2)	4777 (4)	5279 (2)	. . .	4981	4399 (9)	1857 (12)	3128 (11)	4239 (6)
BbxCno-Son64 28146-10Y-4M-1Y-0M	5	4577 (3)	4452 (8)	4532 (8)	4444 (8)	4501	4177 (11)	3244 (9)	3710 (8)	4235 (7)
Jar"s" 18889-6T-8T-4T-2T-1T-0Y	6	3439 (15)	4750 (5)	4266 (11)	4497 (7)	4235	6043 (1)	2408 (11)	4226 (5)	4230 (8)
Inia"s" Np=Ptm"s' 22403-6M-4Y-1M-1Y-0M-0Y	4	4008 (8)	4875 (3)	3812 (14)	4666 (2)	4337	. . .	3617 (2)	. . .	4195 (9)
Cno-Inia 25717-11Y-3M-1Y-0M	7	2208 (16)	4963 (2)	4257 (12)	4390 (9)	3955	5021 (7)	. . .	. . .	4168 (11)
Np63xTzpp-Son64/8156 (R) 28071-7M-3Y-3M-0Y	5	4155 (6)	4466 (7)	5057 (3)	3688 (13)	4341	3955 (13)	3519 (4)	3737 (7)	4137 (12)
Nor67xInia"s"-Np63 30229-8R-1M-1Y-0M	6	4350 (5)	4008 (11)	4337 (9)	4577 (5)	4315	4132 (12)	3386 (6)	3759 (6)	4128 (13)
[(Son64xTzpp-Nai/Np) (LR64xTzpp-Ane)] Cno 24313-12R-3M-1	2	3497 (13)	3692 (13)	4319 (10)	4666 (2)	4044	4399 (9)	. . .	. . .	4115 (14)
LR64^2-Son64xCC/No66"s" 27944-7Y-1M-4Y-0M	8	3492 (14)	4599 (6)	4923 (4)	4017 (11)	4257	4488 (8)	2835 (10)	3661 (9)	4057 (15)
Potam	9	3666 (10)	4088 (10)	4826 (5)	3492 (14)	4018	5421 (5)	. . .	. . .	4298 (4)
Siete Cerros	9	5701 (1)	3648 (14)	3919 (13)	4781 (1)	4512	3732	3333 (7)	3532 (10)	4185 (10)
BT908	6	3755 (9)	1435	3724	3377	3072	2444	835	1639	2595

[a] All materials showed some resistance to *Septoria* in 1970-71.

TABLE W46. Highest yielding (kg/ha) bread wheat genotypes and yield rank (in parentheses) from several international trials grown in Morocco (1971-72).

Variety or cross	Dryland Sidi Kacem	Irrigated Menaca	Average
8TH INTERNATIONAL SPRING WHEAT YIELD NURSERY			
Tanori 71	4384 (3)	8161 (4)	6273 (1)
Jaral "s"	4250 (6)	8272 (3)	6261 (2)
LR 64-N10B x AN$^{3}_{E}$ = Mexicani "s"	4106 (7)	8400 (2)	6253 (3)
Hazera 2152	3878 (8)	8033 (5)	5956 (4)
Kalyansona	3258 (9)	8416 (1)	5837 (5)
Potam 70	4723 (1)	6616 (8)	5670 (6)
México #120 = (Pi "s")	4567 (2)	6683 (7)	5625 (7)
Hira	4367 (5)	6811 (6)	5589 (8)
Era	4381 (4)	5772 (9)	5077 (9)
BT 908	2658	...	...
BT 2306	...	4655	...
3RD REGIONAL WHEAT YIELD TRIAL			
My 54_{E}-LR/H 490[a] (LR 64 x Tzpp-Y 54)	4675 (1)	7994 (6)	6335 (1)
Md-N-K 117 A x Indus 38/8156	4135 (5)	8288 (3)	6211 (2)
HD 832-OL-3 M x Kal	4214 (4)	8166 (4)	6190 (3)
Mexipak 65	3481 (7)	8700 (1)	6091 (4)
Zorawar 71	4250 (3)	7666 (7)	5958 (5)
Mexicani	3603 (6)	8305 (2)	5954 (6)
Cajeme 71	3436 (8)	8122 (5)	5779 (7)
UP 301	4607 (2)	5800 (8)	5204 (8)
BT 908	2608 (9)	6611 (9)	4610 (9)

[a] H 490 = Tacuari (Argentina).

Dr. A. Acosta and Moroccan technician evaluate wheat plots at Merchouche, Morocco.

TABLE W47. Highest yielding durum genotypes (kg/ha) and yield rank (in parentheses) from the Third International Durum Yield Nursery grown in Morocco (1971-72).

Variety or cross	Dryland locations Dorriet	Sidi Kacem	Average	Irrigated Menaca[a]	Grand average
Cisne "s"	4868 (2)	3653 (2)	4260 (2)	7866 (1)	5462 (1)
Cocorit 71	4654 (4)	3478 (5)	4066 (5)	7788 (2)	5306 (2)
Brant "s"	4952 (1)	3484 (4)	4218 (4)	7416 (3)	5284 (3)
Cajeme 71 (Taestivum)	4211 (8)	4850 (1)	4530 (1)	6511 (12)	5190 (4)
Crane "s" A	4332 (7)	3467 (6)	3899 (6)	7383 (4)	5060 (5)
Crane "s" B	4843 (3)	3600 (3)	4221 (3)	6177 (13)	4873 (6)
Jo "s" - Cr "s"	4468 (5)	2872 (14)	3670 (8)	6700 (10)	4680 (7)
D6647	3886 (10)	2931 (12)	3408 (9)	7161 (6)	4659 (8)
T dicoccum (Vernum) - Gll "s"	3604 (13)	2845 (16)	3224 (14)	7366 (5)	4605 (9)
BD 2777 (local check)	3100 (17)	2783 (17)	2941 (17)	2955 (23)	2946 (21)

[a] Experiment after alfalfa plus 100 kg N/ha with 5 irrigations and 214.4 mm of rainfall.

About 2,500 crosses were made in the program to recombine the desirable characters present in different source materials.

The Moroccan Research Program has moved ahead aggressively and has demonstrated the value of close international collaboration. Considerable material which has excellent potential has been built up, and several superior lines are available for immediate use. There is still a great need for developing more young Moroccan scientists to staff this dynamic program.

Fertilizer Research

Fertilizer research on wheat was done as part of the activities of the Fertilizer and Management Research Section (*La Station des Améliorations Culturales*) of the Moroccan Ministry of Agriculture. The 1971-72 program dealt specifically with N application rates since the previous two years of study showed no response to K and only limited response to P_2O_5. Unlike many countries, in Morocco P_2O_5 has been applied on a wide scale for many years and this undoubtedly accounts for the low response.

For N on cereals, farmers have relied considerably on legumes in the rotation. With short-strawed, responsive varieties, N application has become more important in its contribution to yield. Thus, legumes

TABLE W48. Highest yielding (kg/ha) durum, barley and triticale genotypes from several international trials grown at three locations in Morocco (1971-72).

Variety or cross	Dryland locations Sk	Dryland locations Mch	Dryland locations Average	Irrigated Menaca	Grand average
ELITE DURUM YIELD TRIAL #1					
Cajeme 71 *(T. aestivum)*	4078	4236	4157		
Calidad *(T. aestivum)*	3388	3900	3644		
Victor I *(T. aestivum)*	3453	3136	3295		
Crane "s"	3313	2722	3018		
Cocorit 71	3145	2818	2982		
Cr"s"(T pol. 185309xT pol$_E$-Tc^2/GII"s")	3516	2308	2912		
Cisne "s"	2601	3105	2853		
ELITE DURUM YIELD TRIAL #2					
Cajeme 71 *(T. aestivum)*	3866	4291	4079		
Victor I *(T. aestivum)*	3807	3213	3510		
Cocorit 71	3445	3319	3382		
Cisne "s"	2928	3384	3156		
Masa 177Y-0M	3576	2571	3074		
Crane "s"	3501	2460	2981		
INTERNATIONAL TRITICALE YIELD NURSERY					
BT-908 *(T. aestivum)*	3874				
Badger	3774				
Badger	3478				
Armadillo	3404				
Jori 69 *(T. durum)*	3345				
REGIONAL BARLEY YIELD TRIAL					
W1-2197	2507			3620	3064
Svalof Kristina	2361			3700	3031
W.W. Cilla	2540			3158	2849
Svalof Hellas	2567			3112	2840
Giza 120	1732			3587	2660
Svalof Mari	504[a]			4466	. . .
Rabat 071 (local)	965			2245	1605

[a] Severe bird damage.

could provide N for a 20 to 25 q/ha crop, whereas with the new varieties with yield potentials of 40 to 50 q/ha, additional nitrogen will be required. With the present high support price of wheat (US$96.60 for bread wheat and US$105.60 for durum), only a very modest yield increase is required to pay for the N used.

Two types of experiments were conducted. In the North, where higher rainfall and leaching can occur, the experiments consisted of higher rates in split applications. Response levels varied with the preceding crop. Hence, in some places response was limited to 40 kg/ha, whereas in other areas there was response up to 120 kg/ha.

In the central zone, 40 to 80 kg/ha were used. After legumes the lower rate appears adequate. In addition, in this zone N applications must be fit to water availability.

As always in rainfed production, the water factor is highly variable. However, the farmer knows the previous crop, his management practice, variety used, soil depth and something about the differences of his land in comparison to zonal rainfall as a whole. Thus, he must use this knowledge in modifying the regional recommendation. The country has been divided into several zones based on rainfall, soil type, soil depth, average soil fertility and climatic factors. Of these factors, information on soils is not well documented.

Table W49 shows the effect of a previous crop on yield response to N fertilization at several locations. Where a crop follows a legume, the yield increase resulting from N application is much less than when a nonlegume was the previous crop. While this is not unexpected, sometimes little value is obtained with N rates above 40 kg/ha, and there is virtually no yield increase from rates above 80 kg/ha on legume land. When wheat follows sugar beets, considerable residual N is present in the soils. On fallow land results are quite similar. Following a nonlegume crop, however, response often continues up to 120 kg/ha and to 80 kg/ha in all cases. The rotations indicated in Table W49 are common Morocco. Probably, rotations of wheat with annual legumes, such as in South Australia, would be beneficial in areas of low rainfall where wheat follows wheat.

Available moisture in the various zones is important not only in amount but also in timing if N application is to be effective. Adequate spring moisture, either as rain or soil reserve, is critical. Plant growth is rapid and the yield base is being established. In Table W50 a comparison of yields with the same variety at Khourigba (an area of shallow soils) in 1970 and 1971 shows the critical role of spring moisture. In 1971 there was a positive response to nitrogen up to 120 kg/ha, whereas in 1970 there was little response to increasing levels of N beyond 40 kg/ha. At Sidi-el-Aydi in 1970, two replicates were irrigated and two were left dry. Yields from 120 kg/ha of N with irrigation were double those at the same N level without irrigation. At Sidi Kacem an early dry period with high temperatures hastened Tobari 66 heading, resulting in

TABLE W49. The yield effect of the previous crop on response to applied nitrogen for two bread wheat varieties grown at different locations (Morocco, 1971-72).

Variety	Location	Previous crop	Control	Nitrogen used, kg/ha 40	80	120	% yield increase at 120 N
Tobari	Ras Tebouda, 1970	Green manure	45.0[a]	53.3	53.0	50.8	12.9
Tobari	Sidi Kacem, 1970	Sugar beets	28.3	35.6	37.8	39.8	40.6
BT-908	Sidi Kacem, 1971	Sugar beets	40.3	48.8	51.6	53.2	32.0
Tobari	Had B'khati, 1972	Broadbeans	23.2	27.7	29.7	32.2	38.8
BT-908	Merchouch, 1971	Broadbeans	25.9	35.8	35.7	37.8	45.9
Tobari	Moulay Idriss, 1971	Peas	29.6	36.0	43.5	44.5	50.3
BT-908	JeJrri, 1972	Peas	24.9	29.7	32.9	33.7	35.3
BT-908	Douiet, 1972	Vetch and oats	31.2	36.4	42.0	43.7	40.1
BT-908	Ras Tebouda, 1971	Fallow	35.0	43.8	46.0	50.9	45.4
Tobari	Qued Zem, 1972	Fallow	34.4	38.8	42.5	43.7	27.0
Tobari	Berrechid, 1972	Fallow	31.6	35.8	37.5	43.7	38.3
Tobari	Ben Ahmed, 1970	Fallow	22.7	26.8	26.8	25.8	12.7
Tobari	Khemisset, 1972 (Oulad)	Wheat	17.6	26.6	34.5	36.6	108.0
Tobari	Bl Gara, 1971	Wheat	9.4	15.9	24.5	28.4	202.1
Tobari	Khouribga	Wheat	13.0	16.8	25.0	32.6	150.8
Tobari	Ras Tebouda, 1972	Sunflower/safflower	15.6	25.3	38.3	39.5	153.2
Tobari	Arba Aounate, 1972	Irrigated corn	6.2	12.6	20.0	33.9	441.8

* Yields expressed as quintals per hectare.

TABLE W50. The yield effect of available moisture on response to applied nitrogen for two bread wheat varieties grown in different locations (Morocco, 1970-71).

Variety	Location	Rainfall Total, mm	Distribution	Check	Nitrogen used, kg/ha 40	80	120
Tobari 66	Khouribga, 1970	483	82 mm after February 1	17.0[a]	21.9	21.9	23.4
Tobari 66	Khouribga, 1971	570	334 mm after February 1	13.0	16.8	25.0	32.6
Tobari 66	Sidi-el-Aydi, 1970 nonirrigated	361	297 mm prior to February 1	9.9	17.0	17.2	22.5
Tobari 66	Sidi-el-Aydi, 1970 irrigated	361	Plus two supplemental irrigations in spring	17.0	33.4	36.7	42.6
Tobari 66	Sidi Kacem, 1971	533	Dry period during February and early March	31.0	38.9	44.8	45.5
BT-908	Sidi Kacem, 1971	533	(same as above)	40.3	47.8	51.6	53.2
Tobari 66	Moulay Idriss, 1970	599	462 mm prior to February 1	16.5	19.5	23.1	26.1
Tobari 66	Moulay Idriss, 1971	655	304 mm prior to February 1	29.6	36.0	43.5	44.5

[a] Yields expressed as quintals per hectare.

pinched heads and low yield. BT908, a later-maturing variety, was not forced, and it benefited from rains which fell during late March.

Excessive winter rainfall has a similar adverse effect in lowering yields and N response. Lack of soil aeration and denitrification adversely affects the plants. Thus, at Moulay Idriss in 1970 when rains were excessive during the winter, yields and N response were much lower than in 1971 when much less rain fell during the winter months.

The effect of variety on N response reflects the genetic capacity of different varieties to convert varying amounts of N to grain. This is affected by inherent yield capacity, disease resistance and adaptability. Table W51 shows that Potam 70 responded to 160 kg/ha N applications at both Meknes and Merchouch, whereas BT908, the tall local variety, responded only to 40 kg/ha at Meknes and to 120 kg/ha at Merchouch. An even more striking difference is shown between the tall durum variety (BD2777) and the dwarf durum (Cocorit 71). For both low and high applications, the dwarf variety shows superiority. The effect of varietal adaptation is shown by the yield responses of Tobari 66 during two contrasting years at the same locations. Thus, the recommended N application also depends on the variety used.

The effect of disease on response can be very important. The response of three varieties shown in Table W52 illustrates this effect in a year of heavy *Septoria* attack (1971) at the Merchouch station. Tillering was quite normal since *Septoria* normally develops later than this stage, but yields were quite differentially affected. Thus, any character of the variety which affects the conversion of N to grain will determine the N recommendation.

Should all N be applied at seeding or should applications be split? In general, the experiments in Morocco show little advantage for the split application. Only under conditions of high moisture immediately following planting or on sandy soil is some benefit achieved. Data in Table W53 indicate that even in years of excess moisture, little leaching occurs in heavier

TABLE W51. The effect of variety on response to applied nitrogen as related to yield of different varieties grown in two trial sites (Morocco, 1971-72).

Variety	Location and conditions	Control	Nitrogen used, kg/ha 40	80	120	160
	YIELD CAPACITY OF OLD AND NEW VARIETIES					
BT-908	Nationel Agricultural School, Meknes	25.2[a]	43.1	45.3	46.3	44.2
Potam 70	(same)	27.5	42.7	46.0	53.7	57.8
BD-2777	(same)	22.1	29.4	31.1	33.6	26.3
Cocorit 71	(same)	23.6	38.3	43.4	46.5	48.7
BT-908	Merchouch Experimental Station	15.1	28.6	38.6	48.6	50.9
Potam 70	(same)	19.5	30.7	44.3	56.5	61.4
BD-2772	(same)	15.8	23.4	32.3	38.7	38.7
Cocorit 71	(same)	16.6	30.1	38.7	47.2	51.3
	VARIETAL ADAPTATION					
Tobari 66	Ras Tebouda, 1970. Warm, dry spring with 119 mm of rain after March 1	46.0	53.3	53.3	50.8	
Tobari 66	Ras Tebouda, 1971. Cold, wet spring with 337 mm of rain after March 1	26.6	35.1	33.6	36.9	
BT-908	(same)	35.0	43.8	46.0	50.9	

[a] Yields expressed as quintals per hectare.

TABLE W52. The effect of a heavy *Septoria* **infection on response to applied nitrogen as related to several agronomic traits of 3 wheat varieties (Merchouch Experiment Station, Morocco, 1971).**

Trials	Control	Nitrogen rate, kg/ha 40	80	120	160
Tillering response (tillers/m²)					
BT-908	228	249	330	327	352
Tobari 66	258	319	365	389	397
Jori 69	226	258	297	312	329
Yield response (q/ha)					
BT-908	30.9	40.4	46.5	48.6	49.3
Tobari 66	22.6	31.0	37.6	43.3	41.7
Jori 69	22.5	26.9	28.8	30.5	29.6
Head fertility (gm/10 heads)					
BT-908	23.8	22.9	22.1	24.3	22.3
Tobari 66	15.7	16.1	16.0	17.4	17.0
Jori 69	17.9	16.4	16.5	16.0	15.4

soils, such as those of Moulay Idriss, when all N is applied at planting. In the sandy soils, benefits of split application are quite apparent. There is generally a small benefit which seems real because of its regularity, but the advantage is offset by extra loss at second application and the danger that weather or other work will prevent the second application on time. Unless topdressing is applied in the early stage of growth, it will increase grain yield little.

Based on this research, N application recommendations have been developed for the major regions of Morocco (see Table W54).

As for breeding research, there is a very urgent need by the Government of Morocco to rapidly train many more young scientists to continue the soil fertility and agronomic work in order to stay abreast of new varieties, to further characterize the fertility needs and to continue to modify the practices recommended to farmers for maximum yields.

TABLE W53. The effect of split application on the response of applied nitrogen as related to yield (q/ha) of two wheat varieties grown under different rainfall conditions in Morocco, 1971-72.

Variety	Location	Nitrogen (kg/ha) applied at planting + tillering 20 + 00	20 + 20	40 + 00	40 + 20	60 + 00
INTERMEDIATE RAINFALL ZONE						
Tobari 66	Settat 1971	17.8 a	21.5 b	20.7 b	24.7 c	25.0 c
Tobari 66	Sidi Rahal 1971	24.9 a	31.5 bc	29.8 b	35.0 c	31.4 bc
Tobari 66	Arba Aounate 1972	10.4 a	14.0 ab	12.6 a	20.0 b	17.0 b
HIGH RAINFALL ZONE		40 + 00	40 + 20	60 + 00	40 + 40	80 + 00
Tobari 66	Moulay Idriss 1971	36.0 a	41.7 b	40.8 ba	42.4 b	43.5 b
Tobari 66	Moulay Idriss 1970	19.5 a	21.0 b	21.4 b	23.6 bc	23.1 bc
BT-908	Temara 1972 (sandy soil)	23.0 a	23.9 a	33.3 bc	28.1 ab	37.7 c

Values with the same letters have no significant differences at the 5% level.

TABLE W54. Nitrogen recommendations for the Mexican and Italian wheat varieties in the principal rainfed areas of Morocco (1971-72).

Zone	Nitrogen, kg/ha		
	Rotation I[a]	Rotation II[b]	
Prerif	60-80	80-120	Single or split application
Sais Plain	80-100	100-120	Single or split application
Gharb Plain	40-60	80	Single application at seeding
Romani Plateau	40-60	80	Single application at seeding
Phosphate Plateau	40	60	Single application at seeding
Chaouia	40-60	80	Single application at seeding
Doukkala	60	80-100	Single or split application
Abda	40	60	Single application at seeding

[a] Rotation I: Wheat following sugar beets, green manure, legume (edible or forage) and fallow.
[b] Rotation II: Wheat following winter cereal (grain or forage) oil seed crop or spring cereal.

ALGERIA

A Cereal Research and Production Project was established during the summer of 1971 as a collaborative program of the Algerian Ministry of Agriculture and CIMMYT with the CIMMYT program sponsored by the Ford Foundation. Other cooperating agencies included FAO and the French Central Economic Agency of Cooperation (CCCE) which direct extension demonstrations, fertilizer distribution and pilot studies, respectively. The breeding program is connected directly to the National Institute of Agricultural Research for Algeria (INRAA). The Institute operates seven stations throughout the cereal sectors of northern Algeria. The CIMMYT production research in 1971 was divided into an eastern and western region. This will be changed in the 1972-73 season to three regions (eastern, central and western), centred at Constantine, Algiers and Oran, respectively.

In the 1969 season Algeria imported seed to plant 5,100 hectares during the 1969-70 crop cycle. In the following year seed supplies were sufficient for 148,000 hectares, and in 1971-72, based on the success of Inia 66, Siete Cerros and Tobari, Algeria grew 320,000 hectares of these improved varieties, including the improved Italian variety, Strampelli. For 1972-73, 600,000 hectares are projected which will also include 86,000 hectares of Jori 69 (a Mexican durum) and 3,000 hectares of the Italian durums, Capeiti and Montanari.

Very favourable climatic conditions were experienced during the 1971-72 crop year.

Proper distribution of the different varieties, wide availability of fertilizers and strong government support led to a propitious production of grain. Rainfall was above the long-term average in all locations. In general, rainfall was highly beneficial, but excess rain in some regions produced cool, cloudy, wet conditions which hindered weed control and N application as a top dressing. Flooding losses were also encountered in low areas.

Weather conditions enhanced the development of *Septoria tritici*, but losses were restricted to the coastal, higher-rainfall belt. Stem rust was general along the coast and in the Setif region of the High Plateau. Thus, susceptible local bread and durum varieties and Italian wheats were heavily infected, and when infection was early in late-maturing varieties, losses were considerable. Leaf rust and stripe rust appeared but caused little damage.

The Mexican varieties Inia 66, Tobari 66, and to a lesser extent, Siete Cerros, were resistant to all three rust species. Soltane, Zaafrane and Utique, new varieties from Tunisia, were also resistant. Jori 69 and Cocorit 70 showed a moderate level of stem rust.

Insects were of minor importance. Cutworms and Hessian fly were responsible for isolated damage but the overall effect on yield was negligible. Bird damage, widespread in North Africa, damaged some of the earlier-maturing crops.

Fertilizer applications ranged from 55 kg/ha of N with 45 kg/ha of P_2O_5 to 90 kg/ha of N with 90 kg/ha of P_2O_5 in low- and high-rainfall areas, respectively. Application was a split dose of N. Much of the 320,000

A modern seed processing plant at Sidi-bel-Abbes, Algeria.

hectares sown to improved varieties received the recommended rates. In certain areas, lack of equipment and wet weather interfered with the top-dress applications and some 200,000 hectares programmed for aerial applications could not be covered. The resulting uneven hand application reduced overall yield.

In total, the Government supplied sufficient phosphate to provide 45 kg/ha for more than 2 million hectares of the commercial crop. Sufficient N was distributed for a 20 kg/ha application to the entire crop.

Herbicides were used on less than one-half of the area sown to improved varieties. A shortage of chemicals and equipment plus poor weather were responsible. A very large aerial application program was similarly hampered. Where satisfactory applications of herbicides were made, good weed control doubled yields, indicating the tremendous loss caused by weeds. Wild oats, ryegrass and *Phalaris* sp. are common weeds throughout the area and the chemicals applied are ineffective against them. *Ozalis*, found in orchards and vineyards, is also common in wheat fields.

Final production figures have not been tabulated, but estimates indicate a record production. Results from over half the area sown to improved varieties indicate a 15 to 18 q/ha yield for the Mexican varieties compared with a 10 q/ha yield for the local and durum wheats of the same area. In one area where Strampelli was grown, a 17 q/ha yield was recorded.

In addition to the yield reduction due to the factors noted above, lack of combines at maturity caused great harvesting losses. The early maturing, high-yielding varieties were left standing in the fields while barley and other crops were still being harvested. Delays of two to four weeks resulted in wind shattering and sprouting in the field. This situation contributed to an overall loss of about 10 to 15 percent. In well-managed fields with good fertilizer application and weed control, yields were 4 to 6 tons per hectare.

Production Research

Variety demonstrations were sown at 16 locations, 10 in the western region and 6 in the central and eastern regions. In general, these demonstrations included 18 varieties in two replications. Fertilizers and chemical weed control were applied at recommended rates, and farmers supplied the seeding and harvesting equipment. In some locations, less than 18 varieties were sown but, in total, combinations of 24 varieties were used. The data is summarized in Table W55.

Siete Cerros gave the highest average yield even though damaged by *Septoria* at some locations. At Annaba, near the coast, this variety suffered about a 30 percent yield reduction compared with Strampelli, a tolerant variety.

Seeding was delayed by wet weather, which may have accounted for some loss in the late-maturing types. Among the Italian varieties, Strampelli gave the highest yield, equalling Siete Cerros on the high plateau. Both varieties performed best in that area. Italian varieties performed well on the high plateau but yielded low in other areas, and all of them lacked stem rust resistance. Strampelli exhibited a lower intensity of stem rust than the other Italian varieties. Strampelli is very susceptible to sawfly damage in areas where Siete Cerros showed considerable tolerance. Sawfly is prevalent in the high plateau.

The three Tunisian varieties (Soltane, Zaafrane and Utique) and Mexico 1601 (Calidad "S") performed well. Among these, Soltane appears best adapted, particularly on the plateau, and because of its resistance to *Septoria* it should be grown in the high-rainfall areas as well. Utique and Mexico 1601, which are resistant to *Septoria,* performed best in the high-rainfall coastal areas, but they are too early maturing for the plateau. Fletcher shows outstanding disease resistance, but it must be seeded early. Inia 66 and Tobari 66 were not outstanding. Both varieties showed low tillering capacity

TABLE W55. Yield, maximum disease and insect ratings and other agronomic characters of wheat varieties grown in 13 farm demonstrations throughout Algeria (1971-72).

Variety and origin	No. of locations	Yield q/ha	% yield of Inia[a]	Septoria reaction[c]	Stem rust[d]	Saw fly[e]	Lodging[e]	Shattering[e]
Siete Cerros (México)	12	32.3	117	9	R	2	5	0
Zaafrane (Tunisia	7	26.3	116	7	R	10	10	2
Soltane (Tunisia)	13	30.2	113	7	R	5	2	0
Mexico 1601 (Mexico)	3	46.3	112	5	R	5	...	...
Strampelli (Italy)	13	29.7	111	3	S	25	5	0
Utique (Tunisia)	11	26.1	108	5	R	5	10	5
Tobari 66 (Mexico)	12	27.8	106	8	R	5	2	0
Generoso (Italy)	9	22.1	106	3	5	10	0	5
Fletcher (U.S.A.)	3	29.7	103	2	R	5	0	0
Capeiti (D) (Italy)	5	29.9	103	...	S	L	S	...
Inia 66 (Mexico)	13	26.7[b]	100	9	R	10	5	0
Inrat 69 (D) (Tunisia)	13	25.6	96	8	T-R	10	50	0
Moh. Ben Bachir (Algeria)	9	23.6	96	...	S	10	S	...
Jori 69 (D) (Mexico)	8	23.5	93	9	R	3	0	0
Sparta (Italy)	12	25.9	90	3	VHS	5	5	10
Mahon Demais (Algeria)	9	21.4	87	...	S	5	S	10
Padre Gemelli (Italy)	11	20.8	85	3	VHS	10	0	5
Libellula (D) (Italy)	11	23.0	84	2	VHS	5	0	2
Qued Zenati 368 (D) (Algeria)	11	21.6	84	9	S	...	95	0
Montanari (D) (Italy)	3	26.0	79	...	S	...	S	...
Splendeur (France)	13	14.4	54	2	VHS	5	0	0

[a] % of yield of Inia 66 in same experiments.
[b] Average yield of Inia 66 in all locations.
[c] Based on a 0-to-9 scale.
[d] L = light attack; R = resistant; S = susceptible; VHS = very highly susceptible.
[e] Figures express percent damage.

TABLE W56. Yield of four varieties at two seeding dates and two locations on the high plateaus (Algeria, 1971-72).

	Setif South, q/ha			Setif North, q/ha		
	Nov. 25	Dec. 20	Ave.	Nov. 25	Dec. 19	Ave.
Inia 66	21.6	24.1	22.9[a]	24.4	23.6	24.0
Strampelli	23.5	26.1	24.8[a]	26.9	29.5	28.2[a]
Siete Cerros	23.9	24.1	24.0[a]	28.8	28.9	28.9[a]
Mahon Demais [b]	18.0	16.4	17.2	23.9	21.1	22.5
L.S.D. 5%			3.52			5.64

[a] Significantly higher than check.
[b] Local check.

and neither is well adapted to the high plateau. Tobari performed best in the high-rainfall region and until seed supplies of Soltane and Utique are available in sufficient quantities, it is the most suitable variety for these coastal areas.

Among the durum varieties, INRAT 69, Capeiti and Jori 69 show the greatest potential. Jori is best adapted in the 400 to 500 mm intermediate rainfall belt below 800 meters altitude. Capeiti can be grown in the high-rainfall region but has weak straw. INRAT 69 does well in both regions. Cocorit 71 and other new high-yielding durum lines appear to be decidedly superior in yield to any of the varieties tested and will be included in next year's demonstrations.

Three trials for date of seeding were grown in eastern Algeria. One was abandoned as a result of cutworm damage. The data from the other two planted near Setif are in Table W56.

No significant difference was observed between yields from different dates of seeding and there was little date-variety interaction, although varietal differences are evident. The cool spring and good rainfall were probably responsible for the lack of response to seeding date.

Four fertilizer trials were grown in the eastern region. One of these was abandoned because of cutworm damage. Two locations showed a significant N response. In these locations, wheat following sugar beets responded up to 44 kg/ha, and wheat following vetch responded up to 132 kg/ha (see Table W57).

The third trial at Setif was grown after summer fallow and no significant response was observed.

These experiments also involved application rates. The application for each rate was split. Thus, data in Table W57 are based on 12 plots each.

Breeding Research

The cool and prolonged season provided optimum conditions for selection in breeding populations. Two distinct zones must be considered in breeding: (a) the coastal plain, characterized by a mild climate, no frost, high rainfall and high disease intensity and (b) the high plateau to the south at 600 to 1,200 meters altitude with freezing temperatures, late frosts, snow, hot desert winds ("sirocco") and variable rainfall of 250 to 650 mm.

For bread wheats, the prolonged rainfall during the 1972 season favoured medium- to late-maturing varieties. As shown in Table W58, Siete Cerros and Strampelli were the highest yielders in the production plots. Siete Cerros has good general resistance to the rusts, is immune to loose smut, but is highly susceptible to *Septoria*. Strampelli has good resistance to *Septoria*, but it is suceptible to stem rust and leaf rust. Data from the two previous years also showed these two varieties tops in yield despite lower rainfall. The best varieties selected from the Seventh ISWYN Trial are listed in Table W59. The yield averages are from three locations. The Indian variety Chhoti Lerma regularly yields well in the absence of stripe rust. Toquifen, Victor 1 and Penjamo 62 show a good tolerance to *Septoria* and adaptation to North Africa. The poor grain quality of Victor 1, however, precludes its use in commercial production.

The nurseries at Algiers and Annaba provided good screening. *Septoria tritici* developed in mid-March, increased rapidly and developed to a heavy infection level. Lines which showed good tolerance are listed in Table W60. Selection was based on a combination of

TABLE W57. Summary of yield response to various nitrogen applications at two locations in Algeria (1971-72).

Location	Previous crop	Nitrogen, kg/ha 0	44	88	132	Yield increase from O N to 132 kg/ha N	Percent increase from O N to 132 kg/ha N
Guelna	Sugar beet	36.1	44.1	45.0	46.4	10.3	28
Annaba	Vetch (seed)	23.5	37.7	43.5	51.4	27.9	115

L.S.D. at Guelna = 4.79 q/ha; L.S.D. at Annaba = 6.82 q/ha.

Yields expressed in quintals/hectare.

TABLE W58. Top-yielding bread wheat varieties from different national yield trials in Algeria (1971-72).

Variety or cross	Location	Yield q/ha	Highest % yield of Florence Aurore[a]
Strampelli	Guelma	70.2	166.8
Siete Cerros	Guelma	65.2	177.6
Un - Sk x S.Past/ Mara	Algiers	60.8	125.9
Chenab 70	Algiers	59.8	142.1
Un - Sk x S.Past/ Cno - Inia	Algiers	59.6	123.4
Mexipak 69	Guelma	58.5	184.8
CC - Inia"s" (143)	Algiers	57.8	136.1
Calidad "s" (Mex. 160)	Algiers	55.4	144.8
Wt^3_E-Nar59/Son64-Tzpp x Y54	Algiers	53.4	150.9
Cno"s" - Inia"s"^{2}	Algiers	53.1	171.0
Inia"s" - Napo63 (136)	Algiers	52.7	124.1
B21 x KE 3.2 (French)	Algiers	52.5	130.6
Inia 66	Algiers	50.3	133.2
Tobari 66	Algiers	44.3	142.6

[a] % of yield of Florence Aurore in comparable trials.

TABLE W59. Yield average of the 10 highest yielding varieties and lines from the Seventh International Spring Wheat Yield Nursery grown in Algiers, El-Kroub and Sidi-Bel-Abbes, Algeria, (1971-72).

Genotypes	Yield, q/ha
Chhoti Lerma	50.4
Toquifen	49.5
Victor 1	48.4
Penjamo 62	48.3
Chenab 70	48.2
UP-301	48.1
Tanori 71	48.1
Sonora 64 - Klein Rend.	47.9
Pitic 62	47.4
Calidad	46.7

early (April 5) and late (June 10) ratings. Resistant lines maintained bright yellow straw, whereas the susceptible varieties turned a dull gray. Siete Cerros was heavily damaged. Lines starred in Table W60 maintained good leaf tissue and had limited *Septoria* lesions.

TABLE W60. Wheat varieties and lines with the best Septoria **resistance observed in Algiers, 1971-1972 (data from several local and international nurseries).**

Genotype and pedigree	Origin	*Septoria* rating Scale O - 9 Apr. 5	Jun. 10
(My54-N10 x Y50-K Line) [(T/Chin 166 x L-N)M^2-ME] Fr A3538-12P-5P-5P-1D	PON-30	3	6
H490-An64A II-MJ-191-1P-1P-1D	PON-38	3-5	3-5
Ofn (Com-N x Mt-Men) (Kt/Bg-Fn x G4)	PON-44	4	8[a]
Pato (B) 21974-4R-2R-0Y	PON-115	1	7
On-Bb/Cno-7Cerros x Tob-B.Man 34310-6m-1y-0m	PON-183	3	7
CC-Tob^2 24027-13t-1m--1y-0m	PON-192	3	7
Jar-Napo63/LR64 x TzPP-AnE 21823-10y-2m-4y-1m	PON-193	4	8
BYE^2-TC x Tac$_E$-TC^2(BYE^2-TC/Z-B x B) D-31539-3L	PON-207	6	7
Super X	PON-175	8	9
Tob x Kl.Pet-Raf II-23438-5M-1Y-3M-1Y-0M-0Mb	POT-7142	6	7[a]
Mex 1601 = Utique (BT 2349)	POT-7191	6	6
Napo63 x TzPP-Son64/8156(R) 28071-7m-3y-3m-0Y-0Mb	POT-7310	4	5
Kt/Bg-Fn/uxB2a VI-1S-22t-1t-1b-1b-0Mb	POT-7345	4	5
Fn-K58/N x (Er-KAD x Gb)^2 II-14239-5t-1b-1t-0Mb	POT-7346	6	6
Mexicano 1481	POT-7520	4	5
Inia-Cno x Cal 27220-44M-0Y-48M-0Y-(1-3Y)	5th IBWSN-28	3	7
Cno"s"-Gallo 27829-19Y-2M-1Y-0M	5th IBWSN-114	4	6
Tob66-CC x Pato 27369-1R-4M-0Y	5th IBWSN-147	2	4
N066-Cno"s" x Jar66 27343-2R-3M-3T	5th IBWSN-151	1	3
Era	5th IBWSN-211	4	5
Pj62-Ca 30403-19M-2Y-1M-0Y	5th IBWSN-287	2	4[a]
(TzPPWt^2_E x Napo63) (Inia"s"/S64 x TzPP-Y54) 29791-11R-4M-1Y-1M-0Y	5th IBWSN-328	2	5[a]
(Nar59-101Y/PJ62-Gb x TzPP-Kno#2)Cal 30409-44R-1M-3Y-1M-0Y	5th IBWSN-330	3	6

[a] Very small resistant-type pustule not spreading on leaf (tolerance).

Improvement in durums is urgently required for Algeria and all of North Africa. Local varieties are well adapted but tall, susceptible to the rusts and cannot be heavily fertilized. In Algeria, of the 2.25 million hectares devoted to cereals, 1.5 million are sown to durums and only 0.75 million are sown to bread wheats.

The introduced improved dwarf durum varieties are deficient in disease resistance and grain quality. The best-yielding lines of the Third International Durum Yield Nursery are in Table W61. The yield averages are based on three testing locations. The Crane "sibs" have good yields but insufficient disease resistance. The Argentine variety Parana 66/270, a cross of a tall Argentine variety and a dwarf Mexican durum, shows good promise due to high yield and a generally high level of disease resistance. It also has short straw and tillers well. A second line, *T. dicoccum vernum x GII "S"*, has good yield potential and stem rust resistance, but it is susceptible to *Septoria* and leaf rust. Cocorit 71 is well adapted, has some tolerance to Septoria, and is superior in rust resistance to Jori 69. INRAT 69 yields well, has Septoria resistance and is very resistant to scab (*Giberella zeae*), but is losing its resistance to stem and leaf rust. Jori 69 yields good but is susceptible to all major North African diseases. Although it will be grown commercially in the coming year, Jori 69 will have to be replaced in the near future as better varieties become available and are multiplied.

Other promising selections include a *T. polonicum* x Z-B dwarf selected locally which seems adapted to the Setif region, but because of its wide cross derivation continues to segregate. An Anhinga "S" line selected from an earlier IDYN and Mandos (a French variety) are among the better adapted, Mandos in the coastal plain.

TABLE W61. Average yield and disease reaction of the best varieties and lines in the Third International Durum Yield Nursery grown at three locations (Algeria, 1971-72).

Genotype	Yield q/ha	SETIF Stripe rust	ALGIERS Leaf rust	GUELMA Stem rust	*Septoria* (scale 0-9) April 15	*Septoria* (scale 0-9) June 10	*Fusarium culmorum*
Crane "s" (B)	49.3	80S	80S	...	7	9	S
T.dicc.ver-GII"s"	48.1	R	100S	...	6	8	S
Parana 66/270	47.6	R	R	...	4	4	MS
Cocorit 71	47.4	20MR	80S	40S	7	7	S
Cisne "s"	45.2	60S	60MS-S	10MR	4	8	S
Jo "s"-Cr "s"	44.2	40S	60MS	...	5	9	S
Crane "s" A	43.7	80S	80S	...	8	9	S
Capeiti	43.6	80S	80S	...	3	8	R?
Inrat 69	43.1	20S	80MS	...	4	7	R
Quilafen	41.8	80S	100S	...	5	7	R?
Jori C69 (check)	35.9	60S	80S	Tr	6	9	S
Cajeme 71 (check)	50.3	R	R	...	4	8	...

The outstanding leaf rust-resistant and *Septoria*-resistant lines listed in Table W62 were selected from the Third IDSN at Algiers. Heavy attacks of both diseases killed susceptible varieties and caused extensive grain shrivelling. Stem rust infection was low and screening for this disease was not possible. Hopefully, resistance will be found in some of these lines so they may be used for replacing present commercial types.

TUNISIA

The 1971-72 season was above average for plant development. Sowings were done under favourable moisture conditions after good soil preparation and weed control. Rains were adequate, but not excessive, during the growing season and the spring was interspersed with sunny periods which lowered the disease intensity on the crop. Hot winds (Sirocco), which sometimes cause premature ripening, did not appear although a slight reduction in grain filling (reflected in low test weight) occurred in localized areas due to drought stress near maturity. Some of the tall varieties lodged and there was some hail damage in isolated areas.

The wheat project of the Tunisian government is aided by CIMMYT personnel with financial assistance from the Ford Foundation and USAID. Project efforts have been concentrated in the better rainfall areas in the North with most emphasis on bread wheat production. Some attention has been given outside these regions, and there also has been a notable spread of technology outward from demonstration areas.

In the northern wheat region, the new technology has been adopted on 150,000 of the total 750,000 hectares (60 percent durum, 40 percent bread). Improved varieties were sown on 65,000 to 70,000 hectares. As a result of fertilizer demonstrations, a much larger area has received fertilizer and herbicides.

About 18,400 tons of N were applied this season compared to 13,200 tons and 9,400 tons, respectively, in the previous two years. Assuming that 50 percent was applied to wheat, this means that about 150,000 hectares received N. Herbicides, mainly 2,4-D, were applied on the same amount of land, whereas in 1970-71 only 70,000 hectares were treated.

Government estimates show an anticipated production of 570,000 tons of durum wheat and 240,000 tons of bread wheat. This represents a production increase of 25 to 28 percent for durum wheats and 15 percent for bread wheats. Part of this increment may be attributed to the use of improved varieties, but even more to the new technology and favourable weather.

The financial incentives were retained. Prices for durum wheat were held at 5.1 dinars and 4.5 dinars for bread wheat per quintal (US$107.50 per metric ton and US$95.00 per ton, respectively). Certain input import taxes were reduced; most notable was an import tax reduction on N from 14.4 to 8.0 percent.

Diseases, Pests and Weeds

This was a relatively disease-free year. *Septoria* was rarely damaging and the three rusts developed so late that little damage occurred. *Ophiobolus* was present and also powdery mildew; neither were important.

Heterodera avenae, the root cyst nematode, occurred in local areas of the Northwest. Certain fields were badly damaged, particularly where wheat followed wheat. Frit fly, Hessian fly and cereal leaf beetle appeared sporadically. Sawfly was present, particularly in western Tunisia and in drier sites in the South.

Weeds continued to be a serious problem and were the greatest cause of yield reduction. However, the year was better than many previous years because October rains germinated weeds which were then destroyed in the succeeding cultivation. The rapid crop growth allowed the wheat plants to compete favourably. The increased herbicide use referred to above also reduced the weed problem.

Fertilizer Studies

This year's experimentation was the fourth for the Tunisian project. Experiments were purposely concentrated in the 300 to 700 mm rainfall areas.

The experiments combined demonstrations, research and training, all on farmers' field under rainfed culture. Farmers assisted with land preparation, field days and harvesting. Thirty-seven experiments and numerous drill-strip fertilizer tests were grown. The experiments comprised rates x dates of N application, N forms, rates and dates of NPK application, varieties x N, and comparisons of two P_2O_5 rates in demonstration strips.

Eighty-four percent of the trials were successfully harvested with meaningful data. This year Inrat 69 and Jori 69 durums were tested for N response. Inrat 69 has good tolerance to *Septoria*, but Jori 69 can only be grown successfully in low-rainfall areas.

Yield data for all N experiments are in Table W63. The average yield over all locations and all experiments was 37.1 q/ha. This is a 33.7 percent increase in yield with N use. The largest single increase for N was 26.8 q/ha by INIA under a 133 kg/ha N application.

Most fertilizer trials showed N response, particularly with short-strawed varieties. There was less response by the weaker-strawed durum varieties, but Inrat 69 was able to respond up to a yield level of 40 q/ha. On the basis of the tests as a whole, the optimum N rate for dwarf varieties appears to be 90 kg/ha in the 500 mm rainfall areas and 67 kg/ha for the 400 to 500 mm range. At rainfall levels below this, not more than 45 kg/ha

TABLE W62. Durum wheat varieties and lines from the Third International Durum Screening Nursey most resistant to leaf rust and to Septoria **in Algiers (1971-72).**

IDSN entry	Genotype and pedigree	Leaf rust	*Septoria* rating (scale 0-9) Apr. 15	Jun. 10
011	Flamingo "s"	20Mr-MS	4	8
088	Flamingo "s"	40MS[a]	5	7
012	Jo "s"(LD-357$_E$-Tc^2/GII"s") D-27588-5M-3Y-1M-500Y	20MR	4-5?	8
045	D-21563-AA"s" D-27625-5M-2Y-2M-1Y-0M	10MR	5	7
068	D-21563-Jo"s" D-31538-14M-3Y-0M	TrR[a]	4	7
069	D-21563-Jo"s" D-31538-14M-6Y-0M	10MR[a]	5	7-8
0137	(LD-357$_E$-Tc^2) Jo"s" D-27534-3M-2Y-1M	20MR[a]	5	9
0141	Jo"s"(LD-357$_E$ x Tc^2/GII"s") D-27572-20M-3Y-1M	10MR[a]	4	7-8
0142	Jo"s"(LD-357$_E$ x Tc^2/GII"s") D-27572-20M-3Y-3M	20MR[a]	6	8
0146	Jo"s"(LD-357$_E$ x Tc^2 x GII"s") D-27588-5M-3Y-3M	20MR	4	8
0159	D-Buck(By$_E$^{2}-Tc)(LD-357$_E$-Tc^2/GII"s") D-27649-0M-38Y-1M	20R[a]	7	8
0188	Plc"s"-Jo"s" D-31679-4M-1Y-1M-0Y	TrR[a]	4	6-7
0189	Plc"s"-Jo"s" D-31679-9M-1Y-2M-0Y	TrR[a]	6	8
0219	Stw63-GII"s" x RD-119-1W-2Y D-31759-1M-2Y-1M-0Y	20MR-MS[a]	4	7-8
0223	Cr"s"-Gs"s" D-28980-28Y-13M-5Y-1M-0Y	20MR	5	7-8
0230	Masa-177Y-1M-0Y	40MS	6	7-8
0243	Jo"s"/LD-357$_E$-Tc^2-GII"s" D-27588-5M-3Y-3M-1Y-1M-0Y	TrR	3	6-7
0252	D-21563-AA"s" D-27625-5M-2Y-2M-1Y-1M-0Y	20R	5	6
0254	Gs"s"-Cr"s" D-27676-6M-1Y-1M-2Y-1M-0Y	10R[a]	7	9

[a] Also reported resistant to all 3 rusts at New Delhi, India.

TABLE W63. Comparison of experiments involving rates, sources and timing of application of nitrogen for various wheat varieties under different rainfall conditions (Tunisia, 1971-72).

Type experiment	Variety	Experimental mean q/ha	Treatment associated with MAXIMUM YIELD: Rate (kg/ha) and source of N	Treatment associated with MAXIMUM YIELD: Date of application	Treatment associated with MAXIMUM YIELD: Average yield q/ha	Yield of control q/ha	Percent yield increase of maximum over control
I. Average annual rainfall greater than 500 mm							
Forms of N	Penjamo	24.9	90 NH_4NO_3	Average of 4 dates	35.6	14.5	145
RDN	Penjamo	17.0	133 NH_4NO_3	Seeding/ tillering	24.0	18.6	29
RDN	Inia 66	37.8	133 NH_4NO_3	Tillering	54.0	27.9	96
RDN	Inrat 69	41.0	133 NH_4NO_3	Jointing	47.2	33.7	40
RDN	Utique	22.0	133 NH_4NO_3	Seeding/ tillering	32.1	11.7	174
RDN	Inrat 69	18.0	133 NH_4NO_3	Seeding	23.6	15.5	52
NPK	Inia 66	39.3	100 NH_4NO_3	Seeding	51.5	23.6	118
Varieties x Nitrogen	6 varieties	27.1	133 NH_4NO_3	Seeding/ tillering	42.5	30.1	41
Varieties x Nitrogen	6 varieties	42.4	100 NH_4NO_3	Seeding/ tillering	59.2	45.0	32
Average for areas with more than 500 mm annual rainfall		29.9	120		41.1	24.5	68
II. Average annual rainfall less than 500 mm							
Forms of N	Inia	28.5	90 $CO(NH_2)_2$	Average of 4 dates	36.4	21.4	70
Forms of N	Inia	44.1	90 $CO(NH_2)_2$	Average of 4 dates	48.1	40.0	20
RDN	Inrat 69	32.1	67 NH_4NO_3	Seeding	35.8	34.6	3
RDN	Inia	44.8	90 NH_4NO_3	Seeding/ tillering	52.6	40.3	31
RDN	Inia	48.3	67 NH_4NO_3	Seeding	52.2	44.6	17
RDN	Jori	47.9	22 NH_4NO_3	Jointing	53.8	48.9	10
RDN	Siete Cerros	45.7	67 NH_4NO_3	Jointing	54.5	36.6	49
RDN	Inia	35.1	90 NH_4NO_3	Tillering	42.9	34.8	23
RDN	Inia	43.7	45 NH_4NO_3	Seeding	46.5	42.6	9
RDN	Inrat 69	32.2	0 . . .	. . .	34.9	34.9	. . .[a]
RDN	Inia	42.4	90 NH_4NO_3	Tillering	50.1	40.3	24
RDN	Inia	51.8	90 NH_4NO_3	Tillering	59.3	47.2	26
RDN	Inrat 69	30.3	90 NH_4NO_3	Seeding	36.4	27.0	35
RDN	Inia 66	38.9	67 NH_4NO_3	Seeding	43.9	32.7	34
RDN	Inia 66	40.5	67 NH_4NO_3	Tillering	51.8	35.0	48
RDN	Jori	43.4	90 NH_4NO_3	Jointing	48.5	41.4	17
RDN	Inrat 69	39.7	90 NH_4NO_3	Tillering	43.9	35.4	24
RDN	Inrat 69	40.1	90 NH_4NO_3	Jointing	48.9	33.2	47
RDN	Inrat 69	38.6	0 . . .	. . .	44.4	44.4	. . .
RDN	Inrat 69	37.8	90 NH_4NO_3	Seeding/ tillering	44.6	30.2	48
NPK	Inia 66	27.9	100 NH_4NO_3	Seeding	36.5	18.9	93
NPK	Inia 66	48.3	0 . . .	. .	52.4	52.4	. . .
Average for areas with less than 500 mm annual rainfall		40.1	67		46.2	37.1	25
Averages over all experiments		37.1	83		44.8	33.5	33.7

[a] No nitrogen response due to high residual soil nitrogen and lodging of durum wheats.

Dr. Torrey Lyons (right), CIMMYT staff member located in Tunisia, explains his work to visitors.

should be applied. For durums and tall bread wheats, these recommendations should be 1/2 to 2/3 of those above. Similarly, when wheat follows row crops or a winter fallow, about half the rate is sufficient. For wheat after cereal or weedy fallow, a 20 percent increase in N use is advised. The guideliness should be modified for particular local conditions.

Date of N application was less important than rate used if the total quantity was in place during the tillering stage. There were no significant responses to P_2O_5 and K_2O when applied with N. In the demonstration strips on farms, only 3 of 15 locations showed response to P_2O_5. This lack of response undoubtedly resulted from a long history of P_2O_5 fertilizer use. Results of the use of different N forms indicate that urea, which is cheapest, can be used for the presowing application if worked into the soil well. Ammonium, because of its lower volatilization, should have preference for top-dressing.

A benefit-cost ratio was calculated for N applications, using the average yield increase for the 31 tests:

$$\text{Benefit-Cost} = \frac{\text{Value of yield increase (dinars per ha)}}{\text{Cost of N}}$$

$$= \frac{11.3 \text{ q} \times 4.500 \text{ dinars/q}}{0.115/\text{kg N} \times 83}$$

$$= \frac{50.850}{9.545} = 5.3{:}1$$

(Bread wheat sells at 4.5 dinar/q. NH_4NO_3 applied on the field costs 3.8 dinars/q or 0.115 dinars per kg. 1 dinar = US$2.12.)

A benefit-cost ratio of 5.3 to 1 is very encouraging considering the range of environments under which the tests were conducted. Fig. W16 shows that N use has doubled since 1968-69 and that the Government is making provision for 22,400 tons in 1972-73.

These large increases in N use may be attributed mainly to its increased use on wheat. It is obvious that research on technology of fertilizer value has paid very large dividends in furthering N utilization.

Date of Planting Studies

Date of planting studies were conducted at six sites and data were valid from five. Three dates of seeding of six varieties in large, three-replicate plots were used.

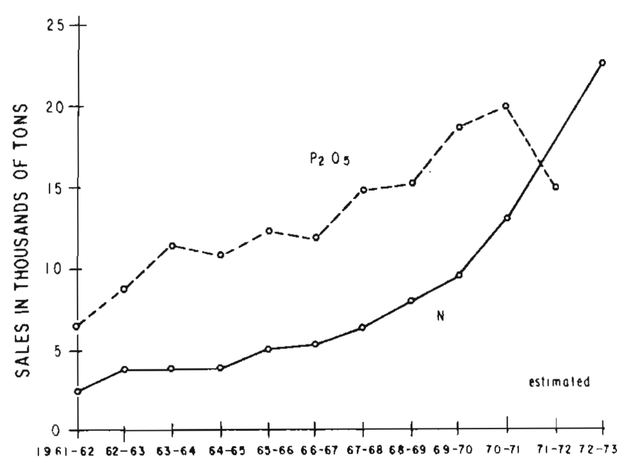


FIG. W16. Nitrogenous and phosphoric fertilizers sold in Tunisia from 1961-62. (Source: División de la Producción Vegetale et de la Conjonture Ministere de l'Agriculture).

The three dates were mid-November, mid-December and, where possible, early January, but because of rains this seeding date extended to early February. Penjamo 62 showed good results, but tended to lower yield at the January date. Florence Aurore, Ariana, Bedri and Inrat gave best results for the earliest sowing and poor results for the latest.

Septoria was most severe on the earliest planting and decreased in intensity with delayed plantings. In the colder, higher plateau area of Le-Kef, early seeding is desirable. This is difficult, however, because of the rainfall pattern and soil structure.

Weed Control Research

Weed infestation tends to be high as a result of inadequate tillage, particularly in the presowing period. Under such conditions, herbicide application is often required. Wild oats and *Lolium rigidum* (rye grass) were about equally harmful in the past season. Rye grass appears to induce lodging in the infested wheat. *Phalaris truncata* and *P. canariensis* (canary grasses) can also be damaging, but on a smaller scale. Herbicide control of grassy species is still not satisfactory (Table W64). Most broad-leaved species are controlled with 2,4-D, but several wheat varieties appear to suffer damage and more resistant types may be needed.

In the past season, three types of experiments were conducted: (1) wild oat control at six sites with data from three, (2) evaluation of broad-leaved herbicides at seven sites with data from six and (3) a study of 2,4-D toxicity at three sites with data from all. In evaluating different herbicides, untreated strips on either side of the test were used as control plots for rating which weeds had been controlled by the various herbicides.

The favourable rainfall pattern prevented moisture stress at all sites so that the effect of weed infestation on moisture removal was minimal. Thus, a reasonable measure of phytotoxicity was possible. Yield results for the wild oat control trials are in Table W65 and results for the broadleaf weeds are in Table W66.

Among the chemicals tested on wild oats, Dicuran and Dosanex performed similarly. Both gave fair control of wild oats and rye grass and good control of most of the important broadleaf weeds. Phytotoxicity was a problem with both herbicides. Suffix gave better control of wild oats but controlled no other weed species. Therefore, a second weedicide will often be required which increases costs. In addition, suffix is applied late, after wild oat damage may already have occurred. In general, it appears that none of the three chemicals (Dicuran, Dosanex and Suffix) are fully satisfactory and all are relatively expensive.

For broadleaf weed control, 2,4-D, MCPA, Buctril, Bronate and Tribunil were applied. Each showed several advantages, and also showed disadvantages. Among these, Tribunil may be better than the others since yields were higher. It showed low toxicity to wheat and gave partial control of rye grass but not of wild oats nor of certain broad-leaved weeds. MCPA, Buctril and Bronate can be safely used somewhat earlier than 2,4-D, but the latter two show some phytotoxic effects. Among these, the tests show that MCPA has some advantage over 2,4-D and is generally less phytotoxic. However, it is somewhat more expensive than 2,4-D, which is now widely used in Tunisia.

The experiments on 2,4-D phytotoxicity were conducted with four varieties chosen to represent different sensitivities based on ear distortion observed in 1970-71: Zaafrane and Soltane, high; Inia 66 moderate; and Jori 69, low damage. The herbicide was applied at the

TABLE W64. Average percent control of weed species in seven herbicide trials (Tunisia, 1971-72).

	Herbicides and development of wheat when applied							
Weed species	2,4-d 6[a]	MCPA 6	Buctril 3	Buctril 4 1/2	Bronate 4 1/2	Tribunil 3	Dosanex 3	Dicuran 3
Avena sterilis	14	4	2	8	7	13	69v[b]	67
Lolium rigidum	13	16	24	24	20	46v	87	68
Phalaris truncata	0	0	0	0	0	0	0	5
Fumaria parviflora	77	93	26	25	92	78v	71	43v
Fumaria agraria	51	88	16	27	89	78v	77	23v
Papaver rhoeas	99	95	68	90	96	99	89	92
Raphanus raphanistrum	100	100	93	96	99	100	100	72
Vicia hirsutum	100	95	59	59	97	36v	65v	56
Vicia sativa	100	100	...	11	91	0	35	20
Medicago hispida	95	95	43	43	73v	53v	90	78
Polygonum aviculaire	100	90	45v	46v	98	67v	100	100
Euphorbia helioscopia	100	98	40	98	100	36	51v	27
Bupleurum lancifolium	100	100	65	87	87	48	100	100
Galium aparine	0	...	...	...	...	...	100	...
Sonchus asper	95	95	30	60v	30v	15v	34v	63v
Chrysanthemum coronarium	91	80	56v	89	99	80	90	91
Calendula arvensis	100	50v	...	...	100	...	...	100
Convolvulus arvensis	94	93	12 7	44v	23	0	...	17v
Convolvulus tricolor	100	100	...	...	...	...	...	
Lamium amplexicaule	50	0	...	...	100	...	...	...
Veronica hederaefolia	72	89	41v	56	91	90	77	86
Linaria reflexa	80	54	43v	63v	99	97	..	74
Anagallis arvensis	70	97	10	0	54v	100	...	100
Rumex sp	12	47	87	98	90	100	100	95
Torilis nodosa	95	100	43	80	96	82	...	...
Ridolfia segetum	100	100	80	97	100	99	...	100
Circium arvensis	67v	70	6	0	24	15	...	23

[a] Number of leaves.
[b] Variable data.

3-, 4 1/2- and 6-leaf stages, at jointing, and at the boot and flowering stages.

At the 3-leaf stage, the onion leaf reaction was common in all varieties and severe ear distortion developed in all but Jori 69. At the 4 1/2-leaf stage the onion leaf symptom was minor but severe ear distortion again occurred in each variety except Jori 69. At the 6-leaf stage Jori 69 was again free of symptoms while ear distortion was light in Inia 66 but severe in Zaafrane and Soltane. In later treatments, development was normal except for some sterility which resulted in upright ears in the plots.

The highest average yield of all varieties resulted from treatment at the jointing stage. At this stage no ear distortion was observed in the bread wheats. The late-tillering habit of Soltane and Zaafrane may provide an extended period of sensitivity, thus accounting for greater damage at the 6-leaf stage. Although Jori 69 did not show symptoms, the greatest yield was also obtained with jointing-stage application. Fig. 17 shows these relationships.

Caution must be employed when using 2,4-D in experimental plots as well as in commercial fields.

Rotation of Annual Forage Legumes with Wheat

A new research area was introduced into the Tunisian

TABLE W65. Wheat yields (q/ha) with various herbicide treatments to control wild oats (Tunisia, 1971-72).

Herbicide and amount of active ingredient per hectare	Plant development	Sites and varieties				
		Beja	Oued Zarga[a]		Teboursouk	
		Sonalika	Inrat	Inia	Inrat	Inia
Dicuran, 1.6 kg	1 leaf	41.7	16.0	22.2	24.8	33.4
Dicuran, 1.6 kg	Pretillering	42.3	15.7	22.6		...
Dicuran, 2.4 kg	Pretillering	37.6	16.5	24.3	26.2	40.0
Dicuran, 2.4 kg	Full tillering	39.5	16.7	24.6	24.7	38.3
Dosanex, 3.2 kg	Pretillering	41.1	17.3	22.6	24.1	27.5
Tribunil, 1.95 kg	Pretillering	...	...	...	26.5	39.8
Dicuran, 1.6 kg + igran, 0.8 kg	Pretillering	31.7	18.5	19.2	...	...
Igran, 0.8 kg	Pretillering	39.8	16.4	22.0	...	...
Buctril, 0.41 kg	Pretillering	...	...	...	23.1	32.5
Suffix, 1.5 kg	Full tillering	41.5	17.1	25.0	25.3	36.8
Suffix, 1.5 kg	Early jointing	40.9	18.0	22.1	28.8	35.5
Suffix, 1.5 kg + 2, 4-D, 0.55 kg	Early jointing	...	17.5	22.9	...	...
Dicuran, 2.4 kg	Early jointing	37.8	14.5	20.0	27.4	35.6
Control, not treated		39.8	16.3	23.7	23.7	33.2
Coefficient of variation, %		10.9	8.5	8.9	11.4	12.1
L.S.D. at 10%		5.2	1.7	2.5	NS	7.3
L.S.D. at 5%		NS	NS	3.0	NS	9.0

[a] At Oued Zarga a hail storm reduced harvested yield of Inia 30% to 45% and that of Inrat 50% to 65%.

TABLE W66. Wheat yields (q/ha) with various herbicide treatments to control broadleaf weeds at six trial sites (Tunisia; 1971-72).

Herbicide and amount of active ingredient per hectare	Plant development	Sites						
		St. Cyprien	Srinja	Oued Rmel	Gaafour	Le Krib	Bendouba	Average
2, 4-D, 0.55 kg	Early jointing	34.5	34.6	40.5	33.9	44.8	34.7	37.1
MCPA, 0.55 kg	Full tillering	29.9	37.0	40.5	26.8	47.0	35.4	36.1
MCPA, 0.55 kg	Early jointing	32.7	41.0	41.7	32.8	47.3	36.2	38.6
Buctril, 0.41 kg	Pretillering	33.0	36.6	37.9	32.0	45.4	34.1	36.5
Buctril, 0.41 kg	Full tillering	36.0	40.2	37.8	30.6	49.2	33.2	37.8
Bronate, 0.41 kg + 0.41	Full tillering	34.0	37.8	37.6	30.0	47.9	36.2	37.2
Tribunil, 1.95 kg	Pretillering	36.7	39.9	42.4	35.7	49.5	37.9	40.3
Dosanex 3.2 kg	Pretillering	35.7	39.1	42.6	30.9	47.3	37.5	37.1
Dicuran, 2.4 kg	Pretillering	29.0	42.6	38.2	33.7	49.7	35.4	37.8
Control, not treated		34.0	37.8	40.9	31.2	45.7	37.9	37.9
Extra treatments				33.1[a]		46.9[b]		
Extra treatments				43.1[c]		47.6[d]		
Coefficient of variation, %		9.0	11.3	6.9	12.4	6.9	5.6	
L.S.D. at 10%		3.1	NS	3.3	NS	NS	2.7	
L.S.D. at 5%		3.6		3.5			3.0	

Extra treatments: (a) Dicuran, 1.6 kg + Igran, 0.8 kg at pretillering; (b) Igran, 0.8 kg at pretillering; (c) Tribunil, 1.95 kg at 2 1/2 leaves; (d) Buctril, 0.41 kg at 2 1/2 leaves.

Dr. Torrey Lyons (left) and Dr. R. A. Fischer, CIMMYT agronomist/physiologist, compare a check plot with a plot treated for control of wild oats.

program this year to investigate the feasibility of growing wheat in rotation with annual forage legumes in a manner similar to that successfully used in southern Australia. In addition to the financial and environmental considerations, advantages include: the supply of N from the legume for the following wheat crop, improvement in physical properties of the soil, greater weed control from competition in the forage year, and control of soil-borne disease by breaking the cycle.

In 1971-72 a preliminary study was made on: (a) variety and plant growth performance, (b) whether suitable native rhizobia are present, (c) what levels of phosphate are needed to get optimum N accumulation, (d) the number of cycles needed to produce sufficient seed supplies in the soil for self-regeneration and (e) time required to build up sufficient N in the soil to support the following wheat crop. A series of demonstrations and experiments will run for two to four years before results are fully available.

Four subexperiments were placed at three sites, including a small rotation, a five-variety performance test sown with and without inoculation, a fertilizer experiment with four rates of P_2O_5 plus trace elements, a management test for weed and insect control, and a grazing study. Each site covered one hectare.

At 15 sites, demonstrations of half-hectare blocks of wheat-medic rotations have been initiated. In the second year it is proposed that the wheat stubble half be sown to medic by two separate methods. The medic half will be split so that one-half of it will be sown to wheat at several N levels and the other portion allowed to reseed and grown as medic.

At all sites medic stands were good. The variety Jemalog (*Medicago truncatula*) and Harbinger (*M. littoralis*) were the best adapted. Paragosa Gama Medic (*M. paragosa*) was adapted on gray-brown, heavy-textured soils. Variety Clare of *Trifolium subterraneum* showed poor growth.

Suitable native rhizobia for Jemalog and Harbinger occur in the soil in all locations where native medics are present. Both produced high yields of pods and seeds. In the early stage of the work, emphasis is on maximizing seed production in order to have plenty of reserve seed in the soil. About 1 to 1.5 tons of dry matter per hectare were obtained.

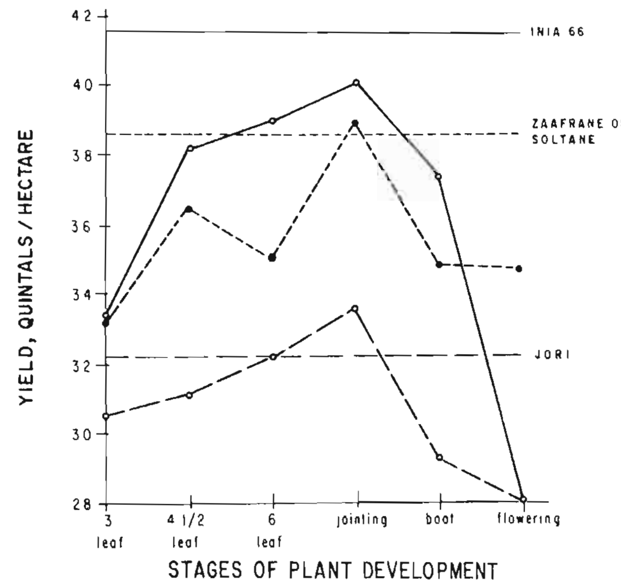


FIG. W17. Yields of three wheat varieties sprayed at different stages of growth with 2, 4-D (0.55 kg/ha) for weed control (horizontal lines represent yields of nonsprayed checks including weeded and nonweeded treatment). Tunisia, 1971-1972.

BREEDING RESEARCH

Bread Wheats

In the first phase of CIMMYT involvement in the Tunisian program, exotic high-yielding varieties such as Inia 66, Tobari 66 and Penjamo 62 were introduced for commercial production on an expanded scale. Breeding work was increased and the variety Soltane was released in the current season. Its yields appear very promising (see Table W67).

Where *Septoria* is normally of low intensity, the new Mexican varieties Cajeme 71 and Yecora 70 show superior yields (see Table W68). The Mateur area showed a high level of *Septoria* while the other stations were relatively low in incidence. Under such conditions, Soltane exhibits its superiority over the newer Mexican varieties.

Although this year was relatively light from a disease standpoint as indicated previously, selection for a high level of resistance is mandatory in the breeding program. Diseases which are most important must take precedence over those which are likely to cause less reduction in production.

In the current year, 12 microtrials were grown in addition to CIMMYT's ISWYN and ESYT No. 1 and No. 2, and the RWYT supplied from Beirut. The advanced yield trials were grown in four locations and the preliminary yield tests at one location. The superior-performing selections are in Table W69. All of these outstanding lines will be again placed in yield trials and preliminary multiplication in 1972-73. The best of these will also be used in demonstrations as a preliminary step to varietal release.

Table W69 shows that all lines except HD 1799, CC-Inia "s"-Napo and Potam have acceptable *Septoria* tolerance. In the cross Napo-Tobari "s" x 8156 (R), *Septoria* resistance was outstanding. Several nurseries were also grown for disease and insect screening. Among

TABLE W67. Yield of standard wheat varieties from 24 trial sites (Tunisia, 1971-72).

Varieties	Average yield q/ha	% of Inia
Soltane	41.65	105
Zaafrane	40.96	103
Tobari	40.79	102
Ariana 66	37.04	93
Florence Aurore	27.42	69
Inia 66	39.62	100

TABLE W68. Yield of some Bluebird lines of wheat at three experimental stations (Tunisia, 1971-72).

Genotypes	Average yield q/ha	% of control	*Septoria* reaction scale 0-9
BEJA STATION			
Yecora 70	57.03	116	. . .
Cajeme 71	56.64	115	. . .
Saric 70	49.91	101	. . .
Inia (contro)l	49.17	100	. . .
ARIANA STATION			
Yecora 70	43.74	117	. . .
Cajeme 71	46.73	125	. . .
Soltane (control)	37.22	100	. . .
MATEUR STATION			
Yecora 70	41.80	85	7-8
Cajeme 71	47.98	97	7
Soltane (control)	49.23	100	4-5

TABLE W69. Yields and disease reactions of outstanding new wheat lines in several trials (Tunisia, 1971-72).

Genotypes and pedigress	Average yield q/ha	% of control	*Septoria* reaction scale 0-9
CC - Inia 23528-7m-1t-1m-8y-0m	52.45	121 Tob	6
CC - Inia 23528-7m-1t-1m-7y-0m	47.20	124 Inia	6
Cal - Nt - 67 27053-7m-2tu-2mb	45.35	120 Tob	5
Kl.Pet.Raf-8156² 27997-4Y-100m-300Y	48.48	107 Tob	4
HD 1799	47.88	105 Tob	6-7
Napo-Tob"S" x 8156 (R) 28071-7m-3y-7m-0y	48.70	107 Tob	3
Cno-No66 25111-6m-7y-3m-0y	41.90	111 Inia	5
No 66--Cno"S" 25361-5m-3y-0m	49.31	112 Inia	5
Son 64 x Tzpp-Y54/CC 22346-39m-1v-2m-1t	49.32	112 Inia	5
PV18A-Cno 27893-3y-4m-1y-0m	46.65	109 Inia	5
S948A1-Cno"S"² H-160-60a-6y-2m-4y-0m	42.02	98 Inia	3-4
CC-Inia x Inia"S"-Napo	45.03	119 Inia	6-7
Potam	53.93	127 Inia	7
Inia (average of 21 trials)	39.62	100	7

these the IBWSN and RDISN have proven very useful sources of new germ plasm.

About 350 crosses have been made in the bread wheats in the current year. Yield, quality and resistance to *Septoria* and the rusts were central to the formulation of these crosses. The F_2 and segregating generations were grown at Beja. Good *Septoria* readings were possible. Many F_4 and F_5 lines were bulked for yield tests. Selection from crosses shown in Table W70 were the most promising, combining *Septoria* resistance with good yield possibilities.

TABLE W70. Promising wheat genotypes in the Tunisian wheat improvement program (Tunisia, 1971-72).

Genotypes	Cross number
Cno"s"²-Tob66 x Kl.Pet.Raf - 8156(R)²	30648
Bluebird - Nar"s"	30857
Gallo x Cno - Pj	30903
Jar"s" - Cno"s"	30906
CC - Inia"s" x Nar59 - On	30973
CC - Inia"s" x On - Nar"s"	30976
Cno"s" - On x Cal	31060

Durum Wheats

Two durum varieties (Inrat 69 and Bedri) released in 1970 have produced grain yields up to 30 to 50 percent more than the older commercial varieties. Hopefully, 40,000 hectares will be sown to these varieties in the 1972-73 season. Both of these varieties, however, are fairly tall and lodge with heavy N applications. To complement these, the varietal release committee this year released Amal 72 and Maghrebi 72, two semidwarf durums. Although both show moderate *Septoria* and mildew tolerance, they are both susceptible to stem rust and leaf rust.

Among the 214 lines and varieties tested, those in Table W71 were superior. Unfortunately, they are mostly susceptible to the rusts, *Septoria* and mildew. The higher-yielding varieties, such as Cocorit and Brant, show excessive grain mottling or yellow belly and are not favoured because of their inferior quality.

In general, Tunisia and other North African countries need high-yielding shorter durums with acceptable disease and quality characteristics. The release of Amal 72 and Maghrebi 72 is a temporary measure until better lines are developed.

Varietal Testing

Sixteen trails, consisting of 15 to 20 varieties, were grown on representative dry land sites. Fifteen gave good data. Comparative performance is shown in Table W72. Lodging reduced yields of Florence Aurore, Bedri 69, Inrat 69 and Roussia. In these on-farm trials, the two *Septoria*-resistant varieties (Soltane 72 and Zaafrane) showed good performance, even in the absence of *Septoria*. Saric 70 and Cajeme 71 also produced good yields consistently. Fletcher and Era were included in trials in the coldest areas where they performed well in relation to Inia 66, which is handicapped by restricted tillering under these conditions. Cocorit produced the highest yields among the durums.

TABLE W71. **Ylieds and disease reactions of varieties and lines of durum wheats (Tunisia, 1971-72).**

Varieties or lines	Average yield q/ha	% of Inrat 69	Disease reactions Mildew (0-9)	*Septoria* (0-9)	Stem rust	Leaf rust
Maghrebi 72	48.23	142	9MS	MR	60S	60S
Cocorit 71	47.99	141	9S	S	80S	50S
BD. 1917 = Brant "S"	47.09	139	9S	MS	80S	30S
BD. 1941 = Cocorit "S"	45.43	134	9S	MS	60S	50S
Amal 72 = Brant "S"	44.87	132	9MS	MS	60S	60S
Inrat 69	34.00	100	9MR	MR	40MR	30S
DMx69.159.4A.7A = UM6301-By^2_ExTc-II-22252	52.41	139	8S	MS	20MS	40MS
DMx69.200.1A.33A = II28953	51.78	137	9S	MS	20S	30S
TM_E-Tc^2xZB.W/B.Ball x By_E^2-Tc = II28929	48.09	127	9MS	MR	40MS	50MS
BB-Mahm981 x Kenya33-EC/BD 1419	44.05	117	9MR	MS	50S	60S
DMx.69.200.1A.41A = II28953	43.97	116	9MS	MS	20MS	30MS
D67.45.12A.11A = BD1419/pi-Bell 116xTc^2	43.67	116	6MR	MS	50S	40S
Tdur-Sph x Mogh Karak (TM_E-Tc^2 x ZB-W)^2 = II28957	43.57	115	9MR	MS	10MR	5MR
D67.51.4A.2A = Mahm BD 1588 -Inrat 69	42.90	113	9MS	MR	10R	10MR
Inrat 69 (control)	37.80	100	9MR	MR	10MR	30S

TABLE W72.. **Average yield, grain test weight and plant height of wheat and barley varieties from 16 farm demonstrations in northern Tunisia (1971-72).**

Variety	No. of locations	Yield q/ha	Yield % Inia	Test wgt kg/hl	Plant height, cm
Ariana 66	15	35.7	100.9	79.5	113.0
Florence Aurore	15	27.3	77.0	79.5	130.0
Soltane 72	15	38.0	107.3	78.8	94.6
Zaafrane	15	36.9	104.2	78.5	94.5
Utique	15	34.4	97.1	79.9	90.6
Inia 66	15	35.4	100.0	79.6	94.8
Tobari 66	15	37.3	105.2	79.4	94.4
Penjamo 62	15	37.7	106.6	77.3	97.5
Saric 70	15	39.1	110.4	77.6	74.8
Cajeme 71[a]	15	39.8	112.4	78.1	77.1
Era	5	37.1	109.0	79.1	102.4
Fletcher	4	30.4	106.0	79.4	97.5
Jori 69	13	33.9	96.6	79.4	81.9
Cocorit 70	12	38.4	106.5	77.3	68.5
Bedri 69	15	30.7	86.8	79.2	96.7
Inrat 69	15	31.3	88.5	78.4	110.6
Roussia	3	20.9	49.8	77.0	115.3
Orge Martin (barley)	8	34.5	114.7	...	103.7

[a] Released in Tunisia as Vaga 72.

These trials serve to measure varietal adaptability and to acquaint farmers with their performance. They are very useful for both purposes.

Barley was tested at the drier sites and performed well. This crop should continue to be included in trials in these areas.

EXTENSION DEMONSTRATIONS

A series of varietal x fertilizer demonstrations were conducted at two levels of N, without any fertilization and with only P_2O_5. Of 38 demonstrations, results were obtained from 29. Some of these demonstrations were grown with bread wheat varieties, some with durums and others with barley. Marked increases were observed for the bread wheats with N addition--about 45 percent for 90 kg/ha. For the durums, the increase was about 25 percent for 40 kg/ha with little increase at 90 kg/ha. Yield advances were correspondingly reduced in the lower rainfall areas.

Twenty-nine variety demonstrations were grown, including the varieties Florence Aurore, Utique, Inia 66, Soltane and Tobari 66 as one comparison, and Inrat 69 with Mahmoudi as the durum comparison. Twenty-four of these demonstrations were harvested. Each variety had two levels of N (0 and 90 kg/ha) with adequate phosphorous in the higher rainfall areas and 0 and 67 kg/ha of N in the drier areas (less than 500 mm).

Marked yield increases were recorded for the improved varieties over those obtained with the Florence Aurore and Mahmoudi checks at the higher N level. The demonstrations have been very successful, revealing the value of recommendations from project research.

ECUADOR

Wheat is a crop of only secondary importance in the overall economy of Ecuador. The area sown to wheat fluctuated widely, depending upon the prices for potatoes and malting barley. Currently, only about 100,000 hectares are grown, and virtually all of the wheat is confined to elevations above 3,300 meters. The most serious disease problems are stripe rust, stem rust and *Septoria*.

The Santa Catalina Experiment Station of the *Instituto Nacional de Investigaciones Agro-Pecuarias* (INIAP) is an ideal location for evaluating wheats' resistance to *Puccinia striiformis* (stripe rust) and *Septoria tritici*. Within the past year arrangements have been worked out between INIAP and CIMMYT to intensify work on stripe rust.

One step taken is to send part of the CIMMYT F_1 single crosses to Ecuador for planting at the same time as an adjacent to the INIAP F_1 crosses. At flowering time CIMMYT will send one staff member to Ecuador to help make double crosses between the F_1 INIAP and F_1 CIMMYT single crosses.

The progeny from such crosses should combine the high stripe rust tolerance and good *Septoria tritici* tolerance of the Ecuadorian lines with the higher yield potential and better stem rust resistance of CIMMYT's lines.

BRAZIL

Brazilian wheat production has increased spectacularly in recent years, especially during 1970 and 1971. This renewed interest in wheat production partly stems indirectly from the rapid expansion of soybean area. Wheat is grown increasingly as the winter crop in a soybean-wheat double cropping rotation.

Wheat area is now about 2.3 million hectares and is increasing. Cultivation has also been intensified. There has been a rapid growth in both fertilizer (especially phosphate) and lime application on land in the soybean-wheat rotation during the past three years. The 1971 wheat harvest reached a record 2 million metric tons. There was hope that the 1972 output would reach 2.5 million tons. These goals were, however, unachievable. Unfavourable weather during the 1972 season, including widespread late frosts, plus an extremely severe epidemic of *Septoria* spp. reduced the anticipated production to less than one million tons.

The losses and disappointments of the past season indicate clearly the need for increasing yield stability in Brazilian wheat production, if output is to be both enhanced and stabilized. Better control of diseases is the most important factor contributing toward increased yield stability that can be manipulated by plant breeders. Have breeders given this aspect of varietal improvement sufficient emphasis on a worldwide basis?

CIMMYT and its predecessor Mexican organization have for many years, and especially during the past three years, cooperated informally with Brazilian wheat research programs. CIMMYT has supplied genetic materials, including F_2 segregating populations, the International Bread Wheat Screening Nursery, and the International Spring Wheat Yield Nursery.

In the past three years CIMMYT also has assisted by providing practical training for 12 young Brazilian wheat scientists in breeding, agronomy, plant pathology and cereal technology. These young scientists now form a valuable part of the research teams attempting to cope with the many problems that must be overcome in order to increase and stabilize wheat production in Brazil.

A CIMMYT staff member spent most of November 1972 visiting the principal wheat production areas and wheat research stations in Brazil to study the scope and magnitude of the production problems. The primary objective was to determine how the CIMMYT research effort might be modified to better assist Brazil in solving its complex production problems.

The visit of the CIMMYT staff member coincided by chance with the height of the most devastating *Septoria* epidemic in Brazil since 1963. The potential 1972 wheat harvest was reduced an estimated 40 percent by *Septoria.* Widespread late frosts accounted for another 20 percent reduction in production.

The Severity and Magnitude of the Septoria Problem in Brazil and on an International Basis

The *Septoria* epidemic of 1972 included both *Septoria tritici* and *Septoria nodorum.* The latter predominated at the height of the epidemic and probably contributed to much of the damage. Many fields were killed outright, while all of those in the heavier rainfall areas were severely damaged. The 1972 *Septoria* epidemic in Brazil indicates clearly that this disease--when ecological conditions are favorable--can be as destructive as a stem rust epidemic at its worst. The current commercial Brazilian varieties are, by world standards, considered to be among the most resistant to *Septoria* diseases. Yet, they were ineffective in controlling the disease under the conditions that prevailed in 1972.

The winter rainfall in much of the area where wheat is grown in Brazil is near the upper limit considered suitable for wheat production. During 1972, however, precipitation was double the long-time average. Moreover, there was essentially a low cloud cover over the entire area from planting to harvest, which provided optimum conditions for disease development.

One might question the commercial feasibility of growing wheat in such high-rainfall areas, yet, there appears to be few alternative choices. Most of the land on which wheat is grown as a winter crop is sown to soybeans in the summer. The area sown to soybeans has been expanding rapidly and within the past four years Brazil has become the world's third largest soybean producer. Much of the soybean area receives 1,000 to 1,500 mm of rainfall. Its rolling topography is vulnerable to erosion if left without cover during winter. Since there are frosts during the winter, the cover crop must be frost resistant. Hence, wheat has been the best choice, considering both agronomic and and economic factors.

Among the most important and difficult challenges confronting the Brazilian wheat scientists during the next decade is the development of high-yielding, disease-resistant varieties which will provide adequate protection against losses from the three rusts, scab and *Septoria* in an environment that highly favors epidemics of these diseases.

Achieving this objective will require breeding varieties with both a broader and higher level of disease resistance--against the wide array of pathogens--than is currently available in commercial varieties anywhere in the world. Moreover, the improved disease resistance must be attained while maintaining or improving the resistance of present commercial wheat varieties to both extreme soil acidity and aluminum toxicity.

Within the past six years CIMMYT scientists have observed equally destructive, but generally more localized, epidemics of *Septoria* in Argentina, Morocco, Tunisia, Algeria, Turkey and Guatemala. There have also been reports of similar outbreaks from Ethiopia and Kenya. The magnitude and widespread distribution of these epidemics indicated the need for establishing an agressive worldwide cooperative research program to "tame" this disease.

CIMMYT, with the assistance of ALAD, in 1971 initiated an International Septoria Observation Nursery (ISEPTON). This nursery has been sent to collaborators in all countries where *Septoria* is an important problem. The nursery includes all varieties and lines reported tolerant to *Septoria* throughout the world. Disease reactions will be recorded. Such data should help breeding programs develop varieties with better resistance.

The preliminary data, after two years of testing, indicate that although no single line or variety has been found that is highly resistant to *Septoria* under severe epidemic conditions, several lines have been identified with useful levels of tolerance.

The best of the lines, based on their reactions in diverse geographical areas of the world, have been widely crossed into the CIMMYT gene pool within the past two years and segregating populations from these crosses have been distributed for selection under epidemic conditions where this disease is a serious problem.

Two locations have been identified in Mexico where, with proper inoculation techniques, epidemics of *Septoria* can be developed for identifying lines with useful tolerance to the disease.

Hopefully, by identifying lines with tolerance to *Septoria* in different areas of the world, intercrossing these types and growing the segregates under conditions where epidemics occur with a certain regularity, genes for resistance can be pyramided to provide better resistance than that present in commercial wheat varieties.

There is only very limited basic information available on the variation in pathogenicity of the *Septoria* pathogens. Moreover, virtually nothing is known about the stability of resistance, "longevity" of resistance, or tolerance in varieties under commercial production. Despite the limitations imposed by the lack of basic information on the variability in the pathogen, much progress can be made to improve varietal disease resistance to *Septoria* by the aforementioned cooperative worldwide approach.

Extreme Soil Acidity and Aluminum Toxicity

Much of Brazil's wheat is grown in high-rainfall areas where the soils are intensively leached. These soils are extremely acid (pH = 4.3 to 4.5) and have high concentrations of soluble aluminum. They are also extremely low in available phosphate.

The majority of the Brazilian commercial wheat varieties are tolerant or resistant to extreme soil acidity and aluminum toxicity. Among the best are: Cincuentenario, Cotipora, C48, Horta, Lagoa Vermelha, Toropi, and many lines and varieties from *Instituto Agronomico do Sul* (ic IAS-20), Pelotas, Passo Fundo and "S" lines.

Few foreign wheats, however, have any usable level of resistance to these very severe soil conditions. Among the few introduced varieties with good resistance are: Amazonas from Ecuador, Benvenuto Inca, Benvenuto Pampa and Klein Lucero, all three from Argentina, and Cajeme 71 from Mexico.

Before CIMMYT's wheat gene pool can be very useful to Brazil, it must be modified to incorporate greater frequency of genes for resistance to soil acidity and aluminum toxicity. Since there are no soils in Mexico to screen the breeding material for tolerance to extreme soil acidity and high levels of soluble aluminum, artificial methods are being introduced.

Laboratory methods developed by Dr. D. P. Moore at Oregon State University involving exposure of roots of young seedlings to different levels of buffered solutions of soluble aluminum will be employed. All progenitors and all lines entering the yield tests and screening nursery will be tested this way. It is believed that by employing such a screening technique, followed by checking the reaction of the same materials under field conditions in Brazil over several years, that the CIMMYT gene pool can be modified to provide a high proportion of segregates with resistance to aluminum toxicity.

Developing Triticales for Brazil

Very little research has been done on triticales in Brazil. A few lines were grown at Passo Fundo, R.G.S., during 1972. Under the severe *Septoria* epidemic, the triticale lines showed considerable more resistance to this disease than the best wheat lines and varieties. There is also some fragmentary evidence that some triticales may be resistant to aluminum toxicity.

On the basis of these very preliminary but positive observations, more detailed research appears to be indicated to explore the feasibility of using triticales as an alternative food grain crop in areas of high aluminum toxicity and high *Septoria* hazard.

ARGENTINA

In 1972 5.6 million hectares were sown to wheat. Other winter cereals included: 2.3 million hectares of rye, 1.2 million hectares of oats and 565,000 hectares of barley. Moisture conditions during the growing season were very favorable across the cereal production area. Diseases were minimal throughout the country and had little or no effect on yield. The most conspicuous wheat diseases were those caused by *Septoria tritici* and *Septoria nodorum* on early plantings of some varieties, but they had little effect on yield. Local late infestations of armyworms in western and southern Buenos Aires threatened the crop, but they were controlled by timely aerial application of insecticides.

The greatest and only important yield reduction was caused by several late widespread frosts during the first week of October when the plants were flowering or in early stages of grain development. The damage was greatest--sometimes resulting in a complete loss--in early plantings in the provinces of Chaco, Santa Fe and Entre Rios. Individual florets or entire spikelets also were sterile on many heads in numerous fields in northern Buenos Aires. Despite this damage, yields thorughout most of the wheat producing areas of Argentina were unusually high. Most farmers were unaware of the reduced yield potential caused by the sterility of individual florets, since despite this they harvested excellent crops.

The 1972-73 wheat harvest is estimated at 8.5 million metric tons, representing a national average yield of 1,520 kg/ha based on planted area. This good wheat harvest was opportune for both Argentina and South America, considering the poor wheat crops in the neighboring countries of Brazil, Paraguay and Chile.

The INTA-CIMMYT Cooperative Wheat Improvement Program

CIMMYT has informally cooperated since 1963 with the *Instituto Nacional de Tecnologia Agropecuaria* (INTA) in developing a national wheat research program involving breeding, agronomy, pathology and cereal technology.

Varietal Improvement

The first two new varieties developed by the Coordinated National Wheat Breeding Program of INTA, which was initiated in 1963, were named and approved for release by the Official Varietal Release Committee during 1972. These are: (1) *Marcos Juarez INTA,* derived from the cross Sonora 64 x Klein Rendidor (19975-68Y-1J-6Y-1J-4Y-1J-0B), and (2) *Precoz Parana INTA*, derived from the cross Sonora 64A x Knott 2 (18893-11P-5P-1P-1B-0J).

The former variety was developed at the Marcos Juarez INTA Research Center and the latter at the Parana INTA Research Center.

These are the first two semidwarf wheat varieties approved for distribution in Argentina. Both varieties are widely adapted, and when sown at the proper date they can be grown successfully over a wide range of the Argentine wheat belt. During the three years they have been under test on experiment stations, they have consistently outyielded all of the commercial varieties, generally by 20 to 50 percent. Both varieties are 5 to 7 days earlier in maturity than the extensively grown varieties Klein Atlas and Buck Manantial.

Both varieties are resistant to lodging with high soil fertility. They respond much more favorably to the application of chemical fertilizer than do the current commercial varieties, and their superiority in grain yield over the later varieties widens as the soil fertility level increases until soil moisture becomes the main factor limiting yield.

Both of the new varieties are relatively insensitive to changes in length of day. Hence, they can be sown successfully as late as mid-July--a month later than the widely cultivated commercial varieties Klein Atlas and Buck Manantial--in northern Buenos Aires, Cordoba, Santa Fe and Entre Rios. In southern Buenos Aires they can be sown successfully as late as August 10. There is considerable evidence, based upon research by Pedro Novello, that the ability of these varieties to yield well from late plantings (when sown on properly fertilized land where soil moisture has been conserved by good fallow practices), may be one of their principal positive attributes.

Normally, most of the wheat crop in the principal wheat growing areas of Cordoba, Santa Fe and northern Buenos Aires is sown during the last 10 days of May and first half of June, when soil moisture is generally adequate. The second half of June, July and the first half of August are nearly always dry and cold. Spring rains normally begin during the second half of August. Consequently, the present late-maturing commercial varieties make much of their vegetative growth during the driest part of the winter when there is frequently a shortage of moisture. If the early maturing new varieties can be sown into moist soil in mid-July with sufficient stored subsoil moisture to support their normal development without drought stress until mid-August, they will tend to escape the drought because they will be in the seedling stage with minimum transpiration demands during the driest part of the winter. This does not imply that late-maturing varieties for early sowing are no longer needed, but rather it indicates the potential value of more flexibile wheat production by introducing new, early maturing, high-yielding varieties adapted to late plantings on good fallows, or following summer crops of corn and soybeans in the better rainfall areas. To effectively exploit the genetic yield potential of these varieties, they must be adequately fertilized at planting. At the same time, fertilizer application must be adjusted to the amount of stored soil moisture.

Marcos Juarez INTA and Precoz Parana INTA represent the first two varieties developed by the Coordinated National Wheat Breeding Program of INTA. Other better varieties will soon follow. Currently, many very promising lines and crosses are in various stages of yield testing (Table W73).

During the 1972 crop cycle, 248 advanced generation lines from the Cooperative National Breeding Program were evaluated in yield tests in Marcos Juarez. These lines represented the outstanding selections isolated from several thousand crosses made in Argentina and Mexico and selected under Argentina conditions. The crosses involved several hundred different parental varieties and lines. Despite the great diversity of parental types employed, five varieties have contributed disproportionately to the success of the lines reaching the yield test stage of evaluation. These include the Argentine varieties Tezanos Pinto Precoz and Klein Rendidor, and the Mexican varieties Sonora 64, Nainari 60 and Ciano 66.

Sonora 64 entered either directly or indirectly into pedigrees in 240 of the 248 lines undergoing yield tests, Tezanos Pinto Precoz in 184 of the 248, Ciano 66 in 118 of the 248, and Klein Rendidor in 55 of the

TABLE W73. Most promising bread wheat lines in the Argentine wheat breeding program (1971-72).

Cross	Pedigree
Sonora 64 x Tezanos Pinto Precoz-Nainari 60[a]	II 18889-3M-100Y-100C-2J-4B-0Y.
Sonora 64 x Tezanos Pinto Precoz-Nainari 60	II 18889-101M-1R-3C-1T-2B-0J.
Jaral"S" - Nariño 59	II 21872-9T-2B-31-2B.
Jaral"S" - Nariño 59	II 21872-9T-3B-1P-1B-0P.
ND81 - Tezanos Pinto Precoz	MJ60-4T-1B-3J-2B-0J.
K. Petiso-Rafaela x K. Rendidor-Mayo Sonora 64	HM 1130-3P-1B-3J-1B.
Cheg285-Gaboto x Jaral"S"	H856-30J-2J-3B-1J-0B.
Cheg285-Gaboto x Jaral"S"	H856-23J-1J-1B-0J.
Cheg285-Gaboto x Jaral"S"	H856-23J-2J-4B-1J-0B.
(Sonora 64A x K. Rendidor) x Bb	II 26502-34B-2B-100B-0J.
Jaral"S" x Purdue-Sonora 64	II 24217-10B-12J-2B-1J-1B-0J.
Jaral"S" - Chris	II 24441-1J-4B-1J-1B-0J.
Ciano - Jaral"S"	II 25007-3J-4B-3J-1B-0J.
Ciano - Jaral"S"	II 25109-16J-6B-1J-7B-0J.
Ciano - Jaral"S"	II 25109-11J-3B-2J-38-0J.
Ciano - Jaral"S"	II 25109-32J-1B-1J-4B-0J.
Jaral"S" - Ciano	MJ-687-2J-1B-201J-204J-201B-0J.
Jaral"S" - Ciano	MJ-687-2J-1B-201J-204J-204B-0J.
Jaral"S" - Ciano	MJ-687-2J-1B-201J-204J-205J-0J.
Jaral"S" - Ciano	MJ-687-2J-1B-201J-202B-0J.
Jaral"S" x Sonora 64-K. Rendidor	MJ-752-1J-205J-203B-202B-0J.
Jaral"S" x Sonora 64-K. Rendidor	MJ-752[b]-1J-205J-203B-204B-0J.
Bb x Tezanos Pinto Precoz-Sonora 64^2	II 27345[c]-5J-203J-202J-0J.
Bb x Tezanos Pinto Precoz-Sonora 64^2	II 27345[c]-5J-201J-207J-0J.
Bb x Tezanos Pinto Precoz-Sonora 64^2	II 27345[c]-5J-202J-202J-0J.

[a] A "sib" of the Mexican variety Jaral.
[b] There are also many other excellent sister selections of this cross.
[c] There are also many other excellent sister selections of this cross.

248. Two newer parental lines and varieties that are currently contributing outstandingly to the success of the lines under yield tests are: (1) Jaral "S", which occurs in the pedigree of 143 of the 248 lines under test and (2) Marcos Juarez INTA, which entered into 53 of the 248 lines under yield test. These two lines are currently being employed widely as parents in new crosses in both the INTA-Argentine and the CIMMYT-Mexican programs. Both varieties are good combiners. Both are relatively resistant to "forced ripening" (laying-off) or *arrebatimento*. Both carry a good level of resistance to the rusts and a degree of tolerance to *Septoria* and scab (*Giberella*). These two lines and several of their sisters are being used widely in the breeding programs of Tunisia, Algeria and Morocco. The two recently named Tunisian varieties, Soltane and Zaafrane, are sister selections from the same cross that produced Marcos Juarez INTA.

Durum Varietal Improvement

A few crosses were made by Alberto Chabrillon in Mexico in 1961 between several of the dwarf Mexican durum lines and several tall Argentine durum varieties, including Candeal Buck Balcarce and Candeal Buck Tagenrog. These crosses were taken back to Parana where they were subsequently backcrossed twice to the Argentine parents.

Although the number of lines selected from this material was limited, several of the most promising ones have been included in yield tests in both Argentina and in the International Durum Screening Program during the past year.

One semidwarf line from the cross Buck Barcarce^3 x Barrigon Yaqui Dwarf^2 - Tehuacan, designated Parana 66/270, has been outstanding in Argentina, Mexico, Tunisia and Algeria. It combines high grain yield with good grain quality and is resistant to the three rusts and *Septoria*. Under Argentine conditions it has consistently outyielded the commercial durum varieties by 30 to 50 percent when adequately fertilized.

Inadequate facilities in Argentina for evaluating the macaroni-making and cooking quality of the durum breeding materials has delayed the release of this variety. Steps are now being taken by INTA to establish adequate facilities for evaluating durum quality.

Provisions have been tentatively made by CIMMYT to obtain several hundred kilograms of Parana 66/270 seed from INTA to begin a seed increase program in Tunisia and Algeria.

During the past three years the INTA durum breeding program has been greatly expanded. Currently, many F_2 segregating populations, the International Durum Screening Nursery and the International Durum Yield Nursery are sent annually by CIMMYT. These materials are being grown in the experimental stations at Balcarce and Barrows, both of which are located in the principal durum producing area. Since many races of each of the three rusts have evolved and persist on the commercial durum varieties in Argentina, there is a great advantage from selecting rust-resistant lines in Argentina instead of in a country such as Mexico. In Mexico, little commercial durum wheat is grown. Consequently, the spectrum of pathogenecity of the rust pathogens is limited. Selections of durum wheat lines made in Argentina are likely to be of value in North Africa and vice versa.

Excellent progress is currently being made in bread and durum varietal improvement in both the public (INTA) and the private sectors (Criadero Buck, Criadero Klein, DeKalb de Argentina, Northrup-King de Argentina and Cargill). CIMMYT, at the suggestion of INTA, has provided segregating populations of both bread and durum wheats to the aforementioned private breeding programs. The combined magnitude and scope of the public and private sectors breeding programs makes the present Argentine varietal improvement effort one of the largest and most dynamic in the world. It will assure a continuous flow of new varieties to meet the changing demands of the Argentine farmers. More trained scientists are needed, however, to improve the efficiency of these programs.

A Breakthrough in Argentine Wheat Production

Over the past 10 years a vast amount of agronomic research has been conducted on farms in order to develop information for implementing an effective package of improved cultural practices, for example, efficient conservation of moisture, proper fertilization, proper rates and dates of sowing, and effective control of weeds and insects, in order to raise yields and production. Data available indicate that it is possible to greatly increase both yields and production. Before the new technology can be put into action, however, a change will be needed in government policy to assure the farmer an adequate supply of reasonably priced fertilizer and a reasonable price for his grain. If such policy is adopted, implemented and sustained, Argentina wheat production can be increased 50 percent within the next five years. The need for such action is self-evident since Argentina is the only important South American wheat exporting nation. In all of the other South American countries there is a widening gap between wheat consumption and wheat production.

TABLE W74. Wheat genotypes with superior resistance to Septoria tritici **selected from the Second Regional Disease and Insect Nursery (entries showed a reaction of 5 or less (based on the 0-9 scale) in 1971-72).**

Variety or cross	Origin	Pedigree
Son64 - Kl.Rend.	Argentina	19975-68y-1j-6y-2j-109e
Pato - Ciano	Mexico	28258-300Y-301M
Tob66-Bomen x Tob"s"-Napo63	Mexico	31321-12e-0y
Calidad A	Mexico	
Carazinho	Brazil	
Gaboto	Argentina	
Buck Manantial	Brazil	
(Ciano"s" - Y50) (TT-Son64 x Chris) x 7 Cerros		II-30608-100L
Kenya-Etoile de Choisy B	Tunisia	
Najah	Israel	
Chris	U.S.A.	
Selkirk	Canada	
Flevina		
Heines VII	Sweden	
Manella		
Tadorna		
Cleo		
Felix		
Flamingo	Germany	
Orca		
Opal	Germany	
Jufy I	England	
94601 **		
Svenno (A-11854)	Sweden	
NS-314	Yugoslavia	
NS-718	Yugoslavia	
Harukihari	Japan	
Dimitrowka	Poland	
Kl.Pet-Son64(Cj x 36896-Gb54/Gb56-11-53-526)	Iran	M1121-1-49-126
Kl.PetSon64 x Kl.Pet-Raf	Iran	M1122-1-49-132
Kl.Pet-Son64 x 8156(R)	Iran	M1123-1-49-135
Cap-Desp/Y54A-N10-B-1C x Kt54B(Nar59-DRP x 8156-Pj62)	Iran	M1169-1-49-164
Cap-Desp/Y54A-N10-B-1C x Kt54B(Nar59-DRP/Son64 x TzPP-Y54)	Iran	M1170-1-49-167
My54 x N10-B/P4160-DRP-My54	Iran	M1171-1-49-168
DRP(Fn-K58 x N10-B/Gb55) /Son64 x TzPP-Y54	Iran	M1175-1-49-170
DRP(Fn-K58 x N10-B/Gb55) /Nai60	Iran	M1176-1-49-171
(Yt54a^2 x N10-B/Kt54)Pj-Gb x TzPP-Knt #2	Iran	M1179-1-49-174
(Yt54a^2 x N10-B/Kt54)Pencreav-Mendos	Iran	M1181-1-49-176
Pi62-11-53-526 x Son64/LR64A x TzPP-AnE	Iran	M1197-1-49-188
Ctf x LR64^2 - Son64	Iran	M1381-1-49-259
Cheyene-Ommid x Sk-Omd		1-1330
Son64 - Kl.Rend	Argentina	19975-68Y-1J-1B-10J
MB - SR		LM72-14-57
(1879 x GII/K804-2E95)Bza		II-8047
Karniaja 12	U.S.S.R.	
Arezu		
Jaafari		
Pi62-Rq66"s" x (Pj"s"-Gb x TzPP-Knt #2)		1-48-242
200H-Vlf x RSH^2		1-45-14699
Pembina x II-52-3293 x II-53-388		
PT2 x RF		1-46-22533
Ommid	Iran	
Kt54-N10B-21-1C x Kt54/Nar59-DRP etc		1-48-38
K58-N^2 x Hope^2 x Th^3 x Chynee^4 etc		
F89/63 Romania		
F.A x Th-MT/OMD		
908 x FNA 12		1-32-438 1-45-21364
K340-S x Mt-Gb/K340-Fr		1-32-1317 1-45-24204
Th-RL2265 x RD^2/RL2705	Rhodesia	Rhodesia
Kharkof	U.S.A.	Kansas
Pawnee	U.S.A.	Kansas
Ponca	U.S.A.	Kansas
Shawnee	U.S.A.	Kansas
Parker	U.S.A.	Kansas
NB 68435	U.S.A.	Nebraska
NB 68513	U.S.A.	Nebraska
Seneca	U.S.A.	Ohio
Knox 62	U.S.A.	Indiana
Arthur	U.S.A.	Indiana
A513A13-12-1-6-6-4	U.S.A.	Indiana
5532D6-1-1	U.S.A.	Indiana
6028A2-5-9	U.S.A.	Indiana
5672A7-1-1-1-2-411	U.S.A.	Indiana
5724B3-5P-8-2	U.S.A.	Indiana

TABLE W74. (continued)

Variety or cross	Origin	Pedigree
Seneca	U.S.A.	Ohio
A5132	U.S.A.	Michigan
Blueboy	U.S.A.	North Carolina
(Luisit-E.de Ch. x Mara/S1) Campodoro		
(Luisit-E.de Ch. x Mara/S1) Campodoro		
Lobeiro		
Amarelejo		
Cl.7800 x Bza		V1-1003-1b-2t-1B
(Kl. 33/BT x Y-E)Fr^3		II-12726-9n-1e-1e-1e-1E
Md/ME-E/T x Bza^3		VI-89-2-2-22b-3T
S.211-K.324/Y.48 x Fr		III-100-12n-1e-2E
(RL.2265-Red x $Y\text{-}ME^2$/S)Fr^2		12079-8b-3t-1B
Kt.54 x Fr-Fn/Y		II-13747-2n-5e-1e-1E
Mg. G x Bza		VI-27-1b-2t-3b-2T
Axminster x $Chancellor^8$		
Ulka x $Chancellor^8$		
Asosan x $Chancellor^8$		
Chul x $Chancellor^8$		
Sonora x $Chancellor^8$		
Khapli x $Chancellor^8$		
Michigan Amber x $Chancellor^8$		
Knox 62	U.S.A.	
Arthur	U.S.A.	
Germany 1956 MI		
Wisc Sel.		
0224/52 Germany		
Normandie Argentina 1949		
Axminster Canada		
Hope		
Norka		
As 11 Norway		
Asosan Japan 1946		
PD Kenya		
Napo x TzPP-Son64/8156R	Mexico	28017-7m-3y-0m
Napo63 x TzPP-Son64/8156R	Mexico	28071-7m-3y-4m-0y
(Fec 28 x 293)885		
Kenya 4983 A.I.D.3.A.	Kenya	
Kenya 4471 E8E2C	Kenya	
PI 293004		
(Illinois 1 · Chinese)^3 x T.timopheevi/$Idead^2$	U.S.A.	Idaho 1877 NR.BJ
Kenya 4970 L.10.B.1.D.		
(K. 1016 P.2. x Idaho 1877NR.AH)	Kenya	Kenya 4328 D.I.A.2
PI.297024 (Kenya)		
Herbrard Sel/(Wis 245 x Sup51) x (Fr-Fn/Y)^2.A	Kenya	Kenya 4500 L.I.A.I.A. Sel.
FKN(17)-184 P2AIF x (Wis 245 x Sup51-(Fr-Fn/Y)^{2}A)	Kenya	Kenya 4573 L.3.D.2
PI 29300 (U.K.)		
Kt-Fn x My48		
Romany		
Kenya 4970 L.10.P.5.D.		
Kenya 4970 L.10.A.5.C.		
Kenya 4958 A.2.H.1.B.		
Kt48 x (M.Es.-Sup-Gb)/Cl 12632	Kenya	Kenya 4135 H.3.D.5
Africa Mayo 48/(Wis 245 x (Fr-Fn/Y)^2.B		
Crespo 63	Colombia	
Herbrard Sel/(Wis 245 x Sup51) x (Fr-Fn/Y)^2.A	Kenya	Kenya 4500 L.6.A.4
150 x (Fr-KAD/Gb)^2/14239		3t-1b-1t-2b
Menco/(Wis 245 x Sup51) x (Fr-Fn/Y)^2.A	Kenya	Kenya 4496 L.5.A.2
Menco x (Illinois 1 x Chinese)^3 x T.timo x $Idead^2$	Kenya	Kenya 4497 L.14.B.1.
Salamouni seafoam P106-19		
S Ec - 28	Ecuador	
Iassul 20	Brazil	
K 4539 - L 30 E 4	Kenya	
K 4496 L. 5A. 2	Kenya	
PI 297024 (K)	Kenya	
K 4328 D. 1A. 2	Kenya	
K 4471 E. 8E. 2C	Kenya	
K 4970 L. 10A. 5C	Kenya	
Kenya Kanga = Menco x (Wis 245-Sup51) x (Fr-Fn/Y)^{2}A	Kenya	
(Africa Mayo-Wis 245-Sup51-Frocor-Frontana-Yaqui)		4527-1
Hebrard Sel. x /Wis 245 x Sup51 x (Fr.Fn/Y)^{2}A		4500-2
Romany x C.I. 8154 x Fr^2		6078-1
Romany x Gabo-Gamenya I.A.2.C.		6295-4A
Romany x Mentor I.B.2.A.		6296-7
Romany x Mentor I.B.8.B.		6296-9
Romany x Wis 245-Sup51(Fr-Fn/Y)^{2}A		6297-2
Cl-5		
Line B	Australia	gene Sr5
Line G	Australia	gene Sr7a

TABLE W74. (continued)

Variety or cross	Origin	Pedigree
Line O	Australia	gene Sr9b
Line F	Australia	gene Sr10
Line S	Australia	
Line A	Australia	gene Sr14
Renown Selection	Australia	gene Sr17
Line AC		
Festiguay		
Golden Ball		
Vernstein		Srdlv
E.541		differential in India
Sambtalia		
Mida. MeM. Exchange		
Yansek Bonza		
Selection 1131		genes Sr6 and Sr9b
Khapstein		genes Sr7a Sr13 Sr14
Robin		genes Sr9b and Sr11
Pugsley's 3-gene		genes Sr6 Sr9b Sr11
No. 43		genes Sr6 plus
Chris	U.S.A.	
Selkirk	Canada	genes Sr6 plus
Kenya Farmer	Kenya	genes Sr7a Sr9b Sr10 Sr11 plus
Pembina		genes Sr6 plus
Veranopolis		
Era	U.S.A.	
Waldron	U.S.A.	
Yuma	U.S.A.	
Leeds	U.S.A.	
Wells	U.S.A.	
Langdon		
Line U		Apropyron line, genes Sr5 and others
Line V		Translocation line, genes Sr6 Sr7a Sr8 and maybe Sr5
Hopps		indication of nonspecific resistance
IRN 63.22		
IRN 63.25		
Lee		
IRN 63.409		Sr5 Sr6 Sr8 Sr9b Sr17 plus
W.R.T. x Pembina		Wheat x Rye translocation
W.R.T. x Thatcher		Wheat x Rye
8704-20		Mexico 120 x with an unnamed Australian hybrid
IRN 66.331		
IRN 68.119		complex cross from Minnesota
Line W		gene from Timopheevi not Sr Tt
Line X		gene Sr Ll derived
Line Y		gene Sr12
Golden Ball Derivative		
Barleta Benvenuto		
W 2691		cross Little Club x Gabo³ x Charter
Marquis		
Chinese Spring		
Excelsior'	Rumania	
Favrit	Rumania	
Manella	Netherlands	
Jubilar	W. Germany	
Demar 4	Italy	
Yaktay 406	Turkey	
Bolal	Turkey	
Likafen	Chile	
Galiafen	Chile	
Victor III	Italy	
NB 68435	U.S.A.	Sut/4/Qv/2/Tm/3/Mgl/Oro
Dwarf Bezostaia	U.S.S.R.	
NB 68510	U.S.A.	Wrr/2/At166/Cmn/3/Lancer
NB 68570	U.S.A.	C.I. 12548/2/At166/Cmn/3 Lancer Sel.
NE 701134	U.S.A.	At166/Cmn/Lancer
NE 701136	U.S.A.	At166/Cmn/Lancer
NE 701137	U.S.A.	At166/Cmn/Lancer
Blueboy	U.S.A.	
NE 701139	U.S.A.	At166/Cmn/Lancer
NE 701152	U.S.A.	Wrr/2/At166/Cmn/3/Lancer
NE 701154	U.S.A.	Wrr/2/At166/Cmn/3/Lancer
NE 701147	U.S.A.	Wrr/2/At166/Cmn/3/Lancer
NE 701124	U.S.A.	At166/Cmn/Lancer
Jo-03045	Finland	
Jo-03021	Finland	
Jo-03057	Finland	
Nisu	Finland	
Atlas 66	U.S.A.	

TABLE W74. (continued)

Variety or cross	Origin	Pedigree
Probstdorfer Extrem	Austria	
NB 68513 (C.I.15074)	U.S.A.	
Jyva	Finland	
Vakka	Finland	
Starke	Sweden	
Backa	Yugoslavia	
Clarion	Netherlands	
Dacia	Rumania	
Maris Nimrod	England	
Roussalka	Bulgaria	
Caribo	W. Germany	
Diplomat	W. Germany	
Moldova	Rumania	
NS-11-33	Yugoslavia	
NS-12-60	Yugoslavia	
Sava	Yugoslavia	
S Ec-28		
Kan x E. de Ch.		
Nar59² x 1088-Kt x(Fr-Fn/Y)Ec 588		II-18979-1e-1e-1e-1E
Kt/Bg-Fn/U x Bza Ec 432		VI-15-22t-2b-1t-1b-1t-1B
Horizon Bt 2322		
Athys BT 2323		
Parker Ci 13285	U.S.A.	
Shawnee CI 14157	U.S.A.	
Ottawa CI 12804	Canada	
Pawnee CI 11669	U.S.A.	
Rex		
Maison Vilmorin		
Ardent		
Germinal		
[(Fr-K58-N x N.,10B)Gb55] (Son64 x TzPP²-An64)		II-21375-2M-3R-3C-2R
TzPP-100Y x 12300		21292-4M-1T-1M-1T
Scout 66 69NBFSS		
Sturdy 69T x FSS		
Benhur		
BT2121 x BB-Mah981 (BT 2447)		T64-2-e
B2121/K17 x Kta-Y(BT 2443)		T64-2-f
B2121/K17 x Kta-Y(BT 2445)		T64-2-r
TP 114/207-208		
Arthur² x 7C		-67129E1-3-6H
Arthur² x 7C		-67129E5-70M
Benhur "S" x LR64-Arthur type		-6646A5-17
Sparta		
Strampelli	Italy	
Libellula		
114B-35 x Nad63		
Polk	U.S.A.	
Aniversario	Italy	
Bowie		
Pembina² x Magnif enterriano		RL 4219
Fronthach, PI 297014	U.S.A.	PI 299419
11-55-10(Pembina-11-52-329/11-53-388-111-58-4 x 11-53)	U.S.A.	546-11-62-24
11-55-10(Pembina-11-52-329/11-53-388-111-58-4 x 11-53)	U.S.A.	546-11-62-1
11-55-10(Pembina-11-52-329/11-53-388-111-58-4 x 11-53)	U.S.A.	546-11-62-49
11-55-10(Pembina-11-52-329/11-53-388-111-58-4 x 11-53)	U.S.A.	546-11-62-51
11-55-10(Pembina-11-52-329/11-53-388-111-58-4 x 11-53)	U.S.A.	546-11-62-56
Wells	U.S.A.	
Leeds	U.S.A.	
Ranjaja 2		
Kaukaz	U.S.S.R.	
4 - 11		
Campodoro	Italy	
Libellula	Italy	
Aurora	U.S.S.R.	
Lucena		
Capitole Vilmorin		
(Fec. 28 x 293)888-2		
220 - 39		
093/44		
T54-01-25-3-7 x Black Hawk/Melez 13		M.64-24-9-1A-101A-1A
Yaktoy (406)	Turkey	
Marim P3	Italy	
Furore		
Ttoile de Choisy 28	France	
Mara	Italy	
Bolal	Turkey	
Atlas 66	U.S.A.	
107		
Tevere	Italy	
220/39		

MAIZE

INTRODUCTION

Maize continues to be the world's third ranking food crop, after wheat and rice.

The world has regarded maize as a Latin American food, because that is where it was found by Spanish explorers almost 500 years ago. Yet there are five countries in Asia (India, Indonesia, The Philippines, Thailand and Turkey) individually producing between one million and seven million tons of maize annually. Another five countries in Africa (Egypt, Kenya, Malawi, Nigeria and South Africa) each produce over a million tons of maize a year. And of course, maize continues to be the principal food crop in most countries of Central and South America.

There are 51 countries in Asia, Africa, and Latin America, each producing over 100,000 hectares of maize. Most of this maize is eaten directly by humans.

Over half these countries had average maize yields in 1971 of one metric ton per hectare or less, which is very little different from the traditional yield of the entire world before the development of Twentieth Century technology.

If maize yields are now to be raised at a rate at least equal to population growth, each of these 51 countries requires the capability to conduct applied maize research under local conditions and to deliver this local technology to farmers through a staff of agricultural officers trained in maize production.

It is the judgment of CIMMYT maize scientists that every one of these countries should double its maize yields over the next 10 years if the necessary resources are applied and if the necessary staff is trained.

CIMMYT maize staff have identified five key limitations which obstruct production in most maize-producing areas, especially in the tropics. These are:

1. Plant height is generally too tall, which causes some plants to lodge (fall over) before harvest.
2. Diseases and insects cause much damage in the tropics where the absence of a cold season permits continuous multiplication of pathogens and predators. Breeders must incorporate resistance to diseases and insects genetically.
3. Varieties must become more widely adapted to enable them to withstand greater variations in temperature, moisture, and day length.
4. A better system of production management is needed for each country. This means that recommendations to farmers on time of seeding, plant population, fertilizer practices and weed control must be developed locally to fit the farmers' conditions.
5. More qualified personnel must be trained for the national program. Competent persons are needed to test under local conditions the wide range of genetic materials now available from Mexico and elsewhere, and to demonstrate the improved practices to farmers.

CIMMYT is working on all five of these limitations.

Protein quality is a very important aspect of the CIMMYT maize program, but questions of protein quality (for example, the percentage of lysine in the total protein) do not limit production. Protein quality is an additive element which CIMMYT is attempting to introduce into all improved maize lines in its research program.

CIMMYT's breeding strategy for better maize for the tropics is based upon several principles which are substantially different from those applied in advanced agricultural nations of the temperate zone.

Historically, maize offered greater variability of germ plasm than any other cereal. In prehistoric times the plant moved from the hottest tropical seashores of America up to the coldest mountain tops.

Wherever maize competed with weeds, the successful plants became taller and later in maturity (longer growing season). Wherever early man selected his seed corn from the largest and best-looking ears, these seeds tended to produce still taller and often later maturing plants.

By natural selection, also, each indigenuous variety of maize became resistant to local diseases and insects and competed well with weeds; but for the reasons stated, the plant was very tall, often late in maturity, and the yield was low.

Today there is still ample variability in the maize seed bank to enable breeders to change all these characteristics; but the centuries of selection have made each variety location-specific (that is, adapted only to its local environment). It is difficult to combine the desirable characteristics of two local varieties only 10 miles apart when the elevation and temperatures are markedly different.

In North America, corn breeders accepted this narrow adaptation, and developed varieties best suited to each microclimate.

At CIMMYT, the opposite philosophy is followed, and the breeders are attempting to achieve maximum adaptability in the plant in order to combine all the best economic characteristics that are needed to make a plant (1) short in stature, (2) disease and insect resistant, (3) widely adapted to differences in temperature and moisture, and (4) high yielding.

In pursuing these goals, CIMMYT researchers and their collaborators evolved another strategy which is not widely used in maize research in the temperate zone. Each year CIMMYT sends its experimental maize materials to more than 300 collaborating scientists in over 40 countries, and the materials are tested under widely differing day lengths, temperatures, elevations, and moisture conditions. CIMMYT believes that in a single year's trials under this system, the breeder obtains information which would take him 50 or 100 years to obtain if he confined his research to a single research station in a single microclimate.

Where this breeding strategy is leading and the progress it produced in 1972 is related in this report.

BREEDING

In 1968 CIMMYT decided that major increases in yield could not be obtained in the tropics and subtropics unless a way was found to shorten plant height to avoid lodging and permit higher plant populations. A program of recurrent selection for plant height and the use of the recessive brachytic-2 gene was initiated in a population called Tuxpeño Crema I. Reducing plant height by recurrent selection was so successful that CIMMYT has begun to apply this technique to all of the populations in its maize improvement program.

Selection for Shorter Plants

Recurrent full-sib selection within broad-based populations has proven to be an effective and relatively rapid means of reducing plant height. Drastic height reduction has been achieved, and crosses of shortened types with tall materials has resulted in intermediate height F_1 plants. Several such combinations have been made and look very promising for commercial use. Present height of the more advanced selection are comparable to a brachytic-2 version of the same material.

Many full-sib family rows are used to represent a population, and selection is done among and within families with the family performance as the principal criterion of selection.

The entire nursery is inoculated with pathogens of stalk rots and ear rots, and insecticide is applied to two meters of each row adjacent to the wide alleys (Fig. 1).

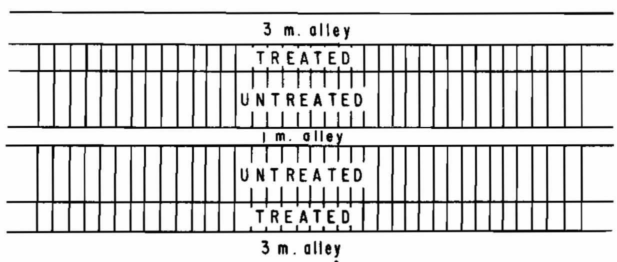


FIG. 1. An outline of a procedure to include resistance to insects as part of the selection criteria in the nursery.

The insects and pathogens considered are: budworm (*Spodoptera frugiperda*); stem borer (*Diatraea saccharalis*); earworm (*Heliothis zea*); leaf diseases (*Helminthosporium turcicum, H. maidis, Puccinia polysora,* and

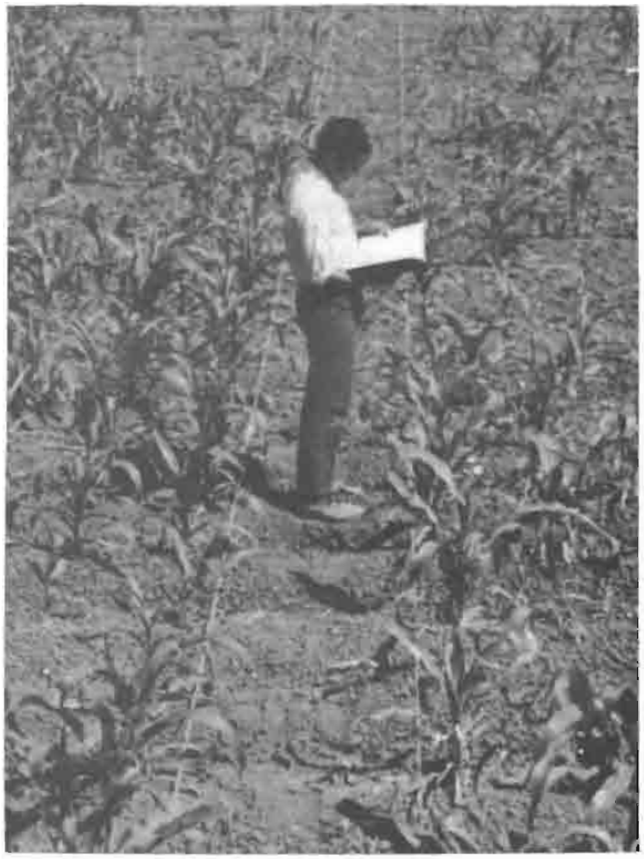
Phyllachora maidis); corn stunt; ear rots (*Fusarium spp.*, and *Diplodia spp.*); and stalk rots (*Fusarium spp.*, *Cephalosporium acremonium* and *Macrophomina phaseoli*).

Selection has been conducted under heavy natural incidence. Forty percent of the plants in a given progeny row are protected with granular insecticides and the rest left unprotected (see photograph). The least damaged are visually identified to be progenies used for the following cycle of selection. This simple procedure should permit a gradual accumulation of genes for resistance and/or tolerance. Studies are being conducted to determine the best techniques for artificial infestations in order to increase selection pressure for resistance.

Reactions of newly produced progenies to pathogens are determined through artificial inoculations with leaf rusts and blights, and ear and stalk rots. Techniques for inoculating large numbers of progenies and monitoring pathogenicity of inoculum have been worked out (see photograph).

Developing Widely Adapted Disease- and Insect-Resistant Germ Plasm

In 1971, 1,000 S_1 lines from the World Composite were tested in seven different environments. The 140 best-performing S_1 progeny across the seven locations were selected. These were again planted in a crossing block. Half sibs were made and evaluated in the same environments, and a total of 134 families were selected on yield performance, disease and insect resistance and wide adaptation. It is expected that recycling of this population will produce a widely adapted disease- and insect-resistant germ plasm source.



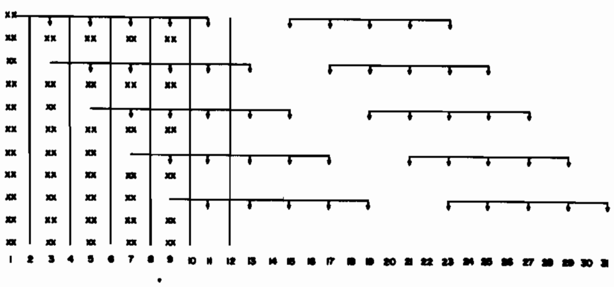
View of breeding plots showing the technique used to evaluate families for their reaction to insect attack. Two meters of each row next to the wide alley were protected with insecticide. The rest of the row was unprotected. Missing plants were killed by the budworm.

Technique used for artificial inoculation of stalk-rotting pathogens in selected families. An electric drill is used to drill a cylinder in the first elongated internode. Infectious toothpicks are then introduced in the wound.

Two other populations are being improved in a similar way. One involves a recombination of 36 tropical materials (early, intermediate and late) which possess some tolerance or resistance to the insects and pathogens mentioned. This population is in its second cycle of selection. Another population comprising germ plasm of Caribbean origin has a high degree of resistance to the budworm. This population, known as Cogollero Resistant, is undergoing selection for greater resistance to the budworm as well as other characteristics. It is a very promising population for those areas where Caribbean germ plasm is well adapted.

Visual selection as near as possible to the time of pollination is practiced, and the rows displaying average or better performance for the trait under selection are identified. Within-family selection is then practiced in each selected row and about five plants per row are crossed to other similarly selected plants in other rows--each plant with a different row (Fig. 2). Crosses are made, to the extent possible, with plants in the portion of the row not protected by insecticide. Selection is done every cycle, and there is no intervening mixing generation. In this full-sib system progenies are tested under several environments. The testing of progeny sets provides a systematic selection under widely varying environments; and those components of a population that do well under different conditions are recombined. The goal is widely adapted varieties.

About 40 composite populations are being used in the program, most of them adapted to low elevations and tropical conditions. In general, all carry reasonable levels of resistance to *H. maidis, P. polysora, Physoderma*, and the more common diseases prevalent in the lowlands of Mexico and Central America.



Families are planted in consecutive row numbers (randomly arranged at previous harvest).

Lines and arrows indicate each selected family is crossed to 5 other families.

Approximately half of families are used in crosses. (Indicated by crosses made only with alternate rows).

FIG. 2. A schematic diagram of a crossing pattern among selected families in full-sib continuous selection.

Similar populations have been formed and are being used for higher elevations and for more temperate conditions, involving germ plasm from the Andean Zone of South America, highlands of Mexico and Central America, and Africa. In both the highland and lowland materials, emphasis is also being given to earlier maturing types, since earliness seems to be a real need in most of the production areas in tropical and subtropical areas of the world.

A system of simultaneous conversion to quality protein parallel to the population improvement program

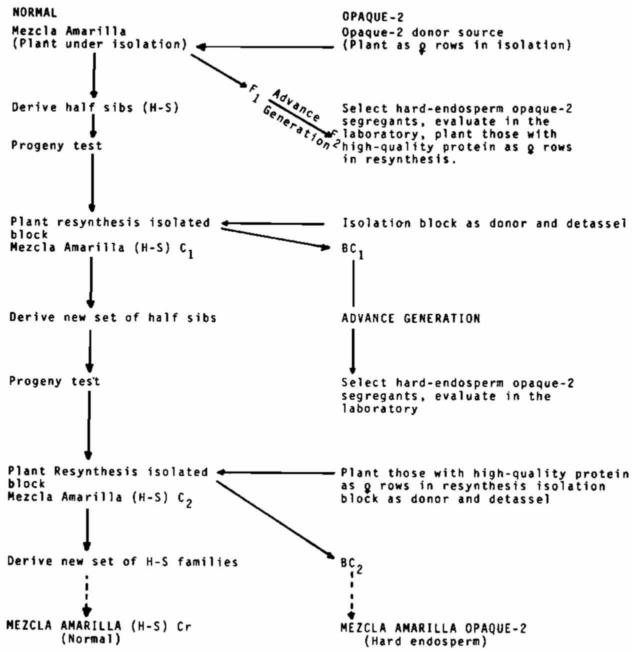


FIG. 3. Scheme for making parallel improvement in normal and opaque-2 counterpart population.

is being practiced in all of the populations in the populations in the improvement program. Fig. 3 illustrates the system.

Much of the work at the CIMMYT maize research stations in Mexico involves the exchange and development of genetic materials for specific regions of the world (such as the Andean countries, tropical Africa and Southeast Asia) and for national programs in different parts of the world. Among such projects is a cooperative evaluation of corn germ plasm for very cool climates being directed from Cornell University. Another is in cooperation with the Ministry of Agriculture in Egypt, in which a series of promising materials are intercrossed in Mexico and then sent to Egypt for use by the Egyptian national program and to provide thesis materials for graduate students in Egypt. Very high yields (14 tons per hectare) were reported in Egypt in 1972 from the cross of American Early (Egypt) and La Posta (Tuxpeño synthetic from CIMMYT).

Visiting scientists and students from the Philippines participated in the formation of progenies involving local and exotic maize varieties for use in that country. While downy mildew is the principal limiting factor of production in that area, much remains to be done to improve the yield capacity and standability of the varieties.

The Central American Cooperative Food Crops Program (P.C.C.M.C.A.) constitutes an active field for a regular exchange of materials and experiences. Uniform variety trials were prepared and distributed through out the area. These trials have also been provided to many other tropical countries.

Two series of uniform trials are regularly conducted. The BA series consists of commercially available varieties and hybrids. Most trials were thrown out of normal perspective in 1972 due to a severe and prolonged drouth. Table 1 gives a summary of the results available for 11 locations in 1972. The standard check hybrid used in this series is H-507 from Mexico.

TABLE M1. Grain yield (15% moisture) and agronomic performance for the 20 top-yielding entries and the check in series BA (average of 11 locations in Central America and Mexico, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)[a]	
						Plant	Ear	Root	Stalk
Poey T-27	5221	59	1.5	1.4	0.6	249	143	1.3	1.8
H-5	5197	59	1.4	1.4	0.6	235	141	1.8	1.7
Desarrural	5142	60	1.5	1.5	0.7	238	139	2.0	1.5
X 306	5043	59	1.6	1.4	0.8	221	132	1.5	1.5
X 352	5041	59	1.6	1.5	0.6	299	134	1.8	1.5
H-101	5017	58	1.5	1.4	0.6	230	142	2.3	2.1
Poey T-80	5001	57	1.5	1.3	0.7	234	143	2.2	1.9
Desarrural H-101	4995	60	1.5	1.5	1.0	238	146	1.6	1.5
X 304-8	4954	57	1.4	1.3	0.8	217	124	1.4	1.6
H-3	4795	55	1.5	1.3	0.8	219	126	1.4	1.6
X 306-A	4782	57	1.4	1.3	0.9	215	123	1.5	1.5
ICA H-207	4750	59	1.7	1.4	0.8	241	145	1.5	1.8
Comp. Bl. Cuyuta	4746	61	1.8	1.3	0.8	246	153	2.3	1.7
X 101-A	4706	57	1.6	1.5	0.6	226	128	1.2	1.6
X 304-A	4676	56	1.6	1.6	0.6	219	123	1.3	1.5
Diacol H-253	4672	60	1.7	1.4	0.9	231	139	1.4	1.4
(Tuxp.xEto Bl.)PB[b]	4596	59	1.5	1.5	0.9	217	126	1.1	1.2
H 354	4589	57	1.6	1.4	0.8	212	122	1.2	1.4
Poey T-72	4586	60	1.5	1.4	0.8	232	134	1.3	1.7
Tuxp. Sint.	4576	62	1.8	1.3	0.7	247	158	2.1	1.7
H-507 (check)	4554	63	1.8	1.4	0.7	245	153	1.5	1.5

[a] 1 = no lodging, 5 = totally lodged.
[b] PB = short plant type.

The other uniform trial is the ME Series, consisting of experimental varieties being considered for release. Different locations than those for the BA series had data available for this report. Tables 2, 3 and 4 show the average performance across 4, 6 and 3 locations, respectively, for the materials included in this series.

Another series of trials constitute a routine check of the available high-quality-protein varieties in Central America. Only 10 entries were included in the trial. Table 5 shows the summary of performance at eight locations. Yields at the reporting locations were generally low and were characterized by relatively high percentages of rotten ears.

Central American countries are also actively assisting in the progeny evaluation of several materials under development at CIMMYT. At each location the better progenies are selected to be recombined at CIMMYT and the recombinations are again progeny tested at several locations.

Since one of the major efforts in the breeding work is to reduce plant size, the brachytic-2 gene has been used to reduce plant height. To get at least a preliminary comparison of the genetic "dwarf" approach and the short-plant quantitative method, the best brachytic-2 varieties together with a short-plant counterpart, Tuxpeño PB (*planta baja*), were included in a trial. A summary of results over 10 locations is presented in Table 6. The short-plant entry gave the top yield and was only a few centimeters taller than the brachytic entries.

TABLE M2. Grain yield (15% moisture) and agronomic performance for the 20 top-yielding entries in series ME (average of 4 locations in Central America, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
Dekalb Exp-4	7527	59	3.0	2.8	0.5	278	146	1.0	1.0
Dekalb Exp-2	6958	61	4.0	2.3	1.5	288	177	1.0	1.0
Poey T-53	6694	64	2.5	2.5	0.5	282	171	1.0	1.0
Poey T-57	6667	63	2.3	2.8	0.8	271	152	1.0	1.0
Poey T-51	6630	64	2.5	2.8	0.3	287	171	1.0	1.0
Poey T-59	6383	61	2.5	2.8	0.8	273	142	1.0	1.0
Poey T-55	6337	63	3.0	2.8	0.3	289	167	1.0	1.0
Poey T-31	6211	62	4.3	2.5	1.0	268	147	1.0	1.0
X 306 8	6200	60	2.5	2.5	1.5	255	134	1.0	1.0
Exp. 70-71 D1-39	5910	58	3.0	3.3	1.3	254	126	1.0	1.0
H-507 (check)	5829	66	3.5	2.8	0.8	284	164	1.3	1.0
(Tuxp.CR.IxEtoBL)PB	5698	60	3.3	2.5	0.3	248	125	1.0	1.0
Poey T-93	5582	58	3.3	2.5	0.5	268	138	1.0	1.0
V520C-Sel. Bla.	5531	61	3.8	2.5	0.3	249	122	1.0	1.0
Poey T-91	5473	59	3.0	2.3	1.0	269	137	1.0	1.0
Poey T-95	5435	58	2.8	2.3	1.0	260	138	1.0	1.0
V520C-Sel. Ama.	5356	60	3.3	2.0	1.0	253	122	1.0	1.0
Dent.Ama.Sel.PB	5171	63	3.0	2.8	0.8	255	141	1.0	1.0
Na-2	5142	60	2.3	2.5	0.8	260	136	1.0	1.0

TABLE M3. Grain yield (15% moisture) and agronomic performance for the 20 top-yielding entries in series ME (average of 6 locations in Central America and México, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
Poey T-59	5037	59	1.7	1.3	1.0	275	161	1.3	2.3
Poey T-53	4965	60	1.7	1.3	1.0	294	185	1.3	2.1
Poey T-31	4910	60	1.6	1.3	1.0	273	163	1.1	2.3
X 306 8	4853	57	1.3	1.3	1.0	258	141	1.4	2.6
E.S.H.E. B-2	4647	57	1.3	1.3	1.0	275	157	1.5	2.8
Poey T-51	4615	61	2.0	1.7	1.1	279	172	1.3	2.6
E.S.H.E. B-1	4559	55	1.4	1.3	1.1	270	156	1.4	2.8
E.S.H.E. A-2	4551	58	1.5	1.7	1.0	273	166	1.8	2.6
Tuxp. CR.I-PB	4387	58	1.7	1.3	1.0	243	128	1.3	2.0
D1-39	4262	56	1.4	1.3	1.0	255	139	1.4	2.3
E.S.H.E. A-1	4157	58	1.5	1.3	1.0	254	149	1.8	3.2
H-507 (check)	4069	61	1.5	1.5	1.1	278	162	1.4	2.8
Poey T-95	4023	57	1.7	1.3	1.0	266	148	1.6	2.8
V520C Sel. Bl.	3981	54	2.0	1.5	1.1	260	143	1.5	2.6
V520C Sel. Am.	3980	58	1.7	1.5	1.3	256	135	1.4	2.7
Poey T-57	3965	60	1.8	1.5	1.1	281	165	1.4	3.1
Poey T-91	3946	57	1.6	1.5	1.1	270	151	1.6	2.9
Mez. Ama. PB	3856	55	1.5	1.3	1.0	236	126	1.4	2.4
Comp. Caribe BL	3803	57	1.6	1.3	1.1	250	140	1.5	2.7
Poey T-93	3779	57	1.7	1.3	1.0	271	155	1.4	3.0

TABLE M4. Grain yield (15% moisture) and agronomic performance for the 20 top-yielding entries in series ME (average of 3 locations in Central America, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
Poey T-31	6306	64	1.6	0.9	1.0	289	152	1.4	1.8
X 306 B	5641	56	1.6	1.0	1.0	244	125	2.1	2.1
E.S.H.E.B-2	5627	51	1.4	1.1	1.0	250	122	1.5	1.9
E.S.H.E.B-1	5591	53	1.7	1.0	1.0	256	135	1.4	2.3
H-507 (check)	5420	60	1.9	0.9	1.0	274	158	2.0	2.0
Poey T-51	5220	60	1.7	1.1	1.0	263	151	1.4	2.0
Tuxp. Cr. I Sel. Pb.	5001	57	1.6	1.3	1.0	230	112	1.5	1.4
Tuxp. Pb.	4979	57	1.6	1.0	1.0	239	124	1.5	1.6
V520C-S. Am.	4898	56	1.7	1.1	1.0	239	121	2.0	2.1
V520C-S. Bl.	4838	56	1.7	1.1	1.0	230	122	1.9	1.4
D1-39	4794	54	1.6	1.0	1.0	236	121	1.4	1.5
E.S.H.E.A.-2	4761	57	1.7	1.0	1.0	245	128	1.8	2.5
E.S.H.E.A.-1	4734	58	1.6	1.1	1.0	228	122	1.4	2.3
Tuxp. Pb.	4640	51	1.7	1.1	1.0	197	100	1.1	1.1
NA-2	4386	56	1.7	0.9	1.0	246	133	1.8	2.4
Comp. Pfister	4234	54	1.7	1.0	1.0	231	108	1.8	1.8
Blan. Cris. Pb.	4218	54	1.7	1.0	1.0	213	107	1.4	1.5
Dent. Am. S. Pb.	4152	58	1.7	1.0	1.0	242	119	1.6	1.9
Cris. Am. S. Pb.	4132	57	1.6	1.0	1.0	243	123	1.8	2.1
Mez. Am. Pb.	3971	54	1.7	1.1	1.0	213	109	1.6	2.0

TABLE M5. Grain yield (15% moisture) and agronomic performance for 10 opaque-2 varieties in series OP (average of 8 locations).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
ICA H-208	3682	59	1.9	1.8	1.3	228	124	2.1	2.2
CIMMYT O2	3496	60	1.7	1.8	1.5	230	129	1.7	2.0
ICA H-251	3340	60	1.7	1.8	1.1	213	116	1.5	2.0
Opaco-2	3078	61	1.6	1.8	1.2	223	117	1.7	1.9
Samaru Comp. II	2915	59	2.2	1.9	1.5	202	109	1.5	1.8
Comp. Opaco-2	2896	60	1.8	2.0	1.8	226	123	2.1	2.1
Comp. K	2778	60	2.0	1.8	2.1	224	119	2.2	2.2
Thai Opaco-2	2658	59	1.9	2.0	1.6	205	109	1.9	2.3
Local variety	2561	54	1.8	1.8	0.9	226	128	1.9	2.2
Guat. O2 Mejorado	1685	58	2.6	2.3	1.8	187	94	1.8	2.1

TABLE M6. Grain yield (15% moisture) and agronomic performance for brachytic-2 and short plant selections (PB) (average of 10 locations in Central America, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
Tuxp. PB	4326	61	2.0	1.5	1.0	206	110	1.2	1.4
Tuxp. br_2	4175	64	1.6	1.5	1.1	203	109	1.4	1.3
Frances Largo br_2	3929	61	1.8	1.4	1.2	216	119	1.4	1.7
Poey E-2	3921	62	1.8	1.5	1.1	189	96	1.4	1.3
Poey E-4	3896	61	1.8	1.5	1.1	184	92	1.1	1.3
Enano br_2 Dent	3566	64	1.6	1.5	1.1	184	94	1.1	1.2
Hojas Erectas br_2	3505	64	1.5	1.7	0.9	194	99	1.2	1.2
Guatemala br_2	3409	65	1.5	1.5	1.3	187	98	1.0	1.2
br_3 Cris. Bl.	3304	62	1.7	1.6	1.0	182	95	1.1	1.3

In pursuing the selection of shorter plants, a series of tests have been established involving progenies from different types of combinations of short-plant selections with other unrelated, short-plant selections, with intermediate-height types, and with tall types--both related and unrelated. One series of this type was called CPBB. Forty-nine crosses of shortened versions of Tuxpeño and Eto Blanco with a range of materials were tested at three locations (5 trials) in Mexico and at Farm Suwan in Thailand. Average results for the six trials are shown in Table 7.

A similar set of intercrosses was developed for yellow-grain varieties (series CPBA) and the trial was grown at three locations in Mexico, in Guatemala and in Thailand. Results are shown in Table 8. Over the five locations, the average yield of the local checks ranked lowest. Results, however, are not directly comparable to those from the white-variety trial because of different check varieties and different sites.

Another effort to gather information on the performance of the populations under selection was to develop a progeny trial of intercrosses of selected

TABLE M7. Grain yield (15% moisture) and agronomic performance for 20 top-yielding, entries and local check, series CPBB (average of 5 trials in Mexico and 1 in Farm Suwan, Thailand, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
(La Posta x Eto PB)	5356	61	1.6	1.0	1.0	253	136	1.5	1.9
(Com. Gr. Duro x Tuxp. PB)	5124	62	1.7	1.2	1.0	254	141	1.8	2.1
(Tuxp. Cr. I-C2 x Tuxp. PB)	5098	62	1.4	1.0	1.0	255	142	2.0	2.1
(Tuxp. Cr. I x Tuxp. PB)	5094	62	1.5	1.3	1.0	257	143	1.9	2.3
(Tuxp. Turcic. x Tuxp. PB)	5013	63	1.3	1.2	1.0	267	143	1.6	2.1
(La Posta x Tuxp. PB)	5002	63	1.5	1.0	1.0	255	151	1.6	2.2
Tuxpeño PB	4989	61	1.6	1.3	1.0	228	117	1.4	1.9
(Mix. 1 x Col. Gpo. 1-C2 x Tuxp. PB)	4960	61	1.5	1.0	1.0	258	141	2.0	2.2
(Tuxp. Cr. I-PB x Eto PB)	4947	60	1.8	1.0	1.0	232	119	1.6	1.8
(Mix. 1 x Col. Gpo. 1 x Eto-C2) (Tuxp. PB)	4907	61	1.5	1.2	1.0	249	131	1.6	2.1
(Eto Bl. Am. Bl. x Tuxp. PB)	4903	61	1.5	1.0	1.0	240	123	1.6	2.0
(Sel. Bl. Caribe x Tuxp. PB)	4900	60	1.7	1.4	1.0	240	127	1.5	1.9
V520C x A6 (A21 x Tuxp. PB)	4895	60	1.5	1.0	1.0	239	131	2.1	2.1
(Mix. 1 x Col. Gpo. 1-C0 x Tuxp. PB)	4889	63	1.5	1.0	1.0	252	136	2.0	2.2
(Comp. Bl. Ame. x Tuxp. PB)	4863	61	1.6	1.0	1.0	246	136	1.8	2.0
(Ant. Gpo. 2 x Tuxp.) (Tuxp. PB)	4859	63	1.7	1.3	1.3	252	139	1.9	2.1
(Comp. CA. Bl. x Eto PB)	4854	60	1.7	1.0	1.0	247	127	1.6	1.8
(Ant. Gpo. 2 x Tuxp. Sel. Bl.) (Eto)	4838	59	1.6	1.3	1.0	241	126	2.1	1.9
(Tuxp. Costeño x Tuxp. PB)	4815	61	1.6	1.2	1.0	250	139	1.7	2.2
(Mix. 1 x Eto PB-C6) (Tuxp. PB)	4806	60	1.8	1.3	1.0	230	123	1.4	1.7
Local check	4418	60	1.7	1.0	1.0	240	133	1.7	2.6

TABLE M8. Grain yield (15% moisture) and agronomic performance for 20 top-yielding entries and the check, series CPBA (average of 3 locations in Mexico, 1 in Guatemala, and 1 in Thailand, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm Plant	Height, cm Ear	Lodging (1-5) Root	Lodging (1-5) Stalk
(Tuxp. Am. F9-S. Dent.) (M. Am.) PB	6889	75	1.8	1.3	1.0	353	184	2.3	2.8
(Eto Bl. PB. Sel. Am.) (Mezama) PB	6651	77	1.9	1.3	1.3	346	177	2.1	2.6
(Flint. Dent. Sel. Dent.) (Ant. x Ver. 181)	6636	79	1.9	1.1	1.3	358	193	2.5	2.5
(Tuxp. Cr. I. PB. Sel. Am.) (Ant. x Ver. 181)	6458	75	1.6	1.0	1.0	331	182	1.8	2.7
(Ant. Gpo. 2 x Ver. 181) (Mezama) PB	6384	73	1.7	1.0	1.0	321	170	2.2	2.6
(Sint. 10 Lin.) (Ant. x Ver. 181)	6378	74	1.7	1.0	1.0	332	184	2.8	3.3
(Mez. Am. Cen. Am. x Mezama) PB	6313	74	1.5	1.2	1.0	339	180	2.4	2.7
(Flint. Dent. Sel. Crist.) (Ant. x Ver. 181) PB	6236	75	1.9	1.0	1.0	327	182	2.3	2.6
(Mez. Am. Cen. Am.) (Ant. x Ver. 181)	6264	75	1.8	1.0	1.0	337	192	2.3	2.9
(Nicarillo) (Ant. x Ver. 181)	6206	75	1.6	1.0	1.0	340	186	2.6	3.2
(Mez. Am. IACP) (Ant. x Ver. 181)	6120	74	1.9	1.2	1.0	328	180	2.4	3.3
(Mez. Am. IACP) (Mezama) PB	6076	73	1.8	1.2	1.0	327	182	2.8	2.7
(V520C x A6) (A21) (Mezama) PB	6057	74	1.9	1.0	1.0	325	161	1.9	2.8
(Cuba x Rep. Dom.) (M. Am.) PB	6012	71	1.5	0.9	0.8	319	170	2.3	2.8
(Mez. Am. Dent.) (Ant. x Ver. 181)	5986	75	1.8	1.0	1.0	329	258	3.0	3.1
(Tuxp. PB Sel. Am.) (M. Am.) PB	5982	71	1.4	1.1	0.8	305	163	2.6	2.3
(V520C x A6) (Ant. x Ver. 181)	5981	75	1.6	1.0	1.0	330	170	2.2	2.9
(Cuba x Rep. Dom.) (Ant. x Ver. 181)	5923	75	1.9	1.0	1.0	341	195	3.0	3.0
(Ant. Gpo. 2 x Cubanos) (Mezama) PB	5889	74	1.9	1.1	1.3	325	167	2.6	2.6
(Pbo. Cristalina x Maz. Am.) PB	5779	70	1.5	1.0	1.0	316	172	2.4	2.7
Check	4992	77	2.1	1.2	1.0	340	181	2.3	3.0

individual families from several populations. Such a set of progenies from white varieties was tested in the CFSB series in Guatemala, El Salvador, and Poza Rica and Obregon in Mexico. The performance means for the four locations are shown in Table 9. Yields were quite satisfactory, but the significant factors here are the consistently shorter plants and low lodging indices.

An analogous series (CFSA) of intercrosses of selected yellow-grain families was grown at the same four locations. Selection for shorter plant height has not yet proceeded quite as far with the yellow materials as with the selected white families, but the same general tendencies are apparent. Results over the four locations are given in Table 10.

To measure progress from selection for shorter plants, the original populations (Cycle 0) and several cycles of selection were tested at three locations. Table 11 shows the results. The reduction in plant and ear height and the increased resistance to lodging are obvious. Maturity (days to flower) shows a change toward earliness in most cases. There has been some increase in yield but the important point is that there has not been any erosion of the yield potential through cycles of selection. Shorter plants can be planted at higher plant densities using higher rates of fertilization and this could contribute to further increased yields per area.

To test this assumption, trials were sent to several countries where brachytic-2, short-plant and original versions of a Tuxpeño population would be compared and evaluated for yield, lodging and other agronomic characteristics under high fertilization. Only results from El Salvador have been received and they are presented in Table 12. At the highest plant density the short-plant selection (Tuxpeño Pl. Baja) shows a reduction in plant height, less lodging, less barren plants, appears earlier and seems to yield about the same as the original populations. Nevertheless, yield estimates were based on complete recovery of produce from the plots. In commercial or large-scale plantings the susceptibility of the original population to lodging undoubtedly will cause harvest losses which would be higher than for the short-plant-selected population.

Results are not yet available from all locations where trials of the short-plant selections were grown, but several observations appear to be pertinent:

1. Major changes in the plant height of tropical maize have been achieved.
2. Shortened varieties tend to be somewhat earlier in maturity and much less subject to lodging.
3. The shorter, earlier plants have not been accompanied by any loss in yield potential.

TABLE M9. Grain yield (15% moisture) and agronomic performance for 20 top-yielding entries and 2 checks, series CFSB (average of 4 locations, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
(Tuxp. PB-47 x Caribe-13)	5357	58	1.5	1.0	1.0	219	111	1.1	1.3
Tuxp. Res. Turcicum	5139	60	1.8	1.0	1.0	239	124	1.1	1.3
(Tuxp. PB. Bl.-48) (Mix. 1 x Col. Gpo. 1-39)	5110	59	1.5	1.0	1.0	223	111	1.1	1.2
(V520CSel. Bl.-24 x Pfister-8)	5097	56	1.5	1.0	1.0	229	128	1.4	1.9
(Tuxp. PB-12 x Caribe-II)	5040	58	1.0	1.0	1.0	229	112	1.4	1.0
(Pfister PB x Tuxp. PB)	4926	59	1.5	1.0	1.0	225	114	1.2	1.5
(La Posta x Tuxp. PB)	4868	61	1.8	1.0	1.0	242	132	1.3	1.4
(Tuxp. PB-317 x Eto Bl.-46)	4866	61	1.3	1.0	1.0	231	109	1.0	1.1
(Tuxp. PB-34 x Pfister-23)	4853	59	1.5	1.0	1.0	220	114	1.2	1.4
(Mix. 1 x Col. Gpo. 1-PB-6 x Eto PB-23)	4848	59	1.3	1.0	1.0	227	115	1.4	1.3
(Eto Bl. PB-23 x Pfister)	4798	58	1.5	1.0	1.0	224	113	1.0	1.3
(Caribe Bl.-13) (Mix. 1 x Col. Gpo. 1-6)	4794	60	1.8	1.0	1.0	221	113	1.2	1.2
(Tuxp. PB-75) (Mix. 1 x Col. Gpo. 1-2)	4763	59	1.8	1.0	1.0	224	107	1.0	1.4
(Tuxp. PB Am.-6 x Eto PB-44)	4716	58	2.0	1.0	1.0	216	107	1.0	1.3
(Tuxp. PB-127 x Eto PB-86)	4731	54	1.3	0.8	0.8	196	96	0.9	1.1
(Pfister-II x Tuxp. PB-54)	4664	58	1.8	1.0	1.0	227	119	1.5	1.8
(Tuxp. PB-146 x Pfister-8)	4663	61	2.0	1.3	1.3	221	111	1.2	1.4
(Caribe-II x Mix. 1 x Col. Gpo. 1-8)	4659	59	1.3	1.0	1.0	220	118	1.3	1.3
(Ant. Gpo. 2-53) (Mix. 1 x Col. Gpo. 1)	4654	58	1.5	1.0	1.0	224	116	1.0	1.4
(Tuxp. PB-30 x V520C-24)	4648	59	1.5	1.0	1.0	224	122	1.2	1.3
Tuxp. PB (check)	4480	58	1.5	1.0	1.0	213	106	1.3	1.3
Eto PB (check)	4107	59	1.0	1.0	1.0	223	112	1.2	1.3

TABLE 10. Grain yield (15% moisture) and agronomic performance for 20 top-yielding entries and 1 check, series CFSA (average of 4 locations, 1972).

Variety	Yield kg/ha	Days to flower	*Helm* Spp. (1-5)	*Pucc* Spp. (1-5)	Corn stunt (1-5)	Height, cm		Lodging (1-5)	
						Plant	Ear	Root	Stalk
(Ant. x Ver. 181) (V520C-109)	5330	60	1.4	1.1	0.6	231	122	1.3	1.6
(Nicarillo x Mez. Am. PB)	5257	58	1.4	1.5	0.5	242	125	1.3	1.7
(V520C x Crist. Dent.-233)	5085	60	1.1	1.3	0.5	243	133	1.4	1.4
(Sint. 10 Lin. x Ver. 181)	5019	59	1.5	1.4	0.6	228	126	1.3	1.8
(Ant. Gpo. 2 x Eto Bl. Am.)	4936	58	1.5	1.5	0.8	224	108	2.1	1.2
(Eto Bl. Am.-12) (Ant. x Ver. 181-168)	4889	58	1.5	1.5	0.5	228	113	1.3	1.6
(Ant. x Ver. 181-62) (V520C x A6-31)	4879	60	1.3	1.5	0.6	234	123	1.9	2.1
(Mez. Am. PB-83 x Crist. Dent.)	4864	58	1.4	1.3	0.8	222	115	1.6	1.3
(Ant. Gpo. 2 x Mez. Am. PB)	4836	57	1.5	1.5	0.6	222	105	1.0	1.5
(Ant. x Rep. Dom.-52) (Ant. x Cuba)	4823	57	1.4	1.3	0.5	221	109	1.8	1.4
(Mez. Am. C. Am. x Am. PB)	4814	58	1.6	1.4	0.5	232	117	1.4	1.6
(Mez. Am. Dent. x Ver. 181)	4803	59	1.5	1.5	0.5	237	134	1.6	1.6
(Sint. 10 Lin. x Am. PB)	4781	57	1.5	1.4	0.6	225	117	1.3	1.5
(Mez. Am. PB-35) (Ant. x Rep. Dom.-52)	4733	57	1.5	1.1	0.5	230	109	1.5	1.5
(Nicarillo x Ver. 181)	4725	59	1.3	1.5	0.5	235	127	1.4	2.0
(V520C x A6 x Am.)-31 (Ant. x Ver. 181)	4681	60	1.3	1.4	0.5	230	119	1.4	1.6
(Tuxp. Pl. Am.-13 x Mez. Am.-53)	4671	59	1.4	1.5	0.5	228	114	1.3	1.4
(Mez. Am. PB-25) (Ant. x Ver. 181)	4659	59	1.5	1.5	0.5	233	124	1.5	1.8
(Crist. Dent.-233) (Ant. x Ver. 181)	4657	60	1.4	1.4	0.8	243	132	1.8	1.5
(Mez. Am. PB-90 x Crist. Dent.-110)	4644	58	1.0	1.3	0.6	231	110	1.0	1.3
Check	4183	59	1.3	1.3	0.8	221	105	1.3	1.3

TABLE 11. Average grain yield at 15% moisture and agronomic performance of several full-sib selected populations grown at Obregón, Poza Rica and Tlaltizapán, 1972.

Population	Selection cycle	Height, cm Plant	Height, cm Ear	Days to flower	Stalk lodging (1-5)	Yield kg/ha
Tuxpeño Crema	C 0	277	175	69	3.2	3739
	C10	212	112	64	1.6	4284
Eto Blanco	C 0	244	136	67	2.3	3003
	C 9	212	99	63	1.4	3308
(Mix. 1 x Col. Gpo. 1) x Eto	C 0	267	157	67	2.4	3317
	C 7	213	102	63	1.8	3969
Mezcla Amarilla	C 0	239	130	64	2.4	3613
	C 5	219	116	62	1.4	3858
Tuxpeño Crema I (2) Inv. Ver	C 0	277	167	69	2.9	3164
	C 4	266	146	67	2.3	4034
Ant. Gpo. 2 x Gpos. Dom. Rep.	C 0	234	124	61	2.8	3016
	C 4	198	99	60	2.6	3332

4. Crossing short-plant selections tend to give F_1 plants intermediate in height between the two parent materials. Plant height appears to behave in an essentially additive fashion.

5. Intensified agronomic practices of plant density and fertilizer levels appear to be indicated for the shorter materials.

TABLE M12. Yield (15% moisture) and agronomic performance for the original, short plant and brachytic-2 versions of Tuxpeño, El Salvador, 1972.

Population	Plant densities (x 1000 plants)/ha: 40	65	90	115
	Plant height, cm			
Tuxpeño Original	304	312	302	310
Tuxpeño Pl. Baja	260	266	273	274
Tuxpeño br_2	218	202	218	215
Local Variety	231	236	250	241
	Root lodging, %			
Tuxpeño Original	18	15	16	25
Tuxpeño Pl. Baja	27	19	6	7
Tuxpeño br_2	12	7	5	11
Local Variety	3	2	1	2
	No. barren plants			
Tuxpeño Original	3	5	18	17
Tuxpeño Pl. Baja	3	5	9	14
Tuxpeño br_2	3	17	24	33
Local Variety	0	9	5	14
	Days to flower			
Tuxpeño Original	61	62	62	62
Tuxpeño Pl. Baja	57	58	58	57
Tuxpeño br_2	60	61	62	61
Local Variety	44	45	45	45
	Grain yield (tons/ha, 15% moisture)			
Tuxpeño Original	4.4	5.1	4.8	5.6
Tuxpeño Pl. Baja	4.2	5.3	5.1	5.7
Tuxpeño br_2	2.7	3.2	4.0	4.4
Local Variety	2.9	3.4	3.7	3.8

6. How far height reduction can be carried is not yet known, but more than 30 percent has been removed in some materials without exhausting the genetic variability. Prospects appear very good for the continued development of agronomically more desirable tropical maize varieties.

Adjacent plots of Tuxpeño Crema I original (left) and cycle 7 of short-plant selection (right) illustrate the drastic change that has occurred in plant morphology in the selection process. Note difference in resistance to lodging.

QUALITY-PROTEIN BREEDING

As progress is achieved with the agronomic traits in the materials under selection, opaque-2 conversions are simultaneously made in all improved populations as shown in Fig. 3. In addition to this routine conversion process, additional information has been developed with respect to the several peculiarities of opaque maize which have not all been desirable. The problems of grain texture, appearance, ear rots and yield loss are well known and have constituted major obstructions to the widespread production of this quality-protein maize.

Intensive efforts have been made to resolve the major objections to opaque-2 maize by developing not only improved agronomic performance, but also modifying the opaque grain to a more normal appearance. In these attempts, a wide range of materials has been assembled from all over the world to study in detail the many aspects of the opaque-2 gene in varying genetic backgrounds. Material from tropical, temperate and high-altitude areas has been utilized.

Several general observations result from studying this wide range of materials. First, the expression of the various undesirable characteristics associated with the opaque-2 gene varies with the genetic background into which it is transferred. Yellow color tends to be diluted, but differentially. Lysine and tryptophan levels are markedly increased in all cases, but vary in amount among different materials. Protein levels tend to diminish slightly with decreases ranging from 2.5 percent to 34 percent, but with little or no decrease in certain cases. Protein and tryptophan levels in selected materials are shown in Table 13. Kernel density generally decreases markedly, but in certain genetic backgrounds the difference is negligible. The germ of opaque-2 maize tends to contribute more to the total kernel protein than the germ of normal maize. This can be an important advantage for grain quality. Table 14 shows a sample series of comparisons. In all these cases, the variation in behavior provides the basis for improving these characteristics.

Three of the converted opaque-2 composites were subjected to selection for yield improvement. Results of progeny selection are summarized in Table 15.

TABLE M13. Effect of the opaque-2 gene on percent protein and percent tryptophan in protein in the endosperm of different varieties and composites (representative sample out of 72 materials analyzed).

Variety	Country of origin	Protein, %		Tryptophan, %	
		Normal	O_2	Normal	O_2
Vijay	India	10.75	9.13	0.50	0.74
Composite A_2	India	10.63	8.00	0.46	0.98
Kisan	India	9.75	9.50	0.48	0.90
Syn. 493	Pakistan	12.13	9.63	0.37	0.64
Composite AC	Mexico	9.63	8.69	0.35	0.70
(USA x Caribbean Comp.)	Mexico	10.00	8.25	0.40	0.70
Rep. Dominicana Gpo. 8	Rep. Dominicana	9.13	7.63	0.33	0.97
Iowatigua	Mexico	9.00	8.00	0.36	0.79
Tuxpeño F. F.	Mexico	10.50	8.50	0.32	0.96
Puerto Rico Gpo. 6	Mexico	11.75	7.75	0.37	1.12
SLP Gpo. 10	Mexico	10.19	7.75	0.33	0.92
(Cupurico x Fl. Comp.)	Thailand	10.50	8.25	0.32	0.94
Colombia Cateto C	Colombia	9.25	7.13	0.34	0.90
Perola Piracicaba	Brazil	9.13	7.31	0.42	1.02
B_{16} (yellow)	Nigeria	10.75	7.75	0.33	0.88
Mex. 5	Ghana	9.63	10.75	0.33	0.54
Samaru Comp. I	Nigeria	10.63	8.25	0.27	0.97
Samaru Comp. III	Nigeria	9.31	7.00	0.34	1.03
(Tuxpeño x Ant. Gpo. 2)	Mexico	10.50	7.06	0.30	0.91
PD (MS) 6 - gr. amar.	Mexico	12.00	8.69	0.37	0.97

Yield trials for the selections were grown at Poza Rica, Tlaltizapán, and Obregón in Mexico and by CIAT in Colombia for the lowland materials, and at Batán and Toluca in Mexico and at La Selva in Colombia for the highland materials.

Modifying kernel texture of opaque-2 materials in order to develop more normal-appearing grain has received high priority. The occurrence of irregularity in texture within opaque-2 converted materials suggested the practicability of selecting for such characteristics. Certain genetic backgrounds appear to contain higher frequencies of variation in kernel textures than others. These were chosen to allow recovery of as nearly normal-appearing grain as possible. The selected materials were successively intercrossed in a recurrent procedure and each of the visually selected progenies were analyzed in the laboratory to assure retention of adequate levels of protein and tryptophan. Laboratory analysis is essential to determine the level of tryptophan and lysine. As the recovery of normal-looking kernels proceeds, visual discrimination quickly becomes impractical.

At the same time that such normal-appearing kernels were recovered, information became available on the relative chemical characteristics of these materials. Table 16 gives the analyses of a series of several kernel texture categories varying from soft opaque to near normal appearance.

Even more detailed data is available on the chemical nature of the hard and soft fractions of the same materials. The amino acids glutamic, proline, alanine, isoleucine, leucine and phenylalanine tend to show a consistent increase in the hard-texture fractions. Protein level also tended to be higher while lysine and tryptophan tended to be somewhat lower (see Tables 17 and 18).

TABLE M14. Contribution of germ to the total kernel protein in different maize varieties and composites (representative sample out of 43 materials evaluated).

Variety	Country of origin	Contribution of germ to the total kernel protein, %	
		Normal	Opaque
Comp. A_2	India	10.5	25.6
J_1	Pakistan	10.9	27.7
PB_5	Thailand	5.5	22.9
(USA x Caribbean Composite)	Mexico	8.1	26.7
Rep. Dominicana Gpo. 1	Mexico	4.1	31.5
Oax. Gpo. 5	Mexico	13.3	30.7
Granada Gpo. 2	Mexico	9.5	34.3
Tamaulipas Gpo. 1	Mexico	7.0	23.6
(Cupurico x Fl. Compuesto)	Thailand	8.2	27.1
Centralmex	Brazil	7.2	22.5
Amagaceño	Colombia	7.4	11.1
UPCA-Var. 1	Philippines	3.1	23.5
UPCA-Var. 2	Philippines	9.3	29.8
B_{16} (yellow)	Nigeria	10.9	27.9
Gs-3	Ghana	8.8	26.0
Diacol 153	Ghana	3.9	18.8
Samaru Composite I	Nigeria	6.0	25.0
Samaru Composite III	Nigeria	5.1	25.4
Comp. grano duro	Mexico	20.2	35.3
Tuxp. x PD(MS)6)Sel. Amar.	Mexico	7.9	27.7

Trials of selections for shorter plants were made in many countries around the tropics in 1972. The trial shown was at Farm Suwan, Thailand, in cooperation with that country and IACP (Inter-Asian Corn Program). Differences in lodging resistance are evident.

TABLE M15. Grain yield in kg/ha at 15% moisture of CIMMYT opaque-2 composites' progenies, 1972B (average of three locations).

Set	Composite K [a] (opaque-2) check	CIMMYT [a] opaque-2 composite check	Tuxpeño [a] planta baja (normal) check	Chalqueño [b] O_2 comp.	Progeny range	Progeny mean	Mean of selected progenies	Selection differential %
Mean [a]	3197	3687	4489	...	2271- 4693	3584	4076	13.8
Mean [b]	...	...	...	7122	4004-10854	7429	8929	20.4

[a] Lowland tropical varieties.

[b] Highland variety.

Response of different maize germplasm to cold growing conditions is dramatically shown in this picture from Toluca, México. The plots of local selections from the area (right) are normal in appearance while materials originating in warmer areas (left) are pale and stunted.

TABLE M16. Percent protein and percent tryptophan in protein of different categories of modified opaque-2 kernels from different opaque-2 populations.

No.	Material	Protein in different kernel categories, %					Tryptophan in protein in different kernel categories, %				
		1	2	3	4	5	1	2	3	4	5
1.	Composite K	8.79	8.29	7.75	7.59	7.47	0.65	0.68	0.75	0.79	0.88
2.	PD (MS) 6-Gr. Amar.	11.07	10.50	10.25	10.44	9.94	0.87	0.79	0.85	0.85	0.93
3.	Composite Blanco Caribe	10.29	10.25	9.58	9.25	8.88	0.70	0.84	0.81	0.73	0.80
4.	(Tuxpeño x Ant. Gpo. 2)-#-#	9.99	9.84	9.65	9.08	...	0.79	0.79	0.82	0.85	...
5.	CIMMYT O_2 Composite	9.36	8.56	9.07	8.69	8.05	0.55	0.72	0.71	0.77	0.87
6.	Thai Opaque-2 Composite	8.58	8.50	8.43	8.82	7.86	0.82	0.80	0.83	0.82	0.93
7.	(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	9.04	8.72	9.06	8.90	8.71	0.63	0.63	0.70	0.74	0.75
8.	Yellow hard endosperm Comp.	7.82	7.16	7.36	7.88	7.33	0.92	1.00	0.94	0.91	0.98
9.	Ant. Gpo. 2-#1-3-2-#	8.98	8.80	9.24	9.07	...	0.76	0.87	0.88	0.84	...
10.	(PD [MS] 6 x Eto) (Cuba 11J)-Pob. Crist. #1(A)-2-#1-#	9.08	9.34	8.87	9.80	8.53	0.73	0.79	0.88	0.86	0.83

Category 1: more or less normal
Category 2: 75% translucent, 25% opaque
Category 3: 50% ,, 50% ,,
Category 4: 25% ,, 75% ,,
Category 5: 0% ,, 100% ,,

TABLE M17. Protein, lysine and tryptophan content in whole endosperm and in hard and soft fractions of the endosperm of modified opaqe - 2 lines.

Line	Protein, %			Tryptophan in protein, %			Lysine in protein, %		
	Whole endosp.	Fraction Hard	Fraction Soft	Whole endosp.	Fraction Hard	Fraction Soft	Whole endosp.	Fraction Hard	Fraction Soft
1. (PD(MS)6xEto)(Cuba 11J)-Pob. Crist. #1(A)-1-#-#	9.88	9.99	7.69	0.70	0.63	0.83	2.67	2.22	2.88
2. (PD(MS)6xEto)(Cuba 11J)-Pob. Crist.-#1-#1-#-#	8.75	8.49	9.13	0.87	0.77	0.87	2.81	2.60	3.30
3. Pob. Crist.-#1-#-#-#	9.42	10.21	8.43	0.73	0.55	0.72	2.73	2.43	3.36
4. Tropical opaque-2 Comp. 163-6-1-#1)(PD(MS)6-#-#-#-#	10.92	11.57	11.25	0.76	0.63	0.85	2.87	2.98	3.65

TABLE M18. Amino acid composition (%) of endosperm protein in hard and soft fractions of modified opaque-2 lines.

Amino acids in protein	(1) Soft	(1) Hard	(2) Soft	(2) Hard	(3) Soft	(3) Hard	(4) Soft	(4) Hard
Lysine	2.88	2.22	3.30	2.60	3.36	2.43	3.65	2.98
Histidine	3.06	3.75	3.41	3.78	3.38	3.52	3.70	3.61
Arginine	3.94	3.81	4.46	4.12	4.09	3.95	5.15	4.24
Aspartic acid	6.26	5.75	7.36	7.95	7.49	7.98	7.58	7.57
Threonine	3.26	3.67	3.45	3.54	3.42	3.61	4.01	3.68
Serine	3.83	4.52	4.04	4.29	3.84	4.32	4.58	4.39
Glutamic acid	16.09	20.59	17.25	21.68	16.70	25.24	17.55	20.62
Proline	9.29	10.61	8.97	10.39	9.05	10.98	9.79	10.37
Glysine	3.77	3.72	3.92	3.99	3.81	3.70	4.62	3.90
Alanine	5.20	6.40	5.54	6.74	5.20	7.14	5.88	6.42
Cisteine	1.38	0.77	...	0.48	0.24	1.42	1.11	0.84
Valine	3.43	4.30	5.02	5.14	4.82	4.86	9.40	4.71
Methionine	1.56	1.26	1.19	1.18	1.51	1.32	1.57	1.30
Isoleucine	2.00	2.82	3.30	3.47	3.02	3.43	3.06	3.16
Leucine	8.00	10.98	9.17	10.95	8.28	12.32	9.62	11.23
Tryosine	2.60	2.77	1.91	3.05	2.24	3.41	2.85	2.59
Phenylalanine	3.25	3.94	3.78	4.12	3.45	4.32	3.99	4.12
Tryptophan	0.70	0.63	0.82	0.93	0.85	0.65	0.84	0.72

(1): (PD(MS)6 x Eto) (Cuba 11J)-Pob. Crist. #1 (A)-1-#-#
(2): (PD(MS)6 x Eto) (Cuba 11J)-Pob. Crist.-#1-#1-#-#
(3): Pob. Crist.-#1-#-#-#
(4): (Tropical O_2 Composite 163-6-1#1)(PD(MS)6Gr.Amar. #-#-#-#

Two populations of the recovered hard modified kernels were compared with their normal and soft opaque counterparts for the acid-soluble, zein and glutelin fractions of protein. Acid-soluble and glutelin fractions were higher in the opaque and modified-opaque types than in the normal grain, while zein was lower. The hard-kernel modified-opaque material appeared to be slightly higher in zein than the soft opaque, but not markedly different. See Table 19.

As selection is carried out for hard kernels, the relationship of tryptophan to protein content may also become modified. Ranges in protein levels and their corresponding tryptophan values are shown in

TABLE M19. Protein fractions in normal, opaque and modified opaque-2 samples of two populations.

Population	Type of sample	Protein fractions in endosperm, %					
		Acid soluble		Zein		Glutelins	
		Actual	% of Normal	Actual	% of Normal	Actual	% of Normal
1. (Ver. 181xAnt.Gpo.2) (Ven. 1)	Normal	27.0	100.0	42.3	100.0	19.8	100.0
	Opaque	39.7	147.0	24.2	57.2	31.3	158.1
	Modified	35.0	129.6	26.3	62.2	29.3	148.0
2. White Composite	Normal	32.5	100.0	45.2	100.0	19.0	100.0
	Opaque	35.0	107.7	25.4	56.2	31.4	165.3
	Modified	33.5	103.1	26.7	59.1	28.5	150.0

On the left, Tuxpeño cycle 0 and the same population after 8 cycles of full-sib selection on the right. Reduction in plant and ear height has been about 70 cm without any appreciable reduction in yield potential.

Table 20. Effects of this on the quality of the whole grain can be appreciated by comparing the protein levels and tryptophan contents listed in Tables 20 and 21.

Tests weights of the recovered modified hard opaque kernels varied from one material to another, but tended to approach the test weights of normal grain. Precise data about the effect of this characteristic on

TABLE M20. Range in protein and tryptophan values in hard endosperm opaque-2 populations undergoing selection and recombination.

S. No.	Population	Cycle of selection	No. of full-sib families	Range in protein values in endosperm	Mean % protein	Range in % trypt. in protein	Mean % trypt. in protein	Frequency of accept. families, %
1	(Ver.181 x Ant.Gpo.2) (Vent. 1)	3	390	5.12-11.88	8.48	0.51-0.96	0.70	58.9
		4	375	6.12-10.63	8.06	0.56-1.23	0.84	82.9
2	Composite K (H-E)	3	205	6.56-12.50	9.19	0.51-0.80	0.65	55.1
		4	182	5.44-10.81	8.14	0.71-1.10	0.87	87.9
3	White Hard Endosperm Opaque-2 Comp.	1	153	6.31-10.63	8.76	0.51-1.17	0.75	77.8
		2	182	5.68-11.38	8.15	0.59-1.32	0.90	90.0
4	Yellow Hard Endosperm Opaque-2 Composite	2	313	4.88- 9.94	7.54	0.56-1.11	0.83	69.7

TABLE M21. Protein lysine and tryptophan in whole grain of opaques and modifieds in two populations.

S. No.	Material	Phenotype	Protein, %	Trypt. in protein, %	Lysine in protein, %
1	Composite K(H-E)C_3	Opaque	9.63	1.05	4.51
		Modified	10.38	1.02	4.27
2	(Ver.181xAnt.Gpo.2) (Ven. 1) (H-E)	Opaque	9.88	0.97	4.71
		Modified	9.69	0.97	4.72
3	Yellow Hard Endosp. Opaque-2 Comp.	Opaque	10.38	1.16	4.51
		Modified	9.38	0.80	4.71
4	Thai Opaque-2 Comp. (H-E)C_2	Opaque	10.13	1.20	4.80
		Modified	9.94	0.78	3.99
5	White Hard Endosp. Opaque-2 Composite	Opaque	7.94[a]	1.03[a]	3.60[a]
		Modified	8.31[a]	1.00[a]	3.12[a]

[a] Endosperm analysis.

TABLE M22. Grain yield of normal, modified and opaque versions of five different populations.

Population	Yield, kg/ha at 15% moisture		
	Normal	Modified	Opaque
Composite K	4,767	4,010	4,072
Yellow Hard-Endosperm Composite	4,685	4,338	3,621
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	3,928	4,235	3,176
CIMMYT Opaque-2 Composite	5,238	4,419	3,744
White Hard-Endosperm Composite	5,606	4,460	4,113

grain yields are not yet available, but yield losses associated with the opaque gene should become minimized. Preliminary results of the hard-endosperm selection on yield are given in Table 22.

An inheritance study of the behavior of the modifying factors involved in the hard-endosperm opaque-2 recovered types has been undertaken. Preliminary results of this study indicate that additive variance associated with the analysis is more important than dominance variance. Dominance was partial. Reciprocal crosses between contrasting types resulted in an apparent difference in phenotype of the crossed seeds. Grain from soft female parents tended to be soft, while the grain from hard-kernel plants showed a high degree of modified kernels. This may be no more than the dosage effect of the genes in the endosperm of the grain as a reflection of how endosperm tissue develops. The study thus far suggests that any breeding system that enables the accumulation of the modifying factors

TABLE M23. Grain yield of uniform opaque-2 trial, 1972 B.

Entry No.	Pedigree	Grain yield (kg/ha at 15% moisture)			
		Poza Rica	Tlaltizapán	Obregón	Batán
1	(Ver. 181 x Ant. Gpo. 2)	2733	4177	2304 (10)	1140
2	Thai Opaque-2 Composite	2709	5163 (4)	2241	1403
3	Composite K (E) C_1	2801	4476	2489 (1)	1549
4	CIMMYT Opaque-2 Composite	3269 (7)[a]	4942	2309 (9)	2553 (3)
5	Flint Compuesto Amarillo	3220 (8)	5022 (7)	1988	1919 (7)
6	Nicarillo	3069 (10)	4428	1968	1900 (8)
7	(Tuxp. x PD [MS] 6)-Sel. Amar	3137 (9)	5564 (1)	2333 (7)	1968 (5)
8	Opaque-2 in flint	2772	4936 (10)	2022	1939 (6)
9	Cuba 11 J	2129	4273	2392 (4)	1218
10	Población Cristalina	3405 (4)	4285	2358 (5)	2446 (4)
11	Tuxpeño Selection	2952	4255	2446 (3)	740
12	(Mix. 1 x Col. Gpo. 1) (Eto)	3517 (2)	5103 (5)	2358 (6)	926
13	La Posta	3464 (3)	5384 (3)	2241	926
14	Compuesto Blanco Caribe	3337 (5)	4972 (9)	2182	1734 (9)
15	Compuesto Grano duro	3293 (6)	4823	2148	3274 (2)
16	Foremaíz-1 Opaco-2	2821	5050 (6)	2226	1179
17	(Comp. K x La Posta)	3634 (1)	4775	2450 (2)	1588 (10)
18	(Tuxpeño x Ant. Gpo. 2)	2660	4303	1822	1130
19	Composite II	2148	3729	1744	1510
20	PD (MS) 6-Gr. Amar.	2777	3992	2324 (8)	1569
21	Venezuela 1 opaco-2	3020	4990 (8)	1837	1267
22	Composite I	97	1231	...	10318 (1)
23	**Tuxpeño-br_2br_2 o_2o_2**	2592	4422	2109	711
24	Agroceres 504	2674	5390 (2)	2285	799
	Normal Check	4282	6101	3059	11877

[a] Rankings of the 10 top opaque-2 entries are in parentheses.

TABLE M24. Grain yield of uniform opaque-2 trial, 1972A.

Pedigree	Yield (kg/ha at 15% moisture)		Average
	Poza Rica	Tlaltizapán	
(Ver. 181 x Ant. Gpo. 2)	3127	6807 (2)	4967 (6)
Thai opaque-2 composite	3313	6215 (10)	4764
Composite K (E) C_1	3634 (10)[a]	6113	4873 (10)
CIMMYT opaque-2 comp.	4345 (4)	6741 (3)	5543 (1)
Flint Comp. Amarillo	3108	6741 (4)	4924 (7)
Nicarillo	3907 (7)	5623	4765
(Tuxp.x PD(MS) 6) Sel. Amar.	3741 (9)	6054	4897 (9)
Tuxp. Selection	4375 (3)	5342	4858
(Mix. 1xCol.Gpo.1) (Eto Bl.)	4453 (1)	6633 (5)	5543 (2)
La Posta	4004 (5)	6448 (5)	5226 (5)
Comp. Blanco Caribe	3410	6221 (9)	4815
Comp. grano duro	3858 (8)	6920 (1)	5389 (3)
Foremaíz-1 opaco-2	3400	6227 (8)	4813
(Composite K x La Posta)	4423 (2)	6352 (7)	5387 (4)
PD(MS)6-Gr. Amarillo	4180 (5)	5665	4922 (8)
Tuxpeño Pl. Baja Normal Check	4014	6848	5431

[a] Rankings of the 10 top opaque-2 entries are in parentheses.

as an additive trait should be effective in developing hard-endosperm opaque-2 varieties.

To maintain current information on the relative performance of the more advanced opaque-2 conversions as varieties, they are regularly compared in yield trials. Such a trial of 25 entries was grown at four locations at CIMMYT stations during 1972. Certain materials performed consistently well at all locations in both planting seasons, although the normal types generally outyielded the opaque materials. Seed used for these trials is not from the most recent cycle of selection due to seed availability. Results are shown in Tables 23 and 24.

Disease-Insect Interactions in Quality-Protein Maize

Documented information concerning the reaction of opaque-2 maize materials to insects and pathogens is rather limited. However, the available reports indicate that there may be an association between the soft opaque-2 endosperm and susceptibility to *Fusarium* ear rots and stored-grain insects.

To make valid comparisons, the opaque-2 gene should be present in similar genetic backgrounds. Recently, such maize populations adapted to high-altitude, subtropical and tropical environments have been available. On the average, the maize varieties used throughout the present work have undergone three backcrosses and the modified types have been selected for at least three cycles.

Field Insects and Diseases

A set of 15 varieties, including the normal and its opaque version in each case, were tested in humid tropical, semiarid tropical and subtropical environments (Poza Rica, Obregón and Tlaltizapán, respectively). Also, a group of opaque-2 converted varieties and their normal counterparts were observed in two high-altitude environments (Batán and Toluca).

In addition, another group of varieties, including the normal, opaque-2, and modified types in each case, were used to determine the rate of ear drying and the reaction of each type to different fungi and ear-feeding insects in a humid tropical environment (Poza Rica) and a subtropical environment (Tlaltizapán). Field trials were established using 5-meter-row plots replicated four times in a split-plot design, where the main plot was the variety and the subplot was the endosperm version--normal, opaque or modified.

The following fungi and insects were observed.

Ear rots: *Fusarium moniliforme, Fusarium roseum, Diplodia maidis* and *Diplodia macrospora.*

Earworms: *Diatraea saccharalis* and *Heliothis zea.*

Rusts and blights on foliage: *Puccinia sorghi, Puccinia polysora, Helminthosporium turcicum* and *Helminthosporium maidis.*

Insects on foliage: *Spodoptera frugiperda* and *Diatraea saccharalis.*

Stalk rots: *Fusarium moniliforme.*

Stem borer: *Diatraea saccharalis.*

Stored-grain fungi: *Penicillum* sp. and *Aspergillus* spp.

Stored-grain insects: *Sitophilus zeamais* and *Sitotroga cerealella.*

The reaction of the varieties in the field was determined under natural incidence of insect pests and pathogens, except for rust (at El Batán), *Diplodia* ear rot, stalk rots, and stored-grain fungi and insects, which were artificially placed on the appropriate plant parts.

The incidence of *Fusarium* in the set of 15 materials was highest in the humid tropical environment of Poza Rica. The mean reaction of the varieties indicated that about 50 percent of the opaque version was affected by *Fusarium*, while incidence on the normals was below 30 percent. There was an extreme degree of susceptibility in some genetic backgrounds, while in others, the differences between normal and opaque versions were not so great. This performance was also similar in the other environments for several populations.

In the irrigated semiarid tropical environment of Obregón, *Fusarium* ear rotting was next highest in frequency. Again, the incidence on the opaque versions was significantly higher than on the normal types. On the average, about 40 percent of the opaque ears had *Fusarium* compared to less than 10 percent of the normals.

In the subtropical environments of Tlaltizapán about 20 percent of the opaque harvest was affected by *Fusarium* compared to slightly less than 10 percent of the normals.

At Batán, located in the Valley of Mexico, the susceptibility of the tested populations was also evident. More than 30 percent of the opaque harvest was damaged by *Fusarium* compared to nearly 15 percent of the normal types. At Toluca, the other high-altitude environment, the incidence was the lowest of all locations. However, the opaque versions also showed a significatly higher rate of ear rot caused by *Fusarium.*

At three (Obregón, Tlaltizapán and Batán) of the five highly contrasting environments, significant differences among populations were determined. The normal versions of Compuesto Blanco Caribe, La Posta and (Ver. 181 x Ant. Gpo. 2) (Ven. 1), and the opaque-2 versions of Nicarillo, Compuesto K, Compuesto Blanco Caribe and (Tuxpeño x PD (MS)6) were, on the average, the materials with the lowest *Fusarium* ear-rot incidence. Among the high-altitude maize populations, Compuesto J and Mexico Gpo. 10 were the least susceptible.

When normal, opaque and modified versions were compared (Table 25), again the opaque-2 converted materials showed a significantly higher *Fusarium* incidence at Poza Rica. At Tlaltizapán there were no significant differences, but the ear-rotting rate was higher in the opaque versions.

This information seems to confirm previous reports. Regardless of genetic background or environment, the opaque-2 and modified versions showed significantly higher incidences of *Fusarium* ear rots than their normal counterparts. However, variations in reaction in space and time have also been reported. Thus, agronomic conditions under which the crop is grown and prevalence of a given race of the fungus may accentuate differences between opaque and normal materials.

Incidence of *Diplodia* ear rot was very similar among the normal, opaque and modified versions (Table 26).

In general, the information indicates a tendency for the opaques to be more damaged by earworms (*Heliothis zea* and *Diatraea saccharalis*) than normals in the four environments sampled. The range in reaction among the tested materials suggests that the degree of susceptibility varies among genetic backgrounds. A close association between earworm damage and *Fusarium* was observed in most environments. The materials with lowest

TABLE M25. Natural incidence of Fusarium **ear rot on normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Poza Rica, Veracruz, 1972.**

Population	Damaged ears, %		
	Normal	Opaque	Modified
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	32	53	60
Compuesto K	23	62	64
Compuesto Bl. Caribe	50	44	63
Compuesto CIMMYT	34	68	56

Fusarium incidence, such as Compuesto Blanco Caribe, Nicarillo, La Posta and (Veracruz 181 x Antigua Gpo. 2) (Venezuela 1), also had the least damage from earworms.

The same tendency was evident in the group of varieties where the three types--normals, opaques and modifieds--were observed.

The stem borer ear injury at Poza Rica (Table 27) and the earworm damage at Tlaltizapán (Table 28) were about 15 percent and 6 percent greater in the modified types than in the normals, respectively. The incidence on the opaques was intermediate between the other two types. In the high-altitude environments, there were no significant differences; however, at El Batán, the opaque versions were damaged twice as much as the normal counterparts.

TABLE M26. Incidence of Diplodia **ear rot artificially inoculated on normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Poza Rica, Veracruz, 1972.**

Population	Damaged ears, %		
	Opaque	Normal	Modified
Compuesto K	27	29	27
Compuesto Bl. Caribe	29	35	31
Compuesto CIMMYT	37	23	37
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	31	43	38

Antonio Mercado (right), visiting scientist from the Philippines, participates in the breeding-production program of high-quality-protein maize. He and Dr. S. K. Vasal of the CIMMYT resident staff screen the best ears for the next cycle of selection at the Poza Rica Station, México.

Rusts are among the important foliar pathogens (Table 29). Records on their incidence did not reveal differences among normal, modified or opaque types in either of the environments sampled (Poza Rica and Batán). Differences in susceptibility were observed among maize populations at Batán.

Foliar damage by the budworm was significantly greater in opaques than in modifieds and normals (Table 30). There were no differences between normal and modified versions. However, in other tests, there were no differences between normal and opaque versions.

Foliar damage by the stem borer was similar in normal, opaque and modified types at Tlatizapán and Poza Rica (Table 31). Also, no differences were detected between normal and opaque versions for incidence of *Fusarium* stalk rot and stem borers on the stalks at Tlaltizapán and Poza Rica (Tables 32 and 33). The observed differences among materials could be associated with an already known reaction to insects rather than to the presence or absence of the opaque-2 gene.

TABLE M27. Natural incidence of the stem borer (Diatraea saccharalis) **on ears from normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Poza Rica, Veracruz, 1972.**

Population	Damaged ears, %		
	Normal	Opaque	Modified
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	25	42	32
Compuesto Blanco Caribe	43	45	54
Compuesto K	33	51	61
Compuesto CIMMYT	44	47	55

These data do not prove that the endosperm character associated with the opaque-2 gene is associated with the reaction to foliar- or stem-damaging agents. Obviously, increased susceptibility of opaque-2 converted materials could be expected in the early generations if a nonadapted opaque-2 donor is used in the cross.

Earlier it was indicated that there seems to be a clear association between opaque-2 endosperm and incidence of *Fusarium* ear rot. Attempts were made to determine to what extent, if any, the known higher kernel moisture content of opaque materials contributed towards this increased susceptibility. The trials were conducted under humid-tropical and subtropical environments (Poza Rica and Tlaltizapán).

TABLE M28. Natural incidence of the earworm (Heliothis zea) **on normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Tlaltizapán, Morelos, 1972.**

Population	Damaged ears, %		
	Normal	Opaque	Modified
Compuesto Bl. Caribe	15	12	13
Compuesto CIMMYT	14	12	18
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	8	19	18
Compuesto K	14	19	24

TABLE M29. Natural incidence of rust (Puccinia polysora) **on normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Poza Rica, Veracruz, 1972.**

Population	Rust incidence index[a]		
	Normal	Opaque	Modified
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	2.2	2.0	2.2
Compuesto K	2.2	2.7	2.5
Compuesto Bl. Caribe	2.5	2.5	2.7
Compuesto CIMMYT	2.7	2.5	3.0

[a] Index: 1 = no damage; 5 = severe damage.

Although there was a low incidence of *Fusarium*, there were clear differences in susceptibility. The opaque-2 types were damaged more than the normals.

The pattern of ear drying in most varieties were similar in both environments. The normals had 2 to 3 percent lower ear moisture than the opaques, and the modified versions were intermediate between the two.

It remains to be determined whether or not differences in ear moisture of 1 to 3 percent are biologically significant in favoring a higher incidence of *Fusarium* ear rot in the opaque types. However, the available information suggests an association. Incidence of *Fusarium* seems to be associated with the incidence of earworms, particularly at Poza Rica.

TABLE M30. Natural incidence of the budworm (Spodoptera frugiperda) **on foliage from normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Poza Rica, Veracruz, 1972.**

Population	Damaged plants,[a] %		
	Modified	Normal	Opaque
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	15	20	24
Compuesto Bl. Caribe	9	20	32
Compuesto K	17	18	31
Compuesto CIMMYT	20	28	31

[a] Leaf feeding.

Stored-Grain Insects

Susceptibility of the weevil *Sitophylus zeamais* varied among types within varieties. Compuesto K was the least-damaged population, regardless of type, while Veracruz 181 x Antigua Group 2 x Venezuela had the highest emergence of weevils and the heaviest damage.

The pattern of susceptibility to weevils seems clear (Table 34). In every case, the normals were the least-damaged type. In Compuesto K and Compuesto CIMMYT, insect emergence rates were twice as high in the modified version as in the normals, whereas in Veracruz 181 x Antigua Gpo. 2 x Venezuela and Yellow Hard-Endosperm Composite there was practically no difference between the normal and modified types. On the average, emergence rates for the opaque versions were three to four times higher than for normals. Differences in weevil damage and emergence between normals and modified types may not be significant.

Except for Yellow Hard-Endosperm Composite, moth (*Sitotroga cerealella*) emergence was slightly higher in the opaque versions than in the modified or normal types. On the average, there were no differences in moth emergence between the normal and the modified types.

Susceptibility to some of the most important stored-grain insect pests may be considerably reduced as progress is made in reducing the soft endosperm portion of the opaque-2 types.

TABLE M31. Natural incidence of the stem borer (Diatraea saccharalis) **on plants from normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Poza Rica, Veracruz, 1972.**

Population	Damaged plants,[a] %		
	Normal	Opaque	Modified
Compuesto K	46	49	47
Compuesto Bl. Caribe	53	48	50
Compuesto CIMMYT	48	47	57
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	52	56	49

[a] Leaf feeding.

Stored-Grain Fungi

Normal, modified and opaque kernels from several gentoypes were subjected to inoculations of *Penicillium* and *Aspergillus* at 75 and 85 percent relative humidity. There were differences among the genotypes, but no indication that endosperm type influenced the growth rate of the fungi.

Only a slight decrease in seed germination in the three endosperm types was evident when the relative humidity was held at 75 percent. At 85 percent relative humidity, germination decreased about 45 percent in all three versions.

Relationships between grain moisture, fungal development and germination reduction were not clear when the data from each population were considered separately. However, the observations suggested that fungal development in some populations could be more closely associated with moisture level rather than with the kind of substratum on which they were being grown.

TABLE M32. Incidence of Fusarium **stalk rot artificially inoculated on normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Tlaltizapán, Morelos, 1972.**

Population	Stalk rot incidence index[a]		
	Opaque	Normal	Modified
Compuesto CIMMYT	3.7	3.6	3.5
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	3.7	3.6	3.8
Compuesto Bl. Caribe	3.5	3.8	3.9
Compuesto K	3.5	3.8	4.1

[a] Index: 1 = stalk rot free; 5 = three or more internodes rotted.

TABLE M33. Natural incidence of the stem borer (Diatraea saccharalis) **in stems from normal, opaque-2 and modified opaque-2 endosperm versions of four maize populations observed at Poza Rica, Veracruz, 1972.**

Population	Damaged internodes, %		
	Modified	Normal	Opaque
Compuesto Bl. Caribe	14	17	28
Compuesto K	31	28	27
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	27	27	32
Compuesto CIMMYT	27	37	27

TABLE M34. Percent emergence of maize weevils and angumois grain moths from normal, opaque and modified endosperm versions of four maize populations, El Batán, México, 1972.

Population	Endosperm version		
	Normal	Modified	Opaque
WEEVIL, *Sitophilus zeamais*			
Compuesto K	5	13	15
Yellow Hard End. Comp.	17	18	29
Compuesto CIMMYT	8	19	56
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	16	20	55
MOTH, *Sitotroga cerealella*			
Compuesto K	65	72	74
Compuesto CIMMYT	70	66	79
Yellow Hard End. Comp.	83	60	74
(Ver. 181 x Ant. Gpo. 2) (Ven. 1)	69	87	93

AGRONOMY AND PHYSIOLOGY

The agronomy-physiology efforts were concerned with two main activities: (1) continued development of a series of maize physiology field trials to provide information for use in the breeding program to guide selection and yield improvement and (2) initiation of two series of agronomy trials to develop efficient systems of production, using the best varieties currently available and comprising on-farm trials in Mexico and international agronomy trials. The trials on experiment stations in Mexico have a dual function--investigation and training.

Maize Physiology

Several studies of the growth and yield of tropical maize have been completed. To provide some measure of the effect of different environments on growth and yield, studies were carried out at CIMMYT's three main maize experiment stations. A summary of the meteorological data for these three stations is shown in Fig. 4 and Table 35. These stations provide a range of temperature environments for testing materials. At Poza

Rica and Tlaltizapán two crops of maize can be grown each year. This provides a further contrast since the temperatures from December to May, when the winter crop is in the field, are usually lower than temperatures from June to October when the summer crop is grown. The results of two such trials, one at Poza Rica and the other at Tlaltizapán, are shown in Fig. 5.

The varieties used were selections of short plants of Tuxpeño and of Tuxpeño x Eto. These are two of the most advanced populations of tropical maize from the CIMMYT breeding program. These materials can be grown at much higher plant populations and with much higher levels of nitrogen than taller varieties which tend to lodge under such management. Plant populations of 50,000, 100,000 and 150,000 plants per hectare were tested. Only the results for the highest and lowest populations are shown.

These results show several interesting points. The rate of dry matter production and the total dry weight produced increased with plant population. Furthermore, the rate of dry weight production, or the "crop growth rate", at Poza Rica was as high as or higher than the rate at Tlaltizapán. Thus, from this and other similar experiments there is little evidence to support the view that crop growth rate limits yield in the lowland tropics.

In these and other experiments grain yield increased with increases in plant population. Even so, it seems that grain yield is limited because a large proportion of the crop dry weight is vegetative growth and grain yield is only a small proportion of the dry weight produced.

Thus, for example, from 13 to 16 weeks after sowing, at which time--depending on variety and location--accumulation of dry weight in the grain began, both varieties had produced between 16 and 20 tons of dry matter per hectare at the high plant population. Furthermore, after silking the rate of increase of dry weight for the grain was smaller than that for total dry weight for both varieties and at both population densities.

In other words, only a part of the dry weight produced after silking was going into the grain. A similar unfavorable pattern of dry weight distribution has now been observed in several trials, including one at El Batán in which five highland varieties were studied.

Examining the components of grain yield to identify those that account for differences in yield between varieties and plant populations provides some indication of what factors appear to be limiting grain yield and what might be done to increase yield and overcome the present unfavorable distribution of dry weight. The grain yields and the components of yield that correspond to the dry weights given in Fig. 5 are shown in Fig. 6. The yields at Tlaltizapán were greater than those at Poza Rica and at both sites Tuxpeño yielded more than the variety cross. Grain yield increased with plant population up to 150,000 plants per hectare, or three times the population normally recommended in most countries. The largest yield (8.3 tons of oven-dry grain per hectare, or 9.5 tons at 15 percent moisture) was from Tuxpeño at Tlaltizapán at the highest population.

The top two graphs in Fig. 6 show that grain yield is almost proportional to grain number per unit area, which ranges from 2,000 to 4,000 grains/m^2. In other words, plant population had only a comparatively small effect on grain size. The number of grains per unit area is the product of the number of ears per unit area and the number of grains per ear. In both varieties at high plant population there were fewer ears than plants because some plants were barren. However, there were fewer barren plants at Tlaltizapán than at Poza Rica, and at the highest population at Tlaltizapán, Tuxpeño produced more ears than the variety cross. The bottom-right graph in Fig. 6 shows that as the number of ears per unit area increased with plant population, the number of grains per ear decreased, but at each population the number of grains per ear was larger for Tuxpeño than for the cross. It was these differences which accounted for the larger number of grains per meter and, consequently, the larger yield of Tuxpeño.

TABLE M35. Climatic data for maize experiment stations in Mexico (1972).

	Station					
	Poza Rica		Tlaltizapán		El Batán	
Month	Rainfall [a]	Evaporation [b]	Rainfall	Evaporation	Rainfall	Evaporation
January	123.5	2.6	0.3	5.2	6.4	4.2
February	39.2	3.2	0.0	7.0	0.0	5.8
March	39.3	4.6	4.8	9.0	11.8	6.3
April	26.2	5.8	43.4	8.9	54.7	7.4
May	100.9	6.0	44.0	8.6	120.5	7.9
June	254.1	5.3	246.4	7.5	111.8	6.0
July	234.2	4.9	102.9	7.2	130.7	5.1
August	240.2	5.4	76.4	7.3	85.8	5.2
September	109.6	5.7	171.8	6.9	79.0	4.7
October	182.4	4.6	22.3	5.9	30.3	4.4
November	52.5	3.4	7.2	5.6	16.5	4.2
December	31.2	2.8	0.4	5.9	1.0	3.8
Total	1433.3		719.9		649.5	

[a] Rainfall: monthly totals, mm.

[b] Evaporation: USWB Class A, mm/day.

Table 36 shows the results of experiments in which the differences in yield between closely related tall, short and brachytic forms of Tuxpeño were examined. The tall Tuxpeño was prone to lodging and was, therefore, grown at lower plant populations (25,000 and 50,000 plants per hectare) than the short Tuxpeño or the brachytic forms (50,000 and 100,000 plants per hectare). The tall Tuxpeño at 50,000 plants per hectare gave the greatest yield (5.8 tons/ha.), but the yield of the short Tuxpeño at 100,000 plants per hectare was only slightly less (5.6 tons). The difference in yield

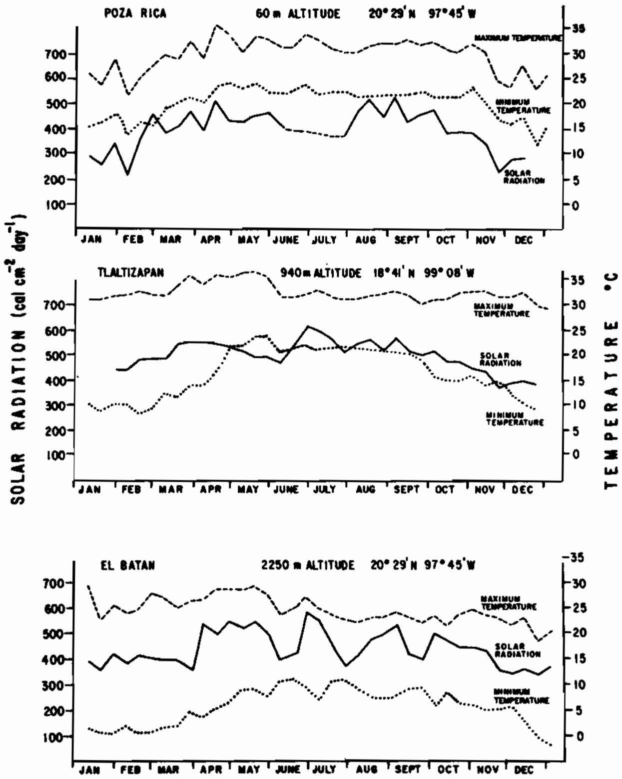


FIG. 4. Climatic data (10-day means) for CIMMYT's Poza Rica, Tlaltizapan and El Batan experiment stations in Mexico (1972).

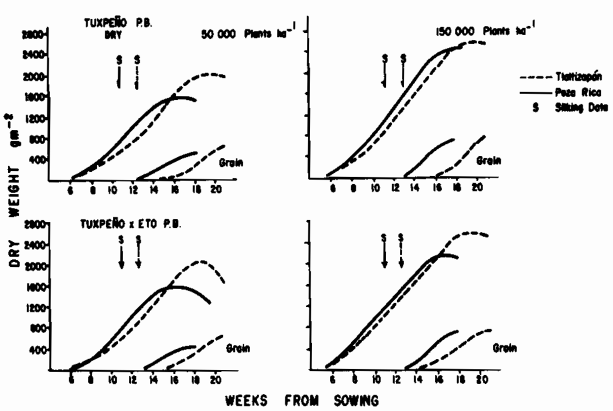


FIG. 5. Dry weight and grain yield of maize grown in two different environments in Mexico.

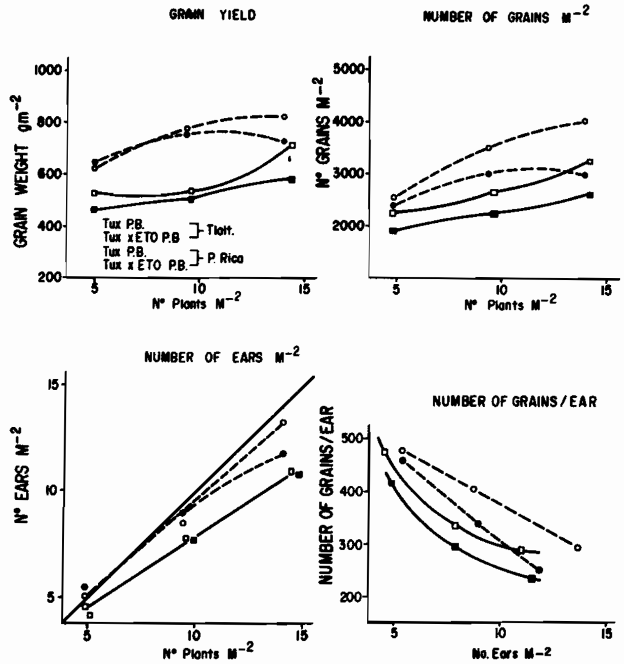


FIG. 6. An analysis of components of grain yield.

was accounted for almost entirely by a difference in grain size, since the number of grains/m^2 was similar in the two varieties. This suggests that one previously unrecognized effect of selection for short plants has been a decrease in grain size.

However, the short plants in this comparison were from early cycles of selection and although they were earlier than the original tall Tuxpeño, probably 100,000 plants per hectare, at which more recent selections give best yields, was above the optimum population. The yield of the short Tuxpeño was larger and increased more with higher plant populations than the yield of either of the brachytics. As in the previous experiments, the differences in yield were determined mainly by differences in the number of grains/m^2. At 50,000 plants per hectare, the difference in the number of grains and, consequently, in yield, was accounted for mainly by the larger number of grains per ear on the short-plant selection.

However, at the higher population differences between varieties in the number of grains per ear were small, but the short Tuxpeño produced more ears/m^2 than either of the brachytics. Even so, 26 percent of the plants of the short Tuxpeño were not contributing to yield at this population. In the brachytics the percentages were even larger, 44 percent and 32 percent. All four of these Tuxpeños exhibited an unfavourable pattern of dry weight distribution similar to that shown in Fig. 5.

It seems unlikely from the evidence of these and corresponding experiments with highland tropical varieties that crop growth rate per se limits the grain yield of tropical maize. The problem is more one of distribution of dry weight and, in the lowland tropics, a comparatively short period of dry weight accumulation in the grain. It seems, therefore, that there is probably considerable scope for developing plants in which a much larger proportion of the resources available are used to produce grain.

The varieties described usually produce about 2,500 grains/m^2 at populations of about 40,000 or 50,000 plants per hectare. This number can be increased by increasing plant population, but with the materials available and at the plant populations needed to produce, for example, 4,000 grains/m^2, a large proportion of the plants are barren.

For selection to be effective in breeding nurseries, plants have to be relatively widely spaced (about 40,000 plants per hectare). There is, therefore, a need to find ways of eliminating most or all of the loss resulting from barreness and the loss associated with a decrease in the number of grains per ear as plant population is increased.

There are two ways in which this might be done. The first is to have a companion nursery at a population of 80,000 to 100,000 plants per hectare. Families that do not tolerate the higher plant population can then be identified and discarded. This system would add another selection variable to the entire breeding program.

A second approach is to examine more thoroughly the potential of early maturing tropical maizes. They have a shorter period of vegetative growth and appear to have a more favourable dry weight distribution.

Active participation and a sense of involvement and dedication in the acceleration of maize production is emphasized by the CIMMYT training program. Ing. Roberto Vega L., former trainee from El Salvador, is a strong supporter of the national maize program in his country.

In the nurseries with widely spaced plants, the yield of early varieties with a smaller leaf area per plant compares unfavorably with the yield of tall, leafy tropical varieties like Tuxpeño. However, in a small plot test last year an extremely early variety, which produces 11 or 12 leaves compared with 24 for Tuxpeño, was sown at 25 plants/m^2. This is an appreciably greater plant density than it has been possible to maintain with larger plant varieties, yet every plant produced an ear. However, any such materials available are susceptible to leaf diseases and ear rots.

CIMMYT has initiated very early maturing populations by combining into two or three populations all of the extremely early and small plant types that it has been able to collect from around the world. These populations are in the early stages of development but should provide material that can be very intensively managed. In addition, these populations should provide very early material for areas of the world needing varieties that will mature in 90 days or less.

Phenology Studies

CIMMYT is concerned with the development of widely adapted maize varieties which will meet the varied climatic requirements of the world. To obtain more information on the basis of maize adaptation, a study is being made of the effects of variation in day length and temperature with season and site on maize development. Most of the observations are being made at the three main experiments stations in México, which are approximately the same latitude (about 20° N) but which differ in altitude. Limited additional observations are being taken at sites 4° N in Colombia in cooperation with CIAT and at 40° N in cooperation with Purdue University. The data suggest that between latitudes 30° N and 30° S most of the variation in time to flowering can be accounted for by differences in temperature. The data now available will be used to construct a model to guide selection of materials that are likely to be suitable for use at a given location and to fit a given growing season.

Maize Agronomy Trials

On-Station Trials in México: There are two main objectives in this series of trials: (1) to develop from the best available technology, practical and efficient systems of production and (2) to teach production trainees the principles of field experimentation. Some nine varieties in combination with plant population, fertilizer, insecticide and herbicide treatments have been included in six basic experiment designs. The trials are at Poza Rica and Tlaltizapán.

International Agronomy Trial: A variety of locations were chosen in different parts of the world to test the materials in as wide a range of environments as possible. The locations chosen for the first set of trials were: Colombia, Egypt, Kenya, Nepal, Nigeria, Pakistan, Philippines, Thailand, Zaire and México (Obregón, Poza Rica, Río Bravo and Tlaltizapán). The trial consisted of eight varieties (seven from CIMMYT and one variety chosen from local material) grown under four nitrogen treatments (0, 75, 150 and 225 kg/ha) in a randomized complete block design with three replications.

Since this was the first attempt at an international

TABLE M36. Grain yield and yield components of four tuxpeños.

	Plants/m²	Variety CR.I	PB	BR	BRPB
Grain yield tons/ha	2.5	3.81	...	4	...
	5	5.81	4.82	3.57	3.67
	10	...	5.61	4.02	3.97
1000-kernel weight, g	2.5	296	...	...	...
	5	282	237	242	229
	10	...	229	242	220
Kernels/m²	2.5	1285	...	...	...
	5	2057	2039	1480	1601
	10	...	2451	1651	1802
Kernels/ear	2.5	514	...	...	...
	5	457	429	333	327
	10	...	331	296	265
Ears/m²	2.5	2.5	...	...	...
	5	4.5	4.8	4.5	4.9
	10	...	7.4	5.6	6.8

Source: J. Yamaguchi.
CR.I = Tuxpeño crema I.
PB = Tuxpeño short plant selection.
BR = Tuxpeño brachytic.
BRPB = Tuxpeño brachytic short plant selection.

agronomy trial, the experimental design was kept simple with few varieties. As the cooperators indicate the ease or difficulty in setting out such trials, modifications will be made in the design and selection of the materials to be used. If certain varieties are not widely adapted they will be dropped from the trial. When outstanding varieties from local materials are identified, they will be put into the trial and given wider distribution.

INSECT CONTROL

Budworm and Corn Stem Borer Control with Insecticides

Even though the ultimate goal of CIMMYT is developing maize populations resistant to the main insect pests, information about their chemical control is necessary. Experiments were designed to gather information with respect to the efficiency of several systemic insecticides for controlling budworm (*Spodoptera frugiperda*) and stem borer, to investigate the advantage or disadvantage of using insecticides in granular form versus sprays, and to study timing of the applications and to determine the effectiveness of alternated plant treatment with granules to the whorl. The effectiveness of insecticides was measured by weekly counts of budworm damaged plants, and the number of surviving plants.

Four systemic insecticides (Lannate, Thimet, Disyston and Temik) were tested for budworm control at Tlaltizapán. At Poza Rica, only Lannate, Thimet and Disyston were tested. Three dosages of each insecticide were used: 2, 5 and 10 kilograms of active ingredient (AI) per hectare. Insecticides were applied to the soil at planting time.

The budworm population, as measured by the number of damaged plants, was higher at Tlaltizapán than at Poza Rica. However, the opposite was true for stem borer populations.

These results seem to indicate that the best of the four systemic insecticides tested was Lannate, regardless of dosage. At both locations Lannate controlled budworm for longer than any of the other systemic insecticides. The effectiveness of this insecticide at Tlaltizapán was reflected in the number of surviving plants, which in turn significantly affected yield. At Poza Rica, Lannate was also the best insecticide for controlling both budworm and corn stem borer.

Yields for the different treatments, summarized in Table 37, show that the highest yields corresponded to Lannate plots and that there was no significant difference between the different dosages (10, 5 and 2 kg AI/ha). Plant growth and appearance on these plots was clearly superior, suggesting some control of root-damaging agents. The least-effective insecticide was Disyston.

TABLE M37. Grain yield summary for systemic insecticides in bud worm and stem borer control, Tlaltizapán and Poza Rica, 1972 A.

Insecticide	Active ingredient kg/ha	Yield, kg/ha Tlaltizapán	Poza Rica
Lannate	10	8426	6345
Lannate	5	7510	6460
Lannate	2	7448	5900
Thimet	10	6919	5375
Disyston	10	6679	4679
Temik	5	6597	...
Thimet	2	6585	4985
Disyston	2	6567	4832
Temik	10	6563	...
Thimet	5	6520	5222
Check		6437	4945
Temik	2	6272	...
Disyston	5	5587	4679

Insecticides and Formulations

The insecticides tested were Sevin (5 percent), Cytrolane, Birlane, Dipterex, Diazinon, Cyolane, and Sevin (5 percent) plus Gardona in foliar applications, both as granules and as emulsifiable concentrates. Two applications were made: two weeks after planting and two weeks later. All the insecticides were used at a rate of 250 grams AI/ha per application.

The results seem to indicate that the most effective insecticides at Tlaltizapán, regardless of formulation, were Sevin (5 percent), Cytrolane and Birlane. Sevin (5 percent) and Gardona gave substantially the same budworm control and yields were not statistically different. At Poza Rica, perhaps because of the low infestation, there were no yield differences between treatments. The different insecticides tested gave the same budworm and stem borer control. When formulation is considered, the granular applications gave better control of both insects than sprays. However, this had no measurable effect on yield.

Products and Interval between Applications

The insecticides Birlane, Cytrolane, Sevin (5 percent), Dipterex, Sevin (2.5 percent) and Gardona were tested as granulars applied twice to the whorl at a rate of 250 grams AI/ha per application. The first application was made two weeks after planting. The second application was made two weeks, three weeks or four weeks after the first application, depending on the treatment specifications. At Tlaltizapán, all the insecticides, regardless of interval between applications, gave substantially the same control of budworm except in the sixth and seventh week after planting when treatments showed some differences which were not reflected in yield differences. At Poza Rica, the results were essentially the same except that the Gardona plots were the most damaged by stem borer and yielded less than the other plots. The results for Tlaltizapán seem to indicate that the interval between the first and the second application did not have much influence on the percentage of surviving plants or on yield.

Insecticides and Alternated Plant Treatments

Different granular insecticides (Sevin (5 percent), Sevin (2.5 percent), Cytrolane and Birlane) were applied to: all plants; alternate plants; two of three plants in a series; and three of four plants in a series.

Two insecticide applications were made: (1) two weeks after planting and (2) two weeks later. Insecticide rates were 250 grams AI/ha where all the plants were treated and 125 grams AI/ha where alternate plants were treated. The insecticides effectively controlled budworm at both locations, and the differences between treatments were not significantly different for yield or for damage by budworm and stem borer. At Tlaltizapán, the "all plants" and "two of three in a series" treatments gave the best control and highest yields. At Poza Rica, differences observed in the control plots were not reflected in yields.

During the summer of 1972 at Poza Rica, the systemic insecticides Furadan, Cytrolane, Lannate and Thimet were tested in several formulations (granules, wettable powder and emulsifiable concentrate) for

Trainees learn the importance of showing to farmers what a few technological changes can do to increase maize production. Using the African hoe, three former CIMMYT trainees, Messrs. Bosa, Binsika and Shabani and a member of the CIMMYT outreach staff, Dr. T. Hart, guide preparation of a field for demonstration plantings in Zaire.

budworm and stem borer control. The insecticides were applied as soil, seed and foliar treatments. The nonsystemic insecticides (Sevin, Gardona, Birlane and Dipterex) were tested as granules applied to the whorl. Tamaron was used as spray. The rates and methods of application with results are in Table 38. These results seem to indicate that good control of budworm and stem borer was provided by Furadan, Cytrolane, Birlane and Lannate.

The differences in yield between the more effective treatments and the control plot point out the magnitude of the insect problem and the effectiveness in tropical environments.

Effective soil dosages of these systemic insecticides are too costly and should not be suggested for farmers' use. However, seed dressing in combination with whorl application of granular materials will provide similar protection at a much reduced cost. In these experiments, similar insect control was obtained when either granules or sprays were used.

MAIZE EDUCATIONAL PROGRAM

The CIMMYT maize educational program prepares technicians and scientists for interdisciplinary teamwork in national programs. This reflects CIMMYT's philosophy that the various disciplines must work together toward the common objective in improving maize production.

To accomplish this, technicians and scientists from various countries and disciplines work within the ongoing CIMMYT programs. No research activity is carried out for educational activities per se.

Participants in the educational program during 1972 may be categorized into three groups: (1) trainees (2) visiting scientists and (3) degree students.

Trainees

The trainees vary in educational background and the amount and kind of field experience. This means that modifications are frequently made to meet the needs of individual trainees. Training in 1972 involved four major areas: maize improvement, production, plant protection and protein quality evaluation. These activities were carried out on experiment stations, in the Puebla Project area, in laboratories and in cooperation with local farmers.

The training program is practically oriented with 85 to 90 percent of the trainees' time devoted to active field and laboratory training with CIMMYT scientists. About 10 to 15 percent of their time is for lectures and seminars. During 1972, 58 trainees from 21 countries either completed or initiated a training program averaging six months.

The countries represented in the CIMMYT maize training program and the number of participants from each country are: Argentina, 1; Chile, 1; Colombia, 3; Dominican Republic, 3; Ecuador, 1; Egypt, 1; El Slavador, 6; Guatemala, 4; Guyana, 1; Haiti, 3; Honduras, 2; Japan, 3; Nicaragua, 2; Nigeria, 3; Pakistan, 3; Panamá, 1; Philippines, 5; Tanzania, 5; Thailand, 1; Venezuela, 3; and Zaire, 6.

These trainees were sponsored by USAID, Inter-American Development Bank, CONACYT (Mexico),

Ing. Alfonso Alvarado (right) former CIMMYT maize trainee, and Ing. Ezequiel Espinoza (center) show experimental plots in Panama to H. Hanson, Director General of CIMMYT.

TABLE M38. **Effectiveness of four systemic and four nonsystemic insecticides for different dosages, formulations and application methods for the control of bud worm and stem borer in maize, Poza Rica, 1972 B.**

Insecticide	Form	Active ingredient kg/ha	Application method	Yield kg/ha 15% moisture	Bud worm — damaged plants, % 1st count	2nd count	3rd count	4th count	Percentage of damaged Internodes by stem borer	Ears by bud worm & stem borer	Surviving plants, %
Furadan	Granules	5	Soil	6036	6.0	2.5	9.4	15.5	22.1	29.6	99.5
Furadan	W.P.	5	Soil	5583	8.8	5.0	12.5	14.5	36.2	44.6	99.0
Furadan	Granules	2	Soil	5569	8.7	3.0	11.1	21.8	35.7	45.5	97.7
Furadan	W.P.	2	Soil	5501	7.9	5.1	16.4	30.0	39.6	52.5	97.0
Furadan	Granules	0.5	Foliar	5413	42.8	3.0	31.3	31.3	22.3	44.3	95.0
Cytrolane	Granules	2	Soil	5341	16.9	3.4	1.5	8.1	26.8	34.6	96.0
Cytrolane	Granules	5	Soil	5316	9.4	2.6	1.1	1.7	20.7	24.8	94.5
Cytrolane	E.C.	5	Soil	5253	14.4	3.4	3.4	2.4	18.7	24.8	94.2
Birlane	Granules	0.5	Foliar	5238	43.6	10.3	33.1	8.2	29.5	53.4	94.7
Lannate	Granules	0.5	Foliar	5136	52.5	4.1	46.9	5.1	31.7	58.0	93.5
Cytrolane	E.C.	2	Soil	5028	18.5	3.4	6.0	10.3	33.3	42.7	93.2
Gardona	Granules	0.5	Foliar	4949	40.8	13.3	37.2	11.3	25.1	49.7	92.7
Lannate	W.P.	5	Soil	4942	6.4	3.0	12.3	17.2	39.1	47.1	94.7
Sevin	Granules	0.5	Foliar	4801	36.7	8.8	36.2	11.4	27.6	50.9	88.0
Cytrolane	Granules	0.5	Foliar	4721	28.6	8.8	37.8	6.2	30.5	51.0	91.5
Lannate	Granules	5	Soil	4522	10.5	3.5	12.3	31.5	44.0	56.3	96.7
Lannate	W.P.	2	Soil	4391	12.7	6.1	15.8	25.8	38.5	51.6	92.2
Furadan	W.P.	0.5	Seed Treat.	4183	16.6	12.5	37.0	45.5	43.5	66.0	99.2
Thimet	Granules	0.5	Foliar	3960	59.1	6.7	45.7	36.3	38.3	73.0	92.5
Lannate	Granules	2	Soil	3956	10.2	5.0	27.4	47.2	44.9	63.9	96.0
Tamaron	E.C.	0.5	Foliar spray	3870	45.4	22.2	46.8	24.9	34.6	66.0	86.5
Furadan	W P	0.25	Seed Treat.	3837	19.6	13.1	32.6	21.8	44.8	67.2	96.0
Dipterex	Granules	0.5	Foliar	3461	37.6	19.9	46.2	12.2	29.3	57.9	84.5
Thimet	Granules	5	Soil	2541	40.4	17.7	49.9	69.5	49.1	86.9	85.5
Thimet	Granules	2	Soil	2290	47.5	24.5	47.6	73.2	47.3	88.0	88.2
Thimet	E.C.	5	Soil	2217	34.9	29.5	42.7	65.9	44.4	80.8	91.7
Thimet	E.C.	2	Soil	2061	39.8	26.5	50.4	66.9	50.0	89.9	90.0
Check				1965	47.57	27.7	44.7	64.8	40.8	82.4	81.6
Lannate	W.P.	0.25	Seed Treat.	1699	18.7	14.1	49.5	61.2	46.4	75.3	87.5
Lannate	W.P.	0.5	Seed Treat.	1403	16.1	23.1	45.8	63.0	38.6	68.2	88.0

From seed preparation, through planting, note taking, harvesting and analyzing the results, CIMMYT maize trainees learn the importance of good experimentation in the process of increasing production. Young scientists from several countries plant an experiment at the El Batán Station, México.

DIGESA (Guatemala), the Ford Foundation, United Nations Development Program and the Government of Zaire.

The 29 production trainees participated in field experimentation, learning the principal factors related to maize production. Also studied were economic concepts and their application, and systems for resource allocation and use at the regional level and farm level. In visits to the Puebla Project, the trainees learned about the organization, progress and evaluation of the results of this project. They also participated in the establishment of 18 one-acre demonstration plots using packages of recomendations in one of the project areas. The trainees organized field days and farm demonstrations on how to increase yields through the application of new technology.

The group of 19 trainees in maize breeding worked on designing, preparing, planting, harvesting, analyzing and interpreting results of experiments conducted at the experiment stations. They studied breeding techniques, selection procedures to produce high-yielding materials, how to select for resistance to insects and diseases, and how to identify material superior in agronomic characters. Trainees became familiar with the CIMMYT genetic material and made their own selections of promising germ plasm sources for their own programs. They also became acquainted with laboratory methods to determine grain protein quality and amino acid composition.

The three plant protection trainees spent their time familiarizing themselves with the principal insects and diseases that attack maize, the breeding procedures used to incorporate resistance, methods of selecting for sources of resistance, methods for increasing inoculants and insects, methods of inoculation, and techniques for testing materials. Also, they were exposed to the work associated with insect control by insecticides.

The protein quality evaluation trainees were concerned with the organization and operation of laboratories for evaluation of maize protein and analyses of amino acids in grain.

In cooperation with the Mexican Extension Service, several demonstrations and experiments were established. These provided valuable experience to the trainees in the use of scarce farm resources and in in setting up meaningful experiments to test the results obtained at experiment stations.

Visiting Scientists

During 1972, 10 visiting scientists from eight countries worked with CIMMYT. These individuals are in key positions in national programs and usually hold advanced degrees. While working with the CIMMYT scientists they have made many valuable research inputs which have assisted the overall program.

These scientists and their countries are: S. Sriwatauapongse, Thailand; A. Shehata, Egypt; B. Aday, Philippines; T. Mercado, Philippines; B. Gabriel, Philippines; M. Shah, Pakistan; H. Hassan, Malaysia; T. Hart, United States; F. de Wolff, Holland; and M. Pandey, India.

Degree Students

The enthusiasm with which education in goal-oriented team research is being accepted is exemplified by CIMMYT's participation with several academic institutions in the preparation of students for the B.S., M.S. and Ph.D. degrees.

During 1972 CIMMYT cooperated closely with Chapingo, Los Baños, The University of Mexico and Cornell University in training 17 students. These students, their degree, their institution, and their country of origin were: C. Torres, M.S., Chapingo, Argentina; I. Bustos, M.S., Chapingo, Argentina; P. Alcibar, M.S., Chapingo, Ecuador; R. Murillo, M.S., Chapingo, Costa Rica; C. Senigagliesi, M.S., Chapingo, Argentina; A. Berardo, M.S., Chapingo, Argentina; A. Coutiño, B.S., Chapingo, México; B. De Orozco, M.S., Chapingo, Colombia; J. Betancourt, M.S., Chapingo, Guatemala; R. Mejía, B.S., Chapingo, México; J. Jiménez, B.S., Chapingo, México; L. Nzarea, M.S., Los Baños, Philippines; T. Mercado, Ph.D., Lo- Baños, Philippines; A. Morales, M.S., Los Baños, Philippines; S. Peniche, B.S., Univ. of Mex., México; D. Sperling, Ph.D., Cornell, U.S.A.; M. Splitter, Ph.D., Cornell, U.S.A.; J. Splitter, Ph.D., Cornell, U.S.A.

During 1973 the visiting scientists and degree student programs will expand with more individuals and institutions participanting.

GERM PLASM BANK ACTIVITIES

New seed storage facilities for the Maize Germ Plasm Bank were completed at CIMMYT's headquarters and became operational during 1972. These facilities consist of two cold-storage chambers in which the temperature is maintained at 0° C and relative humidity at 45 percent. Open iron racks hold seed containers. The racks have a storage capacity of 10,440 two-liter and 15,120 four-liter containers plus 132 drawers for small seed lots. There is enough refrigerated capacity installed to meet all immediate seed storage needs.

A total of 746 accessions were propagated at Tlaltizapán and El Batán during 1972. Of these, 467 were new accessions not included in the Maize Germ Plasm Bank inventory. All seed produced during 1971 was shelled, inventoried and placed in cold storage.

A cooperative agreement to propagate and increase in Perú 1,067 accessions from Bolivia, Chile, Ecuador and Perú was reached with the *Programa Cooperativo de Investigaciones en Maíz, Universidad Agraria-La Molina* and put into effect in 1972. Climatic conditions at CIMMYT's stations in México are not suitable for propagating most of these populations from high altitudes. Growing them in Perú will reduce losses and minimize effects of natural selection.

Fifty shipments totaling 2,390 populations were made to 20 countries in 1972. The pertinent information is summarized in Table 39.

Evaluation of Accessions Available in the Germ Plasm Bank

Six hundred and sixty-three of the accessions available in the Maize Germ Plasm Bank were compared with three checks in randomized complete blocks at Poza Rica, Tlaltizapán and El Batán. The accessions were divided into three tests. One test, involving 57 entries,

A training program broad in scope must include library work. Trainees from the Philippines, Nigeria, Tanzania, Guatemala, and Nicaragua do their library assignments at CIMMYT headquarters at El Batán.

TABLE M39. Number of shipments and maize populations distributed by CIMMYT's Maize Germ Plasm Bank in 1972.

Countries	Number of Shipments	Number of Populations
Argentina	1	7
Australia	1	8
Colombia	1	16
Ethiopia	1	184
Haute Volta	1	24
Holland	1	7
India	2	4
Ireland	4	22
Italy	2	137
Japan	2	91
Kenya	2	69
Malaya	3	105
México	10	75
Nigeria	1	365
Pakistán	1	397
Perú	1	130
Philippines	1	548
Uruguay	1	2
U. S. A.	12	127
Yugoslavia	2	72
Total	50	2,390

included populations originating at high elevations; the remaining two had 77 and 499 entries, respectively, from intermediate and low elevations. The checks were Tuxpeño Planta Baja, Composite 301 and Chalqueño A Composite.

The data collected will be statistically analyzed and only a brief summary of the results obtained in Tlaltizapán with the populations from low elevation will be presented here. Table 40 summarizes grain yields with 15.5 percent moisture content (assuming a uniform shelling coefficient of 80 percent), days to silking, grain moisture at harvest and percent root lodging for the 28 highest yielding entries and Tuxpeño Planta Baja--the best check in the test. These results illustrate the great genetic potential available in the Maize Germ Plasm Bank. The experimental entries in this test have not undergone any selection, and many of them yielded as well or better and were of similar maturity to a check that has undergone several cycles of selection. The results also point out the need for a systemic evaluation of the populations available in the Germ Plasm Bank to isolate the most promising populations and incorporate them into the maize breeding program.

TABLE M40. Grain yield, days to silking, moisture at harvest, ear height and root lodging of the 28 highest yielding low-elevation entries and a check compared at Tlaltizapán, 1972.

Entry	Grain yield kg/ha	Days to silking	Moisture %	Ear height, meters	Root lodging %
Sinaloa 70	8 479	68	14.82	1.55	87
Sinaloa 81	7 991	72	17.07	1.53	47
Tamaulipas 28	7 987	64	15.94	1.52	48
Jalisco 281	7 854	66	16.42	1.54	45
Nuevo León 17	7 782	68	14.34	1.62	45
Sinaloa 85	7 700	72	17.93	1.56	47
Tamaulipas 45	7 567	66	14.64	1.45	81
Tamaulipas Grupo 2	7 444	65	15.77	1.39	46
Nayarit 154	7 411	73	19.41	1.96	58
Tamaulipas Grupo 4	7 203	68	17.33	1.62	75
Jalisco 286	7 198	72	18.03	1.59	69
Nayarit 178	7 167	73	18.08	1.56	36
Sonora 72	7 111	71	19.53	1.59	48
Tamaulipas 30	6 863	64	15.78	1.38	65
Sonora 74	6 760	74	17.61	1.45	59
Nayarit 153	6 647	74	21.39	1.85	31
Compuesto Tuxpeño	6 639	75	19.05	1.94	64
Nayarit 159	6 565	74	20.02	1.77	59
Nayarit 155	6 483	74	17.47	1.66	73
Sinaloa 85	6 397	72	18.48	1.53	51
Coahuila 53	6 390	77	22.38	1.86	55
Cuba 40	6 363	69	17.28	1.47	43
Cuba 168	6 362	74	18.58	1.65	57
Jalisco 279	6 290	68	17.61	1.49	74
Nayarit 162	6 272	70	17.53	1.64	76
Cuba Grupo 2	6 248	73	17.73	1.63	41
San Luis Potosí Grupo 9	6 232	71	17.51	1.88	63
Nayarit 173	6 087	74	19.15	1.72	46
Check:					
Tuxpeño Planta Baja	5 989	74	19.74	1.31	37

Development of Genetic Marker Stocks

A series of genetic stocks marking several segments in 9 of the 10 chromosomes of maize was initiated in 1971. F_1s of genetic stocks obtained from the Urbana (Illinois) Bank and Antigua Group 2 as well as their F_2s were produced in 1971. In the 1972 winter crop, plants showing the desired gene combinations were back-crossed to Antigua Group 2 to recover 75 percent of the genotype of this population. The backcrosses will be self-pollinated to obtain the linked combinations involving recessive genes and then some of these will be combined into stocks marking a larger number of segments of each chromosome.

Tripsacum Collections

With the participation of Dr. L. F. Randolph, Emeritus Professor of Botany at Cornell University, 127 *Tripsacum* clones were collected in the Mexican states of Guanajuato, Jalisco and Colima, and in British Honduras, and added to the garden established at the Tlaltizapán Field Station. Twelve clones from four high-altitude Mexican populations, assumed to be cold tolerant, were planted at El Batán. Table 41 summarizes the species currently available in CIMMYT's *Tripsacum* garden and the number of collections and clones for each of them. Chromosome counts in 20 of the clones have already been made.

The *Tripsacum* collection will be used in an intergenetic crossing program with maize to transfer to maize desirable genes of potential value in corn improvement.

TABLE M41. Summary of Tripsacum species and putative hybrids collected during 1970-72 and planted at CIMMYT's field station in Tlaltizapán.

Species or hybrids	Collections made	Clones available
T. australe	1	1
T. dactyloides ssp. hispidum	9	33
T. dactyloides	31	125
T. floridanum	1	1
T. latifolium	9	33
T. lanceolatum	4	8
T. laxum	1	1
T. maizar	11	37
T. pilosum	11	41
T. zopilotense	9	29
T. sp.	3	8
T. latifolium-maizar	2	6
T. pilosum-maizar	3	11
T. maizar-dactyloides	2	18
Total	97	352

Cooperative Work on Maize-Teocintle Crosses

In collaboration with Dr. G. W. Beadle, Emeritus President of the University of Chicago, large second generation populations of Argentine popcorn x Guerrero teocintle and Argentine popcorn x Nobogame teocintle were grown and classified. The results of this study have confirmed that in F_2 populations parental types are recovered with frequencies corresponding to about four or five major independently segregating genetic units. Backcross populations are consistent with F_2 results, but the frequency of recovered parental types in both types of populations varies with the maize and teocintle used. Recovered teocintle and corn lines were increased at El Batán and enough seed produced for further studies.

Chromosome Morphology Studies on Maize

In 1959 and 1960, Dr. Barbara McClintock of the Carnegie Institute conducted the first research on chromosome morphology of different races of maize in Latin America. From these preliminary studies she concluded that the possibility existed that many presently grown races of maize originated independently in different centers of origin from germ plasm already established in those centers.

Wider cytological studies on different American races of maize were then made and the first report was published by Dr. Albert A. Longley and T. A. Kato Y. in 1965. Later, this program was broadened and Dr. Almiro Blumenschein of the University of Sao Paulo in Brazil participated under the orientation of Dr. McClintock. A detailed report on these investigations is being prepared for publication in 1973 by McClintock, Wellhausen, Blumenschein and Kato.

INTERNATIONAL MAIZE TRIALS

International Maize Adaptation Nursery (IMAN)

In 1972, 81 IMAN trials were distributed to 46 countries in Asia, Africa, the Middle East, Australia, New Zealand, North America, Central America and South America. These trials included materials from the Ivory Coast, India, Colombia, Peru, El Salvador, Argentina, Jamaica and Mexico (CIMMYT and INIA).

Data of the first (1971) IMAN has been summarized, published and distributed to cooperators and other interested persons and institutions. Results of the second (1972) IMAN are being processed and will be published soon.

International Opaque-2 Maize Trials (IOMT)

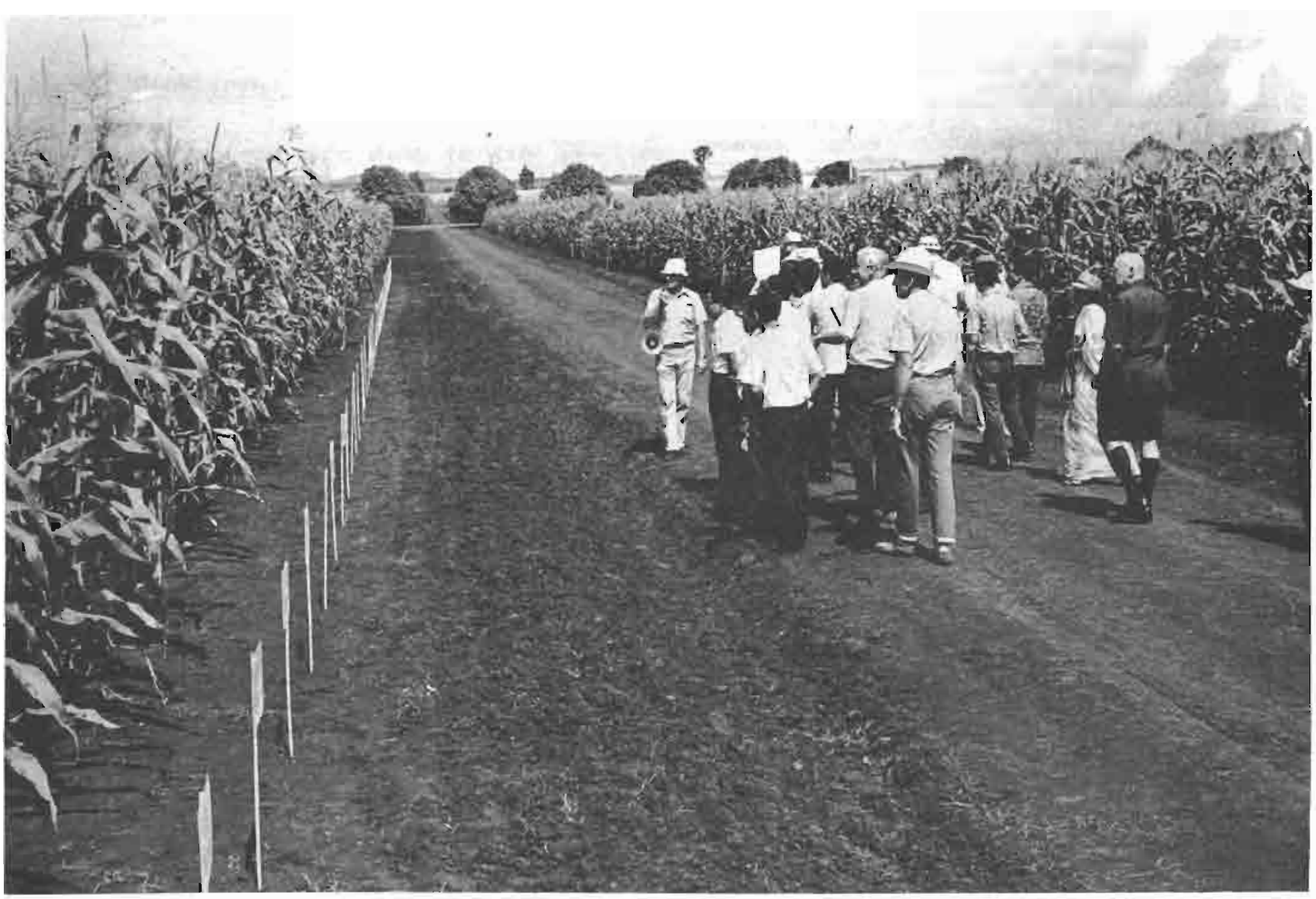
Forty-eight IOMT trials were sent to 34 countries on all continents. The results of the first and second IOMT trials are being processed and will be published soon. These trials pose some particular problems due to the absolute need for growing them under strict isolation. A very thorough screening of the experimental results is required to avoid any possible bias in the yield measurements due to contamination with normal pollen.

The delay in publishing results is mostly due to varying planting dates among all the sites involved in these tests. Planting dates vary from early April to late October. This results in a period of about 18 months between seed shipment (March-April) and return of the field data for analysis.

These trials have demonstrated their usefulness to breeders in many countries. A very intensive exchange of materials has already taken place among many participants in the testing program.

CIMMYT has received several requests for seed included in the IMAN and the IOMT series. These requests are immediately served for those materials from the CIMMYT breeding program. Requests for materials from other sources (national programs, private companies, etc.) are given to the source involved or the necessary steps are taken to facilitate direct negotiations for the provision of the seed requested. The number of participants has increased considerably. Eighty-five IMAN and 62 IOMT sets have been requested for 1973.

A group of delegates to the 8th Inter-Asian Corn Program Workshop observe the International Maize Adaptation Nursery (IMAN) at Farm Suwan, Thailand.



SORGHUM

None of the commercially available sorghum hybrids or varieties will set seed dependably at the elevation of 2,240 meters in the Valley of Mexico (19° N latitude). Night temperature minimums are regularly below 10° C during flowering and seed formation. It is believed that low night temperatures cause ovule abortion and prevent seed fromation even though viable pollen may be present.

In an attempt to develop varieties capable of setting seed at these low night temperatures, collections of materials from high, cool areas of the world have been obtained periodically. Three of the first useful types of such materials obtained from Africa (named Nyundo, Mabere and Magune) did produce seed at 2,240 meters elevation. Since the growing cycles were much too long to allow use as varieties, they were hand crossed to the early genetic stocks Ryer Milo and 40 Day Kafir obtained from Texas. The crossing and growing of several subsequent segregating generations was done at lower elevations in Morelos, Mexico. Material was then planted from bulks of these advanced generations at Chapingo (2,240 meters), Mexico and individual plants that produced seed were selected. In the original attempt at such selection, less than five percent of the plants were saved.

Head rows were then planted from these selected plants. Other materials such as new collections from other areas, commercial varieties and hybrids, and the three varieties Nyundo, Mabere and Magune were interplanted in scattered rows. Again individual plant selection was practiced within the segregating head rows.

When these subsequent selections were planted out in head rows, it became obvious that a fair amount of natural crossing had occurred. As the selections had been made largely for shorter and earlier flowering types, outcrosses were generally distinguishable as taller, bigger and somewhat later to flowering.

A simple procedure to utilize this natural intercrossing was used to obtain additional admixtures of germ plasm and to aid in broadening the genetic base of the pool. (1) The obviously outcrossed plants were selected for the following planting cycle. (2) Additional germ plasm from various sources was included in each planting to provide pollen for adding variability. (3) Approximately one-fourth to one-third of the total plants selected were from the shorter, earlier flowering types to provide an "understory structure" for detecting the outcrosses.

As successive generations of selection are done, these early, short selections become quite uniform and outcrosses are very easy to detect. Maintaining a fairly large segment of short early materials assures reasonable numbers of crosses each season and keeps plant sizes and maturities of selections within desirable limits. The individual "families" that make up this "genetic understory" are gradually and progressively changed as the population develops to prevent the pool from becoming stagnant. With selection being carried out under low night temperature conditions, those types failing to set seed are automatically eliminated.

At any point, desired families can be selected to use as varieties or to test at other locations and under other environments. This type of siphoning off has been done sporadically to observe growth under lowland tropical conditions, to check for type of restorer action in crosses with male steriles, to check frequency of types with nonphotoperiodic responses, etc.

A few pertinent observations include: (1) selections grow quite well at Poza Rica and in Jamaica although heads tend to be smaller and maturity is very early; (2) nonrestorer "B" types are present with a frequency of about 5 percent; and (3) reasonably high percentages of plants were within acceptable limits of maturity in Alberta and Manitoba, Canada, as well as in Mexico.

To make a more systematic effort at evaluating this germ plasm for potential use in other areas, 83 items were selected from the pool and organized into a simple yield trial with three replications and two local checks. In Mexico where the material has been developed, the warmest part of the year occurs at the onset of the rainy season. Therefore, selection for ability of seedlings to grow under low soil temperatures cannot be done. Also, at 19° latitude the day length does not change radically during the year, masking photoperiod sensivity differences. Results with sporadic observations of the material at other locations have been sufficiently encouraging to suggest more extensive and systematic observations.

Hopefully, each cooperating location will harvest and save seed for its own use. Continuing to manage the pool in an intercrossing fashion will incorporate additional variability. Selections will continue to be drawn off for use as lines, varieties, etc.

Also, cooperators are requested to send CIMMYT a little seed of their selections. These selections from other environments will be recombined among themselves as selections and back into the germ plasm pool to gradually widen adaptation.

OUTREACH ACTIVITIES

CIMMYT outreach activities increased substantially during 1972, involving new activities in Nepal, Zaire, Argentina and Tanzania.

Discussion with Nepal during 1971 resulted in CIMMYT placing a staff member in Nepal in 1972 in cooperation with the Nepal National Program and U.S.A.I.D.

On the basis of similar discussion with the Government of Zaire, CIMMYT entered into a cooperative program to develop the first national maize research and production program in that country. During 1972 CIMMYT posted three scientists in Zaire to provide leadership until Zairians have an opportunity to gain the necessary experience. In-service training and degree programs for Zairian scientists are a major objective of the program.

On request from Argentina, CIMMYT staff prepared an outline for a national program that involves cooperative research with CIMMYT and a staff development program that should make Argentina self-sufficient for research and production personnel.

For Tanzania, IITA and CIMMYT agreed in 1972 to a new cooperative program to be financed by U.S.A.I.D. and the Ford Foundation. This program calls for two expatriate maize scientists resident in Tanzania and a substantial amount of training for Tanzanian staff.

Also, consulting visits were made to more than 20 countries in 1972.

NATIONAL PROGRAM REPORTS : ZAIRE

The *Programme National Mais/Zaire* started in 1972 and the Zaire Department of Agriculture designated Kisanga Station as national headquarters. The physical plant at the station, including housing, offices, laboratories and farm buildings, has been repaired and the station is now operational. Kisanga Station is located near Lubumbashi in the Shaba Region.

Presently, *Programme National Mais* also operates at Mawunzi Station in the Bas Zaire Region. Renovation work at Mawunzi was underway in 1972.

Training

Six trainees each received eight months of training at CIMMYT stations in Mexico. All have returned to Zaire. Two of them are posted at Mawunzi and four are currently posted at the headquarters in Lubumbashi.

Six new trainees, all recently graduated from the national university at Kinshasa, have joined *Programme National Mais* on a probationary basis. After six weeks of training with the maize team in Zaire, the new trainees will receive six weeks of English language instruction at Kinshasa before departing for CIMMYT.

Also, Muleba Nyanguila will depart in 1973 for five months of training at CIMMYT before entering a master of science degree program in the United States.

Production-Oriented Farmer Demonstrations

Eighteen farmer demonstrations in collaboration with Department of Agriculture personnel were planted throughout the Shaba Region.

Six fertilizer trials have been planted across the Shaba Region on different soil types in cooperation with C.E.P.S.E. and *Cité Des Pionniers*. Cooperation from and enthusiasm of farmers and Department of Agriculture personnel has been excellent. These trials involve four levels (0, 250, 500 and 1,000 kg/ha of 17-17-17 fertilizer) of fertilizer application broadcast and disked in prior to planting, and two levels of sidedressed nitrogen (100 and 200 kg/ha) when plants are 50 cm tall. For the farmer demonstrations and regional fertilizer trials, second generation seed of Shaba Safe (a white dent type) has been used. Shaba Safe is (SR-52 (Rhodesia, Zambia) x H-632 (Kenya).

Agronomy Trials

Station de Mawunzi, Bas Zaire Region:

1. An observational variety trial consisted of 18 materials. The results are presented in Table 42.

2. A date-of-planting trial began in September. A plot has been planted weekly to IITA Composite A x B. Serious emergence problems have occurred due to insects. To date, no disease problems have been noted. The trial will continue weekly throughout the first season and until the end of February 1973--well into the second crop season.

3. A fertilizer trial using IITA Composite A x B and Tuxpeño brachytic-2 is underway. Five levels of N (0 to 240 kg/ha) and five levels of P_2O_5 (0 to 180 kg/ha) have been applied. Half the replications have received 100 kg/ha K_2O while no potash has been applied to the other replications.

TABLE M42. Yield of dry grain for 18 entries in the Observation Variety Trial, Mawunzi, Zaïre, 1972.

Pedigree	Grain yield kg/ha
(Tuxpeño x Ant. Gpo. 2 Sel. Bl.)	7 487
(Comp. A, CO x Comp. B (S1) (C1)	7 227
Tuxpeño br2/br2	7 200
Tuxpeño Sel. Pl. Baja	6 813
(La Posta x Eto Bl. Pl. Baja)	6 253
(Líneas Illinois x Eto Bl. Pl. Baja) F_2	6 067
[(Mix. 1 x Col. Gpo. 1) (Eto Bl. Sel. Pl Baja) (Eto Bl. Pl. Baja)]	5 907
(Tuxpeño Planta Baja x Eto Blanco Planta Baja)	5 840
(SR52 x H632)	5 800
Eto Blanco Sel. Pl. Baja	5 633
(Mex. 24 x Grand Mawunzi)	5 633
(Tuxpeño x Antigua Sel. Bl) (Eto Bl. Pl. Baja)	5 400
(Líneas Illinois x Tuxpeño Pl. Baja) F_2	5 267
(Hibridos Pfister etc. Pl. Baja, Sel. Bl.) (Eto Bl. Pl. Baja)	5 233
(Sel. Blanca Tipo Caribe x Eto Bl. Pl. Baja)	5 173
(Mix. 1 x Col. Gpo. 1) (Eto Bl. Sel. Pl. Baja)	5 100
(Mix. 1 x Col. Gpo. 1 Pl. Baja) (Eto Bl. Pl. Baja)	4 667
Local maize	3 453

Kisanga Station, Shaba Region

1. Beginning in October 1972 and continuing to the end of the year, a plot was planted weekly to SR-52 x H-632 Shaba Safe. Emergence was excellent with no insect or disease problems, except for some very minor grasshopper damage.

2. A fertilizer trial using SR-51 x H-632 and selected Hickory King is underway. Five levels of N (0 to 240 kg/ha and five of P_2O_5 (0 to 180 kg/ha) have been used. Potash has been applied to half of the replications at a rate of 100 kg K_2O/ha.

3. A fertilizer trial involved both varying placement and rates. SR-52 x H-632 received 500, 1,000 and 1,500 kg/ha of 12-12-17. Fertilizer placement was: (1) all broadcast and disked in; (2) all banded below seed; and (3) half broadcast and half banded.

4. Another trial involved constant population density with varying hill spacing and times of nitrogen sidedressing. The variety used was SR-52 x H-632. The plant spacings were 25, 50, and 100 cm within rows 75 cm apart. A basic application of 136 kg N/ha was made. Nitrogen treatments were 200 kg N/ha when plants were 50 cm tall; 200 kg N/ha at incipient tasseling; and 100 kg N/ha at 50 cm plant height plus 100 kg N/ha at incipient tasseling. This trial attempts to test differences between recommended spacing versus current local methods of within-row maize spacing.

Plant Protection

A survery is being conducted to identify the more important insect pests as a basis for further experimentation. All the materials in the various trials and demonstrations have been evaluated for pest problems.

Breeding

A total of 347 varieties were introduced into Zaire. Most of these came from CIMMYT, while some came from IITA and Kitale, Kenya.

As mentioned above, the advanced generation of a cross between a Kenyan hybrid (H-632) and a Zambian hybrid (SR-52) has been used for farmer demonstrations in Shaba. A large crossing block is planted to SR-52 and H-632 to provide sufficient seed for next year's farmer demonstrations.

Both hybrid parents perform well in Shaba, but at the current stage of development using hybrid seed is impractical. To further improve the advanced-generation cross of the two hybrids, they have been topcrossed to 278 different varieties.

Seventy-eight varieties from Mexico and East Africa are being tested at five different locations in Shaba with two replications at each location. The remaining varieties are being tested this first season at Kisanga only.

Sixteen varieties from CIMMYT likely to perform well in different parts of Zaire are being multiplied this season in isolated fields. Also, each of these 16 varieties has been topcrossed to SR-52 and SR-52 x H-632.

A small observation trial including 18 varieties was grown at Mawunzi in Bas-Zaire during the past season. Three varieties--Tuxpeño x Ant. Gpo. 2 and Tuxpeño brachytic-2 from Mexico, and Composite A x Composite B from IITA--produced over 7 tons per hectare.

EGYPT

Release of Varietal Crosses and Composites

The maize program has progressed to a stage where decisions can be made about the release of new and more productive varieties. Based on two-year performance trials of F_1 varietal crosses and composite varieties, the Ministry of Agriculture decided to recommend for cultivation varietal crosses V.C. 69 and V.C. 80, and the composite variety Shedwan 3.

The two-year yield performance of the varietal crosses is presented in (Table 43).

Table 44 indicates that the two varietal crosses showed greater resistance/tolerance to late wilt disease (*Cephalosporium maidis*) than the open-pollinated variety American Early and the double cross hybrid Giza 186, which are currently under cultivation.

The composite variety Shedwan 3, also released for cultivation, is an advanced generation of the triple varietal cross Kitale Syn. II x (Antigua 2D x American Early). This composite has outyielded the checks by 18 percent during two years of testing and also possesses resistance to late wilt disease about equal to that of the varietal crosses. The composite is currently under the first cycle of full-sib selection for yield, wilt resistance, earlier maturity, reduced plant height. and other desirable agronomic traits.

These three new varieties will be tested regionally in 50 trials on farmers' fields during the 1973 crop season.

TABLE M43. Grain yield at 15 percent moisture of outstanding varietal crosses, mean for two locations, 1970-72.

Variety	Pedigree	Yield, tons/ha 1970	Yield, tons/ha 1971	Mean	% of G. 186
V. C. 69	La Posta x American Early	14.1	12.9	13.5	153
V. C. 80	Tep. 5 x American Early	12.4	11.9	12.1	137
	American Early (check)	9.1	9.4	9.2	102
	Giza/Hybrid 186 (check)	8.9	8.7	8.8	100

TABLE M44. Percent late wilt infection in two elite varietal crosses, four locations, Egypt, 1971-72.

Variety	Pedigree	Infection, % Gemeiza	Sids	Fayoum	Giza	Mean
V. C. 69	La Posta x American Early	18	16	22	16	18.0
V. C. 80	Tep. 2 x American Early	19	16	23	16	18.5
	American Early (check)	44	34	43	38	39.8
	Giza 186 (check)	100	87	98	93	94.5

Seed Production Targets

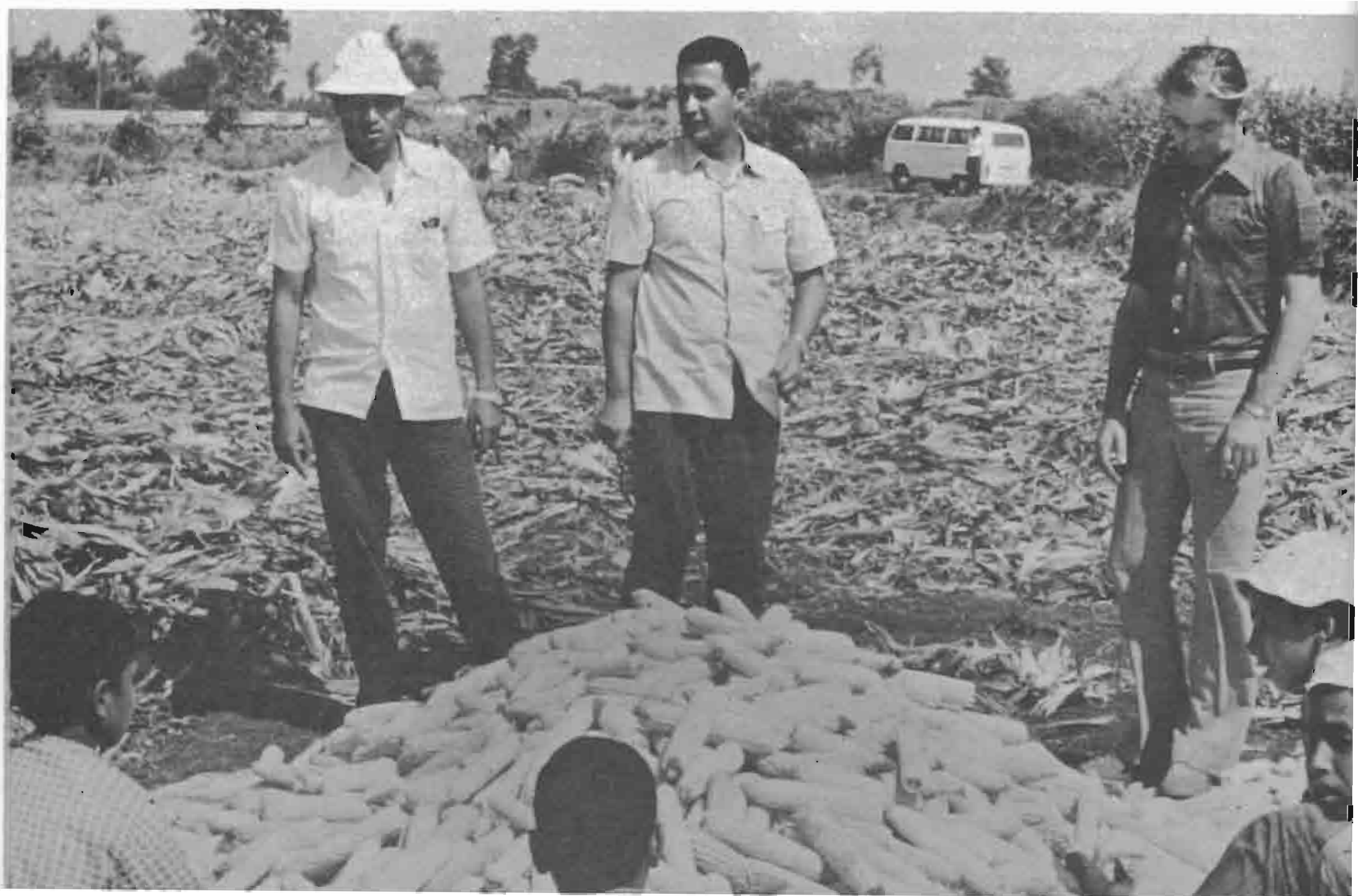
Targets for seed increase have been drawn up so that in the summer of 1975 about 400,000 hectares will be planted to the new varieties. This will require 4,555 hectares for seed increase. The decision as to which varietal cross will be grown commercially should be made during the summer of 1973.

International and Regional Maize Workshop

At the annual CIMMYT Maize Workshop held in México in 1971, it was decided that every second year CIMMYT should hold the Maize Workshop at one of its outreach operations. After consultation with the international group present in México at that time, it was agreed to hold the 1972 annual meeting in the Middle East. Egypt was chosen since it had an on-going maize project sponsored by the Ford Foundation and CIMMYT in collaboration with the Ministry of Agriculture. The Egyptian authorities fully supported the Workshop and made excellent arrangements for its success. Scientists from CIMMYT and other international agencies, delegates from the Middle East countries, and academic and Ministry personnel from Egypt participated.

Dr. Kamal R. Stino, Director for Agricultural Research in Egypt and member of the CIMMYT Board of Trustees, addresses delegates to the International and Regional Maize Workshop, at Gemeiza Station, Egypt.

Nabil Khamis, research assistant (left); Dr. A. Shehata, maize breeder (center); and Dr. E. W. Sprague, Director of the CIMMYT Maize Program, observe the harvest of Syn. Tep. No. 5 from México, one parent of Variety Cross 80 released for cultuvation in Egypt. Dr. Shehata spent six months as visiting scientist at CIMMYT.



The delegates along with the local scientific staff and representatives of the universities and pertinent ministries visited the two main maize experimental stations, Gemeiza and Sids, where the projects in operation were studied and evaluated. The delegates remarked that a wide spectrum of genetic variability further pooling of germ plasm should be the next phase. This would further widen the genetic base and render the populations more amenable to recurrent selection procedures.

Dr. Kamal Ramzi Stino, Director, Agricultural Research Center, chaired the discussion sessions. Wide ranging and comprehensive discussion included topics such as breeding, methodology, plant type, late wilt disease, soil and water management, transferring results of research to farmers' field and regional cooperation. The Workshop provided a forum in the Middle East whereby regional scientists could meet with scientists from CIMMYT, Ford Foundation, Rockefeller Foundation, F.A.O. and U.S.A.I.D. to discuss varied and complex problems of maize production, and techniques and methodologies required for improving yield levels.

Training

Abdrabbo Ahmed Ismail, who is currently studying at Cornell University, has completed his course work and will proceed shortly to CIMMYT to initiate his thesis program. Zaki Abdel Halim Hamza completed a nine-month training course at CIMMYT and has resumed his position at the Gemeiza Experiment Station. Dr. Abdel Rahim Shehata, maize breeder from the Egyptian Program, is at CIMMYT as a visiting scientist.

PAKISTAN

The high-yielding, full-season varieties Khalil (white) and BCC x Akbar (white) for the Northwest Frontier Province, and Neelum (yellow) and Akbar (yellow) for the Punjab were released. These were designed for the progressive farmers who could and would adopt the full package of improved technology which would maximize yields. The emphasis in the breeding program was shifted towards developing short-season varieties which would respond to the improved technology, but which would be superior to the short-season local varieties when grown by farmers who could not or would not adopt the full package of improved practices.

Breeding

The program to develop improved short-season varieties was initiated in 1969 utilizing germ plasm from the United States, Canada, Argentina, India, Pakistan, Afghanistan, Turkey, and South Africa, plus materials from CIMMYT. One approach was to cross exotic materials with the leading local varieties, backcrossing to the local to approach the local variety in agronomic and grain characteristics while improving yield. Another approach was to develop varieties of the required maturity from a wide germ plasm base. Very early and very late introductions were crossed and then these were crossed with the local x exotic crosses of similar maturity. About 120 such populations were grouped into three maturity groups (short season, midseason and full season) and yield trials were conducted. The best entries formed three composites for the three maturity groups for further improvement through half-sib selection.

Some of the entries were selected for initial seed multiplication during 1972, pending confirmation of preliminary results, with particular emphasis on the short-season varieties. Three of these, Changez (Early King x Payette), Swabi White x Changez, and (Salzer's x Changez) Salzer's, each yielding 8 to 9 tons per hectare

A farm variety of maize in a fertilizer demonstration near Bannu, Pakistan. Topping of plants, a common practice, provides forage for animal feeding.

in the high valleys in 100 days when planted on June 10, were named Zia, Pahari, and Fazal, respectively. Changez, a locally developed variety serving as a common parent for these new releases, is a composite of crosses made in 1969 between Swabi White and a group of U.S. inbreds, including A610, M14, Wf9, W64A, Oh45, B37, B14, WM13R, and Hy. Emphasis in seed multiplication for the white maize areas of the Himalayan foothills will be on these varieties.

Among the short-season yellow varieties, Synthetic 501, a fairly narrow-based synthetic constituted from M14, Pa32, W9, A495 and A556, has been identified as a good performer. Synthetic 2, a midseason composite made up of local orange flint varieties and U.S. yellow inbred lines, was backcrossed to a local orange flint variety. The resulting variety is nearly indistinguishable from the local variety except for the slightly larger ears. This and Synthetic 501 will be multiplied in 1973 for general release in the Punjab. The impact of these varieties will depend upon the efficiency of seed multiplication in 1973, the availability of sufficient fertilizer and of pesticides for stem borer control, and the sufficiency of seasonal rains.

Training

Seven men were sent to the Inter-Asian Corn Improvement Program Training Center in Thailand and two to CIMMYT for practical training in breeding, pathology, production agronomy, and cereal technology. In addition, the Project Director of the NWFP Maize and Millets Research Institute toured Thailand and Mexico to study experiment station operation and administration.

Regional Testing

With improved varieties developed by the breeding program, the agronomists conducted regional performance tests in conjunction with fertility tests at 50 locations in the NWFP and regional performance tests at 50 locations in the Punjab.

Production

Final production for 1972 is expected to be well in excess of 700,000 metric tons. This is believed to be short of effective demand by about 300,000 tons. As a result, the Central Government has developed a plan with the directors of the maize and millets research institutes to spur maize production by seed multiplication of the short-season varieties, by allocation of scarce fertilizer resources, and by training extension workers.

COLOMBIA

OPAQUE MAIZE PROMOTION

The project promoting opaque maize in Colombia began in 1969 as a National Government Program with the following objectives.

1. To promote opaque maize use by rural families on small holdings in order to improve the nutritional level of their diet.

2. To study the possibility of introducing quality-protein maize into swine feeding programs.

3. To stimulate the participation of the agricultural, industrial, medical and paramedical sectors, and other sectors in production programs with small- and medium-sized farmers.

4. To study regions and structure programs of agricultural improvement, animal improvement, nutrition and health improvement, etc., where quality protein can play an important role.

5. To provide stimulation and cooperation in solving problems of marketing, storage, industrialization and trading of quality-protein maize.

6. To cooperate with the maize and wheat processing industry in incorporating quality-protein maize flour or substituting it for wheat flour in the manufacture of bread, cookies and pastas for improvement of their protein quality and to reduce wheat imports.

This project operates under the direction of ICA with the cooperation of CIAT and CIMMYT.

Seed Distribution

The *Caja de Credito Agrario*, a government agricultural bank, distributed 106 tons of seed of yellow quality-protein maize (ICA H-208) and 40 tons of the white quality-protein maize (ICA H-255) in 1972.

Adaptation Plots and Family Plots

To study the performance of quality-protein maize in new areas, 256 adaptation plots were planted in 1972 at altitudes from 5 to 1,700 meters. Yields varied from 800 to 5,800 kg/ha.

During the same period, 1,001 family plots were planted in farmers' fields with recommendations on cultural practices and use of quality-protein maize. Most of these plots were managed as a community project.

Trials with Swine

To show small farmers the nutritional value of quality-protein maize as well as the advantages and disadvantages of its use in raising and fattening pigs, nine preliminary trials were carried out in the field using the following rations.

1. Farm wastes (bananas, *arracacha*, sugar cane, potato peelings, etc.).
2. The Diet 1 plus 0.5 to 1.5 kilograms per day of quality-protein maize.
3. Common maize added to Diet 1 at a rate of 0.5 to 1.5 kilograms per day.
4. Quality-protein maize, salt, a mineral mixture and water.
5. Common maize, salt, a mineral mixture and water.

The results of these trials seem to indicate that:

1. Pigs fed Diet 1 showed a daily gain of 180 to 222 grams, going from 35 to 90 kilograms of body weight in 252 to 305 days. Time and daily gain were a function of the quality of the wastes used.

2. Diet 2 was the second most efficient, but it is not recommended due to the price of maize. From the economic point of view, adding only 0.5 kilogram of quality-protein maize is recommended. This produces a daily gain of 300 to 325 grams with 170 to 180 days to go from 35 to 90 kilograms.

3. Diet 3 gave a daily gain of 236 grams and the animals took 238 days to go from 35 to 90 kilograms.

4. Animals fed Diet 4 required 3.9 kilograms of quality-protein maize per kilogram of body weight gain while those receiving Diet 5 required 6.2 kilograms of common maize.

Extension

To show the farmers the advantages of planting quality-protein maize for food and for feeding their animals, the project sponsored 19 field days, 46 conferences, 92 meetings with farmers, 3 nutrition trials with infants, 13 courses for rural populations, 10 meetings on marketing, 24 radio programs and numerous newspaper articles.

Some Indian communities have been visited to establish an integral program dealing with health, agriculture, rural communications, etc. Several groups, including agronomists, medical doctors, veterinarians, livestock specialists, engineers, sociologists, anthropologists, nutritionists, etc., have been integrated for this purpose. In agriculture, 127 trials with quality-protein maize, common maize, potatoes, cassava, wheat, sugar cane, beans, vetch, cocoa, vegetables, rice, pasture, and bananas were planted. From these trials the more promising crops and varieties will be chosen for further recommendations to the Indian populations.

Industry and Marketing

To compensate for the reduced yield of quality-protein maize, a supporting price 15 percent above the price of normal commercial flint maize has been established.

The Institute of Technological Investigations has developed formulas for substituting 70, 50 and 30 percent quality-protein maize flour for wheat flour in pastas, cookies and bread, respectively, demonstrating the feasibility of these substitutions. The results have been profusely distributed to millers and industrialists, and some industrial products with quality-protein maize are in local markets.

Storage

The most common problems with quality-protein maize, as indicated by many farmers, are its susceptibility to ear insects and ear fungi as well as storage problems.

Searching for a better method of storage at the farm level, four types of containers were investigated: polyethylene bags, wooden boxes, sisal bags and metal containers; and five insecticides were used: Malathion (4 percent), weevil-killing mixture, Phostoxin, carbon tetrachloride plus carbon bisulfide and Vapona (24 percent). Preliminary results seem to indicate that the best method for storing quality-protein maize is to use air-tight metal containers where the kernels can be preserved for two months without the use of fumigants or for eight to nine months using Vapona (24 percent). Grain to be stored must contain less than 14 percent moisture. Maize can be kept in plastic bags without using chemicals up to two months with losses of only four percent. Losses up to 40 percent occurred in sisal bags without seed treatment.

RURAL DEVELOPMENT PROJECTS

Faced with the urgency for designing strategies and mechanisms for rural development in areas of subsistence agriculture, Colombia has established six projects involving activities which go farther than the mere acceleration of production through the adoption of new technology. Models of regional rural development involving production, economics, public health, environmental improvement, education, infrastructure, organization and community development are contemplated.

These projects are called Rural Development Projects and are located in the following regions.

1. Oriente Antioqueño, including 8 counties with 161,700 hectares and 20,000 families. This project cooperates with CIMMYT. The main enterprises are potatoes, maize, beans, milk production, swine and poultry. The Faculty of Medicine, Nutrition and Health of the University of Antioquia cooperates in this project.

2. Oriente de Cundinamarca with 9 counties, 227,200 hectares and 12,218 families. The main products are potatoes, maize, beans, vegetables, swine and poultry. This project receives technical and financial support from the International Development Research Center (IDRC) of Canada.

3. Norte del Cauca with 10 counties, 540,000 hectares and a total of 38,000 families. The main products are maize, beans, rice, cocoa, cassava, soybeans, vegetables, swine and poultry. The Faculty of Medicine of the University of Valle del Cauca cooperates in this project.

4. Garcia Rovira with 12 counties, an initial area of 166,633 hectares and 17,000 families. The main products are potatoes, maize, vetch, milk, swine and poultry. This project receives financial assistance plus equipment and training from the Ford Foundation.

5. Region del Ariari with 6 counties, 300,000 hectares and 19,000 families. The main products are maize, rice, bananas, cassava, swine and poultry.

6. Altiplano de Nariño with 11 counties, 240,000 hectares, and 17,000 families. The main products are wheat, potatoes, barley, beans, horse beans, vegetables, sheep and swine.

Fifteen new projects are being organized in 1973. They involve a complete change in the whole system of rural extension toward the form of integral projects of rural development operated by a team located in each region and involving professional personnel devoted to institutional coordination. These projects should be good vehicles for efficiently promoting quality-protein maize at the small-farmer level.

From the initial steps within the projects some recommendations on planting distances, fertilizers and varieties have been made. Furthermore, based on these recommendations a credit system operates for small farmers integrated by the *Caja Agraria* and the Agricultural Marketing Institute, principally for maize, wheat and beans.

Since the initiation of these projects CIMMYT has vigorously sponsored training of Colombian personnel, principally in Mexico. CIMMYT has financed the training of five technicians at the Graduate School at Chapingo, Mexico. Four are back with their M.S. degrees. Six more technicians are presently working on their M.S. degrees at Chapingo; and one more technician will start in 1973.

The projects of Oriente Antioqueño, Oriente de Condinamarca, Norte del Cauca and García Rovira have been reinforced to make them adequate for training technicians from several national institutions at the M.S. degree level in coordination with the Graduate Program of the ICA-National University. In-service training for university students, graduate students and rural leaders is also contemplated. The plan is based on a research-training approach and will be open to foreign students.

The first International Seminar on Rural Development Projects was held in 1972 in Bogotá with the participation of Mexico, El Salvador, Honduras, Perú, Paraguay, Colombia and Canada. The development projects in the first five countries were examined with respect to their accomplishments, mechanisms and limitations. The proceedings are being prepared for publication.

NEPAL

Nepal comprises three distinct geographic regions. In the South next to India is a narrow strip of low-lying jungle and farm land. In the Center is the more populous hill country which includes the fertile Kathmandu Valley. In the North along the Tibetan border are the Himalayan Mountains, ranging from 5,300 to 9,700 meters elevation. Approximately eight million people live in Nepal's hill areas. About 96 percent of the people are directly dependent on agriculture for a living.

Maize is the second ranking crop in Nepal. It is grown on approximately 454,150 hectares. The maize growing areas range in elevation from 90 to about 3,600 meters with an average yearly rainfall of 1,400 mm in the West to 2,200 mm in the East. The traditionally grown maize is a flint type. However,

Maize is an important staple food for the Nepalese people. Planted on these handmade, handtilled terraces in the foothills of the Himalayas, improving production presents a real challenge to scientists involved in the accelerated maize production program sponsored by the Government of Nepal, USAID, and CIMMYT.

Subsistence of the farmer and his family depends upon storage of the maize harvest in these rustic and typical corn lofts in the lowlands of Nepal.

some dents are being grown. The annual maize production in Nepal is estimated at about 833,000 metric tons. In 1972, the Government of Nepal imported 20,000 metric tons. Much of the maize crop in 1971 was destroyed by excessive rains and in 1972 by drought.

The Government reorganized the maize program during 1972 and announced that the Rampur Experiment Station (228 meters elevation) will be used as the national headquarters for maize research. About 10 regional experiment stations will be used for testing and multiplying the maize materials.

In the past years, plant breeders have developed three long-season maize varieties (Kakani Yellow, Khumaltar Yellow and Rampur Yellow). During 1972, the CIMMYT International Agronomy Trial, CIMMYT International Maize Adaptation Nurseries, CIMMYT International Opaque-2 Maize Trials, IACP Opaque-2 Trial, IACP Trial No. 1 and IACP Trial No. 2 were planted.

A population improvement plan is being used to develop materials for adaptation to a wide range of altitudes in Nepal. Progeny will be generated during the winter season at Rmapur and tested during the summer.

The Government is developing a national maize team consisting of a national coordinator, breeders, pathologists, entomologists, agronomists, and economist-statisticians. The team will be trained at CIMMYT, IACP, and in the United States. Gopal Rajbhandary has been appointed national maize coordinator, and Brahamaram Mathema, maize breeder. I.R. Regmi, presently receiving training in the United States and at CIMMYT, has been assigned as farm manager for the Rampur Experimental Station. Rajbhandary and Mathema received additional training at CIMMYT after they graduated from Purdue University and the University of Nebraska, respectively.

One maize pathologist and one maize agronomist have been assigned to the Rampur Experiment Station. Two junior training officers will be assigned to the station during the fiscal year. In addition, Ledwine Damen, breeding specialist from Holland, collaborates as a co-worker, giving additional support to the maize program.

The maize team's objectives are to develop (1) hard-endosperm opaque-2 maize, (2) resistance to downy mildew and rust, (3) high-altitude, cold-tolerant materials, (4) yellow and white flints and (5) early maturing materials to fit farmers' crop rotation sequences. A final objective is to disseminate the materials throughout Nepal. The team will be working with UNDP in a seed multiplication and seed certification program. UNDP is in the process of developing a seed processing plant.

In addition, the Government of Nepal is developing a Protein Quality Service Laboratory for maize, wheat and rice. The building for the laboratory has been completed, and the equipment is expected to arrive early in 1973. P. B. Shakya has been sent to Purdue University and CIAT for training in the operation of the laboratory.

PHILIPPINES

Varietal Improvement

Several breeding materials derived from six early maturing parents were tested and selected for earliness and desirable agronomic characters.

Four of 46 promising yellow and white corn varieties outyielded UPCA Var. 1 in yield trials at eight locations. These were: College White Composite 25; (Caribbean YF x Metro; Cupurico x Bahia III and Tuxpantigua x Tiquisate.

Of several materials tested for early maturity, yield and other agronomic characters, Tuxpeño x PH 9 DMR; [(Cuba Gpo. 1 x Eto Amar.) x 60-day GPM] [(Cupurico x Bahia III) x 60-day GPM]; Metro Syn IV x 60-day GPM; UPCA Var. 2 x 60-day GPM; and UPCA Var. 1 x 60-day GPM surpassed the yield of Aroman WF, the check.

Of 15 derived brachytics evaluated during the wet season, 13 outyielded UPCA Var. 1. The highest yielder was [A206 TMR (Cuba Gpo. 1 x P. Rico Gpo. 6) Tuxpeño br_2 br_2] with 4,582 kg/ha. More crosses were made between brachytic and high-combining populations resistant to downy mildew, opaque and early maturing, and the crosses advanced one generation. In addition, selection for lower plant and ear height was initiated in populations segregating for the brachytic characteristic.

In comparative yield trials conducted in Thailand, India, Taiwan, Indonesia and the Philippines using 11 varieties resistant to downy mildew, Taiwan DMR Composite 10 gave the highest yield (3,414 kg/ha), followed by DMR 3, DMR 2, DMR 6, and DMR 5, in that order. Philippines DMR 5 was the most resistant.

To compare the effectiveness of S_1 progeny and full-sib selection, about 795 full sibs and 795 S_1 lines were made from Caribbean DMR Composite, 485 each from Philippines DMR 2, and 274 each from Chain DMR Synthetic. The test materials were screened for downy mildew resistance. About 200 S_1 lines and full sibs from Philippines DMR 2 and Caribbean DMR Composite are being evaluated for yield at Los Baños. Sixty S_1 lines and 70 full sibs from Chain DMR Synthetic were planted for recombination by chain crossing.

Applied Research Trials

A total of 305 trials involving promising varieties were conducted to determine their potential yield and test their reaction to pests, diseases and fertilizer levels, and familiarize farmers and technicians with the agronomic characters of these varieties. Results of the experiments with nitrogen fertilization and plant population indicated that with 270 kg/ha of N and 40,000 plants per hectare, yield was 3,640 kg/ha. This is 12 percent more than the yield at 62,000 and 81,967 plants per hectare. Results indicated also that to produce 50 and 95 percent of the maximum dry matter yield of corn in a degraded clay soil, the phosphorus soil test values should be approximately 2.3 and 9.2 ppm, respectively.

Pathology

At UPCA, leaf moisture content (LCM) was 16.40 percent in varieties susceptible to downy mildew and 13.90 percent in resistant varieties. It was inferred that high LMC invariably leads to a high guttation potential, providing abundant guttation water which is an effective medium for conidial germination. The result is a successful penetration and invasion of the plant by the fungus.

Nitrogen fertilization at 60, 120, 180, 240 and 300 kg/ha did not influence the incidence of downy mildew on MIT Var. 2. Varying plant population densities of 30,000, 40,000, 50,000, 60,000 and 70,000 plants per hectare did not affect the severity of the disease.

Insect Control

Some 38 strains of rice weevil have been collected and maintained at the laboratory. Using the discrimination-concentration technique, 36 strains were tested for their resistance to 2 percent DDT, 5 percent Carbaryl, 0.05 percent Malathion, and 0.7 percent Lindane. The results showed that 21 strains were resistant to DDT, 36 to Carbaryl, 6 to Malathion, 5 to Lindane, and 4 to all insecticides tried. Shelled corn stored in plastic-lined sacks treated with 2 percent and 4 percent of either Malathion, Pirimiphos (Actellic) or Gardona was not infested by pests after six months. In nine months, Malathion- and Actellic-treated sacks had 50 percent kernel infestation and, Gardona-treated sacks had 95 percent infestation. Vapona at 4 percent concentration was effective for only three months. Lining the sacks with plastic bags did not produce effects significantly different from the control.

The toxicity of six organophosphorus insecticides on rice weevil attacking corn was determined. The ranking was Dursban, Pirimiphos, Gardona, Malathion, DDVP and Abate in decreasing order of toxicity.

Experimental results showed that for UPCA Var. 2, reduction in grain weight due to corn borers with slight to moderate infestations was 0.16 percent per borer and 0.96 percent per tunnel. With heavy infestations, grain weight was reduced by 1.36 percent per borer and 0.94 percent per tunnel.

Disease Control

Downy mildew (*Sclosphora philippinensis* Weston) is the most destructive corn disease in the Philippines. It attacks the plant at all stages of growth and losses up to 100 percent are common, especially in high-yielding varieties. Leads in chemical control have been obtained, but none seem economically feasible.

The research program is mainly geared to increasing the corn yields in the provinces where downy mildew is common by using resistant and high-yielding varieties and using protective measures to minimize the incidence of the disease. In line with this effort, the program must develop adapted and high-yielding varieties which possess an acceptable degree of resistance to the disease and desirable agronomic characters, particularly high yield. The search for effective chemical control in combination with the use of resistant varieties continues and has been supported with studies on the physiological factors surrounding infection. The project is now in its second year.

Seed Production

As of April 1972, about 410.6 hectares were planted to Philippine DMR 2 and 119.5 hectares to MIT Var. 2. The total estimated yield was 746 tons of Philippine DMR 2 and 278 tons of MIT Var. 2. A total of 168 seed cooperators were involved in this accomplishment.

National Training Program

The training program is designed to provide technical training in various phases of corn production and farm demonstration methods. Farmer leaders are also exposed to different aspects of cultural management to familiarize them with modern trends being practiced at UPCA. In 1971-72, 871 technical field workers participated in five types of training courses.

Two specialist-supervisor courses were conducted for 3 1/2 months and dealt mainly with production techniques. In a three-week course on marketing, the participants were detailed as full-time marketing technicians in their respective province of assignment. Some 708 farmer leaders were briefed on the cultural management practices of feed grains crop production through farm demonstrations.

THAILAND

Production

In 1971, Thailand's annual maize production continued to increased, reaching a record 2.3 million metric tons from an estimated one million hectares. However, production in 1972 decreased about 45 percent from 1971 due to a severe drought during the major growing season.

Maize has continued to be an important foreign exchange earner as most of the crop is exported, primarily to markets in East and Southeast Asia. Because of its success and importance to national development, the target for the present five-year development plan ending in 1976 calls for a total annual output of 3.5 million tons.

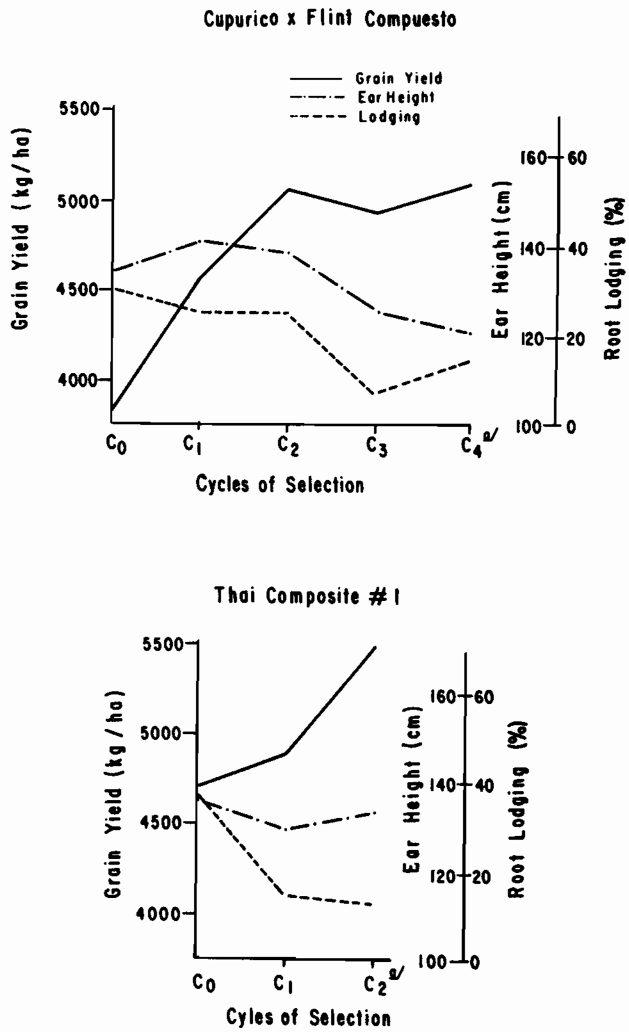
Breeding

The breeding project has concentrated its efforts on developing high-yielding varieties with good lodging and disease resistance. One promising population has evolved from a selection program. Four cycles of full-sib selection in (Cupurico x Flint Compuesto) has provided an improved population for yield, height and lodging resistance (Fig. 7). The yield progress from Cycles 1 and 2 compared to Cycles 3 and 4 is interesting. For the latter cycles, more emphasis was given to lowering height with a concommitant lower rate of gain for grain yield. Whether this resulted from selection for lower plants is not known.

A second promising population has resulted from two cycles of S_1 progeny selection in Thai Composite 1. This composite was derived from a systematic mixing of 36 adapted but somewhat diverse germ plasm complexes. Fig. 7 shows that yield has increased markedly, ear height decreased slightly and lodging resistance improved significantly. These two selected populations have a potential yield 20 to 30 percent above Thai farmers' present variety. They have also performed well in regional trials in Asia.

Plant Pathology

Downy mildew caused by *Sclerospora sorghi* has become a serious threat to Thailand's maize production. The best sources of resistance available have been obtained and are now being used to transfer genes for resistance to Cupurico x Flint Compuesto and Thai Composite 1. It has been possible to recover the grain yield and other good attributes of the elite populations mentioned while obtaining relatively high levels of downy mildew resistance. This is illustrated with Thai Composite 1 in Table 45.



a/ Data from 1972 only

FIG. 7. Grain yield, ear height and lodging for selections from two genetic populations of maize grown at Farm Suwan, Thailand, in 1971 and 1972.

TABLE M45. Data for downy mildew resistant populations grown at Farm Suwan, Thailand, in 1972.

Entry	Grain yield kg/ha	Height, cm Plant	Height, cm Ear	Root lodging %	Downy mildew %
Phil. DMR 5 x Thai Composite F_3	5150	240	137	3	15
Phil. DMR 5 x Thai Composite BC_1	5568	239	131	9	18
Phil. DMR 5	4136	241	126	8	9
Thai Composite #1 (S) C_2	5494	233	129	6	41
Guatemala PB 5	4737	275	164	27	50

Protein Quality

Fourteen populations which have been crossed to sources of downy mildew resistance have subsequently been crossed to Thai Opaque Composite 1 to develop high-yielding, agronomically acceptable, downy mildew-resistant varieties with high protein-quality. The F_2 and F_3 populations were screened for quality protein and hard endosperm. The F_3 generation was also screened for downy mildew resistance.

Yield evaluations were made for all crosses in 1972. Each F_2 population was separated phenotypically into normal, partial opaque and opaque kernels for yield evaluations. The partial opaque and opaque separations yielded 95 and 93 percent, respectively, compared to the normal-like separation. Yield and other data for two opaque-2 populations and two check varieties are shown in Table 46.

TABLE M46. Data from two opaque-2 versions and checks grown at Farm Suwan, Thailand, in 1972.

Entry	Grain yield: Yield kg/ha	Grain yield: % Check	Height, cm: Plant	Height, cm: Ear
Thai Opaque Comp. #1 x (Phil. DMR 5 x Cupurico — Flint Comp.) F_2	4821	116	233	133
Thai Opaque Comp. #1 (Phil. DMR 5 x Thai Composite #1) F_2	4938	119	241	133
Thai Opaque Comp. #1 (opaque check)	4147	100	231	128
Guatemala PB 8 (normal check)	4883	117	275	163

Agronomy

Promising experimental varieties have been evaluated in soil fertility and crop production studies. Fig. 8 shows a typical response to varying fertility levels at the Farm Suwan research station. Varietal response to relatively low to moderate levels of nitrogen and phosphorus are evident but significant interactions between varieties and fertilizer levels are rarely observed even when "good" tropical hybrids (varieties 4 and 5 in Fig. 8) are used.

Response to increasing plant populations are typified in Fig. 9. Slight (often statistically insignificant) yield increases are observed from 40,000 to 53,333 plants per hectare followed by no further positive response. Variety x plant density interactions are observed since tall, lodging-susceptible varieties such as Guatemala do not tolerate high densities.

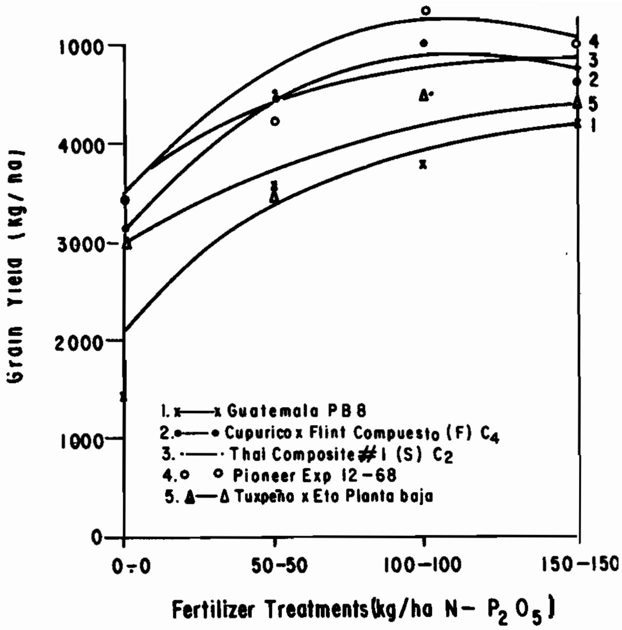


FIG. 8. Response of five maize genotypes to four fertilizer treatments at Farm Suwan, Thailand, 1972.

Seed Increase of New Varieties

A total of 250 tons of Bogor Synthetic 2 and Tainan DMR Composite 10, two downy mildew resistant varieties, will be distributed to farmers in areas of high disease incidence.

Seed increases of Philippine DMR 5 and DMR 3 were also made, since these varieties have high levels of resistance to downy mildew (Tainan DMR Composite is moderately resistant) and yield equal to or slightly less than Guatemala PB8 in experiment station tests. These are intended to serve as stopgap varieties until new, higher yielding varieties are developed and increased.

Other increases included 150 tons of Guatemala (PB5, PB8 and PB9) and breeders' seed of improved experimental varieties.

INTER-ASIAN CORN IMPROVEMENT PROGRAM

IACP is a cooperative Asian program sponsored and funded by the Rockefeller Foundation in cooperation with CIMMYT and national programs. IACP is based in Thailand in cooperation with Kasetsart University and the Thailand Ministry of Agriculture.

IACP activities help to:

1. Facilitate cooperation among Asian maize scientists and to expedite exchange of information and materials.
2. Develop strong national programs.

3. Train maize workers of various disciplines, educational levels and responsibilities to improve their effectiveness in the rapid development and adoption of new technology.

4. Promote and conduct research that can be directly applied to increasing amount and efficiency of maize production in Asia.

The maize area in Asia is second only to North America. In eastern Asia it is usually second to rice in importance and in South Asia to rice and/or wheat. Maize is a staple food for tens of millions of Asians and is becoming important as a livestock feed. The average yield is only 1.2 tons per hectare and demands far exceed production--maize imports of Asian countries equal about one-half of their production. With Asia's present food shortage and rapidly increasing population, maize appears poised to make the third--after wheat and rice--significant contribution to accelerated production.

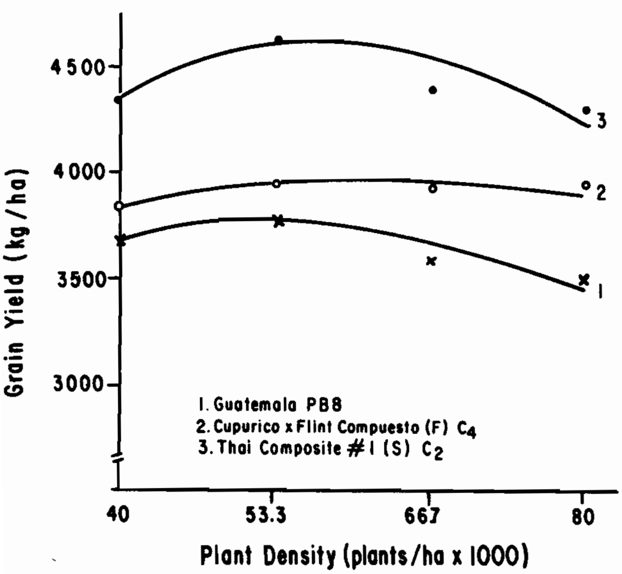


FIG. 9. Response of three maize genotypes to increasing plant densities at Farm Suwan, Thailand, in 1971 and 1972 (averages for 2 years).

Good varieties and hybrids bred for resistance to downy mildew have been recently developed and released in countries of Southeast Asia. This endemic disease has reduced annual corn production in the Philippines, Indonesia and Nationalist China for many years by up to 40 percent; significant losses from downy mildew alsco occur in Thailand, India and Nepal.

Annual IACP Workshop

The eighth annual IACP workshop was held in Thailand during October 9-13. It was inaugurated at Kasetsart University by the Prime Minister of Thailand. Eighty-four delegates and observers, including 62 delegates from 18 countries outside Thailand, registered for the five-day session.

Dr. Akira Tanaka from Hokkaido, Japan, summarized his laboratory's research on the physiology of the maize plant. Discussion topics included: the level of maize production technology, farm testing, quality protein, breeding, plant protection and crop production. Cooperative yield trials and nurseries were planned within the region for tests in 1973. A two-day field trip was conducted at Farm Suwan where on-going research was observed. The workshop proceedings will be published in January 1973.

Regional Testing

The third year of uniform varietal testing was completed in Asia in 1971. Two trials designated as IACP Trials 1 and 2 were formed from varieties and hybrids from local programs in the more temperate-like regions and lowland tropical regions, respectively. Trial 1 was grown in 11 locations, primarily in subtropical and temperate areas. Two open-pollinated varieties from Pakistan, Neelam and Akbar, yielded highest over the area. A hybrid from Japan, K-305, was the highest yielding early maturing entry.

Trial 2 was grown at eight locations in the lowland tropics and eight locations outside this area. Ganga 5 (India), UPCA VAR 1 (Philippines) and Cupurico x Flint Compuesto (Thailand) performed well in both zones and ranked well overall. Experimental Hybrid 4207 (India) yielded exceptionally well outside the lowland tropics but performed rather poorly in several locations of the lowland tropics. Vijay (India) was even more specifically adapted as it ranked third in the more temperate-like regions and very low in the lowland tropics.

Data from the 1971 tests support results for earlier years on the performance of several varieties. Ganga 5, UPCA VAR 1 and Bogor Composite 2 (Indonesia) continued to exhibit rather general adaptability throughout. Entries with a significant amount of lowland tropical germ plasm perform better over the region than entries with a high proportion of temperate germ plasm. The suceptibility of varieties of the latter group to diseases of the humid, lowland tropics no doubt conditions some of this behavior.

A cooperative yield trial of 11 downy mildew resistant to moderately resistant varieties was grown at eight locations in five Asian countries. The variety Tainan DMR 10 had the highest average grain yield (3,922 kg/ha). However, the average yields of Philippine DMR Varieties 4, 3, 2, 6 and 5 were also above three tons per hectare and were much more resistant to downy mildew than Tainan DMR 10.

The third series of downy mildew nurseries were established in 1971 to monitor virulence among the downy mildew species found in the various countries and to the level of resistance being developed in national varietal improvement programs. The data suggest that both intraspecific and interspecific virulence is similar for the world as evidenced by the relative resistance rank of the differential maize used. It is evident that the disease is most damaging in the Philippines, least damaging in Taiwan and intermediate in Thailand and Indonesia as determined by the level of infection of "resistant" varieties in this nursery. However, it is not clear what these differences in infection percentages among countries are due to--differences of environment, inoculum levels or virulence of the pathogens.

A limited number of summary reports for 1969, 1970 and 1971 testing are available.

Staff Visitations

Sixteen staff visitations to 10 national programs and two to CIMMYT were made during 1972. These were for consultation, review, evaluation of materials, helping organize research and extension activities, participating in training programs, making follow-up visits with former IACP trainees and participating in international seminars.

Training

There have been 128 participants in the IACP Training Program since its initiation in 1967. Their distribution by year and country are:

Year

1967	21	1970	14
1968	42	1971	14
1969	16	1972	21

Country

Afghanistan	3	Malaysia	2
Ceylon	8	Nepal	1
Indonesia	12	Pakistan	33
Japan	1	Philippines	11
Korea	2	Thailand	47
Laos	6	Vietnam	1
Khmer	1		

The training period is 6 or 12 months. Classes begin in January and July. About half of the trainees have been from extension services or demonstration farms.

Broadly stated, the general objective of the training program is to develop competence in modern crop production technology with particular focus on maize. This involves an understanding of the agricultural resources and the role of management in their use for improving production and profit to the farmer and the agricultural sector in general. Emphasis is on field activities. Each trainee is expected to complete one or more field projects involving research or demonstration of factors affecting production in his area. The trainees work together so that each learns techniques and skills that are used in working with a wide range of problems: breeding, variety trials, fertilizer trials, disease identification, loss evaluation and control, weed control, insect control, methods of planting, etc. The work experience is supplemented with lectures and reading assignments.

Other Activities

Seed lots other than regional tests were sent from IACP headquarters in Thailand to 15 countries on special request. Included in these were large lots of improved varieties for direct increase and countrywide testing in three countries (Burma, Ceylon and Nepal).

A special downy mildew meeting was held in Taiwan, May 8-11, 1972. An in-depth examination of current problems and research activities was made by representatives from the Philippines, Thailand and Taiwan. The group outlined a program of future activities.

Juan Gil Preciado (third from left), former Secretary of Agriculture for México, participates in discussions of the results of the Downy Mildew Program and regional activities by a group of scientists from Southeast Asia, the United States, and CIMMYT, in Taiwan.

PUEBLA PROJECT

PUEBLA PROJECT

The Puebla Project completed its fifth year of operations in 1972, and plans were drawn up for a thorough evaluation of results during 1973, which is the final year under CIMMYT's leadership and financing.

The Project is a pilot study of how to increase rapidly the maize yields of small farmers using traditional methods in rainfed areas. It has three objectives: (1) to help farmers increase their maize yields; (2) to understand better what services are needed to achieve rapid increases in yields; and (3) train people for carrying out similar programs in other areas.

The Project began in 1967 in cooperation with the Mexican Ministry of Agriculture, the State of Puebla and the Graduate College of the National School of Agriculture at Chapingo. It is located two hours by automobile east of Mexico City in the State of Puebla in an area comprising 116,000 hectares of cultivated land and 47,500 farmers. The Project is operated by a small team of agronomists. They develop recommendations on cropping practices for farmers by conducting field trials in the Project area. They disseminate the information, assist farmers in obtaining credit, fertilizers, etc., and study the social and economic factors influencing farmer utilization of modern technology.

Developing Recommendations on Cropping Practices

The results obtained from experiments conducted on farmers' fields have been used to develop packages of recommended practices for the different conditions in the Project area. The best set of practices varies significantly within the area due to differences in soils, planting dates and the willingness of farmers to accept risk. Recommended fertilizer application rates vary from 80 to 130 kg/ha, for nitrogen, and 0 to 60 kg/ha for P_2O_5. The recommended plant population densities vary from 40,000 to 50,000 plants per hectare. Improved varieties are not yet available which are consistently better than the local varieties. Recommendations were developed initially for only one crop--maize--and, since 1970, have been developed for beans, the second most important crop in the area.

Many farmers have traditionally interplanted beans in their maize. Until recently, however, agricultural scientists have not considered the maize-bean association as a likely alternative for increasing production and net income.

Experiments were carried out at three locations in 1972 to measure the response of a maize-pole bean association to fertilization and plant density. Maize yields were reduced about 30 percent by the interplanting of beans; the yields of the beans were unchanged or increased by the association (Table 1).

The most notable treatment was 10 tons of chicken manure per hectare which increased maize and bean yields above levels obtained with chemical fertilizers alone by about 8 percent and 70 percent, respectively. This level of chicken manure cannot be applied as a general practice because of inadequate supply in the area, but the finding is indicative.

Net returns from the several maize-bean associations and from maize and beans grown alone are given in Table 2. Net returns were calculated by subtracting variable treatment costs from total produce value; fixed costs were not considered. The values in the last column of Table 2 reveal: (1) net returns from fertilized maize and beans, when grown alone, are similar; (2) net income from the maize-bean association is about twice that obtained from either of the crops alone; and (3) the chicken manure treatment gave a net income of US$129 per hectare above that obtained with the best chemical fertilizer treatment. Based on these and similar results obtained in 1971, farmers will be encouraged to use the maize-pole bean association, and recommendations on fertilization and plant density will be provided.

A few farmers in the Project area have applied herbicides after the last maize cultivation. Many

TABLE PP1. The response of a maize-pole bean association to fertilization and plant density.

Treatment				Yield of grain 14% moisture (kg/ha)							
Fertilization		Thousands of plants/ha		Tlaltenango		Chiautzingo		San A. Arenas		Average	
N kg/ha	P_2O_5 kg/ha	Maize	Beans	Maize	Beans	Maize	Beans	Maize	Beans	Maize	Beans
90	40	30	60	3965	850	3070	949	821	1651	2619	1150
120	40	30	60	4561	845	3066	1116	1335	1940	2987	1300
120	40	40	60	4473	792	3960	1046	1486	1900	3306	1246
120	80	30	60	3610	1043	4020	1403	1247	2199	2959	1548
120	80	40	60	3998	905	3423	1306	1802	1967	3074	1393
150	40	30	60	4226	1333	2818	1345	1345	2048	2796	1575
150	40	40	60	4766	910	4398	961	2111	2211	3758	1361
150	80	30	60	4139	999	3331	1326	1548	2401	3006	1575
150	80	40	60	4755	1093	4144	1269	1779	1833	3559	1398
150	0	40	60	4620	977	2835	963	2012	2395	3156	1445
180	80	40	60	4031	1342	4559	1159	2151	2093	3580	1531
150	40	40	60								
+ 10 ton/ha chicken manure				4596	2301	5197	2836	2376	2202	4056	2446
120	40	40	0	5184	0	5514	0	3203	0	4634	0
60	60	0	90	0	894	0	1476	0	1295	0	1222

TABLE PP2. Net returns from a maize-pole bean association using different levels of fertilization and plant density.

Fertilization		Thousands of plants/ha		U.S. Dollars per hectare [a]			
N kg/ha	P_2O_5 kg/ha	Maize	Beans	Tlaltenango	Chiautzingo	San A. Arenas	Average
90	40	30	60	422	412	398	411
120	40	30	60	453	457	493	468
120	40	40	60	436	490	493	473
120	80	30	60	432	560	534	509
120	80	40	60	423	506	513	480
150	40	30	60	543	503	497	514
150	40	40	60	480	505	574	520
150	80	30	60	453	515	573	514
150	80	40	60	507	547	461	505
150	0	40	60	471	406	637	505
180	80	40	60	484	534	540	519
150	40	40	60				
+ 10 ton/ha chicken manure				651	824	471	649
120	40	40	0	325	354	179	286
60	60	0	90	146	273	234	218

[a] Using the following prices for produce in the field:

Maize grain	US$ 54.80/ton
Maize stover	14.40/ton
Beans	219.20/ton

people have questioned the value of an auxiliary hand weeding of maize at the same time as the first or second mechanical cultivation. Experiments were carried out at two locations in 1972 to determine the effect of these weed control measures.

Table 3 shows that: (1) an auxiliary weeding by hand at the first cultivation, second cultivation, or 25 days after the second cultivation had about the same effect and increased grain yields by about 2.30 and 1.24 tons per hectare at Tlaltenango and Apango, respectively, and (2) a broadcast treatment with a mixture of Atrazin and 2, 4-D after the second cultivation gave an additional yield increase of 0.69 and 2.00 tons per hectare at Tlaltenango and Apango, respectively. Thus, both the hand weeding and the herbicide application were high profitable. Weather conditions in 1972 were very favorable for plant growth, so the observed effects of weed control perhaps represent the largest effects that can be expected in the area.

Use of the Recommendations by Farmers

Information on maize and bean recommendations is transmitted to farmers through meetings, movies, field demonstrations at planting and the second application of nitrogen, field inspections and evaluations of plantings, field days at harvest, pamphlets, radio programs, etc. Assistance is provided to groups of organized farmers in obtaining credit and in purchasing opportunely the fertilizers specified by the recommendations.

The new recommendations were used for the first time in 1968 on 76 hectares by 103 farmers. A general effort to extend the use of the recommendations to all farmers was begun in 1969 and has continued for the past four years. Some information is available that indicates the extent to which farmers are using Project recommendations:

Dr. Antonio Turrent, CIMMYT soils scientists and training agronomist, examines a maize-bean association in the Puebla Project area just prior to harvest.

1. Number of farmers receiving credit for fertilizers.

Farmers using the maize recommendations must invest US$28 to US$56 dollars per hectare in inputs, primarily fertilizers. Many farmers can use the recommendations only if credit is available. The extension agents have encouraged and assisted the small farmers to organize into groups so that they may receive financing from the major sources of credit in Puebla-- three public banks and a fertilizer distributor. Progress in increasing the participation of organized farmers is summarized:

	1968	1969	1970	1971	1972
Farmers receiving credit	103	2,561	4,833	5,259	6,202
Hectares under credit	76	5,743	12,661	14,438	17,581
Amount of credit (US$1,000)	6	392	768	608	910

Compared to 1971, the values for 1972 represent increases of 18 percent in the number of farmers, 22 percent in area, and 48 percent in amount of credit. The number of farmers on credit lists in 1972 is about 23 percent of the total area planted to maize.

2. Amount of nitrogen used for rainfed maize.

In addition to the farmers on credit lists, others use the maize recommendations, but purchase the inputs with their own funds or through credit obtained from local sources. There is no way of readily measuring the extent of use of the maize recommendations by this category of farmers. In general, however, farmers prefer to work individually and only join together with other farmers when this is the only way they can obtain credit.

The major input that farmers purchase in order to carry out the maize recommendations is nitrogen. Therefore, by examining the change that has occurred since 1967 in the amount of nitrogen used for rainfed maize, it is possible to get some measure of the extent to which the recommendations are being followed.

TABLE PP3. Effect of several weed control practices on the yield of maize grain in kilos per hectare with 14% moisture.

Weed control treatment [a]	Locations	
	Tlaltenango	Apango
Traditional (T) [b]	4281	4403
T + elimination (E) at 1st cultivation	7048	5626
T + E at 2nd cultivation	6380	5606
T + E 25 days after 2nd cultivation	6305	5700
T + E at 2nd cultivation + herbicide	7066	7605

[a] All plots at both locations had 50,000 plants per hectare. The fertilizer treatment at Tlaltenango was 130-40-0 and at Apango was 100-0-0.

[b] Cultivating 30 and 60 days after planting; uncovering maize plants by hand.

Surveys in 1967 and 1971 collected information on fertilizer use from a random sample of farmers. The two surveys show:

	1967	1971
Percent of farmers using no nitrogen	38.2	28.1
Percent of farmers using 0 to 59.9 kg/ha	52.2	36.4
Percent of farmers using 60 kg/ha or more	9.7	35.5
Average nitrogen application (kg/ha)	29.4	57.1

The percentage of farmers using 60 kg/ha or more of nitrogen increased by 25.8 percentage points. The average amount of nitrogen applied per hectare to all the rainfed maize in the Project area almost doubled during the four-year period.

A study in 1971 of fertilizer use by 240 farmers in the project area indicated that: (1) 47 percent of the farmers applied at least 70 kg/ha of nitrogen on at least one field of rainfed maize, and (2) 38 percent of the farmers applied at least 60 kg/ha of nitrogen on at least half of their fields of rainfed maize.

3. Average maize yields.

The maize yields of the 103 farmers using the recommendations in 1968 were measured. In addition, the maize yields of a random sample of all the farmers in the Project area were determined. Since 1968, maize yields have been estimated for random samples of all farmers on credit lists and all farmers in the Project area. An indirect estimating method involving the length and diameter of ears in a sample area has been used.

Maize yields in kilograms per hectare of grain at 14 percent moisture for the two categories of farmers are:

	1968	1969	1970	1971	1972
Farmers on credit lists	3,985	2,829	2,732	2,679	2,920
All farmers in the area	2,140	1,832	1,962	1,927	2,499

These data appear contradictory, because this is a rainfed area, and there is a significant annual variation due to climatic differences. The most favorable of these five years for maize was 1968 (first year), the second best was 1972 (most recent year), and the three intervening years were less favorable. Also influencing the averages for farmers on credit lists is the tendency for averages to decline as the number of participating farmers increases.

Estimates of adoption are difficult because only a part of the farmers who use fertilizer follow the recommendations exactly while others modify the the fertilizer rate, time of application, plant density, information on this point, a random sample of 57 farmers on credit lists in Zone II (the Project area is divided into five zones) and 51 in Zone V were selected for a detailed study of their use of the maize recommendations.

The percentages of the farmers that followed the recommendations fully or in part are shown in Table 4. Fifty-one percent of the farmers on credit lists in Zone II used the correct amount of nitrogen and 39 percent used the recommended amount of phosphorus. Eighty-four percent used the right amount of nitrogen in Zone V (phosphorus is not recommended there).

Although the recommended time of applying nitrogen is at planting and at the second cultivation, the second and third alternatives shown in Table 4 should have given good results. Twenty percent of the farmers, however, applied all of the nitrogen at the second cultivation which almost certainly reduced its effect on yield. Only 24 percent of the farmers in Zone II applied phosphorus at the right time.

Thirty-two percent of the participants in Zone II and 39 percent in Zone V achieved plant densities close to the recommendation. Forty-five percent of the farmers in Zone II and 31 percent in Zone V had densities less than 35,000 plants per hectare, which would be expected to lower yields significantly.

TABLE PP4. The percentage of farmers in credit lists in Zones II and V that followed fully or in part the maize production recommendations of the Puebla Project.

	Percentage of farmers on credit lists	
	Zone II	Zone V
A. Amount of nitrogen		
Used the recommendation	51	84
Used at least 3/4 of the recommendation	28	12
Used at least 1/2 of the recommendation	14	2
Used less than 1/2 of the recommendation	7	2
B. Amount of phosphorus		
Used the recommendation	39	—
Used at least 3/4 of the recommendation	24	—
Used at least 1/2 of the recommendation	7	—
Used less than 1/2 of the recommendation	30	—
C. Time of applying nitrogen		
At planting and 2nd cultivation (the recommended practice)	18	0
1st cultivation and 2nd cultivation	58	31
1st cultivation	3	49
2nd cultivation	21	20
D. Time of applying phosphorus		
At planting (the recomended practice)	24	—
1st cultivation	66	—
2nd cultivation	10	—
E. Plant density (thousands/ha)		
> 42.5 (approximately the recommended rate)	32	39
35.0-42.5	23	30
27.5-34.9	33	29
< 27.5	12	2

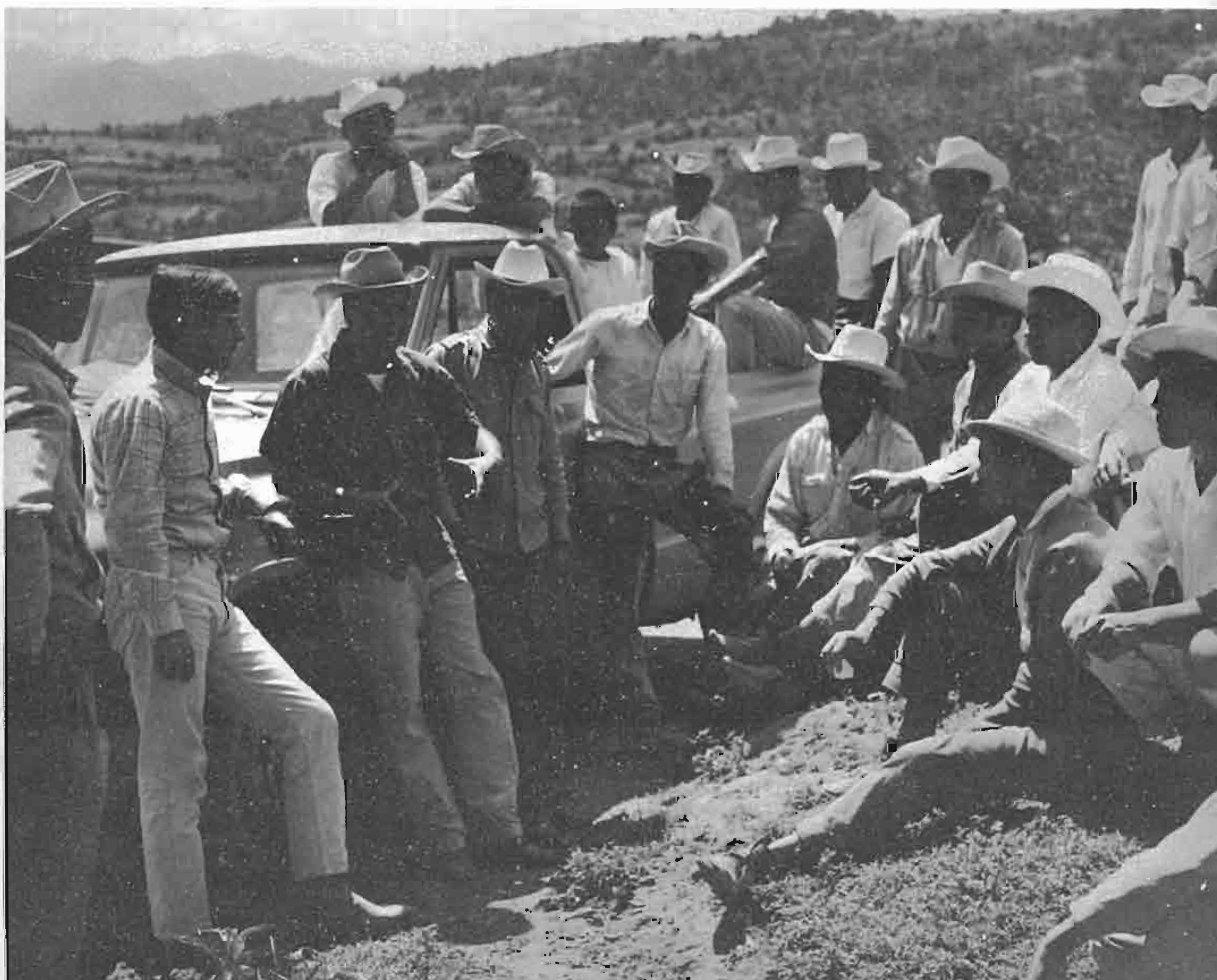
Training

The Puebla Project and the Communications Department of the Graduate College at Chapingo are training agronomists to participate in other production programs similar to the Puebla Project. During 1972, five Colombians completed a two-year training program and five other Colombians began an eight-month program.

Technical Assistance to Other Programs

Assistance in planning agronomic research and in interpreting experimental results was provided to regional production programs in Honduras, Colombia, Peru, and the states of Mexico and Tlaxcala in Mexico.

A Puebla Project extension agent, Ing. Gildardo Espinoza (second from left), meets with a group of farmers to discuss arrangements for credit and fertilizers.




WHEAT QUALITY EVALUATION

SUPPORTING SERVICES

SERVICE LABORATORIES

Protein Quality Laboratory

The protein quality laboratory has become an important working tool of the cereal breeder only since the mid-1960s.

Both wheat and maize are somewhat deficient in total protein, and both are inadequate in amino acid balance. The low nutritional value of cereal protein is generally caused by a deficiency of only one amino acid--lysine, and in the case of maize, by one additional deficiency--tryptophan.

For many years plant scientists believed the shortcomings of cereal protein could be corrected only by a balanced diet (that is, by including different protein sources in the diets), or by adding synthetic amino acids to processed foods. Then in the 1960s scientists at Purdue University discovered that certain mutant genes in maize could greatly alter the amino acid composition. This created new potential for cereal improvement, and it also made the protein quality laboratory a necessary tool in cereal breeding.

In 1972, the CIMMYT laboratory processed approximately 11,800 samples of cereals, including maize, wheat, triticale, and barley. All these crop programs are seeking to improve protein quality while developing better plant types and higher yields.

To obtain reliable evaluation of protein quality for thousands of cereal samples between the two breeding cycles each year, chemical assay methods must be rapid, reliable, and relatively inexpensive. The chemical aspects of these tests have been simplified at CIMMYT during the six years since the protein laboratory was established.

The protein laboratory serves as a training center for laboratory technicians from developing countries. In 1972, four trainees from four different countries worked in the CIMMYT laboratory.

Animal Nutrition Laboratory

Some cereal samples which rank highest in chemical analysis for protein quality are also tested by CIMMYT in January 1972. The feeding trial further verifies the protein quality.

The animal chosen for feeding trials at CIMMYT is the meadow vole (*Microtus pennsilvanicus*). This animal was chosen because of its high growth rate, low rood requirement, and high reporduction rate. CIMMYT imported 100 animals from Dr. F. C. Elliott at Michigan State University where these animals were used for preliminary nutritional evaluation of protein efficiency.

Approximately 650 feeding trials with the voles were conducted at CIMMYT during 1972. The colony had increased to 800 animals by the end of the year.

These meadow voles provide a biological assay of protein quality of cereal strains in CIMMYT breeding programs.

The protein efficiency ratios established by the voles during 1972 have not been wholly consistent with the results of feeding trials at other institutions, where other animals are used. While continuing its biological assays with the voles, CIMMYT is studying the nutritional requirements and physiological behavior of the vole in order to interpret better the protein data from the feeding trials. Also, CIMMYT is gathering the comparative data produced by other institutions in the United States, Canada, and Colombia, where rats, mice, chicks and pigs are used for determining protein efficiency ratios.

Soils and Plant Nutrition Laboratory

This laboratory, established in 1969, serves both the wheat and maize programs.

Soil characteristics are important factors in developing recommended fertilizer practices, and this laboratory has provided analytical services to agronomy trials.

The wheat program has used this laboratory since 1969 to obtain information on certain metabolic processes and to analyze nitrate-reductase activity in wheat plants as one possible criteria in selecting breeding materials with high protein levels in the grain.

Other Activities

Other CIMMYT laboratory activities are described in the wheat and maize sections of this report, including the work on industrial quality of wheats.

ECONOMICS UNIT

The year 1972 was the first full year in which CIMMYT employed an economist. The Economics Unit employed only one staff member, and the activities were necessarily exploratory.

Adoption Studies

First priority was given to a series of adoption studies on new technology for wheat and maize. These studies were prompted by a question from CIMMYT Trustees: who is making use of new technology for wheat and maize, and what factors influence farmers to adopt? The studies were begun in eight countries during 1972:

For wheat: India, Iran, Turkey, Tunisia.

For maize: Mexico, El Salvador, Colombia, Kenya.

In each country the study began with a questionaire, covering four questions:

1. To what extent have different classes of farmers adopted the new technology for wheat or maize? Are the farmer-adopters large landholders or smallholders, or both? Are the farmer-adopters using irrigation or dryland methods, or both?
2. What is the relative profitability of the new technology compared to traditional methods as measured on research stations and in farmers' fields?
3. What was the nature of government support systems--for example, extension service, credit service, fertilizer distribution, and price supports--at the time the new technology was introduced?
4. To what extent have government programs aiming to benefit small farmers helped diffuse new technology among that class of farmers?

CIMMYT's manner of conducting these studies has been influenced by the limited headquarters staff. First, CIMMYT arranged for a local national in each country to serve as the principal researcher, and wherever possible, a researcher was chosen who already had engaged in this type of study. Second, knowledgeable technicians living in the country were asked to advise the project. Third, the local government was asked to give its endorsement, and in some cases, its financial support. With few exceptions, the response was favorable.

By the end of 1972, all studies were under way. An interim progress report is expected by mid-1973, and a final report in 1974. These studies have drawn inquiries from several foreign aid agencies because of widespread interest in whether the new "high-yielding varieties" of wheat, rice, and other cereals are of equal benefit for all climatic conditions and for all classes of farmers.

Other Activities

Besides the adoption studies, CIMMYT's economist was involved in three other major activities, all of them continuing:

1. In-depth evaluation of the Puebla Project, a maize production project in Mexico which completed its sixth cropping cycle in 1972.
2. Consulting with outreach projects in Zaire, Nigeria, Peru, El Salvador, and Honduras. The purpose is to help identify economic constraints in cereal production projects.
3. Participating in CIMMYT's headquarters activities to contribute an economic viewpoint to international workshops, program reviews, training activities, and research planning by the scientists.

TABLE ES1. Information on CIMMYT's six research locations in Mexico, 1972.

Name of station	Distance from Mexico City km	Altitude meters	Ha of experimental land used by CIMMYT per crop	Cropping months
CIANO-INIA	1,800	39	80, wheat	Nov-Apr
			5, maize	Jun-Dec
Río Bravo-INIA	1,600	30	5, maize	Feb-July
Poza Rica-CIMMYT	282	60	45, maize	Dec-May
			twice yearly	Jun-Nov
El Batán-CIMMYT	47	2,249	26, maize	Apr-Dec
			17, wheat	All year
			2, sorghum	Jun-Dec
Toluca-CIMMYT	85	2,640	44, wheat	All year
			10, maize	Apr-Dec
			5, potatoes	Mar-Dec
Tlaltizapán-CIMMYT	132	940	30, maize	Dec-May
			twice yearly	Jun-Dec

EXPERIMENT STATIONS IN MEXICO

During 1972 CIMMYT conducted its crop research at six locations in Mexico with widely differing elevations. Thus, the varying environments simulated growing conditions in many parts of Asia, Africa, and Latin America. The basic information on these locations in Mexico is given in Table 1.

Station Improvements in 1972

Because of generous support by the donors of the CIMMYT capital budget, many improvements were carried out on the experiment stations, some of which had been posponed for several years. The improvements in 1972 are summarized:

El Batán Station near Mexico City: Land levelling and a new irrigation system were substantially completed on 43 hectares of the original headquarters station. An additional 22 hectares of land were purchased on the north boundary of the headquarters in mid-1972, and improvement of this land awaits the 1973 budget.

Atizapan Station near Toluca: Land levelling was completed, and there were no drainage problems during the year. A new block of four crop driers was installed. A shortage of irrigation water caused some crop damage, and will be remedied in 1973 by constructing a new reservoir.

Poza Rica Station, Veracruz State: Land levelling was completed. Four stone spurs were installed along the station's river boundary to stop river erosion. A new drainage system was installed and proved effective. Also, a new building was constructed for the use of trainees.

Tlaltizapán Station, Morelos State: An additional 2.5 hectares of land was purchased on the station boundary, increasing the total tillable land area to about 33 hectares. Land levelling and drainage systems were completed. The rains failed at this station in 1972, confirming the need for a complete irrigation system.

Meteorological Observations

CIMMYT maintains daily weather observations at its stations, and obtains weather data from the Mexican Government where CIMMYT uses Government stations. The CIMMYT records include: precipitation, maximum and minimum temperatures, net and solar radiation, wind movement, evaporation and humidity. Details for 1972 are given in Table 2.

COMMUNICATIONS SERVICES

Information activities at CIMMYT in 1972 included: printed publications, audiovisual materials, visitor services, library services and training.

PRINTED PUBLICATIONS

CIMMYT edits and produces more than 50 printed publications each year. These appear in various series such as the information bulletin series, research series, translation and reprint series, and scientific newsletters.

In 1972 CIMMYT issued more publications than in any previous year.

Special Publications

Under this heading, the following title appeared: CIMMYT Annual Report, 1970-71.

In addition, the following were reprinted and distributed.

The Puebla Project. 1967-69 (English and Spanish, 4th printing).

Strategies for Increasing Agricultural Production on Small Holdings (English and Spanish, 3rd printing).

Information Bulletin Series

No. 1 Results of the First International Triticale Yield Nursery 1969-70. January 1972

No. 2 Results of the First International Durum Yield Nursery, 1969-70. February 1972

No. 3 Results of the First Elite Selection Yield Trial-1 and Elite Selection Yield Trial-2, 1969-70

No. 4 The International Wheat and Maize Nurseries Handbook for Fertilizer Conversions to Basic Units. March 1972 (2nd printing)

No. 5 Report on the Grain Quality of the Entries in The Seventh International Spring Wheat Yield Nursery 1970-71. March 1972

No. 6 Results of the First International Maize Adaptation Nursery. October 1972

No. 7 Instrucciones para el Manejo y Presentación de los Resultados de los Viveros Internacionales

TABLE ES2. Temperatures at CIMMYT experiment stations in 1971 and 1972.

Month	Max.	Min.	Ave.	Precipitation	Days of rain	Max.	Min.	Ave.	Precipitation	Days of rain
E L B A T A N										
			1971					1972		
Jan.	23.3	1.2	12.2	20.4	1	24.6	0.5	12.5	6.4	1
Feb.	24.4	1.3	12.8	...	...	25.5	—0.4	12.5	...	...
Mar.	26.3	4.7	15.5	11.4	5	26.1	2.8	14.4	11.8	9
Apr.	26.7	4.3	15.5	9.0	3	28.1	5.0	16.5	54.7	8
May.	28.4	7.8	18.1	34.1	8	27.7	8.5	18.1	120.5	13
Jun.	24.0	9.8	16.9	192.9	19	25.2	10.0	17.6	111.8	14
Jul.	24.0	9.6	16.8	87.8	17	23.3	9.5	16.4	130.7	21
Aug.	24.2	8.9	16.5	105.0	18	22.9	8.0	15.5	85.8	17
Sep.	25.0	8.9	16.9	137.1	17	23.0	8.3	15.6	79.0	16
Oct.	23.2	6.9	15.1	38.8	13	23.0	6.9	14.9	30.3	8
Nov.	25.3	1.9	13.6	5.2	2	23.1	4.9	14.0	16.5	5
Dec.	24.1	1.1	12.6	8.8	3					
P O Z A R I C A										
Jan.	27.3	15.4	18.6	50.8	3	26.2	16.3	21.3	123.5	9
Feb.	28.3	15.1	21.7	18.7	4	24.5	15.1	19.8	39.2	12
Mar.	30.5	17.2	24.4	24.2	4	30.2	20.3	25.3	39.3	7
Apr.	31.4	18.3	24.8	42.5	3	32.9	22.8	27.8	26.6	3
May.	33.4	22.5	27.9	75.2	4	32.2	23.1	27.7	100.9	10
Jun.	35.3	23.3	29.3	86.6	13	32.5	22.7	27.6	254.1	14
Jul.	32.3	21.9	27.1	215.1	14	30.7	21.9	26.3	234.2	17
Aug.	31.9	22.3	27.1	201.1	17	31.6	21.4	26.5	240.2	19
Sep.	32.3	22.5	27.4	93.7	14	32.1	21.8	26.9	130.3	12
Oct.	30.0	22.1	26.1	319.1	12	31.0	21.6	26.2	182.4	11
Nov.	28.3	19.2	23.8	16.1	9	27.8	18.6	23.2	52.5	15
Dec.	27.2	18.2	22.7	37.2	11					
A T I Z A P A N , T O L U C A										
Jan.	16.8	2.3	9.5	2.0	1	17.6	—3.9	6.8	...	...
Feb.	19.0	— 0.4	10.0	...	...	18.1	—4.1	6.9	1.8	1
Mar.	21.2	2.2	11.6	36.6	5	20.7	—3.0	8.8	15.0	4
Apr.	22.4	1.1	13.1	14.0	4	23.8	2.5	13.1	17.3	6
May.	26.2	6.2	16.2	20.5	7	23.6	4.6	14.1	78.3	10
Jun.	20.1	8.8	14.4	191.3	15	19.8	8.0	13.9	167.3	14
Jul.	18.7	8.6	13.7	201.8	23	18.6	8.1	13.3	164.0	22
Aug.	19.2	8.3	13.8	122.8	20	18.7	10.6	14.6	198.9	17
Sep.	19.4	9.0	14.0	176.0	15	19.6	7.6	13.6	96.8	14
Oct.	19.8	6.3	13.1	40.8	7	16.5	5.2	10.8	52.4	6
Nov.	19.8	— 1.6	9.1	22.5	2					
Dec.	18.3	2.6	10.5	9.0	1					
T L A L T I Z A P A N										
Jan.	31.0	9.1	19.9	1.5	1	31.2	9.8	20.1	0.3	1
Feb.	31.7	9.5	20.5	...	...	32.4	8.8	20.6	...	...
Mar.	35.0	13.5	24.5	3.4	2	33.7	12.3	22.8	...	...
Apr.	36.1	13.3	24.7	...	...	36.4	17.8	26.2	45.6	9
May.	37.6	16.9	27.4	42.8	5	36.2	22.9	29.3	44.0	6
Jun.	32.3	18.7	15.1	218.9	15	38.3	21.2	29.7	246.4	14
Jul.	30.3	17.9	24.2	202.6	20	30.7	20.4	25.2	103.1	17
Aug.	29.8	17.7	23.6	138.2	20	31.7	20.8	26.2	76.1	12
Sep.	27.9	18.9	23.3	307.4	25	31.3	19.7	25.4	171.8	16
Oct.	28.0	17.3	22.8	239.1	13	31.7	15.0	23.1	22.3	5
Nov.	27.1	12.1	19.6	15.4	1	31.8	14.5	22.7	7.1	3
Dec.	30.7	10.5	20.0	7.1	1					

de Selección (Screening Nurseries). (Instructions for the Management and Reporting of Results for all International Screening Nurseries). (2nd printing)

No. 8 Instrucciones para el manejo de los Viveros Internacionales de Rendimiento. (Instructions for the management of the International Yield Nurseries) March 1971 (3rd printing)

No. 9 Preliminary Summary of the Second International Elite Selection Yield Trials (1 and 2). A Spring Wheat Yield Nursery, 1970-71. January 1972

Research Series

No. 20 Chemical Screening Methods for Maize Protein Quality at CIMMYT (Spanish Edition). May 1971 (1972)

No. 23 Results of the Sixth International Spring Wheat Yield Nursery, 1969-1970 (1972)

The following were reprinted and distributed upon request.

No. 2 Statistical Genetic Theory and Procedures Useful in Studying Varieties and Inter-Varietal Crosses in Maize. 1968 (English and Spanish, 3rd printing)

No. 9 Field Technique for Fertilizer Experiments. 1968 (English and Spanish, 4th printing)

No. 12 Combining Data from Fertilizer Experiments into a Function Useful for Estimating Specific Fertilizer Recommendations. 1969 (2nd printing)

Translation and Reprint Series

The Communications program acquired and distributed upon request reprints of the following papers by CIMMYT scientists or papers based on CIMMYT work and published in journals or series outside CIMMYT.

No. 9 Human Population, Food Demands and Wildlife needs. Dr. N. E. Borlaug. Reprinted from Transactions of the 37th North American Wildlife and Natural Resources Conference, March 1972. Wildlife Management Institute, Washington, D.C.

No. 10 Mankind and Civilization at Another Crossroad. Dr. N. E. Borlaug. McDougall Memorial Lecture, FAO. 1971 (English, Spanish and French)

No. 11 Dry Matter Production, Yield Components and Grain Yield of the Maize Plant. Akira Tanaka and Jurichi Yamaguchi. Reprinted from Journal of the Faculty of Agriculture, Hokkaido University, Vol. 57, Pt. 1. Sapporo, Japan 1972.

In addition, new printings were made of the following.

No. 2 Wheat Breeding and its Impact on World Food Supply. N. E. Borlaug. International Wheat Genetics Symposium, Canberra, Australia, 1968. (English and Spanish, 3rd printing at CIMMYT)

CIMMYT Report

A significant change in CIMMYT informational activities in 1972 was the creation of a new bimonthly newsletter in English and Spanish--CIMMYT Report. This replaces "CIMMYT News", which was suspended in 1970 during a series of stall changes at CIMMYT.

CIMMYT Report presents a program progress report and deals with one primary subject in each issue. Subjects include research advances of general interest. The first issue was an updating publication released at the end of 1972.

Maize and Wheat Bibliographies

During 1972, a Maize Bibliography and a Wheat Bibliography were completed by a team of documentalists at the Catholic University in Washington, D.C. These bibliographies, covering world bibliographies on maize and wheat from 1958 to 1968, were compiled, edited and published through a special contract between the Catholic University and the Rockefeller Foundation, which financed the contract. A commercial concern published the three-volume sets on each crop. CIMMYT received 250 sets of each for distribution.

Extension Materials for Puebla Project

Circular letters for farmers (*El Plan Puebla Informa*, 3 issues) and reports for the Puebla Project annual meeting (February 1972) were produced by the CIMMYT information staff.

Translations into French

In the past, CIMMYT publications were issued in English and Spanish, depending on the subject, scope and interest. As CIMMYT activities now extend to French-speaking North Africa and tropical Africa, the need for publishing in French has increased. Two publications were translated into French in 1972 and hereafter, several will be published in English, Spanish and French. Narrations of slide sets and movies also will include French.

Mailing Lists

The permanent mailing lists now include over 7,500 names of individuals, libraries and institutions in 117 countries. This represents the addition of more than 1,500 names in 1972.

AUDIOVISUAL MATERIALS

CIMMYT produces and distributes audiovisual materials pertinent to CIMMYT programs, including still photographs, motion pictures, slide sets, graphs, maps, and charts. These materials are used in CIMMYT publications, training activities, conferences, and exhibits.

Films and Slide Sets

During 1972, two motion pictures in color and sound were edited and the master copies will be available for reprints in 1973.

1. Corn Reproduction was made under the supervision of the maize staff. It shows all stages of corn growth and reproduction. It is intended to be used in training activities, both at the headquarters and in outreach programs.
2. Wheat Rust Handling was made under the supervision of CIMMYT Wheat Program pathologists. It shows how rust materials are collected, prepared, maintained and used in the field and in greenhouses. The film is intended for training. Copies for distribution are expected by the spring of 1973. Color slide sets have been completed based on these movies.

Other slide sets now in production include: Maize Diseases; Nutritional Tests for Advanced Materials at CIMMYT; Milling, Baking and Macarroni Tests for Advanced Materials at CIMMYT; and What is CIMMYT? The last is for showing to groups of visitors at CIMMYT Headquarters. These slide sets will be available in 1973.

The photographers work in collaboration with CIMMYT scientists, who advise on the subjects to be covered and on the technical contents of the pictures.

The audiovisual section also fills requests for graphs, charts and maps needed by the staff, and designs covers for publications.

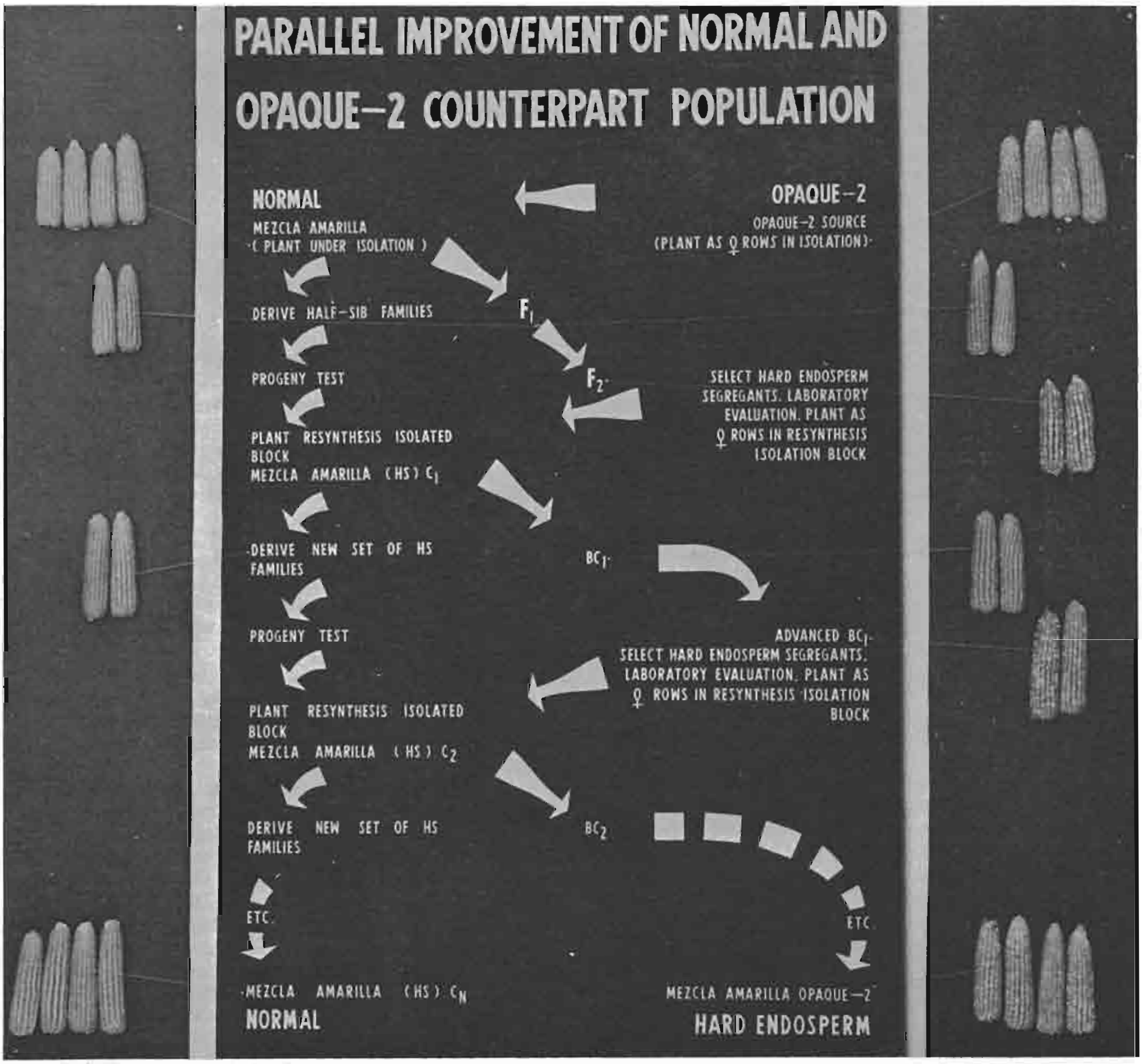
Exhibits

During the year the audiovisual section prepared a set of exhibits for the CIMMYT-Purdue International

Symposium on High-Quality-Protein Maize. This involved the design and production of photo-murals, charts, maps, lettering and arrangement of plant materials to show the kind and scope of CIMMYT programs. The exhibits were mounted in the halls of the CIMMYT Administration Building.

At the end of 1972, a new set of exhibits was being mounted for the CIMMYT International Wheat, Triticale and Barley Symposium, to be held in January 1973.

During 1973, permanent exhibits are partially derived from these two exhibits planned for the Administration Building.



TRAINING

During 1973 the CIMMYT Communications staff continued its cooperation with the Communications Department of the Graduate School at Chapingo in training students in visual aids. The CIMMYT Communications staff offers opportunities for student participation in the planning, production and laboratory processes at CIMMYT. Staff members also serve as consultants in research projects for CIMMYT trainees studying at Chapingo.

These training activities were extended in 1972 to other institutions, and the following persons were trained in audiovisuals: (1) Harry M. Hardy of Desarrural, Honduras, June-Nov., 1972; (2) Javier Juárez of the University of Coahuila, College of Agriculture, México, June-Aug., 1972; (3) Eleuterio Reyes of the Institute for the Improvement of Sugar Cane, Nov.-Dec., 1972; and (4) Roberto Ulibarri of the Extension Service and Graduate School, Chapingo, México, June-Dec., 1972.

At the master of science degree level, one CIMMYT fellow from Colombia completed his degree at the Chapingo Graduate School, and was advised by the Communications staff in his thesis work carried out at the Puebla Project.

VISITORS AND SEMINARS SERVICE

A new service for visitors to El Batán was created in January 1972. The number of visitors has been rising steadily since CIMMYT moved to its present headquarters in mid-1971.

During 1972 registered visitors to El Batán totalled 3,000, and another 1,500 to 2,000 were received at CIMMYT experiment stations and at the Puebla Project, bringing total visitors to approximately 5,000 for the year. In providing service, CIMMYT classified these visitors as follows: (1) individual scientists who wanted to talk to particular scientists at CIMMYT, approximately 1,000 during 1972; (2) groups from universities and scientific conferences registered on 77 occasions, totalling over 1,000 visitors and (3) 900 casual visitors, mostly from within Mexico, who requested general information about CIMMYT.

The Visitors Service arranges appointement schedules for individual scientists wishing to see CIMMYT staff, and has set up tours of El Batán and slide presentations for larger groups making arrangements in advance.

The Visitors Service also prepares information folders for visitors and in 1972 distributed over 3,000 publications.

As a related activity, the Visitors Service publishes *El Batán Informa*, a mimeographed staff information bulletin issued weekly in both English and Spanish. *Informa* carries institutional news, administrative announcements, and reprints of articles relating to international food supply and similar topics affecting CIMMYT programs. The 50 issues of *Informa* in 1972 contained over 500 pages of news and reprints.

LIBRARY

CIMMYT maintains a small agricultural reference library, and relies upon the Mexican National Agricultural Library at Chapingo, 10 kilometers from El Batán, for its basic book loan service.

During 1972, 450 new books were processed in the CIMMYT collections, 68 new periodicals were added to the shelves, and CIMMYT librarians handled 1,180 requests from staff and trainees for reference service.

Dr. Dorothy Parker of the Rockefeller Foundation served as consultant to the library in 1972 and in fullfillment of one of Dr. Parker's recommendations, a CIMMYT librarian spent two months at the Documentation Center and Agricultural Library at Turrialba, Costa Rica.