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CIMMYT Report On WHEAT IMPROVEMENT 1976

A Report on the Wheat Improvement Program
of the International Maize and Wheat Improvement Center
El Batan, Mexico

CIMMYT

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
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Contents

1.0 CIMMYT – INIA

In 1976 CIMMYT conducted research in Mexico at six sites, two of which are operated by INIA, the National Agricultural Research Institute, and the other four are administered by CIMMYT. Some characteristics of these stations are.

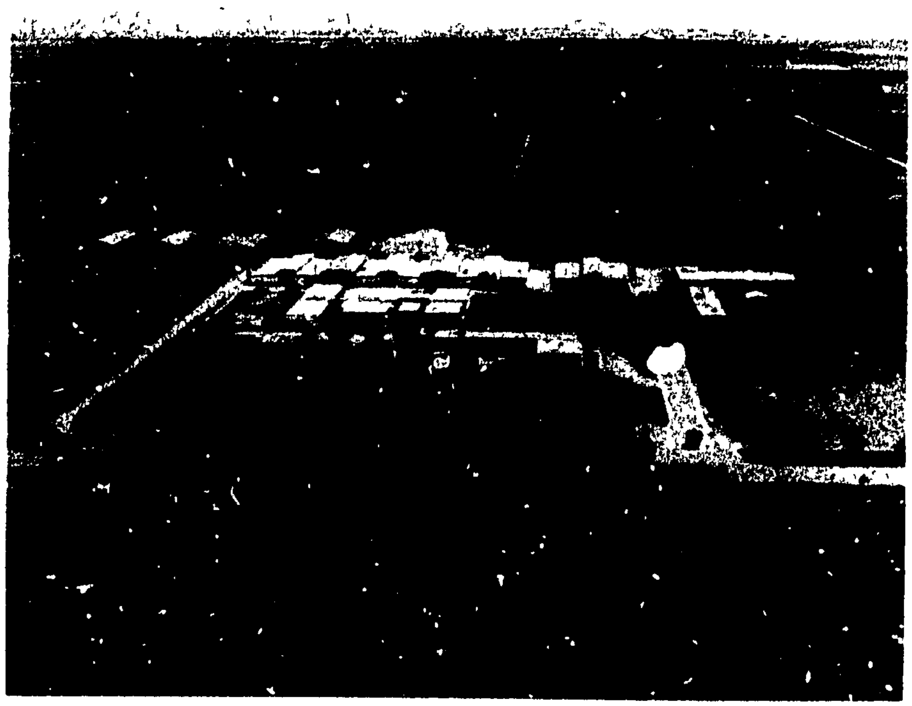
Station	Elevation	Latitude	Hectares used by CIMMYT
CIANO-INIA (Obregón)	Sea level	27°N	162
Navojoa-INIA	Sea level	27°N	5
El Batan-CIMMYT	2240 m	19°N	44
Toluca-CIMMYT	2640 m	19°N	69
Poza Rica-CIMMYT	Sea level	20°N	42*
Tlaltizapan-CIMMYT	940 m	18°N	31*

* twice/year

Three new CIMMYT-INIA wheats were released by the Mexican government in 1976. They were Nacozari, a two gene dwarf with white grain, Pavon, a one gene dwarf with white grain; and Tesopaco, a one gene dwarf with red grain. All three varieties are resistant to the races of stem rust, leaf rust and stripe rust present in 1976 in Mexico.

In other countries, wheats of Mexican origin which were released in 1975 include:

Argentina - Buck Nandu
Egypt - Sakha and Sakha 8
Lebanon - Haramoun & Sunnine
South Africa - Elrina and Liesbeck
Tanzania - Tanzania Kororo
USA (California) - Portola and Yecora Rojo



An aerial view of the Yaqui Valley, Sonora, Mexico and the CIANO Experiment Station with nearby cereal nurseries and trials.

1.1 Introduction

Wheat production continued to expand faster than population growth, both world wide and in the developing countries. In the past decade, wheat production rose 50 per cent and population 30 per cent. World wheat production in 1976 reached a new record of 413.3 million metric tons. In the developing countries, production also set a new record of 80.5 million metric tons.

Algeria, India, Iran, Pakistan and Tunisia made noteworthy large production increases. However despite this progress, developing countries continue to import more than 20 million metric tons of wheat and wheat flour, which indicates a substantial continuing deficet in food production.

In the developing countries,half the production increase has resulted from increases in yield and the other half has come from the expansion in the area sown to wheat The increase in production derived from the increase in yield is particularly significant because many of these countries have little additional suitable lard that is apt for wheat culture.

The high yielding varieties of wheat continue to spread in the developing countries. A survey in 1976 indicated that the improved high yielding varieties are now grown on 25 million hectares in Asia, Africa and Latin America, representing 40 per cent of the wheat production areas in these three continents. The diversity of genetic background of the high yielding varieties now being grown commercially is increasing as more of the national breeding programs in the developing nations release new varieties.

CIMMYT continues to distribute both promising advanced lines and unselected F2 materials of widely diverse genetic backgrounds to more than 60 collaborating countries. The aim is twofold, namely, to diversify the genetic resistance to disease and also, hopefully, to identify higher yielding and better adapted varieties.

Increasing attention is being given by CIMMYT scientists to identify lines and varieties with a broad resistance range—presumably horizontal in nature. This search is expedited by the large number and wide distribution of testing sites (experimental stations) and scientific colleagues, with whom CIMMYT collaborates around the world.

The danger of losses from diseases and insects increases with cropping intensity which produces a more favorable microclimate within the grain field for pests and pathogens. It calls for increased vigilance by plant breeders and pathologists to offset the increased risks, as far as possible.

In a similar way, CIMMYT continues to work on the development of multi-line varieties as another approach to increasing greater genetic variation into commercial varieties in order to reduce the risk from losses from disease. In this approach, extensive research is being done between CIMMYT scientists and the Indian Wheat Research team.

The spring (habit) x winter (habit) wheat crossing program which was initiated seven years ago has reached a stage where many of the most promising lines in the preliminary yield nurseries have been derived from this approach.

Exciting progress continues to be made in triticale improvement. During the year, 38 advanced lines with excellent grain were found. Unfortunately most of these lines have rather tall weak straw. However, a large number of F2 and F3 plants from several other crosses have been found with equally good grain type combined with good plant type and good fertility.

It has become clear during the past several years that triticale will consistently outyield wheat often by 50 to 100 per cent on very acid soils, such as those widely distributed in parts of Brazil, Ethiopia, Kenya and the outer ranges of the Himalayas.

1.2 Bread Wheat

1.2.1 INTRODUCTION

In the last five years the CIMMYT Bread Wheat Program in Mexico has grown at least two fold because of the increased demand for CIMMYT germ plasm from many nations, including traditional non-wheat-growing tropical countries. The Program has also increased because several new problems have been included such as breeding for *Septoria* and *Helminthosporium* resistance and for aluminum tolerance. However, the major objective of the Bread Wheat Program is still the production of germ plasm with high yield potential and wide adaptation.

In particular, this chapter reports on germ plasm improvement for adaptation and disease resistance, the 8156 multiline, the spring x winter crossing program, wheats for tropical countries and the CIMMYT-Brazil cooperative wheat breeding program.

1.2.2 GERM PLASM IMPROVEMENT

CIMMYT believes that it is not possible to breed wheat cultivars individually adapted to every micro-environment where wheat is grown. Thus its breeding methodology is geared to producing wheat germ plasm which will be of wide adaptation and for which purpose, combinations of the following four characteristics are needed:

1. High yield potential under many conditions of growth.

2. Semidwarf characteristics.

3. Disease resistance.

4. Day length insensitivity.

The approaches used to produce germ plasm with wide adaptability and disease resistance are (1), selection in segregating generation material at two locations in Mexico, and (2), international testing programs to help incorporate genetic diversity in the CIMMYT Bread Wheat Program.

Two generations of segregating material are grown and selected for agronomic type and disease resistance at two locations in Mexico each year. One generation is grown during the winter in Sonora, Mexico (27°N) at sea level under irrigated desert conditions, where leaf and stem rust are endemic. The second generation is obtained by planting during mid-May at Toluca, Mexico (19°N). The latter site is characterized by heavy rainfall and cool temperatures throughout the season. Consequently, severe epidemics of stripe rust occur every year. A third location, Patzcuaro, Michoacan, México (19°N), is used for evaluation of *Septoria tritici* resistance of advanced lines.

This procedure halves the time necessary to produce new cultivars. In addition, selection in alternate segregating generations under completely contrasting environments, leads to adapted types capable of growing under widely differing conditions.

Since 1964, the International Spring Wheat Yield Nursery (ISWYN) has provided the vehicle by which the most widely adapted and highest yield potential genotypes available in different countries, can be identified. Presently these highly adapted cultivars, together with materials selected from other CIMMYT and National Program Nurseries, are used in the CIMMYT Crossing Program to take advantage of more than a decade of world wide observations in order to provide a dynamic basis for incorporating the best germ plasm into CIMMYT materials.

Genetic research has established that a wheat cultivar tested in many locations, and showing a low coefficient of infection to a disease, often carries a large number of resistance genes. Among international testing programs that help to identify polygenetically resistant parents, are the USDA International Spring Wheat Rust Nursery (ISWRN); CIMMYT's International Bread Wheat Screening Nursery (IBWSN), and the Near East Regional Disease and Insect Screening Nursery (RDISN).

These trials serve two purposes: They signal changes in pathogen virulence and they identify varieties with broader resistance which can be added to the Crossing Program. The broader resistance is predicated on the principle that a cultivar showing resistance in many parts of the world is resistant to many virulence fators. Hence, such varieties are likelv to carry stable resistance. It is obvious that the cooperation of many national programs in testing these materials is of utmost importance. CIMMYT benefits through the identification of genotypes of great value in crosses designed for many national programs. National programs collectively assist one another in obtaining information on varieties to be crossed and which of their individual varietal entries are most likely to be useful over an extended period of time, since these nurseries form a vehicle for the widespread distribution of potential varieties or germ plasm. Charts 1.2.1 and 1.2.2 illustrate the population handling in the Bread Wheat Program and the flow of germ plasm between national and CIMMYT Programs, respectively.

1.2.2.1 Yield and Adaptation

During the year 1976 at Cd. Obregon, Mexico, about 1,000 advanced lines were yield tested and 205 were selected for superior yield, rust resistance, and suitable agronomic conditions for inclusion in the 10th International Bread Wheat Screening Nursery, which was distributed to 150 locations in the world.

In 1976, INIA, Mexico, released the following three varieties which had been developed in the CIMMYT Bread Wheat Program:

1. Bluejay "S"	CM 5287-J-1Y-2M-2Y-3M-0Y	as Nacozari M76
2. Pavon "S"	CM 8399-D-4M-3Y-1M-1Y-1M-0Y	as Pavon F76
3. Sapsucker "S"	Br69-1Y-3M-3Y-0M	as Tesopaco S76

Nacozari M76 is derived from the cross Tzpp-Pl x 7C and it is a 90 cm semidwarf with white grain. Pavon F76 is from the cross Vcm x Cno"S"-7C/Kal-Bb. It is a 95 cm semidwarf also with white grain. Tesopaco S76 is from the cross Inia"S"-Soty x Czho and it is a 100 cm semidwarf with red grain. All of these three new varieties are resistant to stem, leaf and stripe rust in Mexico, and they all have equal yield potential to Jupateco 73 in Yaqui Valley, Mexico.

In addition, the following varieties derived from the CIMMYT Program have been released:

1.	Buck Ñandu	Inia/Son 64-Tzpp-Y54	Argentina
2.	Sakha 3	Potam "S"	Egypt
3.	Sakha 8	Bluebird "S"	Egypt
4.	Elrina	CC-Inia "S"	South Africa
5.	Liesbeck	Inia-Cno "S"	South Africa
6.	Tanzania Kororo	$Y50_E$-8156(R) x Kalyan	Tanzania
7.	Portola 76CR	Cno-7C x Cno-Pj62	California, U.S.A.
8.	Yecora Rojo 76	Bluebird 2 "S"	California, U.S.A.
9.	Haramoun	Cuckoo "S"	Lebanon
10.	Sunnine	Goldfinch "S"	Lebanon

Certain advanced lines with equal or higher yield potential than Siete Cerros are given in table 1.2.A. Some of these advanced lines such as Pavon "S", CM 8399; Nacozari"S", CM 5287; Emu "S", CM 8527; and Hork "S", CM 8874 are as widely adapted as Anza, Siete Cerros and Jupateco 73 (tables 1.2.B, 1.2.C and 1.2.D). Table 1.2.D indicates that Nacozari "S" CM 5287 has a pattern of adaptation similar to Anza and Jupateco 73, while Pavon "S" and Hork "S" are well adapted in North America, poorly in the Middle East and of intermediate adaptation in other places. Emu "S" shows good adaptation in North Africa and very poor in South East Asia, the Middle East, and North America.

1.2.2.2 Disease Resistance

The level of stem rust resistance in CIMMYT germ plasm has been and is adequate for giving protection against this disease in most areas of the world. In the early 1970's, there was general opinion that CIMMYT germ plasm lacked broad based resistance to stripe rust, leaf rust, and *Septoria tritici*. Since then, a concerted effort has been made to incorporate a high level of resistance to these diseases which would be effective in many different areas, where they are endemic. Table 1.2.E presents 45 advanced lines from the

9th IBWSN which have a low average coefficient of infection (less than 5) to stripe rust.

Similarly table 1.2.F lists 55 advanced lines of the same nursery which had a low average coefficient of infection (less than 4) to leaf rust. A few of these entries, especially entries of the series Emu "S" CM 8327, Brochis "S" CM 5872, Pavon "S" CM 8399, Moncho "S" CM 8288, and Chiroca "S" CM 8963 have also been outstanding in 7th and/or 8th IBWSN (tables 1.2.E and 1.2.F).

These results indicate that these lines might be approaching a level of resistance to stripe and leaf rust similar to the level of resistance to stem rust found in the CIMMYT germ plasm.

Until the late 1960's, most of the CIMMYT germ plasm was susceptible to Septoria tritici especially in North Africa, Turkey, Ethiopia, and Argentina. Because the first semidwarf wheats introduced in these areas were susceptible to Septoria, it was generally believed that resistance to Septoria cannot be incorporated into semidwarf wheats. In 1971 an extensive crossing program was initiated by the CIMMYT Bread Wheat Program to incorporate resistance to Septoria into the CIMMYT germ plasm. This has resulted in semidwarf advanced lines now being available which have a good level of resistance to Septoria tritici, especially in the above mentioned locations. Table 1.2.G presents 51 advanced lines with resistance to Septoria tritici in Ethiopia, Poland, Israel, Argentina and Mexico. It is worthwhile pointing out that of the 386 entries in the 9th IBWSN only 67 (17%) were highly susceptible. Two hundred and sixty eight lines showed an intermediate level of resistance to Septoria tritici.

1.2.3 THE 8156 MULTILINE

The varieties derived from the cross 8156 are characterized by unusually wide adaptability and high yield potential. The success of the 8156 derived varieties is illustrated by the area to which they were sown. At one time (1973, FAO Report) these varieties occupied 13 million hectares annually, largely in the subcontinent of Asia, the Middle East and North Africa. Table 1.2.H presents the different names for the 8156 types. Since then, the area sown to these types has been continuously declining because of increasing susceptibility to new races of the rusts and to Septoria.

It is widely recognized that the use of one variety on a large geographical area presents a potential danger since a single pathogen strain or race could cause widespread destruction. Furthermore, it has been demonstrated that epidemiological zones are rarely local, but can cover substantial areas such as the areas where the 8156 derived varieties were and are grown.

However, a variety with such a wide acceptance and superior performance could continue to produce high yield of wheat, if the danger of widespread epidemics could be removed. Therefore about 6 years ago, CIMMYT initiated a program to create a multiline based on the 8156 phenotype, by producing multiline components with a wide array of resistance in this background.

All components are resistant to the three rusts under Mexican conditions, and some have resistance to Septoria leafspots. Sources of resistance from Argentina, Australia, Canada, Colombia, Ecuador, India, Kenya, Rhodesia, North Africa, USA and the CIMMYT Program have been used in the crossing program to produce the multiline components.

Varieties from these countries have been used in crosses with Siete Cerros (White grain), Super-X and Y50-Kal- (Red grain) to produce about 200 F_1's in both Toluca and the Yaqui Valley. The F_1's that show outstanding resistance to stem and leaf rust in Yaqui, and the ones that have resistance to the three rusts in Toluca, are used in making top and double cross combinations. In this way, there are two doses of the 8156 genotype and two sources of resistance in each double cross combination. This system permits selection for the 8156 phenotype with resistance to the three rusts under Mexican conditions. Furthermore, any F_1 outstanding for phenotype and resistance is also planted as F_2 bulk. All selection in succeeding generations is done for the 8156 phenotype with resistance.

It is emphasized that it is not the responsibility of the CIMMYT Bread Wheat Program to produce the multiline composites for different nations, but to produce the components and to send these to interested nations for agronomic and pathological evaluations. The international testing should allow eventual selection of components to make composites in individual countries. This has been done continuously for five years in the form of the International Multiline (8156) Nursery consisting of between 90 and 300 entries.

The International Multiline Nursery is expected to serve three purposes: (1) to obtain disease and agronomic information on all entries so that CIMMYT can evaluate their adaptation in a wide range of environments; (2) to make available an array of components so that each cooperator can select only the components that will serve his areas and (3), to permit eventual selection of different components in different locations.

The 4th International Multiline (8156) Nursery consisting of 215 entries was distributed in 1975 to more than 30 locations in the world where the 8156 types are well adapted. Thirty five entries of this nursery as listed in table 1.2.I were found to be resistant to leaf rust in India (two locations), Pakistan, Egypt (two locations), and Mexico (two locations). Table 1.2.J presents 40 entries of the nursery which were resistant to stripe rust in India, Pakistan, Chile and Mexico (two locations). Considering the importance of these diseases, it should be noted that this gives enough components for making preliminary composites for further agronomic and pathologic evaluation. Eleven of the entries, entry numbers 4,5,6,7,27,81,97,113,114,169,204, were resistant to both leaf and stripe rust in all the locations reported. Most of the entries presented in tables 1.2.I and 1.2.J also have the same high yield potential as Siete Cerros in the Yaqui Valley, Mexico.

Although CIMMYT is not working to produce and release multiline composites in Mexico, some basic information on the agronomic, pathological and yield performance of composites, is needed to make recommendations. Therefore, in 1975-76, 22 components of the 4th Multiline (ML) Nursery were selected, based on their phenotype and yield performance, and they were used to make 12 ML composites consisting of 3-11 components. The yields of these 12 composites and the average yields of the components in each composite and of Siete Cerros, are presented in table 1.2.K. Considering that the yield of Siete Cerros was not affected by leaf rust during the Yaqui season (non treated Siete Cerros yielded 8384 kg/ha against 8598 kg/ha when protected against leaf rust by Indar), these data indicate that some of the composites are of equal yield potential as Siete Cerros under disease-free conditions. The best composites can be expected to outyield Siete Cerros under highly diseased conditions. This was demonstrated in Toluca 1976 where Siete Cerros was killed by a heavy stripe rust infection while several demonstration plots of ML composites were completely resistant It is also interesting that some of the composites outyielded the average yields of their components (composite BIII) while in others, the average yield was better than the yield of the composite (composite R II). This illustrates that the yield of composites cannot be predicted by the performance of the individual components, but must be determined.

In 1976, 92 advanced lines were produced and distributed as the 5th International Multiline (8156) Nursery to 30 locations. Entries consisted of lines from the 4th ML (8156) Nursery and of new material of the 8156 phenotype selected from segregating generations. Also, two International ML (8156) yield trials, one for white grain and one for red grain, were distributed internationally. The white grain ML trial which consisted of 35 entries, where 9 of the entries were composites, was sent to India, Pakistan, Egypt and was used in the CIMMYT Program in Mexico. The red grain ML trial had 25 entries, of which 7 were composites, and it was distributed to Kenya, Algeria, Guatemala and the CIMMYT Program, Mexico. Furthermore, the 35 components, that were used to make the 16 composites were sent to Dr. I.A.Watson, Australia and Dr. A.P.Roelfs, USA for stem rust testing; to Dr.D.J. Samborski, Canada, Dr. M. Boskovic, Yugoslavia and Dr. A. Dinoor, Israel for leaf rust testing; to Dr. R. W. Stubbs, Holland for stripe rust testing, to Dr. M. Wolfe, England for powdery mildew testing, and to Dr. M. Djerbi, Tunisia, for Septoria testing. These lines will also be tested for stem and leaf rust reaction by the CIMMYT Pathology Section. All this testing should provide information that will allow a genetic interpretation of the resistance in these multiline components.

1.2.4 SPRING x WINTER WHEATS

The crossing of spring and winter wheats offers real potential for improving both groups. The mixing of these two gene pools through intercrossing may bring complementary factors together which can lead to yield increases and improvements in other characteristics. For the spring wheats, it is anticipated that the winter germ plasm may enhance yield, drought resistance, and provide additional sources of resistance to Septoria leaf spots, powdery mildew, stripe rust and leaf rust. For the winter wheats, the spring wheat germ plasm may improve stem rust resistance, increase the yield potential of winter wheats and can provide a range of winter hardiness which could be utilized in different areas. In addition, the hybridization of spring and winter wheats may provide a wide range of maturity to suit a range of ecological conditions for both types of wheat.

This program is conducted in collaboration with the Crop Science Department of the Oregon State University, Corvallis, Oregon. CIMMYT primarily utilizes the Toluca Research Station, Mexico, where winter wheats are vernalized naturally, to make about 1,500 spring x winter wheat crosses annually. The F_1 seed is divided equally between the CIMMYT Spring Wheat Program and the Oregon State Winter Wheat Program. The F_1's are double crossed to spring wheat F_1 in the CIMMYT Program, and they are top and double crossed to winter wheats in the Oregon Program. This dual program allows for exploitation of the basic germ plasm for the improvement of both the spring and winter wheats.

The progenies from these crosses are grown and selected for spring types at two sites in Mexico, viz. Toluca and Cd. Obregon, and at three sites in Oregon, U.S A. viz. Hyslop, Moro and Pendleton, for winter types. The Mexican sites vary in latitude and altitude and have different diseases; the Oregon sites differ in rainfall distribution and in their diseases patterns. This provides the opportunity to select for wide adaptation in both groups. The resulting advanced lines in the spring program are channeled through the International Bread Wheat Screening Nursery to the spring wheat areas of the World. In the same way, the winter types derived from the S x W crosses selected in Oregon are distributed to the winter wheat areas of the World through the International Winter x Spring Wheat Screening Nursery.

To a lesser extent, F_1's from spring x winter crosses are sent to the Wheat Research Center Ankara, Turkey, and to the Indian Agricultural Research Institute, New Delhi, India. In 1977 this cooperation will be extended to Korea.

In the 1975-76 season at Toluca, about 1,400 winter wheats from USA, USSR, Eastern Europe, Western Europe, Turkey, Argentina and Chile were planted in November. Spring wheats were sown at 4 dates in January and February. Crossing was carried out in April and May. About 300 of the best winter wheats were also sown at CIANO, Cd. Obregon, after vernalization under artificial light to induce heading in the winter wheats. Thus, spring by winter crosses are made at both locations.

The S x W F_1's produced at Toluca are grown in the following winter alongside the spring x spring (S x S) F_1 at Cd. Obregon. Likewise, the S x W F_1 made at Cd. Obregon are grown in Toluca with the S x S F_1's. This facilitates making the double cross (F_1 x F_1) at both locations. Eighty five per cent of the double crosses involve one winter wheat parent.

In the 1975-76 season 756 S x W F_1's were evaluated at Cd. Obregón and 433 (57%) were selected as having superior agronomic type and resistance to stem and leaf rust. These 433 F_1's were harvested in bulk, divided and sent to 100 spring wheat cooperators worldwide. Similarly the Oregon Program distributes F_2 germ plasm to the winter wheat areas of the world.

Five hundred and ninety two new S x W F_1's were evaluated at Toluca, 1976 and of these, 317 (54%) were selected as possessing superior agronomic type and resistance to stripe rust. Furthermore, 188 of the best 433 S x W F_1's identified in Cd. Obregon were re-evaluated again in Toluca by planting the reserve seed. Of these, 108 were selected on the basis of agronomic type and rust resistance.

The crosses involving winter wheats from Eastern Europe, Western Europe, North and South America are given in tables 1.2.L, 1.2.M, 1.2.N and 1.2.0 respectively, to show the range of combining ability of certain spring wheats. An appraisal of these tables shows that certain spring varieties have different patterns of combining ability. The varieties Torim 73, Kal-Bb, and Salamanca 75 appear to have good combining ability with winter wheats of all four groups. The variety Cocoraque 75 generally combines well with winter varieties from Western Europe, North America, and South America, while Canario "S" combines well with wheats from Eastern Europe, and from South America. Tanori 71 and Pavon "S" combine best with wheats from Eastern Europe and North America, and Mochis 73 showed better combining ability with Eastern and Western European wheats. Varieties Yecora 70, Zaragoza 75, Jupateco 73, and Nacozari "S" combine well only with the varieties from Eastern Europe. Ciano 67 and Emu "S" combine with varieties from Western Europe and North America, respectively.

Although these observations are preliminary, they do indicate different patterns of combining ability. By double crossing among these groups showing different patterns of combining ability, it may be possible to further broaden adaptation.

For the first time, a large number (287 or 22% total new advanced lines) of spring x winter derived advanced lines, were bulked in Toluca in 1976. These lines will be evaluated for yield potential and disease resistance in Yaqui 1976-77, for inclusion ultimately in the International Bread Wheat Screening Nursery. Table 1.2.P shows the spectrum of winter wheats used as parents in these new lines.

1.2.5 WHEATS FOR TROPICAL COUNTRIES

In the early 1970's many traditional non-wheat-growing countries looked to CIMMYT for wheat varieties which could be grown in hot and humid tropical climates. They wished to grow at least part of their wheat needs, after the sharp increase of wheat prices, in order to supplement wheat imports. Most of these countries fall in the equatorial zone in

South Asia, West Africa, the Caribbean and Central America. Most of the presently known wheat varieties are not adapted to these areas, because they lack the ability to tiller under hot and humid conditions and they lack resistance to Helminthosporium spp.

To evaluate wheat germ plasm for these characteristics, CIMMYT uses the Poza Rica Maize Research Station, Veracruz, Mexico, which has hot, humid conditions typical of the tropics. Helminthosporium sativum epidemics develop in the wheat grown there. Tests made at Poza Rica in the 1973-74 and 1974-75 seasons showed that virtually all the CIMMYT germplasm was highly susceptible to Helminthosporium sativum and therefore did not survive. However, these tests also indicated that many CIMMYT wheats had the ability to tiller under tropical growing conditions.

To identify wheat varieties or lines with resistance to Helminthosporium, 5,000 entries of the Spring Wheat World Collection were planted at Poza Rica in the 1975-76 season. Eighteen of the entries viz. Cl 8873, Pl 167741, 167743, 178721, 182416, 210977, 213849, 225383, 225397, 225466, 225467, 225468, 225470, 236444, 260797, 264443, 278183, and 278284 were found to be tolerant or resistant. These resistant lines from the World Collection and two other resistant winter wheats, Stadler and Stoddard, are now being used in a crossing program to broaden the resistance base to Helminthosporium spp.

In the same season, four F_1's were also planted involving the variety Horizon with Jupateco 73, Hork "S", Pavon "S , and Trifon "S". Earlier, Horizon had been identified as having Helminthosporium resistance elsewhere. These F_1's were resistant and they are the only known resistance which is presently in F_2 and F_3 segregating generations, being grown at Poza Rica. The F_2 populations from the Horizon crosses have been sent for selection to Cameroon, Zambia, India (Assam), Philippines, Dominican Republic, Costa Rica, Nicaragua and Guyana.

It is expected that advanced lines combining tillering capacity in hot humid climates with resistance to Helminthosporium, will be available for distribution in 1977-78.

1.2.6 CIMMYT-BRAZIL COOPERATIVE CROSSING PROGRAM

CIMMYT has great interest in aiding the Brazilian Wheat Breeding Programs to obtain improved wheat varieties. This cannot be done alone at the two locations used by CIMMYT in Mexico, because of the specialized nature of the Brazilian disease problems combined with aluminum toxicity of their soils. To obtain improved wheats for Brazil, the resistance of present Brazilian varieties must be incorporated into high yielding, fertilizer responsive CIMMYT semidwarf wheats.

With this objective, a cooperative crossing program was established at Cd.Obregon, Mexico, in which scientists from Brazil and CIMMYT participate. This has been in operation for three years on a continuous basis with FECOTRIGO, Cruz Alta, and for 1 year with EMBRAPA, Passo Fundo, Brazil. Each year more than 1,000 top and double crosses have been made involving Brazilian and Mexican wheats. The resulting segregating population is grown and selected in Brazil. However, part of the F_2 populations involving Mexican and Brazilian germ plasm have been divided and sent to dryland areas of the world where Septoria is endemic.

1.2.7 SUMMARY

It is now evident that certain new CIMMYT advanced lines possess a yield potential higher than that of Siete Cerros in the Yaqui Valley. Also, certain lines in the series of Pavon "S", CM 8399; Nacozari "S", CM 5287; Hork "S", CM 8874; and Emu "S", CM 8377 have broad adaptation similar to Siete Cerros, Anza, and Jupateco 73. It is clear too, that in CIMMYT germ plasm, leaf and stripe rust resistance have been strengthened and broadened.

Seventy five per cent of the 9th IBWSN had some level of resistance to Septoria tritici in Ethiopia, Israel, Poland, Argentina and Mexico. This clearly demonstrates that Septoria resistance can be combined with the semidwarf characteristic.

The Multiline composites yielding ability program will be strengthened further by improving the components and by more reliable international testing.

Two hundred and eighty seven spring x winter derived advanced lines are available for world wide distribution and testing through the IBWSN. This nursery will give an evaluation of the drought, disease resistance and adaptation characteristics of the lines in areas where neither spring nor winter wheat is adapted.

If Helminthosporium resistance holds in the variety Horizon in humid tropical conditions, lines with this resistance will be available for distribution in 1978.

TABLE 1.2.A Yield performance of certain advanced lines compared to Siete Cerros and Jupateco 73 in Yaqui, Mexico, 1975-76.

Varieties and Advanced Lines	12th ISWYN*			ESYT**	
	Kg/ha	% Siete Cerros	% Jupateco	kg/ha	% Jupateco
Choli	8583	128	112		
Pavon"S" CM 8399-D-4M-3Y-OM	7865	117	102	9042	104
Pavon 76 CM 8399-D-4M-3Y-1M-1Y-1M-OY				9417	108
Pavon "S" CM 8399-D-4M-3Y-1M-OY				9407	108
Pavon "S" CM 8399-D-4M-3Y-1M-1Y-OM				9182	105
Pavon "S" CM 8399-D-4M-2Y-2M-3Y-1M-OY				8912	102
Nacozari 76 CM 5287-J-1Y-2M-2Y-3M-OY	7417	111	96	8792	101
Nacozari "S" CM 5287-J-1Y-2M-1Y-4M-OY	7309	109	95		
Nacozari "S" CM 5287-J-1Y-2M-1Y-1M-OY				8532	98
Tesopaco "S" Br 69-1Y-3M-OY				9583	110
Tesopaco 76 Br 69-1Y-3M-3Y-OM				8073	93
Flicker "S" CM 8954-B-7M-1Y-1M-OY				9547	110
Flicker "S" CM 8954-B-7M-1Y-1M-1Y-OM				9318	107
Brochis"S" CM 5872-C-1Y-1M-3Y-OM	7302	110	96		
Moncho"S" CM 8288-A-3M-7Y-OM	7199	107	93		
Moncho"S" CM 8288-A-3M-1Y-5M-OY				8115	93
Hork"S" CM 8874-K-1M-1Y-1M-2Y-OM	7048	105	92		
Hork"S" CM 8874-K-1M-1Y-OM (1-356Y)				8333	96
Jupateco 73	7701	115	100	8709	100
Siete Cerros	6705	100	87		

* C.V. for ISWYN (two dates combined) = 10.0%

** C.V. for ESYT = 7.3%

C.V. = Coefficient of Variation

ISWYN = International Spring Wheat Yield Nursery

ESYT = Elite Selection Yield Trial

TABLE 1.2.B High yielding entries of 9th International Bread Wheat Screening Nursery (IBWSN) appearing frequently in the top 10 per cent at 35 locations* (non replicated trial).

Entry No.			Frequency in top 10%
164	Pavon "S"	CM 8399-D-4M-3Y-1M-1Y-0M	13
163	Pavon "S"	CM 8399-D-4M-4Y-1M-1Y-0M	10
168	Pavon "S"	CM 8399-D-4M-4Y-1M-1Y-1M-0Y	9
174	Huacamayo "S"	CM 8671-B-1M-1Y-1M-1Y-1M-0Y	12
147	Moncho "S"	CM 8288-A-3M-6Y-5M-1Y-1M-0Y	12
148	Moncho "S"	CM 8288-A-3M-6Y-5M-1Y-0M	8
149	Moncho "S"	CM 8288-A-3M-6Y-5M-2Y-1M-0Y	8
150	Moncho "S"	CM 8288-A-3M-6Y-1M-1Y-1M-0Y	8
151	Moncho "S"	CM 8288-A-3M-6Y-5M-3Y-0M	8
152	Moncho "S"	CM 8288-A-3M-7Y-0M	8
12	Pitic 62		11
15	Penjamo 62		11
17	Chanate#2 = Salamanca		10
277	Hork "S"	CM 8874-K-1M-1Y-0M(1-105Y)	10
73	Tezopaco "S"	Br69-1Y-3M-5Y-0M	9
7	Anza		8
156	Emu"S"	CM 8327-C-9M-2Y-6M-2Y-0M	8
193	Bb-Kal	CM 9160-11M-5Y-6M-0Y	8
272	(Cno-7CxCC-Tob/Cno"S"-N066)Kal	CM 11377-A-1Y-8M-4Y-0M	8
303	WexCno-Inia	CM 7585-1M-1Y-2M-3Y-0M	8
317	Cno-7CxCno-Inia/Sx	CM 8943-F-1M-2Y-1M-1Y-0M	8
340	Jupateco 73		8

* South Africa, Egypt (Bahteen, Mataano, Sakha), Rhodesia, Senegal, Sudan, Tunisia, Bangladesh (Ishurdi, Joydelpur), India (Delhi, Indore, Maharashtra), Iran, Iraq, Israel, Syria, Greece, Spain, (Zaragoza, Rancho de la Merced), Ireland, Canada (Alberta), Mexico (Nuevo León, Chihuahua), Costa Rica, Honduras, Nicaragua, Argentina (Buenos Aires, Tucuman), Brazil, Bolivia, Chile, Colombia, New Zealand.

TABLE 1.2.C The 10 highest yielding entries in the 12th ISWYN averaged over 50 locations (preliminary report).

Rank	Variety		Origin
1	Nacozari "S"	CM 5287-J-1Y-2M-1Y-4M-0Y	Mexico
2	Pi62-Frondosa/Pi62-MazoexM.Pak		Pakistan
3.	Nacozari"S"	CM 5287-J-1Y-2M-2Y-3M-0Y	Mexico
4	Pavon "S"	CM 8399-D-4M-3Y-0M	Mexico
5	Hork"S"	CM 8874-K-1M-1Y-1M-2Y-0M	Mexico
6	Condor "S"		Australia
7	Emu"S"	CM 8327-C-9M-4Y-3M-0Y	Mexico
8	Anza		Sudan
9	Arz		Lebanon
10	Jupateco 73		Mexico

ISWYN = International Spring Wheat Yield Nursery

TABLE 1.2.D Adaptation of new advanced lines from the CIMMYT Program as compared with the standard, highly adapted varieties Anza, Siete Cerros and Jupateco 73. (Numbers indicate ranking in the 12th International Spring Wheat Yield Nursery; blanks show that ranking was more than 10th place).

Varieties	Algeria	Egypt-Sakha	Egypt-Bahtem	Egypt-Upper	Libia	Senegal	South Africa	Tunisia
Siete Cerros			7					
Anza	2	6			1			
Jupateco 73				10				
Nacozari "S" CM 5287-J-1Y-2M-2Y-3M-0Y	8					9		
Nacozari "S" CM 5287-J-1Y-2M-1Y-4M-0Y	6	8	1	3				1
Emu"S" CM 8327-C-9M-4Y-3M-0Y	9	5			8	6	2	6
Pavon"S" CM 8399-D-4M-3Y-0M		1	5					
Hork "S" CM 8874-K-1M-1Y-1M-2Y-0M		7	8			5		

Varieties	Afganistan	Bangladesh-Dacca	Bangladesh-Ishwedi	India-Punjab	India-New Delhi	Nepal	Pakistan-Punjab
Siete Cerros				9		6	
Anza	8	1		8			
Jupateco 73		4				4	6
Nacozari "S" CM 5287-J-1Y-2M-2Y-3M-0Y	1		4			3	3
Nacozari "S" CM 5287-J-1Y-2M-1Y-4M-0Y	5		2			2	1
Emu"S" CM 8327-C-9M-4Y-3M-0Y							
Pavon"S" CM 8399-D-4M-3Y-0M						9	10
Hork "S" CM 8874-K-1M-1Y-1M-2Y-0M	2						

Varieties	England	France	Greece	Hungary	Poland	Portugal	Romania	Spain
Siete Cerros	5	4	7		9	4		7
Anza	2	5	2					
Jupateco 73				6		1		
Nacozari "S" CM 5287-J-1Y-2M-2Y-3M-0Y				1			2	9
Nacozari "S" CM 5287-J-1Y-2M-1Y-4M-0Y				2			4	2
Emu"S" CM 8327-C-9M-4Y-3M-0Y				7	7		7	
Pavon"S" CM 8399-D-4M-3Y-0M			9				9	10
Hork "S" CM 8874-K-1M-1Y-1M-2Y-0M			5			2		

Varieties	Iran-Ahwazt	Iran-Gorgan	Iraq	Jordan	Lebanon	Syria	Yemen
Siete Cerros	3		1		9	3	
Anza	10						2
Jupateco 73		3	9				3
Nacozari "S" CM 5287-J-1Y-2M-2Y-3M-0Y				3		9	
Nacozari "S" CM 5287-J-1Y-2M-1Y-4M-0Y				7		4	4
Emu"S" CM 8327-C-9M-4Y-3M-0Y							
Pavon"S" CM 8399-D-4M-3Y-0M	5				2		1
Hork "S" CM 8874-K-1M-1Y-1M-2Y-0M		5		8			

Varieties	Canada (Manitoba)	Canada (Saskatchewan)	Mexico-Coahuila	Mexico-Guanajuato	Mexico-Jalisco	Mexico-Nuevo Leon	Mexico-Sonora	Arizona-Yuma	Arizona-Mesa	California-Fresno	California-Davis	Minnesota	Idaho	North Dakota
Siete Cerros						9								
Anza		2						8	3	3				
Jupateco 73		8	2	7		7	5			6	5			
Nacozari "S" CM 5287-J-1Y-2M-2Y-3M-0Y	1					4	10		5	8	8			4
Nacozari "S" CM 5287-J-1Y-2M-1Y-4M-0Y			5						7	5			3	7
Emu"S" CM 8327-C-9M-4Y-3M-0Y					2								8	1
Pavon"S" CM 8399-D-4M-3Y-0M	10	6	6	6		6	4						2	
Hork "S" CM 8874-K-1M-1Y-1M-2Y-0M		7	3	2					8		3		6	

Varieties	New Zealand	Bolivia	Brazil-Sao Paulo	Chile-Chillan	Chile Temuco	Uruguay
Siete Cerros						9
Anza	3			3	4	
Jupateco 73		8	1			1
Nacozari "S" CM 5287-J-1Y-2M-2Y-3M-0Y			7		10	
Nacozari "S" CM 5287-J-1Y-2M-1Y-4M-0Y			8			5
Emu"S" CM 8327-C-9M-4Y-3M-0Y	1			2	9	
Pavon"S" CM 8399-D-4M-3Y-0M					7	4
Hork "S" CM 8874-K-1M-1Y-1M-2Y-0M			2	10		

TABLE 1.2.E Entries in the 9th International Bread Wheat Screening Nursery (IBWSN) with a low average coefficient of infection for stripe rust-average for 12 locations*.

Entry No.	Cross and Pedigree	Average CI
352	(ChrxT.T-Son64/Chr) Inia 66^3 H283·70-3Y-2B-1Y-4B-1Y-2B-0Y	1.0
351	(ChrxT.T-Son64/Chr) Inia 66^3 H283·70-3Y-2B-1Y-4B-5Y-1B-0Y	1.3
105	Cno^2 -ChrxTob-8156/Cno"S"-Inia"S" x Bb CM 5811-B-1Y-1M-1Y-3M-1Y-0M	0.4
256	Dz 1-Tob66(Nad-LR64xBb/Bb-Nor67) CM 16705-A-1M-1Y-6M-0Y	0.8
248	Woodpecker"S" CM 15856-6M-5Y-3M-0Y	0.9
282	Bb-Nor67xCno"S"-7C CM 1586-500M-500Y-500B-0Y	1.4
201	/(21931/Ch53-AnxGb56) An64 /Cd1 CM 11243-28Y-4M-3Y-0M	1.7
213	Bb-CnoxInia-Soty(Kal-Bb/Inia-CalxInia-CC) CM 11780-J-1Y-2M-1Y-2M-0Y	1.9
241	CJ -Cpr CM 15070-1M-1Y-1M-0Y	3.6
62	Cno"S"^{2}-LR64^2-Son/Cno-Tota x Jaral II 41915-11R-0N	2.9
254	IAS-WS 1812 (Cha/Tob-CfnxBb) CM 16634-D-1M-1Y-10M-0Y	3.0
49	Cno"S"-Pj62 x Cno"S"-On II 38915-3R-5M-4R-4M-0R	3.4
204	Ska-Cal/CCxCho-Son 54 CM 11667-11-1Y-2M-2Y-1M-0Y	3.4
132	Npo-Tob"S"x8156/Kal-Bb CM 7806-15M-2Y-2M-1Y-0M	3.8
229	IAS-Pato/(Cno-Son64/NP880-Pj62xCal)We/ CM 12373-L-3Y-1M-0Y	4.2
194	Tob-Cha CM 10583-22Y-9M-1Y-1M-0Y	4.4
153	Emu"S" CM 8327-C-9M-1Y-1M-1Y-0M	1.9
155**	Emu"S" CM 8327-C-9M-4Y-3M-0Y	2.9
157***	Emu"S" CM 8327-C-9M-1Y-1M-1Y-1M-0Y	3.0
385	Emu"S" CM 8327-C-9M-1Y-2M-2Y-1M-0Y	3.1
270	Brochis"S" CM 5872-C-1Y-5M-2Y-2M-0Y	0.9
299	Brochis"S" CM 5872-C-1Y-5M-1Y-3M-0Y	1.3
** 110-296	Brochis"S" CM 5872-C-1Y-1M-3Y-0M	1.8

TABLE 1.2.F (Continued)

Entry No	Cross and Pedigree	Average CI
109	- Brochis"S" CM 5872-B-8Y-1M-2M-4M-0Y	2.4
128	Pichihuila"S" CM 7652-26M-3Y-0M	0.7
148	Moncho"S" CM 8288-A-3M-6Y-5M-1Y-0M	0.5
149	Moncho"S" CM 8288-A-3M-6Y-5M-2Y-1M-0Y	0.9
205	Alondra "S" CM 11683-A-1Y-1M-1Y-7M-0Y	1.2
175	Huacamayo"S" CM 8671-B-5M-1Y-2M-1Y-1M-0Y	4.2
174	Huacamayo"S" CM 8671-B-1M-1Y-1M-1Y-1M-0Y	4.9
285	Fury x Cno"S"-No66 CM 4210-10Y-4M-8Y-2M-1Y-0M	0.3
286	Fury x Cno"S"-No66 CM 4210-10Y-4M-3Y-2M-2Y-0M	0.4
84	Fury x Cno"S"-No66 CM 4210-10Y-4M-8Y-2M-0Y	1.2
288	Fury x Cno"S"-No66 CM 4210-10Y-500M-500Y-0M	1.4
124	Wren x Cno -Inia"S" CM 7585-1M-1Y-4M-7Y-1M-0 Y	2.8
121	Wren x Cno -Inia"S" CM 7585-1M-1Y-1M-1Y-0M	2.9
244	Cgñ x Kal-Bb CM 15133-1M-3Y-6M-0Y	2.7
243	Cgñ x Kal-Bb CM 15133-1M-3Y-2M-0Y	3.2
242	Cgñ x Kal-Bb CM 15133-1M-1Y-1M-0Y	3.7
237	Ktz M12-Ti 71 CM 14952-66M-5Y-2M-0Y	2.9
235	Ktz M12-Ti 71 CM 14952-29M-1Y-11M-0Y	3.7
246	Pollo-Pato (B) CM 15818-13M-1Y-1M-0Y	0.3
245	Pollo-Pato (B) CM 15818-19M-2Y-3M-0Y	1.3
247	Pollo-Pato (B) CM 15818-13M-1Y-13M-0Y	1.3

* Kenya, Algeria, Tunisia, Turkey (Izmir, Dizarbakin), Mexico (El Batan, Toluca), Argentina, Chile, Ecuador, Peru, Colombia

** Were among best entries in the 7th and 8th IBWSN.

*** Were among best entries of 8th IBWSN.

TABLE 1.2.F Entries in the 9th International Bread Wheat Screening Nursery (IBWSN) with a low average coefficient of infection to leaf rust; average of 25 locations*.

Entry No.	Cross and Pedigree	Average CI
169***	Pavon"S" CM 8399-D-4M-4Y-2M-2Y-0M	1.9
162**	Pavon"S" CM 8399-D-4M-3Y-0M	2.6
164***	Pavon"S" CM 8399-D-4M-3Y-1M-1Y-0M	2.6
165	Pavon"S" CM 8399-D-4M-3Y-1M-1Y-1M-0Y	2.6
166	Pavon"S" CM 8399-D-4M-2Y-2M-3Y-1M-0Y	2.7
167	Pavon"S" CM 8399-D-4M-3Y-3M-1Y-0M	3.9
149	Moncho"S" CM 8288-A-3M-6Y-5M-2Y-1M-0Y	0.9
143	Moncho"S" CM 8288-A-3M-3Y-10M-1Y-1M-0Y	1.2
148***	Moncho"S" CM 8288-A-3M-6Y-5M-1Y-0M	1.1
144***	Moncho"S" CM 8288-A-3M-4Y-5M-2Y-0M	1.4
151***	Moncho"S" CM 8288-A-3M-6Y-5M-3Y-0M	1.4
150	Moncho"S" CM 8288-A-3M-6Y-1M-1Y-1M-0Y	1.8
139	Moncho"S" CM 8288-A-3M-1Y-5M-0Y	1.8
147	Moncho"S" CM 8288-A-3M-6Y-5M-1Y-1M-0Y	1.9
141	Moncho"S" CM 8288-A-3M-1Y-13M-0Y	2.0
152	Moncho"S" CM 8288-A-3M-7Y-0M	2.6
174	Huacamayo"S" CM 8671-B-1M-1Y-1M-1Y-1M-0Y	0.4
175	Huacamayo"S" CM 8671-B-5M-1Y-2M-1Y-1M-0Y	2.0
177	Huacamayo"S" CM 8671-B-5M-3Y-2M-4Y-1M-0Y	3.1
185	Chiroca"S" CM 8963-A-1M-1Y-1M-3Y-0M	0.9
183***	Chiroca"S" CM 8963-A-1M-1Y-1M-1Y-0M	2.0
186	Chiroca"S" CM 8963-A-1M-1Y-1M-5Y-6M-0Y	2.1
187	Chiroca"S" CM 8963-A-1M-1Y-1M-5Y-9M-0Y	3.3
184***	Chiroca"S" CM 8963-A-1M-1Y-1M-4Y-0M	2.6
83	Sparrow"S" CM 2182-5M-1Y-2M-3Y-0M	0.4
131	Pichihuila"S" CM 7652-35M-1Y-1M-0Y	1.9
127	Pichihuila"S" CM 7652-17Y-24M-1Y-0M	3.1
154	Emu"S" CM 8327-C-9M-1Y-5M-1Y-0M	2.7
153	Emu"S" CM 8327-C-9M-1Y-1M-1Y-0M	3.6
155	Emu"S" CM 8327-C-9M-4Y-3M-0Y	3.8
157	Emu"S" CM 8327-C-9M-1Y-1M-1Y-1M-0Y	4.0
338	Dougga 74	1.8

TABLE 1.2.F (Continued)

Entry No.	Cross and Pedigree	Average CI
323	Hork"S" CM 8874-K-1M-3Y-1M-1Y-0M	2.8
199	(Tob"S"-Inia"S"/Son64xSk$_E$^{6}-An) Bb4A CM 11177-21Y-2M-1Y-1M-0Y	0.9
213	Bb-CnoxInia-Soty(Kal-Bb/Inia-CalxInia-CC) CM 11780-J-1Y-2M-1Y-2M-0Y	1.0
53	Inia"S"-Az67/Inia-Cno"S"xCal II 40007-4M-5R-0M	1.4
282	Bb-Nor67xCno"S"-7C CM 1586-500M-500Y-500B-0Y	1.5
337	HD 1220-Kal^3 72L 222	1.5
67	S 331-Norteño J43-2L	1.7
103	Pato(P)-Cal/7CxBb-Cno CM 5746-G-3Y-6M-1Y-1M-1Y-0M	1.9
201	/(21931/Ch53-AnxGb56)An64 /Cdl CM 11243-28Y-4M-3Y-0M	2.0
223	Cno-Inia"S"^{2}xTor(Cno-7CxCC-Tob/Yr"S") CM 12229-K-16Y-1M-1Y-2M-0Y	2.0
347	TacxT.T S64/S^{15} H550-71-4Y-2B-1Y-2B-0Y	2.2
194	Tob66-Cha CM 10583-22Y-9M-1Y-1M-0Y	2.5
198	Kl.Atl/Tob-CfnxBb CM 11029-84Y-7M-1Y-2M-0Y	2.5
227	(Cno-No66/Son64-Kl RendxBb)Cno"S"-GalloxInia-Jaral CM 12330-K-2Y-1M-2Y-1M-0Y	2.5
333	HD 1220-Kal^3 72L19	2.5
132	Npo-Tob"S"x8156/Kal-Bb CM 7806-15M-2Y-2M-1Y-0M	2.6
137	Cno-SonxBb-Inia/TobxCC-Pato CM 8220-B-6M-1Y-1CM-3Y-1M-0Y	2.7
212	Cno"S"-Gallo/Kal-Bbx7C-Nad63 CM 11771-C-3Y-8M-2Y-2M-0Y	2.7
136	Cno-SonxBb-Inia/TobxCC-Pato CM 8220-A-1M-1Y-4M-2Y-1M-0Y	2.9
318	Cno-7CxCno-Inia/Sx CM 8943-F-1M-2Y-1M-2Y-0M	3.1
228	(Cno-N066/Son64-Kl.RendxBb)Cno"S"-GalloxInia-Jaral CM 12330-K-2Y-5M-2Y-1M-0Y	3.2
61	Inia-Cno"S"xCal/Yr70 II 40041-12M-7R-0M	3.1

* Egypt (Bahteem, Giza, Sakha), South Africa, India (Punjab, Rajasthan, Uttar Pradesh, Delhi, Indore), Pakistan (Tandojam, Islamabad), Bangladesh (Ishurdi, Joydelpur), Nepal, Lebanon, Yemen, Israel, Turkey, USA (North Dakota), Argentina, Uruguay, Romania, Mexico (El Batan, Rio Bravo, Cd. Obregon).

** Were among best entries in 7th and 8th IBWSN.

*** Were among best entries in 8th IBWSN.

TABLE 1.2.G Entries of the 9th International Bread Wheat Screening Nursery (IBWSN) with a low average reading (four and below on a scale of 1-10) for Septoria tritici, in Ethiopia, Israel, Poland, Argentina and Mexico.

Entry No.	Name or cross	Pedigree
12	Pitic 62	
24	Goldfinch "S"	II 23561-E1
47	Bobito "S"	II 38837-9Y-1M-1Y-2M-2Y-0M
66	Pi62-Frond/Pi62-MazoexM.Pak	Pk 2858-7A-3A-4A-0A
68	Dibo-CTF	A-7283-1P-3P-2P-0Y
70	Lee-RL2564xFr/IAS 54	Br 8706-13M-1Y-2M-0Y
181	Lee-RL2564xFr/IAS 54	Br 8706-13M-1Y-5M-0Y
72	Sapsucker"S"	Br 69-1Y-3M-3Y-0M
73	Sapsucker"S"	Br 69-1Y-3M-5Y-0M
76	Sapsucker"S"	Br 69-1Y-3M-0Y
83	Sparrow"S"	CM 2182-5M-1Y-2M-3Y-0M
114	Az 67-Cdl	CM 7085-37M-3Y-10M-1Y-0M
115	Az 67-Cdl	CM 7085-37M-4Y-3M-1Y-1M-0Y
130	Pichihuila"S"	CM 7652-35M-5Y-3M-1Y-0M
134	Tito"S"	CM 8212-D-1M-5Y-4M-9Y-0M
141	Moncho"S"	CM 8288-A-3M-1Y-13M-0Y
142	Moncho"S"	CM 8288-A-3M-3Y-4M-1Y-1M-0Y
143	Moncho"S"	CM 8288-A-3M-3Y-10M-1Y-1M-0Y
148	Moncho"S"	CM 8288-A-3M-6Y-5M-1Y-0M
149	Moncho"S"	CM 8288-A-3M-6Y-5M-2Y-1M-0Y
150	Moncho"S"	CM 8288-A-3M-6Y-1M-1Y-1M-0Y
151	Moncho"S"	CM 8288-A-3M-6Y-5M-3Y-0M
152	Moncho"S"	CM 8288-A-3M-7Y-0M
159	Pavon"S"	CM 8399-D-4M-3Y-1M-0Y
161	Pavon"S"	CM 8399-D-4M-3Y-3M-0Y
162	Pavon"S"	CM 8399 D-4M-3Y-0M
163	Pavon"S"	CM 8399-D-4M-4Y-1M-1Y-0M
164	Pavon"S"	CM 8399-D-4M-3Y-1M-1Y-0M
165	Pavon"S"	CM 8399-D-4M-3Y-1M-1Y-1M-0Y
166	Pavon"S"	CM 8399-D-4M-2Y-2M-3Y-1M-0Y
167	Pavon"S"	CM 8399-D-4M-3Y-3M-1Y-0M
168	Pavon"S"	CM 8399-D-4M-4Y-1M-1Y-1M-0Y
171	(Cno-7CxCC-Tob/7C)Cno-Chr>Flr-No66	CM 8607-R-1M-1Y-4M-1Y-0M
228	(Cno-No66/Son-Kl RendxBb)Cno"S"-galloxInia-Jaral	CM 12330-K-2Y-5M-2Y-1M-0Y
244	Cgñ x Kal-Bb	CM 15133-1M-3Y-6M-0Y
236	Ktz M12-Ti 71	CM 14952-51M-1Y-1M-0Y
245	Pollo-Pato(B)	CM 15818-19M-2Y-3M-0Y
249	An$_E$-My54xTi 71	CM 15928-3M-1Y-7M-0Y
254	IAS-WS1812(Cha/Tob-CfnxBb)	CM 16634-D-1M-1Y-10M-0Y
252	(Fr316/McM-KtxY50)Menq-8156	CM 16227-1M-1Y-1M-0Y
259	Kl.AtlxInia-Bb(NP876-Pj62xCal/Bb)	CM 16716-M-3M-2Y-3Y-0M
262	Pato-Tob66	CM 16860-23M-1Y-11M-0Y
263	Pato-Tob66	CM 16860-23M-1Y-12M-0Y
268	(Tob-B.ManxBb/Cdl)Sx	CM 8972 -F-9M-1Y-1M-1Y-0M
297	Brochis"S"	CM 5872-B-8Y-1M-2Y-1M-0Y
298	Brochis"S"	CM 5872-B-8Y-1M-2Y-4M-0Y
364	Chr-S948.A1xChr^5	CMH 73 489-5Y-0B
365	Chr-S948.A1xChr^5	CMH 73.489-2Y-0B
366	Nar59xCno"S"-Gal o	CMH 73 939-6Y-0B
367	S948.A1-Crim^4	H474.71A-6B-1Y-1B-0Y
368	Chr -S948.A1 x Chr^5	CMH 72A 309-5B-4Y-0B

TABLE 1.2.H Names used for 8156 cross in certain countries.

White grain selection

/(Frontana x Kenya 58-Newthatch)Norin10.Brevor_/Gabo 55
II-8156-1m-2r-4m
8156 Blanco
Siete Cerros T66
PJ"S"-Gb55
V17
S-227
Sona 227
HD 1593
Kalyansona
Kalyansona 227
Kalyan
Kalyan 227
Mexipak
Mexipak 65
Mexipak 69
Mexi-Pack
Sidi Misri 1
Laketch

Red grain selection

8156 Rojo
Super X
PV 18
PV 18A
V 18
Indus 66
MR 548
NP 323

CHART 121 Population Handling in the Bread Wheat Program

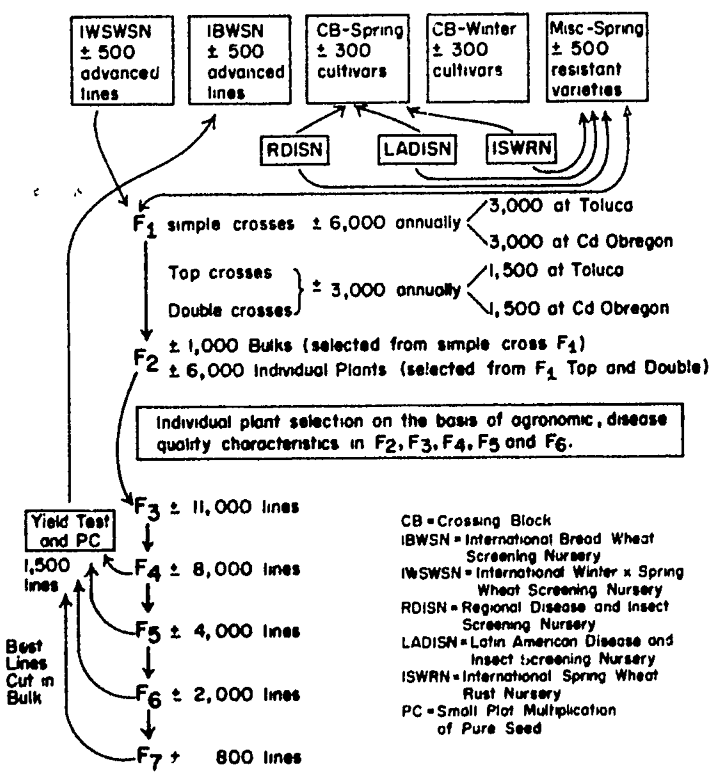


TABLE 1.2.I Entries of the 4th International Multiline (8156) Nursery resistant to leaf rust in India (Punjab and Uttar Pradesh), Pakistan (Islamabad), Egypt (Sakha and Giza), and Mexico (Toluca and El Batan).

Entry No.	Name or cross	Pedigree
3	Ron-Cha x Bb-Nor67	CM 5484-F-1Y-1M-2Y-1M-0Y
4	Ron-Cha x Bb-Nor67	CM 5484-F-1Y-1M-2Y-3M-0Y
5	Ron-Cha x Bb-Nor67	CM 5484-F-1Y-1M-2Y-4M-0Y
6	Ron-Cha x Bb-Nor67	CM 5484-F-1Y-4M-1Y-1M-0Y
27	Ron-Cha x Bb-Nor67	CM 5484-F-5Y-4M-3Y-3M-1Y-0M
9	8156-Nad63xBb/Tob-8156xCno-Inia	CM 5829-N-6Y-6M-3Y-6M-0Y
13	NO66-Bj67/Cno-8156xOn	II 38866-1Y-6M-5Y-3M-0Y
14	NO66-Bj67/Cno-8156xOn	II 38866-1Y-6M-5Y-4M-0Y
18	Bb-Nor67xCno"S"-7C	CM 1536-500M-500Y-500B-0Y
20	Cno-7C xTob-Cno/Pato(R)-Cal	CM 5556-11Y-500M-500Y-0M
23	(Pato/Son-Pdue xCno-Inia)Cno"S"-7C	CM 6838-35M-4Y-1M-1Y-0M
26	Gto-7CxBb-Cno	CM 5278-B-4Y-1M-2Y-3M-1Y-0M
54	Hork "S"	CM 8874-K-1M-3Y-1M-1Y-0M
98	Hork "S"	CM 8874-K-1M-1Y-1M-1Y-0M
63	Cno-7C x Cno-Inia/Sx	CM 8943-F-1M-2Y-3M-1Y-0M
152	Cno-7C x Cno-Inia/Sx	CM 8943-F-1M-2Y-3M-0Y
64	(CC-Kal (Az67xNad63-LR64/Bb)	CM 11663-E-1Y-1M-3Y-0M
129	(CC-Kal (Az67xNad63-LR64/Bb)	CM 11663-E-1Y-1M-1Y-0M
78	(No66-Bb/Cno-Nad63xChr"S") 7C	CM 5375-F-1Y-1M-3Y-1M-0Y
79	(No66-Bb/Cno-Nad63xChr"S") 7C	CM 5375-F-1Y-1M-3Y-4M-0Y
92	Bb-Kal	CM 9160-11M-5Y-6M-0Y
96	Bb-Kal	CM 9160-11M-5Y-4M-1Y-0M
97	Bb-Kal	CM 9160-11M-5Y-5M-2Y-0M
99	Bb-Kal	CM 9160-11M-5Y-4M-0Y
107	HD 1220-Kal^2	72L 221
108	HD 1220-Kal^2	72L 221
113	II 50 17-FKN x Ji	CM 16254-17M-1Y-3M-0Y
114	II 50 17- N x Ji	CM 16254-17M-1Y-4M-0Y
123	(Tob-B.ManxBb/Cdl)Sx	CM 8972-F-6M-1Y-2M-1Y-3M-0Y
127	BbxTob-8156	CM 7723-500M-500Y-0M-501M-0Y
81=171	Brochis"S"	CM 5872-C-1Y-1M-1Y-3M-0Y
169	Brochis"S"	CM 5872-B-8Y-1M-2Y-4M-0Y
170	Brochis"S"	CM 5872-C-1Y-1M-1Y-1M-0Y
179	Tob"S"-8156xCC-Inia"S"	CM 1208-1Y-4M-3Y-2M-0Y
180	Tob"S"-8156xCC-Inia"S"	CM 1208-1Y-4M-3Y-3M-0Y

CHART 1.2.2 Flow of germ plasm between National and CIMMYT Programs

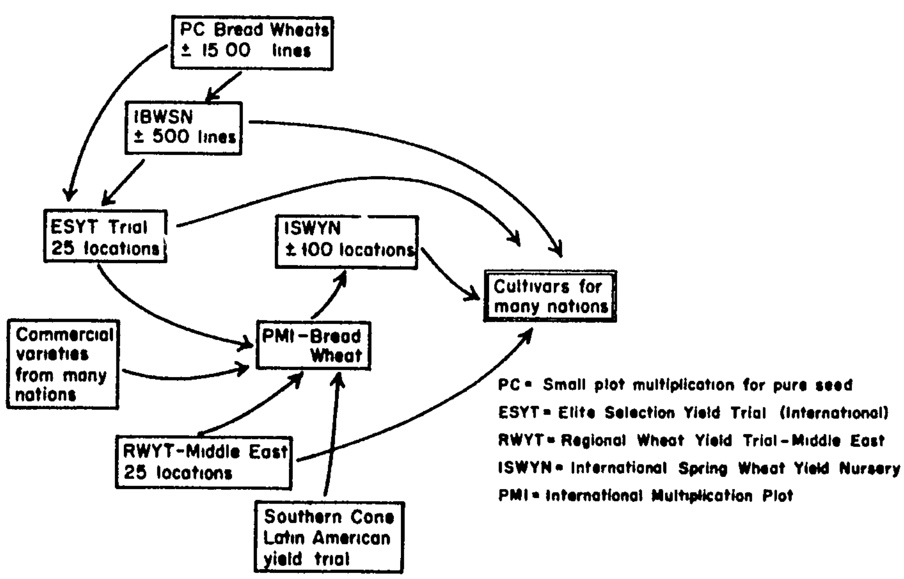


TABLE 1.2.J Entries of the 4th International Multiline (8156) Nursery resistant to stripe rust in India (Punjab), Pakistan (Islamabad), Chile (Chillan) and Mexico (Toluca and El Batan).

Entry No.	Name or cross	Pedigree
24	FuryxCno"S"-No66	CM 4210-10Y-4M-3Y-2M-7Y-0Y
1	FuryxCno"S"-No66	CM 4210-10Y-4M-8Y-2M-0Y
25	FuryxCno"S"-No66	CM 4210-10Y-4M-8Y-2M-1Y-0M
2	Brochis"S"	CM 5872-C-1Y-1M-3Y-0M
81=171	Brochis"S"	CM 5872-C-1Y-1M-1Y-3M-0Y
82	Brochis"S"	CM 5872-C-1Y-5M-1Y-2M-0Y
83	Brochis"S"	CM 5872-C-1Y-5M-1Y-3M-0Y
84	Brochis"S"	CM 5872-C-1Y-5M-2Y-2M-0Y
169	Brochis"S"	CM 5872-B-8Y-1M-2Y-4M-0Y
172	Brochis"S"	CM 5872-C-1Y-1M-3Y-1M-0Y
173	Brochis"S"	CM 5872 C-1Y-1M-3Y-2M-0Y
174	Brochis"S"	CM 5872-C-1Y-1M-3Y-3M-0Y
175	Brochis"S"	CM 5872-C-1Y-5M-1Y-2M-0Y
176	Brochis"S"	CM 5872-C-1Y-5M-2Y-1M-0Y
177	Brochis"S"	CM 5872-C-1Y-5M-2Y-2M-0Y
4	Ron-ChaxBb-Nor67	CM 5484-F-1Y-1M-2Y-3M-0Y
5	Ron-ChaxBb-Nor67	CM 5484-F-1Y-1M-2Y-4M-0Y
6	Ron-ChaxBb-Nor67	CM 5484-F-1Y-4M-1Y-1M-0Y
7	Ron-ChaxBb-Nor67	CM 5484-F-5Y-4M-2Y-1M-0Y
27	Ron-ChaxBb-Nor67	CM 5484-F-5Y-4M-3Y-3M-1Y-0M
90	Ron-ChaxBb-Nor67	CM 5484-F-5Y-4M-4Y-4M-1Y-0M
33	Yr"S"/Bb-Calx7C-Nad63	CM 12534-G-1Y-1M-7Y-0M
36	(Cno"S"/Tob-CCxPato)Kal	CM 16493-B-1M-2Y-0M
94	Cno-7CxCC-Tob/SD648.5-8156	CM 4756-12Y-1M-1Y-0M
95	Cno-7CxCC-Tob/SD648.5-8156	CM 4756-12Y-1M-3Y-0M
46	Cno-7CxCC-Tob/SD648.5-8156	CM 4756-12Y-1M-3Y-3M-0Y
77	Cno-7CxCC-Tob/SD648.5-8156	CM 4756-12Y-1M-1Y-1M-0Y
50	(Cno-7CxCC-Tob/Cno"S"-No66)Kal	CM 11377-A-1Y-8M-3Y-0M
55	(Cno^2 xSon64-K1.Rend/Ron)Sx	CM 8922-H-1M-1Y-3M-2Y-0M
56	Npo-CdlxZbz	CM 8935-D-5M-3Y-1M-1Y-0M
57	Npo-CdlxZbz	CM 8935-D-5M-3Y-1M-2Y-0M
110	(Jar-Npo/LR64xTzpp-An)Cdl	CM 7405-10M-3Y-1M-0Y
111	Ji/CCxK58N-1144 29	CM 14992-17M-2Y-2M-0Y
113	II 50 17-FKN x Ji	CM 16254-17M-1Y-3M-0Y
114	II 50 17-FKN x Ji	CM 16254-17M-1Y-4M-0Y
149	(Cno-K58N/Tob-Cno/We)Sx	CM 8921-B-1M-3Y-1M-0Y
150=214	(Cno-K58NxTob-Cno/We)Sx	CM 8921-G-5M-5Y-2M-0Y
196	Y50$_E$-Kal^{3}xRq"S"-Sot/Sx-We	CM 26604-1-2Y-0Y
204	Cno-No66xKal-Bb/Bj"S"-On^2 x Sx	CM 12421-F-1Y-1M-5Y-2M-1Y-0Y
205	Cno-No66xKal-Bb/Bj"S"-On^2 x Sx	CM 12421-F-1Y-1M-5Y-2M-2Y-0Y

TABLE 1.2.K Yield performance of 12 composites in comparison with Siete Cerros and to the average yield of their components (Yaqui Valley, Mexico, 75-76).

Composite	No. of components	Yield of composite kg/ha	% of 7 C	Average yield of components kg/ha	% of 7 C
BI	5	7525	90	8158	97
BII	4	7926	95	7596	91
BIII	6	8519	102	7867	94
BIV	9	8087	96	7729	92
BV	3	7936	95	7682	92
RI	5	7410	88	7389	88
RII	5	6665	79	7287	87
RIII	4	7608	91	7479	89
RIV	5	7218	86	7481	89
RV	3	7358	87	7781	93
RVI	8	7285	87	7299	87
BRI	11	7556	90	7766	93
7Cerros	-	8384	100	-	-

B= White grain
R= Red grain

7C = Siete Cerros

TABLE 1.2.L F_1 between spring wheats and East European winter wheats showing outstanding agronomic type and rust resistance under Mexican conditions (blanks in the table indicates inferior types or that the cross was not made).

Spring Wheats	Kavkaz	Bezostaya 1	Bezostaya 2	Vorochilovskaja	Romanian F3-71	Romanian F33-68	Romanian F12-71	Romanian F11-71	Romanian F49-70	Romanian F35-70	Romanian F41-70	Romanian F34-70	Lovrin	Favorit	NS 732	NS 984.1	NS 177	Sava	Golden Valley	R 37- Golils 1	R 37- Golils 121	Tetrastichon	Roussalka	Burgus 2	Burgus 2.Sort 12.13	Strampelli	Branosivince	Libalula	
Kalyansona	X								X									X							X				4
Super X										X									X			X						X	4
Tobari 66				X		X														X	X								4
Yecora 70	X		X		X		X	X								X				X	X		X				X	X	11
Torim 73			X	X	X	X		X	X				X		X	X				X	X			X					12
Mochis73				X				X		X								X		X	X		X	X	X				9
Kal-Bb	X									X							X	X				X	X	X	X		X	X	10
Condor "S"	X				X													X											3
Jupateco 73	X	X	X						X												X	X			X			X	8
Cocoraque 75				X			X		X																				3
Potam 70	X								X				X						X		X								5
Zaragoza 75										X			X	X						X		X			X				6
Salamanca 75			X		X								X	X					X	X				X	X				8
Pollo	X																	X		X								X	4
Nacozari "S"				X	X			X	X		X									X						X			7
Pavon "S"		X											X					X		X				X	X			X	7
Emu "S"		X															X	X	X					X					5
Hork "S"		X									X				X								X						4
Canario "S"		X				X						X		X		X	X										X		7
Huacamayo"S"			X												X														2
Africa Mayo							X																					X	2
Tezanos Pintos Precoz							X													X									2
Tanori 71	X				X				X				X		X				X				X			X			7
Bb-Kal		X										X													X				4
																													138

TABLE 1.2.M F_1 between spring wheats and West European winter wheats showing outstanding agronomic type and rust resistance under Mexican conditions (blanks in the table indicate inferior type or that the cross was not made).

Spring Wheats	Heima	Mildres	Riebesel 47.51	Caribo	Badia	Capitole	Bleroy	Capitole Vilmorin	Juquin	Bucquin	Elysee	Gaillard	RPB 14.68	T.Lupton 363.30	TJB 841/1543	Maris Hobbit	Maris Nimrod	Maris Huntsman	VPM.Moisson 33.11.4.8	Joss Cambier	Maris Ranger	Maris Templar	Maris Widgeon	Clement	
Kalyansona		X	X		X																				3
Tobari 66							X						X												2
Yecora 70		X		X																				X	3
Torim 73		X	X	X	X		X	X	X			X	X				X	X						X	12
Mochis 73	X	X	X							X		X												X	6
Kal-Bb	X	X	X		X			X	X	X					X	X			X					X	11
Condor "S"					X																				1
Jupateco 73		X	X	X									X												4
Cocoraque 75			X									X			X		X	X	X					X	7
Potam 70			X									X													2
Zaragoza 75				X										X											2
Salamanca 75			X					X						X	X				X						5
Nacozari "S"														X											1
Pavon "S"						X																			1
Emu "S"						X												X							2
Hork "S"						X																			1
Canario "S"			X								X		X	X		X				X			X		7
Africa Mayo			X																						1
Tezanos Pintos Precoz															X										1
Tanori 71			X																						1
Inia 66		X																							1
Ciano 67	X	X	X													X					X	X			6
Bonanza							X																		1
Sonalika														X	X										2

TABLE 1.2.N F_1 between spring wheats and North American winter wheats showing outstanding agronomic type and rust resistance under Mexican conditions (blanks in the table indicate inferior susceptible type or that the cross was not made).

North American Winter Wheats

Spring Wheats	Arthur Type^2-7C	Bhr"S"2xBhr"S"-Rly67 Type	Bhr"S"5-As	Son 64-SS2	Blueboy	Blueboy 2	Red Coat	Sturdy	Welque Red Mace	Hyslop	Yamhill	V6707	Nor67-6720	NdD-P101	Vg8881-Mln	55.1744	Ymh-Jar	Brevor	NadxTmp-CI12406	Rhodel-Suwon 92	CO 72 4093	CO 72 4660	CO 72 3839	CO 72 5055	CO 72 4085	CO 70472	
Kalyansona								X	X																		2
Tobari 66												X	X								X						3
Yecora 70			X						X									X									3
Torim 73			X		X		X	X	X				X		X												7
Mochis 73	X								X																		2
Kal-Bb	X								X						X			X									4
Condor "S"									X																		1
Jupateco 73																X	X										2
Cocoraque 75						X			X		X	X	X											X			6
Potam 70									X																		1
Zaragoza 75																		X									1
Salamanca 75				X						X				X				X		X							5
Nacozari "S"								X										X									2
Pavon "S"	X	X		X		X							X														5
Emu "S"	X	X					X			X		X				X			X								7
Tanori 71	X	X	X						X													X					5
Inia 66									X																		1
Ciano 67										X													X				1
Azteca 67								X		X		X		X													5
Cajeme 71									X																		1
Pollo																									X		1
Tezopaco "S"								X																			1
Moncho "S"				X												X										X	3
Huacamayo "S"		X		X																							2
Bonanza												X															1

TABLE 1.2.0 F_1 between spring wheats and Cone Sur winter wheats showing outstanding agronomic type and rust resistance under Mexican conditions (blanks in the table indicate inferior susceptible types or that the cross was not made).

	Cone Sur Winter Wheats																			
Spring Wheats	Pumafen	Likafen	Car 113	Car 195	Car 422	Car 853	Car 1071	H490-An64	CD-Pch	Nad-DJ	Vil 29-CD	HnIV x $Kt54_E$-Nar59	Hg -Sonxll $_E$50.18-VG10	$[Pch(Kt54_E-N10BxKt54B/Nar59)^2]$Lfn	{[Ofn(Yt54/N10B-LRxMfo)]DJ}Pch	Kl.Atlas	Panguifen	Car 487	Car 284	
Tobari 66												X								1
Yecora 70	X		X			X	X													4
Torim 73		X				X	X		X	X'					X	X	X			8
Mochis 73												X					X			2
Kal-Bb									X				X		X		X	X		5
Jupateco 73			X			X							X							3
Cocoraque 75					X	X			X	X		X	X						X	7
Anahuac		X			X	X				X					X					5
Salamanca 75		X		X		X	X		X				X		X					7
Nacozari "S"														X						1
Bluetit "S"						X														1
Zaragoza 75						X														1
Canario "S"		X				X	X		X						X					5
Ciano 67						X			X											2
Azteca 67								X												1
Tanori 71								X								X				2
Tezanos Pintos Precoz						X														1
Bonanza									X											1

Cone Sur = Southern Cone Latin America

TABLE 1.2.P Frequency of winter wheat parents involved in 287 advanced lines derived from Spring x Winter crosses currently in yield test in CIANO, Yaqui Valley, México, 1975-76.

Winter wheat	Origin	Frequency
Kavkaz	USSR	98
Aurora	USSR	69
Bezostaya 2	USSR	5
Romanian *T. aestivum*	Romania	21
NS 314	Yugoslavia	1
NS 73	Yugoslavia	1
NS 732	Yugoslavia	2
Mildress	W. Germany	3
Riebesel 47.51	W. Germany	2
Janus	W. Germany	5
Weibul Ring	W. Germany	2
N. Strampelli	Italy	2
Cebeco	Holland	1
Druchamp	France	1
Maris Ploughman	England	4
Yamhill	Oregon	9
55.1744	Oregon	23
Purdue	Indiana	23
Blueboy	North Carolina	3
Arthur Type^3 x Aa-Tranfer-Sudeste	Indiana	1
Roedel-P101^2	Washington	1
NdD-P101^2	Washington	1
P14 x 101-6539	Washington	1
Lilifen	Chile	3

1.3 Durum Wheat

1.3.1 INTRODUCTION

In the 1975 CIMMYT Report on Wheat Improvement, information was provided on the area, production and yield situation of durum wheat throughout the world, as related to the expanding cultivation of semidwarf durum HYV.

World durum trade exceeded the 3 million tonnes level for the first time in 1972. It reached almost 4 million tonnes in the following year and decreased again to about 3 million tonnes in 1974 and 1975. Assuming that the world durum production is 30 million tonnes a year, it means that scarcely 10% of this production enters world trade while the rest is consumed locally. Traditionally, the European Common Market (EEC) has absorbed the largest amounts of durum grain. Recently, Algeria has become the world's largest single durum importing country. In 1975, the EEC and Algeria together absorbed 87% of all durum traded in that year, the details being Algeria 40%, Italy 29%, France 8%, Federal Republic of Germany 5% and the remainder of the EEC 5% (table 1.3.A)

Canada, U.S.A. and Argentina head the list of exporting countries shown in table 1.3.B.

Impressive developments have occurred in world export prices for durum grain. For almost a decade (1963-1972), they averaged approximately 70 U.S. dollars per tonne. In 1973-75, the price reached a peak of 260 U.S. dollars, but dropped to 185 U.S. dollars in January 1976. The prices quoted above refer to No. 3 Hard Amber U.S. Durum, f.o.b. Gulf; the price levels for Argentinian and Canadian durum were very similar.

During this period, fluctuations in export prices for bread wheat followed a similar pattern, though on a lower price level. The price advantage of durum was small until 1973, and it showed a strong increasing tendency thereafter. (Figure 1.3.1).

While little change is expected regarding durum area, production and varietal pattern in the big durum exporting countries like USA and Canada, major changes can be expected to occur in some of the traditional durum growing countries around the Mediterranean, Middle East and Latin America. Increasing local demand and good prospects for export together with the encouraging performance of new, high yielding semidwarf durums have certainly started to enhance durum production in these areas. (See also CIMMYT Report on Wheat Improvement 1975 - Durum Wheat, table 1.4.A).

Little impact on international durum trade has so far been noted. This may be due mainly to the high population growth rate and the consequent increase in local consumption in some of the traditional durum growing countries. Also, the "first generation" semidwarf durums introduced in these areas, often did not meet world market quality standards. However, a change in this situation may be foreseen for the near future.

High yielding, semidwarf durums with improved quality are rapidly spreading in North Africa, Middle East, India, and Latin America. They are increasing in popularity in countries that have not had a significant durum production for decades. For example, Egypt grew a CIMMYT durum yield trial this year, including the good quality cultivar Mexicali 75 which produced an experimental yield of 11 tonnes/ha. Countries like Tunisia and Syria have not had to import durum grain recently, possibly due to self-sufficient local production achieved through the use of improved germ plasm in combination with favourable crop weather during the last 2-3 years.

It is hoped and expected that some of the traditional durum producers may soon have sufficient grain to enable them to become exporting countries again.

1.3.2 YIELD TRIALS 1976

In 16 yield trials grown at Cd. Obregon, Mexico during the 75-76 season, Mexicali 75 continued to be high yielding. It yielded among the first 5 entries in 11 of the 16 trials grown in CIANO, Mexico. However, a great number of new durum lines were superior to Mexicali 75. It is interesting to note that in approximately 50% of these lines, Mexicali 75 was part of the parentage, an observation which was confirmed in the 7th IDSN where half of the 12 highest yielding durum lines had Mexicali 75 in the cross.

Table 1.3.C gives yield figures and agronomic, disease, and quality data for the 13 top yielders at Cd. Obregon, 1975-76 season. It also indicates those lines which have

been high yielding for two consecutive years. Among these, the crosses 21563-AA x Fg with various sister lines, and Gta-21563 x AA are outstanding, having shown high yield and wide adaptation in recent international trials.

From these data, and from information obtained in the 5th to 7th IDYN (table 1.3.D) it may be concluded that Mexicali 75, as an example of the new semidwarf durums, has caught up with high yielding bread wheats both in yield potential and wide adaptation. Furthermore,data on the new lines such as 21563-AA x Fg, Gta-21563 x AA, Mexi "S"-Chap x 21563, and Mexi "S"-Fg "S" seem to indicate that a new level of yield has been reached, which is significantly above that of Cocorit 71 and even somewhat higher than that of Mexicali 75.

The high yielding, good quality combinations which Mexicali 75 has given, encourage the extensive use of this variety in crosses to attempt to combine its high yield with good quality, good disease resistance and better straw strength.

A different yield ranking was found in a yield trial, the 7th EDYT, which was grown on the high plateau of Mexico, El Batan, summer season 1976. Under rainfed conditions and with high disease pressure from Ophiobolus graminis, the triticale check Beagle was considerably better adapted than any durum entry. Beagle outyielded Mexicali 75 by more than 1 tonne of grain per hectare, and it was 600 kg higher in yield than the best durum line. Under these conditions, the wide adaptability of Cocorit 71 was again demonstrated; it occupied rank No. 4 while Mexicali 75 (included twice) ranked in 7th and 10th place (table 1.3.E).

In the 1975-76 season yield trials at Cd. Obregon, spike samples were collected in two experiments to examine the relationships between total spike weight (20 sample spikes/plot), grain weight, ratio grain weight over total spike weight (an expression of spike fertility) and grain yield per plot. The results were considered discouraging because none of these traits showed a sufficiently high correlation with yield to be regarded as a useful indicator of the yielding ability of advanced lines, (figures 1.3.2, 1.3.3 and 1.3.4). The relationship between hectoliter weight and grain yield was also examined and instead of the expected optimum curve, a very scattered picture was obtained (figure 1.3.5) which did not reveal any correlation between the two traits. It is concluded that selecting for high hectoliter weight will not adversely affect yield in durums.

1.3.3 DISEASE RESISTANCE

Routine disease screening in Mexico was carried out at CIANO, Cd. Obregon (leaf and stem rust), Toluca and El Batan (yellow rust), Celaya (leaf and stem rust) and at Patzcuaro (Septoria tritici). At CIANO, only moderate leaf and stem rust epidemics were observed, but the yellow rust epidemics at Toluca and El Batan were severe. At Toluca, fairly strong stem and leaf rust epidemics developed under the favourable moist and warm conditions late in the season. Rust development was apparently not affected by the benlate fungicide spraying against Fusarium nivale.

It is believed that the good infection with stem and leaf rust was partly due to the efficient inoculation provided by the pathology section. The inoculum contained 30% spores collected on durums. Moderate infection data were reported by pathologists from Celaya. The Septoria tritici development in Patzcuaro was stronger than normal and good differential readings could be carried out.

Table 1.3.F shows the disease reactions of 20 durum lines and 5 check varieties with outstanding disease resistance in Mexico. The table reveals the problems of selecting durums for disease resistance in Mexico. With a few exceptions, lines showing complete resistance to the three rusts in Mexico are susceptible in major durum growing areas. One example is Cr "S"^{2}-Gs, a line with complete resistance to stem rust in Mexico, but with high susceptibility outside Mexico. The general conclusion that may be derived from data presented in table 1.3.F is that in breeding for stem and leaf rust resistance, CIMMYT has to rely almost exclusively for the time being on data provided from areas where a large acreage is planted to durums. Consequently, rust races have had the chance to develop more virulence than in Mexico, where little durum wheat is grown. On the other hand, the data shown in table 1.3.F are encouraging with respect to the efficiency of CIMMYT's selection for yellow rust resistance. Lines with yellow rust resistance in Mexico seem to also preserve a certain tolerance in some areas outside Mexico.

No comparative data outside Mexico on Septoria tritici or Fusarium head scab are available for the durum lines presented in table 1.3.F. However, the experience with similar materials shows that little of the relative tolerance to S. tritici and Fusarium species detected in some of CIMMYT's breeding lines at Patzcuaro, is left when they are planted in areas with a strong disease pressure. The lack of information from these areas is a major handicap to making progress with S. tritici and Fusarium species resistance in semidwarf durums. As an example, the only differential reading on S. tritici available for the 7th IDSN was obtained at Patzcuaro. One additional report came from Tunisia, but the reading was carried out at a stage when differential reactions could no longer be detected, all 289 entries were rated 8 using the 0-9 scale.

Breeding for disease resistance in the durum program rises or falls with the amount and diversity of resistance sources available for crossing. CIMMYT is confident that the efforts made during the last two years in the area of assembling germ plasm of very heterogenic origin (see next section) will pay off and will enable the diversification and accumulation of different resistance genes in high yielding semidwarf durums.

1.3.4 CROSSING SEASON 1975-76

During the two crop cycles planted by CIMMYT, approximately 6,000 crosses were made, using data on disease resistance and agronomic characteristics obtained through CIMMYT's own observations, the analysis of international nurseries, and information from CIMMYT Outreach Staff in Turkey, Algeria, and Kenya as guidelines for planning combinations.

A detailed analysis of the crosses made at CIANO in early 1976 shows the type of combinations made between the different groups of materials (table 1.3.G). For simplification, Mexican semidwarf durum lines and Mexican derived commercial varieties are quoted in table 1.3.G as "Mex" whereas commercial varieties or local unimproved lines, which are genetically not related to Mexican semidwarf durums, are quoted as "exotics". From this analysis, the stress on using exotics in crosses to widen the genetic base of our present high yielding lines is evident; 58% of the crosses made included one or more exotic parent. During the 1975-76 period, efforts were made to obtain new breeding material from other durum growing areas. As a result, more than 500 new accessions were added to our nurseries, coming from 13 different geographic areas. The greater part of this material is genetically unrelated to Mexican semidwarf durums, (table 1.3.I). Besides these new accessions, the first part of the durum world collection (1,700 entries) was provided by the USDA and planted in Toluca 76/77 and Cd. Obregon 76/77.

Another approach towards increasing the variability in CIMMYT populations was continued with the interspecific crossing program. Crosses were made between durums and spring bread wheats outstanding for disease resistance and agronomic traits, winter and semi-winter bread wheats with good cold tolerance, and bread wheat F_1's spring x winter.

Besides disease resistance primarily to S. tritici, and cold tolerance, CIMMYT also aimed at transferring traits like heavy tillering, good straw strength and long-lax spike type. In particular, a number of crosses were made with long spike, high spikelet number types of both hexaploid wheats and the tetraploid Emmer-group (T.dicoccum) in order to transfer these spike characteristics to the more compact-spike, low spikelet number semidwarf durums (figure 1.3.6). Increasing the spikelet number, which is a possible approach towards genetically increasing sink size, may help to push yield potential upward while a laxer spike will hopefully make durums less susceptible to Fusarium roseum (head scab)

The interspecific populations grown at Toluca MV76 were the subject of a more detailed study in an attempt to find out about the type of combinations achieved and the way in which these populations might be utilized best to take full advantage of them for the improvement of durum wheat PMC's were taken from 3-5 plants in each of 23 populations (F_2 to F_4) and the cytology department assisted with chromosomal analysis and interpretation of data. Details will be reported separately, but the results may be summarized, as follows.

(a) Plants with intermediate chromosome numbers (29 to 41) are rapidly eliminated under the combined influence of one or more cycles of selfing, selection by breeders, and back crossing to tetraploids in subsequent generations. All plants selected from both straight progenies of pentaploids or back crosses of pentaploid progenies to durums were close to or strictly tetraploids, (table 1.3.J, figures 1.3.7 and 1.3.8).

(b) Plants in two populations of F_2 representing the straight progeny of pentaploids, had retained part of the D genome. Plants in these populations appeared phenotypically more disturbed than those of other populations, possibly due to their unbalanced chromosome constitution, (table 1.3.H, figures 1.3.9 and 1.3.10).

(c) Despite the rapid return of the examined populations to tetraploidy, many tetraploid plants were found with apparent transfer of morphological traits from the bread wheat side, such as straw strength and long, lax spike type. This is indicative of an effective transfer of desirable genes to the tetraploids.

(d) It was concluded that for practical purposes of handling interspecific populations, selection from top cross (pentaploids x tetraploids) progeny may be more effective than selecting from straight pentaploid progenies in recovering undisturbed tetraploid plants with transfer of desirable traits from hexaploid wheats. Back crosses to durums have so far only been made using the pentaploid F_1 as mother (for better seed set). The combination should be tried as well using the durum as mother which would favour the formation of tetraploid progenies from the beginning.

(e) If selections are to be made on straight pentaploid progenies, the populations size or density should be increased. (This has been done in the Durum Program during the last three cycles). If density is increased, spike selections could be made and their assessment be carried out in progeny rows. Thus less space would be needed while the variability in each cross would be recovered to a sufficiently large extent.

Although the use of both exotic tetraploid types and hexaploid wheats in crosses sometimes seems to be a very large job with little benefits, CIMMYT has followed this approach in the belief that widening the genetic base of its gene pool will help to achieve the following four basic goals:

(a) Higher yield potential through improvement of agronomic traits like spike type, straw strength, and earliness in high yielding lines.

(b) Better yield stability through improvement of disease resistance in semidwarf durums by means of accumulating resistance genes effective in many environments.

(c) Better cold tolerance in spring type semidwarf durums.

(d) Improvement of semidwarf durums to make them perform better under adverse cultural conditions such as drought, etc. (See next section for drought tolerance).

1.3.5 DURUM DROUGHT STUDIES

Inadequate moisture supply is probably one of the most important yield limiting factors in durum wheat production. According to climatic conditions, different types of moisture stress may affect crop development and yield. At CIMMYT, research has concentrated on the investigation of the effects of terminal drought. In numerous experiments conducted mainly with hexaploid wheats during the precipitation-free spring seasons at Cd. Obregon in northwest Mexico in 1975-76, the effect of terminal drought on grain yield was investigated. Along with grain yield, other traits such as total dry weight, harvest index, grain number, kernel weight, days to flowering, height in absence of stress, leaf water potential, leaf permeability, and others were examined as to their suitability to explain differences between genotypes in yield under drought conditions.

The only single trait with a high positive correlation to yield under drought was harvest index (r=83**). The more effective distribution of total dry matter in high harvest index semidwarfs was reflected also by yield results under drought when two modern semidwarf durums were compared with four tall, traditional durum cultivars (R.A. Fischer, report of results from Y74-75 season). In a larger durum drought study, conducted by the durum improvement program, results from 54 cultivars confirmed the superior performance of semidwarf durums under moisture stress, and allowed the following interesting preliminary conclusions:

(a) Traditional tall durums as a group showed no advantage over semidwarf cultivars when comparing per cent yield reduction under drought, when the beginning of drought stress occurred at the same developmental stage in both groups. In absolute figures, grain yields of semidwarf durums were at a higher level both under well watered and drought conditions, (figure 1.3.11 and figure 1.3.12). All yield data shown in figure 1.3.11 and figure 1.3.12 are yields corrected for border effect. From a 3m-six row plot, 2m of the four center rows were harvested. Yields were affected by lodging regardless of treatment.

(b) Large differences in drought tolerance, expressed as per cent yield reduction under drought, were observed among genotypes within the groups of traditional tall, tall improved, and semidwarf durums. Among the semidwarf entries, top yielders (figure 1.3.11, group B) were generally more sensitive to drought than durum lines with somewhat lower yields under well watered conditions (figure 1.3.11, group A). Among the check varieties (figure 1.3.11, group C) the bread wheat cultivar Jupateco 73 showed a low sensitivity to drought, exemplified by low yield reduction percentage and the absolutely highest yield of all 54 entries in the drought treatment. In the groups of tall varieties and lines (tall, traditional durums, figure 1.3.12, group A and B; tall improved cultivars, figure 1.3.12 group C and D), the entries with low and high sensitivity to drought were identified. The difference in yield response to drought is possibly due to different degrees of adaptation to dryland conditions.

(c) The performance of "accelerated maturity" lines (figure 1.3.12, group E) was of particular interest. The yield reduction which these cultivars suffered in the drought treatment, was much less than that of all other entries. It is believed that some Ethiopian, Indian, Russian, and North American durums possess superior drought tolerance, but little is known about the influence of morphological or physiological traits on drought tolerance in durums. In some early or fast maturing cultivars, this may be attributed rather to drought avoidance (escape) than to physiological drought resistance. More studies are needed to help identify drought tolerant cultivars for use as progenitors and to generate information on this important characteristic.

1.3.6 DURUM QUALITY

During 1976, a new approach was made by the CIMMYT cereal technology laboratory towards making a more detailed quality assessment in the durums. Besides making spaghetti from durum grain, which is the safest but also the most complicated and time consuming procedure to identify high technological quality lines, quality assessment in some lines was based instead on gluten properties.

A ball is formed of the gluten obtained from a 5 grams semolina sample, which is weighed and then stretched (extended) on a glass sheet. Gluten color is assessed visually using a 1-10 scale. Gluten strength is also determined and is given qualification letters from F (strong) to MSE (very soft elastic) according to the degree to which the gluten ball holds together or flows apart during the stretching on the glass sheet. Color readings on wet gluten are supposed to give a better prediction for the color of the final product (pasta) than pigment determination in the n-butanol-extract, since the pigment breaking-down enzyme lipoxidase, is activated in the washing process and is allowed to operate for about half an hour. Based on gluten color, gluten strength and gluten weight, a general gluten qualification letter is assigned to the sample (B for good, R for medium and M for bad quality). In addition, the earlier used criteria such as pigment content (carotenoids ppm), hectoliter weight and yellow berry and black point evaluations help to complete the quality assessment.

From the latest quality data obtained from high yielding lines tested in yield trials of Y75-76, it seems that CIMMYT is now reaching a better quality level in new, high yielding durum lines. Out of 104 high yielding lines (all yield trial entries with a grain yield not more than 5% below the Mexicali 75 check), 30 combined high gluten color with strong or medium strong gluten. Table 1.3.K shows nine of the best lines in quality having high test weight, low yellow berry and black point ratings and good gluten color and strength. Quality characteristics of Mexicali 75 are given for comparison.

It is interesting to note that seven of the nine advanced lines in table 1.3.K, are not only superior to Mexicali 75 in quality, but they also showed higher grain yields than the check variety.

1.3.7 INTERNATIONAL COOPERATION

Distribution of CIMMYT durum germ plasm continued this year with the shipment of 306 sets of experimental seed, this being an 18% increase over last year's shipment. The nurseries with a wide array of germ plasm for disease screening (IDSN), and the International Yield Tests (IDYN and EDYT) were again the nurseries in the highest demand. Two new groups of sets were assembled this year: an F_2 dryland population with normal height types, and an F_2 interspecific set, this seed being obtained from bread wheat x durum crosses, (table 1.3.L).

TABLE 1.3.A Durum Wheat exports 1964 to 1975, by country of destination.*

Destination (primary)	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
					1000 metric tons							
European Common Market (EEC)	838	1,145	1,386	1,209	1,051	1,571	1,269	1,384	1,009	1,165	1,212	1,445
Non-EEC European Countries	193	350	316	582	245	212	203	246	382	392	306	157
USSR	843	200	275	127	28	15	26	52	467	916	261	54
Near East												
Lebanon	-	20	26	30	12	4	20	68	31	86	79	12
Syria	-	-	-	3	-	-	-	148	141	-	-	-
North Africa												
Algeria	-	-	108	373	319	269	150	374	553	526	1,012	1,224
Libya	6	3	12	-	9	18	-	42	-	-	27	35
Tunisia	-	-	-	-	79	24	81	81	109	39	-	-
Others (North-Central-South America, Asia)	22	364	194	201	82	115	146	408	606	707	124	126
WORLD	1,902	2,082	2,317	2,525	1,825	2,228	1,895	2,803	3,298	3,831	3,021	3,053

* Sources: a) World wheat statistics 1976
The International Wheat Council London, 1976
b) Agricultural Statistics 1975
U.S.D.A. Washington, 1975
c) Monthly bulletin of agricultural economics and statistics
Volume 25 (2), (4), (8).
FAO, Rome 1976

TABLE 1.3.B. Durum Wheat exports 1974 to 1975 by country of origin.*

Country of origin	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
				1,000 metric tons								
Canada	673	928	874	730	348	528	515	1,168	1,701	1,721	1,303	1,467
U.S.A.	762	293	760	1,193	838	1,230	847	1,014	1,194	1,663	1,191	1,381
Argentina	318	789	498	403	406	330	361	604	368	363	465	158
Greece	-	-	70	164	181	51	44	-	-	-	-	23
Syria	11	18	-	-	-	-	-	-	-	64	6	-
Tunisia	-	17	103	1	-	-	-	-	-	-	-	-
Others	138	37	12	34	52	89	128	17	35	20	56	24
WORLD	1,902	2,082	2,317	2,525	1,825	2,228	1,895	2,803	3,298	3,831	3,021	3,053

* Sources: a) World wheat statistics 1976
The International Wheat Council London, 1976
b) Agricultural Statistics 1975
U.S.D.A. Washington, 1975
c) Monthly bulletin of agricultural economics and statistcs
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FAO, Rome 1976

TABLE 1.3.C Yield, agronomic data, disease reaction and quality data of superior durum lines in 16 yield tests at Cd. Obregon, Mexico, 1975-76.

Name and pedigree	Yield kg/ha	Check yield Mexicali 75	Test wt kg/hl	Grain* YB	Grain* BP	Height cm	Flowering days	DISEASE REACTION Y 75-76 SR	Y 75-76 LR	MV-76 YR	PV-76 Septoria**	QUALITY*** GC	GS	GW	Q	CAR ppm	P %
Mexi"S"-Fg"S" D-1895-12Y-0Y	9197	8568	82.4	0	1-	95	80	-	0	5R	5	6	SF	1.70	B	6.4	10.3
Mexi"S"xChap-21563 CD-1294-3Y-0Y-0M	8775	8568	83.4	2	1	95	84	-	TR	5MR	4	7	MF	1.65	B	6.6	10.3
Gs"S"-Gr"S"xRuff"S"/Mexi"S" CD-1314-A-1Y-2Y-0M	8644	8025	82.8	2	1	95	83	-	TR	TR	5	2	MF	1.33	B	3.3	9.8
Mexi"S"xChap-21563 CD-1894-18Y-0Y	8600	8568	81.0	4	1	85	82	-	TS	TR	4	6	MF	1.55	B	5.2	9.7
+ 21563-AA"S"xFg"S" CM-9799-126M-1M-5Y-0Y	8597	7257	83.9	0	1	95	83	-	TMS	5R	4	5	SE	1.58	R	4.5	10.0
21563-AA"S"xFg"S" CM-9799-126M-1M-3Y-0M	8333	7741	82.6	1-	2	95	84	-	TR	TR	4	5	MSE	1.30	M	4.4	10.2
+ Pg"S"xJo"S"-Cr"S" CM-13102-10M-1Y-0M	8155	7257	81.7	0	1	95	-	-	TR-TMS	10MR	3	5	SF	1.70	R	4.6	10.6
+ 21563-AA"S"xFg"S" CM-9799-126M-1M-4Y-0Y	8136	7257	84.5	0	1	90	81	0	TMR	TR	3	3	SF	1.40	R	4.4.	10.0
Mexi"S"xChap-21563 CD-3909-33Y-0M	8126	8025	81.1	4	i+	100	82	-	TMR	TR	4	4	MF	1.32	B	5.4	9.4
+ Yemen-Cr"S"xPlc"S"/Geier"S" CM-17142-8M-3Y-1Y-0M	8049	7941	81.4	0	2	85	89	-	10MS	TR	4	2	MF	1.48	B	4.2	10.8
Yemen-Cr"S"xPlc"S"/Geier"S" CM-17142-8M-4Y-2Y-0Y	7995	7941	78.8	0	2	80	91	-	TR-TMS	TR	4	4	MF	1.41	B	4.6	10.5
+ Gta"S"x21563-AA"S" CM-10143-6M-3Y-1M-2Y-0Y	7328	7257	82.7	1	1	105	90	MS	TR-TS	TR	4	6	MSE	1.45	M	4.5	9.9
Mexi"S"-Fg"S" CD-1895-12Y-1Y-0M	7926	6660	82.2	2	0	80	86	-	TMR	TMR	-	8	SE	1.54	M	7.4	10.1

+ = High yield in Y 74-75
* Grain YB= yellow berry, scale 0-4
BP= black point, scale 0-4
** Septoria tritici Scale 0-9
*** Quality.GC-Gluten color, scale 0-10, 10=most desirable yellow color
GS=Gluten strength, F= strong, MF=medium strong, SF=soft firm, SE=soft elastic, MSE=very soft elastic
GW=Gluten weight
Q=Qualification of gluten in general: B=good, R=medium, M=bad.
CAR ppm= Carotinoids ppm in n-butanol extract
P%=Protein per cent

Y75-76 = Yaqui 1975-76
MV 76 = Toluca 1976
PV 76 = Patzcuaro 1976
SR = Stem Rust
LR = Leaf Rust
YR = Yellow Stripe Rust

TABLE 1.3.D Summary of results from the 5th to 7th IDYN. Names, pedigrees, mean yields, and location frequency of the five top yielders.

	Rank	Name and Pedigree	Mean Yield kg/ha	Frequency of locations where the line was among the 5 highest yielders
5th IDYN 1973-1974 (41 locations)	1	Cocorit 71	3636	21
	2	Brant "S" D.24102-9Y-3M-0Y	3557	20
	3	Anhinga"S" D-22234-52M-3Y-1M-0Y	3518	17
	4	Local checks	3503	21
	5	Cajeme 71	3488	19
6th IDYN 1974-1975 (38 locations)	1	Jupateco 73	[illegible]6	22
	2	Mexicali 75	4521	21
	3	Cocorit 71	4326	15
	4	Brant"S" D.24102-10Y-3M-100Y-0M	4183	11
	5	Gs"S"(D.Buck x Tmε-Tc/Lk) D.27666-4M-1Y-0M	4037	9
7th IDYN 1975-1976 (Preliminary results from 26 locations)	1	Mexicali 75	4662	11
	2	Jupateco 73	4533	13
	3	Snipe"S" CM-13414-1Y-3M-0Y	4485	7
	4	Gaviota"S" D.31725-3M-12Y-2M-0Y	4390	7
	5	21563-AA"S" D.27563-5M-2Y-2M-1Y-0M-0Y	4385	4

TABLE 1.3.E Yield results from the 7th EDYT grown at El Batan, Mexico, 1976.

Rank No.	Variety No.			Kg/ha
1.	22	*	Beagle Tcl	4.272
2	11		Gs-CrxRuff/Mexi"S"	3.682
3	4		Mcax21563-AA/Pg-Fg	3.565
4	21	*	Cocorit 71	3.453
5	24	*	Jupateco 73	3.436
6	3		Mca x 21563-AA/Pg-Fg	3.274
7	25	*	Mexicali 75 (local check)	3.166
8	7		Mexi-Fg	3.078
9	16		D.Dwarf S15-Cr	3.062
10	23		Mexicali 75	2.983
11	19		RabixWils-65150/D.Dwarf-S15-Cr	2.941
12	8		MexixChap-21563	2.758
13	6		21563-AAxFg	2.692
14	20		Mexi-Fg	2.687
15	1		Plc-Cr/GlixLds-56.1	2.629
16	13		21563-AAxFg	2.592
17	10		Clt-Mca(Pg/GlixLds-56.1)	2.592
18	5		21563-AAxFg	2.479
19	14		Marte-Mexi x Chap-21563	2.380
20	17		Mexi x Chap-21563	2.375
21	18		Yemen-CrxPlc/Tc60)Mexi"S"	2.371
22	12		Cr-D 21564xHcl/Pg	2.292
23	15		Mexi x Chap-21563/Magh-AA	2.234
24	2		Rabi-31810	1.943
25	9		Yemen-CrxPlc/Geier	1.235

Precipitation total: 495 mm

Date of planting: June 5, 1976

Date of harvest: October 11, 1976

Seed rate : 100 kg/ha

Fertilizer: 200-80-0 kg/ha of N, P_2O_5, K_2O

* Check varieties

TABLE 1.3.F Durum lines with outstanding disease resistance in Mexico. Disease reaction at other durum growing locations are given for comparison.*

Name and pedigree	Stem rust					Leaf rust					Yellow rust				Septoria** tritici	
	Mexico Y74-75	Mexico Y75-76	Turkey Diarbakir	Kenya Njoro	India M.P.	Mexico Y74-75	Mexico Y75-76	Mexico Rio Bravo	Pakistan Lyallpur	India M.P.	Mexico MV-75	Mexico MV-76	Kenya Njoro	Turkey Diarbakir	Mexico PV-75	Mexico PV-76
Gta"S"-Fg"S" CM-10145-15M-1Y-0M	0	0	-	TMS	-	0	TR	-	-	-	TR	TR	10MS	-	3-4	4
Snipe CM-13414-1Y-3M-0Y	0	0	0	TR	40S	TR	0	30MS-S	0	20R	TMR	TR	10MS	0	0	2
D.D.S15-Cr"S" D-33312-8Y 4M-2Y-0M	TR	0	5MR	TS	30S	TR	0	-	0	20S	TR	TR	5MR	TMR	1	3
Flamingo "S" D-27582-8M-13Y-2M-0Y	0	0	0	TMS	60S	0	TR	20MR-MS	0	10R	TR	TR	TMS	0	4-5	4
Pinguino "S" D-28984-52Y-1M-500Y-3M	0	0	0	0	40S	TR	TR	20S	0	20S	TR	TR	0	0	2-3	3
Gta"S"-Rolette x Fg"S" CM-1/728-C-4M-1Y	0	0	-	0	-	TR	0	-	-	-	10MR	TR	10MR	-	1	2
Parana 66/270	0	0	0	TS	40S	TR	0	0	0	30S	5R	TR	5MR	0	0	3
Crane"S" D-23055-56M-5Y-1M-0Y-82Y-0M	0	0	0	TS	40S	TMR	0	-	TR	20S	TR	TR	TMR	0	0	3
Cr"S"2-Gs CM-595-112M-1Y-0Y	0	0	80S	30S	80S	TMR	0	30MR-MS	0	-	0	TR	5MS	0	1	2
Gdo VZ471-Br"S"xPg"S" CM-13919-11Y-2M-1Y-0Y	TR	0	-	30S	-	TR	0	-	-	-	TR	TR	0	-	3	4
Cocorit 71	0	0	20MR	TMS	20S	5MR	0	40MS-S	0	20R	5MR	TMR	5MR	0	5-6	8
Mexicali 75	0	0	[illegible]0MR	10S	40S	TR	0	-	40MS	-	5MR	TR	0	0	4-5	7
Inrat 69	0	0	30MS	20S	30S	5MR	5R	40MS-S	0	-	10MR	TMR	30S	0	4	3
Hercules	TR	0	5MS	TR	40MR	5MS	40S	60S	0	20MR	60S	-	5MS	0	1	-
Taganrog Buck Balcarce	TR	0	20S	40S	80S	TR	5R	40MS	0	-	5MR	10MR	5MR	0	4	3

* Information collected from CB 74-75

** Scale 0-9

Y74-75 = Yaqui 1974-75
Y75-76 = Yaqui 1975-76
MV75 = Toluca 1975
MV76 = Toluca 1976
PV75 = Patzcuaro 1975
PV76 = Patzcuaro 1976

TABLE 1.3.G Combinations made during the Y 75-76 crossing season.

	No. of crosses	Totals
Simple crosses:		
Mex x Mex	646	
Mex x Exotics	986	1,635
Top Crosses:		
(F1 Mex-Mex) x Mex	354	
(F1 Mex-Mex) x Exotics	73	
(F2 Mex-Exotics) x Mex	154	581
Double crosses:		
(Mex-Mex) x (Mex-Mex)	78	
(Mex-Exotic) x (Mex-Mex)	129	
(Mex-Exotic) x (Mex-Exotic)	46	253
Interspecific crosses:		
Hari x Durum	31	
(F1 Hari S x W) x Durum	34	
(Hari x Durum) x Durum	62	127
TOTAL		2,596

Y 75-76 = Yaqui 1975-76

TABLE 1.3.H Maximum associations observed in F2 individuals from two Bread Wheat x Durum crosses.

Origin MV-76	Plant No.	Trivalents	Bivalents ring	Bivalents rod	Univalents	2n
2036	1		14	-	7	35
2036	2	1	10 13	3 1	4 5	33
2036	3		14	-	7	35
2036	4	1	13 13	- 1	5 6	34
2036	5		14	1	4	34
2041	1	1*	14 15	- -	5 6	36
2041	2		19	-	2	40
2041	3		16	-	5	37
2041	4		18	-	3	32
2041	5	1*	19 20	- -	1 2	42

* Probable trisomics

MV-76 = Toluca 1976

TABLE 1.3.I New accessions obtained during 1975-76, listed with country of origin, properties of the materials, and number of lines received.

Origin	Properties	No. of lines received
A) Spring Durums		
ALGERIA	Selections from Mexican material with good adaptation to Algerian conditions	40
BULGARIA	Durums from local breeding program	18
CALIFORNIA (USA)	Semidwarf durums with good quality. Possibly partly related to Mexican germplasm	25
CHILE	Semidwarf selections with stripe rust resistance, adapted to Chilean conditions. Look like Mexican origen. but are daylength sensitive	30
ETHIOPIA	Local durums with rust resistance. Obtained through ISWRN	35
FRANCE	Commercial variety "Valdur",better quality than "Durtal"	1
INDIA	Durums from Niphad, improved and local unimproved types	19
INDIA	Durums from Indore, improved HI-lines and a few local unimproved selections	188
ITALY	Semidwarf durums, partly incorporating Mexican germplasm (Giorgios), partly derived from mutation lines. Shipment included also local tall types	20
NORTH DAKOTA (USA)	New commercial varieties "Rugby", "Crosby","Botno", "Cando", several advanced lines were selected in Sonora	6
SPAIN	Traditional local durums	50
USSR	Commercial varieties	12
B) Winter Durums		
ENGLAND	Material from PBI, widely differing in winter habit.	27
TURKEY	Crosses between local Turkish cultivars and US-material. Good agronomic type, winter semiwinter habit, selected from 170 durums included in the Turkish WWSN	35
USSR	Commercial varieties	6
TOTAL		512

TABLE i.3.J Chromosome numbers in five generations of Bread Wheat x Durum Wheat material in the CIMMYT Durum Wheat Breeding Program, MV76.

Cross	Origin MV76	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	Generation	No of Plants Sampled	No of Plants Analysed
A. 1. Pentaploids Selfed																			
		42							X							28	P		
									35								F_1		
		42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	F_2		
Aurora x Kal.Bb/Mexi"S" x Chap 21563 /MNIV(KE54A-N10BxKE54B/Nar 59)-	2036	-	-	-	-	-	-	-	2	2	1	-	-	-	-	-		5	5
Cno"S"-GalloxBb#4A/K4496 F_5"S-Bo"S"	2041	1	-	1	1	1	-	1	-	-	-	-	-	-	-	-		5	5
		42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	F_3		
Brochis - Gta"S"	3012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
Fury x Cno"S"-No66/Rabi"S"-31810	3021	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
Gallo"S"-Mexi"S"	3024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
Gallo"S"-Ruff"S"	3061	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
Tob"S"-Cal x D6811	3073	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
		42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	F_4		
Cno"S -Gallo X Cit 71	6517	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
Quelele - Cit 71	6518	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
Cno"S" - Gallo"S" x Pg"S"	6522	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2		3	2
Cno"S" - Gallo"S" x Pg"S"	6523	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
Quelele-Lds Mut	6524	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3		3	3
B. Pentaploids Topcrossed with Tetraploids																			
		42							X							28	P		
									35							28	F_1		
									35	34	33	32	31	30	29	28	F_1 Top cross		
		42						36	35	34	33	32	31	30	29	28	F_2		
Emeck 132xRabi"S"-31810/Cit 71	1948	-						-	-	-	-	-	-	-	-	5		5	5
Chb70xMagh"S"-Gta"S"/Jo"S"-Cr"S"xGs"S"-AA"S"	1949	-						-	-	-	-	-	-	-	-	4		5	4
Brochis x S15-Cr"S"/Pg"S"(21563/LKxCh67)	1953	-						-	-	-	-	-	-	-	2	1		5	3
/(Cno-GalloxBb#4A/K4496)Rabi"S"-31810/Ato"S"	1957	-						-	-	-	-	-	-	-	2	2		5	4
(Fury x Cno"S"-No66/Fg"S")Gta"S"	1970	-						-	-	-	-	-	-	-	-	5		5	5
(Fury x Cno"S"-No66/Mexi"S")Cfn5-Fg"S"xPtl"S"	1973	-						-	-	-	-	-	-	-	1	4		5	5
		42						36	35	34	33	32	31	30	29	28	F_3		
Cno"S"-Gallo"S" x Pg"S"/Pg"S"	4591	-						-	-	-	-	-	-	-	-	3		3	3
Cno"S"-Gallo"S" x Pg"S"/Pg"S"	4595	-						-	-	-	-	-	-	-	-	3		3	3
Quelele-Magh"S" x Magh"S"	4613	-						-	-	-	-	-	-	-	-	3		3	3
Cno"S"-Gallo"S"xMexi"S"/Fg"S"-Magh"S"	4621	-						-	-	-	-	-	-	-	-	2		3	2
Cno"S"-Gallo"S"xMagh"S"/Fg"S"-Magh"S"	4628	-						-	-	-	-	-	-	-	-	3		3	3

MV76 = Toluca 1976

TABLE 1.3.K Durum lines with high yield and outstanding quality characteristics in yield trials, Y75-76, Mexico.

Name and pedigree	Yield kg/ha	Check Yield Mex 75	Test Weight Kg/hl	Yellow berry[1]	Black point[2]	Gluten properties[3] Color[a]	Strength[b]	Weight[c]	Q[d]	Caro-tinoids ppm	Protein %
Cr"S"-Haurani/Mexi"S"xChap-21563 CD-5097-A-5Y-0M	7509	7289	80.5	1	Tr	9	SF	1.50	R	7 8	9.6
Mexi"S"xChap-21563 CD-1894-3Y-0Y	8775	8568	83.4	2	1	7	MF	1.65	B	6.6	10.3
Mexi"S"-Gta"S" CD-1896-1Y-3Y	7511	6660	01.9	2	0	7	MF	' 55	R	6.8	10.1
Mexi"S"-Gta"S" CD-1896-1Y-4Y	7669	6660	80.0	2	Tr	7	MF	.62	R	6.6	9.8
Yemen-Cr"S"xPlc"S"/Geler CM-17142-8M-1Y-2Y-1Y	7610	6660	80 2	0	0	7	MF	1.50	B	5.2	10.1
Harte-Mexi"S"xChap-21563 CD-4404-J-5Y-0M	7541	8034	82.1	1	2	7	MF	1.42	B	7.0	9.7
Ptl"S"-DDS15-Cr"S"/(T.dur ram-Gll"S" x F3 Tun/Cr"S")Gs"S"_/ CD-2686-A-1Y-1Y	6484	6690	81.6	0	2	7	MF	1.65	B	6.3	11.2
Mexi"S"xChap-21563 CD-3909-27Y-0M	7128	7030	80.1	2	1	6	MF	1.50	R	7.6	9.7
Mexi"S"-Fg"S" CD-1895-12Y-0Y-0M	9197	8568	83.4	0	1	6	SF	1.70	B	6.4	10.3
Mexicali 75	8138	8138	80.8	0	0	6	MF	1.50	B	5.6	10.0

1,2 = Scale 0-4, 4= the most affected grain

Y75-76 = Yaqui 1975-76

3 = Gluten properties a) Color scale 1-10,10=the most desirable color
b) Strength: F=strong, MF-Medium Strong, SF= Soft-firm, SE= Soft-elastic, MSE= Very soft-elastic
c) Weight of wet gluten in g
d) General quality of gluten: B= good, R= medium, M= bad

TABLE 1.3.L Number of durum wheat nurseries shipped during 1976.

	CB	F1	F2 irr	F2 rf	F2 Normal Height	F2 Intersp.	8th IDSN	8th IDYN	7th IDYT	Total sets
Africa	4	1	10	7	2	1	21	14	7	67
Asia	5	2	4	4	1	1	15	9	5	46
Central America	-	-	-	-	-	-	1	1	-	2
Europe	4	-	8	4	-	-	16	13	1	46
Middle East	7	-	10	9	-	-	16	14	8	64
North America	5	-	6	1	-	-	7	8	2	29
Oceania	-	-	-	-	-	-	2	2	-	4
South America	5	-	6	5	1	2	12	13	4	48
Totals	30	3	44	30	4	4	90	74	27	306

CB = Crossing Block irr = irrigated rf = rainfed

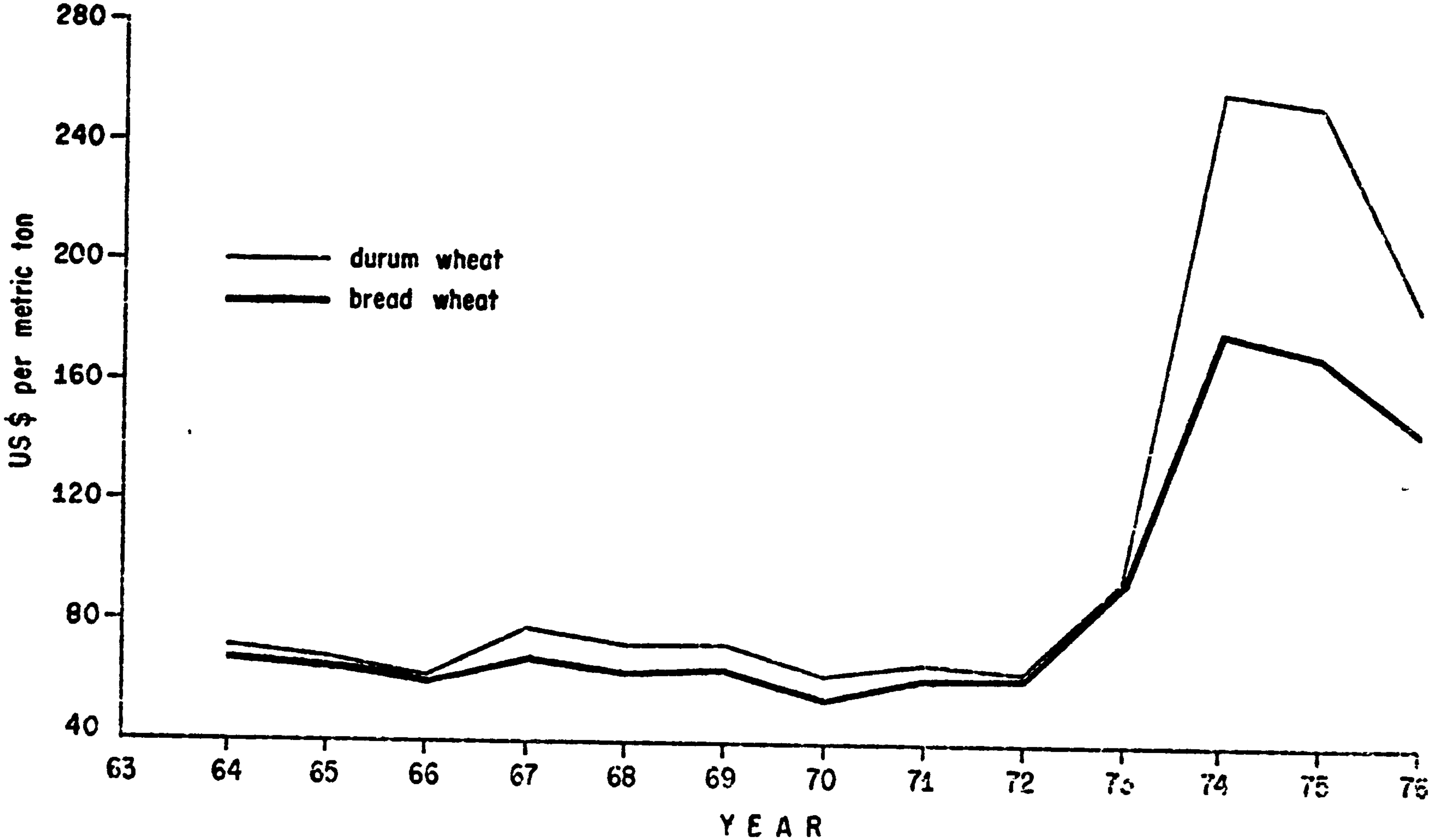


FIGURE 1.3.1 World market export prices of bread wheat and durum wheat, 1964-1976. Prices of bread wheat refer to No. 2 Hard Winter Ord., US$/metric ton, fob Gulf, prices of durum wheat refer to No. 3 Hard Amber Durum US$/metric ton, fob Gulf.

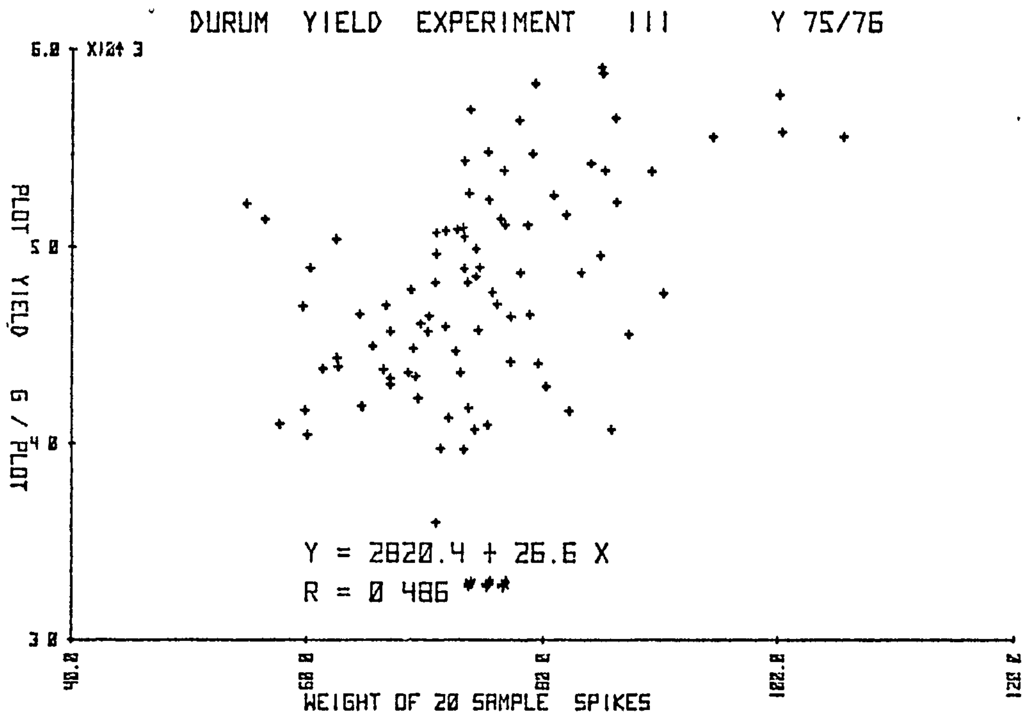


FIGURE 1.3.2 Relationship between grain yield per plot and weight of 20 sample spikes per plot, yield experiment III, Y 75/76.

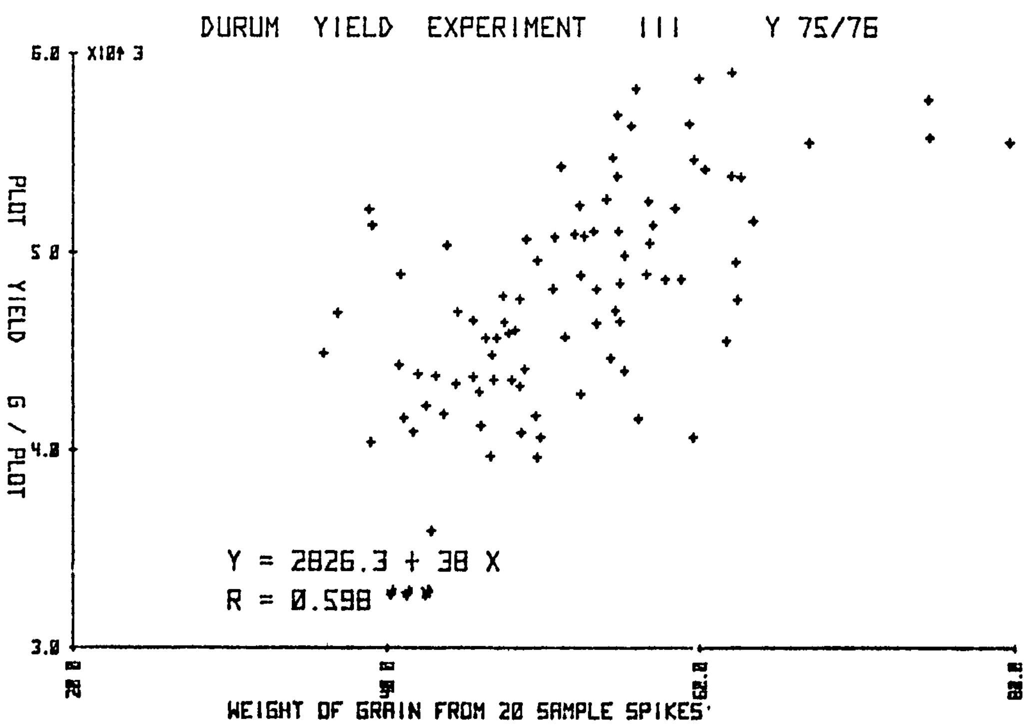


FIGURE 1.3.3 Relationship between grain yield per plot and weight of grain from 20 sample spikes per plot, yield experiment III, Y 75/76.

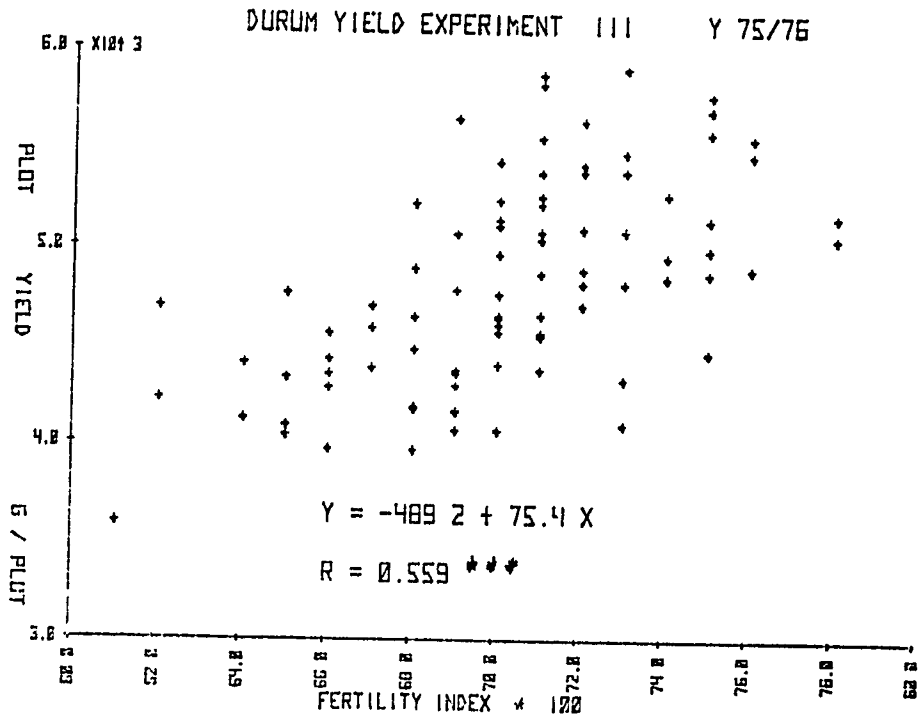


FIGURE 1.3.4 Relationship between grain yield per plot and fertility index (ratio: grain weight over total spike weight of 20 sample spikes per plot) Yield experiment III, Y 75/76.

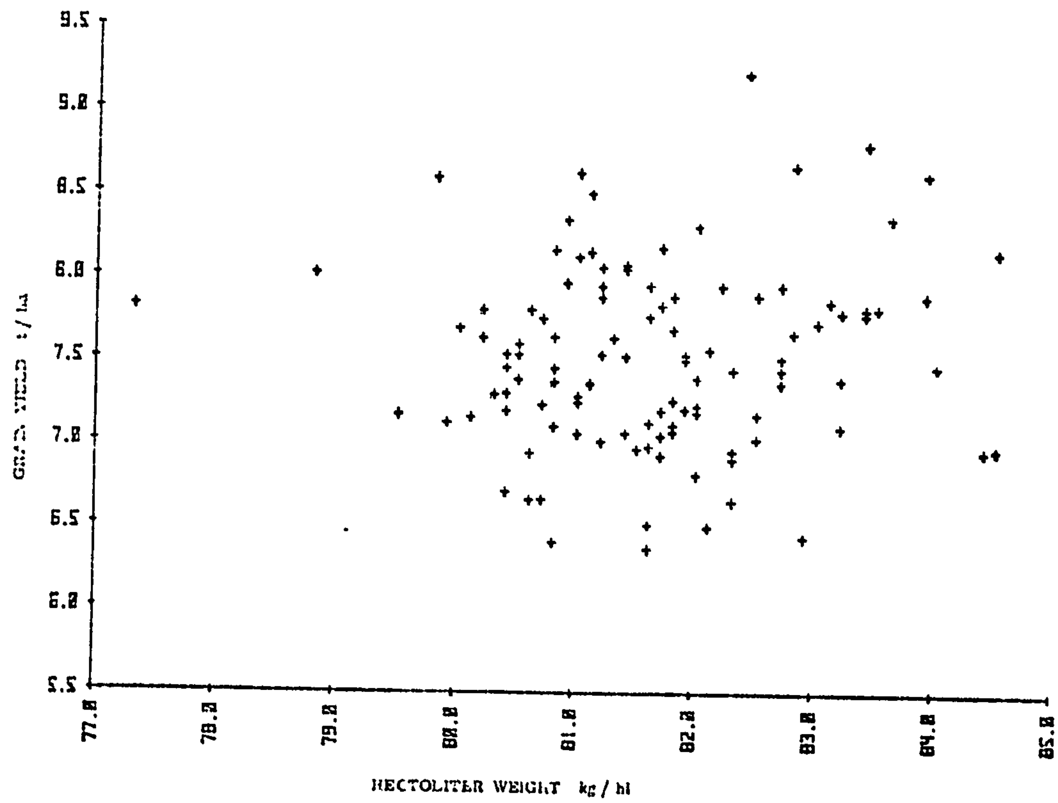
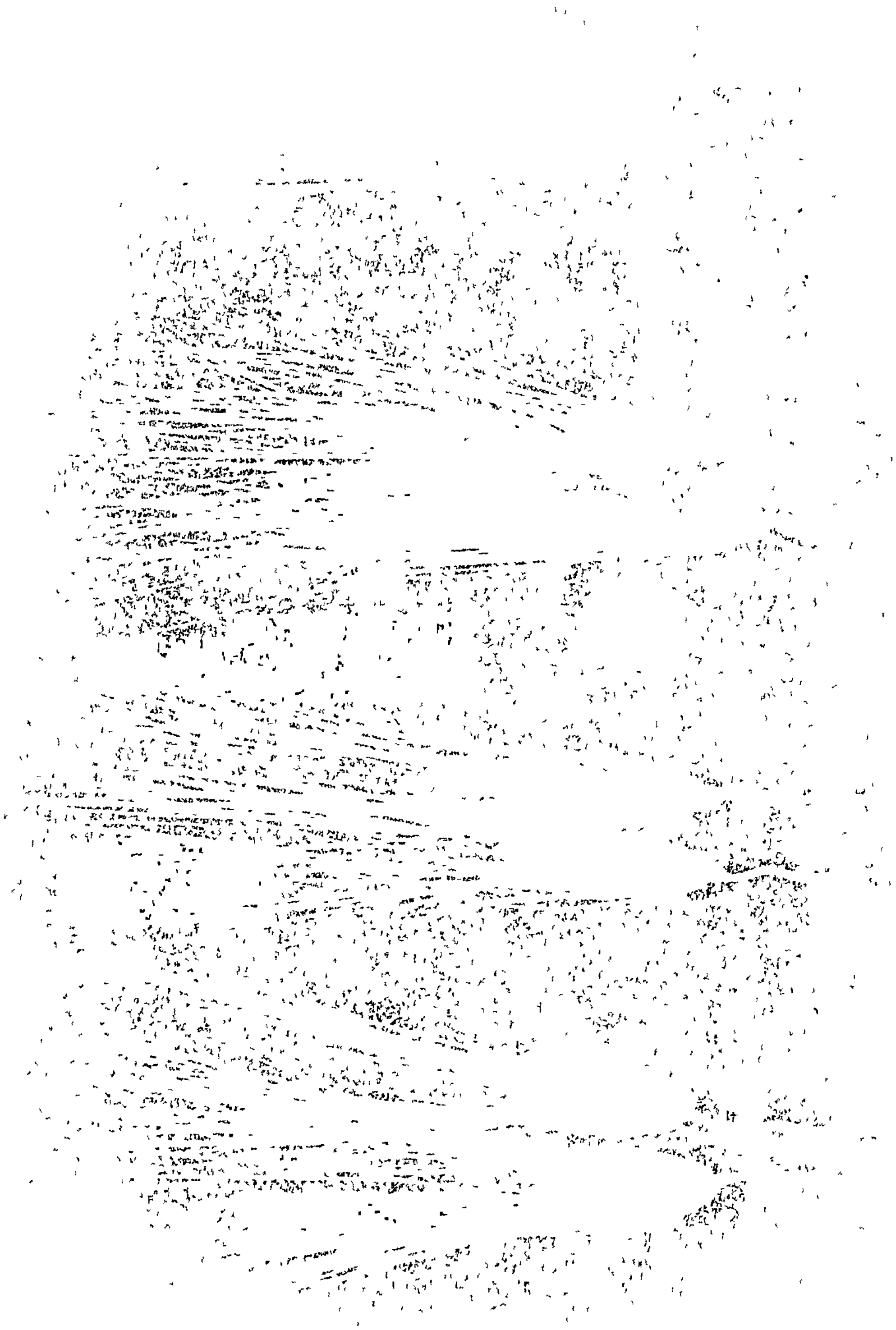


FIGURE 1.3.5 Relationship between grain yield in t/ha and hectoliter weigth of 112 durum lines, yield experiments I to XVI. Y 75/76.



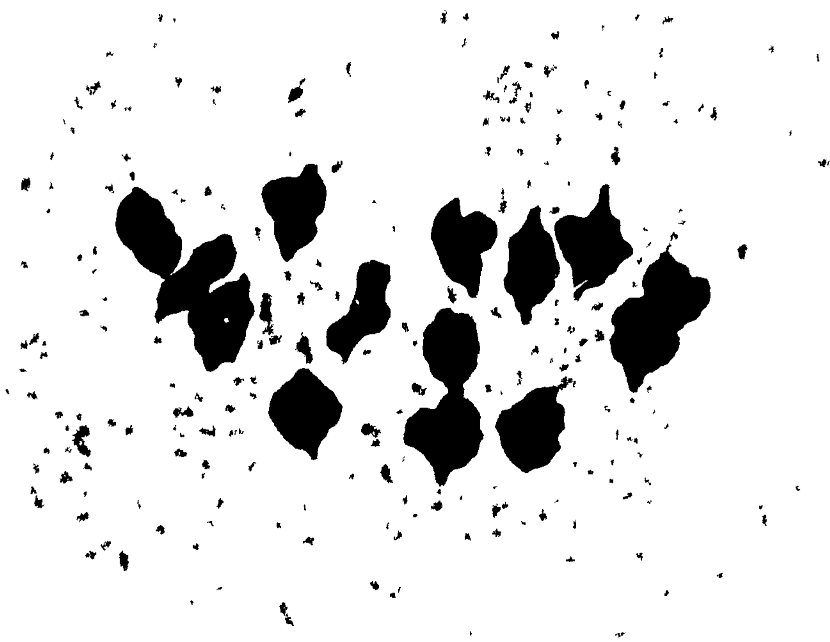


FIGURE 1.3.7 Tetraploid plant in F_3 recovered from a bread wheat x durum wheat cross, showing fourteen bivalents.

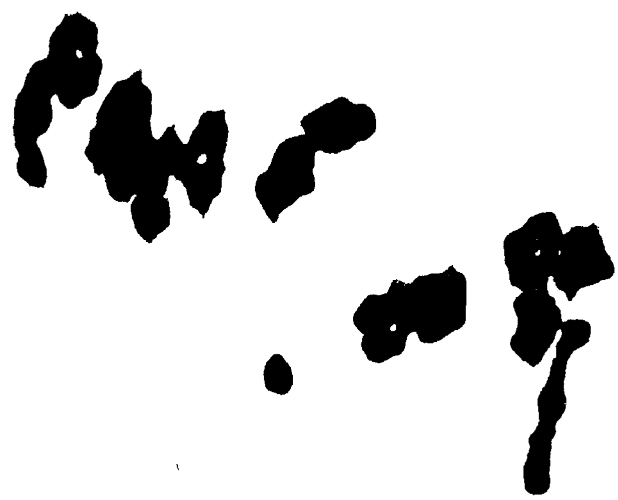


FIGURE 1.3.8 Near tetraploid segregate from the F_2 progeny of a pentaploid x tetraploid F_1 topcross showing fourteen bivalents plus one univalent from the D genome.

FIGURE 1.3.9 Thirtyfour chromosome plant from a bread wheat x durum F_2 showing fifteen bivalents plus four univalents. One D genome chromosome is disomic, four are monosomic, two are nullisomic.

FIGURE 1.3.10 Thirtythree chromosome plant from a bread wheat x durum F_2 showing one trivalent, thirteen bivalents, and four univalents. The trivalent association may indicate translocation between a D genome chromosome and a chromosome of the A or B genomes.

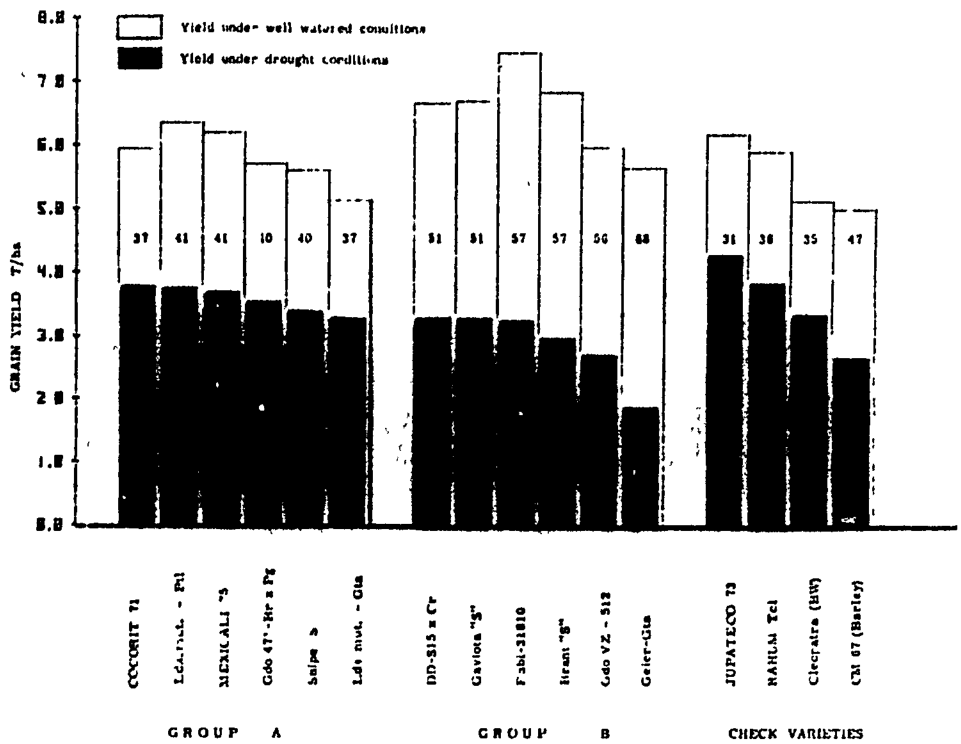


FIGURE 1.3.11 Grain yield of twelve semi-dwarf durum (groups A and B) and four check varieties under well watered and terminal drought conditions, durum drought study Y 75/76. Figures in clear columns indicate per cent yield reduction under drought.

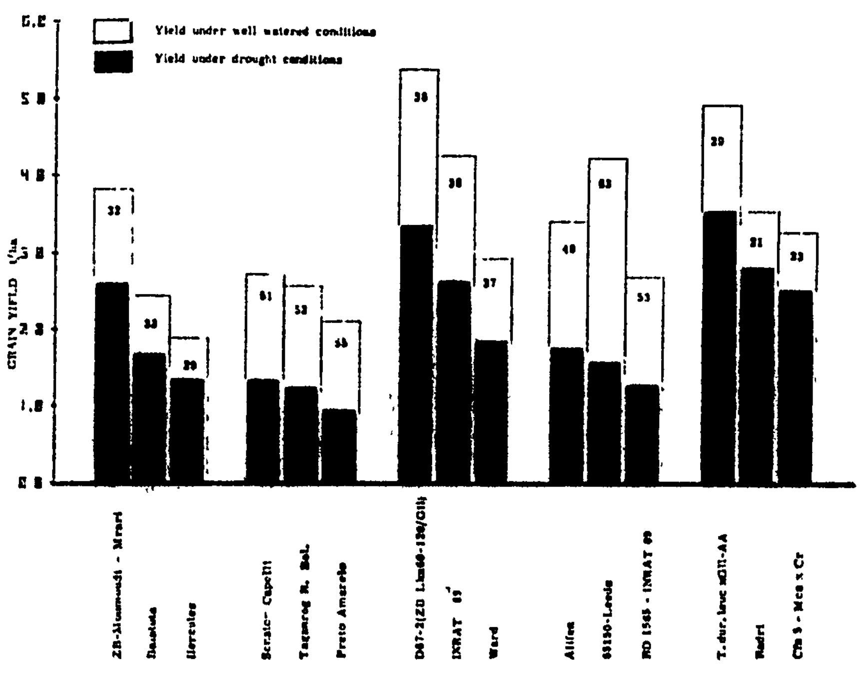


FIGURE 1.3.12 Grain yield of traditional tall (groups A and B), improved tall (groups C and D), and "accelerated maturity" cultivars (group E) under well watered and terminal drought conditions, durum drought study Y 75/76. Figures in clear columns indicate per cent yield reduction under drought.

1.4 Barley

1.4.1 INTRODUCTION

The barley breeding program at CIMMYT is proceeding rapidly in its search for widely adapted high yielding types for growing in areas where barley is used for human consumption. New improved germ plasm which has been generated in the last two years, is now incorporated into the program. In 1976, more such material was created and distributed to cooperators than previously.

Introductions of new material from other programs have been made, so that there is a continuous flow of new germ plasm being evaluated.

In the crossing block, many lines and commercial varieties which were used at the beginning of the program, have been replaced by new improved barleys. Now, more than 50 per cent of the lines and varieties presently used as progenitors, are newly bred types.

1.4.2 ADAPTATION

It is well known that the yield of a particular line at a number of locations which differ in photoperiod length and general environmental conditions, is an indication of its adaptability. Experiences in the CIMMYT Wheat Program have shown that moving germ plasm from one place to another, which differ in general conditions, provides a good means for screening for wider adaptation. In this basis, the CIMMYT barley breeding program has been trying to breed more widely adaptable types.

To identify genotypes with a wider range of adaptation, CIMMYT grows two generations a year at two different locations, and then tests the highest yielding types in different parts of the world. The International Barley Yield Trial (EBYT) was sent to 40 locations in the world.

Preliminary results from this trial, show that a number of selected lines maintained their yield levels at several locations (table 1.4.A). For example, the line CM67-Mona was high yielder in 10 out of 17 locations. The light insensitivity of the two parents involved in this cross largely contributes to the high performance registered over so many locations. This kind of information is very valuable because model genotypes can be identified, which can be further improved in respect of some other characters.

1.4.3 DISEASE RESISTANCE

The breeding program includes the continuous incorporation of disease resistant genes into newly bred lines. In addition to the screening made at the two stations in Mexico, the material is also evaluated in about 50 locations throughout the world.

The 3rd International Barley Observation Nursery consisting of 337 outstanding lines, was distributed to different parts of the world in the summer of 1976. Preliminary data on their response to several diseases, are shown in table 1.4.B.

The results indicate a somewhat low percentage of lines with resistance to more than one disease. There are differences in race specificity because some lines that are resistant to a particular disease in one location are not always resistant to the same disease in another location.

1.4.4 LODGING RESISTANCE

The problem of lodging has been receiving special attention. Heavy losses have resulted in some commercial varieties from the lack of a well anchored crown and a strong straw. In certain areas, where some irrigation is used and some fertilizer is applied, the need for lodging resistant varieties is even greater. The Barley Program has succeeded in obtaining lines carrying a high degree of resistance to lodging (see CIMMYT Report on Wheat Improvement 1975). These lines carry either dwarfing genes or genes conferring straw strength and a well anchored crown. A list of some of the lines found to have good resistance to lodging is given in table 1.4.C. A number of these lines have shown high yields under high irrigation and high dosages of fertilizer.

1.4.5 QUALITY

The use of mutants in the CIMMYT Barley Program to produce high nutritional quality barley lines has continued. In the case of the high lysine induced mutant Risø No.1508, more than 800 crosses to different parents have been performed. The segregates of these crosses have been thoroughly examined, but the results have been disappointing. The linkage between shrunken endosperm and high lysine gene, persists. In the case of the natural hiproly mutant, some lines have been selected with good levels of lysine and a plump kernel (table 1.4.D) and the agronomic characteristics of these lines have to be improved. However, the important fact is that the linkage between shrunken endosperm and high lysine has been broken several times. These lines have already been incorporated in the crossing program.

In addition to the mutants already mentioned, some other lines have also shown high Dye Binding Capacity (DBC) values. These are also being used in crosses.

1.4.6 EARLINESS

The breeding of early types for certain areas will allow the crop to escape some disease hazards and, since it ripens in a relatively shorter time, it can also escape drought conditions. A variety of this kind could also fit some rotation patterns in areas where there is a short lapse of 2-3 months between two crops.

So far the results look promising. Some of the bred lines have already been tested in yield trials at Cd. Obregon, and the results are given in table 1.4.E. Because of their short cycle, the yield levels in these lines cannot be compared with the so called normal cycle type of barleys because they were bred to meet specific purposes.

1.4.7 HULL-LESS TYPES

One of the goals in the CIMMYT Barley Breeding Program is the incorporation of the naked character into the bred lines. The free-threshable grain will serve two purposes: first, it will provide a grain that can be directly consumed by people without having to go to a dehulling or pearling process and second, it will provide extra vitamins and minerals which are present in the pericarp.

The transfer of this character is relatively easy to incorporate because it is simply inherited. Already, a considerable number of lines bred in the program carry the hull-less character Table 1.4.F shows the percentage of segregating lines which carry the hull-less character.

Some of these lines also possess other attributes such as straw strength, earliness disease resistance and nutritional quality. The yields in many of these lines are below what might be expected in the hulled types, but in some others the net utilizable grain weight is comparable and in certain cases, it is surpassed. This is a clear indication that the yield potential of the hulless barleys can be increased substantially by manipulating the different yield components.

1.4.8 WINTER-SPRING CROSSES

A new crossing program using winter barley has been started in order to meet the needs of certain barley growing areas in the world. Winter barleys collected from the USA, Turkey, Korea and Western Europe have been crossed to the spring lines in the CIMMYT Program. This approach will provide a channel to increase variability in both directions, that is, winter and spring.

TABLE 1.4.A Comparative results of selected lines from the 1st Elite Barley Yield Trial.

Var. No.	Variety or Cross	No. of times the line was among the top 5	No. of locations
4	CM67-Mona	10	17
15	Zephyr	7	17
12	Tequila	5	17
25	Local check	5	17

TABLE 1.4.B Selected lines from the 3rd International Barley Observation Nursery with resistance to certain diseases.

Lines with resistance to leaf spot (*Helminthosporium sativum*).

Entry No.	Variety or cross	
1	Apam	
160	Kristina	

Lines with resistance to scald (*Rhynchosporium secalis*)

Entry No.	Variety or cross	
5	CM67	
60	Beacon	
97	H269	
140	Celaya	

Lines with resistance to stripe rust (*Puccinia striiformis*)

Entry No.	Variety or cross	
135	Bco.Mr-Gva	CMB72-121-A-500Y-502B-502Y-0B
148	Apam-Gva	CMB72-1-1Y-1B-1Y-1B-0Y
161	Apam-Aths	CMB-16-40Y-1B-1Y-1B-0Y
170	CM67-Jet	CMB72-29-1Y-1B-1Y-2B-0Y
219	Apam-Dwarf 21 x Apam-Nacta	CMB72-16-40Y-1B-1Y-1B-0Y

Lines with resistance to stem rust

Entry No.	Variety or cross	
81	SD729-Apam	CMB72-204-4Y-1B-1Y-0B
102	Apizaco	
116	Chevalier-Duckhill	XV-2962-1C-2B-1C-0R-500Y-500B-500Y-0B
140	Celaya	
159	Apam-Aths	CMB72-16-37Y-2B-1Y 1B-0Y

Lines with resistance to Powdery mildew.

Entry No.	Variety or cross	
11	CM67-Bon	CMB72A-34-24B-1Y-0B
12	As46-Bco.Mr	CMB72A-38-7C-1Y-0B
28	Bco.Mr-Gva	CMB72-121-6B-1Y-0B
31	Bon-Gva	$F_2$72-9B-2Y-0B
43	CM67-EB489.8.2	CMB72-34-3Y-3B-1Y-0B
44	CM67-Mona	CMB72-41-16Y-2B-1Y-0B
45	CM67-Mona	CMB72-41-29Y-4B-1Y-0B
52	CM67-U.Sask 1744	CMB72-45-14Y-2B-1Y-0B
53	CM67-U.Sask 1744	CMB72-45-19Y-1B-2Y-0B
66	Gizeh 134-M65-220	CMB72-130-2Y-1B-1Y-0B
114	Nacta	501Y-500B-500Y-0B
153	Apam-P1046	CMB72-6-4Y-2B-1Y-1B-0Y
154	Apam-P1046	CMB72-6-4Y-2B-1Y-2B-0Y
155	Apam-P1046	CMB72-6-4Y-3B-2Y-1B-0Y
168	CM67-Gaines	CMB72-28-11Y-1B-1Y-1B-0Y
169	CM67-Gaines	CMB72-28-11Y-1B-2Y-1B-0Y
174	CM67-Mona	CMB72-41-24Y-1B-1Y-2B-0Y
240	Mona	

TABLE 1.4.C Lines from the CIMMYT Barley Program which carry good resistance to lodging.

Variety	Cross
Api-CM67 x 11012.2	CMB73A-366-7B-1Y-0B
Api-CM67 x Mzq	CMB73A-367-13B-1Y-0B
Pro-Kristina	CMB73A-367-1G-1Y-3B-1Y-0B
CR115-Por x Manker	CMB73-520-2Y-2B-1Y-0B
CM67-EB-489.8.2.15.5 x CM67-U.Sask 1800	CMB72A-149-A-1B-2Y-1B-1Y-0B
CM67 x Ds.Apro	CMB72A-32-5B-3Y-1B-1Y-0B
CM67 x U.Sask 1800 x Pro-CM67	CMB72A-160-1-2B-1Y-1B-1Y-0B
Por-U.Sask 1766	CMB72-76-6Y-3B-1Y-0B
Por-U.Sask 1802	CMB72-49-1Y-1B-1Y-1B-1Y-0B
CM67-U.Sask 1745	CMB72-45-19Y-2B-2Y-1B-1Y-0B
Hja C4715 x 011i-M64-69	CMB73-383-2Y-2N-1Y-0B
M66.95-M66-123 x Bgs 0252	CMB73-364-3Y-2B-2Y-0B
Apam-R.L. x Kristina	CMB73-237-11Y-1B-1Y-0B
Mari-Coho	CMB73-301-1Y-2B-1Y-0B

TABLF 1.4.D Lines with high endosperm and which carry the high lysine gene derived from hiproly.

Cross	% lysine	% protein
(Pallidum 10342 x CR115-Por/Bathim 9) Ds-Apro CMB74-1270-C-1Y-1B-500Y-0B	4.60	13.8
CI 1237-Manker/Ds-Apro x 11016.2 CMB74-1254-A-2Y-5B-500Y-0B	4.12	14.9
Bco.Mr x Ds-Apro CMB73-37-16B-1Y-1B-500Y-0B	4.73	14.0
Nopal"S" CMB73-604-A-17Y-1B-1Y-1B-1Y-0B	4.6	16.0

TABLE 1.4.E Comparative yields of selected early barley lines in 1975-76, which received two irrigations and 120 kg N and 60 kg P.

Exp. No.	Variety or cross and pedigree		Yield kg/ha	Days to maturity
VIII	11012-2		5057	104
	Mona		4187	90
	S.precoz (2h)		3920	80
	Mona-Art	CMB73-104-1Y-3B-1Y-0B	3824	90
	Potam 70 (Hari)		3726	120
IX	Puebla		4875	118
	HjaC4715 x 011i-M64-69	CMB73-383-2Y-2B-2Y-0B	4729	92
	Candelilla "S"	CMB73-340-2Y-1B-1Y-0B	4386	103
	CM67		4191	107
	Porvenir		4158	105
	M66.95-M66.123 x BGS0252	CMB73.364-3Y-2B-2Y-0B	4047	93
	HjaC4715 x 011i-M64.69	CMB73-383-3Y-3B-2Y-0B	4003	86
X	Puebla		4669	118
	CM67		4592	107
	Apam-RL x Kristina	CMB-73-237-11Y-1B-1Y-0B	4277	94
	S.precoz (2h)		4228	80
	Porvenir		4074	105
	Potam 70		4195	120
	Mari-Coho	CMB73-301-1Y-2B-1Y-0B	4053	92
XI	Puebla		4933	118
	CM67		4909	107
	Mona		4170	90
	Porvenir		3988	105

TABLE 1.4.F Percentage of segregating lines carrying hulless grain.

Generation	Percentage of hull-less grain
F3	12%
F4	15%
F5	25%
F6	22%
F7	23%

1.5 Triticale

1.5.1 INTRODUCTION

The triticale improvement program at CIMMYT acquired a full crop status in 1968 and since then it has continued to expand in areas of breeding, embryo culture, cytology, agronomy and plant pathology.

Results from international yield trials indicate that some triticale lines are as productive as the best bread and durum wheats at most of the locations where the trials have been grown.

1.5.2 TRITICALE BREEDING IMPROVEMENTS

The main objectives in the breeding research program being conducted in Mexico by CIMMYT relate to matters of infertility, endosperm shrivelling, early maturity, dwarfing and lodging resistance, daylength insensitivity, adaptation, disease resistance, protein quality and industrial quality.

1.5.2.1 Infertility

The major hurdle of floret sterility was overcome with the isolation of Armadillo from the cross X308. All advanced strains of hexaploid triticale in the CIMMYT program have had Armadillo or a derivative of Armadillo as a progenitor. More recent improvements have resulted from introducing more seeds per spikelet or by increasing the number of spikelets per spike into the crossing program. High yielding strains such as Beagle and Drira have long spikes.

The overall improvement in yield potential of triticale is indicated in figure 1.5.1 which compares the yields of the top varieties of triticale and bread wheat grown under tests in Sonora, Mexico. Grain yields and test weights of some of the high producing lines of triticale tested in CIANO, Mexico, in the 1975-76 cycle are listed in table 1.5.A.

Although grain yield in triticale strains has improved annually since 1968, the rate of advance has slackened to approximately that of the best bread wheats during the past three seasons.

1.5.2.2 Endosperm Shrivelling

Progress in improving test weight and reducing endosperm shrivelling has been considerably slower than in improving yield. Lines with test weights of 72-76 kilograms per hectare have been obtained since 1973, but it has been difficult to transfer this improved grain quality to the progeny. Even when different strains with good test weight are crossed very few of the progeny retain a high test weight. In previous years many of the lines having good seed type were agronomically unsuitable, being usually too susceptible to lodging or possessing a low yield potential. This has gradually improved.

Some of the lines having good seed type and a high yield potential are listed in table 1.5.B. Even the best triticale strains are 6-8 kilograms below the best wheats in test weight. It may not be necessary to have test weights equal to wheat for good industrial quality, particularly when whole grain flour is required.

1.5.2.3 Early Maturity

Breeding for earliness appeared to be a relatively simple breeding procedure among the tall to normal height strains. The first early maturity genes were obtained in the Armadillo selections, but complications arose in selecting for early maturity among dwarf plants equivalent to two gene dwarfs in wheat. Nearly all of the dwarf plants were later maturing. Most of the high yielding strains isolated from the program are later maturing than the bread wheats. It is difficult to combine high yield, dwarfing, and early maturity.

1.5.2.4 Dwarfing and Lodging Resistance

CIMMYT has attempted to overcome lodging by introducing dwarf genes, by increasing straw strength or by a combination of the two measures.

Dwarf strains have been easily isolated from the progeny of dwarf UM940 x normal hybrids, but all the dwarfs were insufficiently fertile to be productive. Dwarfing genes from wheat having Norin 10 genes were more useful but they were not as effective in reducing plant height in triticale.

The single gene dwarfs (Armadillo) and two gene dwarfs (Cinnamon) are considerably taller than single gene and two gene dwarfs in bread wheat. Three gene dwarfs (Norin 10 type) have been obtained (Bunny etc.) but they are not sufficiently fertile to be competitive with the two gene types. Dwarfing in rye (Snoopy) was isolated in 1970 but this source has not been as useful in reducing plant height in triticale, as it is in the rye. There appears to be difficulty in isolating vigorous, fertile dwarfs among progenies possessing Snoopy as a progenitor.

Triticale dwarfs possessing dwarfing genes from Tom Thumb were obtained from Dr. Kiss in Hungary. A winter variety Bokolo, has been used extensively as a parent in crosses in recent years, but sterility among the dwarf progeny is nearly always present. Some uniform dwarfs derived from Bokolo crosses which have good fertility, have recently been isolated among the winter type triticales.

The combining of straw strength with dwarfing has been CIMMYT's greatest success in overcoming the lodging problem. The most recent normal height strain with good lodging resistance has been Beagle selected from cross X1530. This strain has been crossed extensively with two gene dwarfs in an attempt to further improve straw strength and to maintain high yield and early maturity. The best high yielding strains in the triticale program have height, maturity and yield characteristics of the bread wheat variety Jupateco in the Yaqui Valley of Mexico.

1.5.2.5 Daylength Response

Daylength insensitivity was introduced into triticales from the Mexican bread wheats with the two most frequently used progenitors for this characteristic being Armadillo (RB#17 1971) and Inia via (Inia x Rye)^2 octoploids.

Most of the CIMMYT triticales develop normally in the cooler regions of the subtropics, but in the higher latitudes they tend to enter the flowering stage too rapidly (similar to Sonora 64 bread wheat) and fail to develop tillers in sufficient numbers to produce high yields.

In cooperation with breeders in high latitude zones (Winnipeg) and intermediate latitudes (Tulelake) a broader spectrum of daylength sensitivity has been introduced into the triticale program.

1.5.2.6 Adaptation

Information on the adaptation of triticales is provided in the section on International Nurseries at the end of this chapter.

1.5.2.7 Diseases and Disease Resistance

(1) Mexico

In the Yaqui Valley in 1975-76, triticales were highly resistant to both leaf and stem rusts present there, but leaf rust resistance appeared to be less stable. To a small degree, bacterial leaf blight (Xanthomonas translucens) affected spring x winter F_2 material.

At El Batan and Toluca in 1976, high levels of stem, leaf and yellow rust inoculum were present. Leaf rust was the principal rust occurring on triticale. Barley yellow dwarf virus was present at both research stations, but not sufficiently evident to allow selections to be made. Bacterial leaf blight (Xanthomonas translucens) severely affected winter planted triticale and selections of apparent resistant materials were obtained.

Fusarium nivale, the "Snow Mold" causing organism, was present in epidemic proportion on triticale in Toluca and little resistance was noted. The Head Scab stage may become a serious problem there and make difficult the procurement of good seed without fungicidal control of this disease.

Certain triticales were affected by a series of necrotic flecking leaf symptoms, especially at Toluca. In many cases these symptoms are associated with certain parents eg. M_2A- Cml. Observations from the Yaqui Valley in 1974-75 and 1975-76, and from Toluca and El Batan in 1975-76, indicate that a good deal of these symptoms are of abiotic origin or relate to genetic incompatibility. Nevertheless, little experimental work has been done to prove or disprove this indication. These symptoms have been reported in some of CIMMYT's international nursery trials and are probably largely influenced by growing conditions.

A "haying off" complex occurred at El Batan in 1975 and 1976, which seemed to be less severe in 1976. Although the cause of this disease complex is unknown, initial experiments indicate that the non-availability of certain soil elements are the primary cause. However, more work must be done to confirm this. Ophiobolus graminis increased in severity on plants predisposed by the "haying off" complex, as also did Helminthosporium sativum and Fusarium roseum.

Trials for Septoria tritici resistance in Pátzcuaro, Michoacán indicate that many triticale lines have excellent resistance to the strains present there.

In a leaf rust survey made in Mexico in 1976, nineteen collections from triticale were taken in the Yaqui Valley in the spring. Early indications suggest that the leaf rust races found on triticale are the same as those on wheat in the Yaqui Valley. One collection taken from Beagle contained genes for virulence additional to those found on wheat. The Beagle culture was inoculated onto the ITSN and TDRN in the seedling stage in order to provide additional information on leaf rust resistance. A lot of the material gave mixed reactions, but some lines were highly resistant.

(2) World Wide Triticale Disease Resistance Nursery (TDRN)

This nursery was arranged to provide breeders with the best available levels of disease resistance for use in their crossing programs. Nine nurseries containing 102 lines including susceptible checks were sent out in the 3rd TDRN.

Data from Canada, Ethiopia, Turkey and Mexico indicate that triticales in the TDRN were highly resistant to all three rusts. In Turkey at Izmir, good resistance to heavy bacterial blight infections was noted.

The 4th TDRN was dispatched in July 1976 and it contained 54 lines of diverse resistance including lines with reported resistance to the three rusts, barley yellow dwarf virus, ergot, Helminthosporium and Septoria.

1.5.2.8 Protein and Industrial Quality

(1) Protein Quality

It has not been possible to maintain very high protein levels (over 17 per cent) among the high yielding strains. Whilst yields have continued to improve, the protein content has remained relatively stable at approximately 13 per cent during the last three seasons. Despite the drop in the level of protein in the grain, the production of protein /hectare has increased steadily.

Protein quality has been improved. Increases in lysine content in the protein increases the nutritional quality of the grain. In the 1968-69 crop, the average lysine content was 2.83 per cent, whilst in 1973 it averaged 3.4 per cent and in the 1975-76 crop, it was 3.43 per cent.

(2) Industrial Quality

In 1974, over 75 per cent of the 122 lines tested had a test weight of 70 kg/hl or more, while in 1976, 81 per cent of the 264 lines had a test weight of 70 kg/hl or more. Because the material has been selected for higher test weight and better plumpness of the grain, the flour yield has increased.

In 1974 and 1975, the triticale tested at CIMMYT had a flour yield of 53-69 per cent, and in 1976 even when the range of flour yield was from 52.2-71.7 per cent, only 5 per cent of the 468 samples tested, had a flour yield less than 60 per cent.

In baking tests, a large number of triticale lines had bread loaf volumes up to 700 cc in comparison with the bread wheat Yecora which had a loaf volume of 765 cc. Satisfactory results were obtained with triticale flour for making tortillas. Some lines of triticale provided flour which is better for cookies than the flour of soft bread wheats. Triticale meals used for making chapatis kept moist [illegible]er than those made from bread wheat flour.

All told, the results indicate that the potential use for triticale is in the production of chapatis, cookies, tortillas and some types of bread other than sandwich bread.

1.5.3 WINTER AND FACULTATIVE SPRING TRITICALES

The CIMMYT triticale program includes developing these types of triticales at the Toluca, México, nursery during the winter months.

Large areas of cereal crop production in the world are located in regions which are subjected to frosts at some time during the growth cycle (above 30°N and below 30°S latitude). These regions require winter or facultative spring type cereals.

Although the number and severity of frosts at Toluca are light during the winter cycle, winter triticale strains sown in late October and early November are sufficiently vernalized to produce seed in July. Spring type strains are sown in January, develop normally without vernalization and flower in time to serve as parents in the crossing program. The spring type triticale strains developed in Mexico are unsuitable as a winter crop even in areas where occasional mild frosts occur. They develop flowering tillers too early in the season and are exposed to frost damage. The winter and facultative types produce an abundance of tillers, and a vigorous root system but delay flower bud initation until vernalization has been completed. The facultative forms are revernalized more quickly than the true winter forms.

The introduced winter forms best adapted to the Toluca climate have come from Dr. A. Kiss in Hungary and Dr. F. Elliot, Michigan State University. They are also more resistant to natural infestations of disease. Consequently, they have been used most frequently as parents in crosses.

Selections among spring x winter populations provided genetic improvement in both spring and winter habit material. Winter forms supplied new genes for growth habit, root development, disease resistance, seed dormancy, and possibly resistance to drought for the spring triticale program. The spring types contributed dwarfing, improved fertility, improved seed development, earliness, and rust resistance to the winter forms.

The early developmental stage of this initial material and the limitation to a single generation per year has made the winter triticale improvement rate appear to be slow.

However in terms of change per generation, the winter forms are improving as rapidly as the spring forms. Screening for frost resistance is not possible because of the lack of sustained freezing temperatures in the Atizapan winter nursery. Segregating material is therefore sent to cooperators in Oregon, Michigan, Ontario, Hungary, England and Sweden, where the material is subjected to a wide range of winter conditions. Selections from these nurseries are returned to Mexico for further cycles of screening and crossing. Marked improvement in lodging resistance, plant height, fertility and seed type is already apparent among the best winter type selections from winter x spring crosses. These combine better resistance to lodging, better fertility and grain quality from the spring parents with resistance to frost, preharvest sprouting and root diseases from winter parents.

A winter triticale yield trial made up of entries developed in Europe was grown for the first time in the 1975-76 Toluca winter nursery. All lines were unsuitable for this environment, being susceptible to lodging and leaf diseases occurring naturally in the area. Most of the lines were considerably less fertile in the Toluca nursery than in the European environment in which they were bred.

1.5.4 FORAGE TYPE TRITICALE

A large proportion of the small farms in the developing countries require feed both for their animals and food for the family. A crop which could provide both without sacrificing the yield of either forage or grain, would be advantageous over the need to grow separate crops for food and forage.

Although the main emphasis in triticale improvement at CIMMYT has been towards grain production and grain quality, forage production studies are also being conducted.

Forage production and grain production of triticale and oats under irrigation, in the State of Sonora, México, have been compared. Farm grazing trials and also clipping experiments to simulate grazing have been conducted on triticale and oats. The first clipping was performed at optimum grazing time, and the second clipping was made three weeks later.

Yields and growth patterns following the clipping treatments were quite consistent in the forage experiments conducted for three years. It appears that triticale strains produce more grain than the oats without clipping, or with one clipping. In spite of the more rapid production of dry matter among oat varieties, the latter tended to lodge at the heading stage which resulted in serious impairment to grain development. Triticale produced as much dry matter as oats when cut as hay during the milk and early dough stage.

The production of high protein forage among triticales is lower relative to oats, particularly with additional clippings. The rapid recovery rate of oats after clipping has not yet been found among triticale strains. The grain production of triticale decreases with each successive clipping. Oats on the other hand tend to increase grain production with successive clippings, until no further lodging occurs.

A series of experiments was conducted in the State of Sonora, México in 1974-75 to evaluate various criteria for selecting more productive forage type strains and to develop management techniques to improve yield and quality. A group of 150 triticale and 5 oat strains were evaluated for grain, hay and high protein forage production following 0 to 4 clippings during the growing season. Protein determinations were made on all grain and forage produced in all strains and all treatments. A similar experiment using only 50 varieties but with the same treatments was conducted at Navojoa during the 1975-76 cycle. Unfortunately the irrigation water was cut off before the experiment was completed and the clipped plots suffered severe drought stress. The experiment had to be discontinued.

All these investigations provided a wealth of information on the capabilities of triticale and oat varieties to produce grain, hay and high protein forage under different clipping managements. In a program of breeding for forage production it was important to determine the selection criterion to be used to screen for high production. Tables 1.5.C, 1.5.D, 1.5.E and figures 1.5.2, 1.5.3 and 1.5.4 provide the production data comparing top strains selected for total grain production,hay production and high protein forage production under each of the clipping managements used. The hay yields were obtained on the unclipped plots only, so the information provided on the clipping data refers to the same group of strains.

There are several very interesting observations on the results of the studies. The top grain producing triticale strain yielding 8.8 metric tons/ha was poor in hay production at 16 metric tons D.M. The top hay producing triticale with 23 metric tons/ha. D.M produced only 4.1 metric tons grain/ha. In contrast, the top grain producing oat variety with 3.1 metric tons/ha was also the top hay producer with 18.8 metric tons D.M. Varieties capable of producing the most high-protein-forage after numerous clippings, were generally not among the top grain or hay producers.

Under the high productivity conditions prevailing in these experiments, it appears that triticale strains have a yield advantage over oats in grain, hay and high protein forage production under 0 and 1 clipping. The oats gain in high protein forage and grain production as the number of clippings increases.

The production of forage by triticale could be improved by selecting for lines which recover rapidly after each of several clippings. Segregating populations from crosses between diverse types such as spring x winter strains should provide a source of material for selection. There is a need for more research on management to maximize production under grazing or clipping.

1.5.5 AGRONOMY RESEARCH

Research on management and production practices in triticale have been conducted in the State of Sonora and the high plateau of México during the last three years. Off-station trials are conducted. They are managed by farmers, except seeding, and they enable the performance of triticales to be observed under farm conditions. These trials also provide an opportunity for trainees from other countries to become acquainted with on-farm triticale production.

1.5.5.1 Nitrogen Trials

Fertilizer trials conducted before 1972 showed that triticales did not respond to nitrogen fertilizers as much as bread wheats and durums. An important factor was their greater susceptibility to lodging. Most of the triticale strains prior to 1972 would lodge if more than 80 kg/ha of nitrogen was used. Factors other than lodging were involved in the poor responses of triticale strains to nitrogen fertilizer. Even when lodging was prevented, the yields from triticales decreased relative to the dwarf bread wheats at high nitrogen levels.

Results from the agronomy trials have indicated that using higher nitrogen fertilizer levels in the breeding nurseries would enable better screening for nitrogen response. Marked improvement in breeding for nitrogen response has been achieved during the past four years. Results from the 1975-76 nitrogen trials at CIANO indicate that the average grain yields of ten triticales were equal or superior to the four best bread wheats and the two best durums, at all nitrogen levels from 0 to 300 kg/ha (figure 1.5.5).

Lodging is still an important factor in grain production among triticale strains at high nitrogen levels. It is expected that further improvement in grain production can be achieved by improving lodging resistance.

1.5.5.2 Dry Matter Production

The response of the most recently developed strains of triticale to nitrogen corresponds very closely to the best varieties of bread wheat. The production of total dry matter per unit area is quite different. Trials conducted at CIANO during the 1974-75 and 1975-76 seasons indicated that at low nitrogen levels, triticale and wheat produce similar amounts of dry matter. As the nitrogen level increased, more dry matter was produced by triticale than wheat. At nitrogen levels of 300 kg/ha, triticales produced about 2 metric tons/ha more dry matter than bread wheat.

This superior level of dry matter production in triticale could be a major advantage if the harvest index i.e. grain versus straw ratio, could be improved to that of the best bread wheats.

In the 1974-75 trials, the triticale strains Drira and Beagle produced 20.3 and 18.4 metric tons/hectare of dry matter respectively. The best bread wheats produce about 16 metric tons/hectare at the top nitrogen levels. If the harvest index could be improved to .45 as in the best bread wheats, a grain yield of up to 20 per cent above those of bread wheat could result. This aspect of triticale is worth exploiting.

In agronomic trials in México, CIMMYT has observed that harvest index could be increased by delaying the application of nitrogen up to 57 days after emergence. Any further delays in nitrogen application seriously depressed grain yield.

1.5.5.3 Wild Oat Competition

It is extremely important that varieties capable of competing with weeds are used in developing countries, where greater problems in eradicating weeds exist. Varieties do differ greatly in their ability to suppress weed growth.

CIMMYT has conducted trials in México in which high yield varieties of triticale (Yoreme), durum (Cocorit), bread wheat (Jupateco) and barley (Celaya) were grown in competition with wild oats and their productivity compared under weed free conditions. Grain losses due to wild oats at maturity were 4790 kg/ha for Cocorit, 4070 kg/ha for Yoreme, 2880 kg/ha for Jupateco and 1200 kg/ha for Celaya. Under weed free conditions, Yoreme produced over 1 metric ton/ha more grain than Celaya, and under a heavy wild oat infestation, Celaya produced 3 metric tons/ha more grain.

1.5.5.4 Herbicidal Weed Control

Experiments to determine the efficiency of various herbicides to control weeds, and their phytotoxicity on crop varieties were carried out in México at Toluca (1975) and at CIANO (1975-76).

Results from experiments in Toluca indicate that two of the herbicides provided adequate control of broadleaf weeds and were not phytotoxic to triticale. These were:

Tribunil at 1 kg/ha. a.i. applied 17 days post emergence
Dosanex at 2 kg/ha. a.i. applied 17 days post emergence

Both herbicides were also effective in reducing the growth and vigor of *Poa annua* plants.

In the Yaqui Valley, México, several grass weeds cause serious losses to the cereal crops. Wild oats (*Avenua fatua*) and canary grass (*Phalaris minor*) are the most prevalent. Studies on the use of herbicides to control wild oats and canary grass were initiated in 1974-75 and continued through 1975-76 at CIANO.

Two herbicides were effective in controlling wild oats and increasing yield. Dosanex applied at 4 kg/ha a.i. at 30 days post emergence provided a 90 per cent control of wild oats. Mataven or Super Suffix (WL 29761) gave excellent control of wild oats. The top yields were obtained when Super Suffix was applied at 30 days post emergence at rates of 0.45-0.60 kg/ha a.i.

Finaven was also satisfactory in wild oat control and its use resulted in an increase in grain yields.

The herbicide studies on *Phalaris minor* indicated that this weed was more easily controlled than wild oats, although some of the products were too phytotoxic to be recommended. Among the herbicides which were considered satisfactory were: Dicuran at 2 kg/ha at 18 days post emergence and Dosanex at 4 kg/ha a.i. at 30 days post emergence.

1.5.6 INTERNATIONAL NURSERIES

The distribution of triticale nurseries internationally has permitted exposure to environments, disease, climates and soil types which differ considerably from those of Sonora and Toluca, in México.

Figure 1.5.6 shows the average relative grain yield performance of the top yielding strains of triticale, bread wheat and durum wheats at all locations in the ITYN trials from 1969-70 to 1974-75. Such comparisons are always biased in favor of the crop having the largest number of entries. A more realistic estimate of broad adaptation may be obtained from comparing the performance of the best varieties in the wheat and triticale trials grown at the same locations. Figure 1.5.7 provides a grain yield comparison between the top 5 triticale strains versus the top 5 bread wheats in their respective international yield trials having common locations, from 1969-70 to 74-75. Inflated values for bread wheat production (figure 1.5.7) during the 1970-71 cycle resulted from too few locations in common (9), two of which were grown under high productivity at CIANO, México and Davis, California.

If the general trend towards broader adaptation of triticales continues, there are excellent possibilities for this crop to increase food production in the more remote regions as well as in much of the area where the world's small grain production now occurs.

During the past two years more attention has been devoted to encouraging and establishing commercial production of triticale in some of the developing countries. There has been a considerable increase in the number of cooperators who are now working with triticale, and in the number and types of nurseries being distributed. Table 1.5.G provides the distribution of spring type triticales based on major geographic regions and table 1.5.F lists the individual cooperating countries and the number and the type of nurseries distributed to them.

Financial support has been provided to some national programs by the International Development Research Center of Canada (IDRC), to encourage research towards eventual commercial production of triticale as a food crop. Among the recipient countries are Ethiopia, Kenya, India, Chile and Algeria.

Reports have been received which indicate excellent possibilities for triticale production in Ethiopia for both food and fodder. Triticale strains have shown superiority in grain production over bread wheat and durums for several years. In Kenya, the situation is very favourable for triticale production. In the 1975-76 national trial there, triticale outyielded the best bread and durum wheat checks by 30 per cent at 4 locations. Copper deficiency in many Kenyan cereal producing areas was corrected with copper oxychloride seed dressings, and yield increases resulted.

In India, aggressive breeding programs are being conducted at Pantnagar (Uttar Pradesh) and at Ludhiana (Punjab). At Ludhiana, triticale strains are outproducing the recommended varieties of bread wheat.

A vigorous program is being conducted in Southern Brazil to develop triticale strains tolerant to soils (unsuitable for wheat production) which are acid and contain high levels of aluminum.

In Chile, top yields of up to 11 metric tons/hectare have been obtained. The average protein content was 13.0 per cent compared with 10.9 for bread wheat checks.

TABLE 1.5.A Yield and grain characteristics of selected triticale lines and wheat checks during 1975-76, Yaqui Valley, Mexico.

Rank	Line or Variety	Mean Yield kg/ha	No. of Trials	Test Weight kg/hl	Grain 1-5 *
1.	Mapache	7987	3	69.8	3
2.	Drira	7898	1	69.2	3+
3.	M_2A^2 x 8266-H-4Y-2M-1Y-0Y	7728	1	66.1	2+
*X 4.	M_2A^2 x 8266-B-6Y-1M-2Y-0Y	7684	1	72.1	3+
5.	Lince	7613	5	70.5	3+
X 6.	M_2A-Ira x 8417-E-1Y-7M-3Y-0Y	7598	1	70.2	3+
X 7.	M_1A x 2148-5N-2M-3Y-2M-0Y	7575	1	72.3	3
8.	Beagle "S"	7572	1	67.0	3,10%BP
9.	Ira^2 x 8319-A-3Y-1M-1M-0Y	7486	2	72.2	3++
10.	IA-Bulk E_2 x 11065-A-1M-1Y-0Y	7449	1	70.6	3+
11.	M_2A-Ira x 8229-D-3Y-2M-2Y-0M	7437	1	68.6	3 tr BP
12.	Kla "S" x 2091-100Y-101B-2Y-2M-3Y-1M-0Y	7371	3	70.6	3+tr BP
13.	Mexicali 75	7179	14	Range:6903-7669	
14.	Jupateco 73	6868	29	Range:6287-7298	
15.	Siete Cerros	6609	29	Range:6044-7272	
16.	Cocorit	6250	15	Range:5758-6835	
17.	Cinnamon	5774	29	Range:5292-6252	

* 1 = Poor; 5 = Best X Marked for Prel. Multiplication

TABLE 1.5.B Selected triticale lines with good seed type and their yielding ability and test weight, 1975-76, Yaqui Valley, Mexico.

PC#	Line or Variety	Yield kg/ha	Check kg/ha	Test Weight kg/hl	Grain Type 1 - 5*
38	IA-Ira x 11207-6M-100Y-0Y	6581	6788 Mex	76.3	4++
54	(PJ - Polko) Arm "S"	6104	6966 7C	76.0	4++
71	IA-Ira x 11202-7M-2Y-0Y	6353	6966 7C	75.1	4+
106 X	Maya - Arm "S"	6879	6763 7C	76.7	4+++
108	Maya - Arm "S"	7000	6763 7C	74.7	4++
231 *X	Kla-1A x 8814-B-1Y-5M-1Y-0Y	7269	7570 Mex	70.3	4+
293	M_2A^2 x 8266H-1Y-3M-3Y-0Y	6312	6889 Bcm	73.8	4+
303 **X	Ira-Cml x 8346B-1Y-1M-1Y-0Y	6929	6889 Bcm	76.0	4++
385	Ira-M_2A x 12055-A-1M-2Y-0Y	6692	7064 Mex	73.7	4+
416	Ira-Cml x 8299-B-3Y-1M-1Y-0Y	6003	7116 Bgl	75.4	4++
456	M_2A-Ira x 8229-D-3Y-1M-1Y-0Y	7071	6903 Mex	75.0	4++
519	Kla-Cin x Cin-$UM940^2$ x 11479-A-1M-100Y-0Y	6111	6753 Jup	75.4	4
522	M_2A-Cml x 8210-A-2Y-2M-1Y-0Y	6259	6753 Jup	75.1	4+
568	Chapala-Snoopy	6581	7179 Jup	75.3	4++
574 X	Ira-Cal x 14600-1Y-0B	7279	7179 Jup	75.4	4++
576	Mt146-ICA	6350	7179 Jup	73.4	4++
612	Octo Bulk-Bush x 7233-32M-3Y-2M-0Y	7592	7251 Jup	72.6	3++
620	Ira^2 x 8319-A-3Y-1M-0Y	7402	7251 Jup	72.2	3++
648	IA-Bush x 7254-29M-1Y-0M	7195	7706 Bgl	73.6	4
651	M_1A x 2148-4N-2M-2Y-1M-0Y	7397	7301 Bgl	73.6	4
79 ± X	M_2A-Canada x 8208-G-1Y-2M-3Y-0Y	7050	6862 Mex	70.7	3+
113	M_1A x 2148-5N-2M-3Y-2M-0Y	7575	6862 Mex	72.3	3
188	M_2A-Kla x Gv x 14930-3Y-1M-0Y	7180	7479 Bcm	69.4	3++tr BP
367	Huamantla Sel	7116	6766 7C	73.5	4

* 1=Poor; 5=Best - X Marked for Prel. Multiplication.

TABLE 1.5.C Production of grain, hay, high protein forage (H.P.F.) and total protein among triticale and oat strains, selected for maximum grain production in clipping trials at CIANO 1974-75, Mexico.

		Not Clipped			Clipped once			Clipped twice			Clipped 3 times			Clipped 4 times		
		Yield	Protein		Yield	Protein		Yield	Protein		Yield	Protein		Yield	Protein	
		kg/ha	%	kg/ha	kg/ha	%	kg/ha	kg/ha	%	kg/ha	kg/ha	%	kg/ha	kg/ha	%	kg/ha
Top triticale	grain	8867	13	1153	7022	15	1053	5789	14	810	4711	14.3	674	3578	14	487
	H.P.F.*				919	26	239	1098	34	372	1577	36	576	1593	32	513
	Hay DM	16133	10	1613		TP**	1292			1183			1249			999
Ave. 5 top tcls.	grain	7883	13	1024	6266	14	[illegible]	5169	15	776	3996	15	600	3115	16	507
	H.P.F.				826	33	272	1081	30	[illegible]	1277	33.7	430	1880	31	584
	Hay DM	16435	9.4	1545		TP	1171			1094			1030			1091
Ave 66 triticales	grain	4922	15	742	4278	16	660	3723	17	607	2774	17	460	1730	16	267
	H.P.F.				758	31	235	1078	31	334	1381	34	435	1763	33	560
	Hay DM	15394	7.6	1170		TP	895			971			895			847
Top oat	grain	3178	16	508	3644	14	550	4456	10	454	4000	13	528	4956	13	998
	H.P.F.				650	29	188	1333	34	381	2000	34	656	3037	31	619
	Hay DM	18844	9.0	1696		TP	738			835			1184			1617
Ave 4 oats	grain	2628	13	342	3219	12	395	3264		384	3036	12	364	3778	12	449
	H.P.F.				755	30	227	1203	34	409	1885	34	640	3042	32	975
	Hay DM	15005	9	1350		TP	612			793			1004			1424

* H.P.F. = High protein forage
** T.P. = Total protein (grain & forage) per hectare

TABLE 1.5.D Production of hay, grain and high protein forage (H.P.F.) among triticale and oat strains selected for maximum hay production in clipping trials at CIANO 1974-75, Mexico.

		Not Clipped yield kg/ha	Not Clipped protein kg/ha	Clipped Once yield kg/ha	Clipped Once protein kg/ha	Clipped Twice yield kg/ha	Clipped Twice protein kg/ha	Clipped 3 Times yield kg/ha	Clipped 3 Times protein kg/ha	Clipped 4 Times yield kg/ha	Clipped 4 Times protein kg/ha
Top triticale	Hay	23567	1885								
	grain	4133	719	3556	658	3111	579	1956	358	1344	238
	H.P.F.			1137	364	1384	443	1599	516	1821	589
Top 5 triticales (ave)	Hay	22429	1754								
	grain	4578	741	4207	701	3440	579	2500	414	1493	258
	H.P.F.			826	258	1078	341	1197	445	1742	557
Ave 66 triticales	Hay	15394	1157								
	grain	4922	742	4278	660	3723	607	2774	460	1730	287
	H.P.F.			758	237	1078	334	1381	435	1763	560
Top oat variety	Hay	18844	1696								
	grain	3178	492	3644	550	3711	520	4000	528	4956	619
	H.P.F.			650	189	1181	369	2000	656	3037	998
Ave 4 oats	Hay	15005	1415								
	Grain	2628	328	3219	395	3264	384	3036	373	3778	449
	H.P.F.			755	227	1203	377	1884	612	3042	975

TABLE 1.5.E Production of high protein forage (H.P.F.) grain and hay among triticale and oat strains selected for maximum production of H.P.F. in clipping trials at CIANO 1974-75, Mexico.

		Clipped once			Clipped twice			Clipped 3 times			Clipped 4 times		
		Yield	Protein		Yield	Protein		Yield	Protein			Protein	
		kg/ha	%	kg/ha	kg/ha	%	kg/ha	kg/ha	%	kg/ha	kg/ha	%	kg/ha
top triticale	H.P.F.	1280		320	1672		510	1976		592	2695		822
	grain after clipping	3589		563	2767		412	2189		420	2056		386
	grain not clipped	5156		830	5356		750	2911		553	2911		553
	Hay	14600		1022	18122		1087	15867		952	15867		952
Ave 5 top tcls.	H.P.F.	1260		377	1506		427	1912		566	2481		760
	grain after clipping	3904		626	3288		515	2751		467	1835		327
	grain not clipped	4784		732	5407		836	4809		769	4380		725
	Hay	16766		1412	17315		1268	17444		1158	16113		1031
Ave 66 triticales	H.P.F.	758		237	1078		334	1381		435	1763		560
	grain after clipping	4278		660	3723		607	2774		460	1730		287
	grain not clipped	4922		742	4922		742	4922		742	4922		742
	Hay	15394		1157	15394		1157	15394		1157	15394		1157
Top oat	H.P.F.	920		249	1333		381	2000		656	3254		1026
	grain after clipping	3456		352	4456		454	4000		528	3389		363
	grain not clipped	2889		320	2889		320	3178		493	3000		285
	Hay	12967		1167	12967		1167	18844		1696	15267		1378
Ave 4 oat strains	H.P.F.	755		227	1203		377	1895		640	3042		975
	grain after clipping	3219		386	3264		384	3036		364	3778		449
	grain not clipped	2628		328	2628		328	2628		328	2628		328
	Hay	15005		1415	15005		1415	15005		1415	15005		1415

TABLE 1.5.F Distribution of Triticale nurseries to individual countries, 1975.

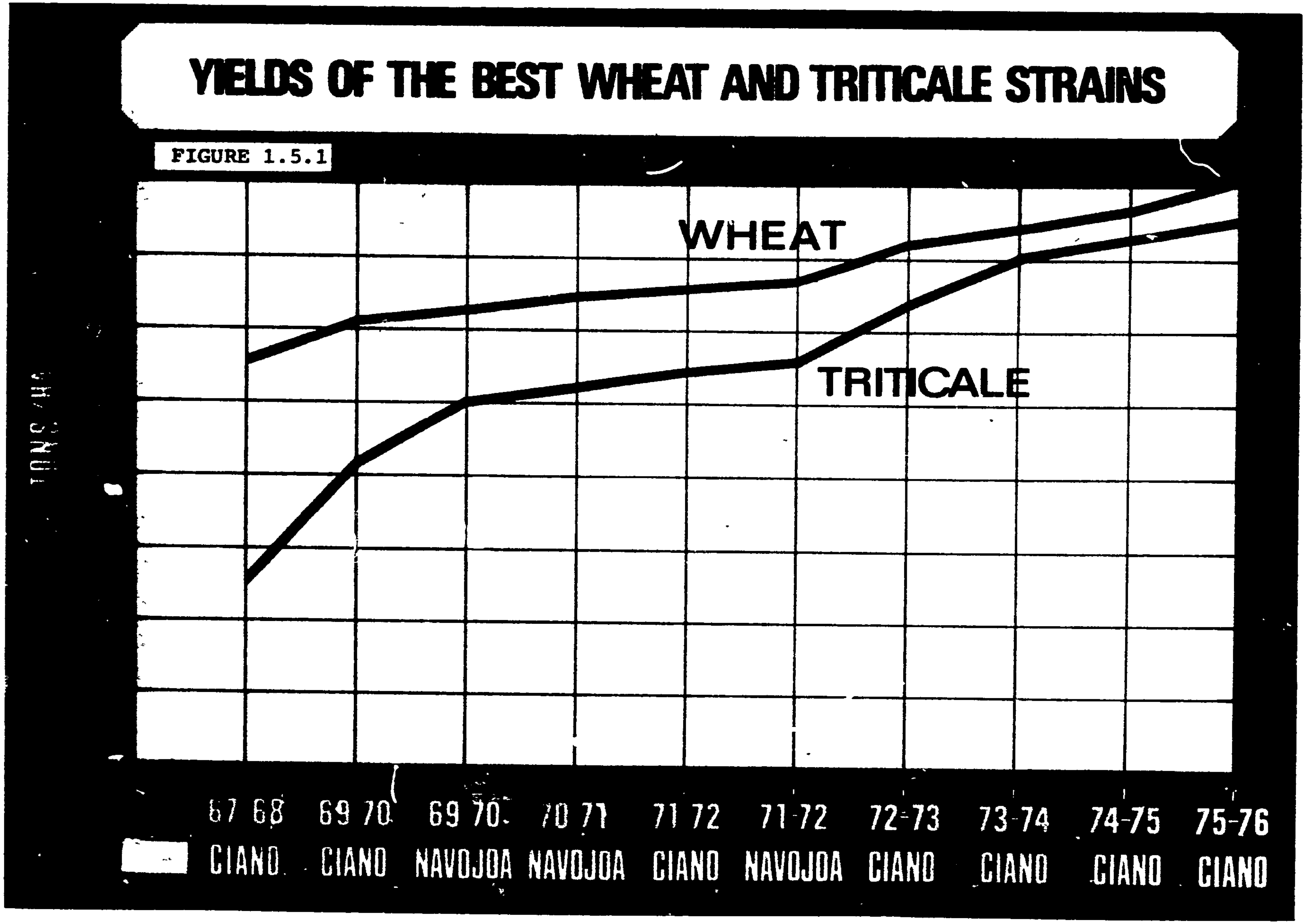
Country	Crossing Block	F2 Irrigated	F2 Rainfed	F2 Spring Winter	ITSN	ITYN	TDRN
AFRICA							
Algeria			1	2	3	3	1
Cameroon					2		
Egypt					1	1	
Ethiopia	1	2	2		3	3	1
Ghana					1		
Kenya	1	1	1		1	1	1
Lesotho					1		
Morocco					1		
Nigeria					1	1	
Rhodesia		1	1	1	1	1	
Senegal					1	1	
Somalia					1	1	
S. Africa		1	1		1	2	
Sudan					2	1	
Tanzania					1	1	
Tunisia					1	1	
Zaire					1		
Zambia					1	1	
ASIA							
Afghanistan					1	1	
Bangladesh		1	1		1	1	
China		1	1	1	1	1	
India	2	6	6	6	7	7	1
Japan					1		
S. Korea				1	1	1	
Nepal					2	2	
Pakistan	1	4	4	2	4	4	
Thailand					1		
CENTRAL AMERICA							
Cuba					1		
Costa Rica					1		
Guatemala		1			1	1	
Honduras					1		
Nicaragua					3		
EUROPE							
Albania						1	
Bulgaria					1	1	
Czechoslovakia							1
England			1		1	1	
Finland					1		
France		1	2	2	1	1	
W. Germany					1		
Greece					1	1	
Hungary		1	1	1	1	1	
Ireland					1		
Netherlands				1	2		
Norway					1		
Poland		1	1	1	1	1	
Portugal					1	1	
Romania			1	1	1	1	
Russia		1	1	1	1	1	
Spain		1	1	1	4	3	
Sweden		1	1	1	1	2	
Switzerland				1	1	2	
Yugoslavia				2		2	

TABLE 1.5.F (continued)

Country	Crossing Block	F2 Irrigated	F2 Rainfed	F2 Spring x Winter	ITSN	ITYN	TDRN
MIDDLE EAST							
Cyprus					1		
Iran				1	1	1	
Iraq					1		
Israel					1	1	
Jordan		1	1		1	1	
Lebanon	1	1	1		1	2	
Libya					1		
Syria		1			1	1	
Turkey					1	1	
NORTH AMERICA							
Canada	1	2	4	3	2	1	1
Mexico		1	1	1	3	2	
U.S.A.	1	4	4	6	2	12	
OCEANIA							
Australia					3	2	
SOUTH AMERICA							
Argentina		3	2	2	4	2	
Bolivia			1		1		
Brazil	1	2	1	1	4	3	1
Chile	1	1	1	1	3	1	1
Colombia					1	1	
Ecuador			1		1	1	1
Paraguay					2		
Peru		1	1	1	2	2	
Uruguay					1		
Venezuela					1		
TOTAL	10	41	45	40	110	56	9

TABLE 1.5.G Distribution of spring type triticale nurseries by geographic regions 1975.

Region	Crossing Block	F2 Irrigated	F2 Rainfed	F2 Spring x Winter	ITSN (Screening) Nursery	ITYN (Yield) Nursery	TDRN (Disease Resis.)
Africa	2	5	6	3	24	18	3
Asia	3	12	12	10	19	17	1
Central America	-	1	-	-	7	1	-
Europe	-	6	9	12	21	19	1
Middle East	1	3	2	1	9	7	-
N. America	2	7	9	10	7	15	1
S. America	2	7	7	5	20	10	3
Oceania	-	-	-	-	3	2	-
Total	10	41	45	40	110	89	9


YIELDS OF THE BEST WHEAT AND TRITICALE STRAINS
FIGURE 1.5.1
WHEAT
TRITICALE
67 68 CIANO
69 70 CIANO
69 70 NAVOJOA
70 71 NAVOJOA
71 72 CIANO
71-72 NAVOJOA
72-73 CIANO
73-74 CIANO
74-75 CIANO
75-76 CIANO

GRAIN AND H P F PRODUCTION FOLLOWING CLIPPING AMONG TOP TRITICALES AND OATS

FIGURE 1.5.2 WHEN SELECTED FOR GRAIN YIELD

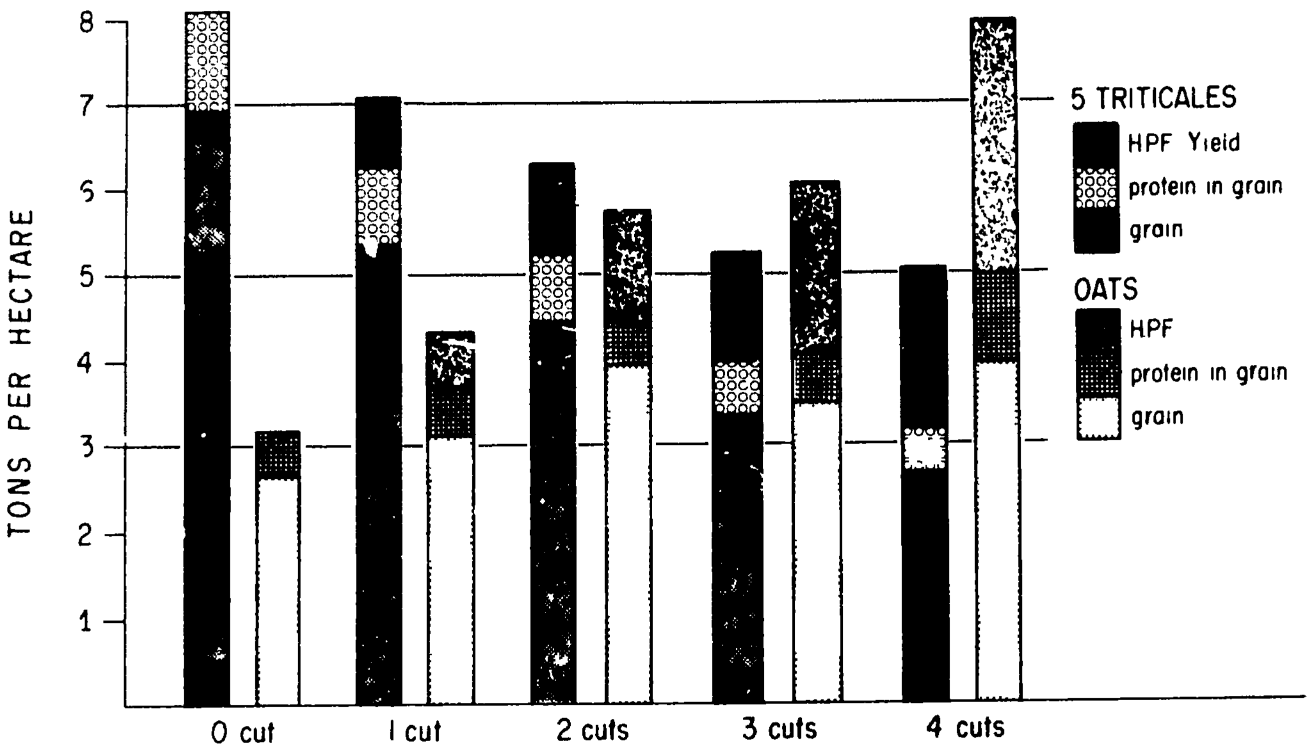


FIGURE 1.5.3

WHEN SELECTED FOR H P.F PRODUCTION

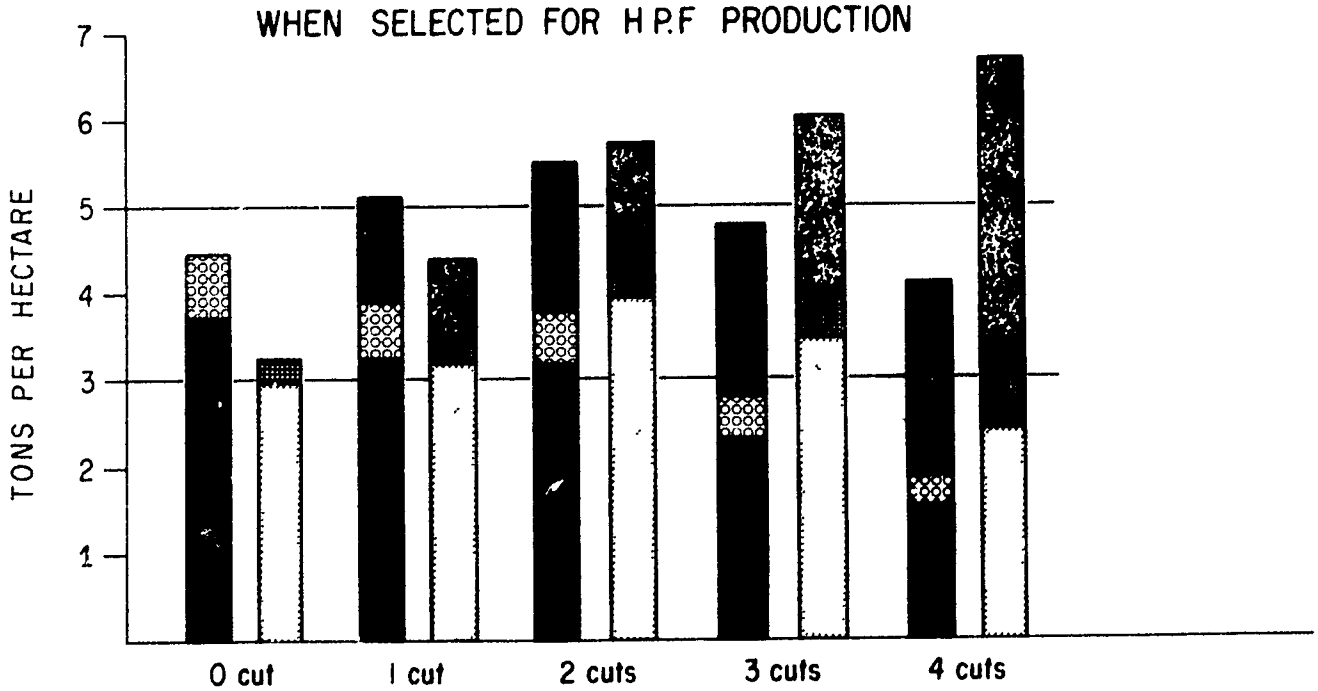


FIGURE 1.5.4 WHEN SELECTED FOR HAY PRODUCTION

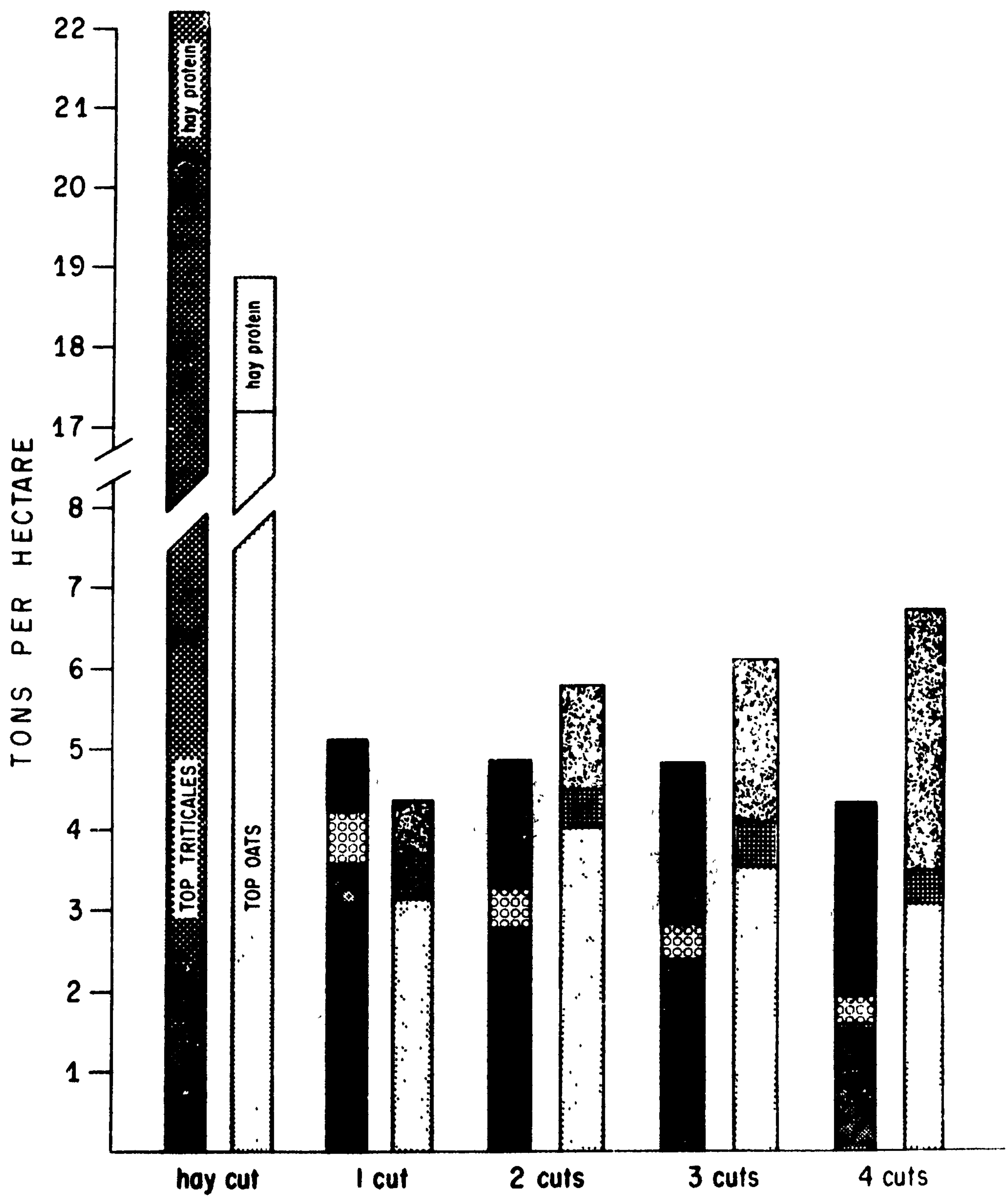
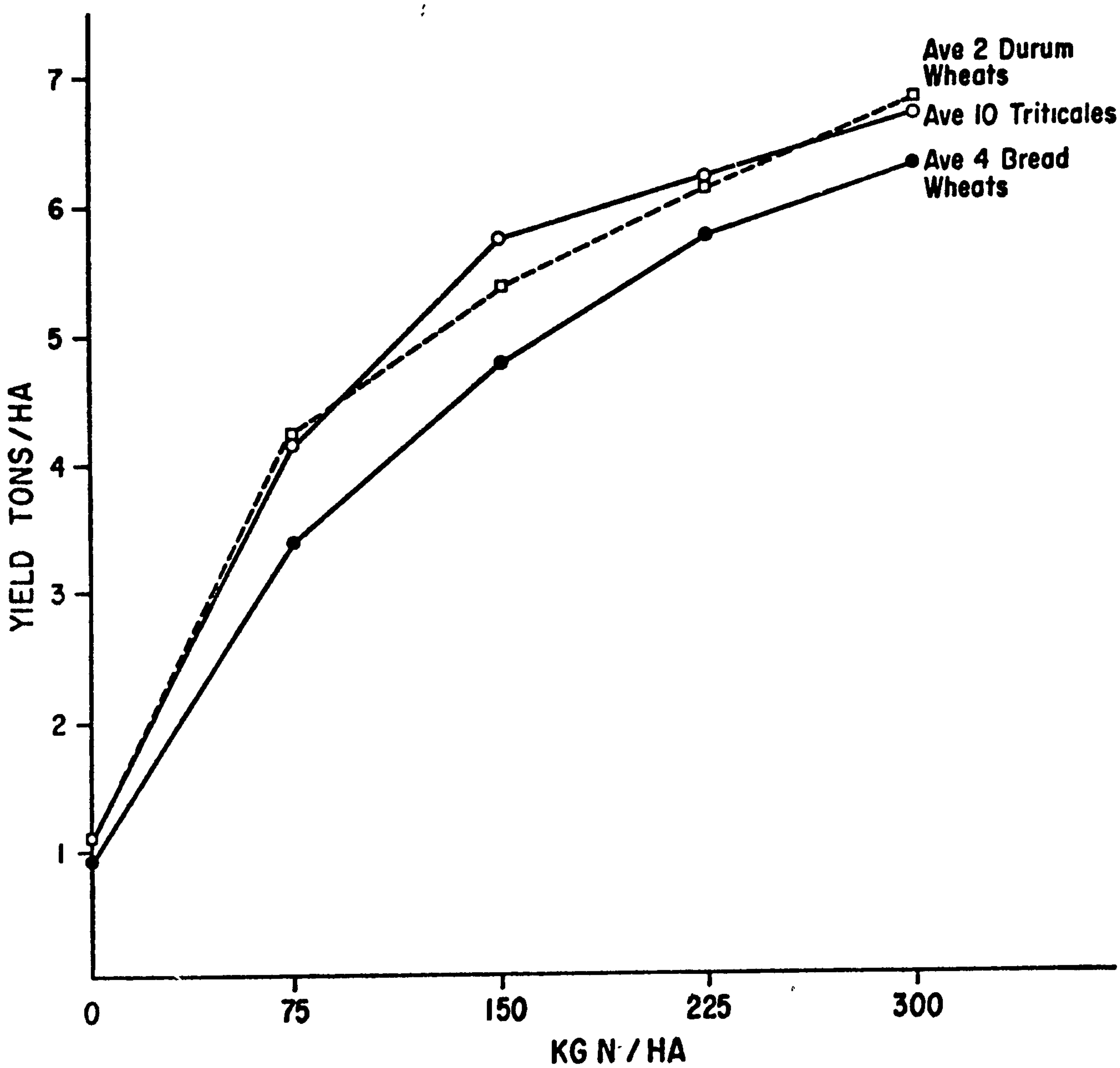
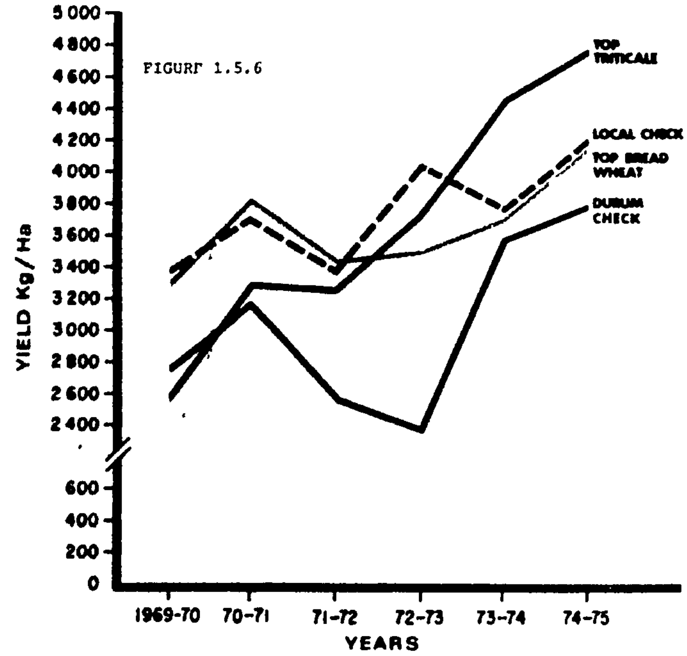
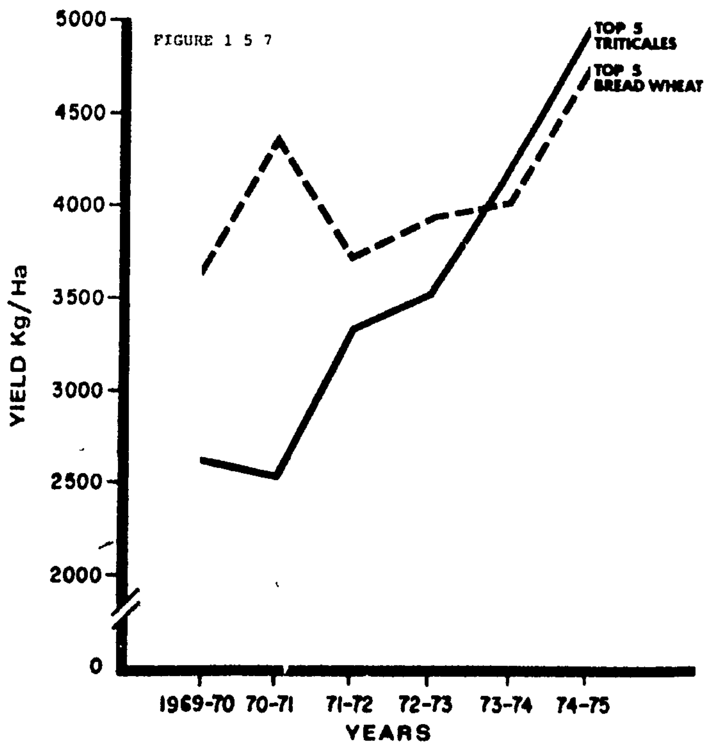


Figure 1.5.5 Ave. response to levels of Nitrogen fertilizer among the best bread wheat, durums and 10 triticales at CIANO 75-76.





AVERAGE YIELDS OF THE BEST STRAINS OF TRITICALE, DURUM, BREAD WHEAT AND LOCAL CHECKS AT ALL LOCATIONS IN THE INTERNATIONAL TRITICALE YIELD NURSERIES 1969-70 TO 1974-75



AVERAGE YIELDS OF TOP 5 WHEATS IN ISWYN TRIALS AND TOP 5 TRITICALES IN ITYN TRIALS IN ALL TRIALS HAVING LOCATIONS IN COMMON

1.6 Agronomy

1.6.1 INTRODUCTION

The agronomy program was conducted during both the winter and summer cycles of 1975-76. The winter cycle was grown under irrigated conditions at CIANO, Cd. Obregón, Sonora and during the summer rainfall season, at the Toluca and El Batan Stations. Off-station testing of triticales, bread wheats, durums and barley was conducted during both seasons. This was done in the Yaqui Valley, Sonora in the winter and in the states of Mexico, Hidalgo and Tlaxcala during the summer.

In the winter cycle, emphasis was placed on developing agronomic practices for triticale, and on nitrogen use and chemical weed control. The summer work mainly involved herbicide work at the El Batan and Toluca stations.

1.6.2 CIANO TRIALS 1975-76

These consisted of off-station, nitrogen fertilizer and herbicide trials, which are reported below.

1.6.3 OFF-STATION TRIALS

The objectives of these trials were to introduce new triticales to farmers, to determine their performance under farmer conditions including farmer management, and to use them for teaching the trainees, who participated in the sowing, management and harvesting of the plots.

In the irrigated areas of the Yaqui Valley, eight locations representing different soil types were used. Well prepared seedbeds resulted in optimum plant stands. The trials were sown between November 15-25. All sites were previously soybeans or fallow and fertility levels were high, ranging from 140-180 kg N/ha. Phosphorus was equivalent to 60-100 kg of triple superphosphate (which contains 46 per cent P_2O_5).

The sites were not treated with herbicides because they were all essentially weed free. The plots were approximately 50 meters long and 2.7 meters wide, i.e. one drill width. At harvest, a Hege combine took a 1.25 meter cut from the center of each plot.

Table 1.6.A shows the variety yields at 12 per cent moisture. The striking feature of the average yields for all locations is the low range of yield differences - from 6160 - 6600 kg/ha. The two highest yielders were Mexicali, a durum wheat, and Jupateco, a bread wheat.

Despite the small overall yield differences between the varieties, there were wide differences in yield stability. For example, there was only a very slight average yield difference of 150 kg/ha between the bread wheat Jupateco (6510 kg/ha) and the triticale variety Rahum (6360 kg/ha). However, Jupateco is very much more stable across all sites, ranging from 5690-6850 kg/ha, i.e. a difference of 1160 kg/ha, whereas Rahum ranged from 4940-7060 kg/ha, a difference of 2120 kg/ha. The two highest yielding triticales viz Yoreme and Navojoa, also showed a high degree of stability. These types of trials in a homogeneous ecological zone provide much useful data about the yield stability of varieties and advanced lines.

1.6.4 NITROGEN FERTILIZER TRIALS

The bread wheat Jupateco was tested for its response to varying levels of different types of solid nitrogen fertilizers viz urea, ammonium sulphate, ammonium nitrate and sulphur coated urea (SCU). The dissolution rate of sulfur coated urea was 20.5 per cent when placed in water for seven days.

Split applications were compared with one application at sowing time, at all levels and for all types of fertilizer. The split application consisted of half at sowing time and half at the second extra irrigation at 53 days after the emergence of the crop. This corresponded to mid tillering in the growth phase. All fertilizers were spread by hand and were then washed into the soil with irrigation water, except in the case of sulfur-coated urea (SCU) which was raked into the surface. The grain yield results are shown in table 1.6.B.

There was no significant difference between applying all the N at sowing time and the split application, except with SCU at 60 kg N/ha, which is probably due to the late date of the split application. The results from urea, ammonium sulphate and ammonium nitrate were similar to each other, but at higher rates of N, consistently higher yields were obtained with urea. All three fertilizers were consistently superior to SCU. In a combination of 24 comparisons, SCU was significantly inferior 18 times.

The four types of nitrogen fertilizer were also each tested at 100 kg N/ha under the following six management regimes on a calcareous soil (pH 8.2), typical of the Yaqui Valley.

1. Broadcast on a dry surface and left for twelve days before sowing.

2. Broadcast on a dry surface twelve days before sowing and sprinkled each day to simulate light rainfall.

3. Broadcast and worked into a dry soil twelve days before sowing.

4. Broadcast on pre-irrigated soil and worked-in twelve days before sowing.

5. Broadcast on the surface at sowing time and irrigated immediately.

6. Broadcast on the surface at sowing time, worked-in, and irrigated immediately.

Table 1.6.C shows the effect of fertilizer application management for four different types of N fertilizer on the yield of Jupateco wheat. Neither ammonium sulfate nor SCU were affected significantly by management treatments. All sources were better than SCU regardless of management. The lowest yield from the urea was obtained when it was applied on a dry surface twelve days before sowing and sprinkled to simulate a light rainfall. However this was only significantly less than one treatment, namely when urea was broadcast on pre-irrigated soil and worked-in twelve days before sowing.

With ammonium nitrate, the lowest yield resulted from the application on a dry surface twelve days before sowing. The best yield results for ammonium nitrate and urea, were obtained from broadcasting onto pre-irrigated soil, and then working-in twelve days before sowing. The two most promising fertilizers appear to be ammonium nitrate and urea, which gave the highest yields when properly managed.

1.6.5 WEED CONTROL INVESTIGATIONS

1.6.5.1 Wild Oat Removal Studies

Wild oat (Avena fatua) is a major weed problem in many wheat growing areas of the world causing large reductions in yields. Due to an irregular dormancy pattern, this weed is very hard to control once an infestation has been established because seed from one year, may carry over and sprout irregularly during the next five or six years.

A number of herbicides will control this weed, but their properties and methods of application vary greatly. Methods of application vary from preplant incorporation to early post-emergence and to mid-tillering spray applications. The effectiveness of any one of these methods of application varies greatly and is dependent on the environment. The economics of application must be considered since some of these compounds are very expensive.

Therefore, it is important to know when wild oat competition begins to reduce yields during the crop cycle since this is a determining factor in selecting the herbicide to be used. For this reason, the effect of varying lengths of weed competition on four crops, namely triticale, bread wheat, durum and barley using the varieties Yoreme, Jupateco, Cocorit and Celaya, respectively, was studied. The results of this study are shown in table 1.6.D.

The wild oat density in this trial was 67 wild oat plants/m^2 and the crop density was 115, 168, 159 and 182 plants/m^2 for Yoreme, Jupateco, Cocorit and Celaya, respectively. Although seeding was aimed to produce identical crop stands, this was not achieved due to poor field germination of Yoreme. Therefore, it was at a disadvantage compared with the other crops due to low plant densities. Table 1.6.D shows that the effect began to show between 48 and 59 days post-emergence of the crop under these conditions, which agrees with results from the previous season. When weeds were not removed until 111 days post-emergence, the crop losses were 4070 kg/ha, 2550 kg/ha, 3190 kg/ha and 520 kg/ha for Yoreme, Jupateco, Cocorit and Celaya respectively as compared with their respective checks. The most competitive crop was barley (Celaya) due to its early seedling vigor and the fact that it covers the ground rapidly to prevent light penetration and the development of the weeds. The two important facts that emerge from this experiment are the importance of variability between crops for competition with weeds, and the importance of crop density.

Another problem in determining the methods of control, is the severity of the infestation and its effect on yield. An experiment was conducted to determine the effect of increasing the density of wild oats on the yield of four crops, triticale, bread wheat, durum wheat, and barley using the varieties Yoreme, Jupateco, Cocorit, and Celaya. These results are presented in table 1.6.E.

Surprisingly low yields were obtained, which were lower than those found in the previous year at similar wild oat densities. In the current trial, the infestation of wild oats was 172 plants/m^2 and the yield reductions were 2180 kg/ha, 1690 kg/ha, 2680 kg/ha and [illegible] kg/ha for Yoreme, Jupateco, Cocorit and Celaya, respectively.

The ability of a variety to compete and the seeding density of the crop are two factors which affect weed competition by the crop. Each of these factors were investigated.

The matter of genetic variability for competition within the three crops, bread wheat, durum wheat and triticale, was examined and the results are summarized in table 1.6.F and figure 1.6.1.

The density of the weed used, namely wild oat (Avena fatua), was 137 plants/m^2. The planned seeding density of the varieties was such that the number of plants germinated were intended to be equal. However there was a range of 123 plants for Jupateco to 158 plants for Alondra, and 75 per cent of the varieties had plant densities from 130-150 plants/m^2. Table 1.6.F and figure 1.6.1 show that there is a wide variation in yield in the infested plot ranging from 3860 kg/ha for Beagle, to 100 kg/ha for Fiserect. Losses also widely varied from 1750 kg/ha for Anhinga "S" to 5130 kg/ha for Kal-Bb.

Two important crop parameters in competition are height and leaf angle. The two extremes are exemplified in Beagle which has a height of 127 cm and a leaf angle of 60° (with the vertical), whereas Fiserect has a height of 56 cm and an angle of 35°. However one factor alone cannot explain these yield differences and within a factor such as leaf angle, there exists quite a range of competitive ability. Table 1.6.F shows that Yr x RAF yielded 56.5 per cent of the weed-free check when infested with weeds although it has a very erect leaf habit and a leaf angle of 30°. However it has a height of 93 cm which compensated for its low leaf angle.

The significance of these results can be seen in the breeding of wheat plants. In the last decade much emphasis has been placed by some breeders on selecting a more efficient plant in terms of photosynthesis. One of the factors being investigated is leaf angle. The reasoning behind this is that the narrower the leaf angle, the greater the light penetration into the canopy and therefore more photosynthesis. The advantages of this type of canopy are very obvious especially in areas of low radiation. However the practical agronomic difficulties in the management of such a crop canopy are also obvious. Since there will be greater light penetration, this should also favor weed growth which is obvious from the data in table 1.6.F. However these data also show that erect leaf types can be selected with good competitive ability as long as a certain plant height is maintained. A lower plant height combined with a low leaf angle would have to be managed very differently in terms of seeding density and weed control.

The effect of seeding density of the crop was also studied using the wheat and barley varieties Jupateco and Celaya, respectively. All plots were sown at 100 kg/ha and were then thinned to the required density. For example, the densities were 100 kg/ha (solid sown), and 1 crop plant per 5, 10, 15, 20 and 25 cm of linear row. The row spacing was 30 cm. The data are presented in table 1.6.G.

The wild oat density was 129 plants/m^2. The tabulated results show that plant density has a marked effect on yield when the crop is infested with weeds. The losses increase as the crop density decreases. At similar plant densities, the barley variety Celaya gives a higher yield than the bread wheat variety Jupateco. Yield increases up to a certain point under weed free conditions as the plant density decreases, but the converse occurs under weedy conditions This is important from the practical viewpoint. As the conditions are made more favorable for crop growth, the environment is similarly improved for weed growth

1.6.3.2 Wild Oat Control

The data for the wild oat control study are presented in table 1.6.H. The wheat variety used was Jupateco and there were 36 treatments. Weed control was expressed on a scale of 0-10, with 0= no control and 10 = complete control. Phytotoxicity notes were also taken after spraying, when ratings of 0-10 were also used, with 0=no chlorosis and 10=complete kill of plants. Although some herbicides did not produce the classical chlorosis symptoms and therefore could not be scored on that basis, they did shorten the plant and thus plant height at harvest was taken as a measure of the phytotoxicity.

The following herbicides were used and the other names by which they are known are listed in parenthesis.

CARBYNE (Barron, Barbamate, Chlorinat)

HOE 23408 (Diclofop-methyl, Hoelon, Hoegrass)

DOSANEX (Methoxuron)

WL 29761 (Flamprop-methyl, Mataven)

FINAVEN (Difenzoquat, Avenge)

C.G.A. 18731 (Isoproturon, Arelon, Graminon, HOE 16410, Tolkan)

SUFFIX (Benzoylprop ethyl, Endaven)

These herbicides were used at different dates and rates. The wild oat population was 44 plants/m^2 and was sufficient to decrease the yield significantly from 5000 kg/ha in the handweeded plot to 3770 kg/ha in the nonweeded plot. Several products gave very satisfactory control.

Carbyne gave significantly higher yields than the non weeded check, but as expected, the yields were lower than the hand weeded checks, which are always higher. Under Mexican conditions, Carbyne never gives complete wild oat control. There is also a slight depression in growth immediately following the application of Carbyne.

Dosanex did not perform well. Regardless of the application time, weed control was poor at 2 kg/ha a.i. Even at double this rate, wild oat control was unsatisfactory.

WL 29761 was applied at two rates and three dates, with very varying results. The best application was 0.45 kg/ha a.i. at 26 days post-emerge giving a yield of 5050 kg/ha. When this was applied at 0.60 kg/ha a.i. at 26 days post-emerge, yield was reduced due to the shortening of the plant. When applied at 40 and 52 days, the plants were shortened and weed control was poor with resultant lowered yields.

Finaven gave very satisfactory results when applied both at 20 and 40 days. The rate of 0.5 kg/ha a.i. was the best. This wide time of application range makes this product very useful. When applied at later than 40 days, the results were poor due to inferior weed control.

C.G.A. 18731 gave low yields due to poor wild oat control irrespective of date and rate of application.

Suffix was not very satisfactory because the two dates on which it was applied were probably too late. Noticeable stunting of the wheat plants occurred at both dates of application and this resulted in lower weed control and lower yields.

HOE 23408 looks extremely promising for wild oat control. The best yield in the experiment was 5210 kg/ha in the HOE 23408 treatment applied at 1 kg/ha a.i. and at 17 days post-emerge. A good yield was obtained when it was applied at 31 days post-emerge. Thus there is some latitude in the application date of this product. It caused some slight scorching when applied at some dates and rates, but the plants recovered normally.

1.6.5.3 Phalaris minor Control

The data from the control study on *Phalaris minor* are presented in table 1.6.I Jupateco wheat variety was used with 18 herbicidal treatments. Weed control is expressed on a scale of 0-10 with 0=no control and 10=complete control. Phytotoxicity is also expressed on a similar scale with 0=no damage and 10=complete kill of the plant. The population of *Phalaris* (227 plants/m^2) was not sufficient to depress yields significantly. The yield of the nonweeded check was 4220 kg/ha as compared with 4690 kg/ha for the handweeded check.

TOK E-25 applied at both doses pre-emerge, did not give satisfactory weed control having only readings of 5.0 and 6.8 for 10 and 15 litres/hectare respectively. Dicuran alone was not very satisfactory at either date of application. Dosanex when applied at 17 days post-emerge gave the two best yields of the trial when applied at 2 kg/ha a.i. and 4 kg/ha a.i. With later applications of this product, phytotoxicity has been a problem and weed control has been reduced.

C.G.A. 18731 gave excellent control of Phalaris minor on both application dates. However there was also some phytotoxicity. HOE 23408 gave poor weed control when applied at this late stage. However it is known that this gives excellent control of Phalaris minor when applied pre-emerge. Tribunil also gave good control of Phalaris minor when applied at 3.2 kg/ha a.i. However this is a very high rate and phytotoxicity can be expected at this level.

The best weed control was found with a combination of TOK with Dosanex and Dicuran, respectively. There was some suppression of wheat growth early, but the plants recovered. However the yield of the TOK + Dosanex combination remained low. The yield of the TOK + Dicuran application was quite satisfactory and this combination needs more research.

While the emphasis in these latter experiments has been placed on the separate control of both Avena fatua and Phalaris minor, these two weeds are very often found in the same field and their joint control is a problem. Therefore, an experiment was also conducted for the joint control of these two weeds and the results are presented in table 1.6.J. Infestation was sufficiently high enough to obtain a highly significant difference between the handweeded and nonweeded controls. All treatments yielded significantly higher than the nonweeded check. However, all treatments were also significantly lower than the handweeded check.

C.G.A. 18731 and Dosanex gave the best joint control of wild oats and canary grass and these need further experimentation with regard to dates and rates of application. Suffix gave poor control of wild oats probably due to its late date of application. Much more work needs to be done on the combined control of these two weeds.

1.6.5.4 Weed Control Trials, El Batan, Summer 1976

A number of products were applied at different dates and different rates. The crop varieties used were Yoreme, (triticale), Jupateco, (bread wheat) and Cocorit, (durum wheat). The most common weeds in El Batan were Galisoga ciliata, Amaranthus hybridus and Tithonia tubaeformis. Also present to a lesser degree were Portulaca oleracea, Ipomea purpurea, Anoda hastata, Lopezia racemoza and Commelina coelestis. Portulaca oleracea is a severe problem when all the other weeds are killed and it can be a serious competitor with the crop in the first six weeks of growth. In a pure stand of weeds, it is barely noticeable due to its poor competitive ability. Chemical weed control has brought about an abrupt change in the proportion of grass weeds to broadleaf weeds in the flora at El Batan. Two grass weeds have become very important over the past two years due to continuous and effective use over the previous three years of broadleaf weedkillers. They are Eragrostis mexicana and Eleusine tristachya, and they complicate the weed control effort at El Batan tremendously.

The data from these trials are presented in tables 1.6.K, 1.6.L, 1.6.M and 1.6.N. Tables 1.6.K and 1.6.M contain weed control data and tables 1.6.L and 1.6.N contain yield and phytotoxicity data.

Tribunil when applied at 1 kg a.i. at 7 days post-emerge gives broadleaf control but poor control of Eleusine tristachya. To get satisfactory control of Eleusine tristachya, the dose needs to be raised to 2 kg/ha a.i. but this causes phytotoxicity problems, especially in triticale and durum wheat and leads to low yields in these two species.

Tribunil when applied in combination with the broadleaf herbicide Bromoxynil gives better control of the grasses. There seems to be a synergistic effect in this combination and this is readily demonstrated by the fact that grass control is improved by increasing the Bromoxynil from only 0.24 kg/ha a.i., to 0.48 kg/ha a.i. Phytotoxicity is also increased by this addition, although it is known that Bromoxynil does not cause any phytotoxicity in wheat. This increased phytotoxicity is quite marked in Yoreme and Cocorit and is reflected in yield reductions. However, the combination of Tribunil and Bromoxynil at the lower rate i.e. 1.0 + 0.24 kg/ha a.i., looks promising for these conditions.

The combinations of Tribunil and Basagran do not give satisfactory control of Eleusine tristachya and therefore they are not very suitable for this environment. Also, the phytotoxicity readings on Cocorit are fairly high and this is reflected in yield along with the effect of the competitive effect of Eleusine tristachya which is shown in the yields of the other varieties.

Dosanex gives good control of everything except Eleusine and the yields are good. The bread wheat Jupateco seems to be more susceptible to phytotoxicity with this compound than is the case with triticale and durum wheat.

San 7104 behaves very similarly to Dosanex in all respects. The yields of the durum wheat variety are low due to phytotoxicity and also to its poor competitiveness in this environment with Eleusine tristachya. Neither Faneron, Baneron nor Basagran control either of the grasses and the yields are reduced by this poor control, especially in Cocorit. Basagran when applied at 22 days post-emerge gives very poor control of the broadleaves as well. The weeds are more susceptible to this herbicide when they are very small.

Bromoxynil and Brominal Plus do not control broad leaves either. However, Bromoxynil combined with such grass killers as Tribunil and HOE 23408 gives excellent results in this environment. When Bromoxynil is applied in a mixture with HOE 23408, the control of Amaranthus hybridus is somewhat reduced.

In the case of the varieties Yoreme and Jupateco, quite high yields are obtained when using 2,4-D even although it does not give very good control of Galinsoga ciliata nor Amaranthus hybridus, and control of grasses is zero. These yields are much higher than those of the other broadleaf herbicides. This is thought to be due to the fact that 2,4-D is sprayed much later than other materials and this allows a much stronger development of broadleaf weeds, therefore smothering the grasses which then cannot compete with the crop at a later stage. Therefore, killing the broadleaf weeds at an early stage may not be the answer in this environment where there are very competitive grasses.

MCPA gives very poor results at El Batan, because of the lack of grass control. In addition, it provides poor control of Galinsoga ciliata and Amaranthus hybridus.

HOE 23408 gives 100 per cent control of both grasses but when used alone, it gives no broadleaf control. However, in mixtures with Tribunil and Bromoxynil it looks very promising for use in this area.

1.6.5.5 Weed Control Trials, Toluca, Summer 1976

The same trials which were conducted in El Batan were carried out simultaneously in Toluca, Mexico. The results are not reported here because the behavior of the herbicides was very similar in both environments. The weeds in Toluca are different from those in El Batan.

The weeds there are Cucumis sativus, Commelina coelestis, Malva spp, Brassica spp and Poa annua. Tribunil when applied at 1 kg/ha a.i. seven days post-emerge gives good control of broad leaf weeds and Poa annua. Commelina is somewhat resistant to this product. There also appears to be a synergistic effect of the Tribunil and Bromoxynil combination on the control of Poa annua. It would be interesting to know just how many grasses are affected by this combination. Phytotoxicity in the durum wheat Cocorit was also increased by this mixture , with a resultant decrease in yield.

HOE 23408 gives no control of Poa annua so its use is not warranted in this environment. As at El Batan, 2,4-D gives very high yields and the reason for this is explained in the section on El Batan. The recommended herbicide for the breeding nursery in Toluca is Tribunil at 1 kg/ha a.i. at about 10 days post-emerge for bread wheats and triticales, while the same herbicide is used pre-emerge on durums at the rate of 2 kg/ha a.i. to avoid phytotoxicity.

TABLE 1.6.A Yields of varieties (kg/ha) in farm trials sown from Nov. 15-25, 1975-76 at Cd. Obregón, México.

VARIETY	KARAM	GARCIA	SANCHEZ	BALDE-NEBRO	VARGAS	IVICH	CASTELO	ELI-ZONDO	X
* Beagle	7190	6720	5530	6070	6140	6350	5790	6610	6300
* Bacum	6780	6820	6200	6140	4660	6060	5720	6890	6160
* Navojoa	7120	6200	6000	6330	6310	6850	5980	6550	6420
* Yoreme	6730	5820	6470	6210	6420	6420	6220	6810	6390
* Rahum	4940	5940	6720	5750	6960	7060	6460	7020	6360
** Jupateco	6230	6590	5690	6560	6630	6770	6850	6790	6510
*** Mexicali	5290	6110	6360	7090	6300	6990	7080	7590	6600

* = Triticale
** = Bread Wheat
*** = Durum Wheat

X = Average yield of all eight sites

TABLE 1.6.B Grain yields of Jupateco in kg/ha (air dried) at different levels of N and from different sources of N, 1975-76, Cd. Obregón, México.

N Rate kg/ha	Urea	$(NH_4)_2SO_4$	NH_4NO_3	SCU
0	1190	880	970	1060
40	2090	1860	1910	1490
20+20*	2320	1980	2160	1650
80	2890	2840	2890	2350
40+40	3400	2860	3020	2140
120	3720	3260	3550	2910
60+60	3780	3050	3860	2000
160	4250	3710	3820	3080
80+80	4200	3650	3450	3140

* Split application = Half at sowing, half at 53 days postemerge (end of tillering)

L.S.D. 0.05 (within sources) = 470

L.S.D. 0.05 (among sources) = 510

TABLE 1.6.C Yield of Jupateco wheat (kg/ha) for four different nitrogen fertilizers at 100 kg N/ha over six management regimes, Cd. Obregón, México, 1975-76.

Treatment	Subtreatment	Yield
Broadcast dry surface twelve days before sowing.	Urea	3950
	$(NH_4)_2SO_4$	3950
	NH_4NO_3	3550
	SCU	2490
Broadcast dry surface and sprinkled for twelve days before sowing	Urea	3560
	$(NH_4)_2SO_4$	3600
	NH_4NO_3	4120
	SCU	2880
Broadcast and worked in dry twelve days before sowing	Urea	4040
	$(NH_4)_2SO_4$	3790
	NH_4NO_3	3760
	SCU	2600
Broadcast on preirrigated soil and worked in twelve days before sowing	Urea	4350
	$(NH_4)_2SO_4$	3660
	NH_4NO_3	4410
	SCU	2780
Broadcast at sowing and irrigated immediately	Urea	4000
	$(NH_4)_2SO_4$	3610
	NH_4NO_3	3880
	SCU	2600
Broadcast at sowing worked in, and irrigated immediately	Urea	3990
	$(NH_4)_2SO_4$	3870
	NH_4NO_3	3770
	SCU	2860

L.S.D. 0.05 (within main treatment) = 470

L.S.D. 0.05 (among main treatments) = 600

TABLE 1.6.D Yield (kg/ha) of four crops under varying durations of competition from wild oats (Avena fatua).

Treatment	Yoreme	Jupateco	Cocorit	Celaya
1. Handweeded.	4710	4660	5190	3700
2. Weeds removed 15 days postemerge	4510	5040	5160	3500
3. Weeds removed 32 days postemerge	4710	4630	5270	3800
4. Weeds removed 38 days postemerge	5190	4950	5360	3410
5. Weeds removed 48 days postemerge	4160	4700	5100	2930
6. Weeds removed 59 days postemerge	4160	4020	3910	3100
7. Weeds removed 69 days postemerge	1510	3150	2650	3150
8. Weeds removed 80 days postemerge	1980	3280	3240	3250
9. Weeds removed 90 days postemerge	1280	3570	2270	3010
10. Weeds removed 101 days postemerge	1510	2930	2330	2870
11. Weeds removed 111 days postemerge	640	2110	2000	3240

L.S.D. 0.05 (within variety) = 920

L.S.D. 0.05 (among varieties) = 1220

TABLE 1.6.E Yield (kg/ha) of four crops under varying densities of wild oats (Avena fatua).

Wild Oat Density	Yoreme (T)	Jupateco (B.W.)	Anhinga (D)	Celaya (B)
0 plants/m^2	3500	4450	5140	2720
88 plants/m^2	3270	3520	4730	3010
95 plants/m^2	3120	3590	4560	3050
125 plants/m^2	2690	3980	4020	2950
150 plants/m^2	1600	3310	3400	2460
172 plants/m^2	1320	2760	2460	2830

TABLE 1.6.F Yield (kg/ha) of weed-free checks and infested plots (with Avena fatua) of 24 varieties of bread wheat, triticales and durum wheats.

Variety	Height cm	Leaf Angle	Weed Free Yield	Infested Yield	% of check	Loss (kg/ha)
Beagle (T)	127	60	5740	3860	67.2	1880
Tanori (B.W.)	93	55	5190	3160	60.9	2030
Anhinga "S" (D)	98	40	4420	2670	60.4	1750
Yr x RAF (B.W.)	93	30	4660	2630	56.5	2030
Bacum (T)	102	45	4710	2260	47.9	2450
Cno"S"-PJ62-Gallo (B.W.)	89	45	4620	2200	47.7	2420
Jupateco (B.W.)	96	60	4630	2070	44.8	2560
Zaragoza (B.W.)	97	35	6360	2790	43.9	3570
Mexicali (D)	82	40	5990	2410	40.4	3580
Canario (B.W.)	78	40	4850	1540	37.9	3310
Arabian (T)	116	45	4840	1820	37.5	3020
P.M. 26 (T)	116	45	5170	1920	37.2	3250
Navojoa (T)	101	40	5390	1760	32.7	3630
Cocorit (D)	88	40	4930	1410	28.6	3520
Yecora (B.W.)	65	45	4910	1360	27.7	3550
Yoreme (T)	91	60	4740	990	21.0	3750
Alondra (B.W.)	100	35	4290	860	20.1	3430
Torim (B.W.)	71	50	4890	870	17.7	4020
Nacozari (B.W.)	84	60	4290	710	16.6	3580
Gav "S" (D)	70	30	4390	520	11.9	3870
Lechuza (B.W.)	80	30	4490	430	9.7	4060
D67-3 x Gav"S" (D)	54	35	4000	260	6.4	3740
Kal-Bb (B.W.)	64	45	5420	290	5.3	5130
Pimerect 3 (B.W.)	56	35	4500	100	2.3	4400

* T = Triticale

D = Durum

B.W.= Bread Wheat

TABLE 1.6.G Effect of crop density on yields under the same density of wild oats.

Treatment	Subtreat	Subsubtreat	Yield (kg/ha)	Loss kg/ha
Jupateco	100 kg/ha	Nonweeded	1770	2540
		Handweeded	4310	
	1 plant/5cm	Nonweeded	1150	3470
		Handweeded	4620	
	1 plant/10cm	Nonweeded	500	4210
		Handweeded	4710	
	1 plant/15cm	Nonweeded	750	4440
		Handweeded	5190	
	1 plant/20cm	Nonweeded	500	4580
		Handweeded	5080	
	1 plant/25cm	Nonweeded	700	4190
		Handweeded	4890	
Celaya	100 kg/ha	Nonweeded	2990	-
		Handweeded	2920	
	1 plant/5cm	Nonweeded	1830	1360
		Handweeded	3170	
	1 plant/10cm	Nonweeded	1590	1970
		Handweeded	3560	
	1 plant/15cm	Nonweeded	1350	2630
		Handweeded	3980	
	1 plant/20cm	Nonweeded	1130	2840
		Handweeded	3970	
	1 plant/25cm	Nonweeded	1060	2570
		Handweeded	3630	

TABLE 1.6.H Effect of different herbicides on wild oats (Avena fatua) control and the yield of the bread wheat variety Jupateco, Cd. Obregón, México, 1975-76.

Compound	Rate/ha	Days Post-emergence	Stage of Wheat	Weed Control	Phytotoxicity	Height (cm)	Yield (kg/ha)
1. Nonweeded Check	-	-	-	-	-	93	3770
2. Handweeded Check	-	-	-	10	-	101	5000
3. Carbyne	3 lt c.m*	10	2 1/2-3 l.	7.7	0	97	4560
4. Carbyne	5 lt c.m	10	"	9.7	0	102	4580
5. Carbyne	3 lt c.m	26	5-5 1/2 l.	8.0	0	97	4880
6. Carbyne	5 lt c.m	26	"	9.0	0	93	4740
7. Dosanex	2 kg a.i.**	26	"	2.7	0	100	4580
8. Dosanex	4 kg a.i.	26	"	6.7	0	97	4520
9. WL 29761	0.45 kg a.i.	26	"	10.0	0	99	5050
10.WL 29761	0.6 kg a.i.	26	"	9.7	0	92	4490
11.Finaven	0.5 kg a.i.	26	"	8.0	0	101	5180
12.Finaven	1.0 kg a.i.	26	"	9.7	0	98	4800
13.C.G.A. 18731	1 kg a.i.	26	"	0.0	0	96	3670
14.C.G.A. 18731	2 gk a.i.	26	"	6.0	0	97	4170
15.Dosanex	2 kg a.i.	40	6 1/2-7 l.	4.7	0	99	4540
16.Dosanex	4 kg a.i.	40	"	6.7	0	97	4410
17.WL 29761	0.45 kg a.i.	40	"	8.0	0	92	4530
18.WL 29761	0.6 kg a.i.	40	"	10.0	0	95	4790
19.Finaven	0.5 kg a.i.	40	"	7.7	0	98	5000
20.Finaven	1.0 kg a.i.	40	"	9.3	0	97	4680
21.Suffix	1.0 kg a.i.	40	"	7.0	0	92	4550
22.Suffix	2.0 kg a.i.	40	"	7.0	0	84	4280
23.HOE 23408	1.0 kg a.i.	17	4-4 1/2 l.	9.3	0	100	5210
24.HOE 23408	2.0 kg a.i.	17	"	10.0	1.0	95	4710
25.HOE 23408	1.0 kg a.i.	31	5 1/2-6 l.	7.3	0	99	4920
26.HOE 23408	2.0 kg a.i.	31	"	9.0	0	93	4960
27.HOE 23408	1.0 kg a.i.	40	6 1/2-7 l.	6.0	0.5	92	4610
28.HOE 23408	2.0 kg a.i.	40	6 1/2-7 l.	8.3	1.0	98	4730
29.Suffix	1.0 kg a.i.	52	2 nodes	0.0	0	73	3110
30.Suffix	2.0 kg a.i.	52	"	0.0	0	75	3640
31.Finaven	1.0 kg a.i.	52	"	5.0	0	101	3860
32.Finaven	2.0 kg a.i.	52	"	8.7	0	94	3860
33.Dosanex	2.0 kg a.i.	52	"	3.3	0	96	3390
34.Dosanex	4.0 kg a.i.	52	"	6.7	0	93	3010
35.WL29761	0.54 kg a.i.	52	"	0.0	0	74	3320
36.WL29761	0.6 kg a.i.	52	"	0.0	0	74	3130

* c.m. - commercial material
** a.i. - active ingredient

L.S.D. 0.05 = 650

TABLE 1.6.I Effect of different herbicides on Canarygrass (Phalaris minor) control and the yield of the bread wheat variety Jupateco, Cd. Obregón, México, 1975-76.

Compound	Rate/ha	Date of Application	Stage of Wheat	Weed Control	Phytotoxicity	Yield (Kg/ha)
1. Nonweeded	-	-	-	-	0.0	4220
2. Handweeded	-	-	-	10	0.0	4690
3. TOK E-25	10 lt c.m.*	Preemerge	-	5.0	0.0	4320
4. TOK E-25	15 lt c.m	Preemerge	-	6.8	0.0	4560
5. Dicuran	2 kg a.i**	17 days post	4-4 1/2 l.	6.8	0.0	4320
6. Dosanex	2 kg a.i.	"	"	7.3	0.0	4870
7. Dosanex	4 kg a.i.	"	"	9.0	0.0	4760
8. TOK + Dosanex	10 lt+2 kg.a.i	TOK-Preemerge DOS-17 days post	"	10.0	0.0	4330
9. TOK + Dicuran	10 lt+2 kg a.i	"	"	10.0	0.0	4600
10.C.G.A.18731	2 kg a.i.	30 days postemerge	5 1/2-6.0 l.	9.3	1.0	4600
11.Dosanex	2 kg a.i.	"	"	3.0	0.5	4210
12.Dosanex	4 kg a.i.	"	"	8.8	1.0	4640
13.HOE 23408	1 kg a.i.	"	"	2.5	0.0	4350
14.HOE 23408	2 kg a.i.	"	"	7.0	0.5	4590
15.Dicuran	2 kg a.i.	"	"	5.8	0.0	4450
16.Tribunil	3.2 kg a.i.	"	"	9.0	1.0	4450
17.Dosanex	4 kg a.i.	40 days postemerge	6 1/2-7 l.	7.9	0.5	4080
18.C.G.A.18731	2 kg a.i	"	"	8.8	0.5	4700

* c.m. - commercial material; ** a.i.- active ingredient. L.S.D 0.05 = 570

TABLE 1.6.J Effect of different herbicides on wild oats + Canarygrass control and the yield of the bread wheat variety Jupateco, Cd. Obregón, México, 1976.

Compound	Rate/ha	Date of Application	Stage of Wheat	Wild Oat Control	Phalaris Control	Phyto-toxicity	Yield kg/ha
Nonweeded	-	-	-	-	-	-	2900
Handweeded	-	-	-	10	10	-	4610
TOK E-25 + Carbyne	10 lt c.m + 5 lt c.m	TOK-Preemerge CARB-9 days post	CARB- 2 1/2-3 1.	5.0	9.3	0.0	3660
TOK E-25 + Dosanex	10 lt c.m + 4 kg a.i.	TOK-Preemerge Dos-31 days post	DOS- 5 1/2-6 1.	8.0	9.5	1.0	3650
TOK E-25 + CGA18731	10 lt c.m + 2 kg a.i.	TOK-Preemerge CGA-31 days post	CGA- 5 1/2-6 1.	9.3	10.0	0.5	4060
TOK E-25 + Suffix	10 lt c.m + 1 kg a.i.	TOK-Preemerge SUFF-44 days post	Suffix 6 1/2-7 1.	3.3	8.8	0	3410
Carbyne	5 lt c.m	9 days post-emerge	2 1/2-3 1.	8.3	6.0	0	4070
Dosanex	4 kg a.i.	31 days post-emerge	5 1/2-6 1.	3.8	8.3	0	4060
C.G.A. 18731	2 kg a.i.	"	5 1/2-6 1.	8.5	9.0	0	4090
					L.S.D. 0.05		440

TABLE 1.6.K Effect of different herbicides on weed control, El Batan, México, 1976.

Treatment	Rate/ha	Date of Application	Galinsoga ciliata	Amaranthus hybridus	Tithonia tubaeformis	Eragrostis mexicana	Eleusine tristachya
3. Tribunil	1 kg a.i.	7 DAE *	9.0**	8.8	10.0	3.3	0
4. Tribunil	2 kg a.i.	"	10.0	10.0	10.0	7.6	8.6
5. Dosanex	2 kg a.i.	15 DAE	10.0	10.0	10.0	10.0	1.7
6. Dosanex	4 kg a.i.	"	10.0	10.0	10.0	10.0	5.0
7. San 7104	2 kg c.m.	"	8.3	8.0	9.7	3.3	0
8. San 7104	4 kg c.m.	"	10.0	10.0	10.0	10.0	4.7
9. Faneron	1 kg a.i.	"	10.0	9.3	10.0	0	0
10. Faneron	2 kg a.i.	"	10.0	10.0	10.0	0	0
11. Baneron	1 kg c.m.	"	10.0	10.0	10.0	0	0
12. Baneron	1.5 kg c.m.	"	10.0	10.0	10.0	0	0
13. Basagran	1 kg a.i.	5 DAE	6.0	8.7	9.3	0	0
14. Basagran	2 kg a.i.	"	10.0	9.7	10.0	0	0
15. Basagran	1 kg a.i.	22 DAE	1.7	3.3	5.0	0	0
16. Basagran	2 kg a.i.	"	1.0	6.7	9.7	3.3	0

*DAE = Days after emergence
** = 0=no control; 10=full control

TABLE 1.6.L Effect of different herbicide treatments on phytotoxicity and the yield of three crops - triticale (Yoreme), bread wheat (Jupateco) and durum wheat (Cocorit), El Batan, México, 1976.

Treatment	Rate/ha	Date of Application	Yield (kg/ha)			Phytotoxicity		
			Yoreme	Jupateco	Cocorit	Yoreme	Jupateco	Cocorit
1. Nonweeded	-	-	410	2120	460	-	-	-
2. Handweeded	-		4420	4650	4550	-	-	-
3. Tribunil	1 kg a.i.	7 DAE *	4120	4030	2920	1.0	1.0	0.7
4. Tribunil	2 kg a.i.	"	3620	4510	3690	1.7	1.0	3.3
5. Dosanex	2 kg a.i.	15 DAE	4120	4260	3580	0.3	1.0	0.7
6. Dosanex	4 kg a.i.	"	3840	4420	4120	0.7	1.7	1.3
7. San 7104	2 kg c.m.	"	4170	4170	3300	0	1.7	1.0
8. San 7104	4 kg c.m.	"	3590	4140	3410	1.3	2.0	1.0
9. Faneron	1 kg a.i.	"	3190	3570	3410	0.7	1.0	0.7
10.Faneron	2 kg a.i.	"	2930	3220	2780	0	2.0	0.3
11.Baneron	1 gk c.m.	"	3530	3860	3590	0	0.3	0
12.Baneron	1.5 kg c.m.	"	3420	4210	3090	0	0.7	0
13.Basagran	1 kg a.i.	5 DAE	3690	4050	2600	0	0	0
14.Basagran	2 kg a.i.	"	3200	4340	2910	0	0.7	0
15.Basagran	1 kg a.i.	22 DAE	1520	2900	670	0	0	0
16.Basagran	2 kg a.i.	"	1900	3320	470	0	0	0

* DAE = days after emergence

TABLE 1.6.M Effect of different herbicides on weed control, El Batan, México, 1976.

Treatment	Rato/ha	Date of Application	*Galisonga ciliata*	*Amaranthus hybridus*	*Tithonia tubaeformis*	*Eragrostis mexicana*	*Eleusine tristachya*
3. Bromoxynil	0.24 kg a.i.	7 DAE *	10.0 **	10.0	10.0	0	0
4. Bromoxynil	0.48 kg a.i.	"	10.0	10.0	10.0	0	0
5. Tribunil + Bromoxynil	(1.0 + 0.24) kg a.i.	"	10.0	10.0	10.0	9.7	6.7
6. Tribunil + Bromoxynil	(1.0 + 0.48) kg a.i.	"	10.0	10.0	10.0	10.0	8.7
7. Brominal Plus	0.48 kg a.i.	15 DAE	10.0	8.7	10.0	0	0
8. Brominal Plus	0.48 kg a.i.	23 DAE	10.0	8.3	10.0	0	0
9. HOE 23408 Bromoxynil	(1.0 + 0.24) kg a.i.	"	9.3	7.7	10.0	10.0	10.0
10.2,4-D	1.0 kg a.i.	29 DAE	5.0	6.7	10.0	0	0
11.HOE 23408 + Bromoxynil	(1.0 + 0.48) kg a.i.	23 DAE	10.0	6.7	10.0	10.0	10.0
12.MCPA	0.48 kg a.i.	"	1.7	7.7	10.0	0	0
13.Basagran+ Tribunil	(1.0 + 1.0) kg a.i.	7 DAE	10.0	10.0	10.0	10.0	3.3
14.Basagran + Tribunil	(2.0 + 1.0) kg a.i.	"	10.0	10.0	10.0	10.0	5.0
15.HOE 23408	1.0 kg a.i.	"	0	0	0	10.0	10.0
16.HOE 23408 + Tribunil	(1.0 + 1.0) kg a.i.	"	10.0	8.3	10.0	10.0	10.0

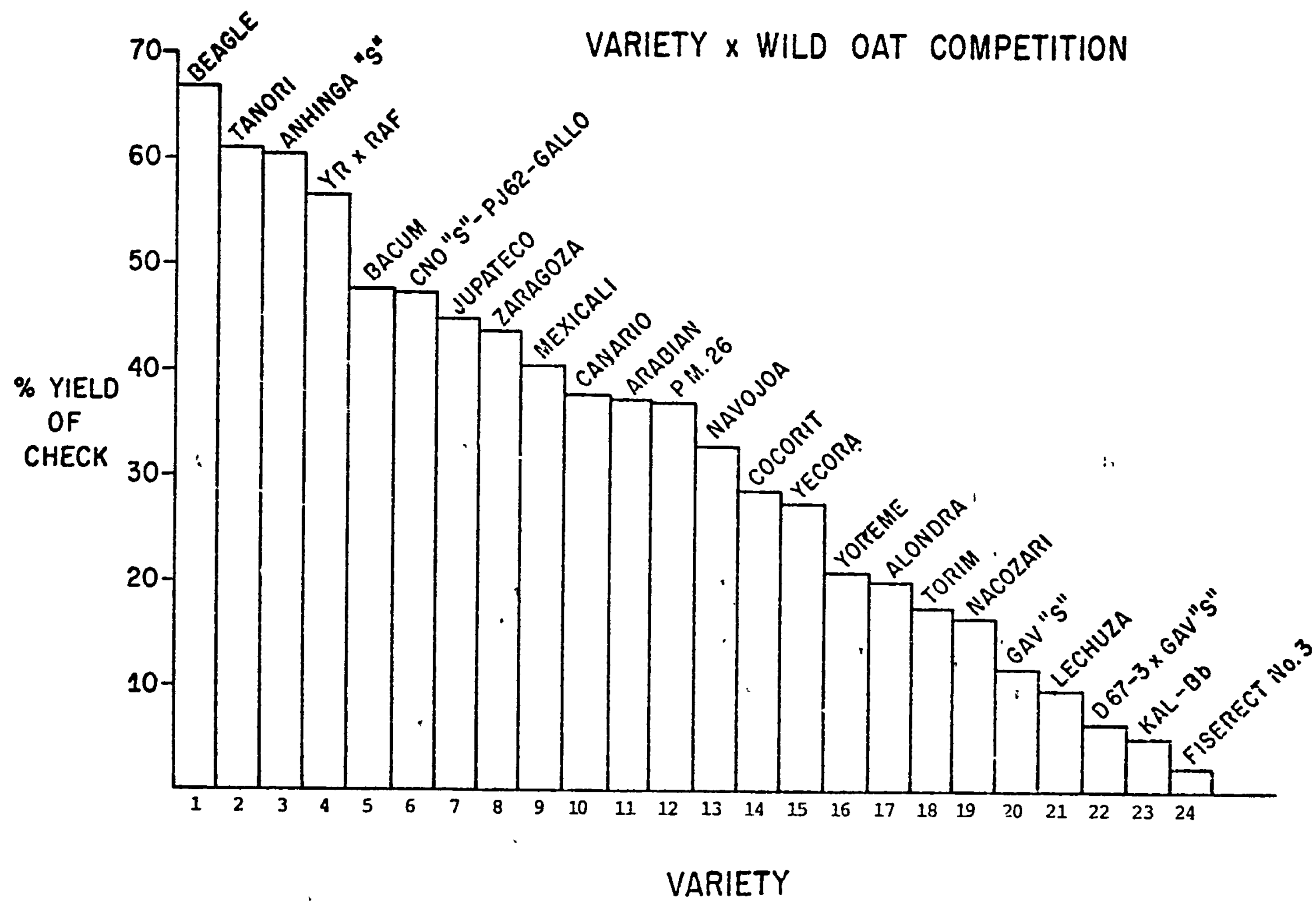
*DAE = Days after emergence
** = 0=no control; 10=full control

TABLE 1.6.N Effect of different herbicide treatments on phytotoxicity and yield of three crops, El Batan, México, 1976.

Treatment	Rate/ha	Date of Application	Yield (kg/ha)			Phytotoxicity		
			Yoreme	Jupateco	Cocorit	Yoreme	Jupateco	Cocorit
1. Nonweeded	-	-	750	2070	540	-	-	-
2. Handweeded	-	-	4070	4200	4150	-	-	-
3. Bromoxynil	0.24 kg a.i.	7 DAE *	3350	3450	2680	0	0	0
4. Bromoxynil	0.48 kg a.i.	"	3520	3940	2550	0	0.3	0
5. Tribunil + Bromoxynil	(1.0 + 0.24) kg a.i.	"	3880	4070	4110	0.7	0.7	1.0
6. Tribunil + Bromoxynil	(1.0 + 0.48) kg a.i.	"	3660	4000	2610	1.7	0.7	3.7
7. Brominal Plus	0.48 kg a.i.	15 DAE	3610	3430	3050	1.0	0.3	0
8. Brominal Plus	0.48 kg a.i.	23 DAE	3120	3810	2621	0	0	0
9. HOE 23408 + Bromoxynil	(1.0 + 0.24) kg a.i.	"	3670	4380	4210	0.7	0	0.7
10. 2,4-D	1.0 kg a.i.	29 DAE	3960	3960	3230	0	0	0
11. HOE 23408 + Bromoxynil	(1.0 + 0.48) kg a.i.	23 DAE	4120	4250	3810	0.7	1.0	0
12. MCPA	0.48 kg a.i.	"	2420	3310	2240	0	0.7	0
13. Basagran + Tribunil	(1.0 + 1.0) kg a.i.	7 DAE	4530	3640	2930	0.7	2.0	1.7
14. Basagran + Tribunil	(2.0 + 1.0) kg a.i.	"	3730	3830	3260	0.7	0.3	1.7
15. HOE 23408	1.0 kg a.i.	"	2490	2310	620	0	0	0
16. HOE 23408 + Tribunil	(1.0 + 1.0) kg a.i.	"	4600	3870	3420	0	1.0	2.0

* DAE = days after emergence

FIGURE 1.6.1 Variety yields expressed as a percentage of the check yield in a variety x wild oat competition trial at Cd. Obregón, México, 1975-76.



1.7 Physiology

1.7.1 INTRODUCTION

Weather conditions at CIANO, Obregón, México, in the 1975-76 cropping season were generally favourable for crop growth and yield. Temperatures were close to the long term means and rainfall was low. Yecora 70, a triple dwarf variety, yielded an average of 7.74* t/ha in the absence of disease. (*One trial was excluded from this value.) This is the third highest mean yield of Yecora 70 in the past six years, after 1974/75 (9.07 t/ha) and 1973/74 (7.95 t/ha).

Yield potential was probably limited by a short period of very low incoming radiation in early February, which coincided with the 60-75 days period after planting, for most of the trials reported here. Shading trials in past seasons have shown that reduction of radiation during this period of early ear growth is normally very detrimental to yield and causes a reduction in grain number per ear. A marked increase in the number of sterile spikelets at the base of the spike, probably due to this low radiation period, was noted in trials throughout CIANO. The heavy cloud also affected the accumulation of soluble sugars in the stem.

1.7.2 YIELD POTENTIAL ASSESSMENT

The yield potential under optimum conditions was evaluated in respect of new lines and segregating populations.

1.7.2.1 Crop

An experiment was conducted with 103 advanced lines and varieties drawn from the bread wheat, durum wheat and triticale programmes, together with 11 lines of physiological interest, to compare the yield potential of the new lines The crop was grown under disease and lodging free conditions with high fertility and abundant moisture.

Weekly leaf and stem counts were made on all plots until anthesis, when a sample of the plot was harvested to measure dry matter production and the photosynthetic area index. At harvest all components of yield, harvest index and grain yield were determined.

Adverse soil conditions, probably related to high soil pH, increased variability in the trial and affected some lines more than others. Thus Yecora 70 yielded only 6.45 t/ha in this trial, whilst in nearby trials the mean yield was 7.74 t/ha In this trial, yields in the absence of lodging, ranged from 4.69 t/ha (Alondra "S") to 8.15 t/ha (Mexicali 75).

Significant correlation coefficients between plot yield and its components for the entries of the three crops are presented in table 1.7.A. Harvest index was again the best yield predictor in the wheats, showing an extremely strong correlation with grain yield in the 20 durum wheats studied (table 1.7.A). Amongst the triticales, total dry matter production was more highly correlated with yield than was harvest index They were the only characters measured on the triticales which showed any significant correlation with grain yield Amongst the wheats, grain number per ear and per fertile spikelet were both highly correlated with yield. In the absence of a significant correlation between kernel weight and yield, these results emphasize the importance of sink size in the determination of yield in this environment.

Maturity date and the mean leaf permeability measured on four occasions with an air-flow resistance porometer were not significantly correlated with yield in any of the three crops. However, amongst the bread wheats, leaf permeability measured just before anthesis was significantly correlated with yield ($r = 0.34^{**}$).

1.7.2.2 Segregating Populations

Studies were initiated in the 1975/76 winter season on the relationships between plant characteristics in segregating populations and the yield potential of later generations derived from the plant.

Plant characters, yield and components were recorded on 150 randomly selected plants in each of ten F_2 populations. Seed from those plants which did not exhibit extreme height, lateness and/or disease susceptibility was increased at El Batan, México in the summer season. Yield trials will be conducted in the Yaqui Valley, Sonora, México in the 1976/77 season on all F_4 lines that showed moderate uniformity in the F_3, whilst random selections of the non-uniform lines will be increased for F_5 yield test the following year.

1.7.3 ENVIRONMENTAL MANIPULATION AND YIELD POTENTIAL

Experiments were conducted to continue the study of sink limitation on yield under the environmental conditions encountered in Northwest Mexico. Most treatments were concentrated in the period between 60 and 90 days after sowing, covering from ±25 days before flowering to ±5 days after flowering in most of the varieties and lines suited to the area.

Low radiation in early February (63-74 days after sowing) probably reduced treatment effects and limited yield.

One shading study examined the effects of four shade levels between 65 and 86 days after sowing, on crops of Yecora 70 that were unshaded or received 17 per cent shade during the rest of the season.

Dry matter production during the 21 days shading period was almost linearly related to percentage reduction in radiation. However, there was a suggestion that at very low levels of shade, dry matter production may proceed unaffected.

Mean stem weight at the end of the shading period was lower only after the heaviest (62 per cent) shade, whereas even the lowest level of shade (17 per cent) reduced mean ear weight at 86 days by 18 per cent which confirms that the stem is the primary sink for the assimilate during this phase.

Soluble sugar accumulated in the stems of all treatments during the 65-86 day period, although only 2.3 g/m^2 accumulated under 62 per cent shade, whilst with no shading there was 55.2 g/m^2 more soluble sugar in the stems at 86 days than at 65 days.

Grain yield was reduced by shade, but these reductions were significant only for the 62 per cent shade level, and by 39 per cent shade on a crop that had received 17 per cent shade for the earlier part of the season. Reductions in yield by 17 per cent shade through the pre-anthesis phase were not statistically significant.

Yield was highly correlated with grain number per ear (r = 0.98***). Ear number per unit area and kernel weights differed only slightly and non significantly between treatments.

In another shading trial, twelve diverse genotypes were subjected to eight overlapping three-week periods of 50 per cent shade. In all genotypes, shading during the three weeks before flowering and/or over the flowering period, reduced yield more than shading during other periods of the crop cycle. Grain number per ear was the component most affected by shade, although yield was not reduced proportionally due to some compensation by both spike numbers and kernel weights.

Siete Cerros, Zaragoza 75 and Beagle were the least sensitive lines in terms of reduction of grain number per ear. The yield level of Siete Cerros was low (5.71 t/ha) and therefore it is unclear whether the relative insensitivity reflects a generally low yield level or a more efficient system. It is interesting to note that both Siete Cerros and Beagle have shown wide adaptability in the international trials.

With early shading, which reduced tillering and final ear numbers, there was some compensation in grain number per ear. This was very marked in Zaragoza, Fiserect 3, Siete Cerros and Beagle where grain numbers per ear were increased by ±20 per cent over the control. In contrast, with RAF and M. Reo-8156(R)[4] (a ramified wheat) there was no such compensation for reduced stem numbers, even though the final spike number was reduced in the same order by early shade as it was in the lines which did compensate by increased grain number.

1.7.3.1 Nitrogen

This trial was designed to investigate the effects of split nitrogen applications and foliar urea application during the ear growth phase on grain yield, grain nitrogen, grain numbers per ear and sugar accumulation during the immediate pre-anthesis phase. The results are presented in table 1.7.B together with the summary of significant effects.

There was a small significant increase in yield with foliar nitrogen applications between 60 and 90 days and this was due to a significant increase in grain numbers per ear.

This increase was slightly smaller than that in grain numbers brought about by splitting the nitrogen dressing, but in this case the increased grain numbers per ear were offset by a decrease in the number of spikes per unit area. The results are encouraging, in that even with low radiation levels in the early ear growth phase, some increase in yield and grain numbers was obtained with foliar urea applications.

1.7.3.2 Daylength

The results reported here and those from many trials in previous years show that in most seasons, the yield component which limits grain production is the number of grains per ear. If the duration of the ear growth phase could be increased, it should result in a concomitant increase in the number of fertile florets per ear, if the floret development limitation is nutritional or hormonal in nature. A range of varieties and lines were grown under normal and extended daylengths, the latter during the entire pre-anthesis phase, or only between terminal spikelet production and flowering. Those lines with a large proportion of the total photoperiodic response after terminal spikelet production could be expected to have a relatively longer ear growth phase, as compared to the total plant cycle when grown in short days.

Large differences between varieties in the partition of the photoperiodic response between the pre and post-terminal spikelet phases were observed. Hira (88 per cent), Yecora 70 (73 per cent), and D67.3-Gav"S" (63 per cent) showed the largest proportions of the total photoperiodic response in the ear growth phase, whilst Lechuza (0 per cent), S-036 (11 per cent), Inia 66 and Olesen (15 per cent each) responded very little to increased daylength in the pre-anthesis reproductive phase. Thirty five of the 46 lines tested had moderate values of between 20 per cent and 50 per cent of the total photoperiodic response in the ear growth phase.

1.7.3.3 Yields under Simulated Drought Conditions.

Work was continued on the effect of a terminal drought situation on the yield of a wide range of varieties. Two trials were conducted, one on bread wheats, durum wheats and triticales and only two barleys, in which the last irrigation was applied at 45 days after planting. The other trial consisted mostly of barley lines and no more water was applied after 25 days from sowing.

As expected, there was a very significant correlation between grain yield and maturity under drought situations, with early flowering favouring higher yields under the stress conditions. However there was evidence that some lines were less affected by drought conditions.

For comparison, yields were corrected for flowering date by regressing yield under drought against flowering date under well-watered conditions. The adjustment to yield was fairly small (2.72 g/m^2 per day delay in flowering) and the range in days to flower was from 81-110 days. Table 1.7.C shows the yield under well-watered conditions, the yield under drought, both unadjusted and adjusted for flowering, and the percentage reduction in yield by drought, based on the adjusted figures, for some of the lines tested. The highest yielders under drought and those with least percentage reduction in yield are tabulated individually.

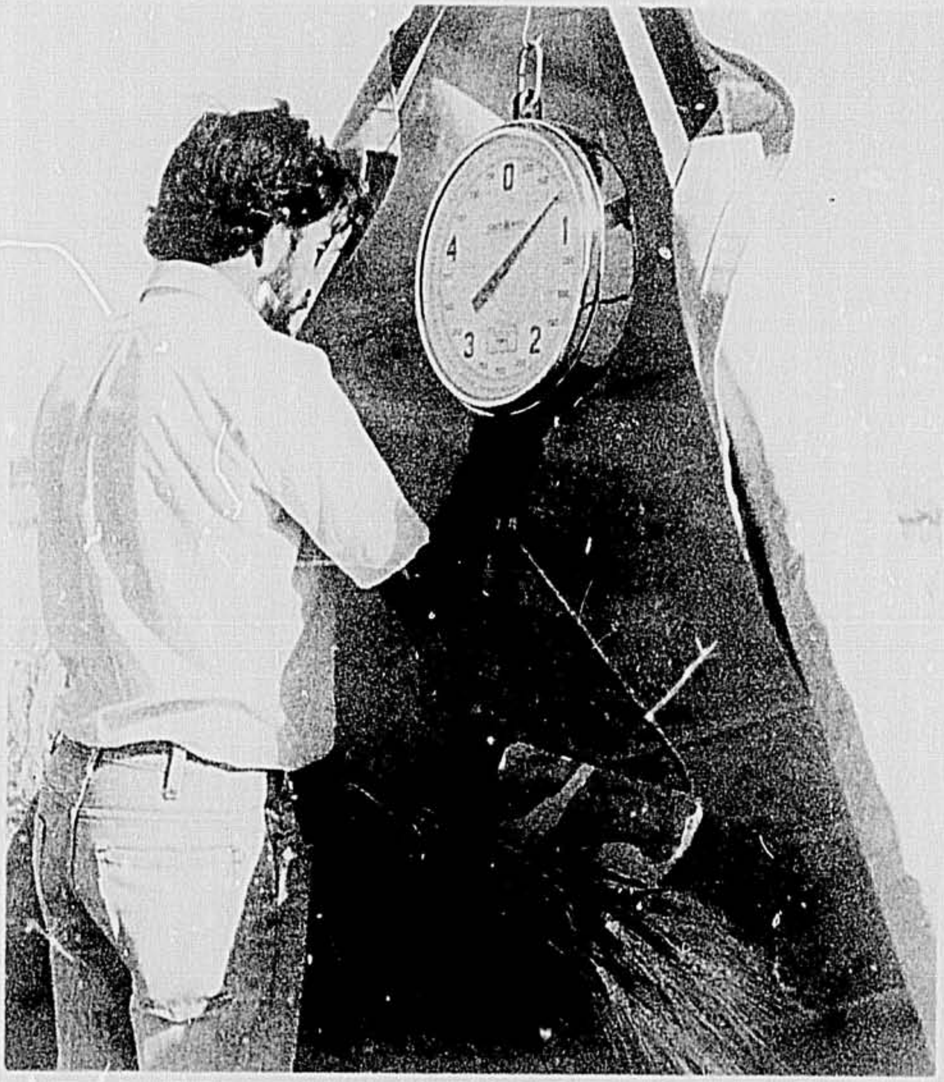
Probably the best measure of drought resistance or tolerance is the yield level under drought conditions. However as flowering date will affect the degree to which a line may escape drought, the adjusted figures should give a reasonable indication of drought resistance. Percentage reduction in yield has been used as a measure of drought resistance, but this measure assumes that the cultivar is able to take advantage of conditions with adequate moisture. If a line has an inherently low yield potential, as appears to be the case in both Gabo and Roshan for example, so that it does not benefit greatly from high fertility or abundant water, the percentage reduction in yield by drought will be small. However, this does not necessarily indicate any greater level of drought resistance than other lines with a higher yield potential and a greater percentage drop in yield under drought.

Care must be taken in extrapolating the results presented here. They represent only one type of drought on one soil type. However, based on the evidence from this trial, it would appear that Flicker"S" (CM 8954-B-7M-1Y-1M-1Y-0M), (Tob-B. Man x Bb/Cdl) Sx (CM 8972-F-1M-1Y-1M-1Y-0M) and Tob"S"-Npo x CC-Inia/Cha (CM 5541-C-5Y-1M-1Y-4M-0Y) should be tested under a wider range of drought environments, and that amongst the triticales, FS477 and Lobo could usefully be used as parents for material intended for drier climates.

Two other points evident in table 1.7.C should be noted. Firstly, the durum wheats appear to be more susceptible to these drought conditions than the bread wheats. Mexicali 75 was the highest yielding durum in both the well watered and drought conditions, and even though it out-yielded all the bread wheats under well-watered conditions, it yielded only 3.7 t/ha under drought. When the 37 bread wheats with a yield, under well-watered conditions, of between 5.9 - 8.2 t/ha (the range shown by the 14 durum wheats) are compared with the durums, the percentage reduction in yield (46 per cent) is 10 per cent less than that of the durums, and is equal to the lowest percentage reduction in yield demonstrated by any durum in the trial. Secondly, the two barley lines in the trial, did not yield as well under drought as many of the bread wheats, durums or triticales. These were comparatively late barleys (83 and 86 days to ear emergence for 11012-2 and S-059-Por respectively) and therefore did not benefit from the drought escape normally associated with the earlier barleys.

The second drought trial included some of the very early barleys emerging from the CIMMYT barley programme. Thirteen of these very early lines were compared with eight later barleys, one bread wheat, one durum wheat and one triticale. The yields, kernel weights and days to maturity recorded in this trial are presented in table 1.7.D.

M66.83-Larker x Apam-Russian line gave an exceptional yield of 4.39 t/ha in only 89 days with an estimated water application of ± 160 mm. However, although escaping drought to a large degree, only six of the very early lines yielded more under drought than the best bread wheat, Cleopatra, and none of the later barleys which flowered at approximately the same time as Cleopatra, could equal its yield. This again suggests that the reputation of barley as a more drought resistant crop than wheat is attributable to its generally earlier flowering, which leads to a greater degree of drought escape, but that it is probably no more drought resistant than wheat.



Mr. P.C. Wall, CIMMYT Crop Physiologist, weighing plot subsamples to determine spike numbers and harvest index in wheat, at Obregon, Mexico.

TABLE 1.7.A Correlation coefficients of crop characters with grain yield under optimum conditions. All characters measured that were statistically significant in at least one group.

Character	All n = 114		B.Wheats n = 68		D.Wheats n = 20		Triticales n = 24	
	R	P	R	P	R	P	R	P
Harvest Index	0.53	***	0.51	***	0.81	***	0.46	*
Total Dry Matter	0.50	***	0.41	***	0.21	NS	0.64	***
Grains per ear	0.35	***	0.50	***	0.48	*	0.31	NS
Sterile basal spikelets	-0.32	***	-0.10	NS	0.12	NS	-0.15	NS
Kernel weight	0.30	**	-0.02	NS	-0.04	NS	0.22	NS
Days to maturity	0.25	**	-0.06	NS	0.19	NS	0.20	NS
+Leaf permeability index	0.26	*	0.22	NS	0.30	NS	0.42	NS
Grains per fertile spikelet	0.20	*	0.42	***	0.60	**	0.05	NS
Spikes per m^2	0.00	NS	0.25	*	-0.01	NS	0.12	NS
Grains per central spikelet	0.16	NS	0.30	*	-0.03	NS	0.01	NS

n = number of entries, R = correlation coefficient, P = Probability
* = 5% P, ** = 1% P, *** = 0.1% P, NS = not significant, + Mean of four occasions, n = 88, 54, 20 and 14 respectively, B = bread, D = durum.

TABLE 1.7.B Summary of main treatment yields, harvest indices (H.I.) and components of yield of four varieties with different forms of nitrogen application.

Treatment	Yield kg/ha	H.I. %	Ears/ m^2	Kernel Wt. mg	Kernel /ear
Varieties					
Yecora	7.76	51	407	47	35.7
Fiserect	6.86	40	469	36	35.9
Beagle	6.44	39	257	44	50.8
Cocorit	7.69	48	375	49	37.2
Soil N					
200N I.A.	7.24	45	389	44	38.6
100 I.A., 100 at 60	7.13	44	364	44	41.2
Foliar N					
Not applied	7.08	44	380	44	38.8
Applied	7.30	44	374	44	41.0
Mean	7.19	44	377	44	39.9
CV%	4.63	3.72	5.20	4.76	8.14
PF:-Var	***	**	***	***	***
Soil N		*	**		**
Foliar N	*				*
Var x Soil		*			
Soil x Fol				*	

I.A. = Planting application
Non significant effects are left blank.

TABLE 1.7.C Yields under well-watered conditions, unadjusted and adjusted* yields under drought, and percentage reduction in yield based on the adjusted data.

Cultivar	Yield t/ha			Percentage reduction
	Well-Watered	Drought	Adjusted drought	
Gabo	4.3	3.4	3.8	12
(Tob - B.Man x Bb/Cdl) SX	5.1	4.0	4.3	16
Roshan	3.3	1.7	2.5	24
Alondra 'S'	4.7	3.2	3.5	25
Fiserect 4A	5.1	3.7	3.7	28
Pavon 'S'	5.3	3.4	3.7	30
FS 477 (T)	5.7	3.7	4.0	30
Ciano 67	6.0	4.1	4.1	31
Tob 'S' - Npo x CC-Inia/Cha	6.3	4.0	4.2	32
Chiroca 'S'	5.5	3.6	3.8	32
Goldfinch 'S'	5.3	3.2	3.6	32
Cal-Lu	5.5	3.3	3.6	34
Flicker 'S'	6.8	4.0	4.4	35
Bb-kal	5.2	2.8	3.4	35
Pavon 'S'	6.2	3.6	3.9	37
Lobo (T)	6.5	3.9	4.0	39
Mean Bread Wheats (69)	5.9	3.1	3.4	43
Range Bread Wheats	3.3-7.5	1.9-4.1	2.2-4.4	12-66
Mean Durum Wheats (14)	6.8	2.7	3.0	56
Range Durum Wheats	5.9-8.2	2.2-3.7	2.5-3.7	46-65
Mean Triticales (23)	6.2	3.0	3.2	47
Range Triticales	4.9-7.4	2.1-3.9	2.4-4.0	30-60
Mean Barleys (2)	4.9	2.7	2.8	44
Range Barleys	4.8-5.0	2.7	2.8	43-45

* = Adjusted for flowering data (See text)

(T) = Triticale

'S' = Sib or sister line

TABLE 1.7.D Yields, kernel weights and days to maturity under well-watered and drought conditions. Barley drought trial. Kernel weight was the only component that differed significantly between moisture treatments.

Line	WELL - WATERED			DROUGHT		
	Yield t/ha	Ker Wt. mg	Days to Maturity	Yield t/ha	Ker Wt. mg	Days to Maturity
1. M66.83-Larker x Apam-Russian Line	4.98	3.70	106	4.39	3.39	89
2. Apam He 1906 x Apam-Russian Line	3.92	3.55	96	2.64	3.10	87
3. S Precoz (6h)-Api	3.24	3.77	90	3.50	3.61	85
4. M69.69-Hja 4715	4.16	3.90	101	2.74	3.69	84
5. Por-Xina 15	*4.73	3.43	90	3.74	2.88	83
6. S.V. Mona-Arivat	*4.54	4.07	103	3.44	3.10	88
7. S.V. Mona-Benton/Cheng-Chou x Apl	3.60	4.86	107	2.76	4.42	91
8. S.V. Mona-Benton	4.91	5.27	108	2.88	4.92	89
9. Masarka	4.55	4.20	123	2.07	3.29	117
10. Hja C4715 x 0111-M64.69	*4.15	3.83	102	2.47	2.93	83
11. Apam-Russian Line	3.56	3.40	89	3.19	3.03	83
12. Cr.115-Por x S. Precoz (6h)	*3.38	3.72	89	3.50	3.22	81
13 M66.83-Larker L.S. x Apam -Russian Line	4.23	3.86	107	2.95	3.24	91
14. Apizaco	2.71	3.04	118	1.25	2.70	113
15. Early Russia-Apam	*3.53	4.24	87	2.96	3.71	83
16. Puebla	5.19	3.98	112	2.57	3.12	102
17. CM67	5.01	5.01	117	2.92	3.65	106
18. Zacatecas	4.65	4.50	125	2.01	3.27	114
19. Cleopatra (Bk)	5.51	4.96	122	3.10	3.99	110
20. S-0729-Por	5.95	4.31	116	2.57	3.03	107
21. 11012-2	7.62	3.67	116	2.66	2.53	101
22. Cocorit (D)	6.00	4.77	125	2.01	3.56	115
23. Yoreme (T)	6.19	4.37	120	2.37	2.91	118
24. W1 2198	4.48	5.37	116	2.17	4.11	107
MEANS	4.62	4.16	108	2.79	3.39	97
L.S.D.between moisture treatments 5%	0.30	0.15				
1%	0.69	0.35				
CV%	13.5	5.8				

* = Lodging score greater than 10

1.8 Pathology

1.8.1 WHEAT LEAF RUST TRIALS IN MEXICO

A uniform rust nursery consisting of Thatcher backcross lines, (each containing a single known gene for leaf rust resistance), tester lines, and highly resistant advanced lines and cultivars was grown in the 1975-76 season in the Yaqui Valley, México, as well as in several other localities during the summer of 1976. The original seed of the Thatcher backcross lines was supplied by D. J. Samborski, Canada Agriculture.

The objective was to observe the different leaf rust virulence patterns and to see if the localities selected might provide sufficient virulence gene diversity to warrant testing CIMMYT materials in these areas.

Table 1.8.A shows that each area tested contains different leaf rust virulence patterns. Yaqui Valley seems to possess the greatest diversity as judged by the different reaction types observed. However, Nestipac in Jalisco presents the greatest amount of virulence genes on the lines tested. Most of the backcross lines are susceptible to the isolates there. Celaya, a wheat growing area in Guanajuato, is most closely related to Nestipac in Jalisco, as judged by the lines tested.

The El Batan and Toluca experiment station nurseries were inoculated with inoculum from the Yaqui Valley as part of the overall inoculation program of CIMMYT although these rust nurseries were not directly inoculated. It would be expected that the reactions would be similar. Nevertheless, Toluca and El Batan present some distinct differences in virulence patterns, as in the case of Lr2a, LrEG, Sonora 64 and Yoreme, which indicate a probable influx of some natural inoculum from some unknown areas.

1.8.1.1 Virulence Frequencies of Leaf Rust Field Isolates

The virulence frequencies of field isolates of *Puccinia recondita* on Thatcher backcross lines containing single genes for resistance, and on tester lines to leaf rust, were investigated in the Yaqui Valley, Sonora, México.

Data presented in table 1.8.B indicate that the leaf rust cultures collected are avirulent on several of the genes or lines tested. The alien genes Lr 9 and Lr 19 are the most effective of those tested with no cultures virulent on them, whereas Lr 16 and 21 provide effective resistance against most of the cultures collected in Yaqui Valley. It should be noted that the leaf rust collections were obtained from wheats in commercial fields and experiment stations that possess functioning race-specific resistance. Thus the virulence frequencies are skewed depending upon which resistance genes they possess. The six tester lines were highly susceptible to the strains of leaf rust present in 1976, except Cocorit 73, which has a high level of effective race-specific resistance. Tanori 71 was susceptible to about 34 per cent of the cultures tested. Previous studies have indicated that the major gene functioning in Tanori 71 in the Yaqui Valley, is probably Lr 10.

1.8.1.2 Physiologic Specialization of Leaf Rust

Leaf rust collections were made in April 1976 from cultivars in the CIMMYT nurseries in CIANO as well as from commercial cultivars planted in the Yaqui Valley. Twenty-one collections were made and a total of 44 single pustule isolates were tested on the 24 differentials noted in table 1.8.C. One to three single pustule isolates were made from each collection.

Thirty two different virulence formulae were obtained indicating a wide diversity of leaf rust strains in the Yaqui Valley.

1976 is the first year that CIMMYT determined virulence/avirulence formulae in leaf rust populations in the Yaqui Valley. Large numbers of near-isogenic lines were used as well as tester lines to determine their usefulness and a rather large number of virulence/avirulence formulae were expected. More work will be done in the future with CIMMYT advanced line material and cultivars to determine their usefulness as differentials in the Yaqui Valley as well as at Toluca and El Batan.

A major point is that Jupateco 73 and Torim 73 both have the same or similar strains virulent on them. These are the two major wheats in Yaqui, 1975-76. Triticales that are susceptible to leaf rust in the Yaqui Valley are also susceptible to the common wheat leaf rust races, for example Beagle which is susceptible to the same strains as on Tanori 71 or on some of the Thatcher backcross lines.

Combined bulk uredospore collections obtained from Yaqui 1975-76, were inoculated on seedlings of several of the most highly leaf rust resistant CIMMYT advanced line materials such as Chiroca, Hork, Huacamayo, Cocoraque, and Moncho 'S'. Although most reactions from these bulk collections were resistant, some susceptible pustules (except on Cocoraque) developed and these were single-pustuled to determine if they were low frequency races with virulence genes for the tested lines. Avirulence/virulence formulae indicated some differences with those previously noted. However, all the lines tested, except Moncho 'S', produced resistant reactions when these single pustule cultures were tested on adult plants, thus indicating the presence of active adult plant resistance as well as seedling type resistance in Hork, Chiroca, and Huacamayo. Cocoraque showed a typical 0 reaction in seedling and adult plants. The Moncho 'S' isolate is probably a low frequency culture present in the leaf rust population of the Yaqui Valley. These observations will be confirmed in Yaqui in the 1976-77 season.

1.8.2 CONFIRMATION OF DIVERSE LEAF RUST RESISTANT GENES IN 8156 MULTILINE COMPONENTS

Dr D. J. Samborski, Canada Agriculture, tested the Multi Line (ML) components of the 1976-ML with 20 distinct races of *Puccinia recondita* endemic to Canada. These data were then sent to CIMMYT in early 1977 where the results were analyzed using the same grouping technique as mentioned in the previous report on the ML. Using four cultures from Mexico, it was possible to discern a minimum of 9 different genes present. Dr. Samborski's cultures allowed a minimum of 19 different resistance genes to be described. This indicates ample diversity of leaf rust resistance in the ML. However, CIMMYT is limited in the testing by the type and quantity of leaf rust cultures used. Also only seedling resistance is being tested here. Many of the groups observed with Dr. Samborski's cultures were the same as those separated with the four Mexican isolates.

When Dr. Samborski visited CIMMYT in Sonora the reactions were analyzed more critically to determine which known resistance genes were present in the ML. Analysis was made by comparing reactions on "Thatcher" near-isogenic lines containing known Lr genes, as well as comparisons between key races with and without corresponding virulence genes.

Based upon the above analysis, nine known resistance genes were postulated to be probably present, plus eight unknown genes, and several adult plant resistant genes. Table 1.8.D indicates the genes determined to be present and the lines which carry them. The unknown genes have been designated according to their respective reactions and hosts. It is apparent that the most common known genes present are Lr10 and Lr1.

1.8.3 GREENHOUSE INFECTION TESTS AND MULTILINE COMPONENTS

Greenhouse infection tests to differentiate multiline components into groups with different leaf rust resistant genes were carried out. The 37 components of the 1976-77 multiline set were inoculated with four leaf rust cultures obtained in the Yaqui Valley 1975-76. These cultures had avirulence/virulence formulae which differed from each other by having reactions differing on at least two near-isogenic lines for known genes for resistance (table 1.8 E).

Nine distinct resistance groups could be differentiated with the cultures used, thus indicating the presence of at least one resistance gene different in each group. Based on these data, components from each group could be used to make a mixture with a high degree of probability, that distinct genes would be functioning to protect individual components in the Yaqui Valley. This would not necessarily be the case in other epidemiological areas. However, these data indicate that the components contain the necessary genetic diversity to make up components of a multiline mixture based on simple greenhouse inoculations with local, distinct leaf rust cultures.

Individual components within the same group are not necessarily identical with respect to leaf rust resistance, but only as far as could be tested with these four cultures Thus it is probable that these products of double and top crosses will express other differences when tested with strains of leaf rust from other areas. The mixtures in these areas should be based on these data as well as on the appropriate leaf rust field observations and agronomic information.

1.8.4 FUNGICIDAL CONTROL OF LEAF RUST

In 1975-76, Indar 70LC was evaluated for control of leaf rust on Yecora wheat in a commercial size trial in the Yaqui Valley, Sonora State, México. Cultural practices were excellent. Six irrigations were applied with 200 kg N/ha and 100 kg P/ha. Weed and aphid controls were timely. Indar 70LC was applied at 400 ml/ha formulation + Triton ACT at 200 ml/ha on Jan 29, 1975. The wheat had been recently irrigated and was in the jointing stage. Foliage from adjacent rows was not fully touching at this stage and a good portion of the spray was applied to wet soil. Application was made with a Piper Pawnee 260, calibrated to spray 60 liters of water/ha. The trial had two replicatons; each treated plot was 6.5 ha and the check plots were approximately 8.5 ha. Yield data were obtained by harvesting a single commercial combine swath (2560 M^2), down the middle of each plot, bagging the grain, and weighing in the field.

Good leaf rust control was obtained with Indar 70LC on a commercial basis. Although leaf rust was present on the sprayed plots, the yield was not affected. The 15 per cent increase in yield was accounted for completely in increased 1000 grain weight. Under high yield, irrigated conditions the use of Indar 70LC on this susceptible cultivar was highly economical.

Treatment and rate/ha	% Leaf rust at Growth Stage		1000 grain weight (g)	Yield (kg/ha)
	Milk (25)*	Dough (28)*		
Indar 70LC 400 ml + Triton ACT 200 ml	Trace	30	47.4	7,179
Check	20	100	41.1	6,257

* = Romig Growth Scale for cereals.

1.8.5 SLOW RUSTING IN LEAF RUST

In recent years there has been an increased interest in and study of the supposed general resistance phenomenon known as "slow rusting". This is the type of resistance which provides a susceptible type reaction in the seedling and adult plant but, which due to various factors, decreases the amount of inoculum produced by the pustules over a period of time as compared with a highly susceptible genotype. CIMMYT's advanced line materials are being studied for the presence of this type of resistance, in order to incorporate them within the crossing program.

Previous studies in the summer of 1975 at El Batan, México on "slow rusting" to leaf rust showed that the area under the curve as described by Wilcoxson et. al. (Ann. Appl. Biol. 80 : 275-281. 1975) was an adequate parameter to describe the slow rusting phenomenon. The lines or cultivars in table 1.8.F which are susceptible to specific collections of rust in the seedling stage, show high levels of "slow rusting" ability to these collections in the adult plant stage over two seasons. It remains to be proved in the near future through international testing programs whether this resistance is truly non-specific.

TABLE 1.8.A Percentage leaf rust infection and reaction types of rust nursery in five localities of Mexico, 1976.

Isogenic Line, Line or Cultivar	Yaqui Valley Sonora	El Batan Mexico	Toluca Mexico	Celaya Guanajuato	Nestipac Jalisco
Lr1 (RL 6003)	20MSS	30S	60MSS	60S	60S
Lr2a (RL 6016)	10MSMRR	10MS	0	70S	100S
Lr2b (RL 6019)	20MSMR	40MS	20MS	70S	90S
Lr2c (RL 6047)	30MSMR	30MSS	30MS	70S	70S
Lr3 (RL 6002)	30MSSMRR	40MSS	30MS	80S	80S
Lr3allele (RL 6007)	20MSMRR	20MSS	TR	30MRMS	0
Lr9 (RL 6010)	TMRR	TR	0	5RMR	0
Lr10 (RL 6004)	20MRMS	10MS	TMR	50S	30MS
Lr13 (CT 263)	--	30MSS	40S	70S	70S
Lr14a (RL 6013)	40MSS	--	20MS	80S	80S
Lr14b (RL 6006)	10MSMR	20SMS	5MR	10MKMS	60S
Lr16 (RL 6005)	20MSMR	20MS	10MS	40MS	30MRMS
Lr17 (RL 6008)	20MRR	10MRR	10MRMS	30MRMS	80S
Lr18 (RL 6009)	20MRMSR	5MR	5MS	80S	70S
Lr19 (RL 6040)	TRMR	--	--	--	--
Lr21 (RL 6043)	10RMR	TR	0	TR	40MSS
Lr22 (RL 6044)	10MRR	TMS	0	TMRMS	70S
Lr23 (RL 6012)	10MRRMS	20MSS	40S	10RMR	70S
LrT (RL 6049)	20MSMRR	20MSS	10MS	TR	50MSS
LrEG (RL 6048)	20MSSMR	10MSS	0	60S	80S
Lr12 (RL 6011)	10MRRMS	--	5MR	20RMR	40MR
Morocco	100S	100S	100S	100S	100S
Jupateco 73	20MRRMS	TMRR	--	50MS	--
Siete Cerros	10MSS	10MR	0	--	--
Cocor t	TRMR	5R	0	--	--
Inia 66	50S	30S	50MS	--	--
Sonora 64	30SMS	60S	0	--	--
Tobari 66	TRMR	--	TMS	--	--
Yecora 70	30S	40S	80S	--	--
Yoreme (Tcl)	5MS	5MR	20MS	--	--
Beagle (Tcl)	10RMR	5MSMR	0	TR	TMSS
Alondra "S"	TMRMS	20S	5MS	--	20MRMS
Tanori 71	--	40S	60S	--	--
HIGHLY RESISTANT LINES					
Toquifen "S"	TR	--	TR	--	5MR
Pavon "S"	5RMR	10MS	20MRMS	--	--
Bb-Nor 67 x Cno"S"-7C	TMRMS	0	0	--	0
Era	0	TR	0	--	0
Nadadores 63	TR	--	--	--	--
Cocoraque 75	TR	TR	0	--	--
Moncho "S"	0	TR	TR	--	--
Hork	0	TR	TR	--	--
Huacamayo	0	TRMR	TR	--	--
Emu "S"	TR	TMRR	0	--	--
(Tob-B.Man x Bb/Cdl)Sx	--	TR	0	--	--
/(SD648.5-8156/Chr x Son-kl.Rend)Bb-Cal)/Zbz	--	TR	TR	--	5MS
An_E-Myt x Ti71	--	TR	0	--	0
Jar 66-Kuz x Yr70	--	TR	0	--	10MR
Trifon "S"	--	5MSMR	TMSHR	--	--

-- = Leaf rust readings not obtained
Data were taken on the following dates: Yaqui, 30/III/76; El Batan, 2/IX/76; Toluca, 4/X/76; Celaya, 27/IX/76; Nestipac, 15/X/76.

TABLE 1.8.B Virulence of field isolates of *Puccinia recondita* on Thatcher backcross lines containing single genes for resistance, and tester lines to leaf rust in Yaqui Valley, Sonora, Mexico, 1976.

Resistance gene or tester Line	% of Isolates virulent
Lr1	97.9
2a	33.3
2b	43.8
2c	68.8
3	95.8
3 allele	39.6
9	0
10	29.2
14a	89.6
14b	89.6
16	2.1
17	79.2
18	31.3
19	0
21	6.3
23	72.9
T	37.5
EG	20.8
(166) Inia 66	95.5
(7C) Siete Cerros	93.2
(S64) Sonora 64	84.1
(Ti71) Tanori 71	34.1
(C73) Cocorit	0
(Y70) Yecora 70	88.6

Virulent isolates produce a 3- and higher rxn. 3-2+ and "X" are considered susceptible.

Walter Kugler and Carlos Pierobom in a disease research greenhouse, Passo Fundo, Brazil

TABLE 1.8.C Combinations of virulence genes of <u>Puccinia recondita</u> collections on near-isogenic lines containing single genes for resistance and tester lines in Sonora, Mexico, in 1976.

Avirulence (Effective) /Virulence (Ineffective) Formulae	Field Host	Total No of isolates
1 2a 2b 2c 3 3al 9 10 16 18 19 21 T EG C73 S64 Y70 T7 / 14a 14b 17 23 7C 166	Potam	1
2a 2b 2c 3al 9 10 16 17 18 19 21 23 T EG C73 T71/ 1 3 14a 14b 7C 166 S64 Y70	Jupateco (1)	2
2a 2b 2c 3al 9 10 14b 16 18 19 21 23 T EG C73 T71/ 1 3 14a 17 7C 166 S64 Y70	Torim (1) Sonora 64	1
2a 2b 2c 3al 9 10 14b 16 18 19 21 T EG C73 T71/ 1 3 14a 17 23 7C 166 S64 Y70	7 Cerros	1
2a 2b 2c 3al 9 10 16 18 19 21 23 T EG C73 T71/ 1 3 14a 14b 17 7C 166 S64 Y70	Cinnamon (Tc1)	1
2a 2b 3al 9 10 14a 14b 16 19 21 23 T EG C73 T71/ 1 2c 3 17 18 7C 166 S64 Y70	Unknown	1
3al 9 10 16 17 18 19 21 23 T EG C73 S64 Y70 T71/ 1 2a 2b 2c 3 14a 14b 7C 166	Morocco	1
2a 2b 2c 3 3al 9 10 16 19 21 T EG C73 T71/ 1 14a 14b 17 18 23 7C 166 S64 Y70	Jupateco	1
2a 2b 2c 3al 9 10 16 18 19 21 T EG C73 T71/ 1 3 14a 14b 17 23 7C 166 S64 Y70	Torim	2
2a 2b 2c 3al 9 10 16 19 21 T EG C73 T71/ 1 3 14a 14b 17 18 23 7C 166 S64 Y70	Tobari Yoreme (Tc1)	1
2b 2c 3al 9 10 14a 16 19 21 23 T FG C73 T71/ 1 2a 3 14b 17 18 7C 166 S64 Y70	Jupateco	1
2a 2b 2c 3al 9 10 16 19 21 T EG C73 T71/ 1 3 14a 14b 17 18 23 7C 166 S64 Y70	Yecora	2
3al 9 10 14a 14b 16 19 21 23 T EG C73 T71/ 1 2a 2b 2c 3 17 18 7C 166 S64 Y70	Torim Jupateco	1
3al 9 10 16 17 18 19 21 T EG C73 166 T71/ 1 2a 2b 2c 3 14a 14b 23 7C S64 Y70	Jupateco	1
3al 9 10 16 19 21 23 T EG C73 Y70 T71/ 1 2a 2b 2c 3 14a 14b 17 18 7C 166 S64	Morocco	1
3al 9 10 16 19 21 T EG C73 166 T71/ 1 2a 2b 2c 3 14a 14b 17 18 23 7C S64 Y70	Lr2a	1
3al 9 10 16 19 21 T EG 7C C73 Y70 T71/ 1 2a 2b 2c 3 14a 14b 17 18 23 166 S64	Torim	1
3al 9 10 18 19 21 23 T EG C73 S64 T71/ 1 2a 2b 2c 3 14a 14b 16 17 7C 166 Y70	Morocco	1
2a 2b 3al 9 10 16 18 19 21 EG C73/ 1 2c 3 14a 14b 17 23 T 7C 166 S64 Y70 T71	Inia	1
2a 2b 9 10 16 18 19 21 EG C73 Y70/ 1 2c 3 3al 14a 14b 17 23 T 7C 166 S64 T71	Tobari	1
2a 9 14a 14b 16 17 18 19 21 EG C73/ 1 2b 2c 3 3al 10 23 T 7C 166 S64 Y70 T71	Lr3	1
3al 9 10 16 18 19 21 T EG C73 T71/ 1 2a 2b 2c 3 14a 14b 17 23 7C 166 S64 Y70	Yoreme	1
3al 9 10 16 17 19 21 T EG C73 T71/ 1 2a 2b 2c 3 14a 14b 18 23 7C 166 S64 Y70	Yecora	2
2a 2b 9 10 16 18 19 21 EG C73/ 1 2c 3 3al 14a 14b 17 23 T 7C 166 S64 Y70 T71	7 Cerros Inia 66	1
2a 2b 9 16 18 19 21 EG C73 S64/ 1 2c 3 3al 10 14a 14b 17 23 T 7C 166 Y70 T71	Tobari	1
3all 9 10 16 19 21 T EG C73 T71/ 1 2a 2b 2c 3 14a 14b 17 18 23 7C 166 S64 Y70	Yecora	1
2a 2b 9 16 18 19 21 EG C73/ 1 2c 3 3al 10 14a 14b 17 23 T 7C 166 S64 Y70 T71	Tanori (3)	5
3al 9 10 16 19 21 T C73 T71/ 1 2a 2b 2c 3 14a 14b 17 18 23 EG 7C 166 S64 Y70	Bgl (2) Yecora	1
2a 2b 9 16 18 19 23 C73/ 1 2c 3 3al 10 14a 14b 17 21 T EG 7C 166 S64 Y70 T71	Tanori	1
2a 9 16 18 19 21 EG C73/ 1 2b 2c 3 3al 10 14a 14b 17 23 T 7C 166 S64 Y70 T71	Lr1 Lr2b	5
9 10 16 19 21 EG C73 T71/ 1 2a 2b 2c 3 3all 14a 14b 17 18 23 T 7C 166 S64 Y70	Lr2c Bgl (2) Yoreme	1
9 16 19 21 T C73 T71/ 1 2a 2b 2c 3 3al 10 14a 14b 17 18 23 EG 7C 166 S64 Y70	7 Cerros	1

1.- Tester lines. 166=Inia 66; 7C=Siete Cerros 66; S64=Sonora 64; T71=Tanori 71; C73=Cocorit 73; Y70=Yecora 70.

TABLE 1.8.D Identification of some leaf rust seedling and adult plant resistance genes in 1976 multiline components.

Entry No.	Components	Lr1	2a	3	10	14a	14b	18	23	EG	Brochis 1	Tob 2	Bk 2	Pollo gene	Carth. gene	Super X	Hork 2	Teso X	Adult Plant Resistance
		Genes																	
1	(No.66-Bb/Cno x Nad-Chrs}7C				+														
2	(No.66-Bb/Cno x Nad-Chrs}7C				+														
3	Ron-Cha x Bb-Nor 67	+			+														
4	Brochis	+			+			+											
5	Brochis	+			+			+											
6	Brochis	+			+			+			+								
7	Brochis	+			+			+											
8	(We/Lr64-Inia x Inia Bb)7C x Tob "S"-Cno "S"	+	+		+														
9	(We/Lr64-Inia x Inia Bb)7C x Tob "S"-Cno "S"	+	+		+														
10	Npo-Cdl x Sam-Tor				+														
11	Npo-Cdl x Sam-Tor				+														
12	7C x Tob-Cno"S"/Kal				+							+							
13	Flicker "S"			+	+				+				+						
14	Flicker "S"	+		+	+				+				+						
15	Bb-Kal	+			+								+						
16	Bb-Kal	+			+								+						
17	Bb-Kal	+			+														
18	Pollo							+						+					
19	Carthage "S"														+				
20	IWP 19 = E6254-Kal^2														+				
21	HD 2167				+								+						
22	7C				+														
23	Cno-7C x CC-Tob/SD648.5-8156					+													+
24	Bluetit						+			+									
25	Super X															+			
26	Brochis "S"				+								+						
27	Ron-Cna	+			+								+						
28	Hork "S"				+												+		+
29	Hork "S"				+												+		+
30	Hork "S"				+												+		+
31	We x$_2$Tob-Cno"S"/Cdl																		
32	(Cno^2 x Son 64-Kl.Rend/Ron}Sx															+			
33	/(21931/Ch53-An x Go56}An64 /7Odl															+			
34	(Cno-7C x CC-Tob/Cno"S"-No.66}Kal																		+
35	Tesopaco "S"																	+	
36	Tesopaco "S"																	+	
37	Y50$_E$ x Kal^3				+														+

TABLE 1.8.E Components of the 1976-77 multiline composite grouped according to reactions of seedlings to four leaf rust cultures*.

GROUP I - Four cultures avirulent = L^1 L^2 L^3 L^4	
(No66-Bb/Cno x Nad-Chr'S') 7C	CM 5375-F-1Y-1M-1Y-1M-0Y
(No66-Bb/Cno x Nad-Chr'S') 7C	CM 5375-F-1Y-1M-1Y-0M
Brochis 'S'	CM 5872-C-1Y-1M-3Y-0M
Brochis 'S'	CM 5872-C-1Y-1M-1Y-1M-0Y
7C x Tob-Cno 'S'/Kal	CM 8865-D-4M-1Y-1M-2Y-0M
Bb - Kal	CM 9168-11M-5Y-5M-2Y-0M
Bb - Kal	CM 9168-11M-5Y-6M-0Y
Bb - Kal	CM 9168-11M-5Y-1M-2Y-0M
HD 2167	
Ron - Cha	CM 6552-16M-1Y-5M-3Y-0M
Hork 'S'	CM 8874-K-1M-1Y-0M
Hork 'S'	CM 8874-K-1M-1Y-1M-2Y-0M
Hork 'S'	CM 8874-K-1M-1Y-1M-1Y-0M (1-356Y) (1-200B)
[(21931/Ch 53-An x Gb56)An 64]Cdl	CM 11243-28Y-4M-3Y-0M
GROUP II - Three cultures avirulent = L^1 L^2 H^3 L^4	
Npo-Cdl x Sam-Tor	CM 8701-A-1M-2Y-3Y-0M
Npo-Cdl x Sam-Tor	CM 8701-A-1M-2Y-1M-3Y-0M
Flicker 'S'	CM 8954-8-7M-1Y-1M-1Y-0M
Flicker 'S'	CM 8954-8-7M-1Y-1M-0Y
Brochis 'S'	CM 5872-C-1Y-1M-1Y-3M-0Y
GROUP III - Three cultures avirulent = H^1 L^2 L^3 L^4	
Brochis 'S'	CM 5872-C-1Y-5M-1Y-2M-0Y
Pollo	II 35129-20Y-2M-1Y-1M-1Y-0M
GROUP IV - Two cultures avirulent = L^1 L^2 H^3 H^4	
$Y50_E$ x Kal^3	II 35188-6M (F_1)-31Y-0M-8M-0Y
GROUP V - Two cultures avirulent = H^1 L^2 H^3 L^4	
(We/LR64-Inia x Inia-Bb)7C x Tob'S'-Cno'S'	CM 8625-G-1M-4Y-1M-1Y-4M-0Y
GROUP VI - Two cultures avirulent = H^1 H^2 L^3 L^4	
Brochis 'S'	CM 5872-C-1Y-5M-2Y-2M-0Y
(We/LR64-Inia x Inia-Bb)7C x Tob'S'-Cno'S'	CM 8625-G-1M-4Y-1M-0Y
(Cno^2 x Son64-Kl. Rend/Ron)Sx	CM 8922-H-1M-1Y-3M-1Y-0M
GROUP VII - One culture avirulent = H^1 H^2 L^3 H^4	
Ron-Cha x Bb - Nor67	CM 5484-F-5Y-4M-2Y-1M-0Y
Carthage 'S'	II 28071-7M-3Y-1M-0Y
IWP 19 = E 6254-Kal^2	72-L-41
We x Tob-Cno'S'/Cdl	CM 8285-T-500M-603Y-0M-501M
GROUP VIII - One culture avirulent = H^1 L^2 H^3 H^4	
Siete Cerros	
GROUP IX - No cultures avirulent - H^1 H^2 H^3 H^4	
Cno-7C x CC-Tob/8.D.648.5-8156	CM 4756-12Y-1M-1Y-1M-0Y
Tob'S'-Npo x CC-Inia/Cha Super -X	CM 5541-C-5Y-1M-1Y-4M-0Y
(Cno-7C x CC-Tob/Cno'S'-No66) Kal	CM 11377-A-1Y-8M-3Y-0M
Tesopaco 'S'	Br 69-1Y-3M-0Y
Tesopaco 'S'	Br 69-1Y-3M-7Y-0M

* L = Low reaction = 0 to 2++; H = High reaction = 32- to 4

Numerical superscripts refer to individual leaf rust cultures with the following avirulence/virulence formulae as follows:

1 = 2a, 2b, 2c, 3a, 9, 10, 16, 18, 19, 21, T, EG/ 1, 3, 14a, 14b, 17, 23
2 = 3a, 9, 10, 16, 17, 18, 19, 21, 23, T, EG/ 1, 2a, 2b, 2c, 3, 14a, 14b
3 = 2a, 9, 16, 18, 19, 21, EG/ 1, 3, 2b, 2c, 3, 3a, 10, 14a, 14b, 17, 23, T
4 = 9, 16, 19, 21, T/ 1, 2a, 2b, 2c, 3, 3a, 10, 14a, 14b, 17, 18, 23, EG

TABLE 1.8.F Lines showing slow rusting reaction to leaf rust in the Yaqui Valley 1975-6 and at El Batan, Mexico, Summer 1976.

Line	Pedigree	A Value*
Inia 66 (check)		178
Yecora 70 (check)		112
Armadillo 105 (Tcl)		74
Yaqui 50		72
Y 50_E-Kal[3]	35188-5M (F_1)-31Y-0M-17M-0Y	55
H 277.69 x Tcl (E_3) - Arm "S"	H 521-71A-1B-1Y-1B-0Y	38
Andes 56		12
RR 68-WW 15/ Ji "S" x Cno "S"-No 66	CM 12272-Ñ-1Y-1M-0Y-0BK	10
Nuri Reselection		9
Bonza 55		8
Soltane		8
Tob 66-Cno "S" x Pj 62	CM 7369-1M-1Y-3M-1Y-0M	7
Kal - Bb (PM 1 - Y 74-75)		6
Chris		3
Tórim 73		3
S 948, Al - Bza[4]	H 472-71A-1B-2Y-1B-3Y-1B-0Y	1
Bluejay "S"	CM 5287-J-1Y-2M-1Y-4M-0Y	1

* A Value = Value as defined in Wilcoxson, R.D., B. Skovmand, and A. H. Atif. 1975. Evaluation of wheat cultivars for ability to retard development of stem rust. Ann. Appl. Biol. 80:275-281. Based on data from El Batan, Mexico, Summer 1976.

Research on soil aluminum toxicity in triticale and wheat, CIMMYT, El Batan, Mexico.

1.9 Basic Germ Plasm Improvement

1.9.1 DWARFNESS

Materials with different sources of dwarfness have been developed from back crosses and individual selections in the segregating populations of each back cross. This procedure has allowed CIMMYT to obtain lines with dwarfness from S948A1 and from Tom Thumb, which are very similar to their recurrent parents Santa Elena, Chris, Ciano 67, Bonza, Tzpp, Andes 56, etc.

During the 1975-76 season, the best lines with that kind of dwarfness were tested again in yield trials. In general, the performance of these lines was similar to that observed in the 1974-75 season. This means that short-straw lines yielded higher than their recurrent parents. However, as shown in table 1.9.A, the yield of lines derived from Inia 66 was slightly lower than that of the recurrent parent Inia 66.

Lines with S948A1 and Tom Thumb dwarfness have been incorporated into the Bread Wheat Breeding Program. Data for some of these lines compiled in the Yaqui Valley in 1975-76, are reported in table 1.9.A.

CIMMYT is now trying to transfer the S948A1 dwarfness to high yield potential varieties, but whose present height is a shortcoming for expressing maximum productivity. Among those varieties are. Pitic 62, Pénjamo 62, Huamantla Rojo, Lerma Rojo, Nainari 60, Jupateco 73, Cocorit 71 and Mexicali 75.

Hisumi, a short-straw winter wheat, is a new source of dwarfness. CIMMYT is trying to incorporate its dwarfness into spring wheats. The purpose is to diversify sources for this dwarfness character. It is expected that homozygous lines with genes from Hisumi can be selected in spring habit plants.

1.9.2 PROTEIN CONTENT AND QUALITY

A major aim is to develop parents with a high quality, high protein content. This project is perhaps the one which requires more work and time in the basic germ plasm development program.

In the CIMMYT Report on Wheat Improvement for 1975, a group of lines was presented having higher protein content and quality than the variety Ciano 67, which was chosen as check because of its good protein content and quality. These lines are of short vegetative cycle, but most of them show certain shortcomings such as poor straw, rust susceptibility, poor plumpness of grain and, in certain cases, poor fertility. Because these shortcomings may alter the protein content in the grain, these materials have not been incorporated into the bread wheat breeding program.

To correct the deficiencies in these lines, crosses are being made with parents having good agronomic type. Table 1.9.B shows the materials used in these crosses.

First crosses with the quality lines were made in the 1975 summer (table 1.9.B). By the 1976-77 winter cycle, the third generation of single crosses will be obtained. In the second generation CIMMYT will have back crosses and multiple crosses in which one or two quality parents are involved. CIMMYT will also have single crosses. In these two generations it may be possible to determine whether a good agronomic type with high yield and nutritional quality can be produced. Many of the selections made in El Batán during the 1975 summer, showed shrivelled and germinated grain, due mainly to heavy rainfall in the maturation period. This grain condition was considered inadequate for protein analysis and accordingly, analyses were not made.

1.9.3 RUST RESISTANCE

Some old wheat varieties such as Yaqui 50, Bonza 56, Africa-Mayo 48, Samaca, Era, and several others are being used in crosses to transfer their rust resistance to better agronomic type plants.

In the particular case of Era, the major aim is to transfer its rust resistance to spring wheats with insensitivity to day length. This is why it has been crossed with Sonora 64, Ciano 67 and Potam, which are very early varieties. For the winter of 1976-77 there will be F_3 lines available of the second back cross to Era, from which early types with the Era resistance can be recovered. In addition, in more advanced generations, selections will be possible in populations of the first back cross and of single crosses, where it will be feasible to recover resistance of Era in lines having diverse agronomic types.

CIMMYT is also endeavoring to assemble in a single line, resistance from several sources. For example, the best material with resistance from Bonza 55 is being crossed with the best lines having resistance from Era, Chris and Nariño 59.

On the other hand, a crossing program has been started with proven high yielding varieties (such as Super X, Inia 66, Yécora 70, Tanori 71, Jupateco 73, Potam 70, Saric 70, and Cajeme 71) to correct some shortcomings in them,especially rust resistance.

Segregating lines of materials with resistance to stem rust are being tested by CIMMYT pathologists in the seedling stage under green house conditions. The data obtained will complement field observations in order to identify those lines with the desired resistance.

1.9.4 SPIKELETS PER SPIKE AND GRAINS PER SPIKELET

Some progress has been achieved in obtaining more spikelets per spike and more grains per spikelet. The improvements achieved, however slight, indicate the possibility of combining both traits in plants which have good tillering and an intermediate vegetative cycle.

At present, the best spikelets per spike material is being obtained from crosses of Tetrastichon x CM-1577, and from H511.71A x Tetrastichon-M.J. 692. Plants from these crosses have been selected which produce 20-35 spikelets per spike under El Batán conditions and 25-41 spikelets under Yaqui Valley conditions. These are late materials, and observations indicate that as the vegetative cycle shortens, the number of spikelets per spike decreases.

In Obregón, the cross H622.71-Morocco x CMH72.428 is segregating 8-14 kernels per spikelet in early plants with few stems. CMH72.428-H570.71 x Morocco, H500.71A - Morocco^2 x CMH72A. 508-Tob 66, and CMH72A.508-H570.71 x CMH72A508 are segregating more than six kernels per spikelet in early maturing, good tillering plants.

The crosses CMH73A.329 x CMH72A.508 and CMH72A.527 x Morocco, are segregating lines with 12-14 spikelets per spike and more than six grains per spikelet.

1.9.5 BRANCHED WHEATS

In a branching wheat yield trial conducted in 1973-74, three branching lines of Noroeste 66 yielded equal or slightly higher than Noroeste 66 normal, and one branching line of Super X yielded equal to Super X normal. Figure 1.9.1 shows branched heads of Super X and Super X normal wheats. The performance of these materials in the 1974-75 season was similar to that observed in 1973-74.

The improvement work in branching wheats has allowed selection of new lines, which were tested in yield trials during the 1975-76 season. A few other will be tested in Obregon, Sonora, in 1976-77.

Some of the wheats currently showing the best performance are reported in table 1.9.?. Varieties No. 20 and No. 22 have a yield potential similar to Cajeme 71, Jupateco 73 and Super X, while varieties 19 and 21 yield similar to Jupateco and Super X, but less than Cajeme 71. The branched heads of Cajeme 71 and Cajeme 71 normal can be seen in figure 1.9.2.

Before the 1974-75 season, none of the durum branched wheat lines had yielded the same as Cocorit 71. But in that season, several branched durums had yields comparable to Cocorit, and some even similar to Mexicali 75. In 1975-76, some branched durums yielded as much as Cocorit 71, but none yielded as high as Mexicali 75.

According to these data, some progress has been achieved in improving branched wheat yields, but there are still large performance variations from one year to the next.

1.9.6 TRITICALE

During 1976 short strawed triticales (E_2), having good stable dwarfness, good fertility and good kernels were selected. Several advanced lines from the crosses CMH73A.762 and CMH73A.785 show these characteristics and some seed will be obtained from them for winter experimental plantings in the 1976-77 season.

Some lines of 55 cm height have been selected from the cross H277.69 x Tor "S" - Tob.66/ F.S. 1029, in Obregón, Sonora. That height is stable and it comes almost certainly from Tor "S"-Tob 66, which is a wheat with dwarfness from Tom Thumb and Norin.

A large number of conventional triticales have been crossed with lines $E_3 \not+$ from H27.7.69 x Tor "S'-Tob.66/F.S.1029 to increase their yield potential solely by shortening the straw height, as happened with dwarf wheats. The degree of dwarfness obtained in this cross may be quite useful in regions such as the Yaqui Valley, because fertilizers will be better used without any danger of lodging.

Some work has also been done on branching spikes, a characteristic which was initially unstable but which has now been stabilized in general lines. In addition, some work is being done to increase the number of spikelets per spike, and number of grains per spikelet, as well as developing erect-leaf triticales.

1.9.7 WHEAT-TRITICALE CROSSING

There has been some speculation about the possibilities of crossing wheat x triticale. CIMMYT now reports the development of triticale lines, 55 cm high, which are in a stable homozygous condition. This height is considered to be governed by genes coming from wheats involved in the crosses which originated those lines. This fact will allow attempts at new combinations for different purposes, such as transferring rust resistance and Septoria resistance, and perhaps improving grain characteristics and yield stability in triticales. Several triticale lines coming from the crosses CMH72A.576, H507.71A, CMH73A.762, and CMH73A.785, have shown good crossing compatibility with wheat, and this is being used to attempt the following crosses:

Triticale x high yielding wheat

Triticale x good grain wheat

Triticale x good gluten wheat

Triticale x high protein content wheat

Triticale x good fertility wheat

Triticale x wheat with different sources of dwarfness.

1.9.8 WIDE CROSSES

During the 1975-76 wheat season, attempts were made again to produce crosses among barley, wheat, oats and rye. Epsilon amino-N caproic acid (EACA) was used to suppress barriers which prevent the crossing of different genera. This chemical was applied by injection (0.1 g/l) and by spray (1 g/l).

Also, gibberellic acid and 2,4-D were used as stimulants to develop the endosperm and embryo. Data from this small test suggested that these two chemicals should be more widely tested, which was partially carried out in the summer of 1976. In the summer of 1976, EACA was applied as in the winter of 1975-76. Gibberellic acid was prepared in a 75 ppm solution which was applied to the stigma, and 2,4-D was applied in two solutions (1 ppm and 5 ppm) which were sprayed onto spikes.

The crosses attempted in the last two cycles are listed in table 1.9.D, which also shows the number of spikes pollinated for each female parent. During the 1975-76 winter, 3,014 spikes were treated, emasculated and pollinated. During the 1976 summer, 2143 spikes were treated which were then sent to the cytology laboratory for cytologic studies, and for culturing plants growing from the embryos.

Attempts are being made, under greenhouse conditions, to cross wheat with some grasses, mainly some species of Elymus, Agropyron and Aegilops. From these crosses some grains have been obtained and planted; some seedlings are being grown and they are under study to verify if in fact, that they are crosses.

The wide crosses project is a joint effort between Kansas State University and CIMMYT and although the results are not spectacular, the studies made on the crosses already achieved, indicate that wheat-barley hybrids have been achieved. This is a positive step in the right direction to create new plants by using new techniques.

TABLE 1.9.A The highest yielding bread wheat lines in the Yaqui Valley, Sonora, Mexico in the winter 1975-76.

Var. No.	Variety or cross	Pedigree	Yield kg/ha	Days to flowering	Height cm	Pucc. recondita
30	Torim 73	II-26591-1T-7M-0M-55Y-0M	6270	79	60	10-20MR-MS
27	Inia 66		6083	76	85	50-60S-MS
28	Jup. 73	II-30842-31R-2M-2Y-0M	5604	81	90	5R-MR
29	Super X		5583	82	85	10R-MR
46	(Chr xT.Th-Son64/Chr) Inia 66^3	H283.70-3Y-2B-1Y-4B-1Y-2B-0Y	5542	84	60	10MR-R
47	(Chr.xT.Th-Son64/Chr) Inia 66^3	H283.70-3Y-2B-1Y-4B-4Y-2B-0Y	5542	79	60	10MR-MS
50	(Chr.xT.Th-Son64/Chr.) Inia 66^3	H283.70-3Y-2B-1Y-4B-1Y-3B-0Y	5542	84	55	10R-MR
49	(Chr.xT Th-Son64/Chr.) Inia 66^3	H283.70-3Y-2B-1Y-4B-7Y-1B-0Y	5458	84	60	40S-MS
48	(Chr.xT.Th-Son64/Chr) Inia 66^3	H283.70-3Y-2B-1Y-4B-5Y-1B-0Y	5437	84	60	5-30MR-MS
36	S948A1-Cno"S"^{2}xCno 67^3	H569.71-3Y-3B-0Y-1B-0Y	5375	74	55	10MR-MS
40	S948A1-Cno"S"^{2}xCno.67^5	CMH72A.429-4B-1Y-4B-0Y	5354	74	55	10MR-MS
38	S948A1-Cno"S"^{4}	H471.71A-12B-3Y-1B-0Y	5333	73	50	TMR
26	Cno.67	II-19957-18M-1Y-3M-9Y	4562	76	80	10-20MS-MR
		CV= 9.78 DMS 5% =	717.66			
		DMS 1% =	952			
62	S948A1-S.E.^{7}	CMH72A.390-1B-1Y-0B	5958	86	80	TR-MR
69	S948A1-S.E.^{7}	CMH72A.390-5B-1Y-0B	5771	84	85	10MS-S
57	Inia 66		5729	91	80	60S
65	S948A1-S E.^{7}	CMH72A.390-2B-2Y-1B-0Y	5667	84	80	TR-MR
53	Jup. 73	II-30842-31P-2M-2Y-0M	5604	81	90	20MR-MS
54	Torim 73	II-26591-1T-7M-0M-55Y-0M	5583	80	60	5MR-R
68	S948A1-S.E.^{7}	CMH72A.390-2B-2Y-0B	5562	84	80	10MR-MS
61	S948A1-S.E.^{5}	H567.71-6Y-1B-0Y	5542	84	75	5MR-R
55	Super X		5500	84	85	20MS-S
56	Zaragoza 75	H223.64-1Y-6C-1Y-1C-4Y-3C-1Y-2B-300Y-0Y	5479	91	85	5MS-MR
60	S948A1-S.E.^{5}	H567.71-6Y-1B-1Y-1B-0Y	5458	83	80	TR-MR
64	S948A1-S.E.^{6}	CMH72A.303-1B-1Y-1B-0Y	5458	84	80	5-10MR-MS
58	S948A1-S.E.^{6}	H498-71A-17B-2Y-1B-0Y	5437	84	80	10MR-R
63	S948A1-S.E.^{7}	CMH72A.390-2B-1Y-0B	5437	84	80	TR-MR
67	S948A1-S.E.^{5}	H567.71-6Y-1B-0Y-2B-0Y	5292	84	80	5MS-S
51	Sta. Elena (S.E.)		3729	82	115	10MR-MS
		CV= 10.10 DMS 5% =	736.16			
		DMS 1% =	976.66			
125	Fury-Kal^2	CMH73A.599-2B-3Y	5479	80	75	5R-MR
115	S948A1-Nai60^5	CMH72.317-3Y-1B-1Y-4B	4958	84	85	5MR-MS
102	Jup. 73	II-30842-31R-2M-2Y-0M	4854	80	85	5MR-MS
116	S948A1-Nai.60^5	CMH72.317.3Y-1B-1Y-0B	4792	86	95	5MR-MS
107	Super X		4625	84	85	TMR
104	Nainari 60		4083	85	105	5MR-MS
		CV= 17.41 DMS 5% =	993.66			
		DMS 1% =	1318.16			

TABLE 1.9.B The main lines and varieties being used in the development of new good quality parents.

Good quality varieties and lines	Protein % in grain	Quality Index
Buitres "S" 11-28867-302Y-304M-0Y	15.7	3.7
Rcn#2-Fnd CMH72A.479-6B-2Y-4B-0Y	18.1	4.0
Cal.-Nap Hal CMH72A 491-11B-1Y-3B-0Y	18.9	4.1
Cal -Nap Hal CMH72A.491-11B-2Y-1B-0Y	18.5	4.8
B.B.#7-Nap Hal/Mahratta x Cno"S"-Gallo CMH73A 497-5B-3Y-1B-0Y	19.1	4.3
H546.71-Samaca CMH73.562-7Y-3B-1Y-1B-0Y	17.0	4.0
Ciano 67 (testigo)	14.8	3.6

Varieties or lines with good agronomic characters:

Variety or line	Pedigree
Ciano "S"-Gallo	II-27829-19Y-1M-500Y-501M-0Y
Torim 73	
Jupateco 73	
Zaragoza 75	
Tesopaco 76	
Samaca-CJ71[2]	CMH 73A.588-4B-1Y-1B-5Y
S948A1-Cno"S"[2] x Cno.67[4]	H499.71A-3B-0Y-1B-0Y
S948A1-Sta. Elena[5]	H567.71-1Y-3B-0Y-2B-0Y
Chr-S948A1 x Chr[6]	CMH73.474-4Y-1B-1Y
Fury-Kal[2]	CMH73A.599-2B-3Y-1B-2Y
Fury-Kal x Fury	CMH73A.600-3B-1Y-1B-3Y

TABLE 1.9.C The comparative yield of the best branched bread wheats and branched durum wheats in the Yaqui Valley, Sonora, Mexico in the 1974-75 and 1975-76 seasons.

Var. No.	Variety or cross	Pedigree	Yield (kg/ha) 1974-5	Yield (kg/ha) 1975-6	
13	Cajeme 71		6979	6021	
22	H844.66-M.ReoxCno.67/Cj.71	CMH72.141-6Y-1B-2Y-1B-0Y	- -	5417	Rah
23	H844 66-M ReoxCno.67/Cj.71	CMH72.141-6Y-2B-1Y-1B-0Y	- -	4458	Rah
18	H844.66-M ReoxCno 67/Cj.71	CMH72.141-6Y-4B-3Y-0B	6083	4417	Rah
12	Jupateco 73		7292	5292	
20	M.Reo-SX^4	CMH72A.127-3B-1Y-2B-0Y		5333	Rah
21	M.Reo-SX^4	CMH72A.127-3B-1Y-3B-0Y		5271	Rah
15	Super X		7646	5083	
19	M.Reo-SX^4	CMH72A.127 -3B-3Y-0B	7771	4750	Rah
2	Stork"S"=Mexicali 75		8542	6937	
11	Rad.2"S"-Rad 3"S"^{2}xH212.70	CMH72A.204-1B-4Y-0B		5771	Rad
1	Cocorit 71		8271	5667	
3	Rad.3"S"-H251 69A	H193.70-4Y-2B-1Y-0B	7208	5562	Rad
4	Rad.3"S"-H251 69A	H193.70-5Y-4B-1Y-0B	7354	5417	Rad
6	Rad 3"S"-H251.69A	H193.70-4Y-1B-1Y-7B-2Y-1B-0Y	7729	5417	Rad
5	Rad.3"S"-H251 69A	H193.70-4Y-1B-1Y-2B-1Y-1B-0Y	7542	5375	Rad
9	H251.69A-Cr."S"xRad.2"S"-Rad 3"S"	H391.71A-9B-4Y-2B-2Y-0B	7938	5250	Rad
	Rad=Ramified durum wheat Rah=Ramified bread wheat	D.M.S. 5%	881.16	725.00	
		D M.S. 1%	1169.00	961.83	

Dr. B Skovmand (left) CIMMYT and Dr. R. Britto (right) from Columbia, inspecting bread wheat plants.

TABLE 1.9.D Wide crosses attempted during the winter 1975-76 and the summer 1976.

Female Parents	Male Parents: Wheat	Male Parents: Barley	Male Parents: Oats	Male Parents: Rye	No. of Pollinated Spikes
Winter 1975-76					
Dic-Hip.	Cit.71,Tob.66,WS1809,Bza.55,T.monococcum		Avena spp.	Snoopy	285
Apizaco	Cit.71,Tob.66,WS1809,Bza.55,T.monococcum		Avena spp.	Snoopy	242
M16	Cit.71,Tob.66,WS1809,Bza.55,T.monococcum		Avena spp.	Snoopy	281
Avena Spp.	Cit.71,Tob.66,WS1809,Bza.55,	Apizaco,Celaya,M16, RM1508		Snoopy	147
Snoopy		Dic-Hip,Apizaco,Celaya,M16,AHOR-2194/70,AHOR-3100/70,C1-2288,RM1508	Avena spp.		309
Cit.71		Dic-Hip,Apizaco,Celaya,M16,AHOR-2194/70,AHOR-3100/70,C1-2288,Riso	Avena spp.		503
Tob66		Dic-Hip,Apizaco,Celaya,M16,AHOR-2194/70,AHOR-3100/70,C1-2288	Avena spp.		440
Jup.73		Dic-Hip,Apizaco,Celaya,M16,AHOR-2194/70,AHOR-3100/70,C1-2288,Riso	Avena spp.		425
Bza.55		Dic-Hip,Apizaco,Celaya,M16,AHOR-2194/70,AHOR-3100/70,C1-2288,Riso,RM1508	Avena spp.		382
					TOTAL 3,014
Summer 1976					
Dic-Hip.	Cit.71,CMH74.540		Avena spp.	Snoopy	241
Apizaco	Bza.55,Jup.73,Cit.71,Mexi.75		Avena spp.	Snoopy	192
M16	Bza.55,Cit.71		Avena spp.	Snoopy	256
Celaya	Bza.55,Jup.73,Cit.71.Mexi.75		Avena spp.	Snoopy	213
Avena spp.	Bza.55,Cit.71	M16			190
Snoopy		M16,Dic-Hip,Trifure PA52	Avena spp.		242
Cit.71		M16,Dic-Hip,CM67-Centeno	Avena spp.		189
Za.75		M16,Dic-Hip.CM67-Centeno	Avena spp.		160
Jup.73		M16,Dic-Hip,OC-712	Avena spp.		220
Tetras-CM1577		M16,Dic-Hip,C1-2288	Avena spp.		120
					TOTAL 2,143

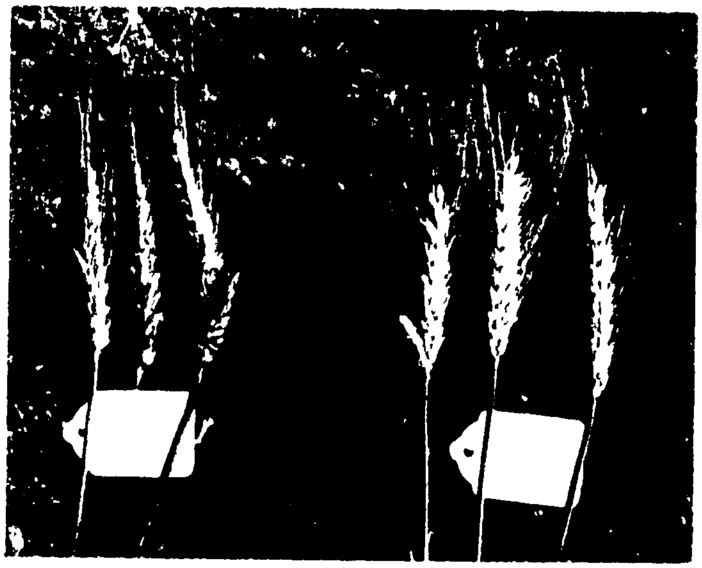


Figure 1.9.1 The branched wheat Super X is shown on the left and Super X normal is located on the right. The spikes were developed under conditions of full competition in the Yaqui Valley, Sonora.

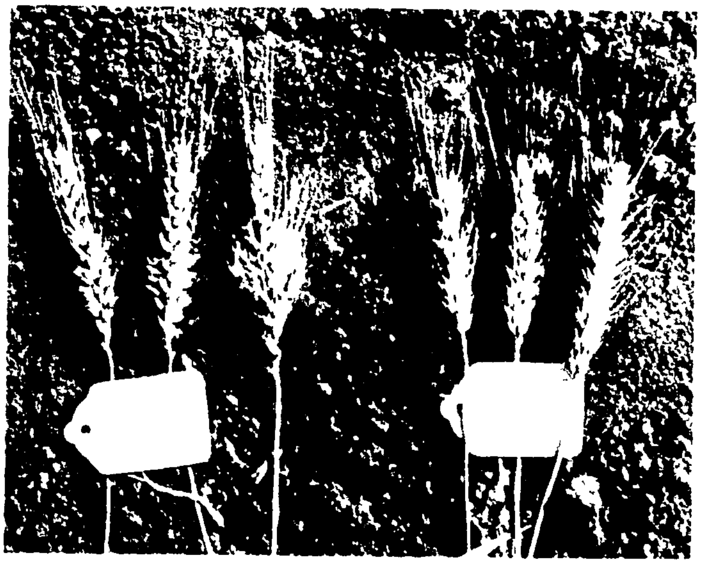


Figure 1.9.2 The picture shows the branched wheat of Cajeme 71 (left) and Cajeme 71 normal (right). The spikes were developed under conditions of full competition in the Yaqui Valley, Sonora.

1.10 International Nurseries

In 1976, collaborating scientist in 95 nations planted over 1575 trials of wheat, triticale and barley nurseries distributed by CIMMYT, figure 1.10.A. The total weight shipped by air, was 4.5 tonnes. A nursery consists of a set of varieties or lines. Identical sets are sent to scientists in numerous locations. The results reveal the adaptability to different ecological conditions and the breath of disease resistance. Data from one year of multilocation testing cannot be equalled by decades of testing at one location. The nurseries are also a means of distributing germ plasm. Local breeders may use an entry to cross with local varieties, or make selections from or multiply the entry for release to farmers. Collaborators can freely use any entry in any nursery. When directly released as a commercial variety, the country of origin should be recognized. Varieties derived from these nurseries and released for commercial production, cannot be protected under patents or plant-breeders' rights legislation.

TABLE 1.10.A Bread wheat, durum, triticale and barley nurseries distributed in 1976.

	Bread Wheat	Durum	Triticale	Barley
NORTH AMERICA	64	20	44	11
Canada	16	2	11	4
USA	48	18	33	7
LATIN AMERICA	186	59	127	41
Argentina	24	19	24	3
Bolivia	2	-	4	8
Brazil	34	9	28	2
Chile	16	9	15	3
Colombia	2	-	3	-
Costa Rica	4	1	1	-
Cuba	1	-	1	-
Dominican Rep.	4	-	1	-
Ecuador	13	3	11	6
El Salvador	1	-	1	-
Guatemala	9	-	4	2
Guyana	3	-	1	-
Honduras	2	-	1	-
Jamaica	2	-	1	-
Mexico	36	9	13	7
Nicaragua	4	1	3	-
Paraguay	7	-	1	1
Peru	17	7	13	8
Puerto Rico	1	-	-	-
Uruguay	3	1	-	1
Venezuela	1	-	1	-
EUROPE	59	46	59	15
Albania	-	1	-	-
Austria	1	6	1	-
Belgium	2	-	-	-
Bulgaria	2	4	3	2
Czechoslovakia	2	-	-	-
Denmark	-	-	-	1
England	5	2	2	-
Finland	2	-	1	1
France	3	2	8	-
Germany	2	1	2	1
Greece	2	2	1	1
Hungary	2	-	4	-
Ireland	1	-	-	1
Italy	1	7	1	-
Malta	1	-	-	-
Netherlands	6	1	1	2
Norway	3	-	3	-
Poland	2	4	8	1
Portugal	4	3	2	1
Rumania	3	3	2	1
Russia	3	1	1	-
Spain	5	6	6	2
Sweden	2	1	6	-
Switzerland	-	-	4	-
Yugoslavia	5	2	3	1
AFRICA	124	63	80	32
Algeria	12	16	10	5
AFRICA (cnt'd)				
Cameroon	4	1	2	-
Chad	2	-	-	1
Egypt	18	12	8	6
Ethiopia	9	8	13	1
Ghana	3	1	2	1
Kenya	10	7	11	4
Lesotho	2	-	1	-
Libya	4	4	2	2
Malawi	2	-	1	-
Mali	3	1	-	-
Morocco	1	1	1	1
Nigeria	7	2	3	2
Senegal	2	-	1	1
Somalia	3	1	2	2
South Africa	15	3	11	3
Sudan	8	1	5	-
Tanzania	3	-	2	-
Tunisia	8	7	2	4
Uganda	1	1	2	-
Zaire	2	-	1	-
Zambia	9	1	2	1
MIDEAST	84	68	44	32
Cyprus	3	5	2	5
Iran	17	9	6	5
Iraq	8	7	6	2
Israel	10	4	5	-
Jordan	9	11	5	5
Saudi Arabia	3	3	2	2
Syria	8	9	4	3
Turkey	16	12	10	5
N. Yemen	4	2	2	1
S. Yemen	2	2	-	2
EAST ASIA AND OCEANIA	138	50	97	35
Afghanistan	8	1	3	2
Bangladesh	5	2	3	4
China	24	2	6	2
India	29	26	31	8
Indonesia	1	-	1	-
Japan	4	-	2	1
S. Korea	9	-	5	7
Nepal	7	2	9	4
Pakistan	25	11	21	5
Philippines	3	1	1	-
Sri Lanka	4	-	-	-
Thailand	2	1	1	-
Australia	11	2	12	1
New Caledonia	3	-	-	-
New Zealand	3	2	2	1
Total	655	306	451	166

1.11 Training

During 1976, thirty nine young scientists from twenty two nations received training at CIMMYT. In table 1.11.A, the number of trainees are listed by country who have received in-service training at CIMMYT since 1966. The training programs last 3-9 months and they aim to develop skills in field and laboratory techniques, to give experience in working in an interdisciplinary team, and to improve the understanding of agricultural developments in relation to wheat production.

1.11.1 FARM TRIALS

In 1976 the curriculum for production (agronomy) was modified to give the trainees more experience in deriving recommendations from sound on-farm trials.

The trainees helped CIMMYT agronomists and economists survey the grain farmers of the high plateau in the vicinity of CIMMYT headquarters. They gathered information on costs of inputs and prices of grains from farmers and dealers. They investigated farming practices and collected data on rainfall and frosts.

From this information the region was divided into three agro-climatic zones and appropriate farm trials were designed for each zone.

Based on the survey, the trials were developed to test better methods for barley production (barley is the major cereal of the region) and to provide a comparison with wheat and triticale. The trainees installed, managed, and harvested the trials, analyzed the results, and prepared recommendations.

The basic principle of this type of training is to bring the applied agricultural technician into direct contact with the farmer and with those forces that govern the farmer as a decision maker. Having considered this environment, realistic recommendations should result.

1.11.2 VARIETY TRIALS

As part of the farm demonstration in the high plateau, the production trainees set out trials of wheats and triticales to test their performance under low and erratic rainfall and a short growing season.

These trials emphasized the need for earlier maturing triticales. Some early-maturing triticales were selected from the trials and will be tested again in 1977. One wheat, Tesopaco, was early enough and yielded well.

1.11.3 NATIONAL TRAINING PROGRAMS

The CIMMYT training staff helped Ecuador set up a national training program in 1976. Two Ecuadorians who were CIMMYT trainees during 1975 form the nucleus of the program. A CIMMYT training officer helped the ex-trainees develop a curriculum and helped analyze current research in Ecuador to plan simple farm-level trials.

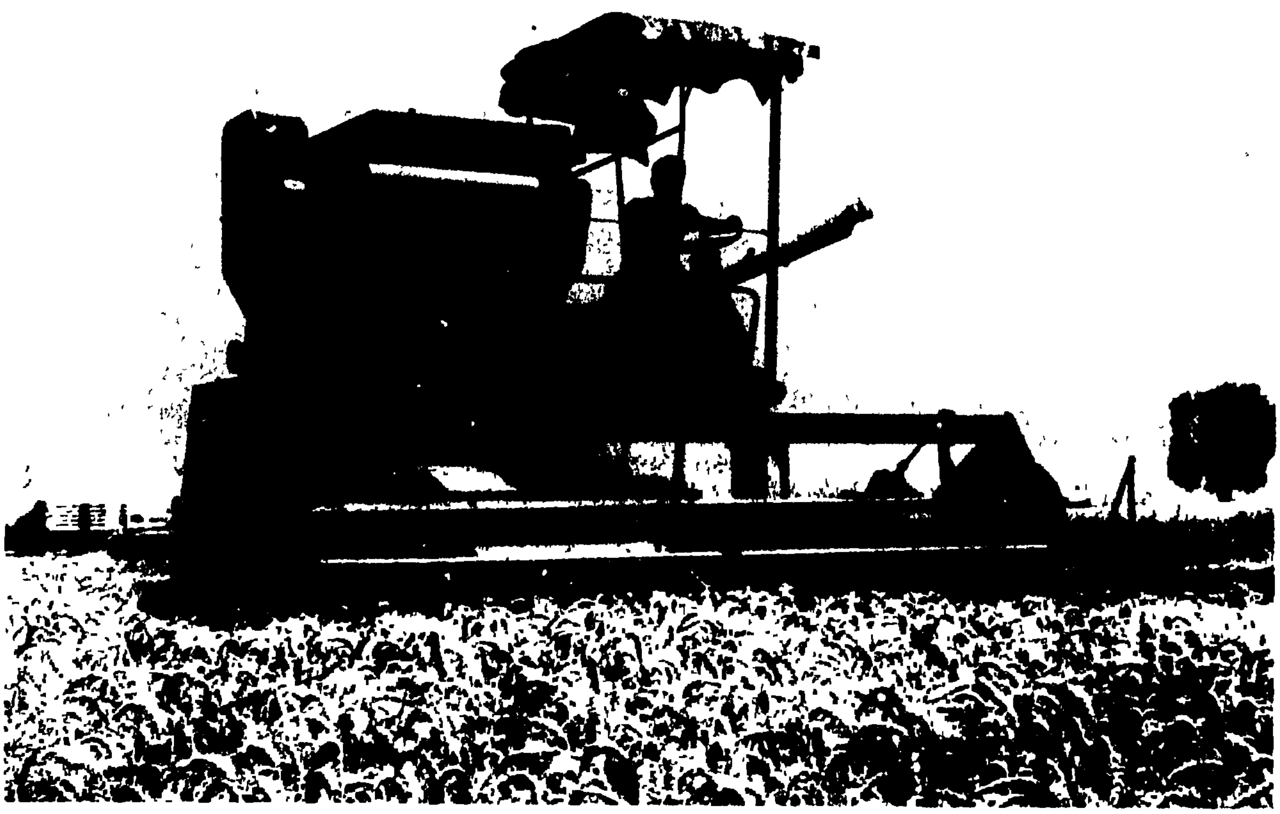
The Ecuadorians conducted a 3-month training course for 20 extension agents who work with small grains. CIMMYT communications and economics staff members provided guest lectures during parts of the course.

Ecuador has now started an in-service training program within its research institute and hopes to provide training in a wide array of subjects.

CIMMYT expects to aid more national training programs in the future and it has increased the size of its training staff in order to be able to respond to requests for assistance.

TABLE 1.11.A Wheat in-service trainees 1966-76 by countries and regions.

	1966-76	1976		1966-76	1976
Latin America	73	13	Yemen	3	0
Argentina	12	0			
Bolivia	2	0	Africa, South of the Sahara	33	6
Brazil	17	2	Ethiopia	9	2
Chile	6	1	Kenya	6	1
Colombia	4	1	Malagasy	1	0
Dominican Republic	1	0	Nigeria	11	2
Ecuador	9	1	Somalia	1	0
Guatemala	5	1	Tanzania	3	0
Honduras	1	1	Zaire	1	0
Mexico	3	2	Zambia	1	1
Panama	1	0			
Paraguay	3	1	South & Southeast Asia	67	9
Peru	8	2	Afghanistan	13	2
Uruguay	1	1	Bangladesh	14	6
			India	5	1
North Africa & Near East	145	8	Nepal	4	0
Algeria	38	3	Pakistan	31	0
Cyprus	1	0			
Egypt	7	1	Other Countries	23	4
Iran	8	0	France	1	0
Iraq	4	0	Hungary	1	0
Jordan	3	0	Korea, South	6	1
Lebanon	4	0	Poland	3	0
Libya	4	0	Portugal	1	0
Morocco	17	0	Romania	2	0
Saudi Arabia	1	0	Spain	2	0
Sudan	3	0	USA	4	3
Syria	4	0	USSR	3	0
Tunisia	22	0			
Turkey	26	4	Total	341	39



Mr N Benattalah, a trainee from Algeria learning harvesting technology at CIMMYT, El Batan, Mexico

1.12 Wheat Quality

In 1976, the Wheat Quality Laboratory at CIMMYT evaluated 40,000 lines from the F_3 and F_4 generations for grain type. Approximately fifty per cent of these lines was discarded because of undesirable grain characteristics. Only those with plump clean grain were evaluated by the micro-Pelshenke test for gluten strength, on an individual plant basis. Only acceptable gluten strength lines in corresponding identical grain type (hard or soft wheat types) were replanted.

A total of 1204 lines of advanced bread wheat material was evaluated. This material included high yielding lines, the crossing blocks, the 10th International Bread Wheat Screening Nursery (IBWSN), observation lines and the winter-spring crossbreds selected in Oregon, U.S.A.

The high yielding material from replicated yield trials was first checked for grain type and test weight. Lines with good grain and high test weight were selected for a complete quality examination which included milling quality, flour protein, mixogram, alveogram, sedimentation and baking test. From this material, some lines with outstanding quality characteristics were incorporated into the crossing blocks for use as progenitors in subsequent crosses. Also, the best material was selected on the basis of agronomic characteristics, yield and disease reactions, for inclusion in the 11th IBWSN.

Each year, detailed quality characteristics of all varieties in the parental crossing block are determined to aid the planning of new crosses. This parental crossing block classification is very important in the international program because it permits the crossing and selection of lines suitable for the needs of different countries.

The spring x winter material grown and selected at Oregon State University was found to be a very good source of lines with weak elastic gluten. From this material, some lines were selected and included in the crossing block to correct the gluten tenacity in the breeding material. (See table below.)

TABLE 1.12.A Quality Data for Spring x Winter material harvested at Oregon State University.

Lab No.	E.O.	Variety or Cross	Pedigree	Pk Min.	Prot. %	Sed. cc.	Alveogram W.	Alveogram P/G.	Loaf vol.
8643	37	PQF/C6301/NAI/3/ANZA	SWD 70059-01W-1P-1H-0P	72	12.8	39	165	2.0	880
8644	38	STC/CLLF//Cno//INIA/3/BBS	SWD-70150-04W- 1P-2H-0H	120	10.9	44	168	1.6	915
8647	41	CLEO/HN IV//PCH/3/BBS	SWD-70318-03W-1P-3H-0P	57	11.2	37	103	1.0	905
8650	44	CLLF/BEZ/3/SV92/CI-13645//NA1	SWD-70328-06W-2P-3H-0H	74	9.9	43	178	1.8	840
8656	51	HK/38MA//LOH/DIRK	SWD-70417-04W-2P-1P-0H	92	11.1	39	170	1.9	925
8657	52	HK/38MA//LOH/DIRK	SWD-70417-04W-2P-3H-0P	95	11.1	42	200	1.5	925
8660	55	LFN/EDCH	SWD-70458-02W-1H-2H-0H	97	12.1	44	185	1.7	905
8693	88	D6301/NA1/FN/3*TH/4/ K58/N/MY54/N60D/ANS	SWD-70341-08W-2H-0P	93	11.1	39	157	1.4	840
8694	89	DFN DW/LR//NAR59/4/ MY54/N10B/LR/3/MD/4B	SWD-70676-04W-2P-0P	83	11.1	36	148	1.2	880
8801	197	INIA 66R//SAMBO/HN1V	SWD-71220-31H-01H-0P	96	12.1	43	231	2.9	840

E.O. = Entry Oregon 1975-76
Pk = Pelshenke (minutes)
Prot. = Protein
Sed. = Sedimentation
Alveogram W = Indicates gluten strength
Alveogram P/G = Dough tenacity/dough expansion

1.13 Regional Wheat Disease Surveillance Program

1.13.1 INTRODUCTION

The CIMMYT Regional Disease Surveillance Program operated from Ankara, Turkey and Cairo, Egypt. The program continued to emphasize that national programs need to develop a competence in assessing the vulnerability of winter cereals (wheat and barley) to epiphytotics and other possible calamities,and to establish some probability frequencies of occurrence and relate all this to the national objectives.

In a number of countries the awareness of the vulnerability to epidemics is accepted, but the development of trained manpower or facilities are limiting factors to implementing a program. In other cases, the understanding of the potential destructive nature of epidemics is not yet fully appreciated. There are also situations where the country concerned is sufficiently small in area that within the national borders a proper assessment of epidemic potentials is not possible. This is especially true for those diseases, such as the cereal rusts, which can be initiated from a distant exodemic source. Such cases demand a strong cooperative effort between nations and the development of a system which collates the information in order to obtain judgment values on the vulnerability of a given commercial variety.

The regional network assists in the gathering of this type of information and communicates this to the national and international programs concerned. The current predicative abilities are centered on skills to assess diseases and to relate this to recommendations concerning commercial varieties, new potential varietiés and on the early identification and incorporation of sources of resistance.

For the past six years the regional disease surveillance program has used a two nursery system in cooperation with the national program to determine the possibilities and feasibilities of establishing parameters for disease occurrence and intensity. There has also been a strong effort to measure genetic virulence changes in the pathogen, and to determine the significance of these changes to the commercially cultivated varieties of wheat and barley. The host population measurements have been limited to those varieties which occupy at least 100,000 hectares. It could be argued that these limits are too high, but additional experience should allow for future adjustments.

A capability, which is now being developed, to establish probability curves for disease frequency is limited to certain areas where CIMMYT is involved or where strong program capabilities exist.

1.13.2 REGIONAL DISEASE AND INSECT SCREENING NURSERY (RDISN)

This type of nursery was first commenced in 1970-71. It was developed from the concept that in this diverse region the pattern of disease attack on commercial wheat varieties was sufficiently different to provide valuable information concerning their possible vulnerability. It was also known that there were areas where severe epidemics occurred with high frequency. At these locations new races (virulences) were also frequently observed at an early date. These new virulences often became the prevalent and wide spread races that had epidemic potential. On occasion an epiphytotic did occur on commercial varieties from just such situations. It was decided that by testing varieties and advanced breeding lines in diverse areas and so-called "hot spot" locations, advanced information could be provided on the potentially new problems. This would permit the additional time needed to identify and initiate a programme of breeding for resistance to new virulences in many cases. The RDISN nursery has continued to focus on this phase of monitoring for new races (virulences) and has supplied valuable information on sources of resistance to a number of diseases.

The RDISN has also been strongly coordinated with the ALAD Regional Program on winter cereals which has concentrated its efforts in identifying superior germ plasm for the areas of Western Asia and North Africa. The germ plasm base represents screening efforts involving materials generated by national programs throughout the area. This germ plasm represents the varieties and lines judged superior and of potential commercial value. The regional program has also made heavy use of CIMMYT's germ plasm base. Other sources of germ plasms are derived from Oregon State University and CIMMYT's winter x spring wheat crosses and the Nebraska winter wheat and high protein varietal development program. Numerous other institutions are also contributors.

The Regional Nurseries such as the Preliminary Observation Nursery for Bread Wheat (PON - BW), Durum (PON - D), Rainfed (PON - Rf) and Barley (PON - B) utilize the data from the RDISN to select entries for this screening nursery. As mentioned earlier, the majority

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* CIMMYT assists the national programs of the Mediterranean-Middle East region and Asia in their pathology research programs through the assignment of CIMMYT scientists.The CIMMYT involvement is financed by a grant from the Government of the Netherlands.

of the entries in the RDISN are contributions from national programs or selections made from international nurseries based on previous observations. This provides a foundation for a more effective promotion system and only the superior lines with adequate levels of disease resistance are advanced.

The Regional Wheat, Barley and Rainfed Yield Trials further use the PON and RDISN data to select candidate entries for promotion from the PON to the yield trials.

The Regional Crossing Block for Bread Wheat, Durum and Barley also utilizes the RDISN data for composing the sections on sources of disease resistance in the nursery. This insures that the best sources of resistance are re-cycled and made available to the national breeding programs. All the data summaries are incorporated into the crossing block field books as well.

1.13.3 REGIONAL DISEASE TRAP NURSERY (RDTN)

It was officially initiated in 1971-72. There were three national programs (Egypt, India and Turkey) which had developed a trap nursery system for their own program needs. Some of these nurseries were distributed to neighbouring countries. There were also several European disease screening nurseries being distributed on an area basis. The RDTN was broadened in its scope to encompass the individual specialized nurseries which were being distributed in the region from Bangladesh to Morocco.

There was also a growing need to generate information on the population dynamics of host-parasite systems and this required a unified nursery system, especially for wheat which is grown extensively and under diverse conditions. Special emphasis was given to the wheat rust diseases which are capable of international movement by wind.

The surveillance program has been focusing its attention on the national programs through the use of the RDTN. The goal is to assist or help establish national wheat disease surveillance programs which can be useful in minimizing the potential loss caused by epidemic diseases. It is hoped that the following specific objectives can be achieved through the effective use of the RDTN:

(1) To monitor and establish disease development probability curves for each of the major wheat growing areas.

(2) To determine the virulence spectrum of the pathogen populations within the region and determine their distribution relative to sources of available resistance.

(3) To determine the influence of commercial varieties on the inoculum potential of pathogen populations.

(4) To provide information on varieties which are potentially endangered and should be withdrawn from commercial production.

(5) To detect new changes in the virulence patterns at the earliest possible date and determine the potential importance of these shifts.

(6) Characterize sources of resistance to the new evolving virulences.

(7) To assist in mapping the movement and geographical spread of diseases especially those diseases which transcend international borders.

(8) Determine the environmental or geographical features that limit or confine disease spread and development.

The RDTN system coordinates its efforts with the European rust nurseries which have a broad base of operations throughout Europe and in other areas of the world.

The present working operation is to use the RDTN as the basis for monitoring and developing the information on population dynamics in the field. The laboratory or glasshouse analysis on virulence identification is divided as follows:

Yellow rust (<u>Puccinia striiformis</u>) collections are sent to Wageningen, the Netherlands. Determination of the virulence pattern from any given location can be compared with other collections. This allows judgments to be made concerning similarities in populations depending upon evolution of the pathogen or the use of common sources of resistance in the host. In other cases the analysis can separate or distinguish sources of resistance. The combined information from the analysis and the field help to determine whether we are confronted with an evolution in the pathogen or a migratory process. In some cases convergent evolution occurs depending upon the host plant bases of resistance.

The analysis for leaf rust (P. recondita) is currently being done at Novi Sad, Yugoslavia and stem rust (P. graminis) in Cairo, Egypt. The identification of other wheat and barley diseases has been carried out by several institutions but now most samples are being identified at Tunis, Tunisia.

1.13.4 AVERAGE COEFFICIENT OF INFECTION (ACI)

In the past few years a number of valuable sources of resistance have been identified to individual diseases. In the case of bread wheats there are now selections with good levels of resistance to the three rusts, and sometimes resistance to other diseases as well. The entries in the 6th RDISN 1975-76 (Bread wheats) with an Average Coefficient of Infection (ACI) of 2.0 or less to each of the three rusts are listed in table 1.13.A.

To reduce the number of entries and to ensure a high level of resistance, an ACI of 2.5 or less was used as the selection basis, although lines with an ACI up to 5.0 are considered resistant. Frequently the ACI is not fully understood by scientists but CIMMYT has found it to be a useful method to rank or rate varieties. This method of analysis was developed for the International Rust Nurseries distributed by the United States Department of Agriculture. In brief, the field scores for the three rusts are scored in the classical manner giving the severity on a modified Cobb's scale along with the field response. These scores are then converted to a coefficient of infection in the following manner: severity (per cent of plant surface covered by rust) as a whole number multiplied by an assigned constant value for the field response. The following field responses have been assigned the following constant values:

Field Response	Symbol	Constant Value
Resistant	R	0.2
Moderately Resistant	MR	0.4
Mesothetic or X	M	0.6
Moderately Susceptible	MS	0.8
Susceptible	S	1.0

If the following scores are noted for a variety at four different locations, the conversions that occur are:

Location	Score	Severity	x	Constant	=	CI
1	TR *	1	x	0.2		0.2
2	5MR	5	x	0.4		2.0
3	10MS	10	x	0.8		8.0
4	20S	20	x	1.0		20.0
					Total	30.2

Average (ACI) = 0.2 + 2.0 + 8.0 + 20.0 divided by 4 = 7.6

* In case of Trace Infection (T), a severity of one per cent is assigned for convenience.

In the 6th RDISN 1975-76 and in 1974-75 the following check varieties were used at each 20th hill number: Penjamo 62, at 20, 120, 220, etc.; Pitic 62 at 40, 140, 240,etc.; Barani 70 at 60, 160, 260, etc.; Mexipak 65 at 80, 180, 280, etc.; Haurani 27 (Durum) at 100, 200, 300, etc.

The ACI scores of the check varieties for the years 1975-76 and 1974-75 were:

Disease	Pj62	Pi62	Bar70	Mxp 65	Haur27
1975-76					
Leaf Rust	20.8	33.6	53.3	45.0	24.0
Stem Rust	5.1	6.4	6.4	7.4	39.4
Yellow Rust	34.5	22.4	20.4	34.4	10.3
1974-75					
Leaf Rust	10.0	30.5	58.1	42.3	20.6
Stem Rust	13.7	14.4	17.8	4.7	21.4
Yellow Rust	33.2	14.9	12.3	23.3	7.5

Abbreviations used:

Pj62 = Penjamo 62; Pi62 = Pitic 62; Bar 70 = Barani 70;
Mxp 65 = Mexipak 65; Haur 27 = Haurani 27 (Durum Wheat)

Information such as the above is useful when comparing varieties, locations or years.

During the 1975-76 season there were 5 yellow rust, 13 leaf rust, 10 stem rust test sites with high levels of rust infection. The locations with the severest test for yellow rust were Izmir, Turkey and Beja, Tunisia. For leaf rust Obregón, México and Sakha, Egypt were the most severe while stem rust was more severe at Njoro, Kenya and Izmir, Turkey. This is reflected in the comparative ACI scores posted for the check varieties as well as the mean ACI for the locations, in respect of yellow rust (YR), leaf rust (LR) and stem rust (SR), which were:

Disease	Location	A. C. I. of Check Varieties				
		Pj 62	Pi 62	Bar 70	Mxp 65	Haur 27
YR	Izmir	66	20	17	42	10
	Beja	28	22	31	48	13
LR	Obregon	15	53	97	63	8
	New Delhi	31	50	76	55	19
SR	Njoro	40	47	33	35	50
	Izmir	53	28	57	9	83

This can be further segregated and a comparison of the difference between the bread wheats, durum wheats and bailey can be made. The number of entries with low A.C.I.'s are much more frequent in bread wheats, followed by durum wheats and then barley.

In table 1.13.B the best rust resistant durum wheats are listed. Here the selection criteria was an ACI of 10.0 or less for stem and leaf rust, and an ACI of 5.0 or less for yellow rust. The groups included resistance to three rusts and resistance to two of the rusts.

In the case of barley, combined disease resistance does not occur very frequently and the data are not as abundant. In table 1.13.C., the lines selected for yellow rust resistance are listed. Because of the many diseases and limited testing so far done on barley some of the more commonly available lines and their resistance to the different diseases are listed in table 1.13.D. This information represents data from several years of RDISN data. The large difference in the ACI between the crops could be a reflection of the total research effort committed to the three crops.

The ability to provide information on varieties is dependent upon good cooperation with national program operations. During the year two workshops were organized on wheat diseases with the assistance of the Royal Government of the Netherlands. The workshops were primarily concerned with the techniques and equipment which are available for the creation of artificial epidemics with the cereal rusts. Through the effective use of these methods a more efficient screening procedure for resistance will be possible, and gradually result in a reduction in the possibilities of a serious epidemic occurring. The workshop concentrated on the methods for collecting, increasing, inoculating, storing and evaluating the rust pathogens. Through the courtesy of the Dutch Government it was possible for CIMMYT to provide the necessary equipment to each trainee representing a major breeding center. The workshops included lectures on principles and field practicals for the laboratory sessions. Each workshop ran for a 12 day period. The first workshop was held in India in February with 13 participants. Included were two trainees from Nepal and Afghanistan. The second workshop was held in Pakistan and 32 trainees attended. A complete report summarizing the workshop experience was submitted to the Dutch Government.

TABLE 1.13.A Bread wheat lines with an Average Coefficient of Infection (ACI) of 2.5 or less to the yellow rust (YR), leaf rust (LR) and stem rust (SR) in the 6th Regional Disease and Insect Screening Nursery (RDISN), 1975-76.

Serial No.	6th RDISN En No.	Variety or Cross	Pedigree	A.C.I. YR	A.C.I. LR	A.C.I. SR
1	3	Bb-Tob66	II34470-4y-1m-5y-1m-0y	2.0	2.0	0.1
2	6	Tob'S'-8156xCC-Inia	CM1208-1y-6m-2y-3m-0y	0.0	0.1	0.1
3	7	Tob'S'-8156xCC-Inia	CM1208-1y-6m-6y-1m-0y	0.1	0.4	0.0
4	9	Brochis 'S'	CM5872-B-8y-1m-2y-4m-0y	0.5	0.9	0.2
5	10	Brochis 'S'	CM5872-C-1y-5m-1y-3m-0y	1.0	1.1	0.1
6	13	IWP 50		0.7	0.3	0.1
7	14	Mexicani-15·Tob	CM4274-2y-1m-3y-1m-0y	0.1	0.6	0.1
8	16	Son64-KlRendxCno-CC/Tob	CM5359-1y-3m-2y-3m-0y	0.5	0.2	0.2
9	18	CCxCal-Sr	CM10630-45y-2m-0y	0.0	0.1	0.1
10	27	Wisc245-[illegible]-Pilot/Tob66	6649-2	0.2	1.4	0.1
11	28	Tob-8156	22964-3y-5m-0y-501y-0m-501tz-0L	0.2	1.2	0.1
12	31	Rfn^{2}xLee/Fn-Kt52A	Ch10596-4p-3p-5p-1p	0.3	1.3	0.1
13	39	Bb'S'-Tob66	26599-2t-14m-1y-0a	0.1	0.8	0.8
14	42	Pb^2-MgE	RL 4219	0.1	0.2	0.3
15	46	Inia-CnoxCal/Tob-NP832	CM1291-2mb-1bj-0bj	0.1	0.2	0.3
16	48	Tob'S'-Tob66	CR39-E-27	0.1	1.3	0.1
17	89	CI8154-Fr^{2}xTob66^3	6671-1	0.2	0.9	0.1
18	90	Bb-Cal	30877-301m-500y-2tz-0L	1.1	0.1	0.1
19	104	RfnxRfn^2-Pj62'S'	A-3797-8p-3p-9p	0.0	0.2	0.1
20	119	CI14361	CM10604-2p-2p-1p-1p	2.1	0.1	0.4
21	123	((908-Fr)^2/4160xYt54Ex CI4^2)xofn)xCT/Ch16bxK. FxL-N/M^2-ME)Fr	A3532-10p-1p-3p	0.1	0.4	0.3
22	128	Brochis'S'	CM5872-C-1y-1m-3y-2m-0y	0.1	1.8	0.4
23	131	Son64-TzppxNai60/Tzpp-An64	22373-2m-1y-3m-3t	0.1	0.1	0.1
24	152	CI14301	II7756-2r-5m-2r-2m	0.1	0.1	0.1
25	161	Cno'S'-Cpo x Sr	CM4719-28y-7m-0y	0.0	0.1	0.1
26	169	BbxCC-Cno^2/Tob-8156xBb	CM5793-G-8y-1m-1y-1m-0y	0.1	0.7	0.8
27	170	BbxCC-Cno^2/Tob-8156xBb	CM5793-G-8y-1m-1y-2m-0y	0.0	0.4	0.8
28	175	Tob'S'-8156xCC-Inia	CM1208-9y-6m-2y-1m-0y	2.1	1.1	0.4
29	179	IWP 16		0.6	0.1	0.1
30	184	Gallo-AustII61-15.7xCno-No66	34920-27y-4m-1y-2m-3y-0m	0.4	0.9	0.9
31	185	Cno'S'-IniaxLfn/TobxKl.Pet-Raf	CM2281-13m-1y-3m-1y-1m-0y	0.5	0.1	1.1
32	187	Cno-Son64xBb-Inia/TobxCC-Pato	CM8220-a-8m-1y-9m-0y	0.4	0.5	0.1
33	190	M2(4777/ReixY-Kt)	A5516-1p-2d-1d-0h	0.1	0.1	0.1
34	205	CI7155-Tob66	6645-2	2.1	0.3	0.7
35	206	Wisc245-FKNxCI8154-Fr^2/Tob66^2	6661-53	2.1	1.4	0.1
36	208	SRPC527-67xCI8154-Fr^2/Tob66^2	6662-5	0.2	0.1	0.1
37	211	HD 220°		0.6	0.4	0.4
38	217	RR68-WW15/Bj'S'-On^{2}xBon	CM12273-A-2y-7m-0y-0bk	2.0	0.8	0.4
39	218	Romany	Code/70 = 12	0.1	0.6	1.1

TABLE 1.13.A (Continued)

Serial No.	6th RDISN En.No.	Variety or Cross	Pedigree	A.C.I. YR	LR	SR
40	224	Inia67-Cal x Inia-CC	28647-6d-1d	1.6	0.3	1.0
41	230	Kl.Pet.Rafx8156R		0.1	0.5	0.2
42	243	K. Sungura		0.7	0.8	0.1
43	244	K4328 D.I.A.2		1.7	0.3	0.1
44	245	K6290/9	AFMxRom^2(Kenya)	1.4	0.1	1.0
45	250	Nova Prata		0.1	0.5	0.5
46	258	Fn-K58/N(Fr.KAD/Gb)^2	II14239-5t-1b-1t-2b	0.5	1.1	0.3
47	259	Cno-7C.CC-Tob66	25918-20y-5m-4y-0m	0.3	1.8	0.8
48	274	Rfn^2-908/FnKl-2824-TFS (Cfn x Tob-8156 (R)	D-69/71-5L-3L-0L	1.8	0.3	1.6
49	278	Cno'S' - No.66 x Ska	34166-23y-7m-6y-0m	1.4	0.2	1.0
50	292	Soty	18888-103M-100Y-100M-100Y-101C-1Y	1.7	0.2	0.1
51	297	Cno"S"-Inia"S" x Lfn/ Tob-Kl Pet Raf	CM 2281-1mb-4Bj-0Bj	1.4	0.2	1.7
52	299	(CC-Inia)(Son64-Knott 2 x Kl Pet Raf)	30882-3Bj-5Bj-7Bj	0.1	1.5	0.1
53	343	Webster x II-62-16	Line 34 - 2	1.1	0.2	1.1
54	363	Ias 20-Pato	CM7478-6Bj-14Bj	0.0	0.3	0.4
55	453	Bb-Inia x 7C-Nad	CM-15365-5K-2J-0R	2.0	0.3	0.4
56	486	HuR^{2}xMy54Ex(Son64^{2}xTzpp-Y54/Am64A)	CM-15911-1K-2J-0R	1.3	1.4	0.8
57	494	Novafen		1.6	0.8	1.6
58	499	((/ (908/Fn)^{2}4160-Pi"S"xC16^2/ Cofen)14777-Rq-YIRT)Gte	CM-2155-13S-11S-0S	0.6	0.6	0.1
59	502	Tac-Bb	33935-500Y-1S-0S	0.3	0.6	0.1
60	506	II-12300-Tob66XCno"S"		0.2	0.1	0.1
61	509	Tob "S"-8156	22964-3Y-5M-0Y-501Y-0M	1.6	0.8	0.1
62	546	Hna R^2/My54-N10B	8834-8Y-2e-1Y-101e	1.3	1.0	2.0
63	618	(Cno"S"-Son64/NP880-Pj62x Cal)Cno"S"-Gallo	CM7669-6S-2S-0S	2.0	0.6	0.8
64	644	Kavkaz/Cno-Chris x On	SE-375-12S-3S-0S	0.6	0.1	0.1
65	796	Bb-Tob(Cno/No66/C273xNp 875.E.853-5-3)2B	CM2699-12m-1y-5m-2y-4m-0y	0.3	0.5	0.2
66	833	Cal-Lundi	CM1076-19M-3Y-8M-2Y-502M-501Y-0M	0.0	1.4	2.0
67	842	Yr x Son 64-NY 5207.85/ cno "S" - 7C x Gto	CM8671-B-5M-1Y-2M-2y-0M	0.5	0.5	0.1
68	948	Inia 67 x Cno-Chris	CR 70-El	1.3	0.5	0.0
69	954	Dougga 74	27997-4Y-100M-300Y	1.3	0.1	0.4
70	966	Bb(Son 64-An64 x Nad/Jar'S'	34795-5y-1m-3y-0m	0.1	1.3	0.8
71	977	Cno-Bb x Cal (7C/Lib 64-Inia x Inia-Bb)	CM5872-C-1Y-1M-1Y-1M-0Y	2.0	1.5	0.1
72	990	Cno'S'-Inia x Lfn/Tob x kl.Pet.Raf.	CM2281-13M-1Y-3M-1Y-1M-0Y	0.1	1.8	0.4
73	997	CC x Cal - Sr	CM 10630-45Y-2M-0Y	0.1	1.6	0.2
74	1045	Tob'S'-8156 x CC-Inia	CM 1208-1Y-6M-6Y-1M-0Y	2.0	0.4	0.1
75	1105	CC-Crespo x Cfn - Pj 62	25949-9Y-1M-1Y-0M	0.1	0.1	1.2
76	1175	Ron-Tob "S"	CM 7705-3M-1Y-2M-2Y-0M	0.1	1.4	0.1
77	1178	Brochis 'S'	CM 5872-C-1Y-5M-2Y-2M-0Y	1.4	1.5	0.8
78	1186	Tob"S"-8156 x CC-Inia	CM 1208-1Y-6M-2Y-3M-0Y	2.1	1.3	0.1
79	1210	Tzpp		0.1	1.7	0.3
80	1238	90S x Fn x P14 x Adl Acc. 377	8529	0.2	1.8	0.1
81	1273	S 227 x Son 64	Jit 16-2L	0.1	1.0	0.1
82	1319	Th6-Kf x Lee-Kf/Tpn	C 987-1K-6K-0L	0.1	1.3	0.1
83	1433	Bb "S" - Tob 66	26599-2T-14M-1Y-0A	2.0	0.7	0.4

TABLE 1.13.B The best rust resistant durum wheats; varieties with the lowest average Coefficient of Infection to three rusts and to two rusts.

Group I - Resistant to 3 rusts (ACI SR 10, LR 10 and YR 5.0)

Group II - Resistant to SR and YR (ACI SR 10 and YR 5.0)

Group III - Resistant to SR and LR (ACI SR 10 and LR 10)

Group IV - Resistant to YR and LR (ACI YR 5.0 and LR 10)

GROUP I

Serial No.	Variety or Cross Pedigree	Source 6th RDISN Durum
1	Golden Ball	1511 *
2	H.Rojo x Haurani	
	ABS-L G60-42L D 77	1522
3	E 3725-Cp^3/Gz-4777^{2}xA4050-1P-1P-5P Pj 'S'	1523
4	USA IVA S.716	1537
5	Cfn(Lan/Dwarf, F4Lan)	1548
6	Jo 'S'/LD 357$_E$-TC^{2}xGll'S'	
	D 27572-2CM-3Y-3M-1Y-OM	1619
7	E 3728-Cp^3/Gz x ((Yt54-N10B.21.1c)xCp^3/Gz)	
	TcD4090-17P-2P-1P	1651
8	Al'S'(By$_E$^{2}-Tc x Stw63/AA'S')	
	D27591-5M-3Y-1M-OY	1652
9	Brant 'S'	
	D 24102-10Y-3M-100Y-OM	1662
10	AA 'S' - Cr 'S' x Cit 'S'	
	CM 10182-7M-OY	1665
11	(Stw 63-Gll 'S'/CI 8133-2bxCPT8)(Gs'S'/D.Buck x	
	TMe-Tc^2/Lak)	
	DM 71-126-OBk	1667
12	[Gu'S'(Br180-LK/62-220x61-130)]Gs"S'-AA-Gta'S'-Cit'S'	1685
13	Berkmen	1764
14	Cocorit 71	
	D 27617-18M-6Y-OM	1784
15	Jo'S'/Ld 357$_E$-Tc^2 x Gll'S') Eg'S'	
	CM 9880-25M-5Y-1M-OY	1835

GROUP II

Serial No.	Variety or Cross Pedigree	Source 6th RDISN Durum
1	Cfn(Lan/dwarf F4Lan)	
	A4590-51P-4P-2P-2P	1504
2	AA'S'(Tgle-Tc^{2}xLak/Belle-Tc^2)	
	CI 2335-13Y-7M-OY	1506
3	E 3725-Cp^3/Gz-4777^2 x Pj'S"	
	A 4050-1P-3P-1P	1509
4	Quilafen	1513
5	((21563/61-130xLDS)AA'S')(CP^{2}e-GzxTc^3/Bye^2-Tc)	
	CM 9778-5M-OY	1517
6	HD 4500	1561
7	Stw 63-Gll'S' x RD-119-1W-2Y	
	D 31759-1M-2Y-1M-OY	1574
8	(Capeiti 8 x Preto Amarela) x Oviachic	1594
9	Kobak 2916-Leeds x 6783	
	YE 0510-5E-3E-OE	1632
10	Urayik 126-61-130xKobak-2916-Lds	
	YE 0543-3E-1E-OE	1634
11	61-130-AKb 253/39	
	C 24-42E-1E-1E-1E-1E-OE	1635
12	ZF-Lds x Kobak 2916-61-130	
	YE 0521-3E-2E-OY	1637
13	Carza 'S'	
	D 22232-3M-3Y-1M-OY	1648
14	Brant'S' x Al	
	D 31695-4Cal-2L	1656

TABLE 1.13.B (continued)

15	Cr 'S' - Cr'S' CM 2912-27Y-1M-0Y	1672
16	Iran Local Durum 5415	1709
17	(Pl'S'-LD-357xYTM-Pl'S')LD 351-Th2	1714
18	[(By^2-E-Tc)(TACE-Tc^2)]x[(By^{2}E-Tc)^2(Z-BxW)] CYID 31539-3L-0L-1A-0A	1721
19	[(By^{2}E-Tc)(TACE-Tc^2)]x[(LD 357E-Tc^2)(Pl-TME xTc^2-Z-B x W)] CYID 31541-1L-0L-3A-0A	1722
20	Cuilafen D 14540-1C-1Y-1C	1767
21	Jori C-69 D 21570-9M-6R-1M	1774
22	Jo "S"-Crane "S"	1807
23	Gediz = LD 357$_E$-Tc^2-AL 'S' D 27534-1M-1Y-1M-0Y	1841
24	Z 3729-Cp^3/Cz x (4777)^2(Fn-K58/N x N10B A 4050-5P-5B-2P	1881
25	Stw63-Cll x RD-119-1W-2Y D 31759-1M-2Y-1Y-0Y	1884
26	PI 293547	1894
27	Gs'S'(D.Buck x TME-Tc^2/Lak) D 27666-4M-1Y-0M	1933
28	Jo'S' - Cr'S' D 27591-5M-3Y-1M-0Y	1946
29	Pinguino 'S' D 28984-1Y-1M-500Y-500B-0Y	1950
30	Crane 'S' CM 23055-56M-5Y-2M-0Y	1953
31	(D-67-3/[AA'S'(CPE^3-CZ x Tc^3/ByE^2-Tc])Cr 'S' CM 17975-F-1M-1Y-1M	1988
32	Cta 'S' - Gs 'S' CM 10139-36M-1Y-1M-1Y	1995
33	FLCS - CRS D.31691-43M-8Y-0M	2004
34	STW63-GLL S x RD-119-1W-2Y D.31759-1M-2Y-1M-0Y	2006
35	Maliani 8D x [(Mex. 1518 x Lobeiro) x Crane]	2008
36	Oviachic x Capeiti 8	2013
37	Ple'S'Cr'S' (Jo'S' x RD-119-2W) CM 17046-10L-1L	2025
38	Cit 71 (21563/AB x Capelli-G7) CM 17145-8L-2L	2026

GROUP III

Serial No.	Variety or Cross Pedigree	Source 6th RDISN Durum
1	Unknown	1502
2	2F - Lds/Fata Sel.185/1 x 61-130-Lds YE 0503-8B-3E-0E	1633
3	Jo 'S'(Gll'S'/61-130 x Lds) D 32364-7Y-2M-2Y-4M-0Y	1642
4	Maliani 11c	1653
5	Cocorit 'S' (Blackawns) D 27617-2M-300Y-0B	1654
6	Cocorit 'S'	1668
7	Ciane 'S'	1673
8	Gs 'S' (D.Buck x TME-Tc^2/LAK) D 27666-4M-1Y-0M	1677
9	[AA'S'(Cp^{3}E-Gz x Tc^3/By^{2}E-Tc] Fg 'S' CM 10162-9CM-1Y-0M	1681
10	(Jo 'S'/LD 357E-Tc^{2}xGu'S')Fg'S' CM 9830-25M-3Y-1M-0Y	1686

TABLE 1.13.B (Continued)

11	P.66/253	
	I 2161(7T)-3T-21T-1T-1B-2T-2T-OT	1687
12	Gs 'S' - AA 'S'	
	D 27664-9M-4Y-OM	1708
13	Capeiti	1712
14	Cocorit 'S'	1713
15	[(By^{2}E-Tc)(TACE-Tc^2)] x (BYE-Tc^5)	
	CYID 31544-1L-OL-1A-OA	
16	[(By^{2}E-Tc)(TACE-Tc^2)] x Jori 'S'	
	CYID 31546-5L-oL-4A-OA	1724
17	'emen-Cn'S' x plc'S' (Cr 11s/ByE^2/Tcy-7BW	1726
18	[(TME-Tc^2)(Z.B x W)](By^{2}E-Tc x TACE-Tc^2) Jori 'S'	
	CYID 31679-1L-O1-2A-OA	1728
19	Anhinga 'S' - Valunteer	
	CYID 31728-3L-OL-1A-OA	1729
20	(BYE^2-Tac E)II-27655-S-147x(TME)(Z.B x W^2)	1745
21	(Pi-By^2)x(Pi-ByxTc^4)B-Bai	1751
22	(Var 12-Fô)x(Oviachi)Fi x DurVZ331 Cap XVZ15oF6-27	1754
23	Amarelejo	1756 *
24	Saba	1766
25	(BY^{2}E-Tc)(TACE-Tc^2) x Crist de Chile	
	CYID 31535-5Cal-OL-3A-OA	1796
26	T.dur "Leve" x G11 x AA "S"	
	D 31679-4L-OL	1811
27	Cr'S'-D 21564 x Hercules/Pg 'S'	
	CM 17747-C-7M-2Y	1843
28	Cocorit 'S'	
	D 27617-17M-3Y-OM	1856
29	E 3728-Cp^3/Gzx((Yt54-N10B.21.1c) x Cp^3/Gz)Tc	
	D 4090-17P-2P-1P	1882
30	Reichenbochii = ED 1645 = FA 025.190	1896
31	Flamingo 'S'	
	D 27582-18M-12Y-5M-500Y-OM	1944
32	(Jo'S'/LD.357$_{E-Tc^2}$ x G11 'S') Fg'S'	
	CM 9880-25M-1Y-1M-1Y	1994

* Known to have Septoria tritici resistance

GROUP IV

Serial No.	Variety or Cross Pedigree	Source 6th RDISN Durum
1	Cr 'S' - Gs'S'	
	D 28980-28Y-13M-500Y-OY	1514
2	Giorgio VZ 394	1519
3	Crane 'S' - Ganso 'S'	
	D 28930-28Y-13M-500Y	1521
4	Maristella	1530
5	Cr'S'-F3TunxAA'S'/Fg 'S'	
	CM 10200-6BK-OBK	1532
6	Castel del Monte	1541
7	USA IV-A S713	1549
8	Flamingo	
	D 27582-8M-12Y-5M-500Y	1565
9	Pinguino 'S'	
	D 28934-44Y-300M-500M-OM	1573
10	Cr'S'(21563/61-130 x Leeds	
	CM 225-2M-1Y-OM-OY	1575
11	Cocorit 'S'	
	D 27617-17M-3Y-OM	1576
12	Ganso 'S'	
	D 22550-1CM-1R-2M-100Y-OM	1582
13	Jo 'S' - Cr 'S'	
	D 27591-5M-3Y-1M	1592
14	AA'S' - Cr 'S' x CIT 'S'	
	CM 10182-7M-OY	1608

TABLE 1.13.B (Continued)

15	Pinguino 'S' D 28984-1Y-1M-500Y-500B-OY	1618
16	Cr'S'(21563/61-130 x Leeds) CM 225-1CM-1Y-GM-OY	1623
17	Sincape 9	1624
18	Gerardo V2469-PLC 'S' CM 373-3M-2Y-1M-OY	1683
19	/(By^{2}E-Tc)(TACE-Tc^2)/ x Cristolichili CYID 31536-5L-OL-4A-OA	1718
20	Lobeiro	1773
21	Jo'S'/LD 357 E -Tc^2-G11 'S' D27572-2CM-3Y-3M-1Y-OM	1830
22	PLc'S'-Cr'S'(ZB-LK x 60-120/G11 'S') CM 13414-1Y-2M-OY	1836
23	Lds.Mut-Ptl 'S' CM 17583-2CM-7Y-1M	1847
24	BY^2-TAC$_E$ x AA 'S'	1852
25	Maristella	1919
26	Plc 'S' - Cr'S'/Mca'S' x Pg'S' - Parana 66/270 CM 18001-2M-2Y-1M	1990

TABLE 1.13.C Barley lines with resistance to severe yellow rust at Rampur, Nepal and at New Delhi, India, March 1976.

Row No.	Variety/Cross	Row No.	Variety/Cross
6	Iris	216	Emir
8	Aramir	255	10-L 2621-2Y
13	Wing	291	CI 3909-2
15	Tellus	302	Krasnordarsky 1918
25	WI 2291	303	NB 2908
27	Arimar x 2763-5L	304	NB 2905
33	Forezzia x 1087-2L	332	Local Barley
57	Martin	333	Local Barley
64	Hatif de Grignon	341	White Barley Samarkalan
68	GV380 Maguelone 1406	381	Nacta
72	Union (BC 190)	391	ASSE
91	Galt-Promesa	413	Proctor
96	Hiproli x Pallas 5/P71317	430	NB 6302
114	Awnless black-Agenais	433	NB 6311
146	Nepal Barley 6314	435	NB 6304
147	Nepal Barley 6307	437	NB 4502
148	Nepal Barley 4501	438	NB 2901
149	Nepal Barley 6302	441	NB 2904
188	Iris	443	NB 4002

TABLE 1.13.D Barley varieties with good levels of resistance to diseases and aphids. Selected from Regional Disease and Insect Screening Nursery data.

Yellow Rust Resistant

Abyssinian 33 (naked)	Martin
Asse white	Mazorka
Arabic white line 3	N 83/68
Arrivat	NB 6312
Arrivat x Local D8	NB 6302
Belle	NB 6303
Beni Durylell Riff	NB 4501
Benton	NB 6302
BHS-12	NB 6314
Bongie	NB 6303
Bigo	NB 7302
Bonus	NB 2908
Cambrinus	NB 2905
Canera	NB 2902
CI 3909-2	NB 6307
CI 6971	NB 6315
Coho	NB 6304
CS/53/3	NB 4502
Cyprus Black Awns	NB 2901
Dayton	NB 2904
Delisa	NB 4002
Emir	NP 108
Giza 68	Pidor
Godiva	Piroline
Herta	Sv. Mari
Ingrid	Torano 07
Iris	Union
Julie	WI 2291
Kervana	WW 6201
Krasnordarsky 1918	Zehra
Line 251/14	
Local Iraq 2218	
Local Iraq 2219	
Local Iraq 2220	
Local Iraq 2222	

Stem Rust

Atlas Kindred	NB 6307
Attiki	NB 6311
Baladi Local 46	NB 2908
Baladi 16	NB 4501
Bonus	NB 6302
Briggs	NB 6303
Celaya	NB 6312
Chang Mae	NB 6306
CI 07931	NB 7302
CI 10297	NB 5314
Comp 259	NB 4502
Edda	NB 4002
Esperance (CI 13181)	N 83/68
Pallidum Russian	Promesa
Herta	Provenir
Local Iraq 2218	Suwon No. 20
Local Iraq 2219	Svalof Mari
Minn 906	WI 2231
Mosul 72	WW 6172

*** *** ***

TABLE 1.13.D (Continued)

Resistant to Powdery Mildew

Abyssinian
Akka
Aramir
Arpa
Arrivat
Asse
Athenais B
Atlas
Attiki
Awnless Black - Athenais
Belle
Blanco Mariout
Bongie
Bussel C
Cambrinus
Chang - Tung
CI 03562
CI 3909-2
Cilla
CM 67
CM67 - Larker - 10L
Conquest
Coast Czar
Daka
Delisa
Giza 68
Gorgan 4 = Herta
Hadak
Hebe
Hege
Herta
Hokudo
Hyprob Rogers
H 2511
H 252
Impala
Iris
Jordan 1
Julia
Martin
Mazorka
Nacta
NP 108
N 83/68
OL 172
Provenir
Sv. Kristina
Roho
Trikedritt
WI 2291
WI 21271
WI 2917 A

Leaf Rust

Athenais
Bonus
Celaya
Emir
Esperance
Jordan 3
Magnif 102
Nepal Barley 6314
Nepal Barley 6307
Nepal Barley 4501
Nepal Barley 6302
Nepal Barley 6306
Nepal Barley 4501
Nepal Barley 2902
Ratna
WI 2291
WI 3127
Zypher

Net blotch resistant

Akka
Athenais New
Baladi Local 46
Bigo
CI 7297
CM 67
Ingrid
Line 251/11/2
Malebo CI 5057
Minn 906
Picador
Somsky
W Wing

Spot blotch resistant

Apizaco
Beacon CI 151180
CI 11814
Hybernum
Kairyo-Baze
Kruglik 21
Lahasa 971
Odesskii
Prilar CI 15241
W Wing

Resistant to Aphids

A. Hor 1581/58
Composite 259
Erom
Giza 68
Rogers

1.14 Regional Activities in Eastern Africa

1.14.1 INTRODUCTION

Several international agricultural research centers have found that a part of their programs cannot be carried out at only their headquarters. For example, CIMMYT needs a wide range of temperatures, moisture conditions, problem soils and disease virulence to develop the food crops of the future.

In 1975, CIMMYT approached the Government of Kenya about the establishment of a Regional Wheat Program at the Njoro Plant Breeding Station. An agreement was concluded and starting in 1976, CIMMYT assigned a wheat breeder to the East African Highlands.

Wheat farmers in East Africa have experienced devastating epidemics of stem rust and stripe rust in introduced wheats. At the beginning of this century the need for wheat improvement was translated into a breeding program which became based at Njoro in 1927. Since then, many varieties have been released that have made the Kenyan wheat industry successful. The varieties gained recognition as sources of resistance to stem rust all over the world.

Highland wheat growing conditions favor the development of virulent new races of stem rust and stripe rust. Sunshine and high elevation are expected to cause mutations in the fungi that can attack resistant wheat varieties as a consequence. Also a range of planting and harvesting dates are needed with the variable rainy seasons at different altitudes. As a result, varieties usually become susceptible to rusts in a limited number of years.

This situation is used by wheat breeders as much as possible, and each year thousands of introductions from other wheat areas of the world are sent to East Africa for screening. Most of the experimental lines developed in Mexico, are also screened in the Highland conditions at Njoro.

1.14.2 ROLES OF THE REGIONAL CIMMYT PROGRAM

Apart from screening work on rusts, the Regional Program consults with wheat growing countries in the region to strengthen their cereal production. Also, Middle East wheat breeders use facilities in Eastern Africa to advance their genetic materials in the summer season. Mediterranean weather conditions often do not allow the growing of a crop in the June-October period which is the main wheat growing season in Eastern Africa. Small amounts of advanced germ plasm from these programs have been grown in Kenya. As a result, breeders in the Middle East are making faster advances.

1.14.3 OFF-SEASON NURSERY FOR NEAR EAST COUNTRIES

In early June 1976, the materials sent to Kenya for evaluation were Egypt Gizah Bread Wheat Lines; Egypt Sakha Bread Wheat Lines; Egypt Barley Lines; Egypt Elite Disease Resistance Group; Tunisia Bread Wheat and Durum Lines; Algeria Durum Selections; ICARDA's Bread Wheat Hybrids; Lebanon Advanced Materials (Bread Wheat, Durum Wheat and Barley); Turkey Bread Wheat Screening Nursery; Turkey Barley Selections; Cyprus Barley Lines; Iraq advanced lines, Jordan Bread Wheat and Durum; and Oman Bread Wheat Varieties and Lines.

From the 3500 entries provided by the breeding programs, some 500 selections were made for planting in three locations: Near East Regional Program - ICARDA; CIMMYT, México; and the remainder for a repeat nursery at Njoro, Kenya to select further for plant type and disease resistance.

1.14.4 SCREENING OF CIMMYT, ALAD/FAO AND OTHER INTRODUCTIONS

The 9th International Bread Wheat Screening Nursery included high yielding lines from CIMMYT, México. It contained good stripe rust resistant entries. The 8156 Multiline Screening Nursery was of considerable value in identifying lines that may serve better than the original variety. One of the important components for the 8156 multiline for this area is Brochis.

A cooperative Bread Wheat Disease Nursery was distributed in 1976. Pathologists in Kenya have tried for more than a decade to evaluate stem rust development in the African Region. In the 1960's a nursery was sent to wheat researchers all over Africa, in particular the Eastern part. In 1976 the best Kenyan varieties were again provided to 20 breeders

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* CIMMYT assists the national programs of Eastern African countries, North Africa and the Near East in their research programs through the assignment of a CIMMYT scientist, based in Kenya. The CIMMYT involvement is financed by a grant from the Canadian International Development Agency.

and pathologists. Varieties in National yield trials were used as well as the susceptible Hindi 62. Data were obtained from Kenya, Zambia, Mexico and Holland, where stripe rust infection was heavy. Also pathologists in Egypt scored the nursery. The cooperative nurseries in the Middle East included the 32 entries in the Regional Disease and Insect Screening Nurseries. A summary of the main findings is shown in table 1.14.A.

1.14.5 DURUM WHEAT

Durums are not widely grown in Eastern Africa. However they form the majority of commercial wheat in Ethiopia. Many tetraploid types of wheat have originated there. In the New Wheat Introductions of USDA 1976 many collections from Ethiopia were included that appear disease resistant. These are intensively screened at Molo, a hot spot location for stripe rust. Generally durums are not heavily attacked by stripe rust in Njoro, but late plantings were sufficiently diseased in 1976 to provide reliable data for stripe rust.

Among CIMMYT types of durums, outstanding resistance has been encountered in Crane (D 23055), Jori-Crane (D 27591), Crane-Ganso (D 28980), Stewart 63-G11 x RD 119 (D 31759), $Grulla^2$ x Tdic-Vern-G11 (CM 86) and Crane - Tdic.Vernum-G11 (CM 199).

Chile durums such as Centrifen (Lan/dw F_4 Lan), Alifen, E 3728-$Capeiti^3$/Gz-4777^2 x Pj and Quilafen showed repeatedly good resistance. Among Italian durums Trinakria and Maristella have been resistant to stripe rust. Also a number of Turkish durums were good in 1976 for stripe rust, but somewhat late for Kenya conditions. A number of advanced lines from CIMMYT appears to have resistance again.

Promising dwarf durum selections with stripe rust resistance are Snipe (CM 13414), Plc-Ruff x Gta-Rolette (CM 17904), Stork x Chap-21563 (CD 1894), Ruff-Gaviotta (CM 18555), Pg-Cit/Cr-Gs x Parana 66/270 (CM 17989), and Hcl-Gta x Kingfisher (CD 1247). A few parents repeatedly occur in segregating populations among the good looking crosses such as Gdo VZ 471-Br x Pg, Wells-65150, and Marte x Chap-21563. Also 65150-Leads was a very useful parent, as well as Ruff-Flamingo and Ddw. 5 15-Crane. The progeny appears vigorous in several crosses with these parents, while stripe rust is low. By using stem rust resistant parents in these complex crosses, superior durums may be selected.

Kenya's stem rust races are more specialized in attacking bread wheat than durums. Durums with good levels of resistance in U.S.A. have been useful in Kenya as well. Varieties released in Kenya such as Tai and Kasuku were adequate at the time of release, but they did not stand up very long. It continues to be a struggle to combine good stem and stripe rust resistance with high yield and wide adaptation.

In 1975 one dwarf durum competed in National Yield Tests with the best bread wheat. This line D 92 is a cross of Flamingo and Leeds. Flamingo is a dwarf durum of Mexican parentage with good disease resistance but with low yield due to sterility in the head. Leeds is a well known variety from U.S.A. with stem rust resistance and yield potential under low rainfall conditions.

1.14.6 BARLEY

In 1975 a large barley collection maintained in Lebanon by ALAD and the national program was sent to Kenya for more detailed screening. This collection was based on winter barleys provided by the USDA. Promising barleys from several other programs were added. In mid 1975 this collection was planted in Njoro and in late July 1976 repeated in Mau Narok, a high location in the barley production area. Many entries were very late in flowering in Kenya and others did not head out. This was observed in both years, and points to the fact that wide adaptation in barley is not general.

Results of disease screening were presented in the Regional Barley Workshop in Jordan. Yellow rust and scald were very serious in the nursery. Sources of resistance can be found, and will be utilized by old and new barley breeding programs.

1.14.7 TRITICALE

CIMMYT sent many triticales in 1975 and 1976 for screening and selection in Eastern Africa. Individual plant selections made in F_2 populations from Mexico are very useful for rapid advancing in this new crop.

In National yield tests, Maya II-Armadillo selections have proven outstanding. Beagle is a very good parent, and several crosses offer good prospects. Already plant type is very acceptable, but the main push is towards finding new triticales with superior grain type. Table 1.14.B lists F_3 entries that combine good plant type and seed type.

About 15 per cent of triticales in East Africa are sufficiently well adapted for further observation. The best adapted varieties yield 20-35 per cent above the best wheats.

Not only are the earlier daylength insensitive types from CIMMYT acceptable, but also late maturing tall varieties such as Fasgro 204.

On triticale, only a mild infestation of leaf rust and some stem rust was observed. Leaf blotches however were severe on many triticales, caused by Septoria avenae fs tritici and S.nodorum. Leaf necrosis caused by bacteria and Helminthosporium sativum and H. tritici repentis was also serious.

In table 1.14.C a list of superior selections in the 7th International Triticale Screening Nursery is given. The Maya II-Armadillo and Beaver crosses were most frequently selected. These selections will be compared with triticales obtained in earlier seasons. Some of these are now multiplied for large scale testing with farmers. Two varieties, Armadillo = T 14 and Cinnamon = T 48 have been yielding 20-30 per cent above recommended wheat varieties in Kenya. This superior adaptation to highland conditions is a strong factor in further triticale work in the Region.

1.14.8 OTHER REGIONAL ACTIVITIES

CIMMYT consults and cooperates with wheat growing countries in the East African region to strengthen their cereal production.

1.14.8.1 Botswana

This large country is between the Kalahari Desert and South Africa. Rain is the limiting factor. The soils are generally sandy. The main food crops are maize, sorghum and millets. Dryland wheat is presently only a minor crop - only 700 hectares were sown in 1976. Wheat is not expected to expand under rainfed conditions. At the Agricultural Research Station, small scale testing has shown relatively low yields for all varieties of wheat and barley. The latter may have a yield advantage. For all food crops, the estimated suitable area is less than 500,000 hectares.

1.14.8.2 Lesotho

Over one million people live in this small land locked high mountainous area where there are less than 400,000 ha of cultivated lands - about 13 per cent of the total land. Staple foods are maize, sorghum and wheat.

Wheat has the most potential for expansion. Government estimates indicate increases by 1980 from the present 80,000 ha and average 700 kg/ha yield, to 100,000 ha and 1,000 kg/ha yield. Currently, Lesotho imports milled maize products and wheat flour.

There are two types of wheat production - winter and also summer in the higher mountain areas. Climatic hazards are low rainfall with poor distribution, frost and hail.

In development plans, wheat is receiving a high priority. There is also interest in high altitude sorghum, triticale and barley. A cooperative wheat yield trial from Kenya includes bread wheat, durum and triticale.

1.14.8.3 Zambia

This large country of 746,000 sq. km has a relatively low population of about 4.5 million people. The rural population depends practically on maize for daily nutrition. Demand for bread has pushed wheat and flour imports up to 100,000 tonnes per year. By 1976, they exceeded 120,000 tonnes, costing over 30 million dollars.

In the early 1970's, the University of Zambia established a wheat research project for irrigated conditions, and many introductions from the Near East and CIMMYT were made. Tests showed yields of 7,000 kg/ha were obtainable. Mexipak, Siete Cerros and Super X and crosses with these varieties such as $Y50_E$ - Kalyan3 proved excellent. By 1976, with strong government backing, a limited number of farms with sprinkler irrigation facilities produced about 800 hectares of wheat with yields of 4,000 kg/ha or more.

Because of the very limited area with irrigation facilities, the government is concentrating on rain season production. This is a formidable task because wheat is not well adapted to hot humid tropical conditions. Therefore a testing program was initiated in 1976 at 11 sites in the Northern Province.

In this area, altitude is about 1600 m and the rain period is not as hot as in the southern areas. By planting in mid February, the early variety Sonora 64 produced about 3,000 kg/ha. Diseases and pests were not serious. The results have stimulated the government to strongly promote rainfed wheat production in the Northern Highlands. A second program to evaluate wheat in the rainy season was developed in the drier areas of the Southern Provinces. Yields were low due to a heavy attack by Helminthosporium.

TABLE 1.14.A Kenyan wheat varieties with high levels of disease resistance in selected locations.

Yellow Rust Resistance		Reaction Levels		
Variety	Cross No.	Holland	Mexico	Kenya, Molo
K Kifaru	K 6675-3	30R	30MS-MR 10MR	10MS/2
K 6661-13 x K 4500	K 6860-1	15MR	tR	5MR/0
K 4500 Swara	K 6820-23	20M	10MS	5MS/t
Agent x Tob^3	K 6670-4	20R	10MR-MS	10MS/2
K 6650 x Tob	K 6664-10	15R	10MR-MS	5MS/t
K Kudu	K 1008	30M	30MS-MR	0/0
K Fahari	K 6648-6	15MR	10MR-MS	10MS/0
K Kanga	K 4496	20MR	10R	10MS/1
K 4500-R35 x K 6849	K 6852-4	20R	10MS	10MS/1
Stem Rust Resistance		Egypt		Kenya, Njoro
K Kifaru	K 6675-3	20MR-MS		5R
K Nungu	K 6661-Bulk	tR		tR
K Nyoka	K 6410-2	0		5MR
K Paka	K 6661-8	0		tR
K 6650 x Tob	K 6664-10	20MR		tR
K Swara	K 5393	tS		tMR
K 4500-R35 x K 6649	K 6852	0		0
Leaf Rust Resistance		Egypt	Mexico	Kenya, Njoro
K Kuro	K 6290-1	0	5MS	tR
K Kifaru	K 6675-3	0	10MR	0
Agent x Tob^3	K 6670-4	0	10MR-MS	0
K Mbweha	K 6106-2	0	5MS	0
Septoria tricici Resistance		Ethiopia	Mexico	
K Kuro	K 6290-1	3	R	
Fanfare	II-4765	3	R	
K Swara	K 6820	3	R	
K Nyoka	K 6410-2	5	R	
Bounty-K 6754	K 6867-10	5	R	
K Kudu	K 1008	2	R	
K Hunter	K 869	5	R	
Hindi 62		2	R	
Scab Resistance		Ethiopia		
K Nyoka	K 6410-2	1		
K Fahari	K 6648-6	2		
K Nyati	K 6290-4	4		

TABLE 1.14.B Triticales with good plant and seed type, in Kenya.

Origin Njoro	Variety or Cross	Pedigree
54	Cin-FS 2024 x Cin-Kla/Bgl	X 18628-1Ke
64	RM-Kla (tall)	X 22108-1Ke
73	FS 551-Nv	X 22156-2Ke
79	Cin-FS 579 x FS 1897	X 22...-1Ke
80	Cin-FS 579 x FS 1897	X 22...-2Ke
85	Yoco R-Kla	X 22334-4Ke
108	M_2A-IRA	X 20811-1Ke
126	Treat 908-Bva x FS 1897	F_2Tcl 75-76/396-1Ke
133	Bgl x FS 554	X 22488-1Ke
141	Ita-IRA	X 18461-1Ke
149	Octo Out-Agrot. x M_2A^2	X 18800-1Ke
154	IRA-RM	X 18966-3Ke
161	RMS-1A-Cin	X 19401-2Ke
170	FW 121-Prol x Cml^2/Misi	X 22359-1Ke

TABLE 1.14.C Superior selection in the 7th International Triticale Screening Nursery made in the National Plant Breeding Service, Njoro, Kenya, 1976.

Origin Njoro	Variety or Cross	Pedigree
55	M_2A	X 28-38N-3M-7N-5M-0Y-2M-0Y
58	M_2A	X 2802-38N-5M-5N-2M-3Y-5M-1Y-0M
81	M_2A	X 2802-75N-3M-4N-4M-1Y-2M-0Y
88	M_2A	X 2802-24N-6M-6N-0M-0Y-1B-0Y
90	M_2A	X 2802-29N-4M-4M-2M-1Y-4M-0Y
98	M_2A	X 2802-72CB-2013-15Y-0M
99	M_2A	X 2802-72CB-2013-15Y-0M
130	M_2A - Inia Arm	X 8634-E-1Y-2M-0Y
131	M_2A - IRA	X 7249-20M-1Y-3M-0Y
191	Beagle	X 1530-A-12M-3Y-3M-1Y-0M
192	Beagle	X 1530-A-12M-3Y-3M-1Y-11M-0Y
193	Beagle	X 1530-A-12M-3Y-3M-1Y-3M-0Y
194	Beagle	X 1530-A-12M-5Y-1M-1Y-100M-0Y
195	Beagle	X 1530-A-12M-5Y-1M-3Y-1M-0Y
196	Drira	X 7100-IN-19M-1N-0M
203	FW 121-Prol x Cin	X 7267-24M-2Y-13M-0Y
257	M_2A	X 2802-70N-4M-2N-3M-2Y-0M
264	IRA	X 73CT 1218-4-YW-21W
286	UC 8825	
297	JNK 6T090	

2.0 Latin America

A discussion group of international personnel reviewing cereal production problems in the Andean Region

2.1 Brazil

2.1.1 INTRODUCTION

Between 1967 and 1976, wheat production in Brazil increased eight times viz., from 364,870 metric tons to 2,974,672 metric tons. This reduction in wheat production in 1972 and 1975 was due to adverse climatic conditions.

The increase in production since 1967 has been mainly due to the large area sown in Rio Grande do Sul, Sao Paulo, Matto Grosso and especially Paraná. The average wheat yield in Brazil during 1967-76 was approximately 900 kg/ha with variations ranging from 500-1100 kg/ha.

The main causes of these low yields have been diseases and pests especially in Rio Grande do Sul, Santa Catarina and south central Paraná. Other important factors are low fertility and aluminum toxicity present in most wheat growing soils in Brazil. In northern and western Paraná, southern Matto Grosso and south eastern Sao Paulo, the highest yield reductions have been due to moisture stress and frosts at flowering time.

Wheat consumption in Brazil during 1967-76 increased 10 per cent per year i.e. from 2,655,136 metric tons to 6,064,250. In real terms, this increase was 5 per cent per year in 1967-72, 13 per cent per year in 1973-75 and 23 per cent in 1976. In 1977 it is expected to be over 24 per cent. This big increase in wheat consumption is basically the result of the government supported subsidy policy on wheat consumption. People in Brazil have found that wheat products are among the cheapest foods in their diets. A continuation of the subsidy on wheat consumption will make it even more difficult to reach the goal of national self-sufficiency with this cereal.

2.1.2 WHEAT PRODUCTION AREAS

The three wheat growing areas in Brazil are the Southern region, the Southern Central region and the Central region.

(1) The Southern wheat growing region comprises the states of Rio Grande do Sul, Santa Catarina, and the Southern Central region of Paraná. The approximate northern unit is located at latitude 24°. There is a uniform rainfall distribution during the different months, with a tendency to be higher in winter and early spring. Winter temperatures are low and do not allow wheat flowering during the months of May, June, July and August. Most of the soils in this region present problems of "crestamento" (aluminum toxicity) and require the cultivation of wheats resistant to aluminum toxicity.

(2) The Southern Central region comprises Northern and Western Paraná, Southern Matto Grosso, and Southeastern Sao Paulo. Its southern limit is located approximately at latitude 24°. This region is characterized by a dry mild winter temperature which permits wheat to be cropped in the fall and early winter, without risk of frosts. Wheat is planted from March to May, taking advantage of the late summer rains; harvest is from July to September. Soils in most of this region present problems of "crestamento" (aluminum toxicity) although large areas do not have this problem, which therefore allows wheat cropping of susceptible cultivars introduced from other countries.

(3) The Central region comprises the states of Minas Gerais, Goiás, Federal District, Northern Matto Grosso and Northern Sao Paulo. This region has a dry winter which does not permit wheat farming without irrigation. The winter is mild with no frost risk. Wheat farming is also possible in the summer with harvest in the fall. The soils have low fertility and aluminum toxicity. This is a region where commercial wheat farming is just starting. In 1975 and 1976 state wheat production (metric tons) in the three regions was:

State	1975	1976
Rio Grande do Sul	1,100,692	1,637,029
Paraná	435,581	1,132,042
Sao Paulo	23,832	165,212
Matto Grosso	8,017	26,447
Santa Catarina	16,867	12,311
Minas Gerais	-	1,607
Goiás	10	-
Distrito Federal	-	19
Total	1,584,999	2,974,672

The technical coordination of wheat research is the responsibility of the National Wheat Research Center (CNPT). It conducts an annual Joint Wheat Research Meeting in which all Brazilian wheat scientists participate.

To facilitate the undertaking of joint work between institutions in one state, or between agencies in a wheat producing region which comprises several states, regional commission meetings are organized. The Southern Brazil Wheat Research Commission comprises representatives from wheat research organizations working south from latitude 24°, while the Northern Brazilian Wheat Research Commission includes representatives from agencies working north of latitude 24°.

During the meetings of these organizations, uniform trials are planned and analyzed, and based on the results, joint recommendations are made. Through these commissions, in all the major wheat producing areas in Brazil, uniform trials of cultivars, cooperative trials of plant production, uniform collections for sources of resistance identification, plus some soils fertility and management trials, are established.

Planning work, as a technical coordination activity, is also performed by CNPT. This activity is developed with other units of EMBRAPA (Brazilian Agency for Agricultural Research) or with other organizations receiving financial support from this agency.

2.1.4 INTERNATIONAL COOPERATION

From its inception, the National Wheat Research Center has developed an optimum relationship with foreign research institutions working with wheat, triticale and soybeans. This relationship is more developed with CIMMYT, and with agricultural research agencies in Argentina, Bolivia, Chile, Paraguay and Uruguay. These countries and Brazil, form the Southern Cone of South America. Joint research programs are being developed with those agencies in several areas of common interest; agreements have been reached and periodic meetings take place between research scientists and administrators.

In 1976, three meetings were held to discuss the problem of wheat aphids which damage the wheat crop in all the above mentioned countries. Three other meetings were conducted to plan and discuss joint wheat work in cultivar breeding and a joint research project to screen for sources of resistance to diseases, and the determination of losses and horizontal resistance.

Since its establishment, CNPT has been receiving cooperation from FAO, through Project BRA/69/535, which has assigned five specialists in the last two years to work in Passo Fundo. Through the FAO Project, Brazilian scientists have traveled to foreign countries, foreign consultants have been hired for 30-60 day visits, and important equipment has been acquired for research programs in crop management. The research program in horizontal resistance in wheat is being developed with the supervision of the FAO specialist at CNPT.

CIMMYT is collaborating actively in the development of wheat work at CNPT. CIMMYT scientists visited Brazil regularly in 1976 to work with Brazilian scientists, and a large amount of wheat and triticale genetic material has been introduced from Mexico. In addition, CIMMYT is collaborating in Mexico by growing a part of the CNPT genetic material summer nursery. CIMMYT provides labor, supporting staff and equipment, and financial aid for CNPT research scientists to travel to Mexico.

During 1976, CNPT also collaborated with the University of California to train two researchers in integral Pest and Disease Control.

In 1976, a Cooperation Agreement was signed between the Brazilian and Canadian Governments, through which the Canadian Ministry of Agriculture will provide technical assistance for the development of research at CNPT. Short visits of Canadian consultants to Brazil and visits of Brazilian scientists to agricultural experiment stations in Canada will be made.

2.1.5 CNPT RESEARCH PROGRAMS

Initial work was the organization of research, the formation of a scientific team and the organization of technical and administrative support areas.

The general orientation of the program was to develop the scientific activities into a multidisciplinary team in order to concentrate its activities in (1), solving problems which limit the increase and stabilization of wheat yields in the traditional wheat producing areas and (2), the search of production systems which favor the expansion of wheat growing in other regions.

The main areas of activity are:

2.1.5.1 Genetic Improvement

This work includes breeding wheat cultivars; special breeding programs; breeding for resistance to *Erysiphe graminis tritici*, stem rust, *Septoria* leaf blotch, *Gibberella zeae*, barley yellow dwarf virus, *Septoria nodorum* and leaf rust; incorporation of good agronomic types; breeding methodology research; improvement by induced mutations; yield comparisons; studies on chromosome stability and its relation to varietal purity and ecological adaptability; triticale breeding; breeding for resistance to germination in the spike.

2.1.5.2 Disease Resistance Sources

Research is being conducted on sources of resistance to all the diseases stated in the previous paragraph, plus wheat mosaic virus and *Drechslera sorokiniana*.

2.1.5.3 Pathogen Races

Physiological races of *Puccinia recondita* and *Puccinia graminis tritici* are being surveyed.

2.1.5.4 *Gaeumannomyces graminis var. tritici*

Studies on the occurrence of this disease are being made.

2.1.5.5 Chemical Control of Diseases

Chemical control of disease investigations are being carried out with systemic fungicides, dithiocarbamates, oidicides,and seed treatments and aerial dustings against *Erysiphe graminis*. Other work is the economic evaluation of chemical treatments to control fungal diseases in wheat in 1976 plus the evaluation of loss due to *Erysiphe graminis* and the determination of leaf rust damage during different stages of wheat growth.

2.1.5.6 Pest Control

This work includes evaluation of aphid population, chemical control of pests, technical/economic efficiency of contact and systemic insecticides in aphid control and the economic analysis of granular insecticides to control wheat aphids.

2.1.5.7 Combined Pest-Disease Control

Economic aspects of fungicide and insecticide applications on 38 farms in Rio Grande do Sul and Parana are being examined. Wheat cultivars are being evaluated in relation to pest and disease complex.

2.1.5.8 Fertility and Plant Nutrition

Included in these investigations are a comparison of phosphatic fertilizers and their effects on soil properties and yield in a wheat-soybean rotation; efficiency of nitrogen sources of slow release; micronutrients; response curves of wheat to NPK.

2.1.5.9 Soil Conservation and Management

Rain simulation and soil conservation research is being conducted.

2.1.5.10 Wheat-Soybean Production System

Crop rotation studies are being made.

2.1.5.11 Genetic Stocks and Lines

Work is in progress on the formation of genetic stocks and the multiplication of lines of wheat cultivars, and also on seed treatment and conservation methods of seeds.

2.1.5.12 Technology Diffusion

Extension methodology includes training, round table and panel discussions, field days, publications and production systems.

2.1.5.13 Statistical Services

The above mentioned areas of research in CNPT are supported by statistical services.

2.2 Costa Rica

2.2.1 INTRODUCTION

Although wheat was widely cultivated in colonial times, it ultimately disappeared. Interest has now been revived in its culture and 29 experimental hectares were sown in 1976, in which CIMMYT material was grown. Its production was promoted by the University of Costa Rica and the Cartago Regional Agricultural Center. Barley and triticale trials with CIMMYT material were also planted.

Costa Rica has been importing all of its wheat grain and flour requirements. In 1974 imports were 65,075 metric tons valued at ¢ 141.8 million and in 1975 they were 81,717 metric tons valued at ¢ 167.4 million.

Experiments are conducted at the Fabio Baudrit Experiment Station and in the Cartago region. The first named is in the Alajuela region in the Central Valley, at 840 m altitude. Annual rainfall is 2000 mm with September-October maxima and a dry season from December-April. The Cartago region in the highlands of the Central Mountains, has a cool humid climate with a rainfall of over 2000 mm. The altitude ranges from 1700-2300 m.

2.2.2 WHEAT VARIETIES

Since 1973, Mexican varieties have been tested. In the first year, yields did not exceed 2 tonnes (t)/ha. In 1974-75, they reached 3-4 t/ha. Wheat yields have been higher at Cartago than at Alajuela. Grain yields (kg/ha; 12 per cent moisture) at both places were:

	Cartago	Alajuela	
Penjamo 62	2025	3551	
*Siete Cerros	2375	3020	(*Most widely grown variety)
Jupateco	3000	4112	
Yecora	5600	2181	
Cajeme	5775	2286	
Navojoa (triticale)	4150	1366	
Cinnamon (triticale)	4650	3000	

2.2.3 NURSERIES

In 1975-76, the 9th IBWSN was planted at Alajuela. The ten best yielding entries with their grain yield figures in kg/ha shown in brackets were 276 (5180), 281 (4340), 297 (4376), 306 (4156), 277 (4148), 296 (4248), 138 (3960), 240 (4112), 259 (3944) and 267 (3908). Likewise, the 7th ITSN was grown at Alajuela and the Yield figures in kg/ha are shown in brackets for the ten best entry numbers - 10 (4952), 50 (4624), 12 (4448), 142 (4236), 41 (4232), 240 (4176), 38 (3976), 155 (3884), 7 (3980) and 34 (3828). In general, triticale yields better than spring wheat viz., 3,430 kg/ha and 2,294 kg/ha respectively when the average of the ten best varieties in each nursery are compared. The most promising triticale varieties were Beagle, Setter, Inia-Rye x Arm"S" and Maya II-Arm"S".

2.2.4 DISEASES AND PESTS

Diseases are the most important factors limiting yield. They include *Xanthomonas translucens*, *Helminthosporium sativum*, *Fusarium roseum*, *Curvularia* sp., and *Rhizoctonia* sp. Insects have not been a problem. The most common pests are *Feltia* and *Agrotis* sp., *Elasmopalpus lignosellus*, *Spodoptera frugiperda* and *Phyllophaga* sp.

2.2.5 WEEDS

They are abundant, highly competitive and shelter rodents which can destroy the whole crop. The chemical application on grasses and broad leaf weeds which gave best yield results was Perfluidone + MCPA (91.0 + 0.5 kg/a.i./ha) as a pre-emergent.

2.2.6 FERTILIZERS

Adequate rates are 120 kg N/ha and 180 kg P_2O_5/ha with applications of all the P at seeding, and half the N then and the remainder at tillering. Costa Rica manufactures and exports fertilizers. The supply exceeds demand in Costa Rica.

2.3 Dominican Republic

Wheat varieties and triticale lines were evaluated by the Instituto Superior de Agricultura (Higher Agricultural Institute), San Cristobal, Dominican Republic. Seven wheat varieties from CIMMYT and seven Dominican Republic varieties were sown on November 24, 1975.

As at March 22, 1976 the yield and other characteristics were:

Variety	Height (cm)	No. Spikes /m^2	No. Fertile Spikelets/Spike	100 Grains Weight (gm)	Yield (kg/ha)
Yoreme	84	365	17	3.93	3977.8
7 Cerros 66	79	320	15	3.41	3356.2
Inia	85	364	15	3.25	2876.3
Inia 66	84	326	14	2.80	2814.9
Tobari 66	84	344	13	3.13	2679.1
Ciano Zn	81	475	16	3.46	3533.4
Sonora 64	74	447	14	4.02	3977.8
Ciano	78	408	15	3.51	3200.0
Anza	70	413	16	2.59	2796.8
Beagle	102	236	28	4.03	3380.4

An outstanding fact is that in only 3 months, some varieties showed a yield potential of 3615 kg/ha. These results compare well with those obtained in Costa Rica, where the best variety yielded 2170 kg/ha. However, it is too early to draw conclusions due to inadequate data and the need to study multiple factors.

At the Instituto Superior de Agricultura (ISA), flowering and maturity characteristics were found to be:

Variety	Start of Flowering	50% Flowering	50% Maturity	Harvest Date
Yoreme	January 6/76	January 13/76	February 24/76	March 4/76
7 Cerros 66	January 14/76	January 14/76	February 24/76	March 4/76
Inia	January 13/76	January 17/76	February 29/76	March 4/76
Inia 66	January 14/76	January 20/76	March 2/76	March 4/76
Tobari 66	January 14/76	January 16/76	February 29/76	March 4/76
Ciano Zn	January 13/76	January 13/76	February 17/76	February 23/76
Sonora 64	January 9/76	January 13/76	February 17/76	February 23/76
Ciano	January 13/76	January 15/76	February 17/76	February 23/76
Anza	January 17/76	January 23/76	March 7/76	March 16/76
Beagle	January 16/76	January 28/76	March 9/76	March 16/76

Fifty triticale lines from CIMMYT were sown on November 25 and December 22, 1975 to be evaluated for length of growing season, flowering uniformity, maturity, spike size, fertility, plant height and lodging resistance. It is intended that a maximum of 10 lines, that is 10% of the total number under observation, will be selected for testing for yield potential in the next season.

2.4 Ecuador

2.4.1 INTRODUCTION

The success or failure of small cereal grain production in Ecuador is influenced by rainfall fluctuations because most of this production is in rainfed areas. In 1975-76 the agroclimatic conditions were generally favourable for wheat and barley.

Of the total wheat area, 29% used chemical fertilizer and the corresponding figure for barley was 20%. Chemical fertilizers in Ecuador are subsidized and are sold tax free, but the prices fluctuate. Some details of products and prices are:

Product (50 kg bags)	Prices: Sucres	Prices: U.S.Dollars
10-30-10	370.00	12.98
18-46-0	380.00	13.57
8-24-0	313.00	11.17
Urea	275.00	9.82
Triple Superphosphate	375.00	12.50
Potassium Sulphate	335.00	11.96
Potassium Chloride	195.00	6.96
Ammonium Sulphate	175.00	6.25
Magnesium Sulphate	210.00	7.50

28 Sucres = 1 U. S. Dollar

Despite adequate technical advice, wheat and barley farmers have failed to adopt the recommended technological packages, and as a consequence, this failure is a serious limiting factor for both wheat and barley production.

2.4.2 WHEAT

In 1975-76, wheat was sown on 70,073 hectares on 41,356 farms. National wheat production amounted to 64,525 tonnes and the average yield was 921 kg/ha. Of the wheat farms, 89.1 per cent had an area less than 10 hectares, 6.5 per cent farmed 20-50 ha and 1.6 per cent grew more than 50 ha of wheat.

The greatest proportion of wheat area, 80.6 per cent, was sown to improved high yielding varieties (HYV's) developed by Instituto Nacional de Investigaciones Agropecuarias (INIAP). Because farmers are widely accepting the new HYV's, it is hoped that this proportion will increase in the next few years.

For most situations, the fertilizer recommendation for wheat is 300 kg/ha of 10-30-10, plus 135 kg urea/ha at the tillering stage. However, the national average rate of use of complete fertilizer was only 158.6 kg/ha in 1975-76, which is about 50 per cent of the recommended rate.

INIAP has recently released two new varieties: Cayamba 73 for areas between 2,800-3,200 meters altitude, and Romero 73 for areas between 2,400-2,800 meters altitude.

Two wheat lines show promising yield potential, wide adaptation and disease tolerance especially of *Puccinia striiformis*. The crosses and pedigree of these two lines are:

Son 64A-SK^6$_E$/An^3$_E$ x M/Rw^2 x Bza^3 II-20911-2E

Cno S-Gallo 27829-19Y-2M-3Y-0M

Disease prevalence was low in most wheat areas. The diseases which were most prevalent were *Puccinia graminis*, *Puccinia striiformis*, *Puccinia recondita* and *Septoria* species. In Carchi and Imbarbura provinces in Northern Ecuador, *P. striiformis* attacked wheat, especially Cayambe 73.

The major problems of the wheat farming industry are lack of certified seed of improved varieties in some areas, an inadequate supply of fertilizers and other production inputs, high cost of inputs, labor scarcity in some areas, irregular topography, poor road infrastructure in wheat areas, a high percentage of small area wheat production units

(1.7 ha average), bottlenecks in the marketing process and poor storage capacity in the marketing centers.

2.4.3 BARLEY

The area sown to barley in 1975-76 was 65,806 ha on 42,824 farms. Of the total farms, 92.9 per cent consisted of less than 10 ha, 3.7 per cent 10-20 ha and 1.8 per cent grew more than 50 ha of barley.

In general, the climatic conditions were favourable for the crop. In contrast to wheat, the use of HYV's of barley is quite low in Ecuador — only 12.2 per cent of the barley area was sown to improved varieties. However due to an increasing demand from the malting industry for better quality materials, there is a good potential for expanding the area of improved varieties.

Barley used 2008 tonnes of chemical fertilizer, on 20 per cent of the barley area. The average fertilization rate was 152.25 kg/ha of formulae such as 10-30-10. In general, the fertilizer recommendation for the crop is 200 kg urea/ha at the tillering stage.

No new varieties were released, but some new varieties are likely to be available in the next few years. Four new lines show promising yield potential, adaptation and tolerance to common diseases. Their crosses and pedigrees are:

Pe-Gal x Funza	V-458-1n-1N
CN.48 x C.I. 8985	II-17641-1e-1e-9E
Abyssinia	P.1. 669
Reselection Ms-Bright Green	

In 1975-76, crop development was good and disease incidence was low. The major diseases in order of importance were: Rh_ncosporium secalis, Helminthosporium graminis, Helminthosporium savitum, Puccinia anomala and Barley Yellow Dwarf virus. In Carchi province in Northern Ecuador near the Columbian border, barley was attacked by Puccinia striiformis sp. hordei.

Most of the problems associated with the wheat industry (as stated above) are also common in barley farming. However, because barley profitability is lower, the problems are more critical.

2.4.4 TRITICALE

It is a newly introduced crop in Ecuador. The only information available is on adaptation work from the last two years in certain areas of the Inter Andean Valley at altitudes between 2,700-3,100 meters. At higher altitudes, higher rates of spike sterility have been observed.

2.5 Guyana

2.5.1 INTRODUCTION

In 1976 there were no commercial cultivations of wheat, barley and triticale in Guyana. Wheat was imported and milled into flour and the by-products were used in the stockfeed industry. The annual importation of wheat is approximately 67,200 metric tons. In 1976, the value of wheat imported was about 13.66 million U.S. dollars but this value fluctuates from year to year when prices change. In October 1975, work on wheat introduction was ordered by the Government.

2.5.2 TESTING PROGRAM

Work on wheat and triticale introduction started in 1976 with the objectives of (a) identifying varieties that could be economically grown in the hot, humid, brown sand zones of Guyana, and (b) initiating a breeding program to develop varieties and multilines more suited to the local environment using the best varieties and lines identified from among the introductions.

In January 1976 wheat investigations commenced with the testing of 167 cultivars originating from Mexico, Philippines, Australia, Egypt, India, Iran, Israel, Pakistan, Rhodesia, Sudan and the United Kingdom. In those tests, poor vigour, low number of tillers per plant, grain-shrivelling, very early maturity, and very short plant height were the main problems identified. Several cultivars gave extrapolated yields of 2 tonnes per hectare or more. Among these cultivars, the varieties which produced non-shrivelled grain were Jupateco 73, Tanori 71, Siete Cerros T66 and Narro. Jupateco [illegible] had the highest 100-grain weight viz., 3.12 g/100 grains. This test was done on a coastal site at near sea level elevation.

In June 1976, the same set of 167 cultivars was sown at 36 meters above sea level at a location 100 kilometers inland from the coast. Also, 108 F_2 populations of wheat crosses supplied by the Queensland Wheat Research Institute, Australia were sown No yield data were recorded. Only the following six cultivars showed satisfactory vegetative vigour and non shrivelled grain, viz C60-5-1G, C44-3-1G, C50-2-16, Jupateco 73, Siete Cerros T66 and Tanori 71. The three lines were selected from Philippine material during the previous growing season. There was low spikelet fertility in most cultivars.

Jupateco produced 6-8 tillers per plant, but all other varieties produced only 1-3 tillers per plant.

2.5.3 DISEASE INFECTION

The main disease of wheat and triticale in Guyana is that caused by *Helminthosporium sativum*. Under highly humid conditions, all the wheat and triticale varieties tested were found to be susceptible to *H. sativum*.

The number of rain days and the amount of rain which fell between sowing and maturity dates for the January 1976 test sowings were:

Period	No. Rain Days	Total Rainfall (mm)
Sowing to 72 DAS	55	721
Sowing to 76 DAS	59	7[illegible]
Sowing to 85 DAS	66	809
Sowing to 90 DAS	70	858

DAS = Days after sowing

In respect of the June planting, all cultivars except the F_2 populations, were protected to a large extent from *Helminthosporium* infection by spraying with Dithane M45 at weekly intervals. The F_2 populations were severely damaged by this fungus. From these populations, 55 single plant selections were taken and from each of three of the populations, the least diseased plants which had non shrivelled grain, were selected.

2.6 Paraguay

2.6.1 INTRODUCTION

In the last five years, wheat production has fluctuated in both the total area sown and the amount of grain harvested. Although the number of sown hectares decreased in 1976 as against 1975, the 1976 yield showed a substantial increase. The annual wheat demand is estimated at 100,000 metric tons of which 70 per cent is imported and 30 per cent is produced in Paraguay.

Year	Sown Area (ha)	Production (metric tons)	Average Yield (kg/ha)
1972	32,000	17,000	550
1973	20,300	23,000	1133
1974	32,100	35,200	1097
1975	29,300	20,800	709
1976	28,700	32,300	1120

The regions in which the most wheat was grown were Itapua and San Pedro, which possess small and large production areas and consolidated cooperatives for production.

Barley has been only recently introduced to Paraguay and only 150 ha were sown. Triticale is not commercially grown.

2.6.2 DISEASES AND DISEASE CONTROL

During 1976, the climate favored the development of *Erysiphe graminis*, which was severe on varieties not protected with fungicides. At the end of the season, some leaf rust, *Puccinia recondita*, was observed. The use of fungicides resulted in higher wheat yields e.g. 1380 kg/ha at Itapua and 1400 kg/ha at San Pedro. In 1976, the area treated with fungicides amounted to 9,648 hectares which was one third of the total wheat area in Paraguay. The highest yield obtained was 3200 kg/ha with variety 281/60 in San Ignacio Misiones. The national yield averages were 1.01 t/ha without fungicides and 1.34 t/ha with fungicides.

2.6.3 CLIMATIC CONDITIONS

In the growing season, the climate was favorable. It was warm, dry and with only small radiation. During the reproductive stage, rains were well distributed, temperatures were warm and radiation was reduced. As the crop was maturing, frequent rains occurred.

2.6.4 FERTILIZERS

They are widely used on sandy soils. Available fertilizers are diammonium phosphate, triple superphosphate, muriate of potash and urea. Nitrogen fertilization is carried out at sowing time and at 30-45 days after germination. Fertilizers are not subsidized in Paraguay, and taxes are not imposed on imports. The supply exceeds demand.

2.6.5 SEED MULTIPLICATION

The experimental stations of the Ministry of Agriculture and Animal Husbandry are responsible for the production of foundation and mother seed. Multiplication of registered, certified seed is undertaken by the National Seed Service (SENASE). Some cooperatives multiply seed under the supervision of SENASE. Approximately 20 per cent of the area sown to wheat in Paraguay, is certified seed.

2.6.6 VARIETIES

The four principal varieties being grown and their per cent area sown in brackets are 281/60, (60) Itapua 1, (20) Itapua 5 (15) and Otros (5). Itapua 1 and Itapua 2 show tolerance and/or resistance to *Septoria*, *Gibberella*, and stem and leaf rusts.

The most promising lines in the wheat improvement program are:

Number	Variety/Pedigree
281/71	Timgalen
128/69	Son 64 A2 x TzPP x Nai60, 18889-3M-2Y-2M-1Y-1C-2Y
98/68-E	Pi 62 x LR 642 x TzPP x Knott ≠ 2,18790-1R-1T-2Y-1C
7605	J 9281-67 x LR64A, B550-160-1C-0C-1C-0Z

2.7 Uruguay

2.7.1 INTRODUCTION

In 1976, wheat was sown on 543,482 ha and produced 504,938 metric tons at an average yield of 929 kg/ha. Adverse climatic factors reduced the yield. Intense epidemics of Septoria tritici and stem rust (Puccinia graminis) occurred in the spring. In October, when most of flowering occurs, precipitation was 221 mm.

Government policy regarding wheat production has been directed basically towards covering internal demand.

2.7.2 WHEAT IMPROVEMENT

Since 1912, Uruguay has conducted a wheat improvement program. Nowadays more than 250 crosses are made annually. Five varieties are now being multiplied within the certified seed category. Their agronomic characteristics, yield, disease resistance and quality are tabled below:

Cultivar	Cycle (days)*	Plant height (cm)*	Lodging	Diseases: Leaf rust	Diseases: Stem rust	Diseases: Septoria	Quality: Milling	Quality: Baking	Yield (kg/ha)
Estanzuela Tarariras	82-102	91-107	MR	B	A	M	MB	MB	2856*
Estanzuela Sabiá	79-100	80-95	R	A	B	A	A	B	2585*
Estanzuela Dakurú	83-103	86-106	MR	A	B	A	B	B	2308*
Estanzuela Young	83-103	100-114	MS	B	M	M	B	A	2628*
Buck Namuncurā	111-119	90-115	MR	B	M	M	MB	MB	2803**

R =resistant
MS=moderately susceptible
MR=moderately resistant

A=high infection (susceptible)
M=moderate infection (intermediate)
B=low infection (resistant)

A=acceptable
B=good
MB=very good

Trials in normal season: * = 7 years average ** = 3 years average

2.7.3 DISEASES

The main pathogens are Septoria tritici, Puccinia graminis, Puccinia recondita, and Gibberella zeae (Fusarium graminearum). Septoria occurs every year especially with great severity in cool humid spring weather. Normally leaf rust attack is high and stem rust is very destructive in hot humid spring weather. Less important diseases which occur are Puccinia striiformis, Helminthosporium sativum, Erysiphe graminis, Ustilago nuda, and Tilletia spp. Barley Yellow Dwarf virus is suspected.

2.7.4 CULTURAL PRACTICES

About 40 per cent of the area sown to wheat is fertilized, mainly with N and P. The rates per hectare are 20-25 units of N and 40-50 units of P_2O_5. Approximately 43 per cent of the area is sprayed with herbicide, especially with amine 2,4-D.

Farmers plough between January and May and sow wheat at 95-155 kg/ha from May-August.

Farmers within the seed certification area (approximately 8000 hectares) obtain higher yields than the national yield average. The difference in favour of the former, is about 700 kg/ha. This higher yield is due to the farmers in the seed certification area adopting all the technology recommended by the Estanzuela Experiment Station.

A substantial increase in wheat production could be achieved if extension and research programs were strengthened.

3.0 Africa

Dr A Daaloul (left), INAT, Tunisia and Dr G Kingma (right), CIMMYT, Kenya discuss head type in a barley nursery, Beja, Tunisia

3.1 Algeria

3.1.1 INTRODUCTION

The 1975-76 crop season was the best cereal production year in Algeria since 1909 (the date from which data were kept). The rain distribution in almost all regions was excellent from seeding to mid dough stage, except parts of western Algeria, where drought during March, April and an early sirocco did considerable damage. Subsequently, there were unusually heavy rains in nearly all regions which caused extensive damage, with barley being the worst affected. Official estimates placed production in the 1975-76 season at 29 million quintals, a figure close to 10 million quintals more than the national average.

The prolonged mild winter season resulted in stripe rust developing into epidemic proportions in the eastern regions of Algeria, but the spectrum of virulence was highly limited. However, the predominant variety Siete Cerros was susceptible. Based on the yield trial results of the past four years, it is estimated that the average loss of Siete Cerros due to stripe rust was about 18 per cent in the eastern regions of Algeria (table 3.1.A).

Stem rust was also present in almost all regions. However, due to prolonged cooler conditions it did not develop into epidemic proportions. The virulence pattern based on the observations of the regional disease trap nursery suggests that, of the single genes, only Sr.11 was effective. Almost all the combinations of Sr. factors also held the resistance. Most of the bread wheats in cultivation, except Mahon Demias, held resistance to the prevailing races, but nearly all the commercial durums were susceptible. Derivatives of Langdon, Leeds and Wells like Mexicali and Flamingo, held resistance to the prevailing races. An analysis of the race spectrum during the 1974-75 season, shows that races 15B, 9, 24, 19 and 17 were present. Since race 11 and its subraces are reported in all the neighbouring countries, this race is also likely in Algeria.

There was very little leaf rust during the 1975-76 season. Of the different LR lines, only Th^6 x Aniversario, Thew and Fn x Mida/K117A showed a susceptible reaction which indicates that the virulence during the year was highly limited.

Septoria was of minor importance although humidity was present in abundance throughout the crop season. The lack of prolonged cloudy days and a relatively warm winter season prevented *Septoria* from developing into a major disease.

3.1.2 CEREAL BREEDING

3.1.2.1 Bread Wheat

Siete Cerros continued to be the dominant bread wheat variety in all cereal regions but stripe rust caused considerable damage to it in almost all the production fields in the eastern region of Algeria. Strampelli and Anza are under rapid multiplication. Promising varieties and lines under final stages of testings are reported in table 3.1.B. (Rfn^2-908/Fn x Gz139-GB1360-3228)$Cllfn^3$ A.6842-6P-1P-1P-3P of Chilean origin, and Arz of Lebanon, were the best.

The best selections from the first year trials are reported in table 3.1.C. Arz and Anza were again the top yielders in the 12th International Spring Wheat Yield Nursery grown at Guelma (table 3.1.D).

The program continued to screen a wide variety of germ plasm and segregating material of diverse origin at different agroclimatic conditions. The season provided good selection against stripe rust, but drought stress was totally absent.

3.1.2.2 Durum Wheat

Because the durums occupy close to 45 per cent of the cereal area, the cereal improvement program in Algeria is mainly concerned with the development of better adapted, higher yielding and better quality durums. All the local varieties are of low yield potential and are susceptible to most of the important wheat diseases, but almost all of them have good quality.

The cereal areas of Algeria are normally divided into three zones viz: littoral

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* CIMMYT assists the Ministry of Agriculture and Agrarian Reform in its research and training programs through the assignment of CIMMYT scientists. The CIMMYT involvement is financed through a grant from the Ford Foundation.

(plain), sub-littoral (hilly) and high plateau. However, from a crop improvement standpoint the latter two can be grouped together and they constitute about 85-90 per cent of the cereal lands. Normally the agroclimatic conditions of the littoral zone are good, but so are the conditions for disease development. Thus varieties for this region must have in addition to high yield potential, adequate resistance to the rusts, Septoria and mildew. In contrast, the agroclimatic conditions in the sub-littoral and high plateau are highly variable. The winter season there is much more severe, with occasional snow during the early growth states. The crop duration is little over eight months with late frosts and early hot winds These conditions demand varieties of semi-winter habit (or spring varieties with fair cold tolerance) and a high yield stability.

During the early stages of the improvement program, Jori C 69 was introduced into Algeria, but unfortunately, its lack of adaptation for higher elevations and its lack of adequate disease resistance for the littoral zone, made it unsuitable. INRAT 69 of Tunisian origin is a good variety for the lower elevations. When the winter is too cold, this variety shows a tendency to nigh sterility, and consequently, very low yields. Capeiti of Italian origin is a fair yielder in most of the regions. Cocorit 71 gives high stable yield, but its high yellow berry content makes it unacceptable. Mexicali seems to have good promise for the littoral zones.

Yield evaluations with many introductions during the past few years indicate that the cross T. dic Ver x G11 "S" can be a potential variety for the high plateau. Results of the most promising varieties from the advanced yield tests are reported in table 3.1.E Crosses Cr "S" - F3Tu x AA "S"/Flg and Cr "S" - Gs "S" are the most promising and they have done well in all zones. The others, although superior in yield to the locals, are adapted only to the littoral zones.

Promising varieties from the second year trials, first year yield trials, IDYN and EDYT are reported in tables 3.1.F, 3.1.G, 3.1.H and 3.1.I. Selections from the cross Rabi "S" - Flg "S" were outstanding with respect to yield and disease resistance. Two other interesting groups were lines of Chilean origin OA547, PA554, PA564, PA556 (table 3.1.F) and lines of Turkish origin Q371 and R388 (table 3.1.H). These two groups are likely to have some winter tolerance. The Chilean lines were much later maturing than desired and may pose a problem with the siroccos (early hot winds out of the Sahara).

Good resistance to stem rust and Septoria are essential for a stable yield in the littoral zones. The experimental station in Algiers during 1975-76 experienced a good infection of stem rust. Of the 282 durum entries in the 7th IDSN, 66 resistant entries were revealed. Unfortunately 54 of them are from crosses involving 61-130 Lds, Leeds, Langdon, Wells, Lakota or Rolette and in 10 others one of these parents is indirectly involved. Thus 64 out of 66 have almost the same background for stem rust resistance. The remaining two entries were IDSN No. 6 and IDSN No. 184. IDSN No. 6 has D117 in the parentage which is M'Rari 549 of North African origin. It is reported to have good stem rust resistance in this region. IDSN 184 has Ag.elongatum as the source of resistance. This situation indicates a lack of adequate width for stem rust resistance in the Mexican germ plasm. To take this into account, many crosses were made during the past season to widen the stem rust resistance base using varieties of diverse origin like Beladi 116, Tremes Molle, CI 8155, Kasuska, Tai and D16, etc. Septoria is the second most important disease in the littoral zone and in order to introduce Septoria resistance, crosses were made with BD1645 of Tunisia and with Jaafri, Lobeiro and Amarelejo of Portuguese origin.

A second group of crosses was made using stable high yielding lines and high quality lines. During the coming crossing season, it is hoped to combine the F1's created for disease resistance with the F1's created for quality, in order to achieve yield stability and quality in the same material. For the high plateau it is intended to combine crosses in F_1 of Chilean and Turkish varieties x Mexican with Mexican x local high quality durums in double crosses to introduce yield spring habit and cold tolerance.

The program of durum improvement is under rapid expansion. Nearly 350 crosses were made during the 1975-76 season and about 650 single plants were subsequently selected from the top and double cross F_1's for growing as F2 individual lines during the coming season. The results of this expanded program will be evident in the yield trials from the 1980-81 season onwards.

3.1.2.3 On-Farm Advanced Variety Demonstration Trials

They are conducted with regular field equipment on representative farms in each of the three general production zones: coastal (littoral), medium altitude (sub-littoral 200-600 meters) and high elevation (high plateau above 600 meters). They consist of the best selections from the third year yield trials with check varieties of high yield and one or more of the best traditional varieties. The trials are replicated with a plot size of about 30 by 2.5 meters. They are seeded in a well prepared seed bed and fertilized at the recommended rates of phosphorus and nitrogen for the region. Herbicides are applied with field sprayers, when needed.

The Constantine region was heavily attacked by stripe rust in 1976 and the yield of Siete Cerros was reduced about 25 per cent. The test weight and the quality were reduced by both the late rain and rust. Mexicano 1481, Marco Juarez and Bb x Ciano were also severely infested with stripe rust. Some stripe and stem rust occurred in the Algiers station, but there was very little damage. Siete Cerros was one of the top yielders in the Algiers and Oran regions.

Rainfall in the Oran region was below normal and a prolonged dry period from December through March reduced tillering and forced heading.

L-te rains helped to mature the wheat. Stands were reduced also by poor seeding due to a dri l malfunction. Brome grass infestation at Sfisef also reduced yield and favored talle more competitive varieties. In tables 3.1.J and 3.1.K the yield data for the advanced yield trials are presented.

In the Constantine region, Anza was the outstanding variety. It was resistant to stripe rust last year. It has good resistance to Septoria and a high yield potential in the littoral and sub-littoral regions. It is too early for the high plateau and also it is too short. It does not compete very well with grassy weeds nor with heavy infestations of broad leaf weeds. The variety is under increase and should be recommended for the higher rainfall sub-littoral and littoral regions.

Syrimex and Chanate #2 also are doing well. These varieties have resistance to stripe and stem rust and are better adapted to the sub-littoral and high plateau regions. With a straw height similar to Siete Cerros, they are better adapted than Anza to compete against serious weed infestations. All three varieties have a better test weight than Siete Cerros.

Several durum varieties were equal or slightly higher yielding than Cocorit 71. Anhinga II has been an excellent yielding variety in previous trials It is taller than Cocorit, somewhat weaker in straw strength, but it has good kernel characteristics and a more suitable maturity date. Cocorit tends to be too early and short, and in addition it produces a high percentage of yellow berry. Capeiti was only grown in the Algiers region and it was exceptional last year when compared with its performance i i previous years.

3.1.3 PRODUCTION RESEARCH

3.1.3.1 Weed Control Studies

3.1.3.1A Introduction

Climatic conditions were excellent for wheat production, and also for weed growth in 1975-76. Table 3.1.L snows the monthly rainfall and the number of days of rain/month. March, April, May and June received rain on 45 days out of a total of 122 days, which made weed control difficult and favoured the development of stripe rust.

Weeds are the most serious cause of yield losses in Algeria. Weed competition decreases the fertilizer response and reduces the effectiveness of the additional inputs, resulting in low productivity. Weed growth is increased by fertilizer application which causes more competition for both moisture and soil nutrient for the crop. A large percentage of the fertilizer inputs are wasted on weed growth.

In Algeria, crops are subjected to serious weed competition from both monocotyledonous and dicotyledonous weeds. Because cereals are also monocotyledons, the grassy weeds are the worst competitors. They are difficult to control by cultivations and by chemicals They cause the most severe yield losses. The presence of both types of weeds in the same field, intensifies the control problem.

3.1.3.1B The Effect of Proper Seed Bed on Weed Control

The elimination of one more crop of germinating weeds before seeding and then obtaining an even vigorous crop emergence by uniform seeding, allows the wheat to be more competitive to later emerging weeds, with a consequent reduction in yield loss.

This is illustrated in table 3.1.M where the results of two seeders are compared The Shearer resulted in a weed free seed bed, and the Nordsten seeded into a seed bed that was not free of germinating weeds. In Algeria it is often necessary to seed into a dry seed bed. Many fields are so heavily infested with weeds that preseeding cultivation is not sufficient control. The problem must be approached by control both from cultivation and herbicides.

3.1.3.1C Herbicides and Weed Control

Herbicide trials were conducted in the Algiers and Constantine regions. With one exception, all trials were applied with regular field sprayers using a plot size 10 meters wide and 30 - 50 meters long. All herbicides were applied at dosages recommended by the label and at the proper stage of growth. The trials were replicated and were used both for demonstration and for research. The experiments were conducted in the production fields of wheat on farms throughout the regions.

The four most serious grassy weeds are wild oats, ryegrass, annual bromegrass and Phalaris sp, which are the most common to the sub-littoral and littoral regions. Dicotyledons and bromegrass are more of a problem on the high plateau.

Effective grassy weed herbicides include the substituted ureas chlorotoluron (Dicuron) and metoxuron (Dosanex); nitrophene (TOK50) and benzoylpropethyl (Suffix) for wild oats. The first three must be applied before the grassy weeds reach the three leaf stage in order to be effective. Primary absorption is by the roots, so rainfall soon after application is necessary for most effective control. These chemicals are also effective on some species of dicotyledons. TOK50 was used in combination with Dosanex or Dicuron. The combination is more effective on Phalaris sp. Combinations of Dicuron with MCPP (Printan 22), and Dicuron plus Certrol (MCPP + Ioxynil) increases the weed control spectrum.

With the exception of Suffix, all of these herbicides are recommended to be applied after the cereal is in the three leaf stage and before the grassy weeds reach the three leaf stage For the control of broad leaf species, 2,4-D is widely used. It must be applied after jointing starts and before the boot stage, to avoid damage to the cereal. This is often too late to avoid damage from early weed competition. To increase the length of the treatment season and to reduce early competition, there is a need for broad leaf weed herbicides which can be applied earlier than the safety period as with 2,4-D.

Herbicides that were tested in Algeria that can be applied after the 3 or 4 leaf stage of wheat include Tribunil (methabenz thiazuron), Oxytril M (Ioxynil + Bromoxynil + MCPP), Certrol (Ioxynil + MCPP), Quinorexone (MCPP + Dicamba), DM68 (MCPP + Dinoterbe) and Actril M (MCPP + Ioxynil). With the exception of Tribunil, all of these herbicides are combinations with MCPP (mecoprop) and all are more expensive than 2,4-D. However, where heavy weed infestation from dicotyledons develops early, good yield increases have resulted from treatment with these products.

Table 3.1.N summarizes the effect of herbicide treatment when the density of wild oats was less than 20 heads per square meter. Tribunil was applied early and controlled a heavy density of dicotyledons resulting in a yield response of 600 kg/ha. Control of the wild oats at this low density gave very little response to yield; however, the average yield of the check was 2 1 to 3.2 tons per hectare. When the wild oat density increased to about 75 per square meter, there was an increase in the response to herbicides that controlled wild oats even though the yields were at the 3.5 to 3.8 ton level in the check plots. In one trial where there was a very heavy dicotyledon infestation as well as some wild oats, the early control by DM68, Basagram and Oxytril M of these weeds gave yield increase of 3 83-6.24 quintals/ha, (table 3.1.0).

When the wild oat density was in excess of 75 heads per square meter, there was a good response to herbicides that controlled wild oats. Although Dosanex + TOK did not control all the wild oats, the combined control of wild oats and dicotyledons gave an excellent yield response of 4.6 quintals per hectare. Dicuron + Certrol also gave similar control and yield response. These data are summarized in table 3.1.P.

In one trial with a high density of ryegrass and low density of wild oats, Dicuron + TOK50 controlled the ryegrass and increased the yield by 40 per cent, with 90 per cent of the ryegrass controlled. Dosanex + TOK50 and Printan 22 were less effective in controlling the ryegrass and the yield response was about half as much. These data are shown in table 3.1.Q

Dosanex + TOK50, Dicuron + TOK50, Printan 22 and Tribunil often show a yellowing of the wheat after application, which persists for 7-10 days. Then the wheat usually recovers completely, although a slight delay in heading may result. Yield losses have not been measured from the early phytotoxic effects. There is a variety difference to the response. Dosanex + TOK applied to crosses involving genetic material derived from Agropyron crosses, caused severe injury. Recovery occurred but yields were decreased.

One observation is that when the wild oat population exceeds 75-100 heads per square meter, the yields were low, even when adequate moisture and fertility were present. With high soil moisture, smaller levels of wild oat infestation were not as damaging as have been reported previously when moisture stress has occurred.

3.1.3.1D Suffix Effect on Wild Oat Seed Production

Table 3.1.R shows the effect of Suffix treatment on wild oat seed production. Total seed production was reduced by 90 per cent. Since most of the seed is returned to the soil due to the high percentage of shattering in wild oats, the chance for future infestation is correspondingly reduced. At a seed weight of 25 grams per 1000 kernels, the average wild oat seed production on the untreated plots was about 11 quintals/hectare. The average for the treated plots was about one quintal/hectare. (One quintal/hectare = 100 kg/ha).

Suffix usually kills the first tillers, or those present at the time of treatment. However, if favorable conditions exist for regrowth after treatment, some new tillers or late tillers will develop heads. These heads are usually small and often only one kernel per spikelet will develop. Some florets are completely sterile. The heads seldom grow above the wheat. If there is a dry period following treatment, and the wheat density is high, competition from the wheat usually stops all further tiller development of wild oats and few heads develop and set seed. This low seed production is an important factor in wild oat control, because it reduces the amount of reinfestations.

Suffix in combination with 2,4-D is less effective for wild oat control. Some reduction in yield and a decrease in wild oat control was noted even when the two herbicides were applied in separate applications with a two week interval. Increasing the dose of Suffix to 9 liters per hectare and in combination with MCPA, has given adequate control of both wild oats and broad leaf weeds for the past two years in the Algiers region without phytotoxic effects on the wheat. The cost of this treatment is too high to recommend. Suffix applied before the end of tillering is not effective, because new wild oat germinations and lack of competition by the wheat then, reduces the effectiveness of treatment.

3.1.3.1E Herbicide Treatments on Barley

Herbicide trials on barley were conducted at El Khemis and El Khroub. The herbicides were applied at the recommended dosage and stage of growth, with field sprayers. All trials were heavily infested with wild oats.

Although barley is very competitive with wild oats, good yield responses to herbicide treatments were obtained as reported in table 3.1.S. The most promising treatment was a combination of Avenge and 2,4-D applied at the end of tillering when excellent control of both wild oats and dicotyledonous weeds was obtained with an excellent yield response. Avenge is very effective on wild oats, and barley appears to be resistant among the varieties so far tested. It will not control dicotyledons species, including Convolvulus sp. and wild carrot. Dicuron + Certrol and Dosanex + TOK50 also effectively controlled weeds in barley. Dosanex is somewhat toxic to barley, causing a yellowing after treatment, but the barley apparently recovers with little damage.

Suffix is toxic to barley. It reduces height and tiller development and also causes some sterility. The applicaton of 2,4-D reduced the yield slightly, although good control of the dicotyledons was obtained. The height of barley was reduced about 10 cm by 2,4-D alone, and with Avenge.

3.1.3.2 Sowing Density Studies

Increasing seed production efficiency in the early generations decreases the time required to produce adequate amounts of commercial seed. The speed of seed multiplication can be increased by reducing the seeding rate in the initial multiplications in generations one (G1) and two (G2).

To study the most effective way to multiply early generations of seed production, Anza, a bread wheat variety, was seeded at 40, 80 and 120 kg/ha at 100 kg/ha with a row spacing of 17.5 cm; at 50 kg/ha with a 35 cm row spacing and at 33 kg with a 52.5 cm row spacing. The stand count at emergence, tillering and harvest, and yield data were determined. Seeding was done with a John Deere double disc drill at a depth of 5 cm. The seeding date was January 5, 1976, the wheat was seed treated and 2,4-D was applied at early shooting (2nd node). Increasing the row spacing to 35 cm and decreasing the seeding rate to 80 kg delayed the heading date by two days. A four day delay in heading date occurred at the 52.5 cm spacing and 40 kg seeding rate.

Table 3.1.T summarizes the data. Yield was not decreased substantially by decreasing the seeding rate at the 17.5 cm row spacing. Yields were significantly lower at the 35 and 52.5 cm row spacings, with the same seed density within the row. Tillering was inhibited slightly by the higher seed density within the row. Increased head size occurred at the lower seeding rates.

The most effective seeding rate to obtain maximum multiplication was at the 40 kg rate with a row spacing of 17.5 cm with 117.1 quintals of seed produced for each 100 kg of seed. (One quintal equals 100 kg.) Increasing the row spacing also tended to increase weed population between rows, but rogueing is easier at the wider row spacing. Lower seeding rates increased seed multiplication more than did increasing the row spacing; however, more studies with different spacing combinations may be even more effective.

Based on these results, about 3 times as much seed would be available for seeding G4 if G1 were seeded at 40 kg per hectare and G2 were seeded at 80 kg per hectare. Further research into row combinations to allow interrow cultivation is needed in order to aid weed control in the initial G1 increase. If all generations were sown at the 40 kg/ha seed rate and gave yield increases as shown in table 3.1.T, over 7 times as much seed would become available after three generations of increase. This is especially important for the multiplication of a new variety.

3.1.3.3 Seed Drill Effect on Yield

Much of the commercial wheat in Algeria is poorly seeded, resulting in uneven stands with poor weed competition. Poor uneven seeding results from inadequate land preparation, unadapted seeding equipment and hand seeding.

A major portion of the seeding equipment now in use is not adapted to Algerian soil conditions. The seed drills are too light in construction to withstand the stresses of high speed seeding over the heavy soil, which is often poorly prepared. Wide 6 meter drills do not allow for uniform seeding over uneven terrain. As a result the life of the seeder is short, often less than one year, and seeding is very irregular.

The type of furrow opener now employed does not penetrate the heavy soil, especially on poorly prepared seed beds. Often the seed is left on the surface and the seeding depth is highly variable. To overcome this problem, heavy constructed shovel type hoe or single disc drills are needed. The station has both types of seed drills and an evaluation of a comparative seeding between the Nordsten hoe drill and the Shearer hoe drill was made. Part of a good uniformly prepared field was seeded with Inrat 69, a durum variety, using a Nordsten seed drill. The seed rate was 120 kg/ha. The soil at this stage was too wet for optimum seeding. Two days later the remainder of the field was seeded with Inrat 69 with a Shearer seed drill at the rate of 80 kg/ha.

Table 3.1.U summarizes the yield from the two different drills with 3 herbicide treatments to control weeds, and the relative wild oat population in the two different seedings. The average yield increase was 64 per cent due to the different seeding equipment. The significance of this information is that seeding equipment is extremely important for maximum production. The Nordsten seeder under optimum conditions will do a satisfactory seeding job; however it is not a good seeder when soil preparation is poor. The Shearer seeder also combines a cultivation at the same time as it seeds. This was particularly effective this year when the soil moisture content was high.

The Nordsten machine seeded into a high moisture seed bed which was already germinating weed seed. The wild oats and other weeds emerged before and at the same time as the wheat, causing extreme competition with the cereal crop. The germinating weeds were killed at the time of seeding with the Shearer combination cultivator and seeder, thereby allowing the wheat to emerge ahead of the weeds. It also decreased the density of weed growth. The wheat was more competitive and was able to develop without much weed competition. This is especially true when the wild oat density and wild oat seed production is compared for the two seeders. The reduction in the potential weed infestation for succeeding crops will be important.

3.1.4 MEDICAGO RESEARCH

3.1.4.1 Medicago Research and Observations, 1975/76.

Algeria started the introduction and experimentation with Medicago species during the 1973/74 crop season. Following poor results with the currently introduced Australian cultivars (Jemalong, Harbinger and Snail) on the high plateau in 1974/75, a variety trial was established at sowing rates approximating to:

(a) the rate sown in the establishment year (10 kg/ha);

(b) the amount of seed expected to regenerate in the 3rd year (50 kg/ha); and

(c) 100 kg/ha corresponding to some later year.

Extremely cold conditions, including 10 days of snow at Ain-El-Hadjar (1000 m), the site of this trial, adversely affected all varieties. In addition to the three cultivars mentioned above. *Trifolium hirtum*, "Kondonin"; *Medicago truncatula*, "Cyprus"; and *M. truncatula* "Borung" were sown.

The only cultivars which showed any promise from this trial were firstly Borung which set seed profusely, secondly Cyprus and thirdly, Jemalong. Snail and Harbinger persisted at low densities and produced a small amount of seed.

The results gained in 1974/75 suggested that there may be some benefit from sowing low densities of oats or barley with the Medicago in the establishment year in order to provide a more favorable microclimate for the young Medicago at high elevations. This was tried in a factorial trial at Ain-El-Hadjar using three cultivars (Snail, Harbinger and Jemalong) at seeding rates up to 25 kg/ha seeded alone, and also with 10 or 30 kg/ha of oats, or with 10 or 30 kg/ha of barley. The companion crops had no sifnificant effects on plant survival. This was observed in another region (800 m) where 50 hectares of Medicago were sown in association with 30 kg/ha of oats. Seed yields from the trial are shown in table 3.1.V.

The results indicated a response to seeding rates right through the range for Snail, and up to about 20 kg/ha for Harbinger and Jemalong. At normal seeding rates, all three have similar performances. However at high density, Snail outperformed the others in both forage and seed yield, but it is inconsistent in regeneration. The complaints voiced in Algeria have mainly indicated that there is too much seed germinating in the second year and that seed continues to germinate right through the wheat phase, even after the application of 2,4-D, thus reducing wheat yields.

On the other hand, reports have been received from parts of the high plateau that indicate very little regeneration for the present introductions. These factors and others (erect habit making it very easy to overgraze, large smooth pod easily foraged by sheep or lost by erosion), suggest that Snail does not suit Algerian conditions.

If sowings are to continue with these cultivars on the high plateau, it is suggested that sowing rates should be increased up to 20 kg/ha mainly to ensure sufficient seed production for the coming years. Even at these densities however, forage production is still minimal.

Another variety by seeding rate trial was established at Tafaroui (60 m) using slightly differing rates from those above. In particular, Snail was sown at rates up to 40 kg/ha to establish how high the seeding rate could go before its effect was non-existent. The results are presented in table 3.1.W. By plotting a "line of best fit" it appears that Jemalong and Harbinger reach a plateau of seed production in the region of 15 kg/ha seeding rate, whilst the optimum for Snail, under these mild conditions, appears to be somewhat higher, probably around 20 kg/ha. There is a response to seeding rate on Snail forage production right through the seeding rate range.

Wheat was sown into the Medicago research plots of 1974/75 at Sfisef (600 m). Medic growth was spectacular in that year but as the plots could not be grazed, there was a large grass weed buildup. The plots were sown to wheat using a seeder which persistently malfunctioned with respect to seeding depth, and the wheat density was low. Finally due to intense weed growth, the plots were cut for hay in mid-May.

However, there are several interesting observations:

(a) The nitrogen status of the crop was directly related to the forage production of the previous year. Thus wheat after Snail medic was the greenest, closely followed by wheat after Jemalong, then Harbinger, Paragosa and finally Clare subterranean clover.

(b) The nitrogen status of the crop was best where the previous medic had been early sown.

(c) Phosphate application rate to the previous Medicago had no visible effect on nitrogen accretion, as indicated by crop colour. In fact, the phosphate application rate had no effect on crop growth; some plots had not received phosphate in either year.

(d) All wheat after medic plots were inferior to wheat after fallow (sown with the same drill), but were superior to wheat following a "weed fallow".

(e) Medic germinations occurred in early autumn, during the preparation for the wheat crop. Jemalong and Harbinger were controlled by these cultivations, but Snail made further, later germinations, adding to the "weed" problem in the crop.

3.1.4.2 Survey of Commercial Medicago Sowings, 1975/76.

The success on otherwise of sowing some 10,000 hectares of medics in Algeria in recent years, has not been registered nor analyzed. Although there is some feedback from the Demonstration Program carried out by FAO, it was deemed desirable to undertake a survey in the spring and summer.

The objective was to identify the problems associated with the introduction of the new rotation and to modify it where necessary in order to make it fit better, the peculiarities of the Algerian farming system.

Forty-two domaires were visited during May, and plant survival and botanical compositions were obtained. Farm management interviews were conducted The farms were visited again in July to take seed harvests and to obtain data on additional grazing since the previous visit. It was found that there was considerable enthusiasm for medics in the first year of growth, and these farmers requested more seed for the following year. However, the enthusiasm rapidly waned following the first crop of wheat after medic. These crops have been extremely weedy and thus, low yielding. There are instances where the farm is unlikely to ever again accept the idea of the medic-wheat rotation.

The survey was conducted in the western region of Algeria and this area has been divided into altitude zones: 0-500 meters; 500-800 meters, 800+meters. These zones differ in the indigenous roadside vegetation as shown in table 3.1.X, the values being an average of Levy Point Quadrat data through the zones.

TABLE 3.1.X Botanical composition of grazed roadside vegetation.

Zone (meters)	Botanical Composition %			Bare Ground (hits/100 points)
	Legume	Grasses	Broadleaf	
0 - 500	38	53	9	4
500 - 800	31	26	43	4
800 +	13	55	32	36

As can be seen the legume component decreases with altitude. In fact this year, above 1000 meters the legume component was as low as 3 per cent. There is a shift from grasses to broadleaf plants in the mid-altitude range and then a switch back at high altitudes, where ryegrass becomes prominent. Wild oats is the predominant grass at low altitudes, in association with bromegrass.

Spring survival populations of the medics sown, were collected in May. These data represent the end-product of many factors which are difficult to separate - efficiency of seeding, grazing practices, insect attack, but the averages do show that the sown medic pastures follow somewhat the same pattern as the indigenous grazed swards. In table 3.1.Y, plant populations are calculated as a percentage of seed sown (data from Domaines which had made gross errors, are not included).

TABLE 3.1.Y Survival of Medicago (in Spring) as per cent seed sown.

Zone (meters)	Survival (% seed)
0 - 500	26.0
500 - 800	17.4
800 +	3.8

The botanical composition of the grazed, sown, Medicago pastures is shown in table 3.1.Z; data from the three regions are averaged over the Domaines of any one altitude zone (Domaines which had made gross errors, are deleted).

TABLE 3.1.Z Botanical Composition of Sown Medicago pastures.

Zone (meters)	Botanical Composition (%)				Bare Ground (hits/100 points)
	Sown Medicago	Other Legumes	Broadleaf	Grasses	
0 - 500	54.2	.3	12.9	27.6	40.0
500 - 800	35.6		10.8	45.0	50.0
800 +	* 1.7	--	6.0	92.3	73.0

* Limited sample - One Domaine only.

In the sown pastures also, the medic component of the botanical composition decreases with altitude, and the grass component increases with altitude. The broadleaf weed component is relatively small, probably due to the 2,4-D treatment during the cereal phases of the wheat-fallow rotation (as distinct from the roadside vegetation which would rarely be touched by 2,4-D application). In addition, pasture availability (total forage) decreased with increasing altitude. Although no herbage yield determinations were taken, the bare ground counts indicate this decrease.

Seed yields were determined in July. Of forty-two Domaines, only twenty-four were harvested. the remaining 18 Domaines having only a trace of seed production. Table 3.1.AA summarizes the seed production in those Domaines which obtained a seed yield (averaged for each zone).

TABLE 3.1.AA Seed production of sown Medicago pastures.

Zone	Sown Medic		Indigenous Medic		Domaines	
(meters)	Yield (kg/ha)	Range (kg/ha)	Yield (kg/ha)	Range (kg/ha)	No. with Seed Yield	Total No. Sown
0-500	153.3	392 - 29	7.5	141 - 0	19	29
500-800	60.6	119 - 3	2.5	12.3- 0	5	10
800+	---	---	---	---	0	3

In the 0-500 m zone, only 19 of a total of 29 Domaines which sowed medic this year obtained any seed production for regeneration. In the mid-altitude zone, only 5 out of the 10 Domaines produced any seed. Many of those Domaines, however, did not produce enough seed to ensure a high plant population for the primary regeneration year.

To start the rotation successfully, it is necessary to aim at a regeneration germination approaching that obtained from sowing 25 kg/ha of pure germinating seed. This is equivalent to a seed production of about 200 kg/ha from the establishment year (taking into account hard seededness).

Of the Domaines studied in western Algeria this year, only 12 per cent had seed yields greater than 200 kg/ha, table 3.1.BB.

TABLE 3.1.BB Medic pastures classified by seed yield.

Seed Yield (kg/ha)	% of Domaines Sown
0 - 100	71
100 - 200	17
200 - 300	7
300 - 400	5

Of these 12 per cent, the Domaines which had seed yields of 300-400 kg/ha (5 per cent) were either ungrazed or only lightly grazed, leading to high weed populations, and consequently to problems in the following crop year. Therefore, only 7 per cent of all Domaines sown to medic in western Algeria could be considered ideally successful. However, if the seed yield objective is reduced to 100 kg/ha (ensuring a regeneration in year 3 of about 12-15 kg/ha; - equivalent to the original seeding rate) then perhaps 20 per cent (disregarding those with weed problems) could be considered successful.

3.1.4.3 Some Observations from the Medicago Survey.

3.1.4.3A Seeding Methods.

In Western Algeria, the three common seeding methods are:

(a) Medic seeded through the boot of the drill.

(b) Medic dropped onto the surface (tubes removed from the drill) and then harrowed.

(c) As for (b) above, but followed by a sheeps'-foot type roller ("Crosskill" roller).

From the survey results, (b) and (c) appear to have given similar results. Seeding method (a) was only used with Snail medic, a large-seeded cultivar which has a fair tolerance to seeding depth variations. With the type of soil preparation etc., common in Algeria, this method would give inferior results for seeding the smaller seeded cultivars

3.1.4 3B Forage Utilization

There were wide variations in the grazing pattern and intensity observed in the survey of the Domaines. At the end of May, only 29 per cent of the Domaines were well grazed, 27 per cent were overgrazed and 26 per cent under-grazed (disregarding Domaines which used Medicago pastures for other purposes).

The overgrazing was of two types. Firstly, some Domaines had commenced grazing at the optimum time (December-January), but the stocking rate was too high. An additional factor was the encroachment often at night, by nomad flocks. Secondly, due to poor extension of the techniques involved in grazing medic, some Domaines had made gross errors. The chief error was to leave the pasture until April before commencing the grazing. The pasture was then stocked with up to 50 sheep per hectare, and this grazing pressure caused severe damage to the erect plants and completely eliminated the medic component (in particular, snail medic) from a number of fields.

As a preliminary estimate of optimum stocking rate, botanical composition of the pastures was plotted against "stocking rate" (corrected for differences in method of grazing). The primary objective is to obtain the greatest proportion of medic in the pasture and the least proportion of grassy weeds. The point where this occurs is where the stocking rate is 7.5 sheep/ha, with grazing from December-January until the end of May.

There were large losses of seed between its formation and the time of the seed harvest survey (July), due to continued grazing over that period. At the end of July, 78 per cent of the Domaines were overgrazed. As an interim measure and until there is better extension of technology and the exclusion of nomadic grazing, first year medic fields should be cultivated to bury the pods immediately following plant senescence in June.

The grazing pattern and intensity naturally affects the weed component of the pasture. Wild oats are well controlled by early, continuous grazing. Ryegrass too, can be held in check by this method. However, bromegrass presents a far more difficult problem. Early grazing may be an aid to control but grazing pressure must be increased during the spring to prevent head formation. This is rarely possible in Algeria where localized sheep populations are reasonably low The other alternative is to "top" the pasture, using a slasher (or reciprocating mower with a height control wheel). It is necessary to carry out this operation two or even three times and even then, it is only partially successful because the bromegrass plants then seed progressively lower after each cut. The survey indicates that 37 per cent of the area sown to medic in 1975/76 will have a substantial bromegrass problem in the following wheat crop.

3 1 4 3C Insect Pests.

Several subspecies of Sitona lineata caused varying amounts of damage to 1160 hectares (43 per cent of the total area) sown to Medicago in 1975/76. Nearly 200 hectares were almost totally destroyed. Chemical control is difficult, because the chemicals which are effective (azinphos ethyl and fenitrothion) are expensive and non-residual. As the adults have a large flying range, re-infestation is rapid. Two insect predators are known to exist in Algeria - Microtonus aethiops and Pygostolus fulcatus. In addition, a fungus parasite, Beauvaria sp. is also present in Algeria. It is hoped that control will be by biological means, although it must be realized that with this type of control there will be occasional cyclic attacks on medics by Sitona.

3.1.4 4 General Conclusions, Medicago, 1975/76.

(a) If sowings of Australian cultivars of Medicago are to continue on the high plateau, they should be confined to M.truncatula, (cultivar Jemalong), sown at 20 kg/ha. In the future, M.truncatula, (cultivar Borung) may prove superior to Jemalong in this zone.

(b) For the littoral and sub-littoral zones Jemalong also appears to be the best adapted cultivar, sown at rates up to 15 kg/ha. Cultivar Harbinger (M.littoralis) may be of value on some sandy sites, whilst Snail should be completely phased out of the program.

(c) The medics should be sown early, (October) in all zones.

(d) Continuous grazing should commence early (December-January) in the 0-500 meter zone; February-March in the 500-800 meter zone when the medic has 4-6 trifoliate leaves. The stocking rate should be approximately 7.5 sheep per hectare, to be adjusted where possible according to pasture availability, particularly with regard to weed control. Grazing should be terminated at the end of May, and the field superficially cultivated immediately following plant senescence, to bury the pods.

(e) There is an urgent requirement for a herbicide to control bromegrass in cereals, in Algeria.

(f) For the medic-wheat rotation to be successful in western Algeria, it is essential that there be continued and greatly intensified extension of technical information to the Domaines and also very much improved supervision of field sowings of Medicago.

A well developed experiment station is necessary for reliable experimentation.

TABLE 3.1.A The effect of stripe rust on the yield of Siete Cerros. Three year averages (1972-75) compared with the 1975-76 stripe rust season in the Eastern Region.

Stations →	Algiers Central Littoral	Sidi-B-Abbes West Sub-littoral	Setif East High plateau	Khroub*) East Sub-littoral	Guelma East Littoral
3 year average Siete Cerros	59.15	34.00	20.25	26.88	34.01
3 year average Strampelli	59.95	35.17	21.12	24.30	36.79
Siete Cerros as percentage of Strampelli	99	97	96	111	92
1975-76 Siete Cerros	52.43	40.29	26.79	44.89	49.27
1975-76 Strampelli	52.14	39.26	34.02	53.39	60.83
Siete Cerros as percentage of Strampelli	101	103	79	84	81
% Gain or loss of Siete Cerros during 1975-76 season over the 3 year average	+ 2	+ 6	- 17	- 27	- 11
			18% (Setif, Khroub, Guelma)		

*) Only two year average

TABLE 3.1.B Promising lines and varieties in the 1975-76 bread wheat advanced yield trials.

V.N°	Cross and Pedigree	Yield Qx/ha	% Strampelli	Average rank/ Rank Strampelli
	Siete Cerros *)	34.25	104	5.4
	Strampelli *)	34.30	100	7.2
	Anza *)	35.26	105	5.7
AA403	EMU"S" CM-8327-C-9M-1Y-0M	33.66	101	5.5/7.3
AA412	Inia-Soty x Czho 3-6G-1Y-3M-3Y-0M	34.71	104	4.5/7.3
BA431	(Cno-7C)^{2}CC-Tob CM-1679-1M-1Y-2M-3Y-501M-0V	30.68	101	8.8/8.0
CA463	(Rfn^2-908/Fn x Gz139-GB1360-3228) Cllfn^3 A-6842-6P-1P-1P-3P	36.66	113	1.8/5.0
DA491	Arz	35.82	106	4.8/5.8
DA500	Jupateco 73	36.27	111	3.5/5.8
EA519	Mexicano 1481	37.41	109	3.3/7.0
AB741	HD832-Nor/Cno"S"-Cal x Nad CM-5618-G-7Y-0M-0Mch-0BK	39.30	95	5.8/3.8
BB773	Cno"S"-No66 x HD832/Cno"S"-Chris x On CM-2293-1MB-2BK-0BK	39.72	91	9.2/4.6
CB778	Bb"S" x CC-Inia 30521-20M-2Mch-2Mch-0Mch-0BK	40.80	106	3.7/7.2

*) Average of all 2nd year trials all stations. Qx = quintal

TABLE 3.1.C The top 10 varieties from the first year yield trials, Algeria, 1975-76.

V.N°	Cross and Pedigree	Average yield Qx/ha in comparison to Strampelli	% Strampelli	Average rank and Rank Strampelli
A-8	Gavilan	36.86 / 35.15	106	1 / 2.5
B.28	WS1877-Sx CM-15255-9Bj-0AL	35.38 / 28.03	132	3 / 13.5
B.36	Bobito"S" 38837-9Y-2M-1Y-3M-0Y-0AL	34.43 / 28.03	129	4 / 13.5
C.69	Anza-Tzpp CM-6438-2Bj-1Bj	34.14 / 31.34	114	3.7 / 9.7
D.83	7C-Pato(B) CM-790-8MB-6Bj-6Bj	40.11 / 36.82	109	1.5 / 4.5
F-141	Inia-Cal x Inia-CC 28467-67Y-1M-1Y-0M	28.86 / 29.03	106	5.5 / 9.0
F-150	RN-Mex1481 CM-7669-5L-0L	28.17 / 29.03	107	6.0 / 9.0
G-171	Tzpp-Son64 x Np/Cno"S"-Inia"S" 34002-2Mch-4MK-0Mch-0BK	50.02 / 47.58	106	3.0 / 5.5
J.226	Hork"S" CM-8874-K-1M-1Y-0M-0AL	53.25 / 51.40	104	3.0 / 5.0
J.237	Cal-Cno x Yr70 Alg-65-1BK-52AL	53.50 / 51.40	104	2.0 / 5.0
Strampelli Siete Cerros	} Average over all the First Year Trials	39.09 39.94	--- ---	6.7 5.3

% Calculated as average over two or three locations. Qx = quintal

TABLE 3.1.D The top 10 varieties of the 12th ISWYN, Guelma, Algeria.

V.N°	Cross and Pedigree	Yield Qx/ha	% Anza
964	Arz	70.86	101
963	Anza	70.19	100
989	$Y50_E$-Kal^3 35188-5M-(F1)-31Y-0M-8M-0Y	70.10	100
959	Ciano"S"	69.14	99
958	Torim.73	68.48	98
998	Tzpp-Pl x 7C CM.5287-J-1Y-2M-1Y-4M-0Y	68.10	97
996	Brochis"S" CM.5872-C-1Y-1M-3Y-0M	67.24	96
997	Tzpp-Pl x 7C CM.5287-J-1Y-2M-2Y-3M-0Y	66.48	95
999	Emu"S" CM-8327-C-9M-4Y-3M-0Y	66.38	95
957	Tanori-Resl.	66.10	94

CV % = 11.14 LSD at 5 % = 10.39 Qx = quintal

TABLE 3.1.E The most promising durums at the final yield evaluation stages in Algeria, 1975-76.

V.N°	Cross and Pedigree	Yield ') Qx/ha	% ") Local Check	Average ") rank
OB854	Cr"S"-F3Tu x AA"S"/Flg"S" CM-10200-1BK	36.43	124	3.2
OB861	Mexicali-75	30.74	103	12.0
OB863	Gta"S"-Pg"S" CM-10142-39M-0Y	32.21	108	7.4
OB864	BY_E-Tc^5 x Gs"S" CM-55-50M-2Y-6M-0Y	31.77	105	10.6
OB865	Capeiti highest check in trial OB	32.95	116	8.4
PB879	D durum S15-Cr"S"	35.31	130	7.8
PB884	Cr"S"-Gs"S"	34.38	127	4.8
PB885	INRAT 69 highest check in trial PB	29.69	111	9.6

') Average of 5 stations Qx = quintal

") Averagesof 5 stations

TABLE 3.1.F The most promising durum varieties of the 2nd year Algerian yield trials, 1975-76.

V.N°	Cross and Pedigree	Yield ') Qx/ha	% '') Local Check	Average '') rank
OA528	Rabi"S"-Flg"S" CM-10162-76M-4Y-0M	50.39	133	5.7
OA532	Cr"S"-Gs"S" x Parana CM-13053-6Y-1M-0Y	49.50	131	7.7
OA534	Cit"S" x Pg"S"-AA"S"/Ruff x T.dic. Ver-Gll"S" CM-14528-C-1Y-1M-0Y	50.69	133	4.7
OA536	Rabi"S"-Flg"S" CM-10162-76M-3M-0Y	50.30	132	6.3
OA547	Bidi 17^2 x Cfn-Landwarf/Lan T.3847-18T-2V-1P	49.81	131	5.7
OA535	Cocorit 71	45.88	121	14.7
PA551	Rabi"S"/LD393 x $Bell_E$-Tc^2 CM-10171-2BK-1BK	46.89	141	4.7
PA554	(CP x Landwarf-Lan)6201 Maliani Carozzi A.10326-1P-2P-2P	45.09	136	6.3
PA564	Alifen x Landwarf-Lan A.8405-3P-2P-2P	47.37	144	4.3
PA572	${BY_E}^2$-TAC x Tc^2/Gll"S" 27570-2M-4D-1D-1D-0H	46.97	141	6.7
PA556	(CP x Landwarf-Lan)^2/BY_E-Tc^2 A.10345-16P-6P-1P	44.40	133	8.3
PA565	Cocorit 71	43.69	131	12.0
QA583	Dwarf D S15-Cr"S" 33312-0Y-2M-0Y	44.62	127	4.0
QA586	Cr"S"-Plc"S" 31724-33M-6Y-0M	45.16	130	7.0
QA580	Cocorit 71	36.59	105	19.0
RA604	Gta"S" x 21564-AA"S"	40.96	126	3.5
RA607	Parana 66/270	40.38	124	4.5
RA623	Masa 8Y-0M-0BK	42.28	130	3.0
RA624	Gerardo 525	40.79	126	5.0
RA620	Cocorit 71	35.40	110	16.0

') Average of 3 stations   Qx = quintal

'') Averages of 3 stations

TABLE 3.1.G Promising lines in the first year yield durum trials, Algeria, 1975-76. (Qx = quintal)

V.N°	Cross and Pedigree	Yield Qx/ha	% Local Check	Average rank
O-306	Rabi"S"-Flg"S" CM-10162-76M-4Y-0M	46.36	148	3.0
O-307	Cit 71"Gta CM-18565-10Y	44.76	140	5.0
O-309	Plc"S"-Ruff x Gta-D6715 CM-17904-B-3M-1Y	46.88	148	3.3
O-313	USA III C-Gs"S" [(Gll"S"/BY$_E^2$-Tc x ZBW)Flg} CM-14403-G-3Y-GM-1Y	43.96	138	7.0
O-312	Jo"S"-Cr"S"(T.dur T.sph-Gll"S" x M.Sad/AA"S") CM-12969-2Y-1M-1Y	43.15	137	7.0
P-326	Ho"S"-AA"S" x Plc"S" CM-3337-1Y-3M-0Y	42.93	145	2.3
P-329	Pg"S"-31810 CM-10071-2M-0Y	41.01	138	6.7
P-343	Booby"S"	42.60	148	3.7
P-350	Cr"S"-AA"S"	43.67	146	4.3
Q-371	Uveyik 126-61-130 C.23-9-0A	40.67	119	7.7
Q-373	B.144	41.03	121	5.7
R-388	Uveyik-61-30 1A-69A-0A	40.36	121	5.7

TABLE 3.1.H The top five varieties in the IDYN, Khroub, Algeria.

V.N°	Cross and Pedigree	Yield Qx/ha	% Mexicali
1040	Rabi"S"-Flg"S" CM-10162-76M-0Y	57.24	101
1046	Gta"S" x 21563-AA CM-10143-6M-3Y-1M-2Y	56.57	100
1035	Mexicali	56.48	100
1027	Quilafen	56.48	100
1037	S15-Cr"S" 33312-7Y-2M-1Y-0M	55.62	99

CV % = 9.94 LSD at 5 % = 8.22 Qx = quintal

TABLE 3.1.I The top five varieties in the EDYT, Khroub, Algeria.

V.N°	Cross and Pedigree	Yield Qx/ha	% Mexicali
1019	21563-AA x Flg"S" CM-9799-126M-1M-4Y-0M	60.00	108
1015	Plc-Ruff x Gta-D6715 CM-17904-D-3M-1Y-0Y	58.36	105
1006	Cr"S"-Gs"S" x Pg"S" CM.13434-5Y-1M-4Y-0M	57.00	102
1004	Jo"S"-Cr"S" {(T.dur. T.sph/Gll x M.Sad)AA} CM-12969-2Y-1M-1Y-0M	56.86	102
1005	Chap-21563 x Cr"S" CM-12857-10Y-2M-1Y-0Y	56.00	100

CV % = 9.61 LSD at 5 % = 7.09 Qx = quintal

TABLE 3.1.J Yield in quintals/hectare for 22 bread wheat selections and varieties in field plot trials in Algeria, 1975-76.

Varieties	N° Trials	Yield Qx/ha +				%
		Constantine	Algiers	Oran	Ave.	Siete Cerros
Anza	10	45.96	35.95	20.05	36.77	114
(Son64 x Tzpp-Nai/Napo)(LR64 x Tzpp-A.N^2)	8	41.07	37.02	----	39.04	113
Syrimex	10	40.49	39.01	22.10	36.22	112
$Y50_E$ x Kal^3	10	39.99	37.87	18.55	34.86	108
Cno-Pj62 x Cno-7C	10	39.66	36.76	21.35	34.84	108
(21931/Ch53-An x Gb)An64	10	41.20	36.05	16.25	34.17	106
Chanate.# 2	10	39.76	35.01	21.20	34.14	106
Nor x Inia"S"-Napo63	10	38.50	36.62	18.80	33.82	105
Kal x Bb	10	38.32	33.68	22.35	33.27	103
Nuri 70	8	40.57 •)	35.37	16.85	32.05	102
Bb"S"	0	35.99	35.80	14.60	32.63	101
Napo63 x Tzpp-Son64/8156	10	38.73	32.39	19.70	32.49	100
Siete Cerros	10	31.56	37.70	23.30	32.36	100
Son64A-SKE/An x St	10	39.09	33.86	15.10	32.25	100
Mexicano 1481	10	33.92	36.51	19.25	32.05	99
Marco Juarez	10	34.59	34.49	21.25	31.82	99
Napo63 x Tzpp-Son64/8156	10	38.55	36.92	14.95	31.69	98
Cal/Cno x LR64^2-Son64	10	33.63	35.62	19.80	31.66	98
Cno"S" x Sk-Cfn	8	31.04 ••)	33.16 ••)	19.80	29.02	96
Bb x Cno	10	32.19	35.13	19.00	30.73	95
Florence Aurore	4	-----	32.15	-----	32.15	85
Mahon Demias	6	20.20	-----	25.50	21.65	75

\+ Average for the trials in each region - 4 in Constantine, 4 in Algiers and 2 in Oran

•) Two trials in Constantine region

••) Three trials in Constantine and Algiers region Qx = quintal

TABLE 3.1.K Yield in quintals/hectare for 20 durum wheat selections and varieties in field plot trials in Algeria, 1975-76. (Qx = quintal)

Varieties	N° Trials	Qx/ha				%
		Constantine	Algiers	Oran	Ave.	Cocorit
Appulo Capeiti x Grifoni	8	34.80	32.19	20.55	30.26	104
Masa 54-CM-OBK	8	36.29	29.88	21.10	30.09	104
Gerardo 598	8	34.32	29.01	23.50	29.03	102
Anhinga II	8	33.92	29.89°	21.80	29.38	101
FD 1303	7	35.14	29.10°)	21.00	29.36	101
Cocorit	8	36.13	27.97	20.05	29.05	100
Giorgio 447	8	35.01°°	27.91	20.60	28.74	99
21563 x AA"S"	7	41.00°°)	29.27	18.75	29.61	99
Gerardo 657	8	32.30	29.74	20.15	28.30	97
T.Dic Ver x Gll"S"	8	35.68	25.47	19.85	27.89	96
Giorgio 653	8	34.38	26.74	17.00	27.17	94
Gerardo 572	8	30.03	27.77	20.70	26.85	92
Giorgio 532	7	27.40°°)	30.50	16.60	25.64	92
Giorgio 449	8	30.97	27.08	19.05	26.53	91
Oued Zenati	8	27.57	22.54	22.65	24.01	79
INRAT 69	5	-----	29.85	24.20	27.59	111
Capeiti	3	-----	35.08	-----	35.08	127
Anhinga I	5	-----	30.43	20.20	26.34	106
Maghrebi	5	36.43+	-----	22.45	30.84	104
Flamingo"S"	3	42.92+)	-----	22.75	29.47	99

°) 2 Locations in Algiers region °°) 2 Locations in Constantine region +) 1 Location in Constantine region

TABLE 3.1.L Rainfall by months with frequency for El-Khroub Station in mm for the crop year 1975-76; El-Khroub, Algeria.

Rainfall	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	TOTAL
Amount	42.0	11.1	74.1	31.4	23.1	43.6	93.2	74.0	88.1	70.0	550.6
Frequency (days)	5	2	13	9	6	7	14	11	11	9	87

TABLE 3.1.M The effect of an additional cultivation on wild oats. A comparison of yield of Inrat 69 seeded with two different drills.

Factors		Nordsten	Shearer
Wild oats	Heads/m^2	152	33
Wild oats	Seeds/spike	54	32
Wild oats	Seeds/m^2	8208	1056
Wild oats	Seed production Qx/ha°)	20.52	2.64
Wheat yield		21.13	38.00

°) Calculated with a factor 25 gms/1000 seed. Qx = quintal

TABLE 3.1.N The effect of herbicide treatments on wheat where wild oat density was less than 20 heads per square meter, Algeria, 1975-76.

Herbicide	No. Trials	% Increase	q/ha Increase	q/ha Check	% Weed Control	
					Wild oats	Dicotyledons
Tribunil	1	29.0	6.0	20.66	---	95
Suffix	3	2.2	0.83	27.30	90	0
Suffix+ 2,4-D	2	5.5	1.76	31.92	80	95
2,4-D	2	6.7	2.2	31.92	---	95

TABLE 3.1.O The effect of herbicide treatments on wheat with a density of wild oats between 20 and 75 heads per square meter, Algeria, 1975-76.

Herbicide	N° Trials	% Increase	Q/Ha Increase	Q/Ha Check	% Weed Control		
					Wild oats	Ryegrass Phalaris	Dicotyledons
Dosanex + TOK50	1	10.6	4.01	37.74	86	---	90
Printan 22	1	6.3	2.40	38.05	65	---	80
Dosanex	1	12.7	4.67	36.74	84	---	85
Buctril M	1	4.5	1.80	39.85	0	---	95
Tribunil	1	4.3	1.65	38.45	80	---	95
DM-68	1	34.4	6.24	18.15	0	0	90
Oxytril M	1	21.1	3.83	18.15	0	0	85
Basagram	1	33.6	6.10	18.15	0	0	50
Suffix	2	6.5	2.53	38.70	90	0	0
Suffix + 2,4-D	2	14.9	5.33	35.79	80	0	95
2,4-D	2	4.8	1.91	40.01	trace	0	95

TABLE 3.1.P The effect of herbicide treatments on wheat with a density of wild oats in excess of 75 heads per square meter, Algeria, 1975-76.

Herbicide	N° Trials	% Increase	Q/Ha Increase	Q/Ha Check	% Weed Control: Wild oats	% Weed Control: Ryegrass Phalaris	% Weed Control: Dicotyledons
Dosanex + TOK50	4	40.4	4.64	11.34	70	65	75
[illegible]tan 22	5	19.6	2.50	12.71	55	58	83
Dicuron	1	18.7	2.20	11.74	40	60	58
Tribunil	2	23.0	3.45	14.95	28	52	88
Suffix	12	31.4	4.89	15.56	90	0	0
Suffix + 2,4-D	3	2.7	0.50	18.59	70	0	95
2,4-D	3	- 3.2	-0.71	22.07	trace	0	95
Dicuron + Certrol	4	39.6	5.13	12.95	70	60	70

TABLE 3.1.Q The effect of herbicide treatments on wheat with a high density of ryegrass and a relatively low density of wild oats, Algeria, 1975-76.

Herbicide	% Increase	Q/Ha Increase	Q/Ha Check	% Weed Control: Ryegrass	% Weed Control: Wild oats	% Weed Control: Dicotyledons
Dosanex + TOK50	17.8	3.20	18.00	50	---	80
Printan 22	16.9	3.04	18.00	50	---	80
Dicuron + TOK50	40.2	7.24	18.00	90	---	80
Tribunil	4.4	0.80	18.00	--	---	80
Suffix	6.7	1.20	18.00	--	90	--

TABLE 3.1.R The effect of Suffix treatment on wild oat density and seed production in treated production fields of wheat in the Constantine region, 1975-76.

Location	Variety	Wild Oat Heads and Seed Production — Suffix treated: Heads m^2	Seeds per head	Total Seeds m^2	Untreated: Heads m^2	Seeds per head	Total Seeds m^2
Khroub	INRAT 69	33	17	561	152	54	8208
	INRAT 69	4	15	60	33	32	1056
	Siete Cerros	2	10	20	57	32	1824
Khroub	Ansa	47	12	564	154	49	7546
Guelma	Siete Cerros	37	18	666	108	44	4752
Ain El Bey	Siete Cerros	69	13	897	147	32	4704
	Mean	32	14.2	461	108.5	40.5	4681

TABLE 3.1.S The effect of herbicide treatments on barley with high density of wild oats, Algeria, 1975-76.

Herbicide	N° Trials	Yield Q/Ha			% Increase	% Weed Control	
		Treated	Check	Yield Increase		Wild oats	Dicotyledons
Avenge	2	21.6	12.9	8.7	67	95	0
Dicuron	1	13.8	9.0	4.8	53	60	60
Avenge + 2,4-D	2	21.6	15.4	6.2	40	95	95
Dicuron + Certrol	1	23.7	18.0	5.7	32	90	90
Printan 22	1	21.0	18.0	3.0	17	50	85
Dosanex + TOK50	2	24.9	22.5	2.4	11	90	90
Suffix	1	18.0	18.0	0	0	90	0
2,4-D	1	26.6	28.7	- 2.1	-7	trace	98

TABLE 3.1.T The effect of seeding rate and row spacing on Anza wheat, Khroub Station, 1975-76.

	seeding rate kg/ha	row spacing cm	emergence plants m^2	heads m^2	calculated tillers per plant	Yield Qx/ha	Yield quintals per 100 kg seeded
	120	17.5	258	624	2.4	55.43	46.19
	80	17.5	172	562	3.3	53.93	67.37
	40	17.5	86	453	5.3	46.83	117.08
CV %			2.6	6	---	3.5	
LSD at 5%			8.26	30.8	---	4.30	
	100	17.5	236	590	2.5	51.52	51.52
	50	35.0	115	391	3.4	42.67	85.34
	33	52.5	80	325	4.1	35.62	107.94
CV %			7.8	9.3		8.5	
LSD at 5%			30.8	72		6.41	

TABLE 3.1.U The comparative yield of Inrat 69 and wild oat infestation from side by side seedings with Nordsten and Shearer drills, Khroub Station, 1975-76.

Treatment	NORDSTEN				SHEARER			
	Wild Oats			Yield	Wild Oats			Yield
	Heads m^2	Seeds/spike	Seeds m^2	Qx/ha	Heads m^2	Seeds/spike	Seeds m^2	Qx/ha
2,4-D	--	--	--	30.08	--	--	--	39.60
Suffix	33	17	561	31.98	4	15	60	41.59
Check	152	54	8208	21.13	33	32	1056	38.00
Suffix + 2,4-D	130	18	2340	12.86	38	15	570	38.02
			Mean	24.00			Mean	39.30

Qx = quintal

TABLE 3.1.V Seed yields from seeding rate trial, Ain-El-Hadjar, 1975-76.

Variety	Seeding Rate (Kg/ha)	Seed Yield (Kg/ha)
Snail	2.0	3.0
	3.3	6.5
	4.4	16.5
	6.3	10.5
	8.7	80.5
	11.6	92.0
	19.6	151.5
	24.9	269.0
Harbinger	2.1	4.3
	5.1	2.7
	7.7	59.8
	9.6	58.8
	11.2	81.8
	12.3	90.0
	19.6	125.0
	25.0	111.5
Jemalong	2.7	6.2
	4.1	10.9
	6.9	14.7
	11.4	38.2
	13.7	39.6
	18.!	53.5
	21.9	83.3
	25.0	107.0

TABLE 3.1.W Results of the seeding rate trial, Tafaroui, 1975-76.

Seeding Rate (Kg/ha)		Establishment		Forage Yield (Fresh Wgt. Tonnes/ha)			Seed Yield (Kg/ha)	
		Plants/ m^2	% Seed	Sown Medic	Other Legumes	Grass Weeds	Sown Medic	Other Medics
Jemalong	2.7	60.7	23.9	0.6	6.6	10.1	126.3	111.7
	4.1	90.9	44.0	1.8	8.0	6.7	163.7	102.2
	6.9	153.9	38.7	4.3	6.9	6.1	179.0	40.8
	11.4	256.0	51.8	5.8	3.7	6.7	231.6	38.7
	13.7	305.8	55.9	7.0	5.0	3.4	317.9	33.4
	18.5	414.4	50.0	7.5	5.2	3.2	400.5	17.5
	21.9	489.4	49.7	7.8	5.2	3.5	382.9	7.0
	25.0	560.7	49.8	8.2	3.8	3.3	409.9	12.6
Harbinger	2.1	27.5	39.9	0.4	5.2	6.9	46.7	86.0
	5.1	74.5	64.2	1.1	7.0	6.3	111.2	62.9
	7.7	115.0	45.4	2.8	7.0	4.2	123.0	67.1
	11.2	198.0	54.0	5.3	5.4	2.6	289.6	41.9
	13.4	238.5	54.4	5.7	5.1	2.7	301.7	22.6
	15.6	221.0	43.5	6.2	5.4	2.3	326.1	10.6
	17.4	308.0	54.0	6.0	5.2	2.1	266.3	16.5
	19.6	328.0	51.1	6.1	6.4	1.6	289.6	9.3
Snail	3.3	17.5	88.4	0.4	7.9	5.6	191.3	64.1
	4.4	25.5	98.8	0.7	9.3	5.4	205.8	76.7
	11.6	45.5	65.8	4.1	5.6	4.2	286.1	56.1
	19.6	87.5	75.2	9.8	6.1	4.1	496.5	----
	24.9	109.5	74.1	10.9	5.9	3.1	513.2	16.9
	33.2	144.5	73.2	15.4	4.4	2.6	571.1	23.7
	38.4	169.5	74.3	16.3	2.0	1.9	591.3	5.1
	40.2	199.0	83.4	19.6	1.3	1.2	527.0	5.6

3.2 Egypt

Wheat is the principal winter crop which is grown on approximately 600,000 hectares. Yields are high, averaging more than three metric tons/hectare. Most of the area is sown to the tall Egyptian varieties, such as Giza 155 and 156. The remainder of the area is sown with varieties such as Mexipak 69 and Chenab 70. A number of local cultivars, many of which are durums,are commonly found in Upper Egypt.

The previous two year's estimated production is summarized in the following table:

Estimated Yields, Area and Production of Wheat in Egypt, 1975 & 1976.

	1975			1976		
Variety	Yield (t/ha)	Area (ha)	Production (Metric tons)	Yield (t/ha)	Area (ha)	Production (Metric tons)
Egyptian tall varieties	3.38	501,220	1,604,123	3.23	507,705	1,639,887
Semidwarfs	4.04	78,632	317,673	4.02	74,238	298,436
Other (local cultivars)	2.57	5,606	14,407	2.35	4,198	9,865
Average/Total	3.46	585,458	2,026,203	3.32	586,141	1,948,188

Wheat is normally sown during the month of November and all the production is under irrigation. The cool temperatures during December and January are ideal for leaf rust and yellow rust development. The semidwarf varieties are now susceptible to the prevalent leaf rust races. There is a need to replace the current varieties Mexipak and Chenab because of their susceptibility to leaf rust. Yellow rust has not been a problem in recent years, but there are races that can attack the varieties. However they are not prevalent. The stem rust situation is not serious because of resistance and escape from early maturity.

In 1976 the Egyptian National Programme released four new commercial varieties, namely:

Sakha	3	Inia 'S' x Napo 63
Sakha	8	Indus 66 x Norteno 'S'
Giza	157	Giza 155 x $Pi62^4$ x LR 64^2 x Tzpp x $Knott^2$
Giza	158	Giza 156 x Siete Cerros

It is considered that the yield potential of the new varieties and their resistance to leaf rust will allow a further increase in average yield. The new semidwarfs could raise the average yield to 4 metric tons/hectare since fertilizers and water are not limiting factors.

The annual production of approximately 2 million metric tons does not fulfill the annual consumption needs of Egypt and each year about 2 million metric tons of wheat must be imported. It is hoped that by encouraging additional wheat production the amount of importation will be reduced.

In 1976 the procurement policy was changed to encourage the use of semidwarf wheats and additional inputs. A price of eight Egyptian pounds per ardeb (ardeb = 150 kg) was paid for semidwarf varieties and seven Egyptian pounds were paid for the tall Egyptian varieties. (One Egyptian pound = 100 piastres). No forced procurement was practiced, whereas in 1975 it was necessary to sell 3 ardebs of wheat for every feddan (feddan = 0.42 hectares) of wheat sown.

The sown barley area was 42,000 hectares all of which was under irrigation, with an estimated yield of 2,968 kg/ha. There is also, a large area planted in the north eastern coastal region when rainfall occurs. This area which fluctuates greatly each year, has been estimated to reach 160,000 hectares; however production is erratic and crop failures often occur. There are no accurate barley yield figures in this area. The rainfall varies between 8-20 cm per year and yields probably range between 250-350 kg/feddan.

Most of the barley in Egypt is used for animal feed or human food with approximately 20 per cent being used for malting purposes.

A number of diseases occur in the irrigated areas. It is common to find net blotch (Helminthosporium teres), and spot blotch is also readily found. Leaf rust can be severe and powdery mildew is common. Aphids are becoming an increasingly important problem. In recent years birds have become a serious problem for barley.

There has been limited breeding work since 1921. Over the years a number of varieties have been selected and released. Giza 119 and Giza 120 are 6-rowed barley varieties and now occupy about 80 per cent of the area. The variety Bonus is the other principal 2-rowed variety being cultivated and used for malting. Some of the new promising varieties are Giza 121 (with the same parentage as Giza 119), Strain 205 and Line 207/14.

The program is concentrating on developing shorter, better strawed varieties. The incorporation of better disease resistance is being continued. There are plans to incorporate higher nutritional values through the use of high protein lines. There is also a project being initiated for developing salt tolerant varieties for some of the coastal areas.

An agronomic trial at the CIANO Experiment Station, Obregon, Yaqui Valley, Mexico to demonstrate the effect of different rates of nitrogen fertilizer. Mr. I. Mohammed Baghdadi, a trainee from Saudi Arabia.

3.3 Ethiopia

3.3.1 INTRODUCTION

Cereals occupy over 80 per cent of the total cultivated land. They are mainly grown by subsistence farmers under rain-fed conditions using traditional production methods. As a result, yields are generally low. It is estimated that about 80 per cent of the total cereal production is consumed in the rural areas whereas about 20 per cent is imported to the urban areas. Ethiopia is a net importer of cereals. In recent years cereal imports have been mostly wheat, averaging 70,000 metric tons of wheat annually. According to an estimate by the World Bank in 1976, the country needs to import 150,000 metric tons of wheat annually until 1980. These brief remarks indicate the importance of cereals in the overall food production in Ethiopia and the need for integrated efforts in food crop research and development.

Wheat and barley improvement work was undertaken in late 1950's. It mainly concentrated on the collection of indigenous material, the introduction and screening of varieties in field tests as well as on agro-techniques which affect production. From the program, a number of improved varieties of bread wheat were released to farmers. Useful information was also gathered on optimum seeding rate, planting date and fertilizer requirements of the various crop varieties at different locations in the country.

It was not until 1967 that crop improvement was systematized when the National Crop Improvement Committee (NCIC) was established to coordinate and organize research. Crop breeding, varietal testing and seed multiplication have been re-organized. Now, the barley, bread wheat and triticale work is coordinated by the Holetta Research Station while the Debre Zeit Agricultural Experiment Station coordinates the work on durum.

The nationally coordinated varietal testing of crops consists of two sets of trials viz., Pre-National and National Yield Trials. On the basis of 2-3 years of superior performance in the National Yield Trial, a variety can then be put on demonstration in farmers' fields while small scale seed multiplication takes place simultaneously. If the variety still proves itself good at the end of the season, it will be officially released by the National Crop Improvement Committee (NCIC). The NCIC usually holds an annual meeting to discuss the results of the National Yield Trials as well as to make plans for the following season.

3.3.2 WHEAT

Ethiopia is one of the centers of genetic variability for tetraploid wheats (*Triticum durum*, *Triticum dicoccum*, *Triticum turgidum*, *Triticum polonicum*, and *Triticum dicoccoides*) which up to now have been explored to a very limited extent for plant breeding purposes.

Wheat has always been one of the most important crops in Ethiopia in terms of area and production. It occupies about 816,000 hectares with an estimated mean yield of 800 kg/ha. Of the tetraploid wheats, durum wheat (*T. durum*) comprises 75-80 per cent of the area. Bread wheat (*T. aestivum*) is also grown, but is exotic and presently only 15-20 per cent of the wheat area is devoted to it.

Durum wheat is mainly grown in the highlands between 1700-2800 meters altitude. Almost all of the cultivars are local, which for the most part are mixtures of various types. They generally lack resistance to lodging and diseases and they have low productivity.

Bread wheat is grown at a wider altitude range than the durum wheat and gives better yield. However, at lower elevations drought may limit its production while stripe rust and frost may become problems at higher elevations. In spite of lower yield, durum wheat is more profitable than bread wheat because its white and amber grain color commands higher prices on the local market.

All Ethiopian wheat is raised under rainfed conditions. The total annual rainfall in the wheat growing areas ranges between 400-1000 mm, with an average of 750 mm. Most of the rainfall occurs between June and September, the peak fall coming in July and August. Bread wheats are usually planted earlier than durum wheats.

3.3.2.1 Disease and Pest Problems

The wheat crop in Ethiopia is subject to frequent damage by a number of fungal diseases. Leaf rust, stem rust and stripe rust are the most important. Leaf blotch and glume blotch also occur and cause considerable damage. Bunt or stinking smut and Helminthosporium are problems in some areas. Fortunately, there is no serious insect pest of wheat in Ethiopia.

3.3.2.2 Varieties

At the 1976 NCIC annual meeting two varieties, 6106-8 and 6290-bulk were recommended for general release while two others, Son 64 x SKE - Ane/CC, PMD 1094-1-49-94 and CI 14393 were recommended for limited release for the higher altitude regions where stem rust is not a major problem. Mamba and $K4500L_6A_4$ (Enkoy) are the two most widely grown bread wheat varieties.

No improved durum wheat variety has been released to farmers. However three varieties are being considered for release for the first time. These include Cocorit 71 "S", Ci "S" x 21563 x Gs "S" CM-9908-302-2DZ-1DZ and Gerardo VZ 466/61-130 x G11 "S" CM-9605-?DZ-1DZ-1DZ. Although these varieties are outstandingly higher in yield than the local cultivars, they are equally susceptible to rusts. No single durum wheat variety resistant to more than one type of rust under local conditions has ever been identified in the program.

3.3.2.3 Breeding

The main objectives of the wheat improvement program are to develop varieties with higher yields, broad adaptation, lodging and disease resistance especially to the three rusts, early maturity and medium height.

These objectives are being attempted through selection from indigenous material, introductions of advanced lines and early segregating material from abroad, and by hybridization.

3.3.2.4 Agronomy

Poor cultural practices are the main problems of wheat production in Ethiopia. There is a wide difference between yields at research stations and on farmers' fields. The extension of research findings to farmers is lagging.

Current agronomic investigations include observations on sowing dates, seeding rates, fertilizer requirements and other cultural practices.

3.3.3 BARLEY

Barley is an important cereal occupying 10 per cent of the major crop area with a national average of about 1000 kg/ha. Generally, the barley growing area ranges from 1800-3000 metres, where cooler climatic conditions prevail, and a minimum of 500mm of rainfall is received during the crop life.

Research work on barley has been undertaken on both malting and food barleys since 1967. The effort is directed towards increasing the local production of malting barley for the breweries and the development of "feed" types for human food, home brewing and livestock feed.

Barley is indigenous to Ethiopia and has a tremendous diversity of forms. This great variety of germ plasm is being collected and maintained by the Ethiopian Plant Genetic Resources Center. This season, 3300 of these local collections have been planted out at the Holetta Research Station for evaluation and maintenance. Most of this indigenous material is six-rowed or irregular types, which are not suitable for malting.

3.3.3.1 Malting Barley

Varietal testing of introduced malting barley varieties accompanied by trials on cultural practices and identification of suitable malting barley growing areas have been in progress for the last nine years.

By 1971, Beka, Kenya Research and Proctor were identified for the highlands of Arsi, Holetta and Sheno. However commercial production has moved forward only in Arsi. At Chilalo, Arsi, the variety Beka, has been under commercial production for the last three years. At present this scheme supplies about 50 per cent of the demand of the breweries in Addis Ababa.

To date, six selections of 2-rowed, good malting quality barley have been identified from the local hybridization program. These selections, presently being tested in the National Trials, have better tolerance to barley shoot fly, and good scald resistance. Under trials, they have yielded up to 5 metric tons/ha compared with 3 metric tons/ha for introduced varieties.

3.3.3.2 Feed Barley

By 1971, five promising lines had been identified in the improvement program but none possessed a high enough level of disease resistance and productivity to justify their release. Since then, the emphasis has shifted from introductions to local material as these are better adapted to local conditions, such as tolerance to frost and waterlogged conditions, better competition with weeds, better performance under low fertility, etc. Some of the outstanding varieties identified from this program are currently under multiplication for release. These include IAR/H/81, IAR/H/485, IAR/H/489, Bedi Black 6R and Bedi White 6R.

A hybridization program based on population breeding, using male-sterile lines is in progress. It is hoped that improved populations or varieties of either food or feed or malting types can be obtained from this program.

3.3.3.3 Diseases and Pests

The major disease of barley in the humid highlands is scald which is estimated to reduce grain yield by about 20 per cent. Introduced barley varieties are susceptible to this pathogen. Net blotch, spot blotch, loose and covered smuts are also problems in some areas.

The most important insect pest is the barley shoot fly (*Delia arambourgi*), which is of economic importance in all barley growing regions. Fortunately, the indigenous barley cultivars are somewhat tolerant to the pest.

3.3.4 TRITICALE

Triticale work started in 1971 with a few lines from CIMMYT. Early results were so promising that financial support from IDRC has been received since 1972 in order to fully exploit this new crop for the production of human food. At present the program focuses on areas which are marginal to the production of other cereals. The major activities include: extensive selection and screening of segregating populations and advanced nurseries in various locations; the development of an optimum package of management practices for the various environments in which the crop may be grown; demonstration and testing of the crop on farmers' fields and utilization studies both on research stations and with farmers' wives.

The crop has been found to be adaptable to a variety of growth conditions within an altitude range of 1700-3000m. The earlier promise of excellent vigour, good yields and high fertility in the crop has certainly been confirmed. In addition, the triticale selections which originated from CIMMYT have the advantage of being resistant to lodging under Ethiopian conditions.

Triticale possesses better disease resistance than wheat and barley. Most of the promising selections in the program are resistant to the prevalent races of stem rust and stripe rust, both under natural field conditions and artificial inoculation. However, most of these lines are susceptible to leaf rust. Triticale is tolerant to *Septoria*, which is a major threat for wheat production in the cooler high altitude areas.

3.4 Kenya

3.4.1 INTRODUCTION

Wheat is grown in Kenya as a commercial crop in the Highlands of the Rift Valley Province and near Mount Kenya. Bread wheats are greatly preferred, but some durum wheat is now grown and triticale is used on an exploratory scale. The produced wheat is bought by the Wheat Board of Kenya at prices determined by Government agencies. Wheat production in 1976 was 187,420 metric tons.

3.4.2 EXPERIMENT STATIONS

The main research station for wheat is the Njoro National Plant Breeding Station which is one of the oldest experiment stations in Africa and started in 1927. It is located 25 km West of Nakuru at an altitude of 7100 ft. (2164m) and at latitude 02.15 S and longitude 35 57 E.

Long term average monthly rainfall is highest during April, August, May and July in descending order. The 45 year average for Njoro is 938 mm. Planting at Njoro is usually carried out in April. But later plantings have also been successful. During the period May 1 - September 30, about half of the total yearly rain falls, so the wheat is truly a rainfed crop.

A substation for wheat research is located at Molo, 50 km from Njoro, at an elevation of 9200 ft. (2804 m). Rainfall is higher (+1200 mm) and the station represents the highest altitude areas where wheat and barley are grown. Planting of small grains usually takes place in July at these high elevations. Some 12 yield trial sites including Molo are used annually in the main cereal growing areas which range from 6100 - 10,000 feet altitude.

3.4.3 RESEARCH WORK

Traditionally wheats in Kenya have been suffering from outbreaks of stem rust, Puccinia graminis. Much research has been carried out to produce wheat varieties with good levels of resistance to stem rust. Introductions from high altitude areas in other parts of the world have been particularly helpful in the breeding program. In 1934 a Colombian variety Sabanero was released and continued as a commercial variety in Kenya and Tanzania for 25 years. Important releases in the 1930's and 1940's were Kenya 294, Kenya Farmer and Kenya 321.

3.4.4 COMMERCIAL WHEAT VARIETIES 1976

The main varieties were Bounty, Mamba, Kiboko, Africa Mayo, Leopard, Nyati and Bongo. In 1976, the following two varieties (with their respective listed parentage) were released:

K. Fahari	Tobari (No.43 x T.dicc.-Aeg.Spelt)Austin^2)
K. Kifaru	Tobari 66 (Wisc 245 x CI8154-Frocor^2)

For many years, recommendations for wheat growing have included the selection of more than one or two adapted varieties on one farm. This has reduced the risk of crop failure due to rust attack. Since varieties carry different kinds and levels of resistance to stem rust and stripe rust, an outbreak of a new race of rust will only attack some of the selected varieties and not all to the same degree. Seed stocks of more than 20 different varieties are used in 90 per cent of the area sown in Kenya.

3.4.5 BREAD WHEAT VARIETY TRIALS

In 1975, reports from 16 tests in ten locations clearly showed the superior performance of K6648-6 which was released in 1976 as K. Fahari. The variety was among the best five yielders in 14 of the 16 trials, while it was the top yielder in six of those trials. (Table 3.4.A) Preliminary results in 1976 confirm the earlier data. K. Fahari had the highest yield on average yield over 11 locations. Other equally high yielding varieties over these locations included: K Nyoka, K. Kanga, K. Tembo, K. Paka and some new cross numbers viz. K.6670 - 4 and K.6852 - 4.

The variety tests also provide a measure for disease susceptibility. The trials in 1975 showed that the main varieties K. Leopard, Africa Mayo, and Bounty have average coefficients of infection from 7.4 to 12 per cent. The newer important varieties K. Mamba, K. Nyati, K. Kiboko and K. Bongo, have coefficients of 52.2, 16.0, 40 and 17 respectively and were higher in stripe rust infection in 1975 than the older ones. But fortunately there are varietal differences in the degree that stripe rust fungus moves into the glumes. In 1976 Bounty suffered greatly at high altitudes. This could not be predicted by the average coefficient of infection as obtained in 1975 from the district variety trials.

In 1976 the National Wheat Variety Trial was located in 14 sites in the main wheat areas of the country. The higher yielding varieties had less stripe rust in 1976.

Table 3.4.B compares the average yields of established varieties and new lines in 11 locations in Kenya in 1976. The new lines yielded more than 10 per cent above the established varieties.

3.4.6 WHEAT DISEASES

Plant pathologists at the National Plant Breeding Station conduct surveys every year in the main wheat growing areas to follow the development of new races of stem rust, (*Puccinia graminis*). Table 3.4.C shows which races have been identified from the survey samples. Currently the most frequently occurring race is East African Race 20, which attacks K. Nyati. The race that attacked K. Kanga in 1972 (EA14) has not yet disappeared but its occurrence among the samples has been less frequent in recent years. The table clearly demonstrates the occurrence of new races following the adoption of a new wheat variety.

In recent years, stem rust outbreaks have been less frequent. The last catastrophe was the development of a new race that attacked K. Kanga in 1972 when it occupied nearly one quarter of Kenya's acreage. Recently there has been more damage by stripe rust, *Puccinia striiformis*. It has been particularly serious in the high elevations, but during the last five years it has been increasingly found in lower elevations as well. When the glumes are attacked, wheat grains shrivel and yields are reduced.

3.4.7 WHEAT AGRONOMY

Wheat cultivation recommendations take the following factors into account:

1. Variety choice based on elevation of the farm.
2. Soil preparation depending on cropping history of the land.
3. Timeliness of soil preparation to conserve soil moisture.
4. Seed rate around 100 kg per hectare.
5. Fertilizer application of phosphorus and capacity nitrogen, with higher doses of P_2O_5 than N.
6. Addition of copper in several areas deficient in this micro element.
7. Herbicide application, generally 2,4-D type but recently also control of wild oats with special chemicals.
8. Combine harvesting.

The approximate cost of wheat growing was calculated in 1975 as Kshs.540 per acre. Advances made to farmers in 1976 for land preparation, seeding, weed control and harvest have been Kshs 640 per acre. The national average yield per acre has been over 6 bags per acre (540 kg/acre). The Government will guarantee the wheat price in 1977 at a level of Kshs.175 per bag.

3.4.8 DURUM WHEAT

A small area of only one variety is grown. Because local demand is growing, efforts are being made to produce more durum wheat in Kenya.

The results of a National Durum Variety Trial in 1976 at six locations in Kenya are shown below. The trial included dwarf introductions and some Kenyan crosses:

Variety	Ave. Yield(kg/ha)	Advanced lines	Ave. Yield(kg/ha)
K Bata	2076	KD2-1	2488
D 69	1990	KD2-2	2597
D 83	1921	KD2-3	2480
D 84	1736	KD2-4	2329
D 85	1663	KD2-5	2470
D 86	2103	KD2-6	2569
D 87	2338	KD2-7	2367
D 92	2190	KD2-8	2461
	Average 2002		Average 2470

The KD-2 lines are yielding almost 20 per cent better than the dwarf introductions. One factor was their better competition with weeds, due to their plant height. Among the introductions, D 87 appears to be the best yielder. It is a cross of Flamingo and Leeds (CM 9821-2M-1Y-F-1) with better stripe rust resistance than Bata.

3.4.9 TRITICALE

Triticales are tested in the main wheat growing areas. In 1975 five locations were included, and at Njoro, the average yield was 5.6 metric tons/ha. The lowest yielding location was Eldoret where acid and poor fertility soils reduced levels to 2.0 metric tons/ha. Under these conditions the highest yielders were T50 = Fasgro 204-6B; T32 = Armadillo Sib, T14 = Armadillo; T55 = Octa-Hexa and T53 = Cinnamon Sib. The best performers in 1975 triticale tests were evaluated again in 1976. The national trials at different elevations in six wheat areas included for the first time, materials locally selected from segregating populations as well as the best adapted lines from Mexico, Canada and USA. In 1976, the triticale T74 was found to be outstanding. It outyielded all other entries in the National Variety Trials. In the following table, three generations of breeding are compared for yield as average over six locations in 1976:

Year	Top Yielder	1976 Yield	1976 Rank
1972	T14	3290	22
1973	T48	3435	18
1975	T66	3824	3
1976	T74	4011	1

T74 = Cinnamon - St 45, X-10149-1-A.

At present, triticale is recommended as a feed grain, in order to build up familiarity with farmers. It also offers a possibility to obtain enough quantity for industrial tests. The yield advantages generate much interest, and the development of food markets for the grain is now under consideration.

3.4.10 BARLEY

It is the third largest cereal crop, following maize and wheat. It is grown on large scale commercial farms as a cash crop under contract to breweries. In the 1975-76 season, 30,000 hectares were harvested. Drought areas and some very wet areas reduced yields to 1166 kg/ha. It is considered that 1500 kg/ha are needed to reach a break even economic level. The main varieties are Proctor and a selection from Research, but they suffer from scald, weak straw and relatively low yields. In 1976 the introduced barley B206 from Ethiopia proved to have 30 per cent higher yields than the standard varieties. Pending quality tests by the breweries, it has been multiplied under the name Amani. A series of crosses of Proctor and Research with Briggs, C63, CI13200, and B225, a barley from Mexico, are now being yield tested.

Agronomic research in barley has been limited until recently. Land preparation is a key to good yields. Timely start of the first tillage helps to conserve moisture and reduce weeds. Quality seeds are an important factor in reducing weeds. Wild oats has spread widely in barley growing areas, and it requires expensive control measures. Contract growers are required to buy clean seed every year. Lodging resistance and weed control are two important targets for barley improvement and production in Kenya. Fertilizer levels have been recommended in a ratio of one of nitrogen to five units of phosphate. On most soils 14 kg/ha of N and 70 kg/ha phosphate have given economic response. Copper deficient areas have been identified. Seed for these areas is treated with 1 kg of copper oxychloride/100 kg of seed. There is a minor program to develop feed barley for the expanding livestock industry. Six-row barleys have been preferred because these types can outyield the two row barleys. Yield advantages must be large however, because the best malting barley commands nearly the same price as wheat.

3.4.11 SEED PRODUCTION

The Plant Breeding Station is responsible for producing basic quality seed of all recommended varieties. Newly released varieties are multiplied on the Station under the supervision of the breeders. This material is inspected by the Kenya Inspection Service of Seeds in the fields of the Plant Breeding Station. Similarly, seed stocks of older varieties are maintained and purified by the breeders and the Kenya Seed Company.

The amounts that are grown by farmers for seed wheat are increasing rapidly. Some 20 varieties are produced under contract with the Kenya Seed Company. In 1975-76 the area of wheat and barley fields inspected (21,000 ha) increased by 27 per cent from the previous season. This resulted in 15 per cent more seed approved. (In 1975, 3.861 metric tons and 4.438 metric tons in 1976). Similarly for barley, 10,000 ha were inspected and 2600 metric tons were approved as quality seed.

With further expansion of use of quality seed, half the wheat area will soon be planted with this approved seed. In barley, all seed used for sowing is now of good quality standard. This has been stimulated by the buyers of the barley crop, who made contracts with the growers. One of the requirements of the contract is that improved seed is used. The goverment agencies for research and inspection are closely working together with the seed production group, which includes the Kenya Seed Company and contract growers.

TABLE 3.4.A Average yields of 16 wheat varieties, with Average Coefficient of Infection (A.C.I.) for stripe rust 1976.

Rank	Variety	Av.Yield (kg/ha)	ACI 13 Loc.
1	Nyoka	2386	17.8
2	Kanga	2378	6.2
3	Tembo	2275	5.6
4	K6852-4	2112	4.6
5	K Paka	2112	9.8
6	Nungu	2047	13.1
7	Mamba	2014	17.8
8	Kiboko	2010	21.1
9	K6852-1	1930	5.0
10	K Kuro	1883	21.7
11	Nyati	1746	28.8
12	Fanfay	1731	26.0
13	K6867-2	1669	10.0
14	K6867-14	1643	16.4
15	K Mbweha	1481	21.6
16	Swara	1157	44.8

TABLE 3.4.B Yields of established wheat varieties and new lines at 11 locations, Kenya, 1976.

Variety	Av.Yield (kg/ha)	Advanced lines	Av.Yield (kg/ha)
Africa Mayo	1700	K6648-6	2227
Bounty	1883	K6675-3	2009
Leopard	1965	K6667-10	1633
Bongo (5 locations)	2163	K6670-4	2162
Hunter	1421	K6820-12	2127
Kudu	1553	K6820-23	1751
Page	1570	K6867-10	1715
Average	1751	K6843-2	2115
		K6860-1	2026
		Average	1975

TABLE 3.4.C Distribution of stem rust races as surveyed in Kenya, since 1968.

Year / EA Race	1968	1969	1970	1971	1972	1973	1974	1975	1976	Attacks Variety
1			0							
2		2.0		0.5						
3	2	0.7	0.4					4.7		
4	9	12.7	24.7	3.1	7.9	28.3	8	10.9	0.8	
5	66	60	34.7	20.4	1.6	1.0				Romany
6	3	1.3	1.7							
7	17	11.3	4.6	1.8	1.6	2.1	1.7			
8	2	9.0	6.7	0.9	0.2	0.7		0.8		
9	1	0	0.8	3.1		1.0				
10		1.3	0.4	0						
11		0		0.9	0.4	6.2	2			CI8154 x Frocor
12		0.7								CI8154 x Frocor
13		1	10.9	12.2	8.5	6.5	4	6.0	8.7	
14			1	0.5	46.5	23.8	21.9	16.4	12.6	K. Kanga
15			11.3	51.0	29.8	16.8	8	5.5	12.6	Trophy
16			0.4							
17			0	0.5						
18			1.7	5.0	2.1	0.3			0.5	
19			1.3			0.3				
20					0.9	5.3	51.4	50.0	57.3	K. Nyati
21					0.4	2.1				
22								5.5	2.5	

3.5 Madagascar

3.5.1 INTRODUCTION

Madagascar is the fifth largest island in the world. There are large coastal populations especially along East Madagascar. The highlands around and south of Tananarive, the capital, are the densest populated areas. The estimated population of Madagascar in 1974, was 8.4 million.

3.5.2 EARLY WHEAT PRODUCTION

In 1775, wheat was found in South Madagascar in the half wild form - probably left by ships en route to the East Indies. From 1896 the French tried growing wheat, but there were frequent failures. However, in the highlands around Antsirabe and Betafo, there was some success. About 1910, a few hundred metric tons were produced.

In the first decades of this century, wheat became less important when the French concentrated on irrigated rice production. In addition, poor soils, no fertilizer, rust outbreaks and poor cultural practices, led to the disappearance of wheat growing.

From 1954, wheat was tested again in the Antsirabe area. In the fifties, varieties such as Florence Aurore, Ariana, Hindi and Rieti reached yields up to 1.5 metric tons /hectare. From 1957, wheat was promoted with small landholders in the Antsirabe area. By 1960 a total of 162 hectares was harvested.

3.5.3 CURRENT WHEAT RESEARCH

A Norwegian development project known as FIFAMANOR, commenced providing aid in the early seventies to the Ministry of Agriculture and Rural Development. Its work has included wheat introductions and improvement by breeding. To broaden available germ plasm, Inia 66, Tobari 66, Romany, Africa Mayo and Sonora 64 have been used in the crossing program.

A top yielder in local tests was Fifa 6 = Africa Mayo x 764 (T73004-46-261-328). Kenyan lines have been crossed with Mexican lines.

In a small triticale variety trial, yields approached 3000 kg/ha. This is 20 per cent more than Romany, the bread wheat used as a check and which has performed well. However, quality tests on these triticales showed very poor results. In another test on acid soils, the best triticale (No. 10) yielded 3300 kg/ha while Tobari, the breadwheat check produced only 1200 kg/ha.

3.5.4 FARMER DEMONSTRATIONS ON WHEAT

Fifamanor carries out wheat improvement work in close cooperation with farmer demonstrations. Extension officers work with research staff to lay out fertilizer trials, with up to 100 kg N/ha, and also seeding rate trials. Liming experiments have been carried out and boron has been applied in some tests.

Results from 35 locations were analyzed in 1976, but boron tests were not very encouraging in the rainy season.

In the cool season, which is May-November, higher doses of fertilizer (200 kg N/ha) in the form of NPK 16-16-16 have given good responses.

3.6 Morocco

3.6.1 INTRODUCTION

Abundant rainfall in the growing season contributed to excellent cereal production in 1975-76. Statistics relevant to production are shown in table 3.6.A. The yields for different cereals varied according to the growing region. The crop yield ranges were:

Crop	Kilograms/hectare
Barley	880 - 1990
Durum	530 - 2070
Bread Wheat	650 - 2000
Maize	440 - 1680

Since 1966, a fertilizer promotion program has been in operation and although there has been an increase in fertilizer usage, the per capita use is still low. Also, to increase grain production further, there has been a rapid increase in irrigated wheat farming.

3.6.2 PRODUCTION ZONES

Morocco is divided into the following twelve agricultural zones - (1) Eastern Mediterranean (barley is the major cereal); (2) Mid Valley of the Moulouya and Upper Plateau (barley is the main crop); (3) North West Zone - Tingitane Peninsula (durum is the leading cereal); (4) Lowlands of Sebou-Zaers and Basse Chaouia (the largest and richest zone in Morocco. Durum occupies 70 per cent of the area); (5) Upper Chaouia - Plateau of Phosphates (durum is the main crop); (6) Abda and Doukkala zone (maize and barley account for 80 per cent of the area sown to cereals); (7) Chiadma area (barley is the main crop); (8) Haouz R'Hamna - Sraghna Zone (cereal cultivation is poor. Barley is the major cereal, but yields are low, 300-700 kg/ha); (9) High Atlas Mountain Zone (Barley and durum are the main cereals. Production is limited by low winter and spring temperatures); (10) Middle Atlas Mountain Zone (an expanding cultivated area. Durum and then barley are the major cereals); (11) South West - Sahara Atlantique area (poorly adapted for cereals. Barley occupies more than 90 per cent of the sown area); (12) Oasis Zone (very marginal, considerable desert. Crops grow near rivers. Wheat is the major crop).

3.6.3 VARIETIES

The bread wheat varieties which have been multiplied during the last four years are Potam, 149 Nasma, 5/70-9, 5/70-11, 5/70-32. Likewise, the durum wheats are Cocorit, Jori, Hadj Mouline and 36/71.

Promising bread wheat lines are Bb-Son64-Kl.Rend/Bb-Gallo, Inia s -SKa, NP887 UP301-10-1, Inia Tob"s"-Napo, Rou-Cha Bb-Nor, Tob66 Cno"s"-No, 7c-On Inia-Bman and promising durums are Yemen-Cr"s" Ple"s" and (21931 Ch52-An Gb56)An64.

The above mentioned lines have been observed in small plots for three years and in 1976-77 they will be grown in regional trials before they undergo multiplication.

3.6.4 DISEASES AND PESTS

Diseases which occur in Morocco are smuts, Septoria, rusts, Helminthosporium and powdery mildew. Except for Septoria which was serious in 1975-76 season, there have been no major outbreaks of the other diseases.

The hessian fly is a problem in the coastal zone each year. It destroyed some breeding nurseries.

TABLE 3.6.A. Production Statistics, Morocco, 1975-76

Crop	Area 1000 ha	Per cent of total cereal area	Average area 1971-76 1000 ha	Average yield kg/ha 1975-76	Average yield kg/ha 1971-76	Production 1000 metric tons 1975-76	Production 1000 metric tons 1971-76
Barley	21,174	45.2	19,717	1350	1060	286,040	211,064
Durum	14,541	31	14,123	1140	1000	159,776	139,896
Bread Wheat	4,675	10	5,011	1150	930	53,711	46,054
Maize	4,327	9.2	4,596	1140	800	49,250	36,763

3.7 Nigeria

The area sown to wheat for the 1975-6 crop was about 4000 ha of which 3500 were irrigated and 500 were on residual moisture (fadama). Total production was about 6375 tonnes with average yields approximating 1.75 t/ha (irrigated) and 0.5 t/ha (fadama). Barley and triticale are grown almost exclusively on research stations.

Temperatures were above average by about 5°C intermittently for about half the 100-110 days growing period. Typical maximum and minimum temperatures for the November-February period are about 34°C, 32°C, 31°C, 34°C and 16°C, 13°C, 13°C and 15°C respectively.

High yielding varieties comprised about 80-90 per cent of the irrigated wheat -mainly Indus and Siete Cerros. Local varieties consist of less than 20 per cent for irrigation. Partly due to a greater availability of HYV seed from official supplies, this figure (20%) is rapidly falling below 10 per cent.

Fertilizer rates adopted were only 50 per cent of the recommended rates of 100 kg/ha N and 50 kg/ha P_2O_5 on irrigated wheat. Fertilizer use remained negligible on fadama wheat. The prevailing prices per 50 kg bag were ammonium sulphate ₦ 7.50, calcium ammonium nitrate ₦ 7.50 and single superphosphate ₦ 7.50. The new prices are only ₦ 1.50 per 50 kg bag for each of these fertilizers and at April 1976, this represented a 90 per cent subsidy by the government.

At present nearly all fertilizer is imported. In 1975 this was below 100,000 t, whilst in 1976 although 200,000 t were ordered, this fertilizer mainly arrived too late for the wet season viz., April-October. The supply does not meet the demand and the real demand is unknown because the supply has always been inadequate. Since the subsidy was increased, the demand has increased.

No new wheat varieties were released. In the Nigerian regional wheat trials, the most promising lines were all bread wheats viz., Anza, 301 x Son-Pi, UQ105, ((Lee x $N_{10}B$' Gb55) Gb56 and (36896-CJ54 x Y54) 5667.

In the wet season wheat seed multiplication on Jos Plateau, *Helminthosporium sativum* was severe, plus some *Fusarium* species. No other particular diseases were noted. Unless sowing can be delayed to put the ripening period into October after the rains cease, a disease problem is likely to occur.

Problems precluding the expansion of wheat relate mainly to the coordination of irrigation scheme management. A rapid expansion in Kano State is expected in 1977, and in the following year in Bornu and Sokoto States when the respective basic infrastructure developments are completed.

Wheat production is less than half its potential in the irrigation schemes due to problems connected with land levelling, drainage and irrigation schedules. There is also a shortage of skilled manpower at all levels from field extension staff to management staff. The lack of drainage on some small irrigation schemes has already resulted in a salinity problem. If weeds continue to be ignored, they could easily become a major problem within a few years on schemes in Kano State.

3.8 Rhodesia

3.8.1 INTRODUCTION

In 1976, Rhodesia experienced its most successful year of cereal production, with record crops of wheat and barley. Wheat production resulted in the country becoming self sufficient for the first time ever, and there was a sizeable carry over. This was also the case with barley. The attainment of self sufficiency in wheat was however helped by the fact that the extraction rate of flour was raised to 85 per cent instead of the normal 78 per cent.

Wheat and barley, are grown in Rhodesia during the winter months starting in April-May, and are harvested in October. Rhodesia is in a summer rainfall area and the total cereal production is under irrigation. Wheat used to be an unimportant crop in Rhodesia, because it was cheaper to import than to produce it locally, due mainly to the expense of irrigation equipment. However with the introduction of sanctions, it was decided to try and increase total production by offering a price to the farmer that was far in excess of the world price. The response to this was rather dramatic. Production rose from 1.5 per cent local consumption in 1965 at 2.2 metric tons/hectare (i.e. tonnes/ha), to self sufficiency in 1976. In 1972 the national yield stood at 3.7 t/ha and in 1976 this reached a record of 4.3 t/ha.

Wheat production in Rhodesia, is a high input crop, mainly due to the irrigation, and production is limited solely to farmers with irrigation. Expansion is still taking place mainly in the highveld regions where new dams are being built, thus making more irrigation water available.

Barley production increased even more dramatically than wheat production, increasing eight fold between 1973 and 1976. The national average in 1975 was 4.6 t/ha and in 1976 it was 5.4 t/ha, which resulted in overproduction in 1976. Diamant was the main variety with Cutter being grown on a smaller scale.

3.8.2 FERTILIZERS

Fertilizers are extensively used, with application rates on wheat being 120-140 kg/ha nitrogen, 60-80 kg/ha P_2O_5 and 40-60 kg/ha K_2O. These high fertilizer applications, coupled with good irrigation management result in the high yields being obtained by the farmers. Although the national wheat yield average in 1976 was 4.3 tonnes/ha, the best yield, which was obtained on a 40 ha block of the variety Gwebi, was close to 10 tonnes/ha.

Less nitrogen is used on barley, with application rates rarely exceeding 40 kg/ha, with the P_2O_5 and K_2O rates being the same. Fertilizers are an expensive input item, with costs ranging from 129 dollars/tonne for ammonium nitrate (34 per cent N) to 63 dollars for superphosphate and 120 dollars for potassium sulphate. Also available are various compounds formulated for specific crops and soil types. The ammonium nitrate is made locally and the phosphate is also obtained locally, with potash being the only imported item. At present supply exceeds the demand, and shortages are not likely in the near future.

3.8.3 WEEDS, PESTS, DISEASES

They are presently a very small problem in the majority of the planted areas. Stem rust, however does play an important role in wheat production in the lowveld, (at present only about 25 per cent of total production) insofar that it has previously caused a crop failure in this area. The races of stem rust found in Rhodesia are 34 and 222, and they have remained unchanged since 1967. The lowveld, being lower and warmer, is also susceptible to leaf rust. There was a fairly bad outbreak of stem rust in the lowveld in 1976, but fortunately it affected only crops of Bubye and especially late planted wheat. However, this was not at all serious since Bubye occupies a very small portion of the total crop.

In the highveld both stem and leaf rust are seldom encountered, but mildew does occur in susceptible varieties in certain areas. However, it is not an overall problem.

3.8.4 WHEAT VARIETIES

For many years the two major varieties were Tokwe (dwarf) and Zambezi (tall straw), with varieties like Devuli, Shashi, and Mexican 16 taking up a very small section of the acreage. In 1974, two new varieties, namely Limpopo and Bubye were released. Limpopo (San

64/T2Pr/NA160/3/Tokwe) is a dwarf, with a high yield potential, and a high level of resistance to stem rust, leaf rust and mildew. Bubye (San 64A//T2PP/NA160/3/nu/Selkirk//Mane 13d) is a semidwarf with medium yield potential, but unfortunately it has turned out to be susceptible to stem rust. Nuanetzi was also released in 1974, /Nuanetzi (Tokwe/3/P162/Chris//San 64A) 7 but it proved to be very unsuccessful in field trials, being susceptible to all the diseases, and it was withdrawn before it reached certification.

In 1976, certified seed of the variety Limpopo became available in large quantities. As is always the case in Rhodesia, farmers tend to go for new varieties and they also insist on certified seed. The result was that the demand exceeded the supply. The popularity of Limpopo was such that it occupied about 80 per cent of the total area planted, with Bubye, Shashi, Tokwe and Devuli making up the other 20 per cent. As a result of this, the seed association planned to produce enough seed for 1977.

In 1975 two further varieties viz., Ngezi and Gwebi, were released. Ngezi, is a dwarf and it was found to be very susceptible to stem rust. Consequently it never reached commercial production. Gwebi, a selection from Yecora 70, is a semidwarf under Rhodesian conditions, and shows a high level of resistance to stem rust, but it is mildly susceptible to leaf rust It has a very high yield potential, and could become a very popular variety.

Torim 73 another CIMMYT variety has done very well under Rhodesian conditions, and it is set to follow the same path as Gwebi.

3.8.5 BREEDING PROGRAM

A number of varieties again performed very well, notably Torim 73 and S1503-115. However, S1503-115 is of poor quality (filler wheat) and as such there is no place for it in Rhodesia. The reason for this is that Rhodesia uses wheats that can be used as straight runs, and very little blending is done. A number of early generation lines showed great promise and most of them were resistant to stem rust. Several lines produced very high yields, but were unfortunately too tall for Rhodesian conditions, and these were sent to CIMMYT for inclusion in their program.

The most promising lines in the program are those which contain S1111 Al Ao in its parentage. S1111 Al Ao is immune to stem rust, but is susceptible to leaf rust. At present, resistance to disease is the main object. A very high yield level has already been reached. All the varieties now being grown are capable of producing yields which are much higher than those being obtained by most farmers. All these varieties are maintained and multiplied by a local seed association in accordance with demand.

The barley breeding programme was started only in 1974 and therefore only early generation lines were tested. Some of these showed great promise and outyielded the present top commercial variety Diamant.

3.9 Senegal

3.9.1 INTRODUCTION

In the Sahelian countries, wheat is considered to be next in importance after sorghum, millets, rice and maize. Each year wheat has gained in importance as a human food as evidenced by the continual increase in area and production. The wheat yield ranges from 300-2,500 kg/ha with the average being 1,400 kg/ha.

The countries in the region of the Senegal River, namely Senegal, Mauretania and Mali, have an annual consumption of 125,000 tonnes of wheat, which are imported.

In Senegal, and Mali, the main wheat growing problem especially under irrigation during the dry cold season, is to have the crop produce more grain than sorghum or rice. Experimental irrigated wheat production in Senegal, Mali and Mauretania was commenced in 1966. It was continued and diversified by FAO under an Agronomic Research Project undertaken in 1969.

The objectives of these experiments were to isolate suitable short season high yielding varieties with resistance to heat, birds, lodging, diseases and insects, and with good bread making quality. Other objectives were the improvement of cultural techniques, tillage, rotations, fertilization, irrigation, use of herbicides, etc.

During this campaign, the better varieties of wheat and triticale have been tested on a large scale and in small plots, and also in microplots according to directions provided by CIMMYT.

This report presents the wheat experiment results obtained at the FAO centre at Guédé in 1975-76.

3.9.2 BREAD WHEAT

Bread wheat variety trials were introduced in 1970. At Guédé in the 1975-76 season, 52 wheat varieties were tested and those which showed the best performance were:

(1) Mexipak. This Mexican wheat yielded 6056 kg/ha. The thousand grain weight was 43-47 gm and the hectolitre weight was 79-85 kg. Siete Cerros is another name for the variety, and when tested under this name, it yielded 6570 kg/ha. The hectolitre and thousand grain weights were essentially the same.

(2) Inia "S"-Or x Inia-Bb. This variety derived from CIMMYT material yielded 8342 kg/ha. The thousand grain weight was 58.8 gm and the hectolitre weight was 81.0 kg. This variety is later than Mexipak, and it is attacked more heavily by birds, because the awns are more or less parallel.

(3) Cc x Cal-Sr. It originated from CIMMYT and the trial results showed 109 days to maturity, straw 85 cm tall, yield 8500 kg/ha, thousand grain weight 40.7 gm and the hectolitre weight 80.6 kg. This variety appears to be a good prospect for the Senegal Valley.

(4) Nor 67-Cno 67 x Jar 66. This CIMMYT material yielded 6627 kg/ha with a thousand grain weight of 41 gm, a hectolitre weight of 80.6 kg, 107 days to maturity and 75-80 cm. height.

(5) Inia 66. This Mexican variety took 104-105 days to maturity, yielded 6069 kg/ha, the thousand grain weight was 41.3 gm, the hectolitre weight was 84 kg and the height was 95-100 cm.

(6) Kalyan 227A x Bb. It is early material from CIMMYT and yielded 6280 kg/ha. The thousand grain weight was 42 gm and the hectolitre weight was 78 kg.

(7) Jerusalem. This variety from Israel is later than Mexican varieties (110 days), but it has very good quality. The thousand grain weight was 48 gm and the hectolitre weight was 78-80 kg. The yield was 7000 kg/ha, which indicates that this variety could be considered for growing in the Senegal.

(8) Sonora 64A x SelkirkE. This early productive CIMMYT variety yielded 5135 kg/ha and may become one of the wheats grown in Senegal. The grains are plump with a thousand grain weight of 40-42 gm and a hectolitre weight of 80 kg.

(9) Y50$_E$ x Kal^3. This CIMMYT material is one of the earliest varieties (95 days) and it yielded 5000 kg/ha. The 1976 harvested grains were outstanding with a thousand grain weight of 44 gm and a hectolitre weight of 79-83 kg. The variety was found to have a tendency towards branching in the spikelets which indicates the possibility of increased grains per head.

(10) SA 42. This Pakistan variety was received from Egypt via FAO. In spite of a late seeding, it yielded 4636 kg/ha. The plants were short (80-85 cm), resisted lodging, were early maturing (98 days) and the thousand grain weight was 55 gm and the hectolitre weight was 84 7 kg.

(11) Chenab 70. This Pakistani variety matured in 105 days and yields ranged from 4112-8817 kg/ha. The height was 95-100 cm and long ears contained 19-21 spikelets. The grains were heavy weighing 44.8 gm per thousand and the hectolitre weight was 80.8 kg. It is considered that this variety will rival Mexipak in yield.

(12) Penjamo 62. This is an early maturing Mexican variety (106 days) with a thousand grain weight of 42 gm and a hectolitre weight of 78.8 kg. It yielded 4130 kg/ha and the height was 95-100 cm. It tended to lodge and shatter. It is not considered to be a good prospect for commercial production due to its moderate yield, lodging and shattering.

Table 3.9.A summarizes the maturity days, the 1975-76 yields and also the yields in previous seasons for the above-mentioned varieties. The yields in the preceding seasons for varieties other than Mexipak were from small plot trials. In 1975-76, the experiments were conducted in plots of 50-5000 square meters, according to the amount of seed available.

The characteristics and yields of 27 other varieties which were tested in 1975-76 in plots of 15-330 square meters, are given in table 3.9.B.

The variety Nor 67-Yr was the most productive It yielded 6000 kg/ha and it had a thousand grain weight of 58.3 gm and a hectolitre weight of 85.5 kg.

It is likely that the following varieties may be excluded for the reasons given - Estanzuela Tararias (loose smut and lodging susceptibility, small heads, late maturity); Estanzuela Sabia (spikelet sterility at the base of the spike); Estanzuela Dakaru (too late); Cno-7C x Cno-Inia/Sx (shatters); Cajeme 71 (grain shrivelling tendency). Other varieties which shatter include Penjamo 62, Bb-Cc x Ron, Azteca 67, Nor 67-Yr and Tob "S"-Npo x Cc-Inia/Cha.

It was concluded from the bread wheat trials that Mexipak should be considered as the best variety for the next 2-3 seasons. Other varieties with outstanding yields which should be put under increase are Inia "S"-Or x Inia-bb, Cc x Cal-Sr, Nor 67-Cno x Jar, Inia 66 and Y50$_E$-Kal^3. The two new varieties SA42 and Chenab 70 should also receive further attention.

3 9.3 DURUM WHEATS

Cocorit 71 from CIMMYT and an Italian durum, Giorgio 180.27.105, were tested. Maturity days were 112 and 113 days respectively and yields were 4.94 and 6.09 kg/ha respectively. These two varieties may be suitable for the middle Senegal River Valley. The experiment will be continued for at least one more season.

Two other Italian varieties, namely Rainieri, a durum, and Strampelli, a bread wheat were tested. They are suitable for colder regions and did not head. However they produced heavy yields of green material - Rainieri 19 metric tons/ha and Strampelli 18 metric tons/ha.

3.9.4 SPRING WHEAT YIELD NURSERY

The CIMMYT International Spring Wheat Yield Nursery consisting of 50 entries was grown in randomized microplots of 2.4 m^2, with three replications. The trial was sown on December 12, 1975 at 18 cm spacing and it was fertilized with NPK in the ratio of 140:80:60. The herbicide Tolion was applied as a pre-emerge at 8 litres/hectare.

The results from 28 varieties are shown in table 3.9.C. Twelve new varieties exceeded the yield of Mexipak by 15 per cent, 6 varieties by 5 per cent and 6 varieties were equal in yield. The varieties numbered 2-9 in table 3.9.C. yielded more than 8 t/ha. Four varieties exhibited exceptional grain quality, namely Jupateco 73 (1000 grain weight 48.2 gm and hectolitre weight 82.2 kg), Jupateco 73 "S" (47.4 gm and 79.0 kg), Condor "S" (44.5 gm and 91.7 kg) and variety 309 (43.6 gm and 87.6 kg).

3.9.5 BREAD WHEAT SCREENING NURSERY

The CIMMYT International Bread Wheat Screening Nursery containing 386 varieties, was tested and 40 varieties were selected on the basis of yield, earliness, resistance to birds and short straw. Table 3.9.D lists the yields and other characteristics.

The results show that many varieties exceeded 5 t/ha yield in the Senegal Valley. The better yielding varieties will be further tested. Fourteen varieties exceeded the yield of the check variety Siete Cerros by as much as 25 per cent, 10 varieties by 15-24 per cent and 8 varieties had a 5-14 per cent advantage.

The best varieties had 1000 grain weights in excess of 40 gm and hectolitre weights above 75 kg.

3.9.6 TRITICALE

This plant is of interest in Senegal because of its resistance to rusts, smuts, Septoria and its protein content which is better than wheat. In addition, triticale is resistant to aluminum toxicity and is adapted to acid soils.

Fifty one CIMMYT varieties were tested on Fondé soils in plots ranging from 12-100 m^2, depending on seed quantities. The plots were seeded on November 22, 1975 at a depth of 2 cm, in rows 18 cm apart. N140, P80 and K60 fertilizer was used. Tolion herbicide was applied at the rate of 8 l/ha and the spray volume was 200 l/ha.

The results are shown in table 3.9.E. All the triticales yielded less than the check, Mexipak. Cinnamon which was considered the best in 1971 was surpassed in yield by many varieties. Generally, grains were shrivelled which accounts for the low 1000 grain weights and hectolitre weights shown in the table 3.9.F.

Sahelian conditions accentuate shrivelling because of the effect of the hot winds on the later maturity of triticales.

To examine the performance of triticales on light sandy soils a mixture of several varieties was compared with Mexipak, a wheat, in large plots on Fondé-ranéré soils, which contain 15-25 per cent clay. Mexipak matured in 105 days and yielded 2.15 t/ha, while the triticale mixture matured in 112 days and yielded 2.41 t/ha, an increase of 12 per cent. In another experiment on these soils, Sonora 64 x Sk_E wheat yielded 2.3 t/ha, while Koala triticale yielded 2.57 t/ha and a mixture of Maya II-Arm "S" triticale lines produced 2.43 t/ha.

Thus on Fondé-ranéré soils, triticales give higher yields than wheat due to their hardiness. Triticales mature earlier on light soils than on heavy soils.

Wheat and triticale production was also compared on heavy soils, namely Hollaldé. It was found that triticale was less productive. The wheat, Mexipak, yielded 4 t/ha and the triticale only 3.3 t/ha.

3.9.7 CULTURAL PRACTICES

Cultural practices which influence the yield of a crop, have been investigated, and they are reported below.

3.9.7.1 Soil Type

In the Middle Senegal Valley, the lighter soils (Fondé) seem best for wheat cultivation. Although this crop can be grown on the heavier soils (Hollaldé), yields are always lower. In an experiment with Mexipak, it yielded 6.06 t/ha on Fondé soils and 4 t/ha on Hollaldé soils, with the maturity days being 105 and 108 days respectively.

3.9.7.2 Preceding Crop

There is favourable wheat production when this crop follows a weed free winter crop of maize or sorghum, or a legume (beans) or after a forage crop or sorghum, sudan grass or millets. The preceding crop must be harvested 30-40 days before preparing the wheat seedbed in order to assure decomposition of the organic matter in the soil.

3.9.7.3 Soil Preparation

An acceptable practice is to rotovate the soil twice. The first working is to 8-10 cm and the second to 12-15 cm. If the previous crop has been sown on ridges, the soil must be scarified before rotovating. With legumes, the residues of this crop should be disced into the soil.

Because wheat is very susceptible to excess water during tillage, it is essential that the area be levelled before seeding.

3.9.7.4 Fertilization

It is considered that the high yield and quality of the 1976 wheat harvest was significantly influenced by using N140: P80: K60 fertilizer with the following four split applications: (a) basal dose N26: P80: K60; (b) tillering N46; (c) jointing N46; (d) after flowering N22. All the above mentioned fertilizer units are in kilograms.

3.9.7.5 Seeding Date

Experiments have shown that the best seeding period in the Middle Valley is between November 15 and December 10. The temperature regime is then favourable for the formation of secondary roots and tillering.

3.9.7.6 Seeding Rate 1975-76

Because of the occurrence of *Fusarium* and *Septoria* diseases in the previous year, the seeding rate was reduced to 160 /ha, which provides a seeding density of 400 grains $/m^2$

3.9.7.7 Chemical Weed Control

A number of herbicides were tested on wheat in an experiment in collaboration with the Senegalese Institute of Agronomic Research. The yield results are shown in table 3.9.G.

Tolion gave a yield increase only when the dose was 10 l of commercial product/ha. It does not damage wheat plants when used at a dose rate of 10 l/ha.

Tribunil contains methabenztriazuron, and it is recommended as a pre-emergent or early post-emergent herbicide. The three rates used resulted in significantly lower yields than the check.

Bay 67-71 contains methabenzthiazuron and metribuzine. Compared with the check, the 5 kg/ha rate gave a yield increase of 320 kg/ha.

Bay 66-76A is similar to the previous compound but it was very ineffective. It produced leaf burn on 50-75 per cent of the plants, especially on plots at the second and third dose rates.

Chandor, a mixture of trifluariline and linuron, is recommended for pre-emergence treatment. In this experiment only the first dose (3 kg of product) was able to give even a weak response. The higher doses were highly toxic to wheat.

Igrane is a herbicide based on terbutrine and is recommended as a pre-emergence spray. In the experiment, the first dose rate of 3 kg/ha gave a significant increase while the higher rates 4 and 5 kg/ha were increasingly ineffective.

Gardoprin is recommended for both pre and post emergence. In this experiment the first dose (0.5 kg/ha) gave an increase of 292 kg/ha while the rates of 1.0 and 2.0 kg/ha were highly toxic and burned the wheat plants.

From the experiment, it was concluded that the only useful herbicides on wheat were Tolion, Bay 67-71 and Igrane. Chandor, Igrane and Gardoprin at low dosage gave some advantage. It may be noted that the average yield of 6.921 kg/ha for the 11 checks exceeded the average yield of most of the treatments.

With irrigated wheat, the use of herbicides must be limited to the case where the preceding cultivar, maize or winter sorghum, is treated with herbicides which are effective against the Cyperaceae.

An experiment was initiated in the 1975-76 season on the performance of some herbicides applied post-emergence with only one replicate, as a screening test to verify the fact that post-emergence application retards plant development and especially causes burning, which reduces the yields. Most of the herbicides used caused a drop in the yields as compared with the average of the checks as is shown in table 3.9.H.

Post-emergence application of herbicides on wheat must be made during tillering and then only in the case where there are a great many weeds. The choice of the herbicide is very important. In the screening test, the most favourable were Printan 22L, a mixture of chlortoluron and mecoprop at a dose of 8-10 kg/ha and Printazel 76, a mixture of 2,4-D and mecoprop at a dose of 0.75-1.0 kg/ha. Most of the herbicides i.e. Tribunil, Bay 67-71, Bay 66-76A, Dicuran, Certrol and Gardoprin are toxic on wheat when applied as a post-emergence application.

During the dry warm season of 1975, a plot of maize was treated with the new herbicide, glyphosate at a dose level of 4 kg/ha a.i. After maize, niébé was sown during the 1975 winter season and in November 1975, wheat was sown. It was noted that glyphosate had no noticeable effect on niébé. The yields of wheat after the niébé following maize treated and non treated with glyphosate, were particularly noteworthy - after maize treated 5083 kg/ha - after maize not treated 2898 kg/ha. The positive residual effect of glyphosate was equal to a gain of 2,185 kg/ha.

Conclusion

In the Senegal Valley herbicides are needed to control such dicotyledonous weeds as Portulaca oleraceae and the monocotylodonous Cyperaceae, especially Cyperus rotundus which multiplies by bulbs and responds vigorously to irrigation. To obtain high yields, control of this latter weed is essential.

3.9.7.8 Irrigation

Because information on the water requirements of plants is lacking, evaporation was measured with a class A pan and it was corrected from a monthly coefficient representing a comparison between actual evapotranspiration and a free surface evaporation of water. These corrected determinations were used as an irrigation criterion.

During 1975-76, the evaporation measured from the class A pan was 633 mm which corresponds to an actual evapotranspiration of 577 mm, which is equivalent to 5770 cubic metres (m^3) of irrigation water per hectare. Water was applied by controlled flooding at 500 m^3/ha/irrigation every 7-8 days. The 1975-76 season compared favourably with other seasons regarding water requirements viz., 1972-73 749 mm; 1973-74 673 mm and for the period 1971-74, also 673 mm.

3.9.7.9 Diseases

Following the presence of Fusarium roseum and Septoria nodorum in 1974-75 the following measures were adopted in 1975-76, and which proved satisfactory in respect of wheat production - seeds were changed and verified for health: wheat was grown only on land previously used for forages, maize and niébé; longer rotations were commenced, the seeding rate was reduced from 200 to 160 kg/ha; N fertilizer was applied in four doses; irrigations were better controlled, with a maximum application of 500 m^3 of water/ha/irrigation, preventive treatments were made with Mancosan and Benomil using 2 5 kg product/ha in aqueous solution applied at 250 l/ha; Beniate fungicide was applied at 0.6 kg product/ha as an aqueous solution in 250 l/ha during the jointing stage

3.9.7.10 Rats and Birds

Because rats attack wheat during the jointing stage, defensive measures must be taken before seeding by using anticoagulant baits in the plot areas and in the habitat areas of the rats. In 1975-76, the greatest damage occurred in wheat on the Hollaldé soils. The affected areas gave yields of 1400 kg/ha and 650 kg/ha for wheat and triticale respectively.

When rats cut the stems before jointing, the tillers replace the principal tiller. In one wheat plot completely destroyed by rats, the tillers grew back and produced 2800 kg/ha.

Bird attack is minimized when varieties with spreading awns are grown for example, $Y50_E$-Kal[3] and Nor 67-Yr. A uniformly dense crop helps to escape bird attack. Awnless varieties are not resistant to bird attack. Thinly sown crop are severely damaged by birds.

3.9.7.11 Harvest Quality

To examine the quality of Mexipak wheat grains obtained at the 1975 harvest, grain samples were sent to the Institute of Food Technology, at Dakar. An imported wheat was used as a check.

The results, which are given in table 3.9.I, show the superiority of the flour obtained from wheat grown in Senegal. The protein content, falling time, strength and tenacity all indicate noticeably superior values. The wheats grown at Guédé can be classed as strong wheats.

Eight wheat varieties and five triticale varieties from the 1976 harvest are being analyzed at the Institute of Food Technology, Dakar.

3.9.8 ECONOMICS OF WHEAT PRODUCTION

For an average yield of 6000 kg/ha in 1976, and at a sale price of 45 F CFA/kg, the total wheat value return was 270,000 F/ha.

Total Production Expenses were:

Seed: 200 kg at 45 F/kg	9,000 F CFA
Fertilizer: 510 kg at 16 F/kg	8,160 F CFA
Herbicides: 8 l at 1200 F/l	9,600 F CFA
Water Pumping: 8000 m^3 at 2.5 F/m^3	20,000 F CFA
Mechanical Work:	20,000 F CFA
Manual Work: 660 hours at 75 F/hour	49,500 F CFA
TOTAL	116,260 F CFA

Thus for a yield of 6000 kg/ha, the net revenue was 153,740 F CFA/ha. For a yield of 4500 kg/ha, the net revenue was 41,000 F CFA/ha.

The fertilizer price includes a subsidy. The mechanical work totalled 15 hours /ha and consisted of 2 passes of the rotovator, one pass of the leveller, fertilizer application, seeding and plot preparation. The hourly charge was 1333 F CFA. The manual work consisted of bund construction (10 hours/ha), irrigation (300 hours/ha), spreading and covering fertilizer (50 hours/ha), sickle harvesting (200 hours/ha), threshing and winnowing (100 hours/ha). The cost of hand labour was 75 F CFA/hour.

TABLE 3.9.A Yields on large plots of the best varieties of wheat at Guédé in 1975-76, and in preceding years.

Variety	Maturity (Days)	Yields (kg/ha)		Botanical Variety Classification
		1975/76	Previous Years	
Mexipak	103	6056	2554-4192	turcicum
Siete Cerros	104	6570	5625	turcicum
Inia "S" - Or x Inia-Bb	109	8342	6937	graecum
Cc x Cal - Sr	109	8500	-	erythroleucon
Nor67-Cno67 x Jar 66	107	6627	-	erythrospermum
Inia66	105	6069	7968	erythrospermum
Kalyan 227 A x Bb	105	6280	6500	erythrospermum
Jerusalem	110	7000	-	erythrospermum
Sonora 64 A x Sk_E	103	5135	5300	erythrospermum
$Y50_E$ - Kal^3	95	5000	6537-6862	ferrugineum
SA42	98	4636	-	pseudomeridionale
Chenab 70	105	4112 to 8817	-	graecum
Penjamo 62	106	4130	4900	erythrospermum

TABLE 3.9.B The yields of other wheat varieties at Guédé in the 1975-76 season.

Varietal Names	Maturity (days)	Yield (kg/ha)	1000 Grain Weight (gm)	Hectolitre Weight (kg)	Botanical Variety Classification
Nor 67 - Yr	95	6000	58.3	85.5	graecum
Cc-We x Yr "S"	108	5553	41.5	79.5	erythrospermum
Cc-Inia x 7C/We	104	5500	37.6	80.2	erythrospermum
(LR64 x N10B) x An_E^3	104	5260	47.0	78.6	erythrospermum
Nad63-LR64A x Bb"S"	107	5389	46.2	78.6	erythrospermum
Tzpp-Pl x 7C	104	4625	40.9	78.4	erythrospermum
Bb - Cc x Ron	95	4921	42.3	81.7	ferrugineum
Tob^2-Np x Inia "S" - Npo	94	5071	41.2	77.9	ferrugineum
Azteca 67	98	4826	45.3	81.7	erythrospermum
LV x Bb-Cno/Kal-Bb	95	5000	42.5	83.0	graecum
Cno "S" - Inia 66	104	4286	42.5	80.4	erythrospermum
Bb-PakF46313	104	5050	48.5	81.0	erythrospermum
Cal-Cc x Son 64-NR	107	5230	41.7	77.0	erythrospermum
Cno-7c x Cno-Inia/S x	104	5111	42.7	79.0	ferrugineum
Ji - Yr "S"	104	5000	44.8	82.4	ferrugineum
Ciano	106	5055	43.6	82.2	ferrugineum
Jar "S" - Nor/Cno - 7C x Cc - Tob	96	4269	40.5	78.0	erythrospermum
Bet Dagan	104	4880	46.4	77.7	erythrospermum
Lakhish	109	3925	42.4	78.2	erythrospermum
RR68 - WW15/Ji "S" x Cno - No 66	104	3083	57.9	77.7	ferrugineum
Bb x Cc - Cno^e/Tob 8156 x Bb	104	4389	43.1	84.2	erythrospermum
Estanzuela Dakaru	110	4687	41.1	80.3	erythrospermum
Estanzuela Sabia	110	4694	48.9	77.5	erythrospermum
Estanzuela Tararias	110	4210	48.0	77.7	ferrugineum
Cajeme 71	95	3760	38.3	74.3	erythrospermum
Tob "S" - Npo x Cc - Inia/Cha	107	4318	48.0	82.0	ferrugineum
Bd/Son 64 - An 64 x Nad/Jar "S"	109	5275	59.1	77.5	ferrugineum

TABLE 3.9.C The best wheat varieties from the CIMMYT ISWYN tested at Guédé in 1975-76.

No	Varietal Name	Origin	Maturity (days)	Yield (t/ha)	1000 Grain Weight (gm)	Hectolitre Weight (kg)
1	Mexipak (check)	Mexico	95	6.584	44.4	79.7
2	Canario "S"	Mexico	102	9.472	40.4	78.8
3	Chenab - 70	Pakistan	108	8.817	44.8	79.9
4	TZpp - Pl x 7C (4M)	Mexico	102	8.643	44.8	77.3
5	Jupateco 73 "S"	Mexico	108	8.208	47.4	79.0
6	Dougga	Tunisia	102	8.187	44.5	77.0
7	Brochis "S"	Mexico	103	8.168	40.0	77.3
8	Pj62 - Gb 55 x Nai 60	Pakistan	102	8.086	44.4	77.0
9	Jupateco 73	Mexico	102	8.027	48.2	82.2
10	Hopps - Ron x Kal	Mexico	102	7.972	37.0	79.8
11	Condor "S" = UQ 105	Australia	102	7.957	44.5	91.7
12	Sparrow "S"	Mexico	102	7.812	43.5	79.9
13	309	U.S.A.	102	7.660	43.6	87.6
14	Carthage	Tunisia	102	7.496	40.2	87.6
15	WW 15 = Anza = Mexicani	Sudan	102	7.420	44.0	91.6
16	Giza 155	Egypt	102	7.288	42.0	82.2
17	Unknown (Desconocido)	Brazil	102	7.273	43.9	77.7
18	Ciano "S"	Mexico	102	7.126	47.2	78.2
19	Siete Cerros	Mexico	100	6.975	44.5	78.8
20	Soltane	Tunisia	102	6.833	43.[illegible]	79.0
21	Pi62 - Frondosa	Pakistan	102	6.818	48.7	82.2
22	$Y50_E$ - Kal^3	Mexico	95	6.699	45.4	78.8
23	Moncho "S" = We-Gto x Kal - Bb	Mexico	102	6.654	47.7	73.0
24	Tzpp - Pl x 7C (3m)	Mexico	94	6.640	41.4	78.9
25	Syrimex	Syria	95	6.616	42.0	76.6
26	Lakhish Line 1568/2	Israel	102	6.523	38.2	80.2
27	Tanori 71 Résélection	Mexico	95	6.338	42.3	77.7
28	Cocorit (durum)	Mexico	102	6.421	45.8	79.7

TABLE 3.9.D The best wheat varieties from the CIMMYT IBWSN grown at Guédé, 1975-76.

No	Varietal Name and CIMMYT Number ( )	Maturity (days)	Yield (t/ha)	1000 Grain Weight (gm)	Hectolitre Weight (kg)
1	Siete Cerros	101	6.570	40.8	80.4
2	Pavon "S" (164)	101	12.175	46.8	84.4
3	Hork (276)	101	9.925	50.9	83.6
4	Cno-Son x Bb-Inia/Tob (136)	94	9.750	44.2	83.5
5	Moncho "S" (150)	103	9.700	43.7	82.6
6	Tob "S"-Npo x Cc-Inia/Chanate (290)	103	9.300	41.3	76.0
7	Moncho "S" (144)	103	9.093	42.6	74.5
8	Huacamayo "S" (174)	101	9.075	46.7	81.7
9	Npo-Cdl x Sam-Tordo (178)	101	8.750	47.2	80.4
10	(We/Lib-Inia x Inia Bb) 7C x Tob - Cno "S" (172)	103	8.725	47.6	79.5
11	EMU "S" (156)	101	8.600	45.3	85.1
12	Moncho "S" (142)	103	8.550	45.4	77.3
13	SD6485-8156/Chr x Son-Kl,Rend (188)	101	8.275	43.3	78.6
14	Cgn x Kal-Bb (244)	103	8.250	51.9	80.4
15	Cno x 7C x CnO-Inia/Sx (318)	101	8.250	47.6	73.4
16	Zbz x Cal-CnO (326)	101	8.150	42.9	82.4
17	Huacamayo "S" (177)	101	7.925	45.6	81.3
18	Ska-Cal/CcxCno-Son 64 (204)	103	7.800	44.4	77.8
19	Tob-Cal x Bb (233)	101	7.800	41.6	78.6
20	Brochis "S" (270)	101	7.800	41.4	79.0

TABLE 3.9.E Yields of certain triticale varieties tested at Guédé during 1975-76.

No	Varietal Names	Maturity (days)	Height (cm)	Yield (kg/ha)
1	Mexipak (check)	105	100	6056
2	Maya II-Arm "S" x 2802-70N-3M-1N-2M-0Y	125	110	4777
3	Maya I-Arm "S" x 2148-1N-2M-0Y	131	100	4410
4	Inia - Arm "S" x 1648-2N-1M-0Y	131	110	4300
5	Maya II-Arm "S" x 2148-1N-1M-0Y	131	110	4300
6	Maya II-Arm "S" x 2802-38N-5M-6N-6M-0Y	131	100	4270
7	Maya II-Arm "S" x 2802-38N-5M-8M-0Y	126	95	4214
8	Maya II-Arm "S" x 2802-38N-5M-6N-0Y	125	95	4180
9	Maya II-Arm "S" x 2802-38N-3M-6N-7M-0Y	126	100	4120
10	Maya II-Arm "S" x 2802-38N-3M-6N-4M-0Y	120	100	3960
11	Maya II-Arm "S" x 2832-24N-3M-7N-4N-0Y	120	100	3831
12	Maya II-Arm "S" x 2802-75N-2M-7N-1N-0Y	130	100	3[illegible]90
13	Cinnamon	120	90	2240

TABLE 3.9.F Some triticale varieties and wheat comparisons for 1000 grain weight and hectolitre weight values.

No	Varietal Names	1000 Grain Weight (gm)	Hectolitre Weight (kg)
1	Mexipak (check)	47.4	83.3
2	Maya II-Arm "S" x 2802-70N-3M-1N-2M-0Y	40.9	69.6
3	Maya I-Arm "S" x 2148-1N-2M-0Y	43.6	69.4
4	Inia-Arm "S" x 1648-2N-1M-0Y	44.2	72.3
5	Maya II-Arm "S" x 2148-1N-1M-0Y	38.7	66.0
6	Maya II-Arm "S" x 2802-38N-5M-6N-6M-0Y	46.5	74.1

TABLE 3.9.G The performance of pre-emergent herbicides in relation to wheat yields, 1975-76.

Herbicides	Dose Rate (kg)	Yield (kg/ha)				Difference ± (kg/ha)
		Rep. I	Rep. II	Rep. III	Average	
TOLIOI	0	6625	6375	6833	6277	T
	6	3408	6625	3708	5416	-861
	8	7458	6250	5708	6475	+198
	10	7333	6708	7750	7263	+986
TRIBUNIL	0	7416	7500	6375	7079	T
	2	6625	7083	5750	6486	-593
	3	7208	6500	6000	6569	-510
	4	6875	6625	5000	6166	-913
BAY-67-71	0	7000	7000	6041	6680	T
	3.5	6458	6708	6458	6541	-139
	5.0	6500	7750	6750	7000	+320
	6.5	6708	7083	8675	6888	+208
BAY-66-76A	0	6750	7333	6541	6875	T
	5	4416	5333	5916	5222	-1653
	10	3708	4708	5250	4555	-2320
	15	2000	2916	3708	2875	-4000
CHANDOR	0	6666	6750	5416	6277	T
	3	5958	7541	6166	6555	+278
	4	5291	6625	6500	6138	-139
	5	5875	6250	6833	6319	+ 42
IGRANE	0	6708	6750	5541	6333	T
	3	7666	6466	6375	6819	+486
	4	6791	6166	6000	6319	- 14
	5	6541	5583	6083	6069	-264
GARDOPRIN	0	6458	6333	7250	6680	T
	0.5	7833	6875	6208	6972	+292
	1.0	6125	5041	5916	5694	-986
	2.0	3750	4083	4166	4000	-2680

Average of eleven check plots = 6921 kg/ha.
T = check

TABLE 3.9.H The performance of post-emergent herbicides in relation to wheat yields, 1975-76.

Herbicide	Dose Rate (kg)	Yield (kg/ha)	Difference ± (kg/ha)	Herbicide	Dose Rate (kg)	Yield (kg/ha)	Difference ± (kg/ha)
TRIBUNIL	0	6208	T	BAY 66-76A	0	5166	T
	2	5666	- 536		5	4458	- 708
	3	6125	- 83		10	3333	-1833
	4	5750	- 458		15	1875	-3291
BAY 67-71	0	6000	T	PRINTAN 22L	0	5666	T
	3.5	6208	+ 208		8	6583	+ 917
	5.0	5875	- 125		10	6666	+1000
	6.5	5666	- 334		12	6416	+ 750
PRINTAZOL 75	0	6083	T	DICURAN	0	5958	T
	0.75	6333	+ 250		3	4916	-1042
	1.00	6416	+ 333		4	5666	- 292
	1.25	6083	-		5	4875	-1083
GARDOPRIN	0	5583	T	CERTROL	0	5958	T
	0.5	5750	+ 167		1	5625	- 333
	1.5	4333	-1250		1.5	4708	-1250
	2.0	2971	-2612		2.0	4625	-1333
FANERON	0	6541	T	Average yield of 14 check plots = 5869 kg/ha			
	0.5	6875	+ 334				
	1.0	5250	-1291				
	2.0	5166	-1375				

T = check

TABLE 3.9.I Results of Mexipak wheat flour analysis, 1975 harvest.

Flour Characteristics	Mexipak from Guédé	Check: Commercial Flour
Calorimetric value	1.8	1.3
Ash per cent	0.65	0.70
Protein per cent	12.03	10.40
Wet gluten	35.5	27.9
Falling time	402	293
Extraction level	70	71
Strength	332	100
Swelling	16.4	15.6
Tenacity (P)	158.4	47.5
Elasticity (L)	62.0	48.5
Ratio P/L	2.55	0.98

3.10 Tanzania

3.10.1 INTRODUCTION

Wheat cultivation was introduced by missionaries in Southern Tanganyika as early as 1898 but it was not until 1935 that wheat became a commercial crop. Around 5,000 ha may have been grown. Up to 1937 the South was the main area but this changed when European and African farmers expanded wheat acreage around Arusha in the North.

With the outbreak of World War II it became necessary for East Africa to grow its own wheat. Guaranteed wheat prices made wheat growing profitable. By 1945 over 10,000 tonnes of wheat were sold per year. Settlers after the war continued with wheat growing, drawing on varieties and wheat seed from Kenya. Later the Tanganyika Farmers Association stimulated wheat seed production. Total production fluctuated with planted areas and rainfall conditions. In some years birds caused heavy damage.

In 1971 a new wheat program started on the slopes of Mount Kilimanjaro in Lyamungu, near Moshi. Canadian and Tanzanian wheat workers began with variety evaluations and purification of seed stocks. The first varieties were produced by a head selection method from advanced wheats obtained from the Plant Breeding Station, Njoro, Kenya. These were released in 1973 to selected farmers in the West Kilimanjaro region for seed multiplication.

3.10.2 WHEAT DEMAND AND SUPPLY

Total wheat consumption is estimated at 60-70,000 tonnes annually, and the national production probably accounts for half of this. Wheat acreage is estimated at 20-24,000 hectares. The national target is self sufficiency in wheat by the early 1980's. Demand is expected to rise to 125,000 tonnes per year.

Climatic conditions determine the production fluctuations to a large extent. In 1976, rainfall was scarce in the Northern wheat region. Winds caused heavy soil drifting North of Arusha. The effects of overgrazing are very serious in such periods of drought.

In the Southern highlands the wheat growing season was characterized by intense rainfall and low temperatures at planting. The rainy season ended abruptly in April. This resulted in generally low infections by Septoria, but very high infections by root rots including Fusarium spp.

Yields in the South averaged from 1.8-2.8 tonnes per ha. There are many small growers of wheat with less than one hectare per farm. Commercial production as stimulated by the Uyole Research Station is not moving rapidly. One large unit, Tanganyika Wattle Company, produced over 2500 tonnes of wheat on nearly 1800 hectares.

3.10.3 FERTILIZER

Fertilizer use is recommended by the Research Stations. Rates of 200 kg/ha triple superphosphate are used in the Southern Highlands

The small growers do not apply these amounts, and their yields are on subsistence levels. Fertilizer supply depends on imports, and it is not always available when needed.

3.10.4 SEED SUPPLIES

The Tanzania Seed Company is in charge of wheat seed. Arusha Seed Farms receive pure seed from the Research Station at Lyamungu. The Tanganyika Wattle Company produces foundation seed and registered seed in the South. Over 7 tonnes of foundation seed and more than 40 tonnes of registered seed were available in the South for the 1977 season.

3.10.5 WHEAT VARIETIES

The intensification of wheat research in the North and the South has resulted in an up-to-date assortment of varieties. The standard variety is Trophy, locally known as 3503, which shows a wide range of adaptation. It was received from Kenya, where it was released in 1968 from a Mexican introduction. Trophy is a tall awnless variety from a cross of Timstein-Kenya^2 x Yaqui 50^2, VI-42-17H-1R-1M.

New varieties must show larger yield potential than Trophy, more lodging resistance and tolerance to the rusts and major diseases. Out of six varieties released in recent years, four have been derived from advanced Kenya lines.

The recommended list of varieties for 1976 included 15 entries which are summarized below:

Variety	Test Number	Pedigree and Cross		Use
Mamba	T 3679	AfM x Wisc.245-Sup51 x Fr/Fn/ ^{,2}A	K4527-1	South
T.Kipanga	T 3519	1010FS Sel4 x Wis Supremo	FU 67	South
T.Yangeyange	T 3525	(Tc-Stacat x FrSel1)CI12632	FN 67	Njombe, S.
T.Korongo	T 3588	FAH/68	K4471-E8E1B	Njombe, S.
T.Tai	T 3697	{ HebrardSel x Wisc-Sup x Fanfare "S"	K 4500-2	North, S.
Trophy	T 3503	T-K^2 x Y50	VI-42-17H-1R-1M	North, S.
T.Kiiga	T 3837	Romany x 390-485FIAM x R^2		North, S.
T.Mbuni	T 26-73	Trophy x 6106-1		North
T.Kororo	T 4140	$Y50_E$-8156R x Kal 28875-300Y-20M-2Y-0M		North
Nyati	T 3742	AfM x Romany K6290-4		North
Mbweha	T 3907	Kiboko "S" K6106-2		North
Swara	T 3704	CI 8154-Fr^2 x Trophy		North
T.Tombo	T 3585	F x Tama68 x (Wis.245-Sup x Fr/Y)^2 A		North
T.Kwecha	T 3654	LR x Son64 19008-52M-6Y-7M-101C		North
Kiboko	T 3904	(CI 8154-Fr^2) x ((Gabo54^2 x 36896)Gb56) x II-53-526	K 6106-1	North

3.10.6 VARIETY DEVELOPMENT

Both regions in Tanzania are working to maintain a good collection of wheat varieties. Large groups of advanced lines are introduced every year. CIMMYT and the Near East have sent many advanced lines and segregating populations. Kenyan germ plasm is also intensively selected as it has proved to be the major source of varieties.

International yield nurseries are evaluated on the Research Stations, but tend to offer few promising varieties. Screening nurseries and early generation material offer more hope.

In 1976, Alondra selections from Mexico, and many crosses with Alondra were identified as promising under conditions in the North. In the Southern highlands, K 6290-17 and Cajeme achieved satisfactory yields for new varieties, but CIMMYT varieties in general showed poor Fusarium and Septoria resistance. K 6290-17 is a sister line of Nyati and K.Kuro, with Romany and Africa Mayo in its parentage.

In National yield trials which are located in 12 sites in both regions, many Northern sites suffered from droughty conditions. Five advanced lines were selected for further testing, viz., K 6648-6, K 6675-3, K 6650-2, 196-74 and K 6793-6. One high yielding line Swara x K4500-2, 37-73 was too susceptible for stripe rust to warrant further inclusion in national tests.

3.10.7 TRITICALE

Triticales display excellent straw strength. Selections with improved endosperm content and good disease resistance are evaluated. Rahum and Beagle lines have been identified as best adapted. Yields are often well above wheat yields.

3.10.8 BARLEY

Barley is needed in the country by the Breweries. Currently 9,000 tonnes are imported, and there are pressures to grow barley to replace these imports. About 1200 hectares were grown in 1976 in Tanzania. Among introductions, the Kenyan barley selections are most interesting, viz., B 206, B 126, B 245 as well as Proctor and Research. One CIMMYT introduction, CI 5791 x Mona, yielded well but had high leaf rust infection.

3.10.9 AREAS FOR EXPANSION

Wheat acreage at the highest altitudes is relatively limited. Also in the South there are many diseases at the highest and wettest elevations. In the North, stripe rust can cause problems. There is now an interest to expand wheat production in somewhat lower elevations. The new areas for wheat are in a rainfall zone of 500-750 mm at an elevation range of 1350-2000 m, south of Arusha.

Parastatal organizations are charged with clearing the area and the production of wheat. One area, Basuto, has been producing for several years now. In 1976 a relatively good crop was harvested on the farm. In earlier years, irregular wheat growth in bands across the fields was puzzling. Improved tillage may be partly responsible for the lack of severe symptoms such as in 1975. Mechanized wheat farming requires a basic understanding about equipment maintenance and operation. The chisel plough is a very acceptable tillage implement in Basuto and Setchet. For the clearing of land and for regular field preparation, the chisel plough is relatively cheap. Also surface trash and soil structure are conserved, which helps in moisture retention. About [illegible],000 hectares have been under wheat production in the two schemes. There is much land available in the general area of the Basuto scheme.

To cater to the need of this area, wheat research is expected to be more relevant at another site than Lyamungu, a coffee research station. Plans for a new station near Arusha are under discussion.

The rising demand for wheat and barley are stimulating rapid expansion of wheat research and production. Research on variety development and soil preparation is being actively pursued. A group of young Tanzanian wheat workers is developing. The target is self sufficiency by mid 1980. With increases in yield per hectare and with further expansion in range land, the target can be reached.

INIA and CIMMYT personnel observing durum wheat material in the pure seed multiplication plots

3.11 Tunisia

3.11.1 INTRODUCTION

3.11.1.1 Important Climatic Factors

The most dominant climatic factor in cereal production is rainfall and it is the variability of the rainfall pattern which is the important feature that has to be considered in interpreting research results and production programs. Some variability exists in respect to total rainfall but much more important is the variability in respect of the start of the growing season, the rainfall distribution throughout the growing period, and the occurrence of stress periods throughout the growing season. The data derived in any single season needs to be examined in the light of that particular season's rainfall

The 1975-76 season was characterized by total rainfalls generally above the 60 year mean. Although Le Kef and Tunis both recorded slightly less than average rainfall, the stations in between were all above average. The medium rainfall areas were well above average-usually in the order of 20 per cent. Much of this above average rainfall was due to unusually high rainfalls in May and June. If these late rains, which were generally ineffective in increasing cereal yield, are deducted, then the overall season was about average.

September and October were well below average whereas November rains were heavy. This autumn pattern delayed land preparation and consequently a lot of area was planted without adequate cultivation for weed control. After November the distribution of rainfall was very good and it allowed farmers to carry out tillering applications of nitrogen fertilizer and chemical weed control effectively. Late rains allowed good grain filling but this was offset to some extent by extensive disease outbreaks. Late rains delayed harvest and reduced the weight and value of wheat in some regions.

3.11.1.2 Diseases, Pests and Weeds:

In 1975-76 there was a greater evidence of disease than in previous seasons The two important diseases were yellow rust (*Puccinia striiformis*) and *Helminthosporium repentis-tritici*. The former was most severe in bread wheat fields, particularly in the variety Soltane, and the latter in durum crops. Both diseases were quite widespread and they reduced yield by affecting the number of florets setting seed and by shrivelling the grain.

Septoria and loose smut, powdery mildew and *Cercosporella* also occurred, but without causing much damage. It will be necessary to broaden the base of disease resistance in breeding programs to incorporate resistance to those two diseases.

Although great progress has been made in weed control, weeds still remain the greatest limiting factor. However, there were many good examples of grass weed control.

3.11.1.3 Yield:

Again it was high, although it was below that expected due to late disease developments and the effect of rains at harvest time. This production is discussed later in the report in relation to the use of varieties, fertilizers and chemical weed control methods.

3.11.2 PLANT IMPROVEMENT

3.11.2.1 Varietal Improvement:

Climatic conditions for crop development and plant expression were generally very good at the main breeding station at Béjà and at the substations of Bou Salem, Le Krib, Bour Bia and Ariana where yield trials were grown.

These conditions particularly favoured the development of stripe rust, stem rust and *Septoria*. Natural infections of stripe rust in the variety Soltane were severe while the varieties Carthage 74 and Dougga 74 appeared to be resistant. The variety Amal 72 appeared susceptible to *Septoria*.

Artificial inoculations resulted in heavy infestations in the crossing block from applying *Septoria*, in the F_3 and F_4 generations from stem rust and in the F_2 material from stripe rust inoculations.

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* CIMMYT assists the Ministry of Agriculture in its research and training programs through the assignment of CIMMYT scientists. The CIMMYT involvement is financed by a grant from the Ford Foundation.

3.11.2.1A Bread Wheat:

The bread wheat improvement work consisted of selecting from a large number of lines in nurseries, and in testing and selecting in yield trials.

Over 1000 F_2 lines were planted at Béja of which 60 per cent were spring x spring crosses and the remainder were winter x spring crosses. Because of severe disease infections, good selections against stripe and stem rust were possible. Artificial inoculation of the F_3 and F_4 nurseries allowed rigorous selection against these two diseases as well as in assessment of vegetative development, maturity, head and grain characters.

From the F_3, F_4 and F_5 populations, over 100 lines were promoted for yield testing. There were 225 lines in preliminary yield trials, 115 lines in first year yield trials and 54 lines in advanced yield trials. In each case, 5 control varieties were incorporated in the experiment layout. Forty lines were promoted from the preliminary trials and 54 lines from the other yield trials.

International nurseries from various sources were planted, namely the ISWYN, PON, RDISN, regional crossing block, ISWSN and RWYT. Careful diseases evaluation was made in all these and 28 lines were selected for inclusion in national yield trials for next year.

The five best lines in the national advanced yield trials in 1975-76 were as follows:

			Quintal/ha
BT2520 =	Inia - Bb x RR68/Cno - No	(CM2300 - 24M - 3Y - 1M - 0Y)	53.42
BT2509 =	Tob"s" - Np x CC - Inia/cha	(CM5541 - 34Y - 0M - 0Mch - OBj)	52.95
BT2514 =	Dakar 49 x Cno"s" - Pj62	(Cr - E_9 . . . . .OBj)	52.50
BT2518 =	Cgn - Cal"s"	(CM21496 - 3Bj - OBj)	52.38
BT2522 =	7C - On x Inia/B.Man	(II28424 - 8y - IM - IY - 0M)	52.29

The lowest yield of the seventeen lines retained was 49.80 quintals/ha and none of the above five was clearly superior to the controls.

3.11.2.1B Durum Wheat:

The introduction of Mexican germ plasm in recent years has provided good material for selection for yield, earliness and the resistance to lodging. However in the main, this material does not have good resistance to the diseases that occur in Tunisia. Strong cooperative efforts in 1975-76 resulted in much attention being paid to disease reaction.

Over 400 crosses were made to combine disease resistance with the attributes provided by the Mexican material. Quality characteristics were introduced with new material from Italy.

An F_1 nursery of 278 crosses was planted which contained simple, double and triple crosses. The simple crosses were mainly Tunisian material crossed with Italian material to give disease resistance, good morphology and grain characters. The top crosses used Mexican material, mainly Cocorit, Maghrebi and Stork, to improve yield. In the segregating material, some 35 per cent was eliminated on the basis of disease reaction, but over 1600 plants were retained.

From the F_3 lines 250 lines were retained. The following crosses produced interesting lines: Flamingo "S" x Maghrebi 72, Flamingo "S" x BD 1917, D68 - 5 - 18A - 2A x Flamingo "S",and D63 - 1 - 17A - 2A x Flamingo "S"

A number of selections were made from F4, F5 and F6 material for preliminary yield testing.

Second, third and fourth year yield trials were conducted at three sites and new material was compared with four control varieties. Amal 72 was the best yielder of the controls and all the new lines retained, were compared with this variety. From these trials, the five following lines were retained:

	L i n e s	M e a n	Y i e l d
		qx/ha	% control
BD 2101 =	Stork "s"	50.38	109.3
BD 2100 =	Stork "s"	49.77	108.0
BD 2098 =	(61130-Lds/GII"s")Gs"s"-CM943-1M-IY-0M	49.15	106.7

(cont'd.)

Lines		Mean Yield qx/ha	Mean Yield % control
BD 2010	= Gs"s" x AA"s"-D27664.9M.4y-3M2y-OM	49.02	106.4
BD 2117	= Cr"s"-Gs"s"(T. x Ram-GII"s" x M.Sad/AA"s"CIT71	47.02	102.0
Amal 72		46.08	100.0

qx/ha = quintals/ha.

The preliminary yield trial produced a few varieties superior in yield to Amal 72 but several more were retained, which are equal to it but have better physiological characteristics.

The durum wheat improvement program planted six international nurseries and from these, 89 lines were retained for use in the 1976-77 preliminary yield trials.

3.11.2.1C Barley:

In the barley improvement program in its fourth year, a crossing program was undertaken with introduced varieties to combine yield, disease resistance and resistance to lodging, which are the principal objectives. F_1 lines from the previous years crossing program and F_2 lines that were derived from crossing in Tunisia and introductions from Mexico, were grown.

Five yield trials were planted of which two were international trials. The two varieties commonly grown in Tunisia, viz. Martin and Cérès, were used as control varieties except in the international trials which only contained Martin. The results showed a number of varieties to be superior to Martin in the areas of more favourable climate but very few in the less favourable conditions.

3.11.2.2 Varietal Testing on Farms:

3.11.2.2A Wheat:

The program of simultaneous varietal evaluation and demonstration on farms was continued, as in previous years. The purpose of this series of experiments is twofold: (1) it allows the final stage of testing the performance of the advanced lines from the breeding program in comparison with the standard varieties under commercial farm conditions; (2) it serves as a demonstration to farmers. Recommendations that are made to farmers can be derived from these trials and shown to farmers at the same time.

Sixteen wheat variety trials were conducted in the North of Tunisia. At each site, the final seed bed preparation, nitrogen application, planting and chemical weed control were carried out by the Project. The preceding treatments were those of the particular farmer. The plots were large (5x40 metres) and there were two replications in each trial.

The bread wheats used in the trials were Florence x Aurora, Ariana 66, Soltane, Siete Cerros, Carthage, Dougga and Fath.

The durum wheats used in the trials were INRAT 69 (D58.25), Bedri (D56.3A), Amal 72, Maghrebi 72, D68-8-6A-3A, D68-8-6A-IA, Chili and Syndiouk Mahmoudi.

In table 3.11.A, all the varieties tested were more productive than the traditional varieties. The new varieties Dougga, Carthage, Fath, Amal 72 yielded more than 50 quintals/hectare at the better sites of Béjà and Mateur.

These new varieties are short in straw height and although this prevents them from lodging it reduces their ability to compete with weeds. They can be recommended in areas where there is less of a weed problem but where early vigorous tillering and taller straw is desirable for weed competition, the taller varieties should be grown.

From this year's results combined with that of previous years, the following variety recommendations have been made:

Littoral zone:

Bread wheat - early planting: Dougga, Ariana 66
late planting : Carthage, Soltane, Fath

Durum wheat - early planting: INRAT 69
late planting : Amal 72, Maghrebi, Bedri.

Continental zone:

Bread wheat : Dougga, Siete Cerros, Ariana 66

Durum wheat : INRAT 69 (higher rainfall)
Bedri (lower rainfall)
Amal 72 (better soils).

3.11.2.2B Barley:

Table 3.11 B lists the varieties and their mean yields in respect of the barley trials at Laroussa and Sers. The same methods and objectives were applied to the barley as in the wheat trials.

This limited testing indicated that within moderate environments, barley varieties much superior to those presently being grown, are available

3.11.2.3 Seed Production and Technology.

The Tunisian seed program includes most of the major components needed including assistance from CIMMYT The emphasis by the government and CIMMYT has been to strengthen each segment and to improve communication and cooperation among the various components. To achieve this objective, a close working relationship was maintained with the Ministry of Agriculture, especially in relation to policy affecting seed and seed legislation.

In addition, work with the two seed production and processing cooperatives was directed primarily toward improving their seed production and quality control capabilities. The major emphasis with the Technical Division of the Office f Cereals concentrated on the marketing and extension functions. Contacts with INRAT were related primarily to the role of that institution in the increase of Breeder Seed.

3.11.2.3A Ministry of Agriculture.

In support of the training and policy objectives of the Ministry of Agriculture, a tour of seed program activities in Canada and the U.S.A. was arranged for the four people most closely associated with the technical aspects of the Tunisian program. They included the head of the seed quality control group, the head of the Genetics Laboratory of INRAT, and the technical directors of the COSEM[1] and CCSPS[2] From this experience, those involved had an opportunity to become better acquainted with the operation of seed enterprises, the way in which seed certification and seed law enforcement is handled, the methods used in multiplying early generations of seed, and the seed production methods used on a wide range of crops in the two countries.

To relate the study tour experiences to the needs of Tunisia, a Special Seed Report was prepared for the Chef du Cabinet of the Ministry of Agriculture and an assessment of the Tunisian seed program with priorities for the future, was prepared to provide guidelines for future action.

Work continued on the proposed seed legislation until it reached a near final form. (It has now been passed in the Legislative Assembly and is a Seed Act.) Assistance was provided to the quality control program on several technical and administrative issues.

3.11.2.3B Technical Division of the Office of Cereals.

A number of issues related to the seed processing, storage, and distribution schedule were reviewed in depth with the director of the Technical Division of the Office of Cereals and specific proposals for the season's campaign were developed.

As a follow-up to the wheat distribution program, especially in relation to seed quality, a seed survey was conducted with special emphasis on the quality of seeds being used by both large and small farmers. Also, seed samples were collected from several farms operating in the organized sector. The Technical Division of the Office of Cereals carried out most of this sampling and prepared a summary of results from the rec cs supplied by the Seed Testing Laboratory.

3.11.2.3C Seed Cooperatives.

Close liaison was maintained with both the COSEM and CCSPS, especially with respect to quality control. A special plan was prepared for a concentrated effort to assure

1. Coopérative Centrale de Semences.
2. Coopérative Centrale de Semences & Plants Séléctionnés.

that seed fields were harvested in a timely manner with respect to seed moisture content. Because of an unusual amount of rainy weather at the harvest period, it was not possible to achieve the objectives of this study as planned, although the results of moisture percentage tests were useful.

3.11.2.3D General

A special paper was prepared on Cereal Seed Storage in Tunisia. It dealt primarily with short-term and long-term storage requirements and it was especially directed at the needs of INRAT and INAT as they attempted to improve their seed storage conditions for seeds in the breeding programs and early generation increases.

Several papers relevant to the Tunisian program were translated from English into French and assembled into a special volume for use in Tunisia and in other French speaking countries.

3.11.2.4 Tunisian Program Progress Assessment:

Improvements have continued to be made in the Tunisian cereal seed program during the past three years. Among the most noteworthy are the following:

(1) The total wheat seed production by COSEM and CCSPS, in terms of hectares of seed under multiplication, increased by 28 per cent during the period.

(2) The amount of wheat seed of new, improved varieties in relation to the hectares of total seed production, increased from 44 per cent in 1973 to 73 per cent in 1975.

(3) The systematic testing of seed lots for germination and purity by the Seed Testing Laboratory is now providing COSEM, CCSPS and the Office of Cereals with good information on the quality of seed being produced and distributed.

(4) The Office of Cereals is putting more emphasis than previously on the quality of seed being distributed by their regional centers as a result of tests made by the Seed Testing Laboratory.

(5) Modifications in the proposed seed legislation have greatly improved the legislation, made easier to enforce and more relevant to Tunisia's needs.

(6) The COSEM built a warehouse at the Manouba location which will help to eliminate one of the seed storage problems.

(7) The CCSPS has decided to further improve and modify the processing facilities at Béjà, in order to increase the capacity of that plant.

The successful completion of the Tunisian seed mission to North America by four key persons should be beneficial in the opening of new horizons for the further development of the seed program.

Throughout the three year period, an emphasis was placed on cereal seed production. Many positive steps have occurred and while recognizing that progress has been made, officials are more aware than ever before of the further progress needed and the steps required to build a first rate seed program.

3.11.3 AGRONOMY

3.11.3.1 Crop Rotation Studies:

The objective of the work in crop rotation in Tunisia is to contribute to the improvement of cereal production by establishing a system of land use that is more profitable and less exploitive than the two course rotation of fallow-wheat.

Similarities exist between Tunisia and the southern areas of Australia in respect to environmental conditions and production goals. In Southern Australia a system has been devised which is superior to the fallow-wheat system. It is logical to assume therefore that a system built on the same principles is likely to be useful in Tunisia.

The goals of the rotation programme are to develop the necessary modifications to the basic system to suit the ecological and social conditions that prevail in Tunisia, and to create the situation which will allow the usefulness of the system to Tunisia to be assessed in an objective manner. At the same time it is intended to develop a technical base from which the adoption of the system might occur.

This land use system links together cereal culture and animal production. Although the emphasis in developing the system must be directed towards the cereal crop, it is nevertheless an integration of farm enterprises and not a study of a single enterprise. The basic system includes a number of annual forage legume varieties as the focal point in the rotation. Varieties of the genus *Medicago* are used because of their suitability for Tunisian soils.

In the first year of the rotation, the *Medicago* is planted into the stubble of the preceding wheat crop with phosphate fertilizer and at a density of approximately 10 kilograms of seed/hectare. As soon as two months after planting, depending on the season, the *Medicago* pasture may be grazed lightly. Sometime between the end of February and the beginning of April, flowering commences and the intensity of grazing must then be reduced to allow adequate flowering and seed production. In early summer, the mature pods will fall to the soil and grazing of the dry plant residue can commence.

Because of the *Medicago* seed dormancy mechanism, mainly displayed in the hardseed coat characteristic, only a small percentage will germinate in the second year. Whilst this may be an adequate germination to support a renewal of the pasture under normal circumstances, the field instead will be prepared for a cereal crop and this seed will be lost. This is not a serious loss because it represents only a small percentage of the original seed produced in the first year.

Soil preparation for the cereal crop must commence in the autumn after the first rains of the season and it must be shallow (10 cm). Any *Medicago* that has germinated will be eliminated with these cultivations. In principle, the wheat crop can be planted with phosphate fertilizer and no nitrogen fertilizer. However, in the first cycle of the rotation it is unlikely that sufficient nitrogen has accumulated and normally small quantity is added.

In the autumn following the wheat crop, the field should receive an application of phosphate fertilizer and this will stimulate the *Medicago* when it germinates with the first rains. A large proportion of the seed produced in the first year will now germinate. The three steps described above represent in its simplest form, the first complete cycle of the rotation which may now continue with one year of crop following a year of *Medicago* pasture. The Tunisian program has been concerned with the first three stages which make up the cycle of establishment.

The current phase of the rotation program is concerned with:

* The installation of commercial areas on private and state farms to provide the sites to study the usefulness of the system, the management problems, the research areas and the foci for future extension.

* The beginning of a seed production enterprise.

* The collection of native varieties of the genus *Medicago*.

* The development of research techniques for the longer term study of the more fundamental issues.

The program for the season 1975-76 was divided into three parts, viz, research activities, extension activities and the multiplication of seed and collection of indigenous varieties.

3.11.3.1A Research Activities

In 1975-76 the research was concerned with an estimation of the improvement of soil fertility by the *Medicago* pastures, and a study of the botanical composition and quantity of forage obtained from such pastures.

(1) Improvement in Soil Fertility:

One of the main features of using an annual forage legume in a system to improve wheat production, is the improvement of soil fertility. If the soil at the beginning is low in fertility, then the *Medicago* pasture will be vigorous, there will be a good root nodule development plus a high level of nitrogen fixation. It is necessary to establish a method of experimentation in the field that will measure the effects of soil improvement.

Work commenced early in the project to test the field response of wheat after *Medicago*, compared with the yield after fallow with nitrogen. At Smindja, the yields of wheat in quintals/hectare (q/ha) were: after the variety Harbinger (best adapted of 5 varieties) (24.3), after variety Jemalong (16.1) and after fallow + nitrogen (20.1). At St.

Cyprien, the wheat yields in q/ha were: after variety Jemalong (best adapted of 5 varieties) (26.2), after variety Harbinger (23.7) and after fallow + nitrogen (22.6)

These early experiments simply demonstrated that with a well adapted variety of legume and good management, yields can be obtained that are as good as those obtained using nitrogen fertilizer on soil which had been fallowed. However, it is necessary to have a measure of the increments of improvement by a simple field experiment This has been examined by using increasing doses of nitrogen fertilizer on wheat following Medicago pasture.

In the first experiment carried out in an attempt to measure the field response by applying nitrogen to wheat planted after Medicago pasture, five levels of nitrogen were used viz 0, 22, 45, 67 and 90 kg N/ha. Insufficient replication and lack of precision in the harvest technique did not allow differences to be detected statistically. In the second series of experiments conducted in 1975-76 at seven sites, four levels of nitrogen only were used, but with more precise application and a more sensitive harvesting technique.

The nitrogen treatments were:

	at planting	at tillering
N_0	-	-
N_1	10	10
N_2	20	20
N_3	30	30

The treatment N_3 can be regarded as the optimum application for a crop grown without any nitrogen accumulation in the preceding year. If no nitrogen has been accumulated, yield should increase with each treatment and the point at which yield levels out, should reflect the available nitrogen that has resulted from the previous treatment. In each case the experiments were superimposed on wheat grown after one year only of Medicago. Actually, this was the establishment cycle of the rotation in each case. It would be unlikely that sufficient nitrogen would have accumulated so early in the establishment but the sites represented a good opportunity to test the technique.

An examination of the results in table 3.11.C shows that no benefit was obtained from added nitrogen at the first two sites. At the third and fourth sites, no further yield benefit resulted after 20 kg of nitrogen per hectare had been applied. In the remaining three areas, yield levelled off at 40 kg of nitrogen. It is reasonable to deduce that at sites 5, 6 and 7 there had been a level of available nitrogen equivalent to 20 units of fertilizer nitrogen, and sites 3 and 4 equivalent to 40 units. On the other hand it is not reasonable to believe that in the first two cases, nitrogen accumulation was beyond 60 units because the actual yield levels do not reflect that level. Other factors may have limited yield, but at least there was adequate nitrogen for the yield level.

In certain of these cases it was possible to compare the data obtained with wheat grown after fallow, (table 3.11.D). In each case the fallow was prepared in the preceding spring by the farmer and the preparation could be regarded as reasonable.

At site 1, 60 units of applied nitrogen were necessary to give a yield equivalent to that obtained after one year of Medicago without any additional nitrogen. At site 2, the soil is clearly of low fertility and is apparently low in organic matter and it shows a classic response to nitrogen, whether artificial or biological. At site 5, an unresponsive durum wheat variety was used. It appears that sufficient nitrogen was mineralized by the following process to meet the demands of this crop. In none of the three cases does there appear to be any benefit from moisture storage in the fallow.

At site 7, Pont du Fahs, the wheat yields in q/ha were:

	N_0	N_1	N_2	N_3
after medicago	21	21	31*	26
after fallow	45	41	37	34

There appears to be little doubt here that moisture was stored in the fallow. The soil is a deep clay soil and the rainfall patterns for the spring of the fallow year were such as to provide moisture to store. It is also reasonable to assume that some nitrogen accumulated under the fallow and aided nitrogen depressed yield which in itself is not uncommon in this sort of environment.

This series of experiments has demonstrated that nitrogen, adequate to meet the needs of commercial wheat crops, can occur after a short period of Medicago pasture. In the establishment cycle, sufficient nitrogen accretion will not occur to eliminate the need for a small supplement but there is enough to allow cropping to continue in the biennial pattern. To make the technique for measuring nitrogen accretion more sensitive, it is now necessary to eliminate the influence of weed competition and to refine it still further.

(2) Quantity and Quality of Pasture Production:

The quantity and the botanical composition of the Medicago pasture are important for several reasons. The total quantity of forage is important simply in terms of animal production and the total amount of Medicago itself and the percentage that it represents of the total forage, is significant too. This determines the net gain in nitrogen and it is also related to the total seed yield, which in turn determines the regeneration. The suppressing effect of the Medicago on other plants in the pasture is important in the weed control program. Total yield of forage is easy to measure by cutting and weighing samples.

Botanical composition was determined in the 1975-76 program for the first time by using the Levy Point Quadrat. The quadrat itself is a simple metal frame which allows metal needles of approximately 50 cm length to drop vertically onto the pasture. The method of the Levy Point Quadrat for the analysis of botanical composition is based on the mathematical concept that the point of the needle is a homogeneous surface. If a sufficient number of points is taken, a clear representation of the constitution of the pasture can be obtained. Each time a needle is allowed to drop into the pasture, the species touched by the point only are recorded. From these data, botanical composition can be calculated.

In the 1975-76 program, 22 fields in their first year of Medicago were sampled for Medicago, grasses, broad leaved plants and bare ground. This gave an objective picture of the success of establishment and the likely performance in the future. Even though all were planted with approximately the same seeding rate, the percentage of Medicago ranged from 36-95. Any site with less than 70 per cent Medicago needed to be regarded with caution. Less than 70 per cent did not mean that it would be unsuccessful, but it did indicate that more managerial skill would be necessary to build it into the system successfully. Many of these fields will be followed in future years to determine the influence of the botanical composition in the first year.

The exploitation of the forage by the animal is an important issue. On the one hand, it is clearly profitable to use as much of the forage as possible, and on the other, high seed production is required to allow the Medicago to regenerate strongly after the cropping phase. The two objectives which appear to be conflicting can be reconciled, but a third factor must be taken into account which is the effect of the grazing animal on weed control. Judicious grazing early in the season will reduce the amount of grassy weeds and allow the Medicago to become dominant. Grazing strategy therefore becomes a compromise between maximum animal production, maximum seed yield and maximum weed control.

The grazing study undertaken was aimed at obtaining an objective measure of the desirable level of herbage in the spring when flowering is profuse. Eleven farmers fields were sampled at the end of March and the following grazing data were collected:

Site	Location	No.of grazing days/ha*	Residue of pasture (expressed as metric tons of dry matter)
1	St. Cyprien	0	4.3
2	Zaghouan	0	4.3
3	Zaghouan	240	3.3
4	Sers	1000	3.0
5	Gaafour	310	3.0
6	Medjez El Bab	1800	2.6
7	Pont du Fahs	1000	2.2
8	Pont du Fahs	1130	2.0
9	Bou Salem	580	2.0
10	Oued Zarga	280	2.0
11	Pont du Fahs	4000	1.0

*Number of grazing days/ha is calculated as follows:

$$\frac{[(\text{no. of sheep}) + (\text{no. of cattle} \times 6)] \times \text{no. of days}}{\text{no. of hectares}}$$

Each of these figures is easily established, but it is difficult to determine what constitutes "a day' in a situation where animals are herded and moved on and off the field each day. In some instances the time on the field might be much different from one farm to another, so the above figures need to be regarded with some caution. Despite this, there will be an intensity which suits the density of pasture, which leads it to the optimum residue in the spring.

An optimum residue is about 2 metric tons of dry matter per hectare in the spring when flowering is between 15-50 per cent. This was attained at sites 8, 9 and 10. Site 11 had been grazed too heavily for a first year pasture with a consequent deleterious effect on seed production. Sites 1 to 6 had been undergrazed and although this may or may not matter for weed control, it does represent a reduction in animal production.

The important problem to study now is the length of the deferment period after germination and before grazing commences.

(3) The effect of herbicide residue on regeneration of *Medicago*:

To study the residual effects of herbicide on the regeneration of *Medicago*, an experiment was established in 1974-75 in which Dosanex and Dicuron were applied to wheat at half dose, normal dose + double dose. The control treatment received no herbicides. In 1975-76, an estimate was made of the number of *Medicago* plants which regenerated after the wheat crop. No difference was found between treatments and it was concluded that there was no residual effect from the use of these chemicals on the preceding crop.

The damage caused to *Medicago* seedlings by the *Sitona* weevil can be confused with that which herbicide residues may cause. This weevil exists in Tunisia and its effects are seen from time to time in the spring where the damage to the leaves follows a characteristic pattern. Occasionally at the end of the autumn when the weather is moist but still warm, the adult insects feed on the emerging seedlings. This insect and its activity in Tunisia needs to be studied in depth.

(4) Extension Activities:

An important part of the program in crop rotations is to assist in the establishment and management of commercial areas. In the 1975-76 season, this involved the organization of the distribution of seed to farmers for the establishment of 3000 hectares of *Medicago*. This was followed by a series of five field days for the farmers and managers concerned at Bou Arada, Medjez el Bab, Bou Salem, Mateur and Siliana. In each case the system was explained, demonstrations were given of how to calibrate the drill and to seed properly. The early management requirements were also discussed. Instruction was given for those who had planted *Medicago* in the previous year and were about to prepare these fields for wheat. Follow up farm visiting was undertaken during the year.
There is definitely a relationship developing between the amount of time spent with the farmers and the success which they achieve.

In respect of commercial seed production, a small number of fields were harvested with the medic seed harvester in order to train technicians in the harvest requirements for seed production.

3.11.3.2 Weed Control

Experiments and demonstrations in chemical weed control were commenced in 1970 and were continued in 1975-76.

The three critical objectives in research are (1) the identification of new herbicides which are effective against broad leaf weeds to replace 2,4-D and which can be used at the early post emergence stage when the wheat is young and when the weeds have little competitive effect and the land surface is accessible; (2) the development of a practical program to reduce grass weeds with new herbicides and (3) the avoidance of phytotoxicity effects.

There are two objectives in extension matters viz., the refinement of practical recommendations for farmers and the extension of herbicide information and its application to cereal growers.

Four types of trials (I-IV) were conducted and the herbicides used plus the application rates and the wheat growth stages are shown in table 3.11.E.

Type I:

Experiments were conducted at the four locations shown in table 3.11.F to test the efficiency and profitability of a wide range of herbicides likely to be effective against grass weeds, broad leaf weeds and in some cases, both categories. This table also lists the wheat yields and degree of weed infestations.

In each trial, the wheat variety was Soltane. There was evidence of phytotoxicity in the experiment conducted at Medjez. The results again demonstrate the efficiency of the herbicides designed to control grass weeds, where yield increases of up to 10 q/ha were obtained.

Early weed control, if possible, is very desirable. The longer the treatment is delayed the more the depressing effect on yield and this is illustrated when the effects of Certol H and 2,4-D, which are both used for broad leaf weeds, are compared. Certol H can be used at an earlier growth stage than 2,4-D.

Treatments 12 and 22 were aimed at controlling rye grass and Phalaris. These were all applied early. In some cases they were effective against the early germinations of wild oats, but when wild oats germinate successively, Suffix is clearly outstanding particularly against late germinations. In come cases, total contiol was obtained. The new chemical Mataven is very promising and it may ultimately replace Suffix. It has the advantage of faster action and also some usefulness against Phalaris.

Type II

The purpose of these trials was to test the tolerance of wheat and barley varieties to some new herbicides. The new products tested were

For wheat	Ipuron at 3.5 litres/ha
	Graminon at 3 litres/ha
For barley	Avenge at 5 litres/ha
	Barnon at 5 litres/ha

Three experiments using six varieties of bread wheat and five varieties of durum wheat were conducted at Mateur, Drijet and Pont du Fahs. Two experiments using 12 varieties of barley were conducted at Sers and Laroussa. The chemicals were applied at right angles to the drill strips of the varieties, and all were applied at the same growth stage

In terms of phytotoxicity and the reductions in the yields obtained, it appeared that the durum wheat and particularly INRAT 69 were more sensitive than the bread wheats. Graminon appeared to be more phytotoxic than Ipuron. Ipuron can be used for the time being on soft wheat for the control of wild oats, rye grass and especially the three species of Phalaris (P. brachystachus, P.paradoxa and P.truncata). In respect of barley, the locally grown varieties are susceptible although some of the introduced varieties under test seemed to be tolerant

From the point of view of weed control especially wild oats, Avenge appeared to be better than Barnon.

Type III:

A number of these experiments were conducted to investigate further the usefulness of early applications of 2,4-D against wild oats, with the main species in Tunisia being Avena sterilis. The herbicide 2,4-D is used against broad leaf weeds and it is correctly applied at the end of tillering and the beginning of jointing to avoid phytotoxicity. Earlier application results in deformed spikes and reduced yield. In previous years, the damage appeared less where there was heavy wild oat infestation.

In the 1974-75 season, the results showed that when 2,4-D was applied at the tillering (4-5 leaf) stage, there was a 50% reduction of wild oats but when the application was delayed to jointing, this was reduced to 14%. In the 1975-76 season, studies were aimed at comparing the effects on yield of 2,4-D applied at both these times and with a soft wheat variety (Soltane) and a durum wheat variety (Bedri).

These experiments were conducted at five sites using the same general application pattern for each site. When 2,4-D was applied to the soft wheat, Soltane, at the early stage, a yield reduction of 2-3 q/ha due to phytotoxicity occurred, but the gains in yield due to weed control tended to mask this. Hence the yield advantage would have been greater without phytotoxicity. The later application gave greater yield.

With the durum variety, the damage due to phytotoxicity when 2,4-D was applied at the early stage, appeared insignificant. So it is possible to use 2,4-D to suppress this weed in durum crops, if the weed infestation is dense.

Type IV:

Twelve demonstrations were conducted adjacent to wheat variety trials to demonstrate to farmers the effects of chemical weed control as a part of good cereal production. In each case, the weed infestation was measured. Two replicates were used so that statistical analysis was possible. For the continental climatic regions, the variety Siete Cerros was used and for the littoral regions, Soltane.

The results obtained clearly showed the advantage of the herbicides designed to reduce the effects of grass weeds. Yield gains were not high, unless there was a heavy infestation of weeds, but where this was so, the detrimental effect of weeds on wheat yield would be high unless careful chemical weed control were practiced. Table 3.11.G shows data for selected sites from this series, to illustrate this point.

High infestations at Drijet (rye grass), Fahs (wild oats) and Siliana (wild oats) caused reduced yields unless treated, but at Bou Salem where weeds were moderate to low, there were no advantages from the added chemicals.

It is clear once again that matching the chemical to the species of weed is important. Chemical weed control is an important component of crop production but should be regarded as a component only, as also is good seed bed preparation, correct choice of variety and fertilizer practice.

The cereal crop itself must be protected as much as possible from the herbicide by using the recommended dosage and by applying it when the cereal is most resistant.

3.11.3.3 Fertilizer Studies

The program for the 1975-76 campaign was similar to that of previous years in which experiments and demonstrations studied the effects on yield and grain quality of both nitrogen and phosphate fertilizers.

Seasonal rainfall and its distribution has an important effect on the results obtained with nitrogenous fertilizers, so it should be noted that overall the rainfall and its pattern were a little better than average. Only at Sers did a dry period in the spring affect the performance of the fertilizer treatments. Some wheat diseases particularly stripe rust and Septoria affected yields in a few cases.

3.11.3.3A Rate and time of application of nitrogen fertilizer

Demonstrations were conducted to show farmers in a direct manner, the optimal fertilizer application rate and the correct time to apply it. Seven demonstrations compared the traditional technique usually adopted by the farmer, with the recommended fertilizer technique.

Yields varied between sites. At six out of seven there was an increase in yield and in one case, a decrease. The overall increase in yield was 40 per cent, which was made up of an increase of 117 per cent, a decrease of 28 per cent and the remainder were between these values. The yield changes were highly significant in all but one case. The date of application and seeding or tillering, had no influence on yield.

Seven experiments were conducted to study in more detail the fertilizer needs of certain newly released varieties of wheat and to examine their response to heavy rates of nitrogen fertilizer. Four of these experiments were with durum varieties and three with soft wheats. Two experiments were irrigated so that over all, there was a big range in yields and responses. In all trials, the response to applied nitrogen was highly significant.

Table 3.11.H shows the yields and responses to increasing rates of applied nitrogen fertilizer.

In the irrigated trial there was an influence of date of application where a deficiency occurred when all the nitrogen was applied at planting. A study of the contribution to yield of tillers, grain number and grain weight showed that the major effect of the nitrogen was to stimulate tillering.

The 1975-76 trials and demonstrations, confirm that the doses recommended to farmers should be 45-67 kg N/ha if the rainfall is less than 500mm, 100 kg N/ha if it exceeds 500mm, but the dose may be decreased if the wheat follows a legume or green manure crop. Nitrogen fertilizer should be applied half at planting and half at tillering. Wherever possible at planting time, it should be distributed with a mechanical spreader.

3.11.3.3B Forms of nitrogenous fertilizer

Sulphur coated urea was compared with urea and ammonium nitrate for the second successive year. In the case of the former, which has a coating of sulphur to allow it to release the nutrient to the plant progressively throughout the year, it is hoped to be able to avoid a tillering application. Supply problems with the new form forced its use a little later than was desired and this may have limited its effect. There was no significant difference between forms. Rate of application was again a highly significant factor.

3.11.3.3C The interaction of varieties and rates of nitrogen

In the 1975-76 campaign, there was a trial conducted using the soft wheat varieties Soltane, Carthage, Dougga and Florence Aurora and a durum wheat trial using Amal, Maghrebi, Bedri and Chili. With the soft wheats, there was no interaction between varieties and application rates, but with durum wheats, there was a highly significant response to nitrogen. However there was no interaction between variety and application rate.

3.11.3.3D Phosphate

Forms of phosphate were studied in an experiment at Béjà where "super 16", "super 45" and ammonium phosphate were compared. Two major observations arose from this experiment. One was that it is difficult to demonstrate a response in yield to phosphate when heavy applications have been made in the past. The other was that there are no differences between forms and from the practical standpoint, the farmer can use super 45 at seeding with safety. Better results can be expected if it is banded with the seed.

Fifteen demonstrations were laid down using super 45 and in only four of these, was there a demonstratable yield increase to added phosphate. It is difficult to demonstrate this with variable and unknown fertilizer histories.

3.11.3.3E The fertilizer needs of barley

The purpose of this experiment at Fahs was to help establish the nitrogen needs of four barley varieties viz., the Algerian variety Martin, the American variety Gem, the French variety Delissa and the Australian line WI 2231.

There was a highly significant response in all four varieties to added nitrogen and there was a difference between varieties in the response pattern. The highest yielder, Gem, responded up to 90 kg N/ha and for the others, the optimal rate appeared to be 45 kg N/ha. The variety Martin lodged and probably would require less than 45 units. There seemed to be little measurable difference between varieties in respect of grain characteristics.

3.11.4 EXTENSION

Extension activities are a vital part of the Tunisian wheat improvement project. They go beyond the normal understanding of extension activities (which implies bringing the best technological advice to farmers) and include forecasting the material inputs for the particular campaign and coordinating the actual provision of these inputs. All of these essential activities are managed by a small administrative team and a team of regional technicians.

The recommended practices for successful wheat growing have been defined by the project's researchers and include suitable varieties, seed bed preparation practices, correct date and rate of seeding, fertilizer practices, chemical weed control measures and harvest techniques. There is a regular two way interchange between the research teams and the regional extension technicians. Both groups are involved in campaign planning and in farmer demonstrations.

3.11.4.1 The Supply of Inputs

3.11.4.1A Seed:

For the 1975-76 campaign, the seed supply was good in all regions in the north. There was a keen demand for seed of high yielding varieties mostly through the seed exchange system. Approximately 101,700 quintals of durum wheat seed were distributed of which 68,800 quintals (68 per cent) were the new high yielding varieties and 20,700 quintals of bread wheat varieties of which 14,200 quintals (68 per cent) were high yielding varieties. The greatest proportion of seed of new varieties was regionally distributed at Béjà, representing 62.5 per cent of the area sown compared with 15.8 per cent at Kef. This was probably due to a better supply of seed as well as to better farmer acceptance.

3.11.4.1B Fertilizer:

Nitrogen fertilizer usage increased to a little over 36,000 metric tons of ammonium nitrate (33.5 per cent N). The quantity of phosphate exceeded 38,000 metric tons and it was almost equally divided between "super 16" and "super 45". Despite the great benefits demonstrated in many ways from the use of nitrogen fertilizer, the actual usage is still low Calculated on a zone basis, the quantity used in relation to the area planted to wheat in the zone shows 30 units of nitrogen/hectare at Béjà and 6.5 at Kef.

3.11.4.1C Herbicide:

Chemical weed control methods have become well established as a short term expediency and they are an important part of the overall production technology. The Government continued to subsidize the chemicals by 50 per cent. The area treated expanded to 212,000 hectares from 160,000 hectares in the previous year, which was divided approximately into 190,000 hectares for the control of broadleaf weeds, mainly with 2,4-D, and 22,000 hectares specifically for the control of grass weeds where Dosanex, Dicuran and Suffix were the main herbicides.

3.11.4.1D Area and yield:

The area planted comprised approximately 670,000 hectares of durum wheat (224,000 ha of new varieties) and 122,000 hectares of soft wheat (64,000 ha of new varieties). In respect to the new high yielding varieties, the durum wheats increased in area from 170,000 hectares in the previous year and the bread wheats from 59,000 in the previous year. What could have been a record yield, was depressed by disease and damage resulting from very unusual late rains.

3.11.4.1E Medicago Plantings:

Thirty metric tons of seed of the two varieties, Jemalong and Harbinger, sufficient to plant 300 hectares, were imported by the Office of Cereals and sold at a subsidized price to encourage farmers.

3.11.4.2 Extension Program

3.11.4.2A Mass Media:

Newspaper articles and radio and television appearances were provided by leaders in the project to promote regional variety recommendations and the nitrogen fertilizer use and herbicide practices.

3.11.4.2B Farmers' meetings:

Before the planting season started, meetings were conducted in 15 districts to explain the requirements to the farmers. In addition, five special field days were conducted to demonstrate planting techniques and to explain early management requirements in the *Medicago* - crop rotation program. During the growing season, meetings were held in the same 15 districts to describe herbicide technology and to recommend the second application of nitrogen fertilizer.

Spring field days were conducted in April and May in which a large number of farmers participated.

3.11.4.2C Practical demonstrations:

More than 50 practical demonstrations were conducted throughout the cereal regions. In each case two varieties of wheat, an old and a new variety, were grown in large plots with and without nitrogen fertilizer, and this enabled farmers to see for themselves the advantages of new varieties and added nitrogen (table 3.11.I).

TABLE 3.11.A Variety performance according to two climatic zones, in quintals/hectare.

Bread Wheat	Littoral Zone			Continental Zone		
	No.of Sites	Mean Yield	% of Control	No.of Sites	Mean Yield	% of Control
Florence x Aurora*	11	28.73	100	3	38.02	100
Ariana 66	11	32.83	114	3	39.83	105
Soltane	11	32.62	114	3	37.06	97
Siete Cerros	2	35.42	118	3	42.30	111
Dougga	11	38.82	135	3	45.65	120
Carthage	11	36.65	128	3	40.47	106
Fath	11	33.90	118	3	36.71	97
Durum Wheat						
Inrat 69*	11	26.24	100	3	36.44	100
Bedri	11	28.89	110	3	35.08	96
Amel 72	11	34.78	133	3	37.65	103
Maghrebi 72	11	31.04	118	3	32.81	90
D68-8-6-3A	11	30.75	117	3	36.21	99
D68-8-6-1A	3	34.67	123	2	33.08	92
Chili	3	21.25	85	1	29.25	97
Syndiouk Mahmoudi	-	-	-	1	33.89	81

* Florence Aurora and Inrat 69 were the controls in the bread wheat and durum wheat groups respectively.

TABLE 3.11.B Yields of Barley in quintals/hectare.

Variety	Laroussa	Sers	Mean
Locale	28.08	16.08	22.08
Martin	25.00	15.18	20.09
Ceres	27.32	11.90	19.61
Gem	35.04	12.80	23.92
WI 2197	36.92	19.50	28.21
Delissa	29.26	16.96	23.11
Ager	33.85	15.77	24.81
Ager x Ceres	-	15.18	-
Manon	29.62	11.32	20.47
Athenais	28.46	16.68	22.57
Julia	29.86	19.34	24.60
WI 2231	37.64	21.50	29.57

TABLE 3.11.C Yield of Wheat in quintals/hectare.

Location	N_0	N_1	N_2	N_3
1. Medjez el Bab	22 *	21	23	19
2. Bou Salem	24 *	25	25	23
3. Zaghouan	18	20 *	20	19
4. Oued Zarga	21	25 *	22	26
5. Medjez el Bab	16	16	23 *	18
6. Goubellat	16	16	24 *	24
7. Pont du Fahs	21	24	31	26

TABLE 3.11.D Yields of wheat in quintals/hectare.

Site		N_0	N_1	N_2	N_3
Medjez el Bab	After *Medicago*	22*	21	23	19
	After fallow	19	19	20	23*
Zaghouan	After *Medicago*	18	20*	20	19
	After fallow	7	14	16	19*
Medjez el Bab	After *Medicago*	16	16	23*	18
	After fallow	23	20	21	21

TABLE 3.11.E Treatments used in herbicide trials in Tunisia, 1975-76.

No	Commercial Product	Active Ingredient and %	Dosage	Growth Stage of Wheat
1	Control	-	-	-
2	2,4-D	LV ester 46	0.60	7 leaves
3	Certrol H	Ioxynil 12 + mécoprop 36(ester)	0.36+1.08	4-5 leaves
4	Quinorexone SP	Dicamba 2.75+mécoprop 42.5	0.08+1.27	4-5 leaves
5	Avenge	Difensoquat 20	1.00	7 leaves
6	Suffix	Benzoylpropethyl 20	1.20	7 leaves
7	Suffix + 2,4-D	Benzoylpropethyl 20 + LV ester	1.20+0.6	7 leaves
8	(Suffix + MCPP)	Benzoylpropethyl 20 + mécroprop	1.20	7 leaves
9	(Mataven + MCPP)	Flamprop Methyl 15% + mécroprop	0.525	7 leaves
10	Mataven	Flamprop Methyl 15%	0.525	7 leaves
11	Tok Ultra	Nitrophene 22.7+Linuron 6.41	3.60	Pre-emergence
12	Ipuron	Isoproturon 50	1.80	2-3 leaves
13	Graminon 80			2-3 leaves
14	Graminon 80			2-3 leaves
15	Graminon + Dicuran		+1.20	2-3 leaves
16	Dicuran Liq	Chlortoluron 50	2.40	2-3 leaves
17	Dicuran Liq+Tok WP50	Chlortoluron 50 + Nitrophene 50	1.5 + 1.5	2-3 leaves
18	Dosanex	Metoxuron 80	3.20	2-3 leaves
19	Dosanex + Tok WP50	Metoxuron 80 + Nitrophene 50	2.4 + 1	2-3 leaves
20	Dicuran PM + Tok WP50	Chlortoluron 80 + Nitrophene 50	1.6 + 1.5	2-3 leaves
21	Dicuran PM	Chlortoluron 80	2.40	2-3 leaves
22	Printan 22 1	Chlortoluron 20 + Micoprorp 20	2.40	3-4 leaves
	(Suffix + MCPA)	Benzoylpropethyl 20 + MCPA		7 leaves
	Barnon	Flamprop isopropyl 20		" on barley

The products between brackets were applied as a mixture, but in treatment 7 the two products were applied separately, but in less than 10-12 days interval.

TABLE 3.11.F Wheat yields in quintals/hectare at four sites in Type I trials.

	Tebourba	Medjez	Bou Arada	Le Krib	Average
Degree of weed infestation:					
Wild oats no.of panicles/m^2	22	10	2	135	
Rye grass no.of spikes/m^2	500	1	750	5	
Phalaris no.of spikes/m^2	48	15	1/2	0	
Broad leaf weeds (% cover)	30	10	10	48	
Treatments and yields:					
1 Control	27.21	24.69	18.22	29.5	24.90
2 2,4-D	26.76	22.63	17.40	30.73	24.38
3 Certrol H	30.23	23.74	19.04	35.54	27.14
4 Quinorexone SP	25.24	22.20	18.67	33.47	24.90
5 Avenge	24.09	15.86	16.95	30.61	21.88
6 Suffix	28.45	21.37	18.64	41.47	27.48
7 Suffix + 2,4-D	30.61	26.23	17.28	43.37	29.37
8 Suffix + MCPP	34.54	25.26	18.47	39.27	29.39
9 Mataven + MCPP	29.03	24.31	17.00	32.26	25.65
10 Mataven	30.53	26.32	17.61	42.52	29.25
11 Tok Ultra	34.66	21.08	26.01	36.00	29.44
12 Ipuron	29.55	9.16	28.92	43.56	27.80
13 Graminon 80 (2.51)	26.02	10.13	24.39	42.05	25.65
14 Graminon 80 (3.51)	23.70	7.80	23.00	41.31	23.95
15 Graminon + Dicuran	28.11	15.26	28.20	43.08	28.66
16 Dicuran Liq	25.70	14.04	25.62	37.19	25.64
17 Dicuran Liq+TokWP50	32.76	18.70	25.38	36.41	28.31
18 Dosanex	30.18	16.40	25.94	37.05	27.39
19 Dosanex + Tok WP50	35.53	19.89	24.71	40.75	30.22
20 Dicuran PM+TokWP50	35.45	21.33	25.43	36.04	29.56
21 Dicuran PM	26.93	16.31	28.56	40.92	28.18
22 Printan 22 1	33.11	22.43	25.82	40.28	30.41
Coefficient of variation:	14.68%	16.31%	13.44%	12.95%	
LSD 5%	6.12	4.47	4.24	6.94	
LSD 1%	8.26	6.03	5.73	9.36	

TABLE 3.11.G Yield in quintals/hectare, in weed control demonstrations.

Weed Infestation	Drijet	Fahs	B.Salem	Siliana
Wild oats (panicles/m^2)	3	110	1	120
Rye grass (spikes/m^2)	500	1	15	50
Phalaris (spikes/m^2)	-	4	0	2
Broad leaf weeds(% cover)	25	9	5	35
Control	19.13	30.94	34.06	29.41
Certrol H	25.65	30.07	35.51	37.20
2,4D	22.24	30.74	34.34	34.01
Suffix + 2,4D	19.63	33.44	35.92	38.74
Suffix +MCPP	22.72	33.44	34.54	37.55
Suffix	20.19	36.96	33.38	43.64
Mataven	-	38.21	33.52	40.83
Avenge	-	29.40	24.30	41.39
Ipuron	22.63	34.12	30.37	37.82
Dicuran PM	27.61	36.33	38.97	43.49
Dosanex	27.83	37.27	35.63	47.55
Dosanex + Tok	28.01	37.38	35.55	47.59
Dicuran + Tok	28.09	35.71	35.42	44.33
Coefficient of Variation	7.34	5.80	8.09	10.35
LSD 5%	3.92	4.32	6.00	9.09
LSD 1%	5.58	6.07	8.42	12.76

TABLE 3.11.H Yield in quintals/hectare at five rates of nitrogen experiments.

Site	Culture	Variety	Treatments N_1	N_2	N_3	N_4	N_5
Robaa	dry land	Dougga	16.5	23.0	26.3	27.6	31.7
Béja	dry land	Carthage	28.6	34.5	38.0	40.0	41.1
Borj El Amri	dry land	Amal	21.0	24.7	25.2	25.6	27.1
Fahs	dry land	Maghrebi	25.2	26.6	28.7	30.2	28.7
Sers	dry land	Siete Cerros	11.9	13.6	13.5	15.2	14.7
Kairouan	irrigated	Amal	9.4	21.0	34.2	47.8	55.7
Kairouan	irrigated	Carthage	15.9	31.7	41.0	57.4	59.2

N_1 = Nil nitrogen application.

N_2, N_3, N_4 were evenly spaced between N_1 and N_5.

N_5 = 200 kg N/ha at the irrigated site.

= 130 kg N/ha at Béjå.

= 90 kg N/ha at all other sites.

TABLE 3.11.I Mean yields in quintals/hectare.

Variety	without nitrogen	with nitrogen
Maghrebi	19.00	22.90
Bedri	19.00	26.20
Inrat 69	17.20	21.60
Ame.	17.30	22.10
Chili	15.50	18.10
Mahmoudi	15.10	17.70
Dougga	20.80	26.20
Carthage	18.00	32.00
Ariana 66	17.10	20.30
Soltane	15.70	19.60
Florence Aurora	15.30	19.50
Siete Cerros	13.00	18.30

It should be noted that for each variety the number of sites varied considerably so that a comparison of varieties from this summarized table is not valid, whereas the nitrogen responses are.

4.0 Middle East

[illegible] CIMMYT plant breeder [illegible] fertilized [illegible]

4.1 Cyprus

4.1.1 INTRODUCTION

Wheat and barley occupy an area of 150,000 ha, almost exclusively under rainfed conditions. As a result, yields are mainly determined by the amount of available moisture (rainfall), which is seldom sufficient throughout the growing season for high yields.

Rainfall in 1975-76 was above average and favourably distributed. It ranged between 350 and 426 mm at the experimental sites. As a result satisfactory yields were obtained in all areas of the island. Yields of barley in experimental plots ranged from 2-4 t/ha and of wheat from 1.5-3.5 t/ha.

Cereals are fertilized with about 40 kg N/ha and 35 kg P_2O_5/ha. The limiting factor for efficient fertilizer utilization is the low and unevenly distributed rainfall Fertilizers are imported and distributed mainly through the cooperatives. There is no subsidy on fertilizers and the present price per kg of N is 210 mils and per kg of P_2O_5 is 229 mils. The value of 1,000 mils is 2.4 U.S.$. Fertilizers have not been in short supply.

Cyprus cooperates with CIMMYT, FAO, the ALAD Programme of the Ford Foundation, the International Atomic Energy Agency and other international and national institutes for research on increasing cereal yields.

4.1.2 CEREAL BREEDING AND TESTING

4.1.2.1 Barley

Lines from the local crossing programme and introduced lines were evaluated at several locations but none of the new varieties outyielded the local variety Athenais. Among the most promising lines which gave equal yield to that of Athenais in 1975-76, were three lines selected from the local crosses Asse x Athenais and Awnless Black x Athenais, and the introductions Trikedritt, Strain 205, Arivat x Athenais-2L Palmella Blue, Giza 121 and Roho.

Crosses were made between Athenais and hooded lines for the development of barley varieties suitable for hay making. The selected lines were evaluated in 1975-76 and the following outyielded both their parents and the highest yielding forage variety 628. Line 116, Line 148, Line 124. Preliminary intake studies with sheep showed that hay from hooded lines was more palatable and losses during feeding were lower than with hay from awned barley varieties.

Barley lines were selected from crosses between Athenais and very early genotypes. The earliest lines were Line 77, Line 78, Line 54 and Line 58 which reached heading 25-28 days earlier than the early local variety Athenais. Early lines will be tested for early grazing.

The protein improvement programme continued with encouraging results. The mutant line M 71 Ath.-8-3 was selected for both high yield and high crude protein content. Several other lines were selected from crosses between high protein lines, such as Hiproly, and the local high yielding variety Athenais. These selections are evaluated for yield at several locations.

Material from hundreds of crosses is under evaluation for increased genetic variability, mainly for characters such as earliness and spike fertility, which are associated with adaptation to dry regions.

4.1.2.2 Durum Wheat

It is used to produce semolina for the macaroni industry and flour which is mixed with strong bread wheat for bread making. The recent release of the durum wheat varieties Capeiti 8 and Aronas (a selection from the CIMMYT cross R.A.E. Tc^2 x stW 63/AA "S") has given new emphasis to the cultivation of durum wheat, which is a very old crop in Cyprus

New lines selected from CIMMYT material are under evaluation. Some of these lines have improved quality characteristics over the released varieties (table 4.1.A).

A large number of advanced lines selected from CIMMYT crosses and locally made crosses are under evaluation.

4.1.2.3 Bread Wheat

Bread wheat became a significant crop in Cyprus only after the introduction of CIMMYT varieties in the early 1960's. The aim now is to select good bread wheat varieties, giving strong flour, to be mixed with the flour of durum wheat for bread making. Lines under evaluation were selected from F_2 populations, uniform nurseries and uniform variety trials of CIMMYT material. The first screening which is based on agronomic characters and grain characteristics, is visually evaluated.

Using the Pelshenke test, the lines with high baking properties are selected for yield trials in representative wheat growing areas. Complete baking quality tests for the high yielding varieties are also carried out at the Government Laboratory which is equipped for this purpose.

The best lines are shown in table 4.1.B where high valorimetric number and Pelshenke time show good baking properties.

4.1.2.4 Triticale

Triticale lines were tested for grain and forage production. They gave yields ranging from 1.5 - 2.3 t/ha compared with 2.1 t/ha of the bread wheat, Pitic 62, and 3 t/ha of the barley, Athenais. The best lines will be evaluated again in 1976/77. Regarding forage production, all triticale lines gave lower dry matter yield at 50% heading stage than the best forage barley variety 628.

4.1.3 CEREAL DISEASES

As in previous years, disease incidence was very low in 1975-76. Traces of rust appeared only in a few isolated places.

4.1.4 INSECT CONTROL

Further to 1974-75 trials in which various low mammalian toxicity organophosphorus insecticides were evaluated against stored grain insect pests, laboratory and field experiments were carried out in 1975-76. Their main objective was to achieve effective control of lepidopterous pests of stored grain. The insecticide DDVP applied at the rate of 0.1 g a.i./m^3 with the aid of a Fontan (R) low volume sprayer resulted in an effective control of both Indian Meal Moth, *Plodia interpunctella* (Hbn.) and Angoumois Grain Moth, *Sitotroga cerealella* (Olivier) infesting stored wheat and barley.

Satisfactory results were similarly obtained with iodofenfos at the rate of 1 g a.i./m^2 one week prior to grain storage in the interior of a store heavily infested with Khapra Beetle, *Trogoderma granarium* (Everts) larvae. Effective reduction of insect infestation during storage was achieved when iodofenfos wall treatment was supplemented with a malathion dust treatment of grain at 10 ppm.

4.1.5 AGRONOMY

4.1.5.1 Rotation Trials

The cereal rotation programme of the Cyprus Agricultural Research Institute aims at determining whether fallow could be replaced profitably by preferably a leguminous crop, and/or whether fallow is a necessary practice in the low rainfall cereal growing areas.

In 1975 three types of rotation trials were initiated in three cereal growing areas of different agroclimatic conditions.

In the first type, the following eight rotation patterns are to be compared for eleven years: grain barley continuous; grain barley continuous with additional nitrogen fertilization; grain barley - fallow; two years grain barley - fallow; grain barley - forage barley; two years grain barley - forage barley; grain barley - woollypod vetch (*Vicia dasycarpa* var. Lana) and two years grain barley - woollypod vetch.

In the second type, five rotation patterns are to be compared for five years: grain barley continuous; grain barley continuous with additional nitrogen fertilization; grain barley-fallow; grain barley-forage barley, and grain barley-woollypod vetch.

The third type is an attempt to introduce annual *Medicago* species in dryland cereal rotations thus obtaining a leguminous pasture for grazing. The rotation patterns compared in this trial are: grain barley-fallow, and grain barley-*Medicago*.

The experimental work includes the soil moisture determination in each rotation pattern and the effect of the leguminous crop on the soil nutrients and soil structure.

A full cycle of the above trials has not yet been completed; thus no conclusions can be drawn as yet. Data recorded from a trial of the second type, which was initiated in 1973 gave the results shown in table 4.1.C.

4.1.5.2 Sowing Techniques

Sowing method trials for dryland cereals comparing the conventional and the Press drills and aiming at increasing the cereal yield at low cost, are in progress. In the treatments where the Press drill is used, sowing is done directly without previous seed-bed preparation.

The results obtained from the 1976 trial are shown in table 4.1.D. There was no significant difference between the two methods of sowing even when the seed rate in Press drill sowing was lower than the optimum seed rate for conventional sowing.

4.1.5.3 Dryland Farming Tillage versus Non Tillage

This investigation aims at determining the effect of various methods of soil management, during the fallow phase of the cereal-fallow rotation on the following crop, by promoting a relatively stable crumb structure in the soil, maintaining the existing organic matter and conserving soil moisture.

A trial in which mouldboard ploughing, chisel ploughing, subsoiling and chemical weed control are compared , was initiated in 1974 at two locations. The cultivations were made in 1974/75 and a crop with Kyperounda durum wheat was grown in 1975/76. The statistical analysis of the yield data showed that the non tillage method gave the lowest yield (table 4.1.E). All the other treatments gave statistically equal yields.

A larger scale trial based on the same principles was commenced in 1975, at three locations.

4.1.6 FERTILIZATION

During the 1975-76 season two nitrogen-phosphate fertilizer experiments on two durum and two bread wheat varieties grown under rainfed conditions (rainfall November 1975-May 1976: 335mm.) were carried out. While responses to added phosphate fertilizer were significant only in the case of bread wheat varieties, all the varieties tested responded to nitrogen fertilization (half applied as sulphate of ammonia at sowing and half as ammonium nitrate top-dressed at tillering). Table 4.1.F gives the effects of N fertilization on wheat grain yields.

In another field experiment, the effects of four levels of nitrogen and three irrigation regimes on a good bread wheat variety, Hazera 18, were studied at another location, (table 4.1.G). A basal P_2O_5 dressing of 37.5 kg/ha together with 40 kg N/ha was applied at sowing; the remaining nitrogen was top dressed at the tillering stage. Irrigation was given at the milk stage (April 7). Rainfall during November (sowing time) to May (harvesting time) was 426 mm.

4.1.7 WEED CONTROL

The 1975-76 season of trials for the control of wild oats in wheat continued with studies on the use of the post-emergence herbicides benzoylprop-ethyl and difenzoquat. The former was applied at 1250 or 1500 g a.i. per ha, the latter at 740 or 1000 g a.i. per ha. Herbicides were applied when wild oats had reached stages of development ranging from three leaves to near flowering. Results varied from satisfactory to very good as regards control of wild oats. Yields were significantly increased in treated plots where the infestation with wild oats was high.

There were no adverse effects on any of the wheat varieties in the trials, namely Kyperounda, Jori C69, Lahish, Capeiti 8, Pitic 62 and Hazera 18. Germination tests on wheat and wild oat seeds harvested from the trials showed no herbicide effect on wheat, while wild oat seeds from plots tested with benzoylpropethyl showed a tendency for reduced germination. The reduction was significant in the 1500 g a.i. rate in one trial.

TABLE 4.1.A The performance of Kyperounda, Aronas and two sets of new durum wheat lines at three locations in 1975/76.

Character	Set 1			Set 2		
	Kyperounda	Aronas	Range of new durum lines	Kyperounda	Aronas	Range of new durum lines
Grain yield (kg/ha)	2678	3692	2479-3241	2486	3567	2627-3234
Plant height (cm)	103	85	72-89	99	82	70-84
Heading date (1=1 March)	41	32	33-37	41	32	30-40
1000 grain weight (g)	43	45	44-53	38	46	43-53
Volume weight (kg/hl)	77	74	74-78	75	75	71-77
Vitreousness (%)	88	93	83-98	80	92	90-99

TABLE 4.1.B Yield and quality of selected bread wheat varieties.

Variety	Grain Yield relative to Pitic 62	Valorimetric number	Pelshenke test (min)
Pitic 62	100	32	21
Jupateco 73	93	66	189
Tobari 66	95	56	127
Potam 70	100	66	66
Tob x 8156	97	74	103
Tob "S"	79	66	104

TABLE 4.1.C Grain yield of Athenais barley (kg/ha).

Rotation	Average for 1973-1976
Barley continuous with 35 kg N/ha	2,184
Barley continuous with 42 kg N/ha	2,611
Barley following fallow	2,261
Barley following barley forage	2,128
Barley following woollypod vetch	2,618

TABLE 4.1.D Average grain yield of Athenais barley at three locations (kg/ha).

Treatment	Seed rate (kg/ha)	Grain Yield
Conventional drill	98	2,541
Press drill	98	2,373
Press drill	66	2,254
SE ±		123

TABLE 4.1 E Grain yield of Kyperounda wheat (kg/ha).

Treatment	Location 1	Location 2	Mean
A. Deep Chiseling in Autumn 1974, Chiseling in Spring 1975, Conventional sowing	2,050	2,116	2,083
B. Mouldboard Ploughing in Autumn 1974 and Spring 1975. Conventional sowing.	1,942	1,850	1,898
C. Shallow Chiseling in Spring 1975 Press drill sowing.	1,917	1,894	1,906
D. Non tillage Chemical weed control in Spring 1975. Press drill sowing.	1,502	1,443	1,473
SE ±	84	78	57

TABLE 4.1.F Grain yields (kg/ha) of four wheat varieties under four levels of N fertilizer at Nisou*.

Variety	kg N/ha 0	35	70	105	Means of Varieties SE ± 33
			SE ± 36		
Kyperounda durum	675	1041	1200	1271	1047
Jori C69 durum	609	934	1103	1239	971
Blue Silver aestivum	512	962	1321	1441	1059
Hazera 18 aestivum	559	1088	1400	1587	1159
Means of N Treatment	589	1006	1256	1385	
			SE ± 18		

* Soil texture Clay loam; nitrates=17 ppm dry soil; seeding rate=120 kg/ha.

TABLE 4.1.G Grain yields (kg/ha) of Hazera 18 wheat under three irrigation regimes and four nitrogen levels, Akhelia 1975-76*.

kg N/ha	No irrigation (rainfall only)	40 mm	80 mm	Means of N treatments
		SE = ± 187		
40	3050	3566	3147	3254
80	3229	3551	3446	3409
120	3498	3521	3581	3533
160	3267	3476	3513	3419
Means of Irrigation Treatments	3261	3529	3422	
		SE = ± 142		

* Soil texture: clay; available P: 10 ppm.

4.2 Iran

4.2.1 INTRODUCTION

Wheat was grown on 2.1 million hectares of irrigated land and about [illegible].3 million hectares of rainfed area throughout the country. The total production was estimated to be approximately 5.5 million metric tons. The area and production of barley were 1.5 million hectares and 1.4 million metric tons respectively.

The climate in 1976 for the growing season consisted of a dry winter, a rather warm early spring followed by a cool mid spring season. The amount of precipitation for rainfed agriculture was inadequate.

4.2.2 FERTILIZERS

The Extension Service supervised some 900,000 hectares of irrigated wheat which received about 100 kg N and 60 kg P_2O_5/ha. The actual price of fertilizer was 30 dollars per metric ton for urea and 43 dollars per metric ton for superphosphate. However, these fertilizers, which were used on irrigated wheat, were subsidized by 20 per cent. The remainder of the irrigated wheat area received about the same amount of fertilizer. It was necessary to import about 400,000 metric tons of fertilizer because Iran does not produce enough to meet the increasing demand. There is negligible use of fertilizer on rainfed wheat and barley crops.

4.2.3 VARIETIES AND SEED PRODUCTION

The principal spring wheats grown were Inia 66, Arvand, Moghan I, Moghan II, Bayat and Khazar I. The main winter wheat varieties grown under irrigation are Omid, Roshan, Bezostaya, Adl, Karaj I and Karaj II. The two main improved varieties grown under rainfed conditions are Azar and Rashed. One third of the barley crop is produced under irrigation and the principal varieties are Zarjo, Goharjo, Gorgan 4 and Sina.

The new varieties released in 1976 were Bayat and Moghan II and seed of them is now under multiplication. The most promising lines in the 1976 breeding program were Sparrow, Jupateco, HD832-5-5, Cno x Jar 826676-8k-15R-Yk and HD832 x Bb.

The seed production programs are organized in such a way that after releasing a variety, the nucleus seed and the breeder seed II and III are produced directly by the government. Registered and certified seeds are produced under contract by advanced farmers and farm corporations.

4.2.4 DISEASES

The climatic situation was not favourable for rust development in 1976.

4.2.5 FACTORS AFFECTING PRODUCTION

The major factors precluding increases in area and production are competition from other crops (especially industrial crops with irrigated wheat), weed competition, lack of fertility in dryland areas and inadequate tillage knowledge. Due to the low yield as well as rapidly growing small industrial businesses, farmer income is not satisfactory.

4.3 Israel

4.3.1 INTRODUCTION

Wheat production is mainly concentrated in Jewish settlements. During the last 8-10 years, the area sown has fluctuated around 80,000 hectares. The area sown in the autumn of 1976 was 70,000 ha.

About 65 per cent of the wheat area in this sector is in the southern part of the country (roughly south of Tel Aviv), and mainly in the Lakhish area (east of Ashkelon) and in the north-western part of the Negev. Average seasonal (= annual) rainfall declines from about 450 mm in the north to less than 300 mm in the south. The area for supplemental irrigation was limited to 13,500 ha. The remaining 35 per cent of the area is in the northern and north-eastern part of the country in the Valleys of Esdrealon and Beit-Shean and in the Jordan Valley. Average seasonal rainfall declines from more than 500 mm in the west to about 400 mm or less in the east. In the Beit-Shean Valley, wheat generally is grown with supplemental irrigation (4,000 ha). In the Arab villages in the Nazareth-Afula area, 4000-5000 ha. are sown. The potential area in the Negev, planted by the Bedouin, is about 35,000 ha. Jewish farmers plant only a small area to barley - 3000 ha. in 1975-76.

4.3.2 PRODUCTION

Total bread wheat production averages about 230,000 metric tons, which is approximately only 50 per cent of the annual consumption.

Durum wheat production fluctuates between 30-50,000 metric tons, which meets local consumption and allows some for export to neighbouring countries. There is a small but growing interest in durum wheat production in the Jewish sector.

4.3.3 YIELDS

In the northern areas, rainfall is marginal every one year in three. In the south, every second year may be dry. Consequently mean yields fluctuate considerably from year to year viz. 3.40 metric tons/ha in 1974, 2.85 metric tons/ha in 1975 and 2.25 metric tons/ha in 1976.

4.3.4 VARIETIES

In 1965, semi dwarf and dwarf varieties started to replace long straw varieties. The most prominent replacement varieties were Cee-on, Mivhor, Yafith and Hai in the early seventies and the varieties Lakhish and Miriam from the Agricultural Research Organization in more recent years. In the 1975-76 season, the per cent area sown to the three leading varieties Lakhish, Miriam and Cee-on was 35, 30 and 22 respectively.

Breeding stations are the Field Crops Department of the Agricultural Research Organization (ARO) of the Ministry of Agriculture at the Volcani Institute near Beit Dagan; the Plant Genetics Department, Weizman Institute of Science at Rehovot; the Breeding Department, Hazera Seeds Ltd., Farm Mivhor near Kiryath Gat.

4.3.5 VARIETY RELEASE; SEED PRODUCTION

Breeders apply for breeder's rights. The commission responsible for the inscription, does not conduct yield trials, nor is it authorized to formulate recommendations. The Extension Service conducts annual Regional Yield Trials, in which a few of the most promising advanced lines of all breeding programs are compared with current commercial varieties. The official Seed Certification Service is authorized to approve only seed production fields of recommended varieties.

Seed production itself is almost exclusively the responsibility of Hazera Seeds Ltd. Its Breeding Department is in charge of the production of Breeder's Seeds of its own varieties, and of Foundation Seeds of its own and ARO's varieties. Hazera's Production Department and its field inspectors are responsible for further multiplication, eventually to Registered and Certified Seeds, executed at the Company's own 5 farms or at contract-growers' premises.

4.4 Turkey

4.4.1 INTRODUCTION

In 1976 Turkey produced 16.4 million metric tons of wheat, setting a new production record for the second consecutive year. In 1975 the production was 14.75 million metric tons. Production in 1976 exceeded production in 1975 by 11 per cent and the previous high year, 1971, by 21 per cent. It was a year of excellent rainfall in 1975 which helped push up yields, but new technology was also a definite factor in increasing production. Rainfall in the spring (the most critical period) for the years 1971, 1975, and 1976 was 146 mm, 255 mm, and 139 mm, respectively, at Ankara. Even though spring rainfall in 1976 was slightly less than in 1971, the production was 21 per cent more in 1976 from only a slightly larger area.

A large part of this increase is directly attributable to the adoption of new technology: improved tillage, new varieties, herbicides and fertilizer. In 1976 about 140 per cent more fertilizer was used in Turkey than in 1971. Herbicide use increased by about 150 per cent in the same period. The use of new varieties and modern equipment such as tractors, combines, and sweep plows has also increased significantly in the past few years. Figure 4.4.A depicts average wheat production in Turkey since 1951 and shows the increase due to expanded area and the increase due to enhanced yields per hectare.

Since mid-1976, the management and operation of the Turkish Wheat Research and Training Project has been entirely in the hands of capable and well-trained Turkish staff. The new 600 hectare experiment station near Ankara is moving into the final phase of development with the construction of farm-center buildings and irrigation facilities. This field laboratory is a very valuable resource for agricultural scientists in Turkey. The Turkish Government is to be congratulated for the intelligent use of its financial resources. There are few field laboratories in this region of the world that can match it in size and quality

4.4.2 PATHOLOGY

The disease situation in the fall of 1975 was much below normal with essentially no diseases. The rusts (stripe, leaf and stem, in this order) caused a conservatively estimated 10-12 per cent reduction in yield. Common bunt and loose smut also contributed their part in bringing the total estimated loss of production from diseases to the 15-17 per cent range. Even though the 1975-76 crop was excellent, it could have reached even higher levels with better disease resistance in the commercial varieties.

4.4.3 VARIETY IMPROVEMENT

In 1975-76 in the Turkish National Wheat Program there were 871 lines that performed better than the standard or check varieties. Of these lines, 538 were in the winter wheat regions and 333 were in the spring wheat regions. The standard or check varieties were:

Winter Wheat		Spring Wheat	
Bezostaya	Bolal	Cumhuriyet 75	Mara
1593/51	Kirac 66	Sakarya 75	Campodoro
220/39	111/33	Nuri 70	Orse
Berkman	1149	Penjamo 62	

Adult plant resistance to stripe rust was identified in 75 lines of bread and durum wheat, resistance to stem rust in 42 lines, and resistance to leaf rust in 32 lines. In addition, 50 lines were found to have excellent resistance to common bunt.

The pipeline of new varieties is now present and Turkey should be able to release several new varieties each year for some time to come. Last year (1974-75) Cumhuriyet 75, Sakarya 75, Gediz 75, and Dicle 74 were released by the project.

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* CIMMYT assists the Ministry of Agriculture in its research and training programs through the assignment of CIMMYT scientists. The CIMMYT involvement is financed by a grant from the Rockefeller Foundation.

In the near future, releases will be considered from among the following:

Variety	C r o s s	Pedigree
Ulucak 75	Cno-Gallo	27829-19Y-3M-5Y-0Y
Nuri 70		
Seyhan # 3	$Y50_E$ x Kal^3	35188-E-20Y-0M
Ceyhan	Robin	
Brochis "S"		
Meric	T54-01-25-3-7 x 7C	
Kirkpinar	Hyslop "S"-7C	
Tunca	Fata Sel.185-1 x 61-130/Lds	
Ç.1360	BY_E-Tc^2	
P-558-21-1	[(K58-N/Cnn-Tm x Mi-Hope)Pn-Cnn]YKT	
P-227-23	Menk "S"-My18 x 4/11 / Yy305	
BVD	Erciyes'S'=Fr-Tm x T x 580-405/908-Fn	
Ç-626	$Scout^5$-Agt	
Ç-650	[(N10B/27-15 x Rio-Rex)R101]Yy305	
Ç-1451	61-130-Uveyik 162	
Ç-1454	Uveyik 162-61-130	
Ç-1460	Uveyik 162-61-13	
Ç-1465	1224/1	
Ç-1378	Uveyik 162-61-130	

4.4.4 ECONOMICS

Economic analysis in the past year has concentrated on the extent to which farmers have adopted the improved technology, the identification of barriers to further adoption and the impact of technology adoption on the national level of wheat production. This program included a survey of about 200 randomly selected Ankara farmers carried out in June, 1976, with a follow-up to collect actual yield data in September 1976. Analysis to date confirms that the producers are using their resources in an economically efficient manner given the contraints and prices they face. Also, it suggests that the pattern of adoption seems to be a sequential one with relatively inexpensive, simple improvements coming before more complex clusters of practices.

Regarding the impact of the new technology on production, regression analysis was used to estimate the effects of weather and technology on wheat yield and production. In addition to fertilizer, it appears that other elements of the package are now in wide enough use to have a significant effect on national production. Because the impact of technology on yield is greater in good years than in bad, fluctuations in production over the cycle are likely to grow larger with widespread adoption of the package. This potential for larger swings in production suggests the need for greater storage capacity. The higher average production also indicates the need to explore more carefully the long-run foreign market potential and/or the possibility of shifting land from wheat to other crops.

Training activities have included a seminar on the use of the new CIMMYT economics manual to analyze agronomic experiments. This manual, now in Turkish, has made an excellent contribution towards helping agronomists formulate economic recommendations for farmers. For example, TOPRAKSU's Central Research Station has instructed that all reports on its agronomic experiments carry a section on economic recommendations using the methodology laid out in the CIMMYT Manual.

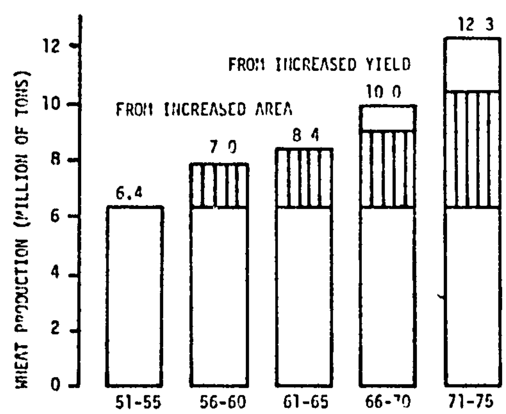

FIG. 4.4 A AVERAGE ANNUAL WHEAT PRODUCTION IN TURKEY 1951-1975 IN MILLION OF METRIC TONS (FROM BRETH, 1977).

5.0 Asia

[illegible]

5.1 Bangladesh

5.1.1 INTRODUCTION

A massive wheat growing expansion programme involving high yielding varieties (HYV's) was undertaken in Bangladesh, for the first time. Wheat seeds totalling 4,000 tons were imported, consisting of 2,800 tons of Sonalika from India and 1,200 tons of Tanori from Mexico. In addition, the Bangladesh Agricultural Development Corporation distributed 2,000 tons of seeds from its own stocks, and it also produced about 800 tons of seed. The quality of the seeds generally, was quite satisfactory.

5.1.2 ACREAGE AND PRODUCTION

The huge imports of seeds helped to boost the acreage of HYV wheat. The Bureau of Agricultural Statistics recorded a total area of 0.37 million acres of bread wheat, of which 0.21 million acres were sown to HYV's. Although the total area did not increase substantially, the HYV acreage was about three times more than the previous year. The co-ordinated efforts of agencies involved in research, extension and also in seed and fertilizer distribution, influenced this trend.

There was practically no increase in the barley acreage relative to the previous year. Triticale is grown in experiment stations, but it is not under cultivation as a commercial crop on farms.

The acreage and production of wheat and barley in 1975/76 were:

Crop	Acreage (million acres)	Production (million tons)
Bread Wheat	0.37	0.21
Barley	0.06	0.01

5.1.3 THE ROLE OF HYV's

Their acreage increased from 0.08 million acres in 1974/75 to 0.21 million acres in 1975/76, and production rose correspondingly from 0.11 to 0.21 million tons due to their replacement of local varieties.

The average yield of HYV's is 2-3 times more than that of the local tall varieties. Even under dryland production, they yield almost double the local varieties.

There is no high yielding barley variety in cultivation.

5.1.4 CLIMATE

In the wheat season i.e. November-March. the average rainfall was 62.98 mm, with no rains in December and January. The maximum rainfall month was March with 52.50 mm Temperatures ranged from 64.06°F to 81.84°F, with the average being 73.30°F. Relative humidity varied from 67-78 per cent.

5.1.5 FERTILIZERS

In Bangladesh, there are fertilizer factories which produce some of its needs of urea, ammonia-urea, ammonium sulphate and triple superphosphate. Various operational difficulties have resulted in production performances ranging from only 40 - 70 per cent of the rated capacity of some fertilizer factories.

Consumption of fertilizers currently stands at 312,000 tons of urea, 110,000 tons of triple superphosphate and 12,000 tons of muriate of potash.

By the end of 1980, the projected fertilizer requirements are 570,000 tons of nitrogenous, 285,000 tons of phosphatic and 135,000 tons of potassic fertilizers.

The Bangladesh Agricultural Development Corporation supplied 5,000 tons of urea, 2,500 tons of triple superphosphate and 600 tons of muriate of potash for wheat cultivation in 1975-76. Fertilizer prices were subsidized, and the subsidized prices on urea, triple superphosphate and muriate of potash respectively were Taka 1,375/-; Taka 1,100/- and Taka 825/- per tonne. The non subsidized prices for these three fertilizers per tonne, respectively were Taka 2,229.70/-, Taka 2,311.65/- and Taka 1,474.83/-. (US$1 = approximately 16 Taka)

5.1.6 VARIETAL TESTING

Varietal improvement is being undertaken through national, regional and international programmes. Among the materials tested in different research centres, 8 lines/ varieties were selected under irrigated conditions from advanced yield tests which will be put into demonstration trials on farmers' field next season. These are:

1. Son64-Kl.rend x 23584	II 26592-8Y-2M-2Y-0M
2. Jaral "s"	
3. Cno "s" - 23584	II 26939-44M-8M-11Y-0M
4. UP301-C306	II 87-I-IP-5P-I-0I
5. Bb-Cno	II 26542-42M-IM-0Y-300M-0Y
6. Bb-Nor67	27100-100M-3Y-3M-3Y-0M
7. Cno-Inia"s"/Tob-Cfn x Bb	CM 1248-54M-2Y-IM-4Y-IM-0Y
8. Pato-7c/CC-8156 x Cno"s"	CM 2264-7M-IY-2M-IY-4M-0Y

5.1.7 NEW VARIETIES

The variety Tanori 71 was released for commercial cultivation. A programme for seed increase of the variety Jupateco was undertaken for release of seeds to the growers next year.

5.1.8 DISEASES

Leaf rust is the main problem in Bangladesh. The varieties Kalyansona and Sonora 64 are susceptible to leaf rust. To a little extent, Sonalika and Inia 66 have also become susceptible to leaf rusts. The varieties Norteno 67, Tanori 71 and Jupateco 73 are maintaining resistance to both leaf and stem rusts.

The leaf spot disease caused by Helminthosporium sp. is also a serious problem in almost all commercial varieties in Bangladesh. Loose smut caused by Ustilago tritici has been a problem with the Indian Sonalika variety (2-3 per cent infestation recorded).

5.1.9 DRYLAND RESEARCH

Wheat is grown in the dry season and is still primarily a rainfed crop (66% of the cropped area). Though higher yields are obtained with irrigation, a moderately good crop may also be obtained under dryland conditions on residual moisture. Therefore, a programme for varietal improvement was started on a limited scale.

5.1.10 TRAINING

During the season, 100 Sub Divisional Agricultural Officers and Thana Extension Officers were trained in HYV wheat cultivation.

5.1.11 RURAL CREDIT

Credit was provided to the wheat growers. The Jatiya Somabaya Bank issued a sum of Tk. 0.10 million to the farmer members of the cooperatives through thirty co-operative banks. Similarly the Integrated Rural Development Programme provided a loan of Tk. 0.22 million through its Thana Central Co-operative Association (TCCA). Tacavi loans have also been given to the wheat growers.

5.1.12 OUTSTANDING PROBLEMS

The non availability of quality seeds is the main constraint for rapid expansion of the wheat area. Although the expansion programme in 1975-76 was undertaken with imported seeds, it is not possible to import every year.

Under the high humidity conditions in Bangladesh, it is very difficult to store seeds from June-October. Due to poor storage, farmers lose a substantial quantity of seeds every year.

The government fixed a procurement target of 0.02 million tons of wheat but ultimately due to the non availability of storage, only 0.007 million tons were procured. This was disheartening, especially for larger growers. Systematic research is needed to develop suitable containers for wheat storage by farmers.

5.2 Nepal

5.2.1 INTRODUCTION

Wheat is becoming increasingly important each year. Compared with the previous year, the per cent increase in wheat area and production in 1975-76 was 12.7 and 15.9 respectively. Area and production have nearly tripled in the last 10 years. However, average yield has not increased. This may be due to the extension of wheat into marginal and rainfed areas plus a big expansion in the tarai where the growing season in only 120 days, versus the 150-180 days in the mid hills. Shortening the growing cycle tends to reduce production.

Statistics related to wheat production are:

Year	Area (1000 ha)	Production (1000 metric tons)	Per cent area sown to improved varieties	Yield metric tons/ha
1965-66	117.7	147.0	3.6	1.25
1970-71	228.4	193.4	43.0	0.84*
1974-75	290.0	332.0	70.0	1.14
1975-76	320.0	385.0	74.0	1.18

* Continuous rain at harvest time.

In 1972, Nepal started a wheat seed multiplication program and it is now self sufficient in seed supply.

5.2.2 VARIETAL RELEASE

RR 21, Sonalika, is the most popular variety in the tarai and hills. Of the two varieties released last year, NL 30 is gaining more popularity in the tarai than HD 1982. Both of these varieties were included in mass demonstrations in 1975-76 and a large seed multiplication was carried out in farmer's fields.

Jupateco 73 and HP 1102 have been amply tested and are considered ready for release. The strength of these varieties is their disease resistance and good yield. However, the red grain and late maturity of Jupateco 73 and the small grain size of HP 1102 are not popular with the farmers. Jupateco 73 is considered to have comparatively good baking quality. In farmers' field trials at Bhairahwa, it outyielded other varieties. This variety seems to be promising in the hills, too.

HP 1102 matures earlier than Jupateco 73 but is later than RR 21 by one week. This variety is good from a disease resistance and yield point of view. It has plump but small sized grains which are soft. There is a good demand for this variety in the hill areas of Pakhribas and Lumle.

Two good characters have been observed in some of the land races included in the program of testing local germ plasm. These good qualities are comparatively high tillering and dormancy of seed after maturity. In the higher hills, wheat must be harvested during the rainy season and seed dormancy is necessary to prevent sprouting. Therefore, the seed dormancy character must be included in new yielding varieties if they are to be accepted in these areas. Prolonged dormancy has been identified in the local variety N 0041 (Jamkhani) from Doti.

5.2.3 VARIETY IMPROVEMENT

High yielding wheat varieties have been the main factor in the wheat revolution taking place in the country. The change to new varieties involves team work. In order to select varieties adapted to various agroclimatic regions of Nepal, fourteen different research stations, and the entire Extension Program, have been involved for the selection and the popularization of the new wheat varieties.

The popularity of the principal variety viz., RR 21 (Sonalika), which covers 95 per cent of the wheat area, is cause for alarm because new physiological races of rust might have the potential for wiping out a single variety, which would cause a crisis in the country. To avoid this situation many varieties of diverse genetic sources should be recommended and popularized. The National Wheat Development Program has recommended NL 30 and HD 1982. Many additional new varieties should be continuously developed to replace the recommended varieties, which become susceptible to rust and other diseases in the course of time.

The National Wheat Development Program is working in this direction by:

(1) Making specific crosses to select suitable varieties for the farmers.

(2) Selection of generation lines. In 1975-76, CIMMYT provided 580 crosses of the F2 generation. Only 29 per cent of the crosses reached final selection, from which 400 individual plants were selected for the next year's '3 program. In other improvement work, 325 F3 plants were selected at Rampur to go into F4. To identify dryland wheat varieties, 295 plants were selected for the F4. Some F4 material was selected for F5 testing and 30 lines of F5 generation were bulked for Advanced Lines testing next year.

(3) Testing and selecting varieties or lines from various international trials and nurseries. Those which were tested included the 5th and 6th Regional Disease and Insect Screening Nursery (RDISN), 8th and 9th International Bread Wheat Screening Nursery (IBWSN), 12th International Spring Wheat Yield Nursery (ISWYN), 7th Regional Wheat Yield Trial and the Indian Uniform Regional Trial (Irrigated).

(4) Organizing National varietal testing and breeding programs to develop varieties for specific agroclimatic areas of the hills, starting with surveys of the various hill areas to determine the specific varietal requirements of these areas. Two sets each of Initial Evaluation Trials (IET) and Advanced Varietal Trials (AVT) were conducted in six Stations in the tarai. Initial Evaluation Trials and Advanced Varietal Trials were conducted in eight locations at various altitudes in the hills.

5.2.4 TRITICALE PROGRAM

Much improvement has been observed in triticales in the past four years. A few lines are now as early as wheat varieties and many triticale varieties now have comparatively better grain and a very low sterility percentage.

It is felt that Nepal should now try to expand its triticale program, especially in the hills. The present plan is to test a few of the better triticale lines at eleven hill locations. These trials will be concentrated in the Western Development Region to enable the wheat technicians to closely supervise them. The National Wheat Development Program plans to employ a man to work in this program. Last year the Seventh International Triticale Yield Nursery was conducted at Bhairahwa and Pakhribas Stations.

At Bhairahwa, 15 triticale varieties outyielded wheat checks but at Pakhribas, no triticale variety produced a significantly higher yield than the wheat check (RR 21). Yields at Bhairahwa were, on an average, 110 per cent higher than at Pakhribas. Inia - Arm 'S' x 1648-8M-3M-OY produced good grain yield in both th. locations. This variety along with Bacum, Rahum 'S', Navajoa, Cinnamon and Yoreme will be tested in the Farmer's Field Trials in many locations in the hills.

Most of the triticales still produced shrivelled grain though their one thousand grain weight seems to be at a satisfactory level. Many triticale varieties are still late in comparison to the most popular wheat variety, RR21. Further improvement in grain characteristics, growth duration and other characters will have to be made to popularize triticales in Nepal.

5.2.5 FERTILIZER INVESTIGATIONS

Several fertilizer investigations were conducted at various stations in the country including rates of nitrogen for different varieties of wheat; NPK rates and their interactions; use of organic manure and efficiency of various sources of N and P on wheat.

5.2.6 WHEAT STERILITY

In a psychological sense, wheat sterility is a major problem in the northern part of the Nepal Tarai and in many parts of the hills. This is because the wheat area is expanding rapidly and growers are sensitive to unexpected developments. In addition, when sterility occurs it often causes severe yield loss. Physically, sterility is a minor problem as only small scattered areas are effected.

Many observations have been made on this problem and the direct cause appears to be failure of anthers to produce pollen. Abrupt changes in temperature and humidity are suspected to kill anthers and caus the problem.

5.2.7 DISEASES

The incidence of leaf rust was negligible this season as it was in the last season. However, on local varieties in the mid-hills the three rusts, smuts, and powdery mildew were observed. *Helminthosporium* was observed in severe form at Bhairawa, Parwanipur and many other stations in the tarai.

A definite reduction in loose smut and bunt incidence in the improved wheat varieties treated with systemic fungicide, was reported from the middle hill areas.

5.2.8 INSECTS

Wire worm was universally present, however damage was insignificant on the whole. Army worm and *Heliothis* damage was not reported during the season. Thrips and aphids were common throughout the country. Borer damage was negligible.

5.2.9 OTHER PROBLEMS

Early flowering and little or no tillering were reported from the Syanja, Kaski and Baglung districts. The early flowering was due to the early planting of an early variety. Tillering was reduced by poor soil moisture during early plant development and also by inadequate use of fertilizers and manures, and by poor field preparation. Zinc deficiency-like symptoms were observed at Bhairahwa.

5.2.10 TRAINING AND EXTENSION

They are major activities in the wheat program. District Agricultural Development Offices (ADO) were provided with information on new developments relating to wheat. Seeds of recently released varieties were provided for mass demonstrations in farmers' fields. Altogether, 200 farmer field varietal trials were conducted. Comparably educated and experienced farmers were provided with two or three sets of field varietal trials. They conducted one trial in their own fields and one or two trials in fields of other farmers. The Bhairahwa Agricultural Farm and the ADO Office of Rupandehi have launched an intensive project at Anandaban Panchayat for development of the small farmers.

5.2.11 WEED STUDY

Weed plants associated with wheat cropping were collected for identification and classification from the major larger areas such as Kathmandu, Bhaktapur, and Lalitpur districts. The collections were made mainly during the flowering and grain forming stage of the wheat crop.

Herbarium specimens were preserved in the Agricultural Botany Division at Khumaltar. The weeds identified during 1975-76 belonged to 36 botanical genera.

5.2.12 THE FUTURE

Technology is now available for producing more than three metric tons of wheat per hectare in the Nepal Tarai. However the national average yield is only slightly more than one metric ton per hectare. Narrowing this wide gap is a great challenge to planners, administrators and all development workers. Improvements are needed in irrigation, the supply of inputs and credit, transport, marketing, utilization and many other factors. A well coordinated approach is required if the problems are to be solved in order to raise the yield of wheat.

ACKNOWLEDGMENT

* CIMMYT assists the national program in its research and training activities through the assignment of a CIMMYT scientist. The CIMMYT involvement is financed through a service agreement with the International Agricultural Development Service, under a grant from USAID.

5.3 Thailand

5.3.1 INTRODUCTION

Wheat following paddy rice has considerable potential on several thousand rai in the Chiang Nai and Chiang Rai valleys of Northern Thailand. One hectare equals 6.25 rai. The Agriculture Faculty at the Chiang Mai University has studied yield trends, input costs and net farm income. These production trials were carried out as three replications of one half rai irrigation plots on a Lampang Sandy Loam low humic gley soil at the Multiple Cropping Project Experiment Station, Chiang Mai University.

Labour, equipment and supply inputs were completely recorded. Inia 66 was the wheat variety used throughout. All grain yields are reported on a 1' per cent moisture basis.

5.3.2 RESULTS AND DISCUSSION

5.3.2.1 Yields

The average wheat yields from the Multiple Cropping Project production plots were:

Yield	1972/73	1973/74	1974/75	1975/76
kg/ha	1,478	3,582	4,000	4,100
t/ha(av.)	1.5	3.6	4.0	4.1

In 1974/75, yield data were obtained from the Experimental Plots because the wheat in the Production Plots was severely attacked by stem borer. The progressive yield increase from 1.5 to 4.1 t/ha was probably related to improved technology such as seed bed preparation, weed control, plant density and irrigation practices.

In 1975/76 another influencing factor was the use of a nitrogenous fertilizer, which was applied at three different rates. The yield responses of 2.67, 3.44 and 4.10 tonnes of wheat to 30, 60 and 90 kg N/ha applied in the form of ammonium sulfate, were highly significant (table 5.3.C)

5.3.2.2 Production Costs

The costs incurred in the 1975/76 wheat production plots expressed in Baht/rai were labour ฿342; equipment ฿638 and supplies N_1฿694, N_2฿747 and N_3฿801. (The fertilizer nitrogen costs per rai were N_1 = ฿52.8, N_2 = ฿105.6 and N_3 = ฿158.4)

Labour costs were therefore only about half those of either equipment or supplies, including chemicals and fertilizer. Tractor costs accounted for half the equipment costs and could be reduced by using a hired tractor at the village (table 5.3.A). Even at the high rate of applied nitrogen (N_3), the fertilizer N accounted for only about 20 per cent of the total supply costs. The cost of the nitrogen per rai at rates equivalent to 30, 60 and 90 kg N/rai were ฿52.8, ฿105.6 and ฿158.4 respectively.

5.3.2.3 Net Income

Based on the 1975/76 wheat yields and input data collected at the production plots (table 5.3.B), the net income under different levels of applied fertilizer N have been calculated (table 5.3.A).

Table 5.3.D shows the gross income, total costs and net farm income derived from growing wheat. The prices which farmers received locally for wheat were used in these calculations. A marked increase in net income is associated with the application of a nitrogenous fertilizer viz., fertilization with rates equivalent to 30 and 90 kg N/ha raised the net farm income from ฿461.4 to ฿1500.8 per rai respectively.

On many farms in Thailand, labour costs might be omitted because of seasonal unemployment and few job opportunities. Omitting labour costs, net income ranged from ฿803.7 to ฿1,844.7 per rai at low (30 kg N/ha) or high (90 kg N/ha) fertilization rates, respectively.

5.3.3 SUMMARY AND CONCLUSIONS

(1) Wheat yields (Inia 66) have steadily increased in the production trials in Chiang Mai in the last four years. Average yields in the production plots during 1975 and 1976 were of the order of 4 tonnes/hectare.

(2) Wheat has shown a highly significant response to applied N fertilizer on the Lampang Sandy Loam under irrigation. The addition of 30, 60 and 90 kg N/ha in the 1975/76 season produced wheat yields of 2.67, 3.44 and 4.10 t/ha.

(3) Net farm income derived from growing wheat based on current world and local input prices suggests a range of ฿461.4 to ฿1,500.8 per rai, depending on whether 30 or 90 kg N/ha equivalent was applied.

(4) Supplies represented the major cost, viz., about 45 per cent, while equipment and labour accounted for 36 and 19 per cent of the wheat production costs.

(5) Net farm income was greatly influenced by the rate of N fertilization because the nitrogen resulted in a large wheat yield response whilst fertilizer nitrogen costs were relatively small.

(6) Potential returns from wheat production in the n‹ ‑hern region may be compared under different management by computing net income with and without labour, and with and without a hired tractor. In each instance, wheat appears very promising.

TABLE 5.3.A Return to wheat production at the University Experimental Plot 1975/76.

Nitrogen (kg/ha)	Total Yield	Gross Income[1]	Total Cost	Net Income	Net Income Without Labor	Estimated Net Income[2] With Hired Tractor	Estimated Net Income With Hired Tractor but Without Labor
	kg	Baht	Baht	Baht	Baht	Baht	Baht
30	427.2	2,136.00	1,674.60	461.40	803.76	671.4	1,013.76
60	550.4	2,752.00	1,727.40	1,014.60	1,366.96	1,234.6	1,576.96
90	656.0	3,280.00	1,780.20	1,499.80	1,842.16	1,709.88	2,052.16

Note: 1 Wheat price = 5.00 ฿/kg (minimum price in April 1976).
2 Hired tractor = 120 ฿/Rai This excludes cost for tractor rotovator (330 Baht/Rai)

TABLE 5.3.B Cost of wheat production at the University Experimental Plots, on the area of 1/6 rai, 1975/76.

Labor		Equipment			Supplies			Total Cost	
Hours	Cost	Item	Hours	Cost Baht	Item	Quantity	Cost Baht	Baht per 1/6 Rai	Baht per Rai
28.53*	57.06*	Tractor rotovator	0.62	55.16	Seed	2.6 kg	16.00		1,674.60
		Hoe	8.40	6.88	Lime	19.0 kg	9.50		
					Sticker	10.0 cc	0.20		
		Spray	0.64	0.45	Lasso	100.0 cc	13.00		
		Planter	1.66	3.17	Furadan	0.66kg	16.50		
		Tractor thresher	0.77	31.48	Sevin 85%	33.0 cc	18.15		
		Seed cleaner	0.77	9.15	Lannate	14.0 gm	6.65		
					Malathion	10.0 cc	0.69		
					Dithane M45	25.0 gm	1.75		
					Triple superphosphate	1.8 kg	16.20		
					K_2SO_4	1.2 kg	8.40		
					$(NH_4)_2 SO_4$	4.0 kg*	8.80*		
28.53	57.06*			106.29			115.75	279.10	1,674.60
28.60+	57.20+				$(NH_4)_2 SO_4$	8.0 kg+	17.60+	287.10+	1,727.40+
28.66⌿	57.32⌿				$(NH_4)_2 SO_4$	12.0 kg⌿	26.40⌿	296.70⌿	1,780.20⌿

Note.

	Ammonium sulfate per 1/6 rai		Nitrogen/hectare
*	4.0 kg	≡	30 kg
+	8.0 kg	≡	60 kg
⌿	12.0 kg	≡	90 kg

TABLE 5.3.C Average wheat yields expressed in t/ha in Production Plots 1975/76 as influenced by Nitrogen fertilizer.

Nitrogen Rate	kg N/ha N_1 = 30	N_2 = 60	N_3 = 90
Replication 1	1.76	2.43	3.75
Replication 2	3.59	4.86	5.04
Replication 3	2.66	3.20	3.50
Av. tonnes/ha	2.67	3.44	4.10
Av. kg/rai	427.2	550.4	656.0

Treatment		N (kg/ha)		Ammonium sulfate (kg/ha)
N_1	=	30	=	150
N_2	=	60	=	300
N_3	=	90	=	450

Production plots = 1/6 rai (6 1/4 rai = 1 hectare)

TABLE 5.3.D Calculated net farm income per rai derived from wheat production.

Treatment	Gross Income	Total Costs	Net Income (Less Labor)	Net Farm Income
N_1	2,136.00	1,674.60	803.76	461.40
N_2	2,752.00	1,737.40	1,357.80	1,014.60
N_3	3,280.00	1,780.20	1,844.72	1,500.80

Treatment		Ammonium sulfate		Nitrogen
N_1	≡	4.0 kg per 1/6 rai	≡	30 kg/ha
N_2	≡	8.0 kg per 1/6 rai	≡	60 kg/ha
N_3	≡	12.0 kg per 1/6 rai	≡	90 kg/ha

6.0 Glossary

ACI	Average Coefficient of Rust Infection
ACSAD	Arab Arid Zone and Dryland Research Center
a.i.	active ingredient
ALAD	Arid Lands Agricultural Development
BV	Biological Value
BV77	El Batan Verano (Summer), México, 1977
BWYT	Bread Wheat Yield Trial
CB	Crossing Block
cc	cubic centimeter
CCGC	Coopérative Centrale des Grandes Cultures
CCSPS	Coopérative Centrale de Semences et Plants Séléctionnés
Cd	Ciudad (e.g. Cd. Obregón = City of Obregon)
CI	Coefficient of Infection (Rust)
CIAB	Centro de Investigaciones Agrícolas del Bajío (México)
CIANO	Centro de Investigaciones del Noroeste (Cd. Obregón, México)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
cm	centimeter
CNPT	National Wheat Research Center (Brazil)
COCEBLE	Coopérative Centrale de Blé
COSEM	Coopérative Centrale de Semences
CRI	Coefficient of Rust Infection
CV	Coefficient of Variation
DAP	Diammonium Phosphate
DBC	Dye Binding Capacity
DM	Dry Matter
donum	Equals 0.227 acres = 919 sq. meters
EACA	Epsilon Amino N Caproic Acid
EBYT	International Barley Yield Trial
EDYT	Elite Durum Yield Trial
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agency for Agricultural Research)
ESYT	Elite Selection Yield Trial
FAO	Food and Agriculture Organization of the United Nations
g	gram
ha	hectare
hl	hectoliter
HYV's	High Yielding Varieties
IBON	International Barley Observation Nursery
IBWIN	International Bread Wheat Increasing Nursery
IBWSN	International Bread Wheat Screening Nursery
IC	Index of Quality
IDRC	International Development Research Center (Ottawa, Canada)
IDSN	International Durum Screening Nursery
IDYN	International Durum Yield Nursery
INAT	Institute National Agricole Tunisienne
INCAP	Instituto de Nutrición de Centroamerica y Panama (The Institute of Nutrition for Central America and Panama)
INIA	Instituto Nacional de Investigaciones Agrícolas (The Mexican National Institute of Agricultural Research)
INIAP	Instituto Nacional de Investigaciones Agropecuarias (Ecuador)
INIP	Instituto Nacional de Investigaciones Pecuarias
INRAT	Institut National de la Recherche Agronomique
INTA	Instituto Nacional de Technología Agropecuaria (Argentina)
ISA	Instituto Superior de Agricultura (San Cristobal, Dominican Republic)
ISEPTON	International Septoria Observation Nursery
ISWRN	International Spring Wheat Rust Nursery
ISWYN	International Spring Wheat Yield Nursery
ITSN	International Triticale Screening Nursery
ITYN	International Triticale Yield Nursery
IWSWSN	International Winter x Spring Wheat Screening Nursery
kg	kilogram
kg/ha	kilogram per hectare
kg/hl	kilogram per hectoliter
LADISN	Latin American Disease and Insect Screening Nursery

LR	Leaf Rust
LSD	Least Significant Difference
m	meter
m^2	square meter
MLN	Multiline Nursery
MV77	Toluca Verano (Summer), México, 1977
N	Nitrogen
NCIC	National Crop Improvement Committee
NPU	Net Protein Utilization
PC	Small plot multiplication for pure seed
PER	Protein Efficiency Ratio
Pgt	Puccinia graminis tritici
PMC	Small increase plot
PMI	International Multiplication Plots
PON	Preliminary Observation Nursery
PRONASE	Productora Nacional de Semillas (The Mexican National Seed Production Agency)
Ps	Puccinia striiformis
P_2O_5	Oxide of Phosphorus
PzV77	Patzcuaro Verano (Summer), México, 1977
q	quintal (= 100 kg)
q/ha	quintal/hectare
Rad	Ramified durum wheat
Rah	Ramified bread wheat
Rai	Equals 1600 sq. m
RCB	Regional Crossing Block
RDISN	Regional Disease and Insect Screening Nursery
RDTN	Regional Disease Trap Nursery
RfWYT	Rainfed Wheat Yield Trial
RTN	Regional Trap Nursery
RV	Roque Verano (Summer), Celaya, México
RWYT	Regional Wheat Yield Trial
SAG	Secretaría de Agricultura y Ganadería, México
SCU	Sulphur Coated Urea
SR	Stripe Rust
t	tonne (= 1000 kg)
tarea	Equals 628 sq.cm
TCCA	Thana Central Cooperative Association
TD	True Digestibility
TDRN	Triticale Disease Resistance Nursery
t/ha	tonnes/hectare
TL	Turkish Lira
tonne	metric ton (= 1000 kg)
USDA	United States Department of Agriculture
YR	Yellow Rust
Y76-77	Yaqui, México, 1976-77

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