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on December 31, 1973

STAFF

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Deputy director, Outreach and special programs	Keith W. Finlay, Ph.D.
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Director, International maize program	Ernest W. Sprague, Ph.D.
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Mexico City office	Rosa María Vázquez V.
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Associate director	R. Glenn Anderson, Ph.D.
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Agronomist/physiologist	R. Anthony Fischer, Ph.D.
Pathologist	Santiago Fuentes F., Ph.D.
Triticale breeder	Man Mohan Kohli, Ph.D.
Training agronomist	John H. Lindt, M.S.
Training agronomist	Paul N. Marko, M.S.
Consultant, Computer services	Kasem B. Mexas*
Durum wheat breeder	Marco A. Quiñones L., Ph.D.
Bread wheat breeder	Sanjaya Rajaram, Ph.D.
Barley breeder	Enrique Rodriguez C., Ph.D.
Geneticist and wheat breeder	Ricardo Rodriguez R., M.S.
Triticale breeder	Frank J. Zillinsky, Ph.D.
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Wheat physiologist	D. Hille Ris Lambers, Ph.D.
Triticale agronomist	Matthew A. McMahon, Ph.D.
Cytology laboratory/Triticale	Arnulf Merker, Ph.D.
Physiologist	David Midmore, B.S.C.
Bread wheat breeder	Robert Redden, Ph.D.
	Research assistants
Agronomy/physiology	Immer Aguilar M.,* Ing. Agr.
Bread wheat	Pedro Brajcich G., Ing. Agr.

Assistant triticale breeder	Jose Angel Daniel, M.Sc.
Bread wheat	Juan E. Delgado G., Ing. Agr.
Laboratory technician, Triticale	Margarita Hernandez de Sosa
Bread wheat	Juan Joaquin Kritzler H., M.Sc.
Durum wheat	Carlos Leôn Ochoa., Ing. Agr.
Assistant triticale breeder	Alfonso Lopez B.,* M.Sc.
Agronomy/physiology	Roberto Maurer O.M., Ing. Agr.
Durum wheat	Guillermo Ortiz F.,* Ing. Agr.
Hybrid wheat	Carlos Peña O., Ing. Agr.
Triticale	Juan J. Salmeron, Ing. Agr.
Bread wheat	Jose Venegas.,* Ing. Agr.
Wheat international cooperative programs	*CIMMYT staff*
Wheat breeder, Morocco	Aristeo Acosta,* Ph.D.
Agronomist, Morocco	William E. Hall,* Ph.D.
Wheat breeder/team leader, Algeria	Willis L. McCuistion, Ph.D.
Wheat breeder/agronomist, Algeria	Walter Nelson, M.S.
Agronomist, Algeria	Herb Floyd, M.S.
Wheat agronomist, Algeria	Francisco Plouin
Agronomist/team leader, Tunisia	J. B. Doolette, B. Ag.Sc.
Wheat breeder, Tunisia	George Varughese, Ph.D.
Agronomist, Tunisia	Torrey Lyons, Ph.D.
Pathologist, Turkey	J.M. Prescott, Ph.D.
Wheat breeder, Turkey	Arthur Klatt, Ph.D.
Pathologist, Lebanon	E.E. Saari, Ph.D.
	Program-associated staff
Wheat breeder, Ford Foundation, Lebanon	Gerbrand Kingma, Ph.D.
Agronomist, Oregon State University, Turkey	Floyd E. Bolton,*
Agronomist/team leader, Rockefeller Foundation, Turkey	Billy C. Wright, Ph.D.
Seed production specialist, Rockefeller Foundation, Tunisia	J.E. Douglas
Maize headquarters staff	
Director	Ernest W. Sprague, Ph.D.
Experimentalist, Agronomy/physiology	Elyn Bacopulos T.* Ing. Agr.
Maize breeder	Alfredo Carballo Q., Ph.D.
Maize agronomist	Michael Colegrove,** Ph.D.
Pathologist	Carlos De Leon, Ph.D.
Agronomist	Peter R. Goldsworthy, Ph.D.
Entomologist	Gonzalo Granados R., Ph.D.
Geneticist, Maize germ plasm bank	Mario Gutierrez G., Ph.D.
Experimentalist, Maize germ plasm bank	José Jimenez R., Ing. Agr.
Maize breeder	Elmer C. Johnson, Ph.D.
Entomologist	Alejandro Ortega C., Ph.D.
Maize breeding/physiology	David W. Sperling,** Ph.D.
Maize breeder	S.K. Vasal, Ph.D.
Maize breeder	Willi Villena D., Ph.D.
Training agronomist	Alejandro Violic, Ph.D.
Soils scientist	Reggie J. Laird, Ph.D.
Soils scientist and training agronomist, Plan Puebla	Antonio Turrent F., Ph.D.
Coordinator, Plan Puebla	Mauro Gomez A., M.S.
Evaluation specialist, Plan Puebla	Franciso Garcia H.,* M.S.
Assistant soils scientist	Alvaro Ruiz B., M.S.

	Research Assistants, Plan Puebla
Associate in agronomic research	Ramon Barraza M.* Ing. Agr.
Associate in agronomic research	Jose T. Morales G.,*
Technical assistance to farmers	Oziel Montañez G.* Ing. Agr.
Technical assistance to farmers	Arturo Camarena M.*, Ing. Agr.
Technical assistance to farmers	Jose Marcos F.*, Ing. Agr.
Technical assistance to farmers	Miguel Sanchez H.*, Ing. Agr.
Technical assistance to farmers	Alfonso Macias L.*, Ing. Agr.
Special collaboration in the organization of farmers	Jose Zaragoza P.*, Lic.
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Agronomist	Kenneth S. Fischer, Ph.D.
Maize breeding	Wayne L. Haag, Ph.D.
Sorghum breeding	Shree P. Singh, Ph.D.
Production agronomy	Roberto Soza, Ph.D.
Plant protection	N'Guetta Bosso, M.S.
Maize breeding	Abdrabboh A. Ismail, M.S.
Visiting scientist	Bibhash K. Mukherjee, Ph.D.
Visiting scientist	Sutat Sriwatanapongse, *, Ph.D.
Visiting scientist	A. H. Shehata, * Ph.D.
Plant protection	Richard Wedderburn, Ph.D.
Maize international cooperative programs	*CIMMYT staff*
Agronomist, Colombia	Canuto Cardona*, Ph.D.
Maize breeder, Egypt	N. L. Dhawan, Ph.D.
Maize breeder, Nepal	Melvin Splitter, Ph.D.
Maize breeder, Pakistan	Takumi Izuno, Ph.D.
Agronomist, Pakistan	A. Frederick E. Palmer, Ph.D.
Agronomist, Zaire	Thomas Hart, Ph.D.
Maize breeder, Zaire	Frans de Wolff, Ph.D.
Plant protection specialist, Zaire	Mahesh C. Pandey, Ph.D.
Maize agronomist, Tanzania	Michael Colegrove, Ph.D.
Maize breeding/Physiology, Tanzania	David W. Sperling, Ph.D.
	Program-associated staff
Maize breeder, CIAT, Colombia	Charles Francis, Ph.D.
Maize breeder, IITA, Nigeria	M.N. Harrison
Pathologist, team leader, Rockefeller Foundation, Thailand	Bobby L. Renfro, Ph.D.
Maize breeder, Rockefeller Foundation, Thailand	Charles L. Moore, Ph.D.
Training agronomist, Rockefeller Foundation, Thailand	Dale G. Smeltzer, Ph.D.
Economics	
Economist	Donald D. Winkelmann, Ph.D.
Information services	
Head	Gregorio Martínez Valdés, Ph.D.
English editor	Dean C. Bork, * M.S.
Visual aids specialist	Gil Olmos B., M.S.
Photographer	Leobardo Terpán
Photographer	Juan Zamora L
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Visitors and seminar service	Linda Ainsworth

General service laboratories	
Biochemist, In-charge	Evangelina Villegas M., Ph.D.
Nutritionist, Protein quality laboratory	Reinald Bauer, D.Sc. Agr.
	Research assistants
Chemist, Protein quality laboratory	Ernesto G. Alcantar G.
Chemist, Protein quality laboratory	Ma. de Lourdes Escamilla H.
Biochemist, Wheat quality laboratory	Arturo Fuentes C.
Biochemist, Protein quality laboratory	Jose Angel Juarez
Chemist, Plant and soils nutrition laboratory	Jose Natividad Leal S.,* M.S.
Biochemist, Protein quality laboratory	Jaime Lopez C.
Chemist, Plant and soils nutrition laboratory	Enrique Ortega M.,*
Chemist, Wheat quality laboratory	Luis Ramon Patiño G.,*
Chemist, Wheat quality laboratory	Roberto Javier Peña B.
M.S., Chemist, Plant and soils nutrition laboratory	Franciso J. Rodriguez B., *
Experiment stations operations	
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Assistant	Roberto Varela
Superintendant, El Batán	Rafael Trujano
Superintendant, Toluca	Jose Antonio Miranda
Superintendant, Poza Rica	Florentino Amacende
Assistant superintendant, Tlaltizapan	Angel Palma

*Left during the year.
**Transferred to Tanzania during the year.

FOREWORD

The year 1973 marked the 28th year of continuous research on wheat and other small grains in Mexico by CIMMYT and its predecessors. It also marked the ninth year of CIMMYT's activities as an international center, based in Mexico, but distributing new seed and technology to wheat-growing countries throughout the world, with emphasis on developing countries.

From 1945 to 1973, Mexico's average wheat yields rose from 700 kg/ha to 4200 kg/ha. This is a remarkable achievement which Mexico and CIMMYT can cite to other countries.

Several significant periods can now be identified during this work in Mexico:

1945-56: Mexico overcame its wheat deficit and achieved self-sufficiency.

1956-62: Mexican dwarf wheats were developed by crossing local wheats with a short Japanese wheat, Norin-10. Mexico released the first "one-gene dwarfs," Pitic-62 and Penjamo-62 in 1962, for its own commercial use. The two-gene and three-gene dwarfs were also released by Mexico during the 1960's.

1966: CIMMYT was created as an international center (the name comes from the acronym for Centro Internacional de Mejoramiento de Maiz y Trigo).

1966-72: Mexican wheats moved to India and Pakistan where they doubled the local wheat crop, from 15 million tons in 1966 to over 30 million tons in 1973. These wheats also moved to the Middle East, North and East Africa, and South America, where the original one-gene dwarfs were not so well adapted, but breeding and selection of varieties suitable for those regions is now well advanced.

This volume reports the progress of the wheat program in 1973. Significant developments included:

Two new bread wheat varieties, Jupateco 73 and Torim 73, bred by CIMMYT and the Mexican agency INIA, were released by Mexico, showing yield gains of 5 to 10% above previous dwarfs.

Multilines of bread wheats, which are intended to stabilize bread wheat yields against attacks of the three rusts, are now being tested in 31 countries.

New durum varieties bred in Mexico were released in the Mediterranean region and gave substantial yield gains above local varieties.

Triticale, a new cereal grain created from the wheat-rye cross, is undergoing tests on five continents and showing superiority to wheat under some climates, soils, and moisture conditions.

Training by CIMMYT in Mexico included 47 young scientists from 19 countries who spent at least one full crop season in the Mexico research and production programs.

International nursery trials distributed by CIMMYT were grown in 71 countries.

Outreach activities (help to national wheat programs) included consultation by CIMMYT staff with 40 governments, and the resident services of 12 CIMMYT staff members posted in the following countries: Algeria, Morocco, Lebanon, Tunisia, and Turkey.

CIMMYT's wheat staff consisted of only 15 senior scientists at headquarters, but they were responsible for the above progress, in association with a network of more than 1000 scientists who collaborate voluntarily outside of Mexico.

Haldore Hanson
Director General

WHEAT

INTRODUCTION

In 1973, world wheat production showed a modest increase, due in large part to a record crop in the USSR. However, the world wheat stocks continued to be drawn down reaching a 22-year low in the USA. This coupled with a drought-induced, smaller-than-usual crop in Australia, and continued strong import demand, caused wheat prices to rise throughout the year. A price of US$100 per ton for wheat in international trade was recently considered exorbitant, but the increases during 1973, which culminated in a price of nearly $250 per ton, placed a tremendous burden on importing nations, particularly the developing countries. This happened even though grain production world-wide surpassed the previous record of 1106 million tons established in 1971 and is now estimated to have been about 1163 million tons in 1973.

Much of the shortage of cereals is due to the rapid increase in the world's population. CIMMYT scientists consider that if civilization is to persist, efforts to limit population must have first priority. The resources of the earth are simply incapable of continuing to supply the increasing demand for food and other necessities beyond the space of a very few years in many countries. Should the present half-hearted attempts to meet the population problems be continued, we can expect not only famine on a scale beyond comprehension, but a breakdown in supply of all of the other essential products used in a modern society. In the densely populated countries signs are evident that this point is near indeed. The political chaos which is likely to ensue could rock international relations to its foundations.

On the plus side, the shortfall of supply and high prices have alerted all countries to the need to expand their production, and world-wide interest in food has greatly increased. Unfortunately, there is a coincident shortfall in the production of nitrogen and phosphate fertilizer. The temporary overproduction of fertilizers, 2 to 3 years ago, resulted in lowered prices and the closure of less efficient plants. The sharply rising demand from developing nations soon reduced the inventory stocks, however, and supply is now extremely critical. For the 1972/73 wheat crop in India, for example, supply of fertilizers was estimated at 30 percent below demand, and for the 1973/74 crop, 40 percent below. Similar shortages are reported for many other countries. The situation was further aggravated by the "energy crisis" of late 1973, since petroleum is the base of nitrogen fertilizer production. As a result of shortage and rising cost of basic materials, fertilizer prices have more than doubled and fertilizer was being purchased during the year at almost any price. By the best estimates supply cannot saturate demand in less than 5 years, if ever. Unless immediate action is taken to build more fertilizer plants and improve the production efficiency of existing ones, the world food situation will rapidly deteriorate.

In the 1973 crop year, had the record production been properly distributed, the extra grain would have been sufficient to meet the additional needs of the 77 million extra people estimated to have been added to the world's population. Some countries, however, were well served by weather while in other countries unfavorable conditions limited production. Damaging sirocco winds in Algeria, for example, virtually halved that country's expected wheat production. Turkey showed a marked decline from 1972. On the other hand, Afghanistan had a record wheat crop as did the USSR where an estimated 105 million metric tons were harvested, placing the latter country in a particularly favorable position.

In summation, the world food situation remains critical.

Participants in the 1973 wheat, triticale and barley seminar.

High prices, for grain and fertilizer cast a particularly heavy burden on the developing nations. Food shortages and higher-than-normal prices are likely to remain with us.

Genetic improvement of crops can only be expected to provide some alleviation of the food problem. Improvement in fertilizer supplies offers the best chance of extending the period of grace. Unless we use this time wisely and bring our numbers into equilibrium with the earth's capacity to provide nourishment we will be visited by famine and anarchy.

CIMMYT continued to train scientists from the developing nations. In 1973, 94 men and women participated in training in the wheat section programs or visited for a week or more. Of these, half were enrolled in the "in service" programs. Hundreds of persons visited the wheat section nurseries at Ciudad Obregon, El Batan, and Toluca in Mexico. CIMMYT also continued to supply germ plasm material to interested countries, increasing the number of nurseries to 1140, more than double the number sent in 1972. This reflects the increased interest and demand for assistance. The outreach programs in Morocco, Algeria, Tunisia, and Turkey moved ahead aggressively to establish sound research and production programs. In 1973, a regional pathologist, centered at Beirut, was added to the CIMMYT staff to assist national programs and to maintain an overall surveillance on the diseases throughout the wheat-growing areas of Africa and Asia.

Mexico-based wheat staff members spent about 500 man-days consulting with research personnel and government planners in about 20 countries. Members of the outreach staff, stationed in five countries, also visited many programs outside their country of assignment in similar outreach activities. CIMMYT scientists benefit greatly from such visits which enable them to assess the problems and needs of national programs. It provides them with an opportunity to select promising materials for placement in CIMMYT's crossing programs both at base and in the national programs.

An International Wheat, Triticale, and Barley Seminar was conducted at El Batan in January 1973, attended by scientists from 23 countries. The theme of the workshop was a forward look at CIMMYT's plans for wheat, triticale, and barley research in the 1970's.

MEXICO

CIMMYT cooperates closely with the national wheat improvement program of Mexico. The Instituto Nacional de Investigaciones Agricolas (INIA) through the Centro de Investigaciones Agricolas del Noroeste (CIANO) at Ciudad Obregon provides experimental land for CIMMYT to use in the main winter season. In turn CIMMYT makes available all its materials to the national program and also receives selections and materials for its use from the Mexican wheat program. During 1973, the two staffs exchanged visits at their Chapingo and Toluca nurseries on alternate days and reviewed the progress of the work.

CIMMYT does not release varieties. Those known worldwide as "Mexican varieties" are truly Mexican varieties, some of which were derived from CIMMYT-developed materials and others from the Mexican national program. CIMMYT in similar fashion makes its germ plasm available to any country requesting it.

The particularly good relationship between INIA and CIMMYT is a matter of considerable pride in both organizations.

BREAD WHEAT

During 1972/73 at Cd. Obregon and during 1973 at El Batan and Toluca, the nurseries developed well. A severe infection of stem and leaf rust at the CIANO station in Cd. Obregon allowed good selection both in generation material and among the advanced lines. A new race of leaf rust occurred which is virulent on the lately released Bluebird varieties, Nuri 70, Yecora 70, Saric 70, and Cajeme 71, as well as in materials combining this resistance in the breeding program. That made it possible to screen out these susceptible genotypes. Similarly, a new race of stripe rust appeared at Toluca. This race attacked the Bluebird-derived varieties and the advanced line Mengavi-8156 for the first time. Again because of a high epidemic level, heavy selection pressure was applied.

Breeding. During the 1972/73 season at Cd. Obregon, 3500 single crosses were grown together with 1200 three-way and double crosses. At Toluca an additional 2000 single crosses and 1200 three-way and double crosses were grown in the following season. The aim in producing this large number of F_1 crosses is to broaden the base of genetic diversity in the program in order to provide suitable materials for CIMMYT's world-wide network of assistance to national programs. Disease resistance, stabilization of yield, and winter x spring crosses are receiving priority.

Continuing effort is being made to broaden the spectrum of resistance to the three major rusts and to septoria, all of which could potentially be catastrophic for national production programs. Varieties that have shown outstanding resistance in geographic areas where these rusts are endemic and destructive are continuously introduced into the crossing program. In this way CIMMYT germ plasm is amassing a large degree of polygenic or so-called horizontal resistance. Similarly, for septoria, sources of resistance are being introduced from varieties selected in North Africa, Turkey, Ethiopia, Brazil, Argentina, Europe, and North America where septoria often is destructive.

To stabilize yield, varieties are identified that possess wide adaptation and high yield. From such varieties, multilines can be developed. In this system, many sources of resistance are bred into the selected variety and then grown as a composite variety consisting of several lines mixed together. A multiline is well advanced in development for the 8156 genotype (Siete Cerros, Super X varieties, etc.). A similar approach is under way using the Lerma Rojo x Norin 10-Brevor/$Andes_E$ which has given rise to such varieties as Anza, WW15, Mexicani, Karamu, and Moghan in widely diverse countries.

In the winter x spring wheat crossing program CIMMYT is using the largely unexploited source of variation available through crossing these seldom-crossed gene pools. The

Table 1. **Characteristics of superior bread wheat lines in large multiplication at CIANO, Sonora, Mexico 1973**

Genotype and pedigree	Yield t/ha	Check yield[a] t/ha	Grain wt kg/ha	Grain color	Height	PK min	Protein %	Alveogram P/G	Alveogram W	Sedimentation cc	Loaf vol cc	Rust reaction Stem Rust	Rust reaction Leaf Rust	Rust reaction Stripe Rust
Meng-8156 H 223-64-1Y-1E-1Y-1C-4Y-3C-100Y	8.4	7.5	81.5	Red	E_2–	34	9.1	4.1	190	12	600	TMS	TR	20MS
Kal-Bb 26702-30M-1Y-1M-3Y-0M	6.7	7.0	81.8	White	E_3	120	9.1	6.3	262	31	640	TMS	10MR	10MR
Kal-Bb 26702-30M-1Y-1M-500Y-0M	7.2	7.0	82.9	White	E_3	116	10.4	5.2	291	35	675	TMS	30MR	5MR
Tob-Sr[2] CM 5211-B-2Y-1M-1Y-0M	7.7	7.3[b]	82.9	Red	E_3–	119	10.8	4.7	342	47	730	TR	TR	5MR
VcmxCno-7C/Kal-Bb CM 8399-D-4M-3Y-0M	6.7	6.3[c]	83.3	White	E_1	112	9.7	7.7	258	44	710	5S	5R	TR
Jupateco 73 "S" 30842-58R-1M-4Y-0M	8.0	8.0[d]	83.0	Red	E_2–	120	10.6	5.9	359	36	720	5S	TMR	10MR
Cno-BbxCdl (7C/Lib-INIAxINIA-Bb) CM 5872-C-1Y-1M-3Y-0M	8.3	8.3	82.8	Red	E_1	38	8.8	4.9	182	26	630	TR	20MS	5R
Y50E-Kal[3] 35188-5M(F1)-31Y-0M-8M-0Y	7.6	7.3	82.5	Red	E_1+	41	9.5	9.5	263	28	620	20S	20MR	20MR-MS
7C x Tob-Np63 C789-21-1A-2Y-0M	9.0	8.0	81.7	White	E_1+	68	8.4	4.2	187	27	620	10S	5MS	20MR
Hopps-Ron x Kal CM 8874-K-1M-1Y-0M	7.9	8.1	84.1	Red	E_1+	>120	9.1	––	280	34	635	10S	TR	10MR
INIA "S" -Soty x Czho 3-6G-1Y-3M-3Y-0M	8.8	7.7[b]	80.4	Red	E_1	44	6.3	2.9	117	––	––	10S	10MS	TMR
Bb x Tob-Cno CM 1561-38M-5Y-3M-4Y-0M	7.9	7.5	82.5	White	E_1+	>120	10.3	5.1	277	46	715	TR	5MR	10MR
[(KI.Pet-RafxPj/Cno)Nor67]INIA-Cnox Cal 11 34841-59Y-2M-1Y-3M-1Y-0M	7.7	7.1[e]	81.7	Red	E_2–	56	10.2	4.4	179	26	690	10S	20MR	10MR
(Fn-Md x K117A/Cofn[2])Son-KI Rend/Cno "S" xLR64[2]-Son 64 CM 2182-5M-1Y-2M-3Y-0M	7.8	7.6[c]	82.7	Red	E_2–	72	8.3	4.0	163	33	615	10S	TMR	20MR-MS
(HK-38MAxRfn[2]-908/Fn)Yr70 CM 2097-31M-1Y-1M-4Y-0M	9.1	8.3[e]	80.5	White	E_2+	50	8.6	4.9	184	25	670	5S	TMR	10MS
(HK-38MAxRfn[2]-908/Fn)Yr 70 CM 2097-31M-1Y-2M-1Y-0M	8.5	8.3[e]	80.0	White	E_2+	48	7.7	3.8	141	21	615	5MS	5MR	TS
Cno "S"-Pj62 x Gallo 30793-1M-2R-2M-0R	8.3	8.5[d]	79.0	Red	E_2	85	10.2	3.0	190	37	745	10MS	10MR	TR

a/ Check variety is 7C unless otherwise indicated. *b/* Check variety: Sr70 *c/* Check variety: INIA. *d/* Check variety: Cj71. *e/* Check variety: Ti71.

aim is to select spring wheats of new agronomic type with greater yield potential, drought resistance, and resistance to septoria derived from the winter-wheat parents.

In addition to these major steps which are all aimed at improving yield and yield stability, such characteristics as degree of dwarfing, shattering resistance, resistance to other diseases, and quality, are being combined simultaneously.

In 1973, CIANO and the government of Mexico released two varieties derived from CIMMYT materials: Jupateco 73 is from the cross 12300 x LR64-8156/Norteno 67, II 30842-31R-2M-2Y-0M, and Torim 73 is from the cross Bb-Inia 26591-1T-7M-0Y-55Y-0M. Jupateco 73 is a red-grained, single dwarf variety while Torim 73 is a white-grained, triple dwarf. Both have excellent resistance to both stem and leaf rust.

Seventeen advanced lines are considered to have superior yield, disease resistance, and good agronomic characteristics (Table 1). In general yields were equal to or greater than the check variety with which they were compared. The variety Mengavi-8156, which had the fifth highest yield, has shown outstanding performance internationally. Based on 38 locations it was the highest yielding variety in the Ninth International Spring Wheat Yield Nursery. Kal-Bb, 26702-30M-1Y-1M-500Y-0M, is a three-gene dwarf which matures 10 days earlier than Siete Cerros 66, and has equal yield potential and improved quality. These two lines may be released by CIANO in 1974. The advanced line (H. Kolben-38 MA x Rfn^2-908/Fn) Yr 70, now known by its breeding name Canario "S" CM2097-31M-1Y-1M-4Y-0M, yielded more than 9 t/ha, approximately 1 t/ha above Tanori 71. This is a selection from a cross involving a winter wheat and it clearly represents a yield increase over previous Mexican dwarfs. All of these lines are presently under test in an International Elite Trial at 25 locations throughout the world. The results will give an indication of the breadth of adaptation of this new germ plasm.

The Seventh International Bread Wheat Screening Nursery assembled in 1972 comprised 330 advanced lines with checks. Each of these lines was selected from yield trials and advanced generation material which had reached relative homozygosity. These were distributed to 120 cooperators world-wide for evaluation and selection for agronomic type and disease resistance. The nursery was also evaluated in Toluca in 1973. Because of the shift in stripe rust virulence and a severe infection with *Fusarium nivale*, many of the lines were found unsuitable for those diseases in Mexico. Eighty-six lines, however, showed excellent resistance to all three rusts at El Batan and Toluca. Their entry numbers:

12	62	112	190	262	301
19	65	113	192	263	302
25	69	114	204	264	306
27	71	116	205	265	307
29	73	125	210	273	309
30	78	134	216	275	310
44	79	139	221	278	311
45	81	150	225	279	315
47	88	155	229	281	316
48	91	163	230	282	317
50	103	179	238	283	318
53	104	186	239	284	319
54	105	188	255	285	322
55	106	189	257	286	323
	324		328		

Although the germ plasm involved was derived from 13 countries representing diverse areas of the world in each of which rust epidemics regularly occur, the great bulk of the parental material was of Mexican origin because Mexican germ plasm is primarily responsible for the high base of yield potential:

Country	Parents involved
Mexico	269
Argentina	26
U.S.A.	18
Chile	9
Colombia-Ecuador	7
Europe	5
Australia	4
Kenya	4
Rhodesia	4
Brazil	1
Korea	1
Pakistan	1
India	1

Programs now under way will further broaden the CIMMYT gene pool.

The 8156 multiline. Based on its high yield potential, the 8156 genotype has achieved world-wide cultivation under a variety of names. Growing a single variety throughout large geographic areas could be dangerous since a new race of one of the rusts, for example, could cause widespread epidemics and production loss. Aerobiological studies of spore movements show that considerable areas fall within an epidemiological zone. Still, because of its widespread popularity and good performance, this variety could continue to provide high yields of food. This is the point at which the multiline within the variety can remove the danger of loss. Five years ago a program was undertaken to produce a wide array of resistance in this basic genotype, including resistance to the rusts and to septoria. No backcrossing is followed but selections for the 8156 type are made from segregating populations of crosses between 8156 and many varieties with differing resistance. Contributing to this resistance were varieties from USA, Argentina, Kenya, Australia, Canada, Colombia, Ecuador, and other countries. In 1973, 285 advanced lines of this type were produced, derived from about 100 crosses. These lines are being yield tested in Mexico and assessed for their basic characteristics. In addition small samples of each line have been distributed to 20 cooperators throughout the world particularly in South Asia, the Middle East, and North Africa, where 8156 is grown extensively, to assess their performance for resistance to the different diseases. After adequate testing, any country wishing to use this variety may pick out 15 to 20 lines which will be then mechanically mixed to provide multiline varieties suitable to the specific country. Each component of such varieties would possess a yield potential equal to or higher than 8156 and each would have similar maturity, height, grain color, and chaff color.

Such multiline varieties would carry different types of resistance in their component parts, so that if one subgenotype becomes susceptible, the plants representing the other genotypes would be resistant and yield their full potential. The multiline would also limit spore production thus precluding the epidemic level possible with a pure line variety.

While the variety is in production, the single component lines and a number of additional lines are grown separately at research stations so that a line which becomes susceptible is readily identified. When this happens that line is withdrawn from the mix and replaced by another resistant line in new seed stocks. Meanwhile current production is not materially affected. In the CIMMYT system no attempt is being made to analyze genetically each of the contributed resistances to establish how different they are from one another. Instead, dependence is placed on multilocation testing to warn of the breakdown of certain of the elements. A considerable number of different multiline varieties are conceivable. In North Africa resistance to septoria in addition to rust resistance would be mandatory. In the subcontinent of South Asia, septoria resistance would be of little moment.

The multiline would, in effect, act in a similar fashion to the conditions obtaining in such cross-pollinated crops as maize where rust has never created a major problem in areas where it is endemic.

Winter x spring wheats. Crossing winter x spring wheats offers real potential for improving both groups of wheats. Crosses of these seldom-crossed groups of bread wheats bring together two gene pools which have general complementarity in characteristics. For spring wheats, germ plasm from winter wheats should provide enhanced drought resistance, better resistance to *Septoria tritici* and *S. nodorum*, and increased yields due to the incorporation of new genes. Further, from the spring segregates it is expected that a wider maturity range can be selected for suitability to particular ecological conditions. For winter wheats, germ plasm from spring wheats can enhance the resistance to the rust diseases and also contribute genes for yield advance. Winter segregates with superior performance will benefit agriculture in Turkey, Iran, Afghanistan, South Korea, Algeria, Eastern and Western Europe, Chile, Argentina, and USA.

Previously CIMMYT made a limited number of crosses between vernalized winter wheat and spring wheats in plots at Cd. Obregon. In 1972/73, however, seed of a large collection of winter wheats was sown at Toluca near Mexico City in November. The spring-wheat crossing block was sown at several dates beginning in Janurary. Good vernalization occurred with the winter wheats and a good nick was obtained with the spring wheats. More than 1000 crosses were completed. Further crosses were made as usual at Cd. Obregon.

In the CIMMYT program, improving wheat by crossing with winter wheat is an integral part of CIMMYT's spring wheat work. Winter wheat improvement is conducted in a partnership of the national wheat program in Turkey, where CIMMYT staff members are located, Oregon State University, and CIMMYT.

In 1973, half the F_1 seed produced in Mexico was sent to Oregon State for fall planting and crossing in May 1974. In future, F_1 seed will be divided four ways among Oregon, Turkey, India, and CIMMYT. In the winter wheat improvement, top crosses and double crosses are made to winter wheats and selection is done at Oregon under both high and low rainfall conditions. Similar selection is made in Turkey.

The F_1 plants from winter-spring crosses are generally of spring habit, although various gene combinations for vernalization requirement, photoperiodic response, and cold tolerance cause some to be late in heading and others to be winter-killed. Spring habit dominance, however, provides an opportunity for top crossing and double crossing to

Ingenier Ricardo Rodriguez explaining his work on branch-headed wheats to a group of scientists attending the triticale conference in October.

spring-habit materials each season in Mexico so that, respectively, two thirds or three fourths of the germ plasm is of spring derivation in the F_1 generation of such crosses. Observations on general vigor and disease resistance at Toluca and Cd. Obregon, Mexico, can guide the programs in Oregon and Turkey in selecting suitable parents for crossing in the winter wheats. Table 2 shows the transmission of various traits of parental varieties in a series of F_1 crosses. For some varieties complete dominance for certain characters is present while in others there is no trend in either direction.

The CIMMYT winter x spring improvement program is still in its infancy. However, a large collection of winter wheats was obtained from several countries and organizations. The winter wheat crossing block assembled in 1972 comprised more than 300 varieties including ones from the USA, USSR, Western Europe, Turkey, and Chile. In addition CIMMYT grew about 2000 varieties supplied by the U.S. Department of Agriculture, 1300 Chilean wheats known as CAR lines from Dr. J.R. Rupert's collection, 1200 lines from Oregon State University, 800 lines from Turkey, 500 lines from the International Winter Wheat Screening Nursery supplied by CIMMYT personnel in Turkey, and the Fourth International Winter Wheat Performance Nursery from the University of Nebraska. All of these lines were evaluated for disease resistance and agronomic type at Toluca. More than 300 spring varieties were sown later for crossing. More than 1300 single crosses were made in May and June. A portion of these crosses were sown at Cd. Obregon in fall 1973 and the remainder are slated for growing at Toluca in summer 1974.

The winter wheat gene pool was subjected to a severe epidemic of stripe and stem rust at Toluca, enabling the plant breeders to select a group of elite materials with combined good agronomic plant type and disease resistance. These materials will form the basis of the winter wheat crossing block.

Preliminary observations on winter x spring F_1 plants clearly indicate a strong positive heterosis in plant type, tillering capacity, head length, and leaf type. Segregates of the spring type arising from earlier crosses, made by Dr. J.R. Rupert, strongly support the view that much of the improvement can be fixed. It has further been shown that these spring segregates have much enhanced drought resistance. Frost resistance could logically be expected to

Table 2. **Parental transmission of traits in more than 70 percent of F_1 plants from spring x winter bread wheat combinations at Oregon, U.S.A., and Toluca and Cd. Obregon, Mexico 1972/73.**

	Oregon			Toluca		Cd. Obregon	
Parent	Stripe rust	Straw strength	Cold tolerance	Stripe rust	Days to flowering	Stem rust	No. of combinations
			Winter wheat				
Aurore	S	Exc	Low	S	176-190	TR-10R	12
Bezostaja	S	R or S	H or L	90-100S	< 175	S	20
Kawkaz	R or S	Exc	Low	S	176-190	TR-10R	22
Yamhill	R or S	Good	H or L	R or S	196 +	S	25
Riebesel	TR-10R	R or S	Low	≥5S or 20MS	196 +	R or S	17
Yt54^2-A/NIOBxKt54B/Ponche	R or S	R or S	Good	R or S	196 +	R or S	7
			Spring wheat				
Anza	R or S	Good	Low	S	176-190	R or S	9
Kal-Bb	≥5S or 20MS	R or S	Low	R or S	175	R or S	9
Sonora 64	R or S	R or S	Low	90-100S	176-190	S	15
Siete Cerros 66	S	S	Low	90-100S	176-190	S	27
Cno "S"-Pj	≥5S or 20MS	Good	H or L	R or S	176-190	R or S	8
7C-Cno x Cal	R or S	R or S	H or L	S	176-190	5S or 20MS	13

accrue, too. Additionally, a wide array of varieties with different maturity periods probably can be selected to fit differing regimes of cropping practice. In wheats of southern Europe, a considerable reservoir of genes for resistance to septoria and other foliage diseases has been built up. Thus greater resistance to the causal organisms of these diseases should be possible.

Based on the crosses entering the spring wheat program from Dr. Rupert's crosses and the few crosses earlier made at CIMMYT, several advantages can be expected. Current advanced lines which show increased head length, better tillering, and good yield performance while maintaining maturity and height comparable to the present spring varieties, include:

Heines Kolben - 38MA x Rfn^2 - 908/Fn) Yr 70
CM 2097-31M-1Y-2M-1Y-0M
D6301-Nai 60 x Weique-Red Mace/Cno^2-Chris
CM 11683-A-1Y-1M-2Y-0M
Maris Ploughman x Cno "S" -7C/CC
CM11693-F-1Y-1M-1M-0M
TL 365A/34-Sx x CC
CM 11699-K-1Y-4M-1Y-0M
Weibull's Ring - We x Ron
CM8218-K-3M-1Y-1M-7Y-0M

In 1973, more than 200 F_2 populations of spring x winter varieties were supplied to over 40 cooperators throughout the world. This will provide cooperating national programs with early generation material for selection and increase world-wide activity in exploiting such crosses. Meanwhile CIMMYT will intensify its activity in this field.

Emphasis in both winter and spring wheat improvement is being placed on earliness, cold and drought tolerance, and diseases associated with rainfed agriculture. New winter wheat germ plasm is being supplied by national programs of the cooperating countries. In return Oregon State distributed F_3 and F_4 lines and F_2 segregating populations to a large number of selected countries. CIMMYT distributed F_2 populations of winter x spring crosses to another group of countries where spring wheats are grown to provide materials for selection in those national programs.

Preliminary observations suggest that the new variability being supplied from winter x spring wheat crosses, will provide national breeders with germ plasm which will greatly improve agronomic characteristics of both spring and winter cultivars.

DURUM WHEAT

CIMMYT's program in durum wheat aims at rapidly providing improved varieties for regions in which durum is an important food: North and East Africa —Morocco, Algeria, Tunisia, and Ethiopia; the Middle East —Turkey, Syria, Jordan, Afghanistan, Iran, Iraq, and India; and Argentina. At one time durums were an important source of foreign exchange for these countries, and for Argentina, it still is. But population increases in the last two decades coupled with continuing low yields have changed most of these countries from large exporters to large importers.

Most varieties presently grown are either land races or selections made from land races. These varieties have adaptation to rainfed agriculture and resistance or partial resistance to insects and occasionally to certain of the stable diseases such as *Septoria tritici.* They lack yield potential, broad adaptation, and satisfactory resistance to such diseases as the rusts. They generally do not respond to fertilizer in areas of higher rainfall.

Breeding. Since the CIMMYT durum program was expanded in 1967/68, there has been a realization of the need for adequate resistance to such major diseases as stem and stripe rust, septoria, fusarium, mildew, and scab, and to insect pests, if the potentially high yielding semi-dwarf germ plasm was to be exploited. These precepts are as valid today as they were then.

At the end of 1973, CIMMYT sowed its 13th cycle of durum. The advances made during this period:

1. High yielding, widely adapted durum germ plasm has been developed. Most of this germ plasm, when introduced in durum areas of Africa, the Middle East, and South America, shows good promise. Information from the International nurseries which CIMMYT grows in collaboration with national programs shows that the improved germ

plasm is widely adpated and outyields the indigenous varieties by a wide margin where diseases are not a problem. Table 3 shows the average yields of the varieties in the Third International Durum Yield Nursery (IDYN). Cocorit 71 gave average yields equal to the bread wheat check, Cajeme 71, and these two were closely followed by several CIMMYT-derived semi-dwarf lines. Table 4 shows the 14 best yielding lines from yield tests grown at Cd. Obregon during 1972/73. Several yielded from 0.5 to 1.5 t/ha more than the Cocorit check. These lines will be used in further crossing and also tested for suitability for release.

2. Sources of disease resistance were identified for such widespread pathogens as stem, leaf, and stripe rust; septoria; fusarium; mildew; and scab. Similarly, sources of resistance to sawfly and Hessian fly were located. Breeding work to combine desirable sources of resistance with the high yield potential and adaptation of many CIMMYT lines has continued through segregating populations which are screened for resistance in the countries in which these diseases and insects are important. This selection *in situ* is a basic part of the CIMMYT philosophy.

Several of the varieties and lines in the Third IDYN had reasonable levels of resistance to the rusts and a few showed moderate tolerance to *Septoria tritici.*

The CIMMYT summer nursery at Toluca is an excellent disease garden for such diseases as stripe rust, fusarium, septoria, and scab. The high level of moisture and cool conditions favor the development of these diseases. No variety can be considered as an escape to these diseases under the kind of epidemic that can be created.

Fusarium and stripe rust were particularly severe in 1973 at Toluca. Fusarium destroyed most of the durum nursery. This disease pressure, however, allowed sources of resistance to this disease to be identified, although, by the end of

Table 3. **Mean yield, agronomic, and disease data for the Third International Durum Yield Nursery (40 locations)**

Variety or cross	Origin	Yield t/ha	Test wt kg/hl	Days to flowering	Days to maturity	Height cm	1000-grain wt, g	Powdery mildew	*Septoria tritici*	*Septoria nodorum*	*Septoria* spp.	Stripe rust	Leaf rust	Stem rust
Cocorit 71	Mexico	4.3	76.2	97	139	82	45	53	66	20	38	19	21	15
Cajeme 71	Mexico	4.3	74.4	101	136	71	45	41	80	10	65	8	5	28
Crane S (B)	Mexico	4.2	71.1	98	139	75	43	65	61	10	52	24	28	26
Cocorit S	Mexico	4.2	77.9	108	147	94	51	44	75	10	46	17	30	22
Brant S	Mexico	4.1	73.1	98	139	73	45	50	75	10	53	35	25	40
Crane S (A)	Mexico	4.0	74.3	95	138	75	42	43	67	30	44	25	30	41
Jori S x Crane S	Mexico	3.9	71.8	101	142	75	48	60	76	10	55	27	28	24
Anhinga S	Mexico	3.9	78.3	97	140	97	46	53	73	10	49	18	25	26
Quilafen	Chile	3.9	74.7	104	148	80	43	72	41	20	44	22	27	31
T. Dic. Var. Vernum	Mexico	3.8	69.2	98	141	79	37	44	77	10	43	13	30	36
Jori C-69	Mexico	3.8	75.9	99	140	77	51	73	88	10	48	40	27	30
Local check		3.8	70.0	97	143	95	45	42	53	10	63	11	24	29
Parana 66/270	Argentina	3.7	75.8	108	148	79	50	64	51	20	23	16	3	16
Ganso S	Mexico	3.7	67.0	100	145	82	58	73	60	10	33	28	20	30
Capeiti	Italy	3.6	77.3	100	142	101	44	67	52	30	39	25	36	25
D 6647	USA	3.5	74.5	104	147	81	39	38	56	10	42	26	31	12
Gerardo 574	Italy	3.5	64.9	105	145	75	41	71	64	10	41	14	21	37
BD 58-25A	Tunisia	3.5	74.9	105	144	103	46	28	39	20	38	17	15	23
61-130 x Leed S	USA	3.4	74.0	104	148	78	39	47	39	10	32	30	30	20
Gab-125	Italy	3.4	71.0	105	145	102	48	65	50	10	49	27	26	35
Gerardo 565	Italy	3.3	66.7	106	149	88	48	39	57	10	44	20	25	35
Hercules	Canada	3.1	71.4	99	144	118	43	17	52	10	47	30	39	14
Leeds	USA	3.0	69.1	106	148	117	36	40	42	10	41	26	28	19
Harkovskaia	USSR	2.4	60.4	105	147	128	34	44	67	20	31	36	30	46
Hilba	Lebanon	2.0	58.3	103	144	107	41	73	15	30	62	63	31	62
Mean		3.6	71.1	102	144	89	44	52	59	14	45	25	26	29

the season, it was difficult to select for other characters. Since one of the principal *Fusaria* involved, *F. nivale,* is relatively unimportant outside the temperate zone, the level of infection was deleterious. Steps are being taken to reduce the level of this organism in the nursery for 1974 to permit selection between resistant and susceptible lines without losing the material of the nursery as a whole.

Table 3 lists some of the durum varieties that provide the basic germ plasm for septoria resistance. The list is not complete, but it includes varieties on which some detailed information has been collected.

3. In 1973, CIMMYT had, for the first time, the laboratory equipment necessary for durum quality determinations. All parental materials were assessed for their pasta-making quality. In addition, early generation material is analyzed for carotene pigment. CIMMYT's breeders now expect to improve quality rapidly.

Maturity. To meet the varying conditions in the durum-growing countries, a wide array of maturity classes are required. Currently, CIMMYT's germ plasm includes lines and varieties covering the needed range. Environmental conditions and cropping systems within individual countries or regions determine the maturity class required. In North Africa and other Mediterranean-type climates, for example, varieties should possess a relatively prolonged vegetative period with a short period from flowering to maturity to escape hot winds and drought at the late grain-filling stage. India requires early maturing varieties. In the high plateaus of Algeria, Turkey, Iran, Afghanistan, and similar areas, varieties need some degree of winter-hardiness for adequate stands. These are some of the factors which determine the breeding inputs. Segregating populations, in which the parentage possesses these characteristics, must be then subjected to selection in these areas on a regular basis. This is accomplished through the collaborative efforts of national programs and CIMMYT.

New procedures. In previous years, three heads of each cross were pollinated in Mexico and the entire F_1 seed was grown in the CIMMYT nurseries. In 1973, however, four heads of each cross were pollinated, and the F_1 progeny from two heads were grown in Mexico while the crossed seed of the remaining two heads was divided among the Algeria, Tunisian, Turkish, and Indian programs. The change was made in consultation with breeders of these four countries who indicated that, with CIMMYT's ability to produce crossed seed, they would appreciate this service to provide a wider genetic base for use both in crossing and selection in their programs.

This change should not materially affect the number of crosses (currently more than 4000) made in Mexico and it will provide the collaborating programs with material for screening from the F_1 generation forward. It also provides genetically diverse F_1 materials which can be used in making top crosses and double crosses with F_1 plants and varieties in their breeding programs. It was further agreed that where outstanding F_1 lines were noted in each

Table 4. **Yield of superior durum wheat lines in a yield test at Cd. Obregon, Mexico, 1972/73.**

Genotype & Pedigree	Yield t/ha	Avg. test wt. kg/hl
Jo "S"-Cr "S"xGs "S"-AA"S"		
CM-9902-5M-0Y	8.59	83.0
[AA"S" ($CP_E{}^3$-Gz x Tc^3/$By_E{}^2$-Tc)] 31810		
CM-10172-44M-0Y	7.64	83.3
Stork "S"		
CM-470-1M-4Y-0M	7.58	82.0
Crane "S"		
D-23055-56M-5Y-1M-0Y-43Y	7.55	81.5
Gerardo Vz469 x Garza "S"		
CM-362-21M-2Y-7M-0Y	7.42	83.0
$By_E{}^2$-Tac_E-Anhinga "S"		
D-27625-5M-2Y-2M	7.40	83.5
Stork "S"		
CM-470-1M-3Y-0M	7.23	82.5
D. Dwarf S15 x Crane "S"		
D-33312-7Y-2M-1Y-0M	7.23	82.0
Jo"S"/GII"S" x 61-130-Leeds		
D-32864-7Y-2M-2Y-4M-0Y	7.20	83.0
Crane "S"-Ganso "S"x Parana 66/270		
CM-13053-6Y-0M	7.15	82.0
Crane "S" x Ganso "S"		
CM-224-1M-1Y-2M-0Y	7.15	81.0
Stork "S"		
CM-470-1M-2Y-0M	7.04	83.5
Gerardo Vz-469 x Anhinga "S"		
CM-363-5M-4Y-3M-0Y	7.00	84.0
21563 x Anhinga "S"		
D-27625-5M-2Y-2M-2Y-0M	6.83	82.5
Cocorit 71 (Check)	7.05	81.0

program, harvested F_2 seed would be sent to the other collaborators to facilitate the rapid spread of improved germ plasm to other countries. The information generated in this program will provide CIMMYT with a firmer idea of which materials are giving the best results so that the breeders will be able to better program top crosses and double crosses using reserve F_1 seed retained in Mexico. This new approach should speed the development of improved germ plasm.

Multilines. CIMMYT breeders are considering the multiline approach in durums using the same methods employed in bread wheat. This will not incur extra costs. Efforts are being made to identify and classify diverse sources of resistance for stripe and stem rust and septoria. Thus far, Cocorit 71 has demonstrated the widest adaptation, and it has been chosen as the first recipient parent. Crosses are being made as new resistance sources are identified. This requires some time and quick results are not anticipated, but multiline production will carry with it the stability of yield, which is essential.

Distribution of improved germ plasm. The spread of germ plasm to all collaborating national programs and research institutions is one of CIMMYT's primary roles. This is accomplished by distributing international nurseries. In 1973, CIMMYT sent 66 nurseries to countries of Africa, 21 to Asia, 45 to Europe, 41 to North America, and 44 to South America. Some of these nurseries provide advanced line materials which are potential varieties. All high yielding experimental lines are used as basic germ plasm in CIMMYT's crossing program.

TRITICALE

Triticale research at CIMMYT is conducted as a joint program with the University of Manitoba. The program is financed by the International Development Research Centre and the Canadian International Development Agency.

During 1973 a research bulletin, *Triticale Breeding and Research at CIMMYT,* was published and an International Triticale Symposium was held at CIMMYT in October under the joint sponsorship of CIMMYT and the University of Manitoba. Triticale research was reviewed by scientists from most of those countries where research is being conducted.

Breeding research. Triticale yields have continued to improve. Field tests conducted in Cd. Obregon suggest that triticale may become competitive with wheat in the northwestern coastal plain of Mexico. In the higher valleys of the states of Mexico and Tlaxcala, where field-size triticale multiplications were made in the past 2 years under somewhat dry conditions and under very wet conditions, triticale has equalled or outyielded commercial wheat varieties. Where rainfall was high, diseases were also high, and triticale in general showed better resistance to stripe rust, leaf rust, septoria, and fusarium than wheat. Yield results of different triticale lines grown in Mexico are compared with a number of standard wheat varieties in Table 5. Much of the continuing advance in yield has been derived from the greater lodging resistance of the newer materials, which resulted from the incorporation of dwarfing genes from wheat and rye.

Efforts have been made to create greater variability. Improved methods of embryo culture have permitted many new amphiploids from wheat x rye crosses to be obtained during each crossing cycle. The technique for doubling chromosome numbers of the polyhaploids has also been improved. As a result the number of primary triticales available for widening the genetic variation has greatly increased without an appreciable increase in the time spent on crossing and embryo culture. During 1973, more than 125 new primary triticales were produced. This is the largest number ever produced anywhere in a year.

Another source of genetic diversity is the crossing of spring x winter triticales. Formerly, because of the difficulties encountered in vernalizing large numbers of winter varieties so that flowering would coincide with flowering in the spring types, little was done in this field at CIMMYT. During the winter of 1972-73, however, a nursery was

Table 5. **Yield and test weight of triticale strains grown at four locations in Mexico during 1972-73**

Identity	Cd. Obregon 1972/73 Yield t/ha	Cd. Obregon 1972/73 Test wt kg/hl	Toluca 1973 Yield t/ha	Toluca 1973 Test wt kg/hl	El Batan 1973 Yield t/ha	El Batan 1973 Test wt kg/hl	Huamantla 1973 Yield t/ha	Huamantla 1973 Test wt kg/hl
M-A"S"X2832-24N-7M-2N-0M	7.1	70.0	5.0	56.0	3.9	56.2	5.0	62.0
I-A"S"X1648-2N-0M-0Y	8.0	69.5	3.3	56.5	2.9	51.1	5.4	62.6
M-A"S"X2802-38N-1M-2M-0M	7.0	70.3	3.4	55.2	2.9	50.8	5.2	61.5
M-A"S"X2802-1N-2M-3N-5M-0Y	7.2	67.6	4.2	60.5	4.0	50.3	5.5	59.1
M-A"S"X2802-38N-3M-6N-4M-0Y	7.4	71.6	4.2	59.7	4.1	60.3	5.5	68.3
M-A"S"X2802-38N-3M-6N-5M-0Y	8.2	71.8	4.0	59.4	3.5	59.0	6.0	63.9
M-A"S"X2802-38N-3M-6N-6M-0Y	8.0	72.4	4.1	59.7	3.7	56.2	5.6	66.7
M-A"S"X2802-38N-3M-6N-7M-0Y	7.5	71.0	4.0	57.3	3.7	54.7	4.8	65.7
M-A"S"X2802-38N-3M-6N-8M-0Y	7.3	71.1	3.9	58.6	4.0	59.6	5.2	67.4
M-A"S"X2802-38N-3M-7N-5M-0Y	8.4	72.0	3.7	54.6	3.8	53.6	5.3	64.9
M-A"S"X2802-38N-5M-5N-3M-0Y	7.0	71.7	4.0	52.4	4.2	61.5	4.6	63.3
M-A"S"X2802-38N-5M-6N-5M-0Y	7.8	70.9	3.6	51.7	3.6	57.2	6.3	62.4
M-A"S"X2802-38N-5M-6N-6M-0Y	7.8	70.4	3.3	52.6	3.1	53.6	5.1	61.8
M-A"S"X2802-38N-5M-8N-1M-0Y	7.6	70.9	3.6	54.5	2.0	50.1	5.5	61.8
M-A"S"X2802-38N-5M-8N-2M-0Y	7.4	70.5	3.6	53.8	3.3	57.5	4.2	60.0
M-A"S"X2802-38N-5M-8N-4M-0Y	7.8	70.9	4.3	55.5	2.2	52.4	4.9	61.2
M-A"S"X2802-41N-1M-5N-1M-0Y	7.2	68.2	–	–	4.6	55.5	6.4	59.6
M-A"S"X2802-41N-1M-6N-1M-0Y	7.2	64.5	–	–	3.5	50.0	4.8	54.1
M-A"S"X2802-64N-3M-1N-1M-0Y	7.2	70.9	4.6	56.1	2.5	52.0	4.5	62.7
M-A"S"X2802-70N-3M-1N-1M-0Y	7.2	68.7	4.5	57.7	1.9	49.5	5.0	60.4
M-A"S"X2802-70N-3M-1N-2M-0Y	7.6	71.6	5.0	58.1	3.5	54.8	5.8	63.0
M-A"S"X2802-75N-2M-7N-1M-0Y	7.6	67.5	4.3	55.5	3.7	53.8	5.9	59.4
(Inia-Rye)^{2}Arm"S" X2144-12N-4M-2N-1M-0Y	7.1	72.8	–	–	3.9	62.4	4.7	61.0
(Inia-Rye)^{2}Arm"S" X2146-7N-8M-3N-1M-0Y	7.2	71.3	5.2	54.4	3.2	56.0	4.0	59.7
M-A"S"X2832-24N-3M-7N-4M-0Y	7.3	70.8	3.8	56.2	4.7	59.1	7.1	62.4
M-A"S"X2832-29N-1M-3N-4M-0Y	7.0	67.5	–	–	3.0	54.9	5.3	57.3
Mayal-A"S"X2148-1N-1M-0Y	7.7	72.0	5.0	54.6	4.8	57.0	6.0	63.0
Mayal-A"S"X2148-1N-2M-0Y	7.8	70.4	4.8	55.5	4.5	55.6	5.4	62.2
M-A"S"X2802-38N-2M-1N-2M-0Y	7.4	70.3	4.1	56.0	1.8	49.5	5.4	62.6
M-A"S"X2802-41N-1M-1N-1M-0Y	7.1	67.5	–	–	4.6	57.1	5.0	61.1
(Inia-Rye)^{2}Arm"S" X2145-4N-1M-2N-1M-0Y	7.1	74.2	3.7	54.3	2.6	56.8	5.3	64.3
Koala"S" X2091-100Y-101B-2N-2M-0Y	7.1	68.6	3.3	54.7	1.7	50.2	5.2	57.1
I-A"S"X1648-2N-1M-0Y	7.9	71.1	3.6	57.0	2.6	51.3	5.9	62.6
I-A"S"X1648-3N-1M-0Y	7.2	72.7	3.6	55.1	2.3	52.3	4.8	62.0
M-A"S"X2802-75N-2M-7N-1M-0Y	7.2	70.0	3.7	53.3	4.0	52.7	5.4	59.6
M-A"S"X2802-38N-2M-6N-3M-0Y	8.0	70.5	3.0	57.2	2.4	54.4	4.8	59.7
Cajeme 71 (bread wheat check)	6.8	81.4	3.2	66.8	2.9	67.7	5.0	75.3
Siete Cerros 66 (bread wheat check)	6.6	81.4	0.7	52.0	3.1	64.8	6.0	74.5
Jori 69 (durum check)	4.7	81.2	0.7	59.3	1.9	62.1	2.7	70.1
Cocorit 71 (durum check)	6.4	80.5	1.7	57.6	4.0	68.5	3.8	71.8
Arm"S" (triticale check)	5.6	69.9	4.3	59.0	4.1	61.3	4.4	63.3
Cinnamon (triticale check)	–	–	4.3	58.1	4.4	61.7	4.6	63.2

established at Toluca. The high elevation of the Toluca nursery (2640 meters) provides a long cold period sufficient for vernalization. Winter triticales were sown in October while the spring-type triticales were sown in January. Both types flowered in May and June. Winter triticales could be of immediate use in parts of North Africa and the Middle East at high elevations. In addition, winter triticales can provide increased variation and such specific characters as resistance to preharvest germination and resistance to certain diseases in the improvement of spring varieties.

During 1972, an extensive collection of rye materials was made in Turkey where rye grows as a weed in the wheat crop. These materials represent a considerable range of type and growth habit. The collection was grown at Toluca in the winter of 1972-73 and the more promising types were used as the rye parent in new primary triticales.

In addition to these methods of introducing new variation in the triticale nursery, crosses are also made from triticales to wheat and to rye with backcrossing to triticale. This infusion of new genetic materials promises to provide triticales with a much broader base of adaptation to a variety of conditions.

Grain quality. Both grain plumpness and grain density are improving each year. In 1973 some materials were identified which were much superior to those previously available. Selections made from crosses between octoploid and hexaploid parents had plumper grain and test weights up to 75 kg/hl. The greatest improvement in grain quality was found in material that had been screened visually in early generations for fertility and grain development.

As the material has been selected for higher yield and better plumpness and density of grain, the protein percentage has fallen. This is not unexpected since the improved grain has better starch deposition. The earlier triticales had higher protein content largely because of poor starch formation and shriveled endosperm, so the outer layers, where protein is primarily located, made up a larger proportion of the grain than they do in a plump grain. While this might appear to be working at cross-purposes with improvement in quality, the balance of amino acids within the protein has greater significance for nutrition than does high protein *per se.*

Lysine is the most limiting of the essential amino acids in the cereals. Thus if the percentage of lysine in the protein is high, nutritional quality is likely to be high. A simple technique for testing for protein and lysine combined has been developed. Using a modified dye binding technique (DBC), Dr. Villegas is able to separate lines which have high protein or high lysine or both, from lines that have low levels of lysine or protein. Once lines with a high dye binding capacity have been established, protein level is then determined to determine which portion is due to high protein. DBC values are then corrected, and, for lines of this group that have high DBC values, an amino acid analysis for lysine is run to establish which have high lysine. In Table 6, among lines of similar protein percentages, a fairly close association exists between DBC and lysine content. This would not have necessarily been true had the protein levels covered a wider range.

Even here, however, the DBC values and lysine content of the protein vary somewhat since the highest DBC value has the lowest lysine content in the protein.

The lines with the high lysine percentages are nearly equal to high lysine maize lines but the protein content of the grains is considerably above that of maize.

Broadening adaptation. Results from international and national triticale trials have shown the broad adaptation of current triticale lines. In national trials in Ethiopia,

Table 6. **Protein and lysine values of triticale lines possessing high dye binding capacity values.**

Identity	DBC value	Lysine in sample, %	Protein in sample, %	Lysine in protein, %
70 HN 470	63	0.566	13.00	4.35
Badger "S"	62	.562	13.17	4.27
Koala "S"	64	.517	13.91	3.72
X 2802-41N-1M	61	.514	13.28	3.87
X 2802-19N-0M	58	.474	12.43	3.81
Maya II-Arm "S" (1)	55	.498	12.31	4.04
Maya II-Arm "S" (2)	53	.494	12.20	4.05

triticale strains significantly outyielded durum and bread wheat check varieties. This is in part because the triticales have greater resistance to septoria, a principal disease in that country, but there apparently is an additional advantage which is not clear. In Kenya, the triticales appear to have greater rust resistance, particularly to stem and stripe rust, and they appear promising there. Reports from Ludhiana, India, indicate superiority for triticales in the northern plains and, based on tests organized from Pantnagar, in the higher elevations of the Himalayas. These areas have somewhat lower temperatures than other parts in India. Although the triticales' greater resistance to rusts may account for a part of their superiority in the Himalayan tests, the triticales may have been more tolerant of low pH soils. Several developing countries are greatly interested in triticales. As the genetic base is broadened it can be expected that adaptation to most conditions of growth will be realized.

Cytology. Since the beginning of triticale improvement at CIMMYT, the program has suffered somewhat from a lack of cytological assistance. Although breeding has progressed consistently, the status of chromosome numbers

Dr. Matthew McMahon, post-doctoral fellow in agronomy of triticales discusses a row-spacing experiment with staff members in Mexico.

and types and frequency of chromosomal abnormalities were not known for the lines being used as parents in the crossing program. During the past 18 months, CIMMYT has acquired two competent research personnel in this field, Dr. Arnulf Merker and Mrs. Margarita Sosa. Both received cytological training at the University of Lund under Dr. Arne Muntzing. Dr. Merker is developing techniques aimed at identifying chromosome substitutions of the R genome of rye with D genome chromosomes from bread wheat.

Until recently, triticales were regarded as pure amphiploids in which, for the hexaploids, the chromosome number was 42. The question of substitution of chromosomes was raised with the development of the Armadillo lines. Zillinsky and Borlaug in 1971 concluded that bread wheat was involved since certain *T. aestivum* characteristics were evident. Gustafson and Zillinsky in 1973 were able to show that chromosome 2D of bread wheat was present in Armadillo and that this is a substitution for 2R. Thus one homeologue of the R genome has been replaced by its homeologue from the D genome.

How does this occur? When triticale is crossed to bread wheat the F_1 plant has the constitution AABBRD. Plants of succeeding generations will all have A and B, but they

Dr. N.S. Sisodia, right, and his colleagues with Dr. Frank Zillinsky, CIMMYT triticale breeder, in the triticale plots at Indore, India.

may have various combinations of the R and D chromosomes. Theoretically all the D chromosomes could be present, or all the R chromosomes, or any variation of euploid or aneuploid plants lying between. Similarly, chromosome substitutions could occur in crosses of octoploid and hexaploid triticales.

The new Giemsa staining technique for chromosomal heterochromatin permits the rye chromosomes present to be identified since these chromosomes have a block of heterochromatin at the ends. Wheat chromosomes do not. With this technique, breeding lines are being investigated. The Armadillo substitution has been confirmed. In Cinnamon and Camel, there is a further substitution. In these lines only five pairs of rye chromosomes are present with two pairs from the D genome of common wheat. One of the latter is likely to be 2D, the other is unknown as yet, but the missing rye chromosome is one in which the heterochromatin is located in the short arm. In F_4 material from a cross between Camel and Pato, a bread wheat, two other substitutions have been noted. In one line, in addition to the two chromosomes substituted in Camel, a third rye chromosome with a median centromere is missing, and in several lines rye chromosome 5R, on which the hairy neck character is located, is also missing. In these lines only four pairs of rye chromosomes are present.

There is a slight possibility that D' genome chromosomes could substitute for those from A or B.

It seems evident that substitution of chromosomes explains the empirical observation that crossing with the bread wheats is important in improving triticales. In both crosses of triticale x bread wheat and hexaploid triticale x octoploid triticale, better segregates are obtained. In breeding, therefore, it should be possible to not only form favorable gene combinations, but also the most favorable chromosomal admixture of the R and D genomes. The best combinations are yet to be determined.

The substitutions of chromosomes have significance in the breeding approach. F_1 plants of these types of crosses have an imbalance in chromosome complement and are usually inferior in fertility and viability. In later generations with reassortment and selection this imbalance is corrected and balanced genotypes result. Thus, severe selection in the F_1 generation should be avoided. Moderately large F_2 populations should be grown to ensure the possibility of selecting balanced genotypes. Similarly, seed produced on F_2 plants should be grown in bulk to allow recombinants of superior type to develop in the succeeding generation.

BARLEY

Since 1972 the wheat section of CIMMYT has been operating a barley improvement program as a parallel program with bread wheat, durum wheat, and triticale. The barley program uses the same laboratory facilities and has the advantage of having a ready-made delivery system for its outreach which has already been developed for other crops.

The program has as its first objective the breeding of varieties with high nutritional value to be used in those countries where barley is a staple human food; second, the breeding of varieties for use as animal feeds, with emphasis on high nutritional value for monogastric animals.

Such varieties need wide adaptation and stiff straw, short stature, and well-developed root systems which will provide the plant with lodging resistance. Resistance to drought is also important. The varieties should have high nutritional value (high protein with a well-balanced lysine level). Medium to early maturity is needed. Finally, free-threshing hull-less varieties offer advantages where the grain is to be used as food since pearling problems are avoided.

Since the program began, more then 5000 lines have been collected and screened for observable differences in major characteristics. From these lines many progenitors were selected and incorporated in the breeding program. In 1972, 148 lines were included in the crossing block; in 1972/73, 296 were included. Varieties have been arranged within the crossing block according to their value for specific characteristics. For example, the crossing block is divided into six-row and two-row types. There are then subdivided in groups for characteristics such as resistance to specific diseases, straw-stiffness, height class, earliness, and high protein.

In 1972, 196 single, three-way, and double crosses were made. A total of 296 F_2 single-cross bulks are being grown in 1973/74, as well as 425 individual plant selections derived from three-way and double crosses. In addition, 636 F_4 selections and more than 2000 F_3 lines are being grown. The distribution of the first set of advanced lines will be made in 1974.

Outstanding agronomic superiority has been found in crosses involving Godiva, a large-seeded, naked-grained variety. Other good combiners include California Mariout, Blanco Mariout, and CM 67. These varieties have high yield potential and high test weight.

Adaptation. As with wheat, the barley breeding material is moved in alternate seasons from near sea level in northern Mexico to over 2300 m. above sea level near Mexico City. Climatic conditions are dissimilar. In the former location the barley materials are grown in a near-desert climate with irrigation and in the latter they are grown under somewhat temperate conditions with little irrigation. Since only selections that perform well in both climates are advanced, materials derived in this way have considerable built-in adaptation to many locations.

The summer nursery at El Batan provides good conditions for screening against such diseases as powdery mildew, scald, spot blotch, net blotch, bacterial blight, loose smut, stem rust, leaf rust, stripe rust, and the barley yellow dwarf virus. The winter nursery at Ciudad Obregon in northwest Mexico provides ideal conditions for selecting for good agronomic types and yield potential. The development of varieties in the short-day regimes at the two Mexican locations will ensure that they are daylength insensitive and have resistance to a majority of the diseases. As the program develops, an increasing amount of material will be moved to cooperating national programs to enlarge the range of conditions under which they are selected.

Disease resistance. Barley is attacked by a host of diseases. For this reason the breeding of disease-resistant strains is a primary concern. In spite of its general susceptibility as a crop, it is quite possible to identify resistant germ plasm which can be incorporated into the desired agronomic type. The problem is not so much incorporation of resistance but identification of sources. Under a heavy epidemic of one disease, particularly among the leaf disease group, it is difficult to determine resistance to other diseases because of the masking effect of the first. To overcome this, 350 entries have been selected and distributed to 20 locations throughout the world where one or more diseases is known to exist in epidemic form. Cooperators have been asked to report the occurrence of specific diseases in these nurseries so that resistance genes are identified.

In the meantime, considerable information has been amassed from nursery observations in Mexico, from observations made in other countries, and from findings of scientists in other institutions. This information is being used as a basis for incorporation of resistance into the breeding germ plasm. As an example, such varieties as Emir, Chile Common, and Benton have shown a high degree of resistance to net blotch, spot blotch, scald, and powdery mildew in the local nurseries. Some of the Japanese varieties appear to be resistant to powdery mildew, and selections from California material are highly resistant to leaf rusts races present in Mexico.

Lodging. Lodging in barley may be the main barrier to higher yields. Lodging results from weak straw which is sometimes caused by high fertilizer dosage, from genetically weak straw, or from a weakly anchored crown which causes the plant to lodge from the base. It is important to know which type of lodging is involved so that corrective crosses can be made. Simply shortening the straw, or improving straw strength, will not necessarily reduce lodging.

Within the barley collection, sources of resistance genes for both types of lodging have been identified. The Japanese varieties, for example, have excellent straw strength but weak crown development. Some Mexican varieties have strongly develpped crown and moderately good straw strength. A combination of good straw and strong crown is characteristic of Minnesota lines and semi-winter types from Indiana. All of these have been used in crosses.

Nutritional value. The hiproly lines discovered by Swedish workers made possible the improvement of the protein and lysine content of barley. But this line has many defects, so few segregates with good agronomic type can be obtained from single crosses with it. Thus, we have made three-way and double crosses. In 1973, F_2 and F_3 populations were grown involving the hiproly parent. Several show marked superiority to the original line. Recently, seeds of a new set of mutants developed in Denmark have been received. These are high lysine mutants from the variety Bomi. The best of these is reported to have 45 percent more lysine than normal (hiproly has only 30 percent more than normal) and is much more agronomically acceptable than hiproly. It should give superior segregates.

Protein evaluation is made on seed samples immediately after harvest by measuring dye binding capacity (DBC). This method provides a preliminary evaluation of individually selected plants. It is a simple test, easily applied. Samples with a high DBC value are then analyzed for protein using the Kjeldahl method. After correcting for protein level, i.e. bringing the values to a common protein percentage, DBC values are again determined and those which still show a high DBC value in this new assessment are evaluated for lysine.

Generally samples that have low protein and low lysine values are discarded unless the line has superior yield or an agronomic type which may make it suitable for use as a forage crop or for use as a progenitor.

Earliness. In many areas served by the CIMMYT barley program, the growing season is restricted by low rainfall, in the approaches to deserts, or by a short frost-free period at high altitudes. Such areas need varieties that can give good yields in a short period. Genes for earliness are present in such varieties as Early Russian, Svalof Mari, and Svalof Mona. These varieties flower within 40 days and mature 65 to 70 days after sowing. In addition to other defects, their yield potential is relatively low, but it appears possible to correct these deficiencies. Many crosses have been made and among the segregates are ones which appear to be considerably superior to the varieties used as donors for earliness.

Naked types. Naked or hull-less types of barley would have advantages for use in direct human consumption. The character is simply inherited and there appears to be little problem in working with it. The gene for nakedness is present in many varieties particularly land races. Some of the Danish hull-less lines being used have the further advantage of a large plump kernel.

Nursery testing. Close cooperation is maintained between the Mexican national barley breeding program of the Instituto Nacional de Investigaciones Agricolas and that of CIMMYT. Nurseries are being evaluated in areas of Mexico where barley is a commercial crop. Four locations are being used for testing CIMMYT materials. Because of the variations in rainfall and diseases at these locations, the centers are useful as selection sites for developing germ plasm for the various barley-growing regions of the world.

This is a relatively new program in its present form, full-scale distribution of material will begin in 1974. In 1973, 39 nurseries consisting of F_2 barley material, an International Barley Observation Nursery, and the barley crossing block were distributed to 19 countries. Nine of the nurseries were in Africa, 23 were in Asia, 2 were in Europe, 3 were in North America, and 1 was in South America.

GERM PLASM DEVELOPMENT

CIMMYT's germ plasm development section is concerned with transferring useful genetic factors from poorly adapted, tall, native land races to well-adapted, suitable agronomic plant types as, for example, high lysine or high protein from Nap Hal (the best quality variety identified by the Nebraska screening program) to a semi-dwarf, daylength-insensitive, spring-type background. The program also in-

Table 7. **Yields of ramified wheats at three levels of nitrogen. Cd. Obregon, Mexico, 1972/73.**

Variety or cross	Yield, t/ha 150 kg/ha N	175 kg/ha N	200 kg/ha N	Avg
Cocorit 71 (check)	6.2	6.3	6.3	6.3
Cajeme 71 (check)	5.7	5.8	5.6	5.7
Siete Cerros 66 (check)	5.8	5.7	5.6	5.7
INIA 66 (check)	5.1	5.6	5.2	5.3
Rad#3"S"(Rad#2"S"/Nach-Tc60xNach) a/ H193-70-5Y-4V1Y-0B	4.8	5.3	5.7	5.3
Rad#3"S"(Rad#2"S"/Nach-Tc60xNach) a/ H193-70-4Y-2B-1Y-0B	5.1	4.2	6.2	5.2
M. Reo-No.66[2] H155-70-2Y-5B-4Y-0B	4.4	5.6	5.4	5.1
Noroeste 66 (check)	5.2	5.0	5.0	5.1
Jori 69 (check)	4.7	5.1	5.4	5.1
M. Reo-No66[2] H155-70-2Y-5B-7Y-0B	4.4	4.8	5.4	4.8
M. Reo-No66[2] H155-70-2Y-7B-2Y-0B	4.7	4.6	5.0	4.8
H844-66-M. ReoxCno[2]-Chr H135-70-12Y-103B-1Y-0B	4.1	4.1	4.8	4.3
(H844-66-M. Reo) (Cno[2]-Chr)[2] H378-71-2Y-0B	4.1	3.8	4.4	4.1
H844-66-M. ReoxCno[2]-Chr H135-70-12Y-103B-2Y-0B	4.1	3.7	4.3	4.0
H844-66-M. ReoxCno[2]-Chr H135-70-6Y-1B-1Y-0B	3.4	3.1	3.6	3.4
Avg.	4.8	4.8	5.2	4.9

a/ Durum varieties

Fig. 1. Spike of triticale with nonstable ramification.

cludes the identification and assembling of yield enhancing characteristics in the various crops. Work is being conducted on all four crops to prepare materials that can be directly exploited in the main breeding programs. This section also deals with the program of interspecific and intergeneric crosses jointly conducted by Kansas State University and CIMMYT.

Branched-headed wheats. The branched-headed (ramified) character has been transferred from *T. turgidum* sources into bread wheats that have good agronomic type, and derived lines are being tested for yield potential. During the 1972/73 season a yield test was grown comprising ramified bread wheats, ramified durums, and corresponding checks at three levels of fertility (Table 7). No differences were observed from different nitrogen applications although differences between varieties and the variety x nitrogen interaction were significant. The two durum varieties were lower in yield than Cocorit 71 but somewhat superior to Jori 69. Among the bread wheats, H155-70-2Y-5B-4Y-0B, from the cross M. ReoxNoroeste 66[2] was equal to INIA 66 and Noroeste 66.

As previously observed, the ramification in durum was highly developed, whereas it was relatively poorly developed in the bread wheats. Under competition, as opposed to spaced plantings, ramification is reduced but does not totally disappear.

These deficiencies of the ramified wheats, poor-agronomic type, fertility, and grain development greatly influence their grain production. The true yield level cannot be defined until these deficiencies have been eliminated. Consequently, further studies must be made on the better lines that are obtained with improvement in each of these characters. With the experience gained, it should be possible to obtain ramified wheats with as good agronomic characters and efficiency as is present in the conventional varieties. With this in mind, the ramified wheats have been crossed with the best varieties of durum and bread wheats coming from the conventional programs. From the segregating populations derived from these crosses, it is hoped that selections combining the good agronomic type and efficiency of the normal varieties can be developed with ramified spikes.

Once this is done and the basic potential for production has been bred into them, the ramified varieties have the capacity of producing more grains. That should increase yield levels since under good conditions there are more spikelets and florets in which to produce grain.

New dwarf improvements. A yield test was sown for the first time which included a group of dwarf lines (50 to 80 cm tall) derived from Tom Thumb and S948-A1. This group consists of wheats 50 to 80 cm tall:

	Height cm	Origin El Batan
Topo "S"-Nar 59 H485-71-4Y-2B-0Y	50	E4849
TacT. Th-Son64/S. Pre^5 H550-71-14Y-6B-0Y	80	E4857
TaxcT. Th-Son64/S. Pre^5 H550-71-14Y-7B-0Y	80	CB247
S948-A1xSta. Elene^5 H567-71-6Y-1B-0Y	70	E4863
S948 A1xSta. Elene^5 H567-71-8Y-3B-0Y	55	CB248
S948 A1-Cno "S" xCno 67^3 H569-71-1Y-10B-0Y	55	E4865
S948 A1-Cno "S"^{2}xCno 67^3 H569-71-3Y-4B-0Y	60	E4866
S948 A1-Cno "S"^{2}xCno 67^3 H570-71-4Y-1B-0Y	55	E4867
S948 A1-Cno "S"^{2}xCno 67^4 H499-71A-1B-0Y	55	CB243
S948 A1-Cno "S"^{2}xCno 67^4 H499-71A-3B-0Y	60	CB244
Nad63xT. Th-Son65/Nad 63^3 H270-70A-3B-1Y-2B-0Y	65	CB254

All the lines were superior to Tordo in grain development and some of them have been moved to the conventional wheat program.

The short-straw character of Tom Thumb and S948-A1 have been transferred into superior agronomic background, and as a consequence these two new types of dwarf habit can be more easily handled in the conventional bread wheat program. The character has been transferred to several tall varieties that have desirable characters, but which, because of their height, could not be readily used with good results.

New triticale germ plasm. The long straw of triticale has been a major restraint to triticale improvement. From a commercial viewpoint, the straw had to be shortened if the crop was to be competitive.

Some triple-dwarf triticale plants of unknown origin were selected and crossed primarily with Armadillo types. Homozygous lines were obtained with heights of E_2 and E_2–. All E_3 plants selected were unstable and continued to segregate into E_2 and E_3 plants. Some of the lines homozygous for E_2 and E_2– heights were turned over to the conventional triticale program in 1973. Other crosses have been made between triticale and wheat to transfer dwarfness from wheat to triticale and in this way provide maximum protection against lodging. These crosses have produced stable E_3 plants.

A degree of ramification (Fig. 1) has been found in triticales that are unstable, very sterile, tall, and late. We hope to stabilize the ramification by crossing them with the best triticales and at the same time correct the other deficiencies so they can be used in the conventional program.

From a cross of UMX-2 from the University of Manitoba, lines have been selected with 45 spikelets per spike and other selections with 8 to 10 florets per spikelet (Fig. 2). These were produced on late, tall plants. In this material, in general, the larger number of florets per spikelet is associated with a high degree of sterility. During 1973 some early maturing selections were made with shorter straw and better fertility, derived from the cross CMH 72A-579, involving TCL (E_3)-Arm "S" x UMX-2^2.

Finally a small-scale effort is being made in wheat x triticale crosses, to interchange germ plasm between the two cereals.

Improvement of basic materials. Certain important characteristics for improvement, such as content and quality of protein, resistance to diseases, resistance to lodging, and branching of the head, are generally found in varieties or species which otherwise are undesirable for most other characters. It is difficult therefore to use these varieties directly in the conventional breeding program since the

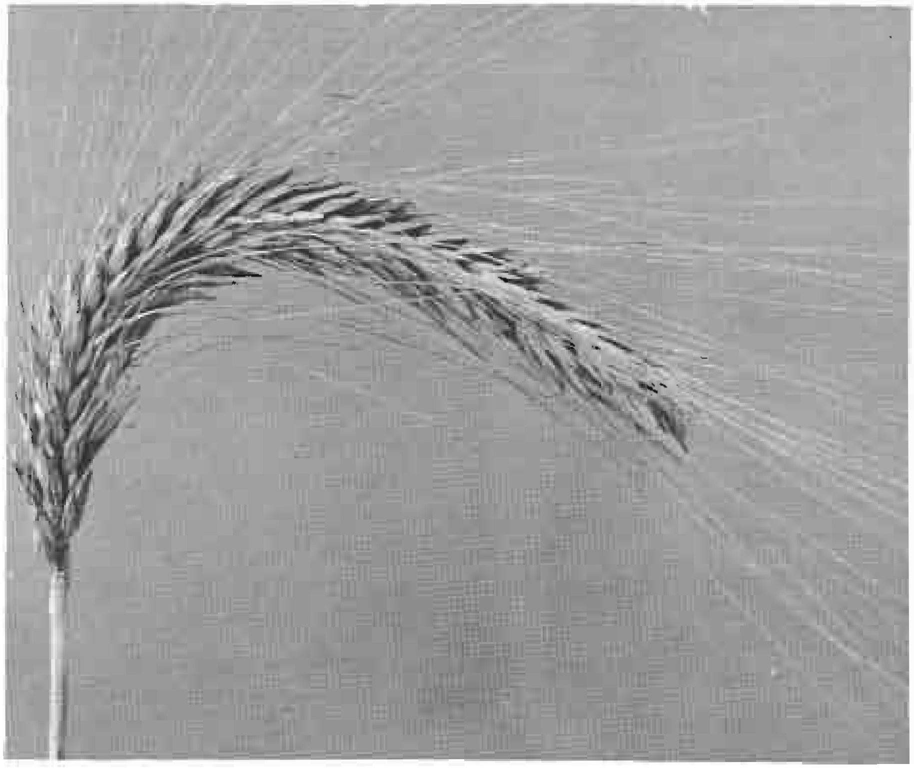


Fig. 2. Spike of triticale with 47 spikelets, left. Spikelets of triticale with 10 florets potentially capable of producing grain, right.

segregates from crosses would normally be discarded because of factors other than the one of particular interest. Thus they are treated individually and the useful character is moved into a good agronomic background so that the derived line can be used directly in crosses. In this way, several characters are being transferred, including dwarf habit from Tom Thumb and S948-A1, strength of straw, length of peduncle, leaf type, rust resistance, insect resistance, quantity and quality of protein, grain type, spike ramification, and daylength insensitivity. For some of these characters such as dwarfness, protein quality, and ramification, work continues to be done in bread wheats, durums, and triticales. In all this material, backcrossing is used while selecting for the genotypes of interest.

Intergeneric crosses. In the 1972/73 crop season, intergeneric crosses, particularly crosses of wheat x barley, were emphasized. The male and female parents were treated with different chemicals to break or eliminate the barriers to cross fertilization. In summer 1973 the project was continued but also included were intercrosses of varieties of wheat, barley, oats, and rye. In winter 1973/74 rice was added.

The chemical treatments and the crosses are made under field conditions, crosses are harvested at the embryonic stage and cultured on artificial media, and root tips are taken for cytological study from each plant. From cytological examination the true crosses can sometimes be determined.

From the first cycle of crosses, 56 F_1 plants were obtained and from the second cycle, 74 plants. The material in both cycles was grown under greenhouse conditions at El Batan. All field work was conducted by the basic germ plasm project, while the laboratory work was done by other staff members. This is a cooperative project with Kansas State University.

Seeds were obtained from crosses of triticale x barley, wheat x triticale, triticale x rye, and wheat x rye in 1972. In 1972/73 from about 2000 head pollinations, 171 potential haploid embryos were recovered. From these, 74 plants, representing 47 crosses were grown. The 74 plants were from durum wheat x barley, bread wheat x barley, barley x rye, barley x triticale, bread wheat x rye, triticale (6X) x bread wheat, triticale (6X) x rye, and durum wheat x bread wheat.

Some did not survive, but 25 crosses of bread wheat x barley, durum wheat x barley, and barley x rye were partially fertile after colchicine treatment, and 339 F_2 plants were grown from seed set. Very peculiar chromosome counts were obtained. Some segregates apparently contain chromosomes from the two species involved. More detailed studies are planned.

PHYSIOLOGY AND AGRONOMY

The wheat physiology-agronomy program was expanded in 1973 with two postdoctoral appointments, Dr. D. Hille Ris Lambers and Dr. M.A. McMahon, and the initiation of a new cooperative project with the University of California, Riverside. In addition, several CIMMYT production trainee projects were designed to answer questions relevant to the program.

In physiology, comparisons of many diverse wheat genotypes were continued by various techniques including growth analysis. Yield-limiting factors were also examined in greater detail in several of the best genotypes. These studies are conducted under optimal agronomic conditions (irrigation, high fertility) and insofar as possible in the absence of disease. More genotypes, in particular erect-leaved types, were included in comparative studies in 1973. In addition, less crop sampling was done in the early stages of crop development and more after anthesis. Comparative studies were also conducted for the first time at El Batan and Toluca in the summer. As a new project Dr. Hille Ris Lambers has begun a rapid incorporation of potentially useful plant characters into commercial varieties and populations to test their effect on yield.

Agronomy trials as in the past were designed to study the fertility response of new varieties and promising varieties arising from the breeding programs. Many additional genotypes were included. In summer 1973, Dr. McMahon expanded these activities with new trials on production practices for triticales and on herbicides since weed problems on the CIMMYT stations and in many developing countries are severe.

Studies of the response of genotypes under simulated drought were augmented considerably. Mr. R.J. Sojka, graduate student, and Prof. L. Stolzy, University of California, Riverside, undertook a detailed comparative study of 15 genotypes in the field at Cd. Obregon. In an adjacent trial a less detailed study involved 36 genotypes.

A large volume of data was collected during the past 3 years on various physiologic and agronomic experiments. Good progress was made toward reducing and statistically analyzing this data. The process is now entirely computerized with the data collected in a form subject to computer handling at most steps. All grain yields in this section are based on plant samples without border effect and yields are presented on a basis of 12 percent moisture content.

Comparisons of yield potential. Weather conditions for the winter crop at Cd. Obregon and the summer crop at El Batan are summarized in Figure 3. At Cd. Obregon, solar radiation was unusually low in February (including several periods of heavy clouds and 5 days with less than 200 cal/cm^2), temperatures were below normal in March and April, and spring rains were much above average. Heavy rains (37 mm) accompanied by high winds on February 21 caused widespread lodging of the early sown crops. At El Batan, temperature and radiation levels declined as crop growth and development proceeded from the late May sowing to the end of August in contrast to the decline and rise over the crop season at Cd. Obregon.

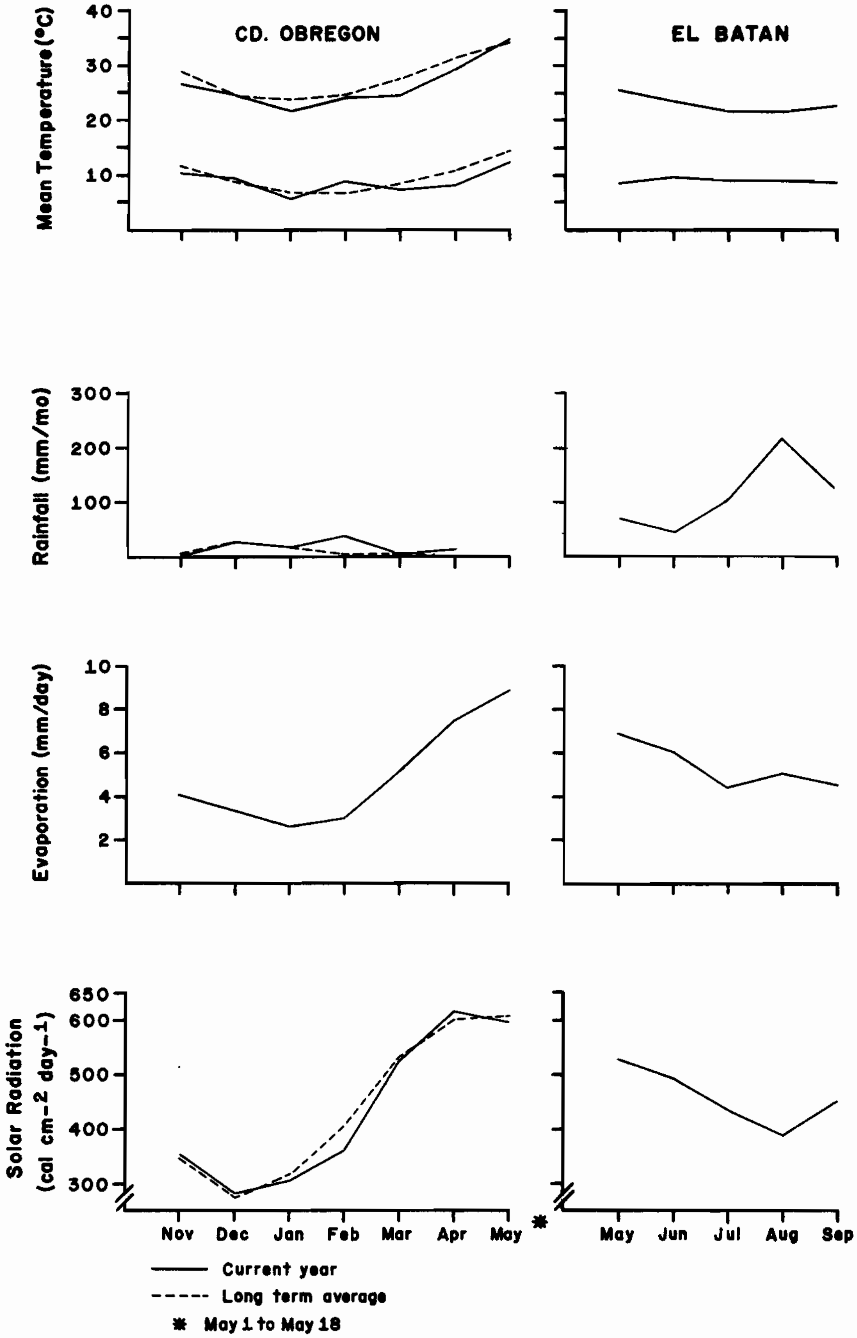


Fig. 3. Weather during wheat seasons at Cd. Obregon 1972/73 and El Batan 1973. (Long term average is for 1960-72 except for solar radiation which is for 1970-72; evaporation from USWB class A pan).

At Cd. Obregon, judged by the yield of the early maturing variety Yecora, the yield potential for 1972/73 was lower than that of other years. For all years this variety was sown at about the same date (November 15-December 10) and under high fertility. Yields averaged 6.41 t/ha compared with 6.88 t/ha in 1971/72 and 7.42 t/ha in 1970/71 There appeared to be great sensitivity to date of sowing. Particularly low yields were harvested from mid-November sowings and maximum yields from those of December (Fig. 4). A similar response to date of seeding was observed in other varieties studied in 1972/73 (Table 8). Maximum yields for Hira, Yecora 70, Cajeme 71, and Cocorit 71 approached 8 t/ha in the December seeding. These yields appear to be about the upper limit of these varieties under optimal agronomic practices at Cd. Obregon. Although lodging was quite severe in the earlier sowings, the yield components that were most depressed in these seedings were ears per square meter and grains per square meter. Both of these characteristics were already determined before the first lodging occurred on February 21. That suggests that factors other than lodging caused the poor yield from November sowing. This will be discussed later.

Table 8 also contrasts the effect of optimizing the pre-anthesis environment (reflected in yield potential at anthesis as estimated by number of grains per square meter) and optimizing the post-anthesis environment (reflected in weight per grain). Late December or mid-January sowings with late March flowering had the best pre-anthesis environment. The early December date with late February flowering had the best post-anthesis environment. Undoubtedly, high radiation combined with unusually moderate March temperatures represent the most favorable condition for both stages of development.

The lower yields from the November sowing date, coupled with a high incidence of lodging, particularly in the taller semi-dwarfs, casts some doubt on the usefulness of the extensive genotype comparisons made in 1972/73, since the observations made were on material sown in late November (Table 9). The standard check varieties in Table 9 are Yecora 70 and Cocorit 71. Severe lodging in Cororit was no doubt responsible for its reduced weight per grain as compared with other seasons. As outlined above, the cool maturing period of 1972/73 favored lateness and as a result Oviachic 66 and Mengavi-8156 yielded more than

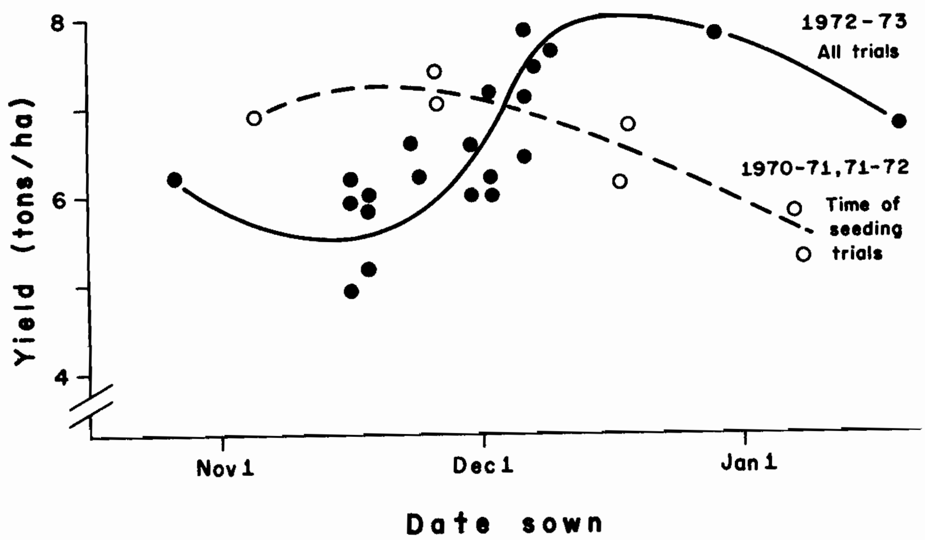


Fig. 4. The effect of date of seeding on grain yield of Yecora 70 grown under optimal management.

Table 8. **Yield and related parameters for key genotypes sown at different dates; seeded at 120 kg/ha, fertilizer 200 kg/ha N, 80 kg/ha P_2O_5. Cd. Obregon, Mexico 1972/73.**

Variety [a]	Yield t/ha	50% ear emerg	Grain no. 1000/m^2	Wt/grain mg	Harvest index	Lodging score [b]
		Sown 26 Oct 72				
Hira	5.73	1 Jan	14.4	35.5	0.48	55
Yecora 70	6.20	31 Jan	13.5	41.1	.45	42
Cajeme 71	5.37	7 Feb	11.2	42.8	.41	30
Cocorit 71	5.68	21 Jan	12.0	42.2	.43	100
Cinnamon "S"	6.04	22 Jan	12.1	45.0	.42	75
		Sown 16 Nov 72				
Hira	4.88	28 Jan	10.6	41.2	.41	22
Yecora 70	5.20	8 Feb	11.5	40.7	.41	7
Cajeme 71	4.82	22 Feb	9.4	45.8	.37	51
Cocorit 71	4.98	5 Feb	10.9	40.9	.38	97
Cinnamon "S"	5.25	5 Feb	11.1	42.1	.37	87
		Sown 7 Dec 72				
Hira	5.80	20 Feb	12.5	41.7	.40	0
Yecora 70	7.81	4 Mar	15.6	44.9	.45	0
Cajeme 71	8.12	12 Mar	16.3	44.5	.42	11
Cocorit 71	7.39	1 Mar	14.2	46.6	.43	89
Cinnamon "S"	6.76	28 Feb	13.6	44.6	.38	83
		Sown 27 Dec 72				
Hira	7.95	12 Mar	18.1	39.3	.47	0
Yecora 70	7.91	22 Mar	16.3	43.4	.46	0
Cajeme 71	7.70	29 Mar	16.6	41.5	.44	0
Cocorit 71	7.83	20 Mar	15.1	46.4	.44	47
Cinnamon "S"	7.07	17 Mar	15.0	42.2	.38	37
		Sown 18 Jan 73				
Hira	6.62	26 Mar	17.1	34.6	.43	0
Yecora 70	6.80	5 Apr	16.8	36.2	.42	0
Cajeme 71	5.98	13 Apr	15.7	34.0	.37	0
Cocorit 71	7.87	2 Apr	16.8	41.9	.43	0
Cinnamon "S"	6.31	30 Mar	14.3	39.2	.36	0
LSD within dates:	0.65		1.5	2.2	.02	12
LSD between dates:	0.73		1.5	2.1	.03	13

a/ Cocorit 71 is a durum wheat, Cinnamon "S" is a triticale. b/ Scale: 0-100 (100=crop flat on ground).

usual. Notwithstanding these confounding influences, it is noteworthy that three of the erect-leaved selections (leaf angle less than 55 degrees) yielded significantly more grain than Yecora.

In most trials, the leaf angle of the canopy was estimated visually every 10 days or so until after anthesis. Although the absolute value may not be highly precise, the figures represent a relative value for leaf erectness. Some rankings changed at different points during the season, and the figures given are averages for the season as a whole. Genotypes with leaf angles of 45 to 55 degrees are considered moderately erect and those with ones of less than 45 degrees, very erect. Several very erect types have been identified in CIMMYT nurseries. The high yielding erect lines of Table 9 were all superior, within their species, for number of grains per square meter. Data from several trials with many genotypes (Table 10), confirm that in bread wheats erect leaves are associated with more grains per unit area, probably because the erect types have more ears. In durum wheats, the relation between erectness of leaf and ear number is quite evident, but because of poor spikelet fertility in several of the erect-leaved lines, no relationship was established between erectness and grains per square meter. In neither bread wheats nor durums was grain yield correlated with erect leaves. The question of erect leaves will be pursued with greater intensity in future studies. None of the current commercial varieties have erect leaves under high nitrogen levels. Erect leaves, by allowing higher tiller survival, hence greater production of ears, may be one avenue toward higher yield potentials.

Results of growth analysis studies are not yet fully interpreted. In one trial with 24 diverse genotypes, there was a higher correlation between harvest index and grain yield (0.87**) than between total dry matter production and grain yield (0.60**). Hira and Yecora continued to have the highest harvest indexes, about 0.45 (Table 8).

Another continuing study of genotype comparisons involves phenological patterns: days to floral initiation, terminal spikelet formation, ear emergence, anthesis, and maturity. Included in 1972/73 was the response of varieties to seed vernalization and artificially lengthened photoperiod. Results in Table 11 are based on material sown on March 7. Lamps used for photoperiodic extension for the December 7 sowing (a more appropriate time) were not effective. Varietal response to daylength and seed vernalization varied considerably as did minimum vegetative period (24-hour photoperiod with seed vernalized). The extreme lateness of Cajeme 71, Late Mexico 120, and Klein Rendidor stems from relatively large responses to vernalization. Pitic 62

Table 9. **Grain yield and related parameters for several diverse genotypes in several trials. All seeded 16-24 November 1972; seeding rate 120 kg/ha, fertilizer 200 kg/ha N, 80 kg/ha P_2O_5. Cd. Obregon, Mexico, 1972/73.**

Genotype [a]	Yield t/ha	Yield % Yecora in same trial	Date 50 % ear emerg.	Grain no. 1000/m^2	Wt/grain mg	Mean leaf angle [b]	Lodging score [c]
			Bread wheats				
Yecora 70	6.26	100	13 Feb	13.5	42.1	63	27
Siete Cerros 66	5.88	101	18 Feb	15.5	34.0	63	52
Mexico 120	6.37	102	18 Feb	16.0	35.6	49	38
Pitic 62	6.34	96	22 Feb	13.2	42.9	64	4
Vicam 71	6.63	102	19 Feb	16.8	35.4	59	0
Fiserect 3	7.42	123	23 Feb	17.7	37.7	45	0
Torim 73	6.62	110	10 Feb	16.1	36.6	64	21
Mengavi-8156	6.07	101	4 Mar	15.4	35.0	61	50
Fiserect 1	7.54	114	28 Feb	17.0	39.6	41	0
Cajeme 71	7.06	106	4 Mar	13.8	45.9	62	30
Lechuza	5.79	87	14 Feb	15.0	34.5	44	35
			Durum wheats				
Cocorit 71	5.12	82	12 Feb	11.2	40.4	60	91
DurumS-0195	7.15	110	9 Feb	14.4	44.5	53	9
Oviachic 66	6.17	102	12 Mar	11.8	47.0	63	26

a/ Fiserect = Meng-8156(R)/Tob-CfnxBb, CM-6531. Lechuza = Tob-8156 x CC-Inia/Jar"S", CM-5629. Durum S-0195=AA"S"/LD357$_E$-Tc^{2}xGll"S". D-31708-11M-2Y-1M-0Y. *b/* Angle to vertical estimated visually, mean of seven dates late Dec. to Feb. *c/* Scale: 0-100 (100 = crop flat on ground). Pitic 62 was prevented from lodging with mesh.

and Mexico 120 also responded substantially to vernalization. Comparing Pitic with Nadadores and Mexico 120 with Manitou shows how a similar vegetative period can result from differing combinations of vernalization and photoperiod sensitivity. It is interesting that Siete Cerros had the longest minimum vegetative period.

A study of yield potential of diverse genotypes at El Batan in the summer was complicated by stripe and stem rust and scab infections which attacked the more susceptible genotypes in spite of repeated applications of fungicide. Information on several genotypes is shown in Table 12. None of these varieties was materially affected by disease or lodging.

Genotype manipulation under optimal conditions. As in the past years we studied the high yielding triple-dwarf variety Yecora to identify factors which limit its yield under optimal agronomic treatment at Cd. Obregon. We found that grain yield was markedly reduced by heavy shading in the period 30 to 10 days before anthesis and to a lesser extent in the next period beginning 20 days before anthesis (Fig. 5). The reduction was mainly due to a drastic drop in number of grains per square meter. Such

Table 10. **Linear correlation coefficients (r) between certain dependent variables and mean leaf angle to the vertical of bread wheat and durum genotypes, involving all genotypes shorter than E_1, seeded in the period 16 to 23 Nov. 1972. Cd. Obregon, Mexico, 1972/73.**

Wheat type	Genotypes, no.	Leaf angle range, deg.	Ears, no./sq.m. r	Ears, no./sq.m. range	Spikelets, 100/sq.m. r	Spikelets, 100/sq.m. range	Grains, 100/sq.m. r	Grains, 100/sq.m. range	Grain yield, t/ha r	Grain yield, t/ha range
Bread	37	41-65	−0.39*	350-580	−0.52**	62-104	−0.44**	90-177	−0.07^{ns}	3.68-7.54
Durum	28	39-64	−0.58**	240-410	−0.28^{ns}	52-76	0.11^{ns}	65-144	0.31^{ns}	3.59-7.15

Table 11. **Effect of daylength and vernalization on days to ear emergence in spring wheats seeded in the field on March 7, 1973 at Cd. Obregon, Mexico.**

Genotype	Seeding to ear emergence, days			
	Natural photoperiod, seed not vernalized	Reduction with 24h photoperiod[a]	Reduction with seed vernalization[b]	24h photoperiod, seed vernalized
Sunset	51	9.5	-0.5	42
Inia 66	54	11.5	0.5	42
Sonora 64	56	9.5	-1.5	45
Yecora 70	62	11.0	3.0	48
$(LRxN_{10}B)An_E$[3]	62	12.0	-2.0	52
Siete Cerros	65	12.5	-2.5	55
Nadadores 63	67	17.0	2.0	48
Pitic 62	67	10.0	5.0	52
Buck Manantial	70	25.5	-6.5	51
Mexico 120	71	13.5	10.5	47
Manitou	72	20.5	-0.5	52
Era	73	21.5	-1.5	53
Cajeme 71	77	16.0	13.0	48
Late Mexico 120	>80	24.0	18.0	52
Klein Rendidor	>80	17.0	>26.0	54

a/ Mean of non-vernalized and vernalized except for last two genotypes; natural photoperiod extended to 24h with incandescent light. *b/* Mean of natural and 24h photoperiod except for last two genotypes; seed vernalized 30 days in dark at about 4°C.

large effects were not observed in the previous two seasons and were likely related to lower-than-normal solar radiation levels 30 to 10 days before anthesis (February). As in other years, shading early in the plant cycle had no effect. Post-anthesis shading had only a marginal effect, clearly less than in other seasons. In an adjacent trial, heavy post-anthesis thinning increased kernel weight by only 10 percent as compared with 20 to 25 percent in previous years. Thinning, by allowing more light to reach the remaining shoots, is the equivalent of increasing photosynthetic output or essentially the reverse of shading.

These results suggest that grain number as opposed to kernel weight was a major factor limiting yield in the 1972/73 season, and that crop conditions during the 1-month period before ear emergence determined grain number, This was confirmed in several other experiments.

Again this year, CO_2 fertilization was given in the field

Table 12. **Grain yield and relevant parameters of some genotypes under optimal agronomy. Seeded at 120 kg/ha on 31 May; fertilizer 265 kg/ha N, 150 kg/ha P_2O_5. El Batan, Mexico, 1973.**

Genotype	Yield t/ha	Yield as %Yecora	Date of 50% ear emerg.	Grain number 1000/sq m	Wt/grain mg	Mean leaf angle
Yecora	5.14	100	4 Aug	14.8	30.9	61
Lechuza	5.61	109	7 Aug	18.6	26.9	47
Torim 73	5.37	105	2 Aug	18.4	26.1	61
Fiserect 4A	5.35	104	10 Aug	16.5	29.2	43
Jupateco 73	5.19	101	9 Aug	15.9	29.2	59
S-948-A1x Sta Helena 5	5.07	99	7 Aug	17.0	26.7	53
Tzpp-SNxNP3/ Tob-8156	4.77	92	30 July	19.2	22.2	31
Cocorit	3.96	77	14 Aug	12.7	27.7	55
Cajeme 71	3.92	76	22 Aug	11.5	30.8	59
LSD (5%)	0.86	—	—	2.5	3.3	—

Table 13. **Effect of reducing leaf area at anthesis (3 March) on yield and yield components in Yecora 70; seeded at 120 kg/ha on 6 December; fertilizer with 300 kg/ha N, 100 kg/ha P_2O_5. Cd. Obregon, Mexico 1972/73.**

Leaves removed	Yield t/ha	Relative yield %	Grain no. 1000/sq m	Wt/grain mg	Relative grain wt. %
None (Control)	7.38	100	14.4	45.9	100
All except flag leaf	7.06	96	14.7	43.0	94
Half all leaves[a]	6.86	93	14.0	43.9	96
LSD (5%)	0.79	—	1.9	1.3	—

a/ Distal half of all leaves cut off.

at four stages of development: 12-39, 40-67, 68-95, and 96-123 days after seeding. Yecora was grown under exactly the same conditions as in the shading experiment. Grain yield increased (slightly, significant at 10% level of probability) only with fertilization in the third or late vegetative-anthesis period. This was associated with a highly significant increase in grains per square meter. Neither grain yield nor kernel weight was affected by CO_2 fertilization during the post-anthesis period.

In a new experiment, heat and cold treatments were applied to Yecora in crop enclosures during the same four periods as in the previous experiment. In the heat application, the aim was to maintain the air temperature inside the enclosure 4 to 10°C above the ambient temperature at all times. In the cold treatment, the aim was to reduce air temperatures 2 to 6°C whenever the ambient temperature rose above 10°C. The cold treatment, however, had little effect on daytime temperatures in the last period since the cooling capacity was inadequate. Significant effects on yield occurred only in the second and third periods—heat reduced yield and cold increased it as compared with untreated control plots. In the second period, change in grain number occurred while in the third period (which extended a few days after anthesis) both grain number and kernel weight were affected. There were no significant effects in the last, or grain-filling stage.

In another trial, leaves were removed at anthesis in substantial areas of the crop (1.1 x 1.5 square meters). Again grain yield and kernel weight were only slightly affected (Table 13).

Figure 6 shows the response of grain size and grain yield to changes in grain number for all of the above-mentioned treatments, excluding only treatments that may have directly affected yield during the post-anthesis period

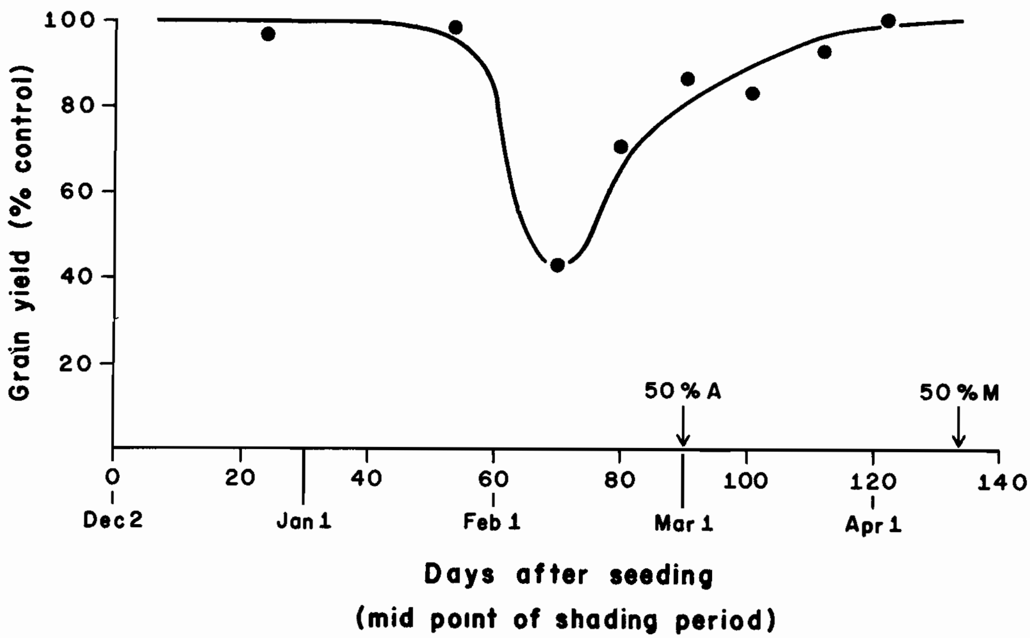


Fig. 5. The effect on grain yield of Yecora 70 of a single 21-day period under 65% shade at different stages of development; seeded 2 December 1972 at 120 kg/ha with 300 kg/ha N and 100 kg/ha P_2O_5.

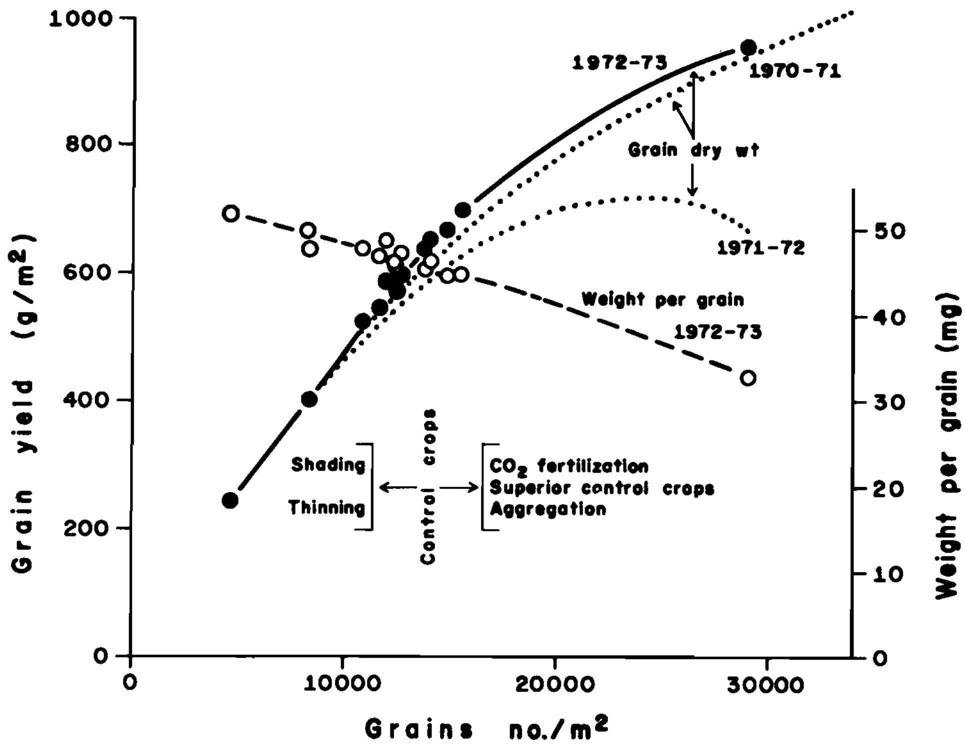


Fig. 6. Response of weight per grain and grain yield to changes in post-anthesis sink size as indicated by grains per square meter. Yecora 70 seeded 2-9 December 1972, Cd. Obregon, Mexico 1972/73.

(compared with indirectly affecting yield through changes in grains per square meter). In Figure 6, the two points at the extreme right are each derived from a plot in which plants were transplanted closely together after being grown widely spaced in pots until just before ear emergence. The influence of grain number on grain yield was greater in 1972/73 than in previous years. Because of this and because the grain numbers of the control crops were lower this year than in other years, yield in Yecora was clearly limited by sink size. Presumably, the weather was responsible, particularly the low radiation before anthesis and the cooler post-anthesis conditions as compared with the previous 2 years.

An attempt was made to determine whether source (carbohydrate via photosynthesis) or sink (grains per square meter) was limiting yield in the post-anthesis period in 11 other varieties by using crop shading, crop thinning, and individual shoot manipulations applied at anthesis. Fifty percent shading during the entire post-anthesis period had little effect on weight per grain with a range from + 5 percent to −14 percent and averaging −5 percent for all genotypes. Shading caused a larger reduction in number of grains per spikelet ranging from −2 to −25 percent with an average of −9 percent. Extreme crop thinning increased kernel weight from 10 to 19 percent with an average of 14 percent. These small responses support the conclusion found with Yecora that in 1972/73 yield was little affected by manipulation of light in the post-anthesis period and therefore sink size limited its yield potential more than source. Nevertheless, the genotype x treatment interaction for weight per grain was highly significant and, compared with the other 11 genotypes, Yecora appeared to be among the least sensitive to source manipulation. The expected correspondence in results between source manipulation of the crop and sink reduction (grain removal) treatments applied to individual shoots of these 12 genotypes did not occur. Exactly what this implies awaits further investigation.

Genotype comparisons under simulated drought. Sixteen genotypes were grown with three levels of terminal post-anthesis drought in an experiment similar to one conducted in 1972. In a second experiment, plot sizes were reduced to test more genotypes (36) and to determine whether similar results could be obtained. Exceptional rains on February 21 (37 mm) and April 6 (15 mm) greatly modified the drought treatments, however. Stress was only moderate, resulting in a 0 to 50 percent yield reduction. In nearby plots, wheat which had received only one irrigation at seeding yielded 5 t/ha. The unusual effects of seeding date and a high incidence of lodging complicated the interpretation. One low yielding durum line showed no yield reduction as a result of drought. Cocorit 71 again appeared to be more sensitive than Yecora 70. Such varieties as Nainari 60, K 338-Et. de Ch. x Koudiet 17-Kt-Y, and Gabo showed no greater sensitivity than Yecora to drought in spite of their later maturities, hence their longer exposure to water shortage. The triticales tested did not show evidence of enhanced resistance to drought stress.

Observations of plant moisture stress with the pressure chamber and leaf-resistance meter revealed significant differences between genotypes. These studies will be intensified. Also, the smaller plots (two 3-m rows spaced 30-cm apart and third row unsown between plots) gave results similar to those from plots with nine 3-m rows spaced 30-cm apart. More extensive drought trials will be conducted in 1973/74 using the smaller plots.

Genotype and planting density. Several agronomy trials were conducted at Cd. Obregon under irrigation and high fertility in which the response of genotypes representing different plant types to row spacing and seed rate were compared. In spite of the inclusion for the first time of some moderately erect-leaved bread and durum genotypes, the genotype x seed rate and genotype x spacing interactions, as in previous years, were usually nonsignificant and always small. An example is given in Table 14. The absence of response to spacing agrees with earlier trials whereas the moderate negative response to seed rate contrasts with the small and usually nonsignificant response of other years. Grains per square meter and weight per grain both contributed to this negative response. The negative response may reflect the increased lodging noted in the higher seed rates.

Table 14. **Grain yield responses to seeding density and spacing in four contrasting genotypes; seeded November 16, fertilizer 213 kg/ha N, 85 kg/ha P_2O_5; Cd. Obregon, Mexico, 1972/73.**

		Grain yield, t/ha					
	Plant	Seeding density[a] kg/ha			Row spacing[b] cm		
Genotype	type	40	100	250	15	30	45
Yecora 70	Bread wheat non-erect	6.50	5.90	4.76	5.49	5.85	5.82
Mexico 120	Bread wheat mod. erect	6.49	5.81	4.79	5.58	5.65	5.85
Cocorit 71	Durum non-erect	6.37	5.85	5.48	6.12	5.95	5.63
S-0195[c]	Durum mod. erect	7.05	6.84	5.70	6.26	6.66	6.67
Mean		6.60	6.10	5.18	5.86	6.03	5.99
LSD (5%) within genotype			0.43			0.46	

a/ Mean of three spacings. *b/* Mean of three densities. *c/* AA"S"/LD357$_E$-Tc^2 x GII "S".

Nitrogen trials with wheat. Several nitrogen fertilization trials were conducted. The nitrogen status in the soil was low following a summer sorghum crop. The results were as expected (Fig. 7) and reflect a reduction or elimination of lodging with the shorter varieties at higher nitrogen levels. Further, short stature gives, independent of lodging, an advantage in yield potential at high nitrogen, as reported in 1971/72. The triticales in general showed greater lodging resistance in any given height class than did the wheats at the same nitrogen treatment.

The nitrogen fertilizer trials provided interesting data.

on grain protein and lysine percentages and yields (Table 15). Although 100 kg/ha N depressed protein content in the grain compared with zero N (a consequence of the extremely low nitrogen level at zero N), protein yield per hectare increased several-fold. Comparing 300 kg/ha N with 100 kg/ha N, both protein percentage and yield of protein increased considerably. But, as expected, the percentage of lysine in the protein fell about one sixth in all genotypes studies. Nevertheless the percentage lysine in the grain (not shown) and actual yield of lysine per hectare increased substantially. The economic dose of nitrogen for grain yields in these tests was about 200 kg/ha at which level protein and lysine yields would have been clearly superior to those at zero N or even 100 kg/ha N.

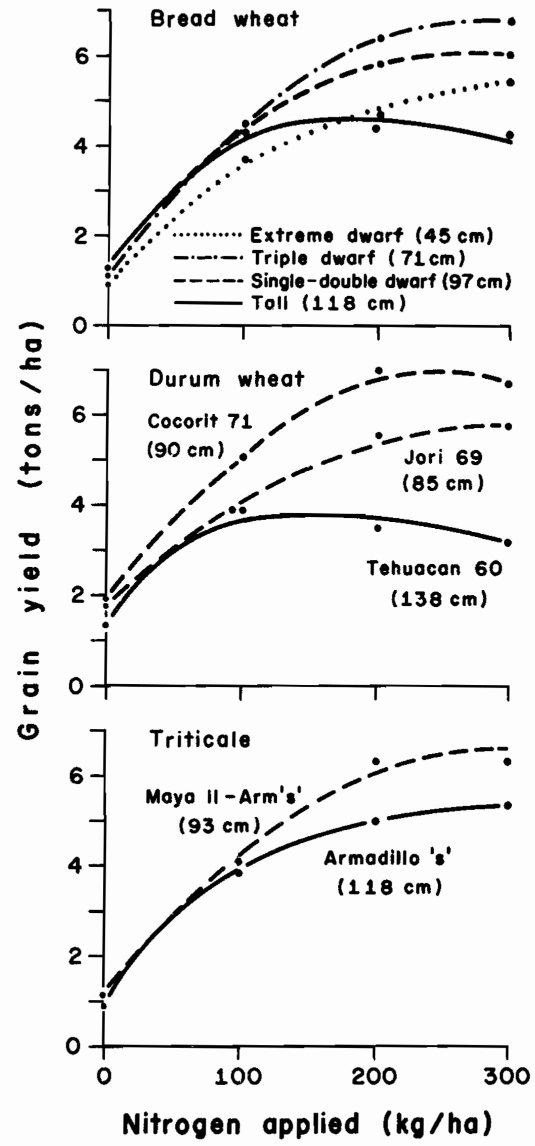


Fig. 7. Nitrogen response of bread wheats, durum wheats, and triticales in adjacent trials on a soil of low nitrogen status. Height levels for the different genotypes or groups at maturity are shown in parentheses. The tall bread wheats were Mentana, Yaqui 50, Nainari 60; the single-double dwarfs, Pitic 62, Siete Cerros 66, INIA 66; the triple dwarfs Yecora 70, Cajeme 71, and Mexico 120; and the extreme dwarf, Olesen, seeded 30 November 1972 at 100 kg/ha with 80 kg/ha P_2O_5.

Nitrogen trials with triticale. In trials to study the response of promising triticale genotypes to nitrogen, Yecora, a bread wheat, and Cocorit 71, a durum, were included as checks. One of the trials was located at El Batan and one on a farm field near Huamantla. At Huamantla, the soil is a light loamy sand. Both trials were conducted under rainfed conditions. The nitrogen status of the soil at both sites was exceptionally high so that significant positive yield responses were not obtained. Triticales gave high yields at both sites and did not lodge (Table 16). Yecora, the bread wheat check, ranked second at Huamantla, but was low yielding at El Batan. Cocorit, the durum check was low yielding at both sites. The three consistently high yielding triticales were Variety 306, PM-308, and PM312.

Herbicide trials. Herbicide trials were aimed at finding a suitable chemical for controlling weeds in cereal grains at the CIMMYT stations of El Batan and Toluca. They further provided a demonstration of weed control both for staff and "in service" trainees. These trials comprised date and rate of application of two chemicals which were promising in previous trials. Tribunil (1,3-dimethyl 1-3 (2 benzolthiazolyl)-urea) was tested at Toluca, and Dozanex (Metoxuron) at El Batan. Cinnamon, Yecora, and Cocorit were used to represent triticale, bread wheat, and durum wheat, respectively. The infestation of broadleaved weeds was

Table 15. **Effect of nitrogen fertilization on grain protein and percentage lysine in protein for some bread wheats and triticales in several trials. Cd. Obregon, Mexico, 1972/73.**

Genotype	Nitrogen applied kg/ha	Grain yield t/ha	Grain protein %	Protein yield kg/ha	Lysine in protein %	Lysine yield kg/ha
Yecora 70	0	0.93	10.9	91	—	—
	100	4.18	9.4	361	3.03	10.6
	300	6.56	13.3	779	2.59	20.1
Siete Cerros 66	0	1.28	9.8	112	—	—
	100	4.21	9.1	342	3.33	11.4
	300	6.54	12.5	730	2.81	20.5
Cajeme 71	0	1.09	10.5	102	—	—
	100	4.53	9.4	380	3.05	11.6
	300	6.92	13.7	846	2.48	21.0
Beaver	0	1.02	11.7	107	—	—
	100	3.43	8.7	267	3.96	10.6
	300	5.55	14.5	721	3.36	24.2
Maya II-Arm "S"	0	1.10	8.9	88	—	—
	100	3.83	8.3	284	3.94	11.2
	300	6.29	11.9	668	3.43	22.9
LSD (5%) within genotype		0.53	1.3	—	—	—

Table 16. **Yield comparison of promising triticale lines with standard bread and durum wheat checks, Yecora and Cocorit, under rainfed conditions at El Batan and Huamantla, Mexico, Summer, 1973.**

Line or variety	Days to flowering	Yield, t/ha Huamantla	El Batan
PM 312	65	6.1	4.5
PM 307	64	5.7	4.3
PM 212	73	5.1	3.5
PM 308	64	5.7	4.9
PM 724	73	4.6	4.5
PM 519	72	5.2	4.1
V 2012	52	5.7	4.7
V 306	63	5.7	5.2
Cinnamon	59	4.8	4.8
Yecora (bread wheat)	59	6.0	4.1
Cocorit (durum)	64	4.6	4.1

severe at both locations. Toluca also had a heavy infestation of meadow grass, *Poa* sp. At both locations, the non-weeded control plots were completely destroyed by weeds.

Tribunil applied at sowing or at emergence gave only modest control resulting in poor yields for all crops with bread wheat faring best (Table 17). In contrast,with application 10 days after emergence, weed control ranged from 89 to 96 percent for both rates used, though with 1 kg/ha the yield was below that of the hand-weeded control. When 2 kg/ha was applied at 10 days after emergence or 1 or 2 kg/ha at 19 days after emergence, somewhat poorer control was achieved but yields were close to that of the hand-weeded check for all crops. The best control of *Poa* sp. resulted from 2 kg/ha at 19 days after emergence.

Phytotoxicity symptoms were most severe on Cocorit. The phytotoxic effects led to a consistent reduction in number of plants in this variety. The most severe effect occurred with 2 kg/ha applied 10 days after emergence which reduced the number of wheat plants by 69 percent

Table 17. **Effect of Tribunil at different dates and rates of application on weed control and grain yield in triticale, bread wheat, and durum varieties. Toluca, Mexico, Summer, 1973.**

Time of application (Stage of growth of crop)	Application rate kg/ha a.i.	Triticale var Cinnamon: Phytotoxicity rating [a]	Weed control %	Grain yield [b] t/ha	Bread wheat var Yecora 70: Phytotoxicity rating [a]	Weed control %	Grain yield [b] t/ha	Durum wheat var Cocorit 71: Phytotoxicity rating [a]	Weed control %	Grain yield [b] t/ha
Non weeded control	—	—	0	0	—	0	0	—	0	0
Hand weeded control	—	—	100	2.5	—	100	3.2	—	100	1.2
Sowing	1	0	55	0.4	0	60	1.7	0	70	0
Sowing	2	0	75	1.0	0	80	2.7	0	85	0.5
Emergence	1	0	40	0	0	50	1.2	1.3	55	0
Emergence	2	0	75	0.9	0	70	2.2	2.3	90	0.2
10 days after emergence	1	2.2	90	1.3	1.2	90	2.8	3.2	95	0.9
10 days after emergence	2	3.5	95	2.1	1.5	95	3.1	4.7	95	1.1
19 days after emergence	1	0.7	75	2.2	0.2	80	3.8	2.8	80	1.0
19 days after emergence	2	3.0	90	2.0	1.5	90	3.5	4.2	85	1.2

a/ 0 = no dead leaves; 10 = complete kill. *b/* At 12 % moisture.

compared with the untreated controls. Yield, however, was not as adversely affected: 1.1 t/ha compared with 1.2 t/ha in the hand-weeded control. Phytotoxicity effects were quite high for Cinnamon at the later dates as well, but reduction in plant numbers was slight. It is difficult to estimate what effect phytotoxicity had in leading to the somewhat reduced yield. Phytotoxicity was very low on Yecora and yield and plant numbers were not affected.

None of the herbicide treatments in the Dosanex trial gave yields equal to those of the handweeded check (Table 18). There could be many reasons for this. It might be due to phytotoxic effects, but this is unlikely since no obvious signs were noted in any crop. Cocorit, for example, with 4 kg/ha applied at full tillering, showed no phytotoxicity, but it yielded less than half as much as the control. It is more likely that the reduction occurred because spraying took place when the weeds were fairly well advanced so weed competition had already exacted its toll. Further, Dozanex did not control a species of *Malva*, a large broad-leaved spreading weed which shades a large area and is very competitive. Clearly this herbicide requires further testing.

Table 18. **Effect of Dosanex at different dates and rates on phytotoxicity and yield in triticales, bread wheat, and durums. El Batan, Mexico, Summer, 1973.**

Time of application (Stage of growth of crop)	Rate of application kg/ha a.i.	Phytotoxicity	Grain yield t/ha
	Triticale var. Cinnamon		
Non-weeded control	0		0
Hand-weeded control	0		3.6
Five-leaf stage	2	0.5	2.9
Five-leaf stage	4	2.3	2.5
Full tillering	4	0.2	3.1
	Bread wheat var. Yecora 70		
Non-weeded control	0		0
Hand-weeded control	0		3.1
Five-leaf stage	2	0.5	2.4
Five-leaf stage	4	2.0	2.6
Full tillering	4	0.2	2.6
	Durum wheat var Cocorit 71		
Non-weeded control	0		0
Hand-weeded control	0		2.5
Five-leaf stage	2	0.3	1.5
Five-leaf stage	4	1.3	2.2
Full tillering	4	0	1.1

PATHOLOGY

CIMMYT screens its nurseries for stem rust and leaf rust at Cd. Obregon and for all three rusts at El Batan and Toluca. At Toluca, scab (*Gibberella zeae*) is endemic and in recent years screening has been possible for *Septoria tritici.* The El Batan site develops epidemic levels of all major barley diseases from natural infection. For the first time in 1972/73 some selection was made at Poza Rica for adaptation of CIMMYT materials to the humid tropics. Here screening for resistance to *Helminthosporium* sp. and leaf rust is possible. Greenhouse seedling tests are run at El Batan on advanced lines for the three rusts.

Septoria. An International Septoria Nursery (ISEPTON) is sent out from CIMMYT to national programs in countries where *Septoria* spp. are important. The results of the Third ISEPTON are shown in Table 19. Although ISEPTON was established as a cooperative effort to gather information on *S. tritici,* some of the cooperators in United States and England were also able to provide data for *S. nodorum* and for a mixture of both. The infection at all sites under report developed sufficiently to allow the more resistant types to be identified. Certain varieties showed resistance to both *S. tritici* and *S. nodorum.* These include Ciguena (Son 64^2xTzpp-Y54/Andes 64A, 21406-6-2-300Y-30IM-0Y), Toropi, Iassul, Carazinho, S12-Nb Romany, II.60.157, Sk-RL-2973, and Sudeste. In addition PI-297024 (K) registered a low reading for *S. tritici.*

The importance of *S. nodorum* in the spring wheat belt of southern Brazil, northern Argentina, Uruguay, and Paraguay was brought sharply into focus after the devastating epidemics of the fall of 1972. In Brazil more than 80 percent of the crop was lost primarily to *S. nodorum. S. tritici* was also considered to be present. For this reason, genotypes with possible resistance to *S. nodorum* should be included in septoria nurseries along with materials for

Table 19. **Wheat genotypes from the Third International Septoria Nursery most resistant to S. tritici and S. nodorum in 9 locations. (Scale 0-9 on leaf symptoms). 1972-1973.**

Genotype and Pedigree	Resistance to *S. nodorum* Indiana USA	North Dakota USA	Montana USA	Resistance to *S. tritici* Montana USA	Patzcuaro Mexico	Pergamino Argentina	M. Juarez Argentina	Mateur Tunesia	Holetta Ethiopia	Resistance to *Septoria* spp. Cardiganshire England	Origin
Tob x CC- Pato 27369-1R-4M-0Y	4	3	5	4	7	6	4	6	2	1	Mexico
Tob - B.Man x Bb 25998-5B-3J-101J-1Y-0M	8	6	4	4	6	Tr	6	4	1	–	Mexico
Corre Caminos 19792-2M-7T-1C-3T-100M-0Y	6	5	–	–	6	5	5	5	3	–	Mexico
Pato B (Jar-Np/LR64 x Tcpp - An_8) CM1020-500M-500Y-501M-0Y	8	2	6	4	6	2	7	4	2	–	Mexico
Ciguena 21406-6-2-300Y-301M-0Y	4	2	5	3	5	2	5	6	3	2	Mexico
Calidad 22429-16M-1Y-1M-0Y	5	7	3	5	6	3	5	4	3	–	Mexico
PV18A - Ciano 27893-1Y-8M-2M-500M-0Y	4	4	–	–	5	5	4	7	3	2	Mexico
Ariana 66	3	5	–	–	3	1	6	6	2	2	Tunisia
Ariana "s"	8	4	3	4	7	1	7	5	5	2	Tunisia
Pato "B" 21974-4R-4M-2R-0Y-0P	9	2	4	5	6	5	6	3	2	–	Argentina
Pato "R" 21974-4R-4M-2R-0Y-0P-0Y	9	2	3	6	6	2	5	3	1	–	Argentina
Klein Toledo	6	5	5	5	5	7	2	3	2	–	Argentina
Jaral "s" 18889-6T-8T-4T-2T-1T-0Y	7	2	3	5	8	5	7	3	4	–	Argentina
Gaboto	3	5	–	–	3	1	7	5	3	–	Argentina
Tacuari	3	4	–	–	4	4	6	3	1	–	Argentina
Texanos Pinto Precoz	4	4	–	–	6	2	8	2	2	–	Argentina
Precoz Parana INTA II18893-6T-4T-1B-4J-0J-0Y	6	3	2	5	7	Tr	5	7	2	–	Argentina
Md x McM - Exch B284-Fg-Fp-11252-83/6310334/69-1M-0Y	6	4	4	4	7	Tr	5	3	1	2	Argentina
MAG-41	5	2	–	–	5	4	7	4	2	–	Argentina
En-Dor	4	4	7	6	5	3	7	6	3	1	Israel
K-4135 (H3.D5)	5	3	4	5	6	3	5	5	2	–	Ethiopia
K-4328 (D1A)	7	6	4	6	4	1	7	3	1	–	Ethiopia
K-4500 (L1A1A)	4	4	–	–	5	Tr	8	3	1	2	Ethiopia
K-4983 (A1D.3A)	3	2	–	–	2	Tr	6	3	2	–	Ethiopia
Idaho/877 (NRBJ)	5	6	–	–	5	1	4	2	2	–	Ethiopia
PI-297024 (K)	5	6	–	–	4	2	4	2	2	2	Ethiopia
Romany	3	3	–	–	2	2	2	2	4	–	Ethiopia
Toropi	2	2	–	–	2	1	1	2	2	–	Brazil
Iassul	3	2	–	–	4	1	1	2	1	–	Brazil
Carazinho	2	2	–	–	3	2	1	2	0	–	Brazil
C-29	5	5	–	–	5	6	1	4	0	–	Brazil
S-2	2	4	–	–	3	4	3	3	1	–	Brazil
S12-Nb	4	2	–	–	3	4	1	2	1	–	Brazil
II-60.157	3	3	–	–	4	2	4	6	3	–	USA
Sk-RL-2973	5	5	–	–	6	1	4	4	2	–	USA
Sudeste	3	2	–	–	3	1	5	2	2	–	USA
Salamouni - Seafoam	5	5	–	–	6	3	5	2	2	–	Lebanon

Table 20. **Bread wheat genotypes from the Crossing Block Yaqui 1972-1973, immune or almost immune to two collections of Ustilago tritici. El Batan, Mexico, 1973.**

Genotype and pedigree	Smutted heads (%) Argentine collection	Smutted heads (%) Mexican collection
Tobari 66	0	0
Penjamo 62 [a]	0	0.6
Zambezi	0	0
Zenzontli No. 1 27106-23M-1Y-300M-500Y-500B-0Y	0	0
Corre Caminos 19972-2M-7T-1C-3T-100M-0Y	1.8	0
Bb-CC x Ron CM4698-500Y-500M-500Y-0M	0	0
Tob x CC - Pato 27369-112-4M-0Y-500Y-0M	0	1.5
Tob x CC - Pato 27369-112-4M-0Y-500M-0Y	0	0
CC/K58-N x II.44.29 25348-5M-2Y-1M-5T-0Y	1.2	0
CC/K58 - N x II.44.29 25348-5M-2Y-1M-5T-500M-0Y	0	0
Tzpp - SD648.5 x Bb-On CM9311-D-500M-500Y-0M	1.4	0
Chr-Bb/Cno"s" - Cal x Nad CM5598-B-1Y-500M-503Y-0M	1.9	0
8156-NadxBb(Son64-K.Rend/Cno-Chr x Bb) CM5826-F-6Y-500M-503Y-0M	1.2	0
Tob 66- Cno "s" x Pi62 CM7369-5M-101Y-0M	0	0
Nariño 59 [a]	0	0
Son64-P4160xNai60/My-An_e 208N-8C-2E-0Y	0	0
Girua Purple Straw	0	0
S-45	0	0
Th^3 x Fn^2 - K58N/No66-Cno"s" E27009-1C-1C-2C-0C	1.3	0
Sel5 x K58 - N/Desc	0	0
K58 - NxFn/Nar(Md x McM-Ex/Af-My) EII.67-4439-1F-1C-2C	0	0
Cpo x Tzpp - Son64A EII67-2743-1F-1C-1C-0C-0C	0	0
C17800-Bza(Md x McM-Ex/Af-My) EII67-2765-1F-1C-1C-0C-0C	0	0
K332-Et.Chiosy = Bt 2121 = Ariana "s"	0	0
Son 64-Kl.Rend = Bt 2296 = Soltane	2.1	0
Introd. 4057 = Salamouni - Seafoam	0	0
Son 64-Kl.Rend = Marcos Juarez INTA	0	1.8
Son 64 - Knott No. 2 = Precoz Parana INTA	0	0
MAG-41	0	0
Tacuari	0	0
Zambezi	0	0
Tob66 - Ciano "s" 24908-13M-3Y-3M-0Y	0	0

continued

Table 20, continued

Genotype and pedigree	Smutted heads (%) Argentine collection	Smutted heads (%) Mexican collection
(Kl.Pet-Raf x Pj62/Cno)Bb 30623-18M-1Y-2M-0Y	0	0
Tob x CC - Pato 27369-1R-4M-0Y	1.5	0
Jilguero - Yecora "s" CM4985-26Y-0M	1.3	0
Calidad - Penjamo 62 CM1079-4M-1Y-0M	0	0

a/ Immune to Pakistani collections of *U. tritici* tested for 3 years by Dr. S.F. Hassan of the Cereals Diseases Research Institute, Pakistan.

resistance to *S. tritici.* These nurseries are grown in areas where both organisms are present and can be assessed there.

Loose smut. Loose smut is caused by *Ustilago tritici.* It is found world-wide but tends to have lower incidence in warmer regions. Although its occurrence is usually relatively low, in certain areas the losses can become appreciable. Treating seed with systemic fungicides can control the disease fairly well, but genetic resistance offers a better and cheaper approach.

To find genetic sources of resistance, parental materials from CIMMYT's breeding program were tested for loose smut resistance in 1972/73. At Cd. Obregon a water-spore suspension of two collections of the fungus were inoculated into florets 4 to 6 days after pollination. The harvested seed was grown at El Batan the following summer. The most resistant genotypes are listed in Table 20.

INTERNATIONAL NURSERIES

The international nurseries program was expanded during 1973 by the addition of the International Barley Observation Nursery and the F_2 Winter x Spring Bread Wheat Nursery. CIMMYT now distributes 21 different nurseries from Mexico, including various bread wheat, durum wheat, triticale, and barley materials, to approximately 71 countries throughout the major spring and winter wheat regions

Table 21. **CIMMYT seed nurseries distributed in 1973.**

Nursery	Africa	Asia	Europe	Mesoamerica	Middle East	North America	Oceania	South America	Total
					Bread wheat				
Crossing Block (CB)	5	4		4	2	1		8	24
F2 Group 1	19	27	14	7	11	15		14	107
F2 Group 2	17	23	11	7	13	15		25	111
7th International Bread Wheat Screening Nursery	36	24	13	9	8	4	4	19	117
4th Elite Selection Yield Trial	4	3		6	3			4	20
10th International Spring Wheat Yield Nursery	27	15	22	3	9	19	3	15	113
4th International Septoria Nursery	6	1	3	4	2	2	1	6	25
1st & 2nd Multiline	11	12	1	7	8	2	1	7	49
F2 Spring x Winter	9	7	2	2	6	6		8	40
2nd Latin American Disease & Insect Screening Nursery				5	3	2		14	24
Total	134	116	66	54	65	66	9	120	630
					Durum wheat				
Crossing Block (CB)	1				1			1	3
F2	19	3	15	4	15	7		14	77
5th International Durum Screening Nursery	19	6	15	4	8	8		12	72
4th Elite Durum Yield Trial	8	2	2	4	3	1		4	24
5th International Durum Yield Nursery	18	8	13	7	7	7		12	72
Total	65	19	45	19	34	23		43	248
					Triticale				
5th International Triticale Yield Nursery	18	8	14	7	6	12	2	7	74
5th International Triticale Screening Nursery	31	15	6	14	2	5	1	22	96
F2	11	13	8	3	2	6		8	51
Total	60	36	28	24	10	23	3	37	221
					Barley				
Crossing Block					1				1
F2	7	5	1	3	3	1			20
1st International Barley Observation Nursery	5	6	1	2	4			2	20
Total	12	11	2	5	8	1		2	41
Grand Total	271	182	141	102	117	112	12	202	1140

of the world. The aim of these nurseries is to provide germ plasm to the cooperating countries either for direct use as varieties or as breeding material to assist in their national breeding programs. In return the national programs send CIMMYT materials which they consider of possible value in enhancing the germ plasm base of the ciruclated materials.

In the summer of 1973, CIMMYT distributed 1140 nurseries (Table 21) and received 104 shipments of seeds from 34 countries for the various crop programs.

In recent years, the numbers of nursery shipments has increased greatly in response to requests for more nurseries from some countries and the addition of others to the list of recipients (Table 22). In 1970 only 435 nurseries were sent compared with 1140 in 1973. Part of this increase is also due to the increase in kinds of nurseries since there were nine types in 1970 compared with 21 in 1973. While this represents a considerable increase in work load, CIMMYT will endeavor to supply national programs with those materials which they feel are of assistance.

During 1973 results of the second and third international triticale yield nursery and the seventh international spring wheat yield nursery were published.

WHEAT TRAINING AND VISITORS

Ninety-four persons participated in training in the wheat section programs or remained at CIMMYT for a week or more as visitors. The majority were enrolled in one of the

Table 22. **Location of international wheat nursery trials 1971-73.**

Region & country	1971	1972	1973
Latin America	122	215	302
Argentina	28	46	68
Bolivia	0	2	3
Brazil	17	35	51
Chile	7	20	26
Colombia	5	10	11
Ecuador	5	8	13
Guatemala	4	7	12
Guyana	0	0	1
Honduras	0	0	1
Mexico	49	63	87
Paraguay	0	6	6
Peru	6	14	20
Uruguay	1	4	2
Venezuela	0	0	1
Asia & Pacific	64	87	226
Afghanistan	3	6	13
Australia	5	2	9
Bangladesh	17	1	5
China	0	1	0
India	20	30	98
Indonesia	0	0	2
Iran	8	10	23
Japan	1	1	4
Nepal	0	6	7
New Zealand	4	3	3
Pakistan	3	21	45
South Korea	0	5	12
Thailand	3	1	5
N. Africa & Near East	116	151	268
Algeria	8	24	40
Cyprus	1	1	12
Iraq	3	10	0[a]
Israel	7	10	11
Jordan	3	7	0[a]
Lebanon	20	18	32
Libya	1	5	0[a]
Morocco	16	6	27
Sudan	3	1	8
Syria	2	0	0
Chad	0	0	2
Tunisia	21	24	27
Turkey	25	35	38
U.A.R.	6	10	71
Africa south of the Sahara	30	39	95
Cameroon	0	1	2
Ethiopia	12	17	27
Ghana	1	0	0
Kenya	5	8	14
Lesotho	2	1	2
Nigeria	1	0	3
Senegal	0	1	4
Somalia	1	0	0[a]
Southern Africa	6	8	30
Tanzania	2	3	9
Uganda	0	0	2
Zambia	0	0	2
Canada, Europe, Oceania & U.S.A.	131	145	249
Austria	0	0	4
Bulgaria	1	1	5
Canada	11	13	25
Denmark	1	2	5
England	5	3	12
Finland	0	0	1
France	2	2	15
Greece	1	1	5
Hungary	1	2	5
Italy	7	1	4
Netherlands	1	0	2
Norway	1	0	0
Poland	5	4	6
Portugal	5	6	9
Romania	5	4	8
Russia	3	8	34
Spain	7	5	12
Sweden	3	5	3
Switzerland	4	2	2
U.S.A.	62	82	81
East Germany	1	0	0
West Germany	1	1	1
Yugoslavia	4	3	10

a/ During 1973, these countries as well as the Sultanate of Oman, Yemen Arab Republic and Yemen P.D.R., received their nurseries through Dr. Abdul Hafiz, Project Manager, Regional Project, Field Food Crops, of the FAO in Egypt.

four regular in-service training programs—production, breeding, cereal chemistry and pathology (Table 23). There were four post-doctoral fellows in 2-year service positions, participating as additional staff members in the research section. Nearly 30 senior scientists spent times varying from 1 week to 9 months in the program to become familiar with CIMMYT methods and materials. The longer term senior scientists also assisted in program activities.

An increasing number of young men are being invited to CIMMYT for short visits as visitor trainees. Recent graduates who are returning from degree training to take part in national wheat programs are likely candidates. A short period at CIMMYT allows the candidates to see how academic training is used in a practical approach to field problems.

Since 1960, 266 young scientists from 40 countries have received in-service training in wheat at CIMMYT (Table 24). Eighteen countries have had five or more scientists trained and seven countries more than 15. In recent years there has been a marked increase in annual numbers under training.

In 1973 hundreds of visitors from other countries spent one to a few days at the CIMMYT nurseries or at the El Batan headquarters.

Table 23. **Wheat trainees in specialized courses 1970-73.** [a]

Course	1970	1971	1972	1973	Total
Breeding	30	22	18	23	93
Production	6	7	10	14	37
Cereal chemistry	4	1	2	4	11
Pathology	—	2	5	6	13
Seed production	—	—	3	—	3
Total	40	32	38	47	157

a/ Before 1970, trainees were not entered in specialized courses.

REGIONAL ACTIVITIES

The Arid Lands Agricultural Development Program (ALAD) of the Ford Foundation in Lebanon works closely with CIMMYT and FAO in distributing nursery materials to many countries throughout Asia and Africa. The programs centered at Beirut and Cairo form an intimate association with the national programs of a large number of cooperating countries.

The relationship between the Lebanese national wheat program and ALAD has been particularly close. Land, facilities, buildings, and supporting staff have been generously shared with the ALAD program. Since many activities of the national program of Lebanon coincide with those of ALAD's regional program in cereals, their joint endeavors have provided mutual benefit. The experiment stations in Lebanon have been fully mechanized and this has permitted work to be greatly intensified.

Some years ago Dr. I. Narvaez was appointed in the ALAD program. During this period wheat research was expanded in Lebanon and in the region as a whole. Assistance was given in wheat production campaigns in Egypt, Saudi Arabia, Syria, and Iran. Within Lebanon, intensive use was made of the dryland stations for testing wheat and barley for adaptation to low rainfall. At another station where irrigation facilities were developed, segregating populations could be screened. The volume of hybridization was also intensified.

Table 24. **In-service wheat trainees completing training, 1960-73.**

Country	1960-72	1973	Total
Afghanistan	15	2	17
Algeria	12	6	18
Argentina	8	9	17
Bangladesh	3	3	6
Bolivia	2	—	2
Brazil	14	—	14
Chile	1	2	3
Colombia	2	—	2
Cyprus	2	—	2
Ecuador	5	1	6
Egypt	6	2	8
Ethiopia	6	1	7
Guatemala	2	1	3
India	4	—	4
Iran	6	1	7
Iraq	7	—	7
Jordan	5	—	5
Kenya	2	1	3
Korea	2	3	5
Lebanon	4	—	4
Lybia	3	3	6
Morocco	14	3	17
Nepal	2	—	2
Nigeria	1	—	1
Pakistan	30	—	30
Paraguay	1	1	2
Peru	3	—	3
Philippines	1	—	1
Poland	2	—	2
Portugal	1	—	1
Romania	2	—	2
Saudi Arabia	1	—	1
Sudan	4	—	4
Syria	5	—	5
Tanzania	3	—	3
Tunisia	17	—	17
Turkey	27	2	29
Uruguay	1	1	2
USSR	—	3	3
Yemen	3	—	3
Total	229	45	274

In 1969, variety demonstration trials were distributed to about 50 locations in the Near East. These tests showed that three sister selections, Indus 66, Mexipak 65, and Mexipak 69 derived from cross 8156 had high yield potential in this region just as had earlier been shown for India and Pakistan. A second season of demonstration trials confirmed the results.

Since 1971 FAO and ALAD have cooperated closely in distributing regional nurseries to avoid duplication of variety materials. Regional wheat and barley trials were jointly prepared at the National Research Institute in Lebanon. In 1972/73 a Rainfed Wheat Yield Trial was established to evaluate bread and durum wheat for dry conditions. The results of these trials are reported in the FAO Regional Bulletin prepared by Dr. A. Hafiz in Cairo. Table 25 summarizes the data from bread wheat trials conducted from 1969 to 1973.

In the 1972/73 Rainfed Wheat Yield Trial, an equal number of bread and durum varieties was distributed to 20 countries for testing in locations with 300 to 400 mm rainfall. Ten results were received from stations recording 196 to 464 mm rainfall. Super X and Syrimex topped the list, closely followed by Capeiti durum. Sonalika gave higher yields than either Florence Aurore or Senatore Capelli. As a group the bread wheats exceeded the durums in yield. This is probably a reflection of the greater breeding effort placed on bread wheats.

Regional barley yields have been traditionally low. A cooperative yield trial has been distributed for 3 years. FAO prepated the first trial which consisted of 64 varieties collected from many countries. The best yielding varieties included two from Australia, A-16 and WI2197, and three six-row barleys of the coast type from USA, Numar, Arimar, and Giza 118 (Beecher). In the second year of trials, the same varieties plus some two-row varieties from Sweden had the highest yields. The 1972/73 results confirmed those of the previous 2 years. Numar, Beecher, Arivat, WI 2197, and Bussell were best, and gave average yields of about 3 t/ha.

In addition to the yield trials a Preliminary Observation Nursery was distributed to make available promising advanced materials from participating national programs and from CIMMYT. This non-replicated nursery includes bread and durum wheats and barley together with checks. At some centers where yields were taken, such bread wheat varieties as Barouk, HD 832-ON x Kal, and Siete Cerros 66 were among the leaders, as in the yield trials. Finally, a network for cooperative crossing and selection work is being established. Promising parental materials have been collected into a Regional Crossing Block. This, in effect, increases the genetic base available to breeders in national programs. Again bread and durum wheats and barley are included. The barley section has provided more resistant, more widely adapted, and stiffer-strawed materials.

In 1973 an attempt was made to located a suitable summer nursery site for Near East materials in East Africa.

Table 25. **Results of regional wheat trials in the Near East (Micro-plot Wheat Yield Trial and Regional Wheat Yield Trial). 1969-73.**

1st MPWYT 1969/70[a]		2nd MPWYT 1970/71[b]		3rd RWYT 1971/72[c]		4th RWYT 1972/73[d]	
Variety	Yield, t/ha	Variety	Yield, t/ha	Variety	Yield, t/ha	Variety	Yield, t/ha
Indus 66	3.5	Super X[e]	4.2	Arz[f]	4.5	Arz[f]	4.5
Mexipak 69	3.4	Mexipak 69	4.0	HD832-OnxKal	4.4	UP301xSon-Pi62	4.5
Mexipak 65	3.3	INIA 66	3.8	Barouk[g]	4.3	Siete Cerros 66	4.4
C271-Son 64	3.1	Chenab 70	3.8	Chenab 70	4.3	HD832-OnxKal	4.4
Chenab 70	3.1	Penjamo 62	3.8	Zorawar	4.3	Barouk[g]	4.0
				Mexipak 65	4.3		

a/ 28 locations, *b/* 43 locations, *c/* 30 locations, *d/* 13 locations, *e/* Indus 66, *f/* Mayo 54E-LRH490/LR64 x Tzpp-Y54, *g/* Mida - N Th-K117A x Indus 38/8156.

With the help of the national programs of Kenya and Tanzania, selections from Pakistan, Iran, Lebanon, and Egypt were sown in June. This nursery permitted rigorous selection for resistance to rusts and foliar diseases, and a second generation was achieved in the same year. In November, the material was returned to the participating Near East countries for replanting. The linking of Asian and African programs in this way will be of mutual benefit. There is a need to firmly establish this program with adequate manpower and financial support.

The regional exchange of germ plasm and collection of data have expanded rapidly. India and Pakistan have participated heavily in providing materials for regional use. Countries of the Near East are becoming increasingly interested in conducting yield tests of new materials. The efforts of FAO and ALAD have provided comprehensive coverage of the region. Most countries also collaborate directly with CIMMYT in evaluating new germ plasm. Exchange of seed and data regionally on a shared basis provides depth to the international effort.

Regional pathology. Dr. E.E. Saari, formerly of the Ford Foundation staff in India, joined CIMMYT in 1973 as regional pathologist for the cooperating countries of Asia and Africa. He is stationed with ALAD at Beirut but travels extensively in the region from Thailand to Morocco and throughout East Africa. He has had wide experience in pathology and was instrumental in the development of the Regional Disease and Insect Screening Nursery (RDISN) which has been distributed from Beirut since 1970. This nursery is an international counterpart of a similar nursery established earlier in India.

Advanced lines of contributing national breeding pro-

Mr. Abdul Rahman, Afghan scientist and Dr. E.E. Saari of CIMMYT inspect a field of dwarf Bezostaya near Kabul.

grams of the region are entered in the nursery together with materials having desirable disease resistance from many sources. The nursery is grown in disease "hot spots" in the collaborating countries of the region. It provides a way to assess these advanced lines over a wide geographic area for disease and insect resistance. Together with the Trap Nursery in Turkey, the RDISN helps breeders decide which of their promising new strains are most likely to have satisfactory disease resistance for some years. An advanced line showing wide geographic resistance is likely to be long-lived if released. In combination, the Trap Nursery and RDISN can warn countries when their commercial varieties are likely to break down to disease and can help identify advanced lines which might be used to replace them. The RDISN, additionally, provides a vehicle for distributing promising lines from one program to another. Thus, for example, an advanced line which might be discarded in the normal selection process in the Indian program, might be a successful variety in Tunisia or vice versa. Such a mutuality of effort introduces a new element

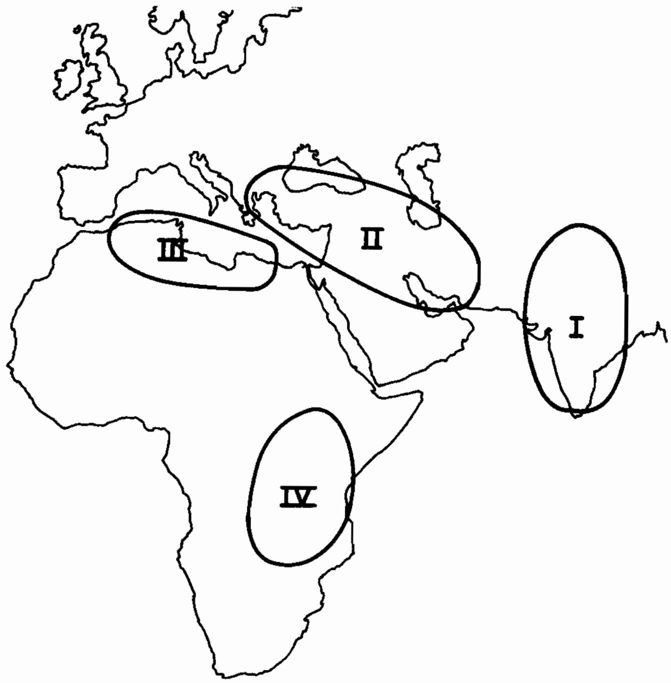


Fig. 8. Zones used for pooling rust response data.

to international plant breeding and strengthens and makes more efficient the world-wide plant breeding effort.

The third RDISN was sown in 17 countries of the Eastern Hemisphere. Included in the nursery were 1800 bread wheats, 240 durums, and 160 barleys. Sixteen national and international wheat programs submitted entries for testing. In the past year excellent data were provided for identification of sources of resistance to stem rust, stripe or yellow rust, and leaf rust. *Septoria tritici* data were limited but results confirm the extensive test results obtained last year.

For purposes of convenience and simplicity, the data have been pooled for zones. South Asia includes data from Afghanistan, India, Nepal, and Pakistan; West Asia includes Iran, Lebanon, and Turkey; North Africa includes, Algeria, Egypt, Morocco, and Tunisia; and East Africa includes Kenya and Ethiopia (Fig. 8).

In the bread wheats, stem rust was particularly severe at Njoro, Kenya, and only a few varieties exhibited a high level of resistance to the virulent races present. Many lines were resistant to stem rust at other test sites in the different zones. Appendix 1A-1 lists the lines with greatest resistance and their response at different test sites. In the South Asia data, the high score observed for the zone as a whole is given. The appendix includes the rust response in Mexico and the seedling reaction to race 113-69A from tests conducted at Beltsville, Md., USA. Selected bread wheat lines with stem rust resistance at Njoro, Kenya are listed in Appendix 1A-2.

In the durum wheats, stem rust was severe in Kenya and no line or variety was highly resistant. The more resistant entries are listed in Appendix 1B.

The barley varieties as a group were susceptible to stem rust. The better lines are listed in Appendix 1C.

Many bread wheat lines were identified with superior yellow rust resistance (Appendix 2A). Several durums had good resistance to yellow rust (Appendix 2B). All barley entries were severely attacked by yellow rust in North India. Some of the lines resistant at other test sites in South Asia and in other zones are given in Appendix 2C.

Leaf rust data were obtained from 13 sites. The number of lines of bread and durum wheats which were resistant at all locations is too large to list separately. However varieties resistant to leaf rust and to at least one other major diseases—stripe rust, stem rust, or *Septoria tritici*—are presented as a multiple disease-resistance list in Appendices 3A and 3B. Leaf rust of barley caused by *Puccinia hordei* was severe in Morocco and all lines were considered susceptible. Lines that were less severely attacked and that possess a degree of resistance to another disease are listed in Appendix 3C.

The only site providing adequate screening for *Septoria tritici* was Tunisia. Many entries had good resistance. The results confirm the previous years' extensive tests. Entries with resistance to *S. tritici* and resistance to one or more of the rusts are shown in Appendices 3A and 3B.

Valid data on the occurrence of other less destructive diseases were not obtained during the past year.

A similar nursery known as the Latin American Disease and Insect Nursery (LADISN) is now in its second year in the countries of the Western Hemisphere. The better lines emerging from one regional nursery should be placed in the other one to provide a global interchange of plant breeding efforts.

CIMMYT consultations. In 1973, the CIMMYT core wheat staff spent about 500 man-days consulting with governments and research personnel in wheat producing countries of Asia, Africa, and Latin America. Such activities include assessing the research programs; giving suggestions for improvement; conveying information on not only wheat, barley, and triticale, but on other crops; and advising where materials or information is available. Considerable time was spent in research planning seminars, in discussion with farmers on problems they face in increasing production, and with national policy makers on fertilizer supplies, grain prices, grain storage, national research planning, and so forth. In addition, members of CIMMYT outreach staff in other countries provided considerable time outside the countries in which they are stationed for similar activities.

These activities also helped acquaint staffmembers with problems for which breeding is required and gave them a better appreciation of the needs in training young scientists from those countries. While a good deal of staff time is required, these activities are an integral part of the *raison d'etre* of the international center.

MOROCCO

For the past 4 years the Morocco Ministry of Agriculture has been assisted by CIMMYT, the U.S. Agency for International Development, and the Near East Foundation in the technical development of its cereal improvement project.

During 1972/73, two CIMMYT scientists, Dr. W. Hall and Dr. A. Acosta, completed a 4-year assignment with funds supplied by USAID. This project was implemented through a committee of the Moroccan Ministry of Agriculture.

Rainfall in the 1972/73 season was generally low. A few areas such as the Fes area in the northeast, received higher than average rainfall, but this was exceptional. Distribution of rainfall was important. For example, in the Fes and Merchouch areas, rainfall was well spaced and at no time did fields show noticeable symptoms of drought. At Sidi Kacem, on the other hand, rainfall was not only low but was poorly distributed over the growing season. As a consequence, much of the crop ripened prematurely. Temperatures were quite favorable for plant growth throughout the country. Estimates prior to harvest indicated a total wheat production of 900,000 tons which would be somewhat less than the previous year.

Breeding research. Over 9100 entries of spring type bread wheat were grown. About half was homozygous material including a wide range of genetic material. In addition to the bread wheat, 602 entries of durum wheat were tested. Again these represented a half-and-half split between homozygous lines and heterozygous populations. In triticale, the International Triticale Yield Nursery was

Mr. Benjoulous and Mr. Tegey, Moroccan wheat scientists show wheat materials in the Guiche nursery to Dr. A. Acosta, right, of the CIMMYT outreach staff.

tested. In barley, 128 lines derived from various sources were grown.

Experimental materials were tested at five rainfed stations and at two locations under irrigation. Together these stations gave a good representation of conditions in all parts of the wheat-growing areas of the country.

Wheat populations, lines, and varieties were received from CIMMYT-Mexico, Algeria, Turkey, ALAD-Lebanon, Chile, Netherlands, Yugoslavia, FAO-Cairo, Purdue University Hessian Fly Program, Portugal, Rothwell Plant Breeders, England, and from other sources.

Nursery growth and development. The nurseries developed well except at Sidi Kacem where drought conditions accelerated growth, consequently reducing tiller and head development and interfering with grain development because of premature ripening. Good rainfall distribution and good soil management ensured a good nursery even at locations where rainfall was materially below average. At Merchouch, for example, nursery growth was excellent.

Diseases and insect pests. Yellow rust, leaf rust, and stem rust appeared in that order. On the whole, however, the rusts were of little importance since only the very susceptible varieties were attacked severely. Certain varieties were, however, killed outright by leaf and stripe rust. *Septoria tritici* was light compared with epidemics that have occurred in previous years, but it was present in sufficient intensity to screen materials on a resistant-susceptible basis. The dry conditions of the season were unfavorable for its development.

Mildew developed well at the Guiche (Rabat) station where striking differences were observed among the entries in the Regional Disease and Insect Screening Nursery.

Attacks of sawfly and Hessian fly occurred at the Merchouch and Sidi Kacem stations but these were less severe than normal. At the beginning of the season, ants caused some damage at these centers, resulting in reduced stands.

Table 26. **Best yielders at three rainfed and two irrigated stations. Morocco, 1972/73.**

Variety or cross & pedigree	Rainfed yield, t/ha			Irrigated yield, t/ha	
	Merchouch	Fes	Sidi Kacem	Marrakech	Beni Mellal [c]
Maghreb 73 [a] II-21419-288	5.6	4.0	1.7	4.4	4.0
Son64-Kl. Rend/Bb "S" 26804-6y-1M-0Y	5.3	3.7	1.9	5.1	5.0
S227xFAO 215-1-2 Jit-45-9L	4.5	4.7	1.5	6.0	5.1
Cno-INIA "S" x Bb 28339-ITY-4M-2Y-0M	4.6	4.6	1.6	4.0	5.3
Merchouch 73 [b] 30350-IM-2Mch-1Mch-0Mch	4.9	3.7	1.8	5.7	4.8
Zambezi	4.2	4.1	1.8	5.0	4.2
(Cno-Son64) NP880-PJ62xCal 30511-32M-2Mch-1Mch-0Mch	4.9	2.6	2.4	5.4	—
Cal-CCxSon64-Nr 5752-H-3Y-0M-0Mch	4.5	3.5	1.8	4.5	—
P4160-Jus (Son64-Ktt2) (KlPet-Raf)	4.6	3.4	1.8	—	—
PJ62xCal 30403-15M-1Mch-1Mch-0Mch	4.6	—	1.8	—	—
Cno-Note 66 25111-6M-7Y-3M-0Y	4.2	—	1.9	5.9	4.6
Siete Cerros 66	4.6	3.9	1.7	5.2	4.3
Potam 70	5.0	3.4	1.7	5.5	4.8
Pato x Cno "S". Tob 66 30524-6M-2Mch-4Mch-0Mch	4.8	2.1	1.6	6.7	—
BT-908	3.2	2.6	1.3	3.4	3.8

a/ $MY54_E$xLR/H490 (LR64xTzpp-Y54) *b/* INIA.67 (TZpp-Son64xNapo 63) *c/* Station Cotonniere.

Chemicals controled the damage. Rats and wild boars caused occasional damage.

Activities of Moroccan scientists. Several of the field assistants (*adjoint techniques*) trained at CIMMYT took over a major part of the responsibility in plot supervision and care. Mr. Ali El Alaoui was active in all parts of the wheat program.

Mr. Hamdali was outstanding in his care of the nurseries at Menara (Marrakech) and the Jema-Shaim stations. He conducted the entire wheat research for those centers. Mr. Aomar El Kotbi and Hassan Laasmi conducted the program at Merchouch and had excellent nurseries. Mr. Brahim El Cadi assisted in the planting at Sidi Kacem and took care of the international nurseries sown at Guiche.

The directors of experiment stations at Merchouch, Sidi Kacem, Marrakech, Beni Mellal, and Sidi Allal Tazi have all contributed immensely through their enthusiasm and interest to the success of the program. A number of other Moroccan scientists assisted in different parts of the season with program activities.

Three additional Moroccan scientists went to Mexico for training during the course of the year. On their return it is expected that these three men will take up positions in breeding, pathology, and cereal chemistry.

Extension. Several field days were held at different centers on new varieties and wheat production problems. Students, extension workers, farmers, teachers, and officials of the Ministry of Agriculture participated.

Experimental results. The 13 highest yielding experimental bread wheats are compared with the check varieties Siete Cerros 66, Potam 70, and BT 908 in Table 26. Maghreb 73 yielded well at all stations. Yields of all varieties were low at Sidi Kacem, but, considering the severe drought, such results were not unexpected. (Cno-Son 64) NP880-Pj62 x Cal produced well under drought and also showed good potential under irrigation. Potam 70 yielded well. The yields of all varieties in Table 26 show a 20 to 40 percent yield advantage over the main commercial variety BT 908. These varieties had reasonable to good tolerance to septoria and can be safely grown in the higher rainfall regions of the country.

Certain varieties such as Pato x Cno "S" - Tob 66 excel under irrigation. The drought conditions at Sidi Kacem permitted selection of drought-resistant types and definite genetic differences were observed. Some varieties in Table 26 show a 20 percent yield advantage over the high yielding check, Siete Cerros, nearly all others produced approximately equal amounts of grain.

Table 27. **Yields of five varieties that have been tested in Morocco during two or three seasons at five stations.**

Season	Rainfed yield, t/ha Merchouch	Sidi Kacem	Fes	Avg	Irrigated yield, t/ha Marrakech	Beni Mellal	Avg	Sidi Kacem septoria reading
			Menara 73 [a]					
70/71	4.5	––	4.5	4.6	––	––	––	8
71/72	4.8	3.7	4.9	4.5	5.7	4.9	5.3	
72/73	5.1	1.9	––	3.5	6.3	4.6	5.5	
Avg	4.8	2.8	4.7	4.2	6.0	4.7	5.4	
			Sika 73 [b]					
71/72	4.5	3.7	5.1	4.4	4.0	3.5	3.7	5
72/73	5.1	1.8	4.0	3.6	4.1	––	––	
Avg	4.8	2.7	4.5	4.0	4.0	––	––	
			Kourifla 73 [c]					
71/72	5.0	3.8	––	4.4	5.3	4.1	4.7	5
72/73	5.0	2.0	3.7	3.6	4.3	––	––	
Avg	5.0	2.9	––	4.0	4.8	––	––	
			Agadir 73 [d]					
71/72	4.6	4.3	3.9	4.2	4.4	3.2	3.8	5
72/73	4.9	2.0	––	3.5	5.4	3.7	4.5	
Avg	4.7	3.1	––	3.8	4.9	3.4	4.2	
			BT-908					
70/71	3.2	3.9	3.7	3.6	3.3	––	––	––
71/72	3.4	3.2	3.5	3.4	4.4	2.6	3.6	
72/73	3.2	1.3	2.6	2.4	3.4	3.8	3.6	
Avg	3.3	2.8	3.2	2.9	3.7	3.2	3.6	

a/ CC-INIA "S" (23528-7M1T-1M-8Y-0M) *b/* Napo 63 x Tzpp-Son64/8156 (R) (28071-7M-3Y-3M-0Y) *c/* 12300 x LR64-A-8156/Nor 67 (30842-31R-2M-2Y-0M) *d/* Bb 4 (R) Resel (23584-26Y-2M-3Y-2M-0Y-300M)

The variety Menara 73 has been among the highest yielders in the past 3 years, and Sika 73 and Agadir 73 for the past 2 years (Table 27). All have been quite consistent over stations. Kourifla 73 and Agadir 73 performed well under moisture stress. Sika 73, Kourifla 73, and Agadir 73 show good tolerance to *Septoria tritici.* Sika 73 and Kourifla 73 are recommended for increase and distribution in areas of higher rainfall. Although Menara 73 and Agadir 73 can also be sown in these areas, they should be sown in the second half of December. These two varieties probably will perform best under irrigation in southern Morocco.

The varieties listed in Table 28 have been selected and tested under Moroccan conditions for 4 years. In addition to promising yield potential, they show good tolerance to septoria. The varieties have striking differences in adaptability. Varieties 1, 2, 3, 4, 5, and 11 show good yields in all locations. Others, such as 12 and 13, yield well only under irrigation and even here they are better adapted at Beni Mellal than at Marrakech. The better lines of this group can be considered for increase after an additional year of testing.

A total of 177 individual lines were bulked at harvest for inclusion in the yield tests of next season.

A total of 1291 lines from F_3 to F_7 were selected from segregating bread wheats lines at Merchouch and Sidi Kacem. In the durums, 147 lines from F_3 to F_5 were selected. These materials form a continuation of the flow of lines into the yield tests after further selection.

The better lines and varieties selected from the various international nurseries are listed in Table 29.

Among the 10 two-row barley varieties submitted by Rothwell Plant breeders, I,II,III,IV,V,VI, and VII had the best yield and disease resistance (Table 30). Varieties I,II,IV, and V had superior agronomic type. They should be tested and reselected under a wider range of conditions.

Seed supplied to other programs. The best homozygous materials selected during 1971/72 were distributed to Algeria, Tunisia, Lebanon, and Mexico for use in those programs and to test under a wider range of environmental and disease conditions.

Date of seeding. Fourteen varieties including four check varieties were grown in date-of-seeding trials. The experiment was conducted at seven stations of the Agricultural Research Division. Four biweekly sowings were made beginning November 15 and ending January 1. The results were complicated by the onset of hot winds in the maturing period, the incidence of disease particularly septoria, the differing lengths of maturity of the varieties, and varietal susceptibility to disease. Infestation of insects such as the Hessian fly may also have played a role. In 1972/73, on the average, the highest yields were obtained at Fes from the November 15 sowing; at Merchouch, Sidi Kacem, Souilha, and Sidi Allal Tazi from the December 1 sowing; at Tassaout from December 15 sowing; and at Afourer from January 1 sowing.

The results vary somewhat from year to year at the different locations, but in general in Morocco the later maturing varieties should be sown early. The earlier maturing varieties can be sown at a wider range of dates, but should be used when seeding must be done late. In a septoria area, sowing of susceptible varieties should be delayed to escape much of the damage.

Rate of nitrogen application. In studies of rate of nitrogen application, 0 to 160 kg/ha N at 40-kg increments was applied at non-irrigated locations and from 0 to 200 kg/ha N at irrigated locations.

An attempt was made to place the experiments on land where a major response could be expected. This, however, worked to the detriment of yield this year at locations where the previous crop had exhausted much of the soil moisture. With increasing nitrogen fertility, short plants increased in height by a minimal amount whereas the height

Table 28. **Yield of most promising lines in six-row plots at five stations. Morocco, 1972/73.**

Variety or cross & pedigree	Rainfed yield, t/ha			Irrigated yield, t/ha	
	Merchouch	Fes	Sidi Kacem	Marrakech	Beni Mellal
1. Tob-Cno "S" x 7c cm-1257-1MK-0Mch	4.9	4.4	1.2	5.3	5.6
2. FuryxTob"S"-NP/Son64-KlRend 5313-K-6Y-1M-0Mch	4.7	4.5	1.5	6.7	4.5
3. CnoxNar-Chris "S"/Tob-8156xCno "S" 1223-2K-0Mch	4.6	—	1.4	7.3	4.8
4. Cno-Son64/Tob-CfnxBb 1212-0M-9MK-0Mch	3.9	—	2.3	5.6	6.5
5. Fortuna-7C 34204-1Mch-1Mch-0Mch	5.1	—	2.2	5.6	4.2
6. (Tzpp-Son64xNp63)INIA 30412-14M-2Mch-1Mch-0Mch	5.8	—	1.4	3.5	4.3
7. Pato x Cno "S"^{2}. Tob66 30524-2M-2Mch-1Mch-0Mch	5.5	—	1.3	1.7	3.2
8. CC-INIA (CnoxEl Gau-Son64) 30565-57M-1Mch-2Mch-0Mch	4.8	—	1.4	3.8	5.6
9. CC-INIA (CnoxEl Gau-Son64) 30565-1M-2Mch-1Mch-0Mch	4.2	2.9	1.4	2.8	5.4
10. CC-INIA x 23584 30566-9M-3Mch-2Mch-0Mch	5.7	—	2.0	3.2	5.4
11. 23584 x Gallo 30590-11M-1Mch-2Mch-0Mch	5.5	4.3	1.4	5.1	4.6
12. (U-SKxSan Past) Mara (Cno "S"-Son 64)	3.0	—	1.3	1.4	5.9
13. Cno "S"/Tzpp-Son64xNp63	1.9	—	0.9	2.8	5.8
14. Potam	4.6	—	2.0	4.0	4.8
15. Siete Cerros 66	4.4	4.1	2.7	2.4	5.2

Table 29. **Best yielding varieties and lines from the international wheat, durum, and triticale yield nurseries. Morocco, 1972/73.**

Variety or cross	Origin
9th ISWYN	
Zaafrane	Tunisia
Parana 68/1116	Argentina
INIA 66	Mexico
Bb-INIA	Mexico
Tanori 71	Mexico
Calidad	Mexico
Marcos Juarez INTA	Argentina
Sonalika	India
(21931/CH53-AnxGb56) An64	Israel
WW15^2/Pj62-Gb56xTzpp-Nai60	Australia
Tob-8156	Ethiopia
Moti	India
Giza 155	Egypt
(Local check) (BT-908&BT-2306)	Morocco
4th IDYN	
Anhinga	Mexico
Crane A	Mexico
Jo "S"-Cr "S"	Mexico
Gab 125	Italy
Cocorit 71	Mexico
Inrat 69	Tunisia
Yemen	Yemen
Crane B	Mexico
T. Dic Vernum	Mexico
(Local check) BD-2777	Morocco
ITYN	
Aries	
INIA-Arm "S"	
Maya II x Arm "S"	
Armadillo 122 PN	
(Local check) BT-908	

Table 30. **Yield and disease reaction of some barley varieties grown at Merchouch station. Morocco, 1972/73.**

Var. no.	Yield t/ha	Rust leaf	Reaction Yellow	Reaction to: leaf blotch	Reaction to: Scald
I	4.9	T-MR-R	0	0	0
IV	4.3	T-MR-R	0	0	5 %
II	3.9	0	0	T	T
III	3.5	0	0	0	0
V	3.5	T-R	0	R	0
VII	3.4	T-MR	R	H. Teres=MS	5 %
VI	3.1	T-R-MR	0	0	T

of tall varieties increased markedly. Figure 9 illustrates the effect of preceding crop and moisture reserves. At Merchouch in 1973 the experiment was sown on safflower land with little moisture reserve in a year of low rainfall. In 1972 the experiment was sown after safflower but in a year of above average rainfall. In 1971 the crop followed wheat and there was adequate moisture. In 1973, maximum yields were obtained at 40 kg/ha N whereas in 1972 response continued up to 160 kg/ha N and in 1971 up to 120 kg/ha N. Thus, in assessing the rate to be recommended for dryland agriculture, the preceding crop and the moisture status must be considered carefully. The shorter varieties in the experiment showed response to a higher level of nitrogen than the taller, as expected.

At Sidi Kacem, under limited rainfall, the yields were low. In spite of this, the dwarf varieties yielded 0.5 to 1.0 t/ha more than the best tall variety at rates up to 80 kg/ha N. At Fes, where the basic fertility was high and distribution of moisture through the season was good, Cajeme responsed up to 80 kg/ha N whereas all other varieties showed no response or a negative response to nitrogen.

At Tassaout, under irrigation, all varieties under test gave a near straight-line response to increasing nitrogen up to 120 kg/ha. Thereafter the yield of tall varieties began to decline and the dwarfs continued to increase up to 200 kg/ha N. Even at zero nitrogen the dwarf varieties were, without exception, higher in yield. At another irrigated site, Afourer, where the crop was late seeded after cotton, both tall and short varieties responded up to 120 kg/ha N while the stronger strawed ones continued increasing in yield up to 200 kg/ha N.

In all, this experiment was conducted at seven locations. Among the varieties tested, Cajeme, var no. 149, and Potam gave the greatest response to increasing levels of nitrogen. Generally speaking, Potam did not respond to as high rates as Cajeme. Varieties 908 and 2777 showed the least response to nitrogen. Potam, Cajeme, and var 149 (a durum x bread wheat derivative) were the highest yielding at all the dryland stations as well as at the irrigated stations. Tobari and Cocorit were the next highest and were slightly superior to 908. The durum variety 2777 (a selection of Kyperounda) was the lowest yielding variety in the test.

It is significant that the dwarf varieties at all rainfed stations had higher yields than the tall varieties at all levels of fertility. The idea that dwarf varieties require high levels of fertility is incorrect, but they are able to respond and produce higher yields at higher fertility levels. These tests were conducted under some of the driest conditions to which wheat is subjected.

Rate of seeding. Six varieties were sown at 60,80,100, and 120 kg/ha at six stations, four rainfed and two irrigated. The below-normal rainfall of 1973 favored the lower seeding rates. Under these conditions 60 to 80 kg/ha appeared equal to higher rates. In 1971, however, similar results were obtained in a year of relatively good moisture. It appears, the, that a lower seed rate can be safely recommended.

Although at stations that had higher soil moisture the 120 kg/ha showed some advantage over 80 kg/ha, the differences in varieties at different seed rates appeared to be similar at the different levels. Cajeme, Potam, and 149 were again the highest yielding of the group. Increased seed rate did cause an increase in the number of plants and number of heads per square meter up to 120 kg/ha.

Weight per thousand kernels tended to decline at most stations as seed rate increased. It is apparent that the plants of these varieties have a distinct ability to yield equally at different seed rates through readjustment in tillering and grain and head size.

ALGERIA

The year 1972/73 marks the second year of research results of the Algerian Cereal Project in which CIMMYT is directly involved. Technical assistance in this project is provided by three cooperating agencies each of which is charged with a specific section of the program.

CIMMYT personnel are responsible for all phases of cereal research, preliminary multiplication of cereals through foundation seed and research in the introduction of an annual medic-cereal rotation. Four CIMMYT scientists are stationed at three regional centers covering the production areas. The area involved reaches 150 km inland from the Mediterranean and 1000 km east to west from the Tunisian to Moroccan borders. Financial support is provided by the Ford Foundation.

FAO is responsible for all extension and demonstration work with cereals. Four agronomists are stationed in the major cereal regions.

French technical personnel of Caisse Centrale de Cooperation Economique in three pilot zones in cooperation with Algerian regional agricultural centers. They provide assistance in the placing of demonstrations on pilot farms

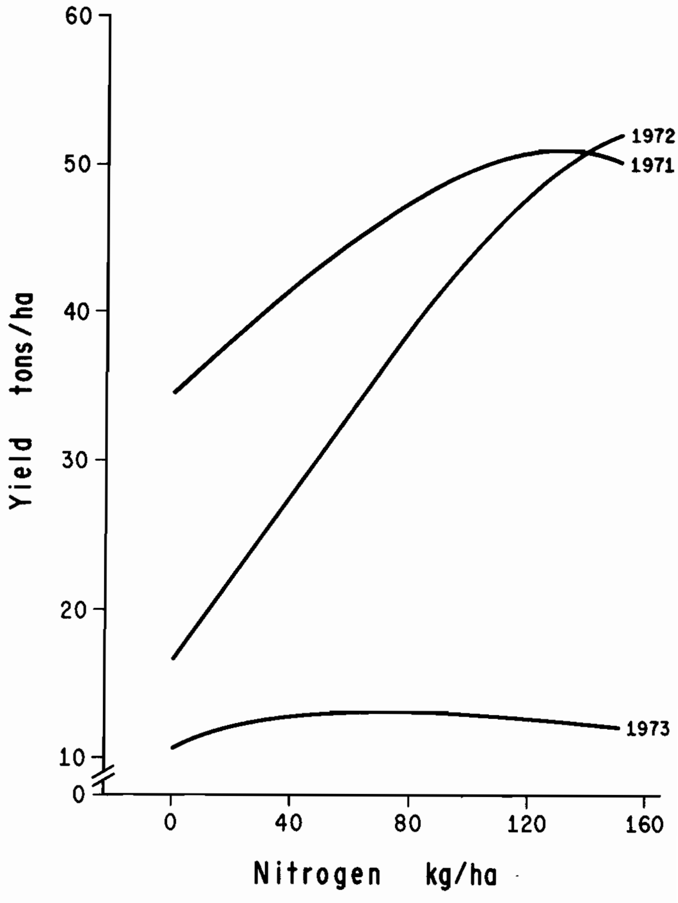


Fig. 9. Average yield of five varieties (Potam, Cajeme, Cocorit, 908, and 2777) in rate-of-nitrogen experiments. Merchouch, Morocco, 1971-73.

using recommended practices and advising on the growing of cereals in the pilot regions.

Weather. Virtually all cereal production in Algeria is rainfed. In the 1972/73 season, rainfall ranged from below average in the south to above average in the coastal region near Algiers. Of great importance was its maldistribution. The onset of adequate rainfall was delayed, resulting in late seedbed preparation and seeding and, thus, preventing weeding before seeding.

Once rains began, there was a heavy concentration in the December-to-March period which delayed wheat development and favored weed growth particularly the grassy types. Further, the wet soil prevented timely ground application of herbicides in large areas. The damage caused by heavy weed competition was compounded by late maturity and subsequent heat damage in May and June. There was some frost damage in early-seeded wheat on the high plateau. The long, cool winter and spring were followed in late April by the onset of widespread hot southerly winds which caused premature ripening and shrivelled grain in late-seeded, lower elevation plantings and the normally late wheat of the high plateau. In this region large areas were totally destroyed.

Commercial production. Of the 3.2 million hectares of cereals sown in Algeria in 1972/73, there were approximately 750,000 hectares of bread wheat, 1,500,000 hectares of durum wheat, 840,000 hectares of barley, and 60,000 hectares of oats. Taking wheat as a whole about 25 percent was sown to high yielding varieties—about double the amount in 1971/72. But because of adverse weather and weed infestation, wheat production was down from the 1971/72 level of 2.6 million tons to an estimated 1.3 million tons in 1972/73. Substantial imports will be required to bridge this production gap.

The introduction of improved varieties had proceeded very rapidly. In the 1969/70 season the first improved varieties were sown on 5000 hectares. Because of their superior performance, the area rapidly increased to 140,000, 320,000, and 600,000 hectares in the following 3 years.

In 1972/73, 480,000 hectares of high yielding bread wheat varieties were planted. Seventy percent was Siete Cerros 66, 25 percent was INIA 66, and 5 percent was Tobari. The Italian variety Strampelli has yields equal to those of Siete Cerros, but it is still in the seed multiplication stage. In the durum wheats about 120,000 hectares were sown to Jori 69, a high yielding variety whose seed was imported in 1972.

With the increase in plantings of high yield varieties, use of nitrogen and phosphorus has increased, too, and the major portion of the area under high yielding varieties has been receiving the recommended applications. Domestic production of these fertilizers as well as imports have been rising rapidly.

Diseases and pests. Diseases were not a serious factor in reducing yields. *Septoria tritici* appeared on early plantings in certain areas, but dry weather in April prevented its further development. Similarly rusts did not develop to a damaging level. Insect damage was confined to localized outbreaks. Sawfly, stink bugs, and wireworm caused some losses. Birds continued to do extensive damage in early maturing varieties particularly near roosting sites.

Seed production. With the increased commercial production of high yielding vareities, the CIMMYT technical staff has emphasized improved production and processing of seed. CIMMYT personnel will help direct early generation multiplication and train Algerian personnel to operate an expanded seed production program.

Production management research. Twenty varietal demonstrations which received the recommended fertilizer applications and weed control practices were sown on state farms with land preparation done by the farm. Thirty-six varieties of wheat and four varieties of triticale were sown with 16 to 20 varieties at each location. The varieties used were derived from the Algerian National Program and from Mexico, Tunisia, France, Yugoslavia, Italy, and USA. A limited supply of seeds of certain varieties restricted their use to only a few trials.

The results obtained from these trials reflected the adverse weather conditions (Table 31). High yielding varieties yielded 1.9 to 2.8 t/ha while local varieties gave 1.7 to 1.8 t/ha. Half the demonstrations failed to average 2 t/ha. Only the yields of varieties grown at five or more locations are included.

In general the early varieties were superior except in areas affected by frost damage. Cajeme 71 suffered severe frost damage in several locations. Soltane which is a few days later suffered much less. Test weights were low at several sites because of premature ripening and late drought. The later varieties were more damaged from drought, with shrivelling of grain accounting for lowered yields.

Strampelli, which is a few days earlier in maturity than Siete Cerros, had the best yield record of varieties sown in the largest number of locations. It is under large-scale seed multiplication and will be recommended for the high plateau region along with Siete Cerros 66 and also in the coastal high-rainfall region where its resistance to septoria gives it a decided advantage. Soltane is being increased as a replacement for Tobari 66 and INIA 66. It has wide adaptation and is septoria tolerant. Era may have a place on the high plateau when seeded early. Zaafrane and INIA 66 gave excellent yields but were tested only in regions where they are known to be well adapted. At these same locations Soltane was equal to Zaafrane in yield and superior to INIA 66. Siete Cerros 66 was damaged by the Sirocco to a greater degree than Strampelli or Soltane.

Cajeme 71 and Yecora 70 were included in most of the demonstrations. Their short height makes them unsuitable for much of the rainfed area primarily because they are less competitive with grassy weeds and also because their short height causes harvesting problems. The two-gene height is better for rainfed culture. The yield of these two varieties was mediocre, but in some demonstrations under higher rainfall they were top yielders when septoria was not present.

Cocorit 72 and Jori 69 were outstanding among the durums. Capeiti and Inrat 69, however, yielded better than the local variety Inrat 69 has a limited region of adaptation. It does well in the 400 to 500 mm rainfall pattern below 500 meters elevation. Jori 69 is too short in regions of less than 400 mm rainfall and is very susceptible to septoria. Cocorit 71 is a little taller, has wider adaptability and disease resistance, and is equal to or better than Jori 69 in yield. It is now being increased for commercial production. The somewhat lower quality of Cocorit is likely to provide it a short useful life and it is likely to be replaced by new varieties that have better yield and quality. Capeiti is earlier maturing than local varieties, and does well in poor soils and under conditions which limit the productivity of the high yielding types.

Cinnamon triticale was tested in eight trials. It outyielded Oued Zenati by 30 percent. The test weight was poor, however, averaging 10 kg/hl below that of wheat. Triticale needs further testing in comparison with barley as a possible feed grain and its rapid growth may make it attractive for cereal pasture. As improvements are made in the triticales, they may replace a part of the durum plantings in the dryland areas.

Table 31. **Yields from demonstration trials. Algeria 1972/73.**

Variety	Source	Demonstrations (no.)	Yield t/ha	Relative to check, %
		Bread wheat		
Zaafrane	Tunisia	7	2.84	166
Inia 66	Mexico	8	2.22	137
Strampelli	Italy	19	2.27	136
Soltane	Tunisia	18	2.35	126
Siete Cerros	Mexico	20	2.02	120
Tobari 66	Mexico	16	2.06	119
Cajeme 71	Mexico	16	1.90	119
Yecora 71	Mexico	11	2.04	115
Era	USA	5	2.23	118
Utique	Tunisia	9	1.84	110
Fletcher	USA	9	1.59	101
Mahon Demias	Algeria	17	1.73	100
		Durum wheat		
Jori 69	Mexico	18	2.11	134
Cocorit 71	Mexico	20	2.12	130
Capeiti	Italy	16	1.93	119
Inrat 69	Tunisia	17	1.87	115
Mendos	France	6	1.71	114
Montanari	Italy	6	2.26	113
Ranieri	Italy	7	1.90	111
Oued Zenati	Algeria	16	1.78	100
		Triticale		
Cinnamon	Mexico	8	2.35	130

Table 32. **Yields of new improved varieties in comparison with local checks. Algeria, 1972/73.**

Variety	Trials avg. less than 2 t/ha Locations no.	Yield t/ha	Relative to check, % at same locations	Trials avg. 2 t/ha or more Locations no.	Yield t/ha	Relative to check, % at same location
Strampelli	9	1.45	107 [a]	9	3.07	146 [a]
Siete Cerros 66	9	1.37	100 [a]	10	2.89	133 [c]
Soltane	9	1.59	117 [a]	10	3.04	146 [c]
Tobari 66	8	1.43	100 [a]	8	2.76	134 [c]
Cajeme 71	8	1.28	96 [a]	7	2.88	141 [c]
INIA 66	—	—	—	5	2.77	143 [c]
Zaafrane	—	—	—	5	3.40	156 [c]
Cocorit 71	8	1.37	123 [b]	10	2.84	131 [d]
Jori 69	6	1.15	125 [b]	10	2.92	134 [d]
Inrat 69	6	1.10	113 [b]	10	2.46	113 [d]
Capeiti	7	1.30	125 [b]	8	2.70	116 [d]

a/ Check variety: Florence Aurore. *b/* Check variety Oued Zenati or Mohamed B. Bachir.
c/ Check variety: Mahon Demias or Florence Aurore. *d/* Check variety: Oued Zenati.

Improved varieties showed superiority in trials where the average was above 2 t/ha. At this level they averaged 0.7 to 1.2 t/ha above the local varieties. When the average yield level was below 2 t/ha, all varieties showed about the same yield. The real value of improved types is shown when management and climatic conditions are conductive to high yield. Table 32 emphasizes the importance of good management in realizing the benefit of the high yield ing varieties. Although continued varietal improvement is being made, the major improvement in yield in Algeria will come from improving cultural practices, land preparation, weed control, and timely seeding. Present varieties are quite capable of giving twice the current production.

Fertilizer experiments. Four experiments were harvested in which date and rate of nitrogen application were compared. Nitrogen was applied all at seeding, all at tillering, or in a split dose at seeding and at tillering. Ammonium nitrate was the source. Three of the four trials gave a significant response to nitrogen (Table 33). Date of application showed no significant differences.

Table 33. **Yield of wheat at different rates of N at four locations in the 400-500 mm rainfall pattern. Algeria, 1972/73.**

Location	Variety	Yield t/ha ON	33 kg/ha N	67 kg/ha N	100 kg/ha N
Beni Slimane	Siete Cerros 66	2.30	2.82	2.73	2.91
Bouira	Stampelli	2.48	2.67	2.69	2.71
Sfisef	Siete Cerros	2.84	3.11	3.40	3.60
El Asnam	Siete Cerros 66	2.07	1.81	1.97	2.07

Fertilizer trials for the past 2 years in Algeria and for 4 earlier years in Tunisia indicate, first, that date of fertilizer application does not normally influence wheat yields significantly when application is made at seeding or tillering or in a split dose. Further, there appears to be no advantage to splitting the application in areas where rainfall is below 550 mm. Second, the preceding crop has a pronounced effect on wheat yields. Such crops as oats and vetch for hay, vetch for seed, sunflowers, wheat, and chickpea tend to deplete nitrogen. After these crops there is a marked nitrogen response. When wheat follows melons, potatoes, sugar beets, peas, tomatoes, or green manure, residual nitrogen tends to be higher and nitrogen response is low.

In regions with below 550 mm rainfall, all nitrogen should be applied before seeding wheat. For uniform spreading, applications should be made with a fertilizer spreader. The rate should be based on the expected residual from the preceding crop. These steps will improve the efficiency of nitrogen use and improve the uniformity and timeliness of application.

No further work is planned by the CIMMYT team on fertilizer application on wheat in Algeria. Enough results are available to provide recommendations. There are, however, other sections of the cereal project working on fertility problems.

Date of seeding. Heavy rainfall in December and January prevented the seeding of all dates in date-of-seeding experiments. At El Khemis a trial of five varieties sown at two dates was grown. Although total rainfall during the year was sufficient for high yields, its concentration in 4 months and the early onset of the sirocco reduced yields and hastened maturity. For these reasons, later seedings were lower in yield particularly with the later maturing varieties. Thus Soltane was only marginally affected while Siete Cerros, Fletcher, and Cocorit were much higher in yield for the earlier sowing (Table 34). Cajeme headed early and suffered frost injury in the first date of seeding.

At Bouira the fertilizer trial was sown 1 month before the varietal demonstration. Here the yield of Strampelli was 1.5 t/ha more in the fertilizer trial than in the demonstration. This can be attributed directly to seeding date.

Correct seeding time and choice of correct variety for a particular time greatly influence production of rainfed wheat. Longer duration varieties should be used in early seedings and shorter duration varieties in later seedings. This procedure overcomes the risk of frost and drought.

Herbicide trials. Preliminary experiments with herbicides were undertaken in 1972/73. Only a few treatments were possible because the chemicals arrived late, but the results indicate ways to improve testing and suggest what chemicals hold promise for further tests. The herbicide trials are designed to evaluate herbicides already in use. They were selected with the aim of extending the period in which they could be applied. The chemical 2,4-D, which is most widely used, can only be applied between the tillering and boot stage. If earlier applications could be made, the weed competition would be reduced and the use of spraying equipment could be prolonged.

In preliminary tests at five locations, several formulations of herbicides gave good control of broadleaved, dicotyledonous weeds when applied at the three- to five-leaf stage (tillering). All of these formulations were MCPA or MCPP combined with such herbicides as Dicamba, Bromoxynil, Ioxynil, Dinoterbe, and Dicuron. Each of these products costs two to four times as much as 2,4-D. Additional testing is required to compare their net returns with those of 2,4-D. When applied as recommended these chemicals had phytotoxic effect on the crop.

Table 34. **Yield of five varieties of seed sown at two dates. El Khemis, Algeria, 1972/73.**

Variety	Yield, t/ha Nov 21	Dec 19	Difference
Siete Cerros 66	2.06	1.68	0.38*
Soltane	2.00	1.84	.16
Cajeme 71	1.00	1.69	.69*
Fletcher	1.95	1.29	.66*
Cocorit 71	1.97	1.64	.33*
Avg.	1.80	1.63	.17
LSD (5%)	0.33	0.33	

Because wild oats are a major problem in Algeria, a chemical that controls wild oats would be very desirable if the price were reasonable. Suffix appears effective for this purpose when applied at the tillering to boot stage of the wild oats (Table 35). At all locations wild oats was the dominant weed although others were present. Suffix prevented seed development and stopped the growth of wild oats. The competition before and after the application of Suffix reduced its benefits. But the prevention of seed set extends the benefits from its use beyond the year of application. At 1972/73 wheat prices, an increase of 300 kg/ha will pay for the Suffix application.

Table 35. **Yield of Suffix-treated plots of wheat in comparison with untreated checks at four locations. Algeria, 1972/73.**

Location	Variety	Yield, t/ha Check	Treated	Increase, %
Guelma	Siete Cerros 66	2.06	2.60	27
El Khemis	Oued Zenati	1.10	1.46	33
El Khemis	Siete Cerros 66	0.73	1.10	51
El Asnam	Siete Cerros 66	1.10	1.62	46
Avg.		1.25	1.70	36

Table 36. **Yields of the best commercial bread wheat varieties over all experiment stations. Algeria, 1972/73.**

Variety	Trials, no.	Yield t/ha	Yield Relative to check, %
	Algiers		
Strampelli	8	4.3	133
Siete Cerros 66	8	4.1	126
Soltane	6	3.3	102
Florence Aurore	8	3.2	100
Avg	8	3.4	—
	Algiers and Guelma		
Strampelli	13	4.9	123
Siete Cerros 66	13	4.8	121
Soltane	9	4.1	104
Florence Aurore	13	4.0	100
Avg	13	4.0	—
	All trials at all stations		
Strampelli	29	3.1	113
Siete Cerros 66	29	3.1	113
Soltane	23	2.6	98
Florence Aurore	29	2.7	100
Avg	29	2.7	—

Table 37. **Best advanced lines from the screening nurseries at two stations, Guelma and El Kroub. Algeria, 1972/73.**

Line	Yield, t/ha Guelma	Yield, t/ha El Kroub
Cno x Son 64		
23582-12M-2Y-1M-0Y-0MB	4.3	2.4
CC-Cno"S"		
1125024-23M-3Y-0M-0MB	4.5	3.2
S948 x Mxp 65		
PK2834-6a-0a-0MB	4.2	2.7
Cal/Cno"S" x LR64^2 - Son 64		
27172-146M-3Y-1M-0Y-0MB	4.4	3.1
Napo 63 x Tzpp - Son 64/8156		
28071-7M-3Y-1M-0Y-0MB	4.5	3.7
Inia-Cal x Inia "S" - CC		
28647-67Y-1M-0M	5.2	2.7
Y50$_E$-Kal^3		
35188-5M(F1)-31Y-0M	4.3	2.4
Inia 66-RL4220 x 7C		
35038-7Y-1M-0Y	4.4	1.8
Tob 66 - B. Man x Bb		
25998-5B-3J-101J-4Y-1M-0Y	5.1	3.3
Son 64 x Tzpp-Y54/Tzpp-Son64A		
Mic63-1649-78	4.3	3.1
My54$_E$-Yt54AxNor 67	4.8	2.9
LR64-P4160^3$_E$ (BT 2354)	4.8	2.4
Cno "S" - Inia "S"		
23959-13T-1M-1Y-0M-0MB	5.1	2.2
Strampelli	4.9	2.0
Siete Cerros 66	4.8	2.3

In one demonstration, the reduction in yield from wild oat infestation was about proportional to the ratio of wild oats to wheat. At Tafraoui, near Oran, one replication of a 20-variety demonstration was infested with wild oats while the other replication was relatively free. A visual estimate of wild oats infestation was made at harvest. The visual estimate averaged 27 percent of stand and yield reduction came to 30 percent. These data support the previous data obtained in Tunisia where reduction in yield was proportional to percentage infestation.

The research is now focussed on management problems in wheat production. Methods of controling wild oats and other weeds by cultural methods will be the subject of research and demonstration. Better management practices in all crops of the rotations are necessary. The use of an annual medic in the wheat rotations will be a part of the overall management program.

Proper time of tillage and seedbed preparation will be emphasized to improve weed control, provide more timely sowing, establish better stands, incorporate herbicide applications, and improve moisture retention in the soil for higher wheat production.

Varietal improvement. The generally poor distribution of rainfall during the winter and spring of 1972/73, accompanied by continuous cool weather followed closely by the early siroccos, greatly complicated selection of the breeding materials at all stations. Nearly 95 percent of the large nurseries of winter and winter x spring crosses grown at Setif (1150 m altitude) were lost because of the siroccos. This region of the high plateau is subject to snow, late frost, early siroccos, and rainfall varying from 250 to 650 mm annually.

The breeding section of the cereal project was expanded in 1972/73 with the return of three additional young scientists from training in breeding and pathology at CIMMYT, Mexico. In the previous season bread wheat research was emphasized. This year the durum breeding work was increased and is expected to equal the bread wheat program in scope in the coming year. The commercial high yielding bread wheat varieties, Siete Cerros

66, INIA 66, and Strampelli, have defects, but they provide an opportunity to increase production while more disease-resistant, better-adapted varieties are developed. The introduced durum varieties are less adapted than those in the bread wheat class.

The triticale program was expanded to include screening nurseries and segregating materials. Several of the more promising lines are being tested in larger production plots.

Barley is an important crop. Much of it is consumed as livestock feed. The local varieties, Saida and Tichedrett, are well adapted and have good yield levels. For the present, barley improvement is confined to the selection, screening, and yield testing of segregating populations, lines, and varieties. There are large numbers of materials available and an immediate launching of a full-scale breeding program is not planned.

Bread wheats. The results of micro yield trials grown in 1972/73, which support the data obtained for the previous 2 years, are shown in Table 36. Strampelli and Siete Cerros 66 still have the best overall adaptation and yielding ability at both the high and low elevations. Although Siete Cerros 66 is recommended for use on the high plateau and in zones which have below 500-mm rainfall where septoria is normally of no consequence, Siete Cerros has moved into the higher rainfall areas because septoria attack has been light during the past 3 years. When seed supplies are adequate, Strampelli will be recommended as a replacement for Siete Cerros in these regions because of its septoria tolerance. The main weakness of Strampelli is its susceptibility to stem rust. Siete Cerros shows good stem rust resistance. Together, the varieties grown in the proper environments are complementary.

Soltane was not tested as widely in the micro trials and its yield was unexpectedly low considering its performance in the large-scale production trials and its performance in previous years. Soltane has good tolerance to *Septoria tritici* and stem rust. Although it has a lower yield potential than Siete Cerros or Strampelli it is being considered as a replacement for INIA 66 in low elevation, high rainfall regions. Soltane has good general adaptation and a good yield level, both of which will increase stability of production.

Screening nurseries for observation and disease evaluation were distributed to seven research stations in Northern Algeria. Conditions at only two stations, Guelma and El Kroub, were favorable for selection. The best lines at these stations are shown in Table 37.

Durum wheats. The durum wheats probably suffered more from the climatic fluctuations than did the bread wheats. Only at Guelma in eastern Algeria did conditions allow the expression of yield potential in the advanced lines and varieties.

Table 38 compares the better lines and varieties with the local variety Bidi 17. The two commercial varieties of Mexican durum wheats were the highest yielders, followed closely by two Anhinga "S" selections from Algeria. Cisne "S" which is a sister of Cocorit, also performed well. Under good climatic conditions these varieties and selections can express their true potential. Both Cocorit 71 and Jori 69 had as good adaptation as local varieties under stress. More than 100,000 hectares of Jori were seeded in Algeria this year and results were generally favorable. Cocorit 71 is only in its initial stages of multiplication.

Two selections from the screening nurseries were of particular interest for their agronomic type and yielding ability in relation to Cocorit: Gs"S"-AA"S" (D27660-6M-

Table 38. **Top yielding varieties and advanced lines from national durum yield trials at Guelma. Algeria, 1972/73.**

Variety or line	Yield t/ha	Relative to check, %
Cocorit 71	5.56	139
Jori 69	5.43	136
Anhinga "S" II	5.22	130
Anhinga "S" I	5.20	130
Cisne "S" D27617-21M-300Y-0B	5.18	129
Jo "S" - Cr "S" D27591-6M-4Y-0M	5.12	128
Cr "S" B D23055-56M-5Y-1M	5.02	126
66DM x 0329 - Jori "S"	4.93	123
Brant "S" I	4.87	122
Bidi 17	4.00	100

1Y-1M-2Y-1M-0Y) and D21563-AA"S" (D27625-5M-2Y-2M-1Y-1M-0Y).

Both lines have the same maturity range and plant height as Cocorit 71. Table 39 shows some of the promising lines received from Mexico and Tunisia.

TUNISIA

Overall the 1972/73 season was about average for cereal production. Seeding and emergence occurred under adequate moisture. From January to April heavy rains caused some flooding but little loss of crop. Waterlogged soil, however, interfered with topdressing of nitrogen and the application of herbicides.

After mid-April the rains stopped, and through May the virtual absence of rainfall caused moisture stress during the filling period. There were a few days of hot sirocco winds which increased the moisture stress and caused fairly general reduction of yield. Weather, therefore, had a considerable effect on the final production figures.

Table 39. **Promising durum wheat lines from Mexico and Tunisia selected in Algiers, Algeria, 1972/73.**

Line	Yellow berry %	Shriveling %	Yield t/ha
D70-5 BD1831xBD1771-BD1708	10	0	3.45
Cr"S"-F3 Tun x AA "S"/Fg "S" CM10200-1BK-0BK	0	20	4.39
DM71-126 (Stw63-Gll"S"/C18133-2HxCpt8) (Ga"S"/D. Buck x TM$_E$-Tc^2/Lak)	10	20	3.94
DM71-249 Jo "S"-Cr "S"xFg"S"	tr	5	3.94
DM71-250 Jo"S"xCr "S"x Cit "S"	40	5	3.82
D69-40-6A BD1706xkyp-Yra/BD1419/AD5x Mahon-Kokkini	5	40	3.75
DM71-103 Fg"S" (Jo "S"/LD357-Tc^2 x Gll "S"	0	10	3.56
D70-9 BD1831-BD1835	80	0	3.45
D69-73-8A BD1407AxBD1749	5	5	3.32

About 641,000 tons of durum wheat and 244,000 tons of bread wheats were produced for an overall total of 885,000 tons. This figure compares with an estimated 1.2 million tons harvested in the previous year.

The diseases of wheat were relatively unimportant during the season although some septoria damage occurred surprisingly in the normally dry and septoria-free region south and west of Tunis. Powdery mildew was widespread because of the exceptionally damp conditions and may have reduced yields somewhat. The new Tunisian durum variety Amel appeared less affected. Helminthosporium on barley was quite serious. Rhizoctonia on medicago was fairly widespread. The cereal cyst nematode, *Heterodera avenae*, was seen throughout the northern region, but its effect was much less than in the 2 preceding years probably because of high moisture conditions.

Frit fly, *Ocinella frit*, caused damage in a few early seeded fields. Hessian fly, *Phytophaga destructor*, caused only minimal damage in the southern parts of the country, and sawfly, *Cephus cinctus*, caused little damage. Cereal leaf beetle attacks were low.

Infestation of broadleaved weeds, wild oats, and annual ryegrass were severe. Inability to use chemical sprays because of the continuous and heavy rainfall was responsible for much of the deleterious effect.

AGRONOMY

Fertilizer. The results of fertilizer application were obscured by the lack of weed control. Only 30 percent of the experiments and demonstrations were treated with herbicides. In addition, the high rainfall led to nitrate reduction and leaching, and waterlogged soil. Eight trials on rate and date of nitrogen application were conducted on bread wheats. Yields ranged from 1.46 t/ha to 3.71 t/ha and averaged 2.58 t/ha. In 1971/72 these tests averaged 3.9 t/ha and in 1970/71, 3.0 t/ha. The reduction can be attributed primarily to excessive and poorly distributed rainfall.

The use of higher rates of nitrogen caused significant differences, but date of application appeared to have little effect provided fertilizer was applied up to late tillering. In general, yields at 133 kg/ha N were greater than at 67 or 90 kg/ha N. Applying nitrogen all at seeding or half at seeding and half at tillering made little difference. Application at seeding is easier and more uniform. Split application is advantageous when rainfall is scanty and the half level of application is sufficient to provide the plant with adequate nitrogen for the level of rainfall, hence the farmer has less fertilizer expense by not applying the rest.

Nitrogen trials with durum were conducted at three sites and two were successful. Results were similar to those with bread wheat. This year, however, Inrat 69 lodged at levels above 67 kg/ha N.

In most of these trials the semidwarf varieties gave better response to the higher levels of nitrogen. In the durums, Inrat 69 and Bedri outyielded the check at all levels. Only under high wild oat infestation did the taller varieties give better response to nitrogen than the shorter varieties since the wild oats used most of the nitrogen in competition with the wheats.

Dr. Torrey Lyons of the CIMMYT outreach staff explains the effect of chemical weed control on wheat in Tunisia.

Table 40. **Grain yields of wheat in relation to herbicide treatment at 6 locations (weed [a] intensity shown in parentheses). Tunisia, 1972/73.**

Herbicide [b]	Rate kg/ha a.i.	Yield, t/ha Smindja (v. low)	Bou Arada (v. high)	Bou Salem (high)	N. Dougga (high)	Beja (low)	Goubellat (v. low)	All locations	Locations with low weed pop.	Locations with high weed pop.
Control	—	3.71	2.34	2.74	1.61	2.61	3.79	2.80	3.37	2.23
2,4-D	0.6	3.24	2.51	3.62	1.64	3.00	3.88	2.98	3.37	2.59
MCPA 60	0.6	3.64	2.36	2.99	1.62	2.80	4.01	2.90	3.48	2.32
Printan 22L	c	3.64	2.95	—	1.93	2.92	3.93	3.07	3.50	2.44
Faneron	2.0	3.60	2.83	3.29	1.54	2.79	3.95	3.00	3.45	2.55
Certrole H	d	3.83	3.03	3.56	1.89	2.92	3.80	3.18	3.52	2.83
Tribunil	0.88	3.51	3.07	3.70	1.60	2.86	3.79	3.09	3.39	2.79
Tribunil	1.75	3.75	3.00	3.80	1.91	2.70	4.06	3.21	3.50	2.91
Tribunil	3.50	3.94	3.19	3.35	1.88	2.58	3.75	3.12	3.42	2.81
Dozanex	3.2	4.01	3.43	3.88	2.32	2.86	3.97	3.41	3.61	3.21
Dicuran	2.4	3.96	3.42	3.68	2.23	2.80	3.82	3.32	3.33	3.11
Dicuran granules	2.4	4.08	3.82	3.82	1.95	3.14	3.77	3.43	3.66	3.20
Dicuran +	2.0									
Tok [e]	1.5	3.71	3.60	4.26	2.22	2.93	3.73	3.32	3.46	3.36
Tok	3.0	3.64	3.03	3.70	1.81	2.67	3.85	3.12	3.39	2.85
Suffix +	1.2									
2,4-D [f]	0.6	3.84	3.61	3.79	1.90	3.11	3.86	3.35	3.60	3.10
Suffix	1.2	3.71	3.55	3.77	1.76	2.90	3.51	3.20	3.37	3.03
LSD (5%)	—	0.38	0.58	0.27	0.25	NS	NS	—	—	—

a/ Monocot infestations were primarily wild oats except at Nouvelle Dougga, where ryegrass was dominant. *b/* Applied at three-leaf stage of development of wheat except 2,4-D which was applied at start of jointing; MCPA at late tillering; Dicuran granules at one to two-leaf stage; Suffix + 2,4-D at end of tillering for Suffix and start of jointing for 2,4-D; and Suffix at end of tillering. *c/* 2.4 kg/ha chlortoluron-20 + 2.4 kg/ha MCPP-20. *d/* 0.42 Ioxynil-12 + 1.26 kg/ha MCPP-36. *e/* Mixture. *f/* Separate application.

Data taken on the effect of increasing nitrogen levels on number of heads per square meter, hectoliter weight, and 1000-grain weight using the varieties INIA 66, Cajeme, Soltane, and Florence Aurore indicate that most of the yield increase comes from the increase in heads per square meter and possibly in number of grains per head.

Nitrogen in the form of urea and as ammonium nitrate was compared in trials at three locations. Although there was no significant difference between the two forms, urea did give a somewhat higher yield. Since the effect seems equal the lower cost of urea for use at seeding makes it more attractive. Its volatility, however, makes it unsuitable for topdressing—then ammonium nitrate should be applied.

Check plots with and without phosphorus were grown at several locations. In previous years little response was observed. This year, however, application of phosphorus resulted in significant yield increases at several sites.

Benefit-cost studies were conducted on the data from two trials using INIA 66 and Inrat 69 to represent bread and durum varieties, respectively. These studies showed that under the present domestic price of fertilizers and grain, the use of nitrogen fertilizer is highly profitable.

Weed control. The weed control program is designed to demonstrate improved practices to growers while evolving information for improved recommendations. The project is coordinated with that of the Division de la Defense des Cultures and the Institut National de Recherche Agronomique de Tunisie.

In a practical demonstration on a farmer's field, three extra cultivations in preparing the seedbed gave wheat yields of 3.8 t/ha as opposed to 0.2 t/ha with the farmer's seedbed preparation. Results suggest that the use of a weighted drag harrow in the last cultivation is superior to the use of a disc or cultivator since the former does

Table 41. **Yields of wheat in six herbicide demonstration trials (wild oats infestation in parentheses). Tunisia, 1972/73.**

Herbicide [a]	Yield, t/ha Mateur (v. high)	Medjez (high)	Siliana (med)	N. Dougga (v. high)	Beja (med)	Jendouba (v. high)	All locations	Locations with Wild oat pop. med.	Wild oat pop. high
Non-treated	3.36	2.66	3.47	1.62	3.68	1.77	2.76	3.57	2.35
Dozanex	4.19	3.14	3.89	3.01	3.55	3.39	3.53	3.72	3.43
Dicuran	3.68	3.65	3.83	2.60	3.70	4.04	3.58	3.76	3.49
Suffix	4.53	3.37	4.16	2.11	3.65	3.19	3.51	3.90	3.30
Suffix + 2,4-D	4.62	3.60	3.93	2.04	3.42	3.20	3.47	3.67	3.37
2,4-D	3.36	3.09	3.48	1.61	3.56	2.33	2.91	3.52	2.60
Tribunil	3.53	2.89	3.79	1.71	3.60	3.40	3.15	3.69	2.88

a/ Rates and application times shown in previous table.

not raise new weed seeds to the surface. The large difference in yield resulted from reduction in weeds.

Herbicide trials were designed to evaluate new herbicide treatments, to establish the sensitivity of Tunisian varieties to herbicides, to demonstrate the effect of 2,4-D applied at different stages of wheat development, and to demonstrate the effect of different herbicide treatments.

To assess the economics of weed control it is necessary to establish what factors affect yield loss due to weeds. Three years' experiments have shown that moisture stress on wheat because of weed competition is a key factor. In 1970/71 when moisture stress occurred from flowering to maturity, the yield of wheat under heavy infestation of wild oats and broadleaved weeds at one site was 1.3 t/ha. Where Dicuran was applied yields were 2.3 t/ha. The loss of 1 t/ha was directly attributable to weeds.

In 1971/72 weeds caused little damage. Rainfall was well distributed and there was no stress during the growth cycle. Non-treated plots averaged 3.2 t/ha and the Suffix treatment for control of wild oats gave 3.2 t/ha. Similar results were obtained where non-treated plots were compared with 2,4-D for broadleaved weed control.

In 1972/73 the wild oat competition caused heavy losses, but broadleaved weeds did little damage. Moisture supply was high from January to mid-April. During this period broadleaved weeds went through to maturity and were overshadowed by the wheat. Non-treated plots gave 2.8 t/ha as opposed to 3.0 t/ha for the plot treated with 2,4-D. Perhaps because of the waterlogging, the broadleaved weeds may have been beneficial in removing some of the water and allowing air to enter the soil so that the wheat developed deeper roots. The situation with wild oats was much different. In six trials with heavy wild oat infestation the treatment with Suffix gave 3.4 t/ha while the non-treated plot gave 2.4 t/ha (Tables 40 and 41).

The loss can be attributed to the extra water stress at grain filling when the rains stopped. Both wheat and oats in untreated plots lodged completely because of the shallow root system and the sudden moisture stress. The relation between wild oat infestation and loss in yield is illustrated in Figure 10.

The phytotoxicity of some of the new chemicals has interfered with their acceptance, particularly the substituted ureas, Dicuran and Dozanex, which are used for wild oat control. A high soil nitrate level at the time of application may contribute to the adverse effect on the wheat crop. The two trials where greatest phytotoxicity occurred were treated with nitrogen fertilizer and herbicide on the same day. From observations made on other plots it appears that if herbicide is applied at least 12 days before or at least 12 days after the nitrogen fertilizer, there is little damage.

Other factors affecting phytotoxicity with these chemicals include clay content of the soil, amount of rainfall, seed depth, permeability of soil over the seed, and growth stage of the wheat.

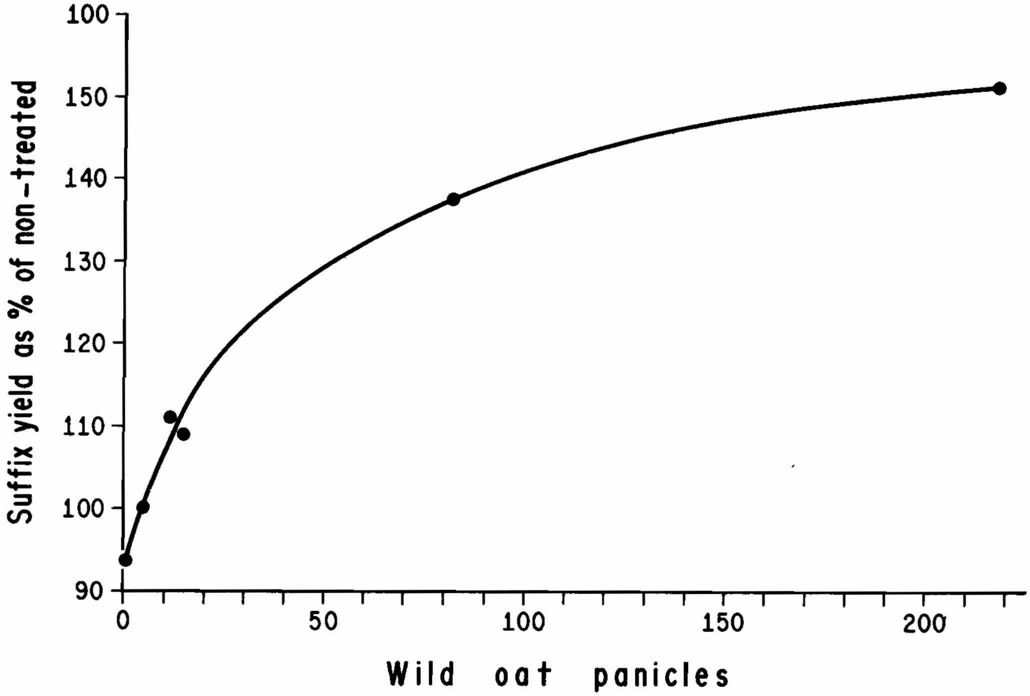


Fig. 10. Effect of wild oats infestation on wheat yields in six herbicide trials. Tunisia, 1972/73.

Suffix, used for wild oats, causes little phytotoxicity when applied before the second node stage of jointing. When applied later, plants show necrosis, new growth is yellow, and stems are shortened. Vaga (Cajeme 71) shows great sensitivity, and yield was reduced in one trial by nearly 0.6 t/ha. When treated before nodes showed above the surface, no damage was observed.

Several similar observations were made concerning varietal response to treatment. When a double dose of Tribunil was used on durum wheats, growth was reduced by a quarter and yield was reduced by more than 0.5 t/ha. The normal dosage had no effect. Durum wheats appear to be more sensitive to Dicuran than to Dozanex, as judged by growth retardation, but no yield differences were noted. Era was reduced in yield by treatment with Dicuran. The barley varieties Ceres and Martin were sensitive to Suffix. But when 2,4-D was applied after Suffix, the yield reduction was less.

In a third series of trials an attempt was made to demonstrate the proper time to apply herbicides. Weed-free sites were chosen to remove the weed effect and assess damage. In general early treatment had little effect while treatment at the boot stage at one location caused a marked reduction in yield (Table 42).

The usefulness of herbicide treatments was measured in a series of tests by estimating the percentage control of each species in each treated plot (Table 43). In general, for broad-leaved weeds, 2,4-D is very good and gives broad spectrum control; MOPA is good but under heavy rain its potassium salt base allows it to wash off; MCPA is good particularly if control is needed before 2,4-D can be safely applied; Faneron gives only fair control; Certrol H is excellent; Tribunil is only fair.

For control of wild oats and ryegrass, Dozanex and Dicuran are usually good but cause some phytotoxicity. Control is less on soils with over 50 percent clay and if application is made after the 4.5-leaf stage. Both gave 100 percent control of ryegrass as compared with 85 percent for Dozanex and 70 percent for Dicuran in the previous year. Dozanex gives good broadleaved weed control and Dicuran fair control. With either it is generally unnecessary to use 2,4-D.

Suffix controls only wild oats. Good control was obtained in every application except where wild oats had reached the tillering stage. Dicuran mixed with Tok gave about the same control as Dicuran alone. Tok provides little weed control. *Phalaris truncatuta* and *P. paradoxa* were somewhat retarded, but *P. canariensis* was not affected. Dicuran granules appear promising if they can be uniformly distributed, and selectivity may be better than with the wettable powder.

Table 44 summarizes the benefits and costs of selected effective treatments. Increase in yield and in income per hectare was greatest with Dozanex which gives early control of wild oats and broadleaved weeds. Although 2,4-D controls only broadleaved weeds, its benefit-cost ratio was best. The choice of treatment must be based on the weeds that are the greatest problem. In areas where wild oats and ryegrass are major weeds (most of the North African wheat belt), the reduction in reseeding of weeds brought about by the use of chemicals extends the benefits beyond the year in which application is made. While cultural practices are an ultimate goal in weed control, chemicals can greatly assist in destroying these weeds in large numbers to reduce the load of weed seed in the soil. Better control methods for *Phalaris* sp. and *Hypericum crispum* are needed since these weeds grow over the entire wheat area of Tunisia and satisfactory chemicals are not available.

Table 42. **Average yields of Soltane in three trials with 600 g of 2,4-D applied at different stages of wheat development at three weed-free sites, Tunisia, 1972/73.**

2,4-D applied at	Yield, t/ha Pont du Fahs	Gaafour	Le Kef	Avg. difference from non treated, kg/ha
Non treated	3.86	2.48	2.07	0
Mid-tillering [a]	3.68	2.34	—	-60
Tillering completed [b]	4.14	2.20	1.79	-90
Jointing [c]	3.97	2.34	2.01	-30
Boot	4.21	2.17	0.70	-440

a/ 4.5 leaves. *b/* 6 leaves. *c/* 1.5 nodes.

Rotation studies. The purpose of the rotation studies in the cereal project is to adapt the land-use system of South Australia to Tunisian conditions. The system is based on a free-seeding, self-regenerating, annual forage legume used in rotation with a cereal crop. In its simplest

Table 43. **Control of important weed species by promising herbicides in six evaluation trials. Tunisia, 1972/73.**

Herbicide [a]	Control, % *Avena sterilis*	*Lolium rigidum*	*Phalaris* sp.	*Calendula arvensis*	*Chrysanthemum coronorium*	*Convolvulus arvensis*	*Fumaria parviflora*	*Papaver rhoeas*	*Raphanus raphanistrum*	*Rapistrum rugosum*
2,4-D	5	0	0	99	97	83	57	99	100	100
MCPA	0	0	0	95	79	16	76	72	92	100
Printan	46	100	11	100	100	32	100	93	99	100
Faneron	0	0	7	100	100	13	80	82	64 [f]	99
Certrol H	16	6	3	100	100	28	100	99	100	100
Tribunil [b]	8	10	2	82	74	0	19	63	32 [f]	66 [f]
Tribunil [c]	24	48	—	99	96	0	82	83	43 [f]	97
Tribunil [d]	28	78	5	85	100	12	88	30	96	94
Dosanex	70	100	5	95	100	0	85	91	79 [f]	99
Dicuran	60	100	0	100	98	0	36	64	10	95
Dicuran granules	82	100	3	100	96	6	58	64	50	88 [f]
Dicuran + Tok	54	99	17	100	99	10	39	38	0	70 [f]
Tok [e]	16	14	28	10	0	0	20	20	0	15 [f]
Suffix + 2,4-D	85	0	3	99	96	29	55	99	100	100
Suffix	88	0	4	—	0	—	0	5	0	6

a/ For rates and treatments see table 40. *b/* 0.88 kg/ha a.i. *c/* 1.75 kg/ha a.i. *d/* 3.5 kg/ha a.i. *e/* Late application may have reduced percentage control. *f/* Variable.

Table 44. **Average yield increase from herbicide applications, cost of herbicide, net benefit, and benefit/cost ratio in evaluation and demonstration trials with promising herbicides. Tunisia, 1972/73.**

Weeds controlled	Herbicide	Yield increase, kg/ha Type I [a]	Type II [b]	Avg	Herbicide cost [c] kg/ha	Net benefit kg/ha	Benefit/cost ratio
		All trials [d]					
Broadleaved	2,4-D	180	150	175	39	136	4.48
	Tribunal	410	390	400	187	213	2.13
Wild oats	Suffix	400	750	575	315	260	1.82
Both	Dosanex	610	770	690	315	375	2.19
		Trials with high wild oats infestation [e]					
Wild oats	Suffix	800	950	875	315	560	2.77
Both	Dosanex	980	1080	1030	315	765	3.26

a/ Evaluation trials. *b/* Demonstration trials. *c/* Based on on-farm prices of bread wheat and herbicides in 1972/73. Prices of Suffix and Dosanex are estimates. *d/* Six evaluation trials and six demonstration trials. *e/* Three evaluation trials (includes one trial with few wild oats, but very high ryegrass infestation) and four demonstration trials.

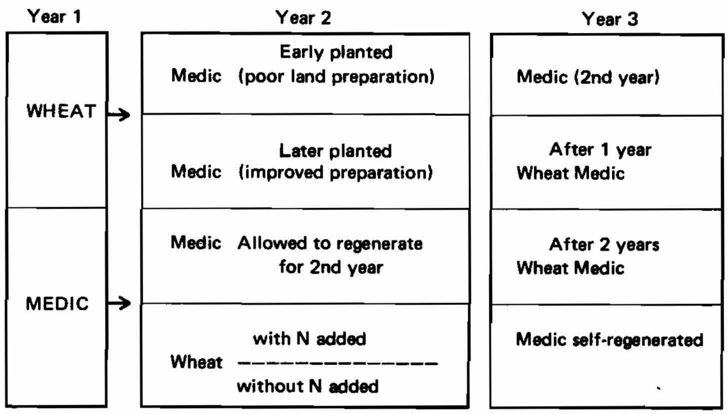
form this is a rotation of 1 year of forage and 1 year of cereal.

In the first year, 1971/72, the program aimed at establishing the potential of the system, what varieties could be best used, if the native rhizobial bacteria were satisfactory, and whether a stand could be readily established. In its second year, 1972/73, the problems likely to occur were observed and commercial plantings were set out.

Varieties of annual medicago are being used. In the first year 15 demonstrations and three experimental sites were established. Ten additional sites were established in 1972/73. To set up these sites an ordinarily prepared seedbed for wheat is used in a farm field with plots of "medic" and plots of wheat. In the second year the wheat stubble from the previous crop is sown to medic. Of the previous year's medic plot, half is sown to wheat and various levels of nitrogen applied, and half is allowed to regenerate with medicago for the second year. (Fig. 11).

The experiments indicate that the optimum seed rate is actually a function of the cost of seed. Thus in the initial

Fig. 11. Planting scheme for medicago-wheat demonstration plots in Tunisia.



Sheep are important in Tunisian agriculture. Here flocks are being grazed on a newly established stand of burr clovers. CIMMYT scientists in Tunisia are studying forage legume-wheat rotations.

stages because of high cost, a relatively low seed rate of 10 kg/ha is used. Later, after the system is in operation, the seed level in the soil should reach 50 to 100 kg/ha of germinable soft seed. If the seedbed is rough or the weed population high, a somewhat higher initial seed rate should be used.

If the site is weedy it is desirable to delay seeding to destroy another crop of weeds before sowing. Otherwise sowing should be done at the same time as wheat is sown.

Phosphate is required and should be placed close to the surface. If it is incorporated too deep the seedlings are deprived in the early growth period. Native stands of other annual legumes have been shown to respond markedly to phosphate application.

To maximize seed production in the first year, the medicago should be grazed lightly or not at all. Strategic grazing or mowing can be desirable in late winter if the crop is vigorous. This reduces height and increases seed set. The effect of cutting the medicago at the time of seed setting was demonstrated at one site. A farmer who was impressed with the amount of forage produced cut it for hay Seed set was low and the amount of soft germinable seed for the second year was low.

Sometimes in establishing a stand, it is better to grow the medicago in two successive seasons. In the second year, however, the build-up of nitrogen from the legume encourages weeds which will made the medicago grow long and spindly to compete. This can be avoided by heavy grazing early in the season, or, where this is not possible, by cutting off weeds above the legumes (top cutting).

A major problem in wheat culture in North Africa is the high weed population. A dense medicago stand combined with judicious grazing has a strong repressive effect on weeds, particularly grassy weeds, although in the second year, when nitrogen has accumulated, these same grassy weeds may compete well. Medic competes strongly with annual ryegrass, *Lolium rigidum*, and since this is a major weed the system greatly benefits the following wheat crop.

Table 45. **Yield of five varieties sown November 10-14 and December 6-12, Tunisia, 1972/73.**

	Yield, t/ha											
	Ariana 66		Soltane		Vaga		Inrat 69		Bedri		Avg	
Location	Nov	Dec	Nov	Dec	Nov	Dec	Nov	Dec	Nov	Dec	Nov	Dec
Pont-du-Fahs [a]	5.3	4.6	4.2	4.8	1.4	4.6	5.2	4.3	2.9	4.0	3.8	4.5
Medjez-el-Bab	3.0	3.3	3.1	3.8	2.3	2.9	2.8	2.8	2.5	3.0	2.7	3.2
Mateur	3.2	4.4	3.2	3.8	2.2	2.8	3.7	3.8	2.3	3.6	2.9	3.7
Bou Salem	2.3	3.6	2.6	3.5	2.8	2.5	2.9	3.5	2.3	2.6	2.6	3.1
Le Kef	3.0	2.4	3.4	2.4	3.2	2.4	2.4	1.9	3.2	1.9	3.1	2.2
Avg	3.4	3.7	3.3	3.6	2.8	3.0	3.4	3.3	2.8	3.0	3.0	3.3

a/ Second seeding date: December 18.

To build up the seed level in the soil in the development years, the medic system does not permit fallow. Thus when wheat is to follow medic, if the rains come early, the weeds can be cultivated, but if rains come late and seeding must be done before weed cultivation, a heavy weed infestation may occur in the following wheat crop.

Unless the crop is grazed heavily during summer and autumn, the excessive dry matter on the surface of a medic field makes cultivation for the following wheat crop difficult. The soil should be grazed to be almost bare by the time of the first rain. The dry matter of medicago is much more nutritious than weeds on grain stubble and should be viewed as a reserve for the animals in summer and early fall.

In 15 tests during 1972/73, wheat was sown on a 1-year medic pasture. In these trials, one half received additional nitrogen and the other half none. At one site the yield of wheat without and with 300 kg/ha N was the same. At another site, by contrast, where the medicago stand had been poor, and ryegrass heavy, the wheat with and without nitrogen were both very low in yield.

Table 46. **Performance of standard bread wheat and durum varieties averaged over all the trials and stations. Tunisia, 1970/71-72/73.**

	Yield, t/ha		
Variety	1970/71	1971/72	1972/73
	Bread wheat		
Soltane	3.80	4.16	4.09
Ariana	3.08	3.70	4.26
Saric	3.15	4.99	3.76
F.x A	2.73	2.74	3.45
INIA	3.17	3.96	3.37
	Durum		
Maghrebi	—	—	3.66
Amel	—	—	3.51
Bedri	—	—	3.09
Inrat 69	—	—	3.38

Commercial strains of medicago are unable to withstand flooding. At one site the variety Jemalong was killed by snow. Native strains appear to be able to withstand snow, however.

More commercial plantings are needed to teach the farmers how to use this system. They provide a large-scale experimental area for differing management practices particularly in regard to grazing. On one large commercial planting of 1971/72, second year grazing was done in 1972/73 during the summer. One can also use these plantings to compare wheat after fallow with wheat after medic.

In 1972/73, 500 hectares were planted with 5 tons of imported seed. These were supervised at planting and throughout the season by project personnel.

Date of seeding. Date-of-seeding studies were conducted at five sites in Northern Tunisia. Although three dates were planned the third was not sown because of rain. The two dates of planting were November 10-14 and December 6-12.

At Pont du Fahs and Mateur, yields were low because of an early, heavy attack of septoria (Table 45). The low yield of Vaga (Cajeme 71) at Medjez-El Bab likely resulted from damage by Suffix. Yields from the second date of seeding tended to be higher except at Le Kef which is a cold location. The higher yield of Aurora 66 and Inrat 69 in the first seeding date at Pont du Fahs was probably due to their septoria resistance and late maturity.

Much of the advantage in seeding at the second date lies in avoidance of septoria attack and in the extra cultivation possible which destroys many more weeds in seedbed preparation. By tradition, farmers plant between the two dates mentioned. This is correct for the traditional varieties, but too early for the new improved varieties.

PLANT IMPROVEMENT

Varietal improvement. As a joint effort, ACPP, INRAT, INAT, and CIMMYT scientists develop new varieties of bread and durum wheats for Tunisia. The Tunisian program actively collaborates with the Algerian and Moroccan national programs, FAO/ALAD, North Dakota State University, Oregon State University, and others.

Varietal distribution and performance. Such local varieties as Florence Aurore, Mahmoudi, and Chili still occupy the bulk of the area sown to wheat:

Bread wheat		Durum wheat	
Florence Aurore	75%	Mahmoudi	40%
Inia, Tobari, Ariana	25%	Chili	25%
		Other locals	25%
		Inrat 69, Bedri	10%

These are improved varieties developed over the past 40 years. Newer varieties such as Soltane, Amel, and Maghrebi are superior in yield potential (Table 46) and are gradually replacing them.

The variety INIA which comprises the largest plantings of dwarf varieties did not do well in the past season. The stability of the new variety Soltane, shown by its yield over the past 3 years, is particularly important in rainfed agriculture. It appears that this variety is flexible in its response to excess moisture and to moisture stress. The newer varieties of durum are considerably above Mahmoudi and Chili in yield potential. Hence they have been dropped as checks in the yield trials. The varieties Inrat 69 and Bedri will likely double in area next year to about 120,000 hectares.

Varietal evaluation in microplots. In 1972/73, 21 microplot yield trials of bread and durum wheats were conducted together with nine regional and international yield trials. About 775 varieties were involved.

Of the many bread wheat varieties tested for the second year, crosses Klein Petiso Rafaela x 8156 (R) and Napo-Tob "S" x 8156 (R) were most promising (Table 47). Both will be multiplied and grown in national demonstrations. Many other lines are being put in small-scale multiplications and will be tested on a wider scale.

Table 48 lists promising durum varieties. Varieties of

Table 47. **Promising bread wheat crosses from the micro-plot yield trials. Tunisia, 1972/73.**

Pedigree	Yield, t/ha	Yield, relative to Soltane [a]	Septoria [b]
CC-Inia "s" xOn-Nar "s" 30976-8Tu-1MB-0BJ	4.8	119	5
Anza or Mexicani	4.8	112	4
No 66-Cno "s" x Jar 66 27343-2R-3M-3T	4.6	110	6
OnxSon64-Kl.Rend/Cal 31206-1Tu-2MB-0BJ	4.8	109	5
Son 64-Knott No. 2xGallo 30922-1Tu-1MB-0BJ	4.3	108	6
Cal-CCxTob 30745-5BJ-3BJ-0BJ	4.6	107	5
On-M2824²-2-50-72/NtxCno-Inia "s" 31159-2Tu-1MB-0BJ	4.3	107	6
HD832-BbxNorteño 67 31044-6BJ-1BJ-0BJ	4.6	107	5
Cno-InIaxCal 27224-53m-1y-3m-0y	4.0	106	5
Cno "s"-Gallo 27845-5y-3m-4y-3m-0y	4.0	102	6
Kl.Pet.Rafx8156 (R)² 27997-4y-100m-300y	4.7	114	6
Napo 63-Tob "s" x8156(R) 28071-7m-3y-7m-0y	4.4	106	4

a/ Lines are chosen from many yield trials and percentage of Soltane is calculated for every yield trial. *b/* 0 = no Septoria attack, 9 = Septoria up to the top including the spike (under the same conditions INIA = 8, Siete Cerros = 9 and Soltane = 6.

Table 48. **Yield of promising durums. Tunesia, 1972/73.**

Pedigree	Yield, t/ha	Yield relative to Inrat. %
21563-AA"s" 27625-5m-2Y-2m-1y-1m-0y	5.3	130
LD357$_E$-Tc^{2}xJo"s" 27534-1M-1Y-1M	5.0	123
BY$_E$-Tc^{4}xAA"s" 27512-9m-7y-1m	4.9	122
[INRAT69xBD1708] [BD1419xBD1705] D68-11-6A-2A	4.8	126
AA"s" [LAK$_E$-LD390] Ch67 DNx69-331-2A-1A	4.7	123
21563-AA"s" 27625-5m-2y-2m-2y-0m	4.6	122
[BD1419xBD1708] [BD1705(53AB-5xKyp.Kam)] D68-8-6A-1A	4.7	132
BD1750 [Bidi17(Kyp.Yrollourico)] D68-55-9A-3A	4.3	110
[BD1705(53ABxKyp.Kam)] [BD1708xBD1419] D68-9-21A-5A	4.7	127
[(BD552-LD341) (552-BB-552) BD1708] BD1750 D68-1-93A-2A	4.6	123
Jo "s" xRD119-2W-3y-D31568 DMx69-44-1A-4A	4.3	115
[(53AB-5xKyp-Kam)BD1705] [BD1708xBD1419] D68-5-18A-5A	4.2	113
Jo"s"-Cr "s" 27591-5M-2Y-2M-0Y	3.9	122
Gs "s"-AA "s" 27664-9M-4Y-3M-2Y-0M	3.9	122

Mexican origin have excellent yield potential, but, unfortunately, many lack adequate disease resistance and have a high percentage of yellow berry. They are useful mostly as parents in the crossing program.

This was the first year of evaluation of the dwarf derivatives of North Dakota and Mexican dwarfs crossed in 1968/69 to Tunisian and Lebanese varieties. Among these crosses D68-8, D68-1, D68-11, D68-5, D68-9, and D68-55 are the best. D68-8 although late has excellent drought tolerance. Many of these crosses have good quality and disease resistance and fair-to-good drought tolerance, but they tend to be late. All of these lines are under small scale multiplication.

Varietal development. The departments of plant pathology and cereal technology are adding strong support to the improvement work. In 1972/73 selection was being made from 996 F_2 populations and from over 4900 F_3-F_6 segregating lines. Most breeding work is conducted at Ariana and Beja. Artificial epidemics of the rusts and septoria were created at both centers. Stripe rust attack was quite heavy, and Soltane was among those attacked. Stripe rust is, however, not an important disease in Tunisia.

All lines harvested from Ariana yield trials were tested for industrial quality. Pelshenke tests were conducted on all single plant selections—about 3500 determinations. All varieties of the regional crossing block were evaluated. Disease resistance, quality, and yield stability are of major importance.

Since the crop season in North Africa is long and usually has a dry period in the latter part, varieties with a long vegetative, short reproductive cycle or ones with long duration and high drought tolerance can be expected to perform well. The winter-spring crossing program now under way at CIMMYT promises to supply varieties of the latter type. In 1972/73 where drought occurred in the late stage of development, many F_2 plants of winter x spring crosses were ripening normally while other spring types were prematurely ripened. Of the many winter x spring crosses grown, the more promising are:

Anza-Sdy	D71/164
Aurora-Anza	D71/167
Cj-Ibis	D71/170
Cj-Nudif	D71/171
Cno-Bb-Gallo/Sdy	D71/175
Car12-Anza	D71/187
Inia66-Car421	D71/215
Inia66R-Hbgn-Cd	D71/217
Inia66R-Hbgn-HnIV	D71/219
Inia67-OnxHbgn-HnIV	D71/223
Jar66-Sta	D71/225
Jar66xCD^2-WW	D71/227
Tob66-Hys	D71/351
Tob66-Sta	D71/355

In durums, many crosses from the D68 series seem so show special adaptation to North African conditions. The durum program is now being rapidly expanded.

Varietal testing on farms. Twenty varietal demonstrations of 12 to 17 varieties were seeded throughout Northern Tunisia. Four of the trials were discarded and 16 harvested. Plots 5m x 50m were used in two replications.

Table 49. **Yields in farm demonstrations. Tunisia, 1969/70 to 1972/73.**

	1969/70			1970/71			1971/72			1972/73				
	Sites	Yield		Sites	Yield		Sites	Yield		Sites	Yield		Test wt	Plant ht
Variety	no.	t/ha	relative [a]	no.	t/ha	relative [a]	no.	t/ha	relative [a]	no.	t/ha	relative [a]	kg/ hl	cm
Bread wheat														
Florence Aurore	16	3.35	79	16	2.73	90	15	2.73	77	16	2.93	100	82.8	122
INIA 66	16	4.24	100	16	3.04	100	15	3.54	100	16	2.95	100	83.9	94
Ariana 66	15	3.95	93	16	3.32	108	15	3.57	101	16	3.27	111	82.2	108
Soltane	5	4.87	105	16	3.10 [b]	102	15	3.80	107	16	3.34	113	82.5	94
Vaga (Cajeme)	—	—	—	2	2.79	108	15	3.98	112	16	2.79	95	82.2	80
Tobari	16	4.10	97	16	2.87	94	15	3.73	105	16	3.06	104	82.4	92
Siete Cerros 66	15	3.87	95	6	2.99	96	1	2.68	73	6	3.16	109	80.0	90
Era	—	—	—	—	—	—	—	—	—	4	2.50	97	78.1	85
Pato	—	—	—	—	—	—	—	—	—	4	3.39	100	83.6	96
Durum wheat														
Inrat 69 (D58-25)	16	3.32	78	16	2.90	95	15	3.13	88	16	2.93	99	80.9	109
Bedri (D56-3A)	10	2.78	70	13	2.95	96	15	3.07	89	16	2.83	96	84.0	92
Jori 69	—	—	—	16	2.92	96	15	3.39	96	12	2.71	94	80.9	76
Cocorit 71	—	—	—	—	—	—	12	3.84	106	16	3.11	105	80.5	85
Mahmoudi	—	—	—	—	—	—	—	—	—	16	2.22	75	82.1	120
Amal 72 (1830)	—	—	—	—	—	—	—	—	—	16	3.06	103	79.4	74
Chili	—	—	—	—	—	—	—	—	—	2	1.88	95	82.5	109
Barley														
Martin	—	—	—	4	2.62	101	8	3.45	115	10	2.46	91	63.3	96
Ceres	—	—	—	—	—	—	—	—	—	11	2.81	104	65.5	92

a/ Relative to INIA 66 in same trial. *b/* 2,4-D applied at a sensitive stage of development for this variety.

Adequate nitrogen was supplied. Weather played a relatively important part in yields (Table 49). Florence Aurore did not lodge because rains were not present after heading in 1972/73, and it did exceptionally well. INIA 66 was quite mediocre since it is susceptible to septoria and is not adapted to waterlogged soils. Ariana 66 had good yields. It tolerates saturated soil and is resistant to septoria. Soltane tolerates saturated soil and is tolerant to septoria. As a result it yielded well. Vaga (Cajeme 71) had poor yields. It is susceptible to septoria and is not adapted to saturated soil conditions. Late application of Suffix also reduced its yields in some tests. Tobari reacts similarly to INIA, but is somewhat more tolerant to waterlogging. Siete Cerros 66 showed its normal good performance in well-drained sites and areas where septoria was light. Era was poor because of its late maturity and the occurrence of late drought.

Among the durum wheats, Mahmoudi showed its low yield potential; Chili was only grown at sites where it is best adapted hence it did well; Inrat 69, Bedri, and Amel 72 gave good performance; Cocorit 71 gave high yield but low quality grain; Jori 69 is not adapted to waterlogging.

In the barleys, low yields resulted from a severe attack of helminthosporium and, particularly for Ceres, damage by Suffix.

Data collected over a series of years from these varietal demonstrations give a measure of yield stability (Table 49). The low yield of Florence Aurore in the excellent 1969/70 season indicates its lack of potential. At this low level, however, it maintains stability. Ariana and Soltane show relatively good stability, but Soltane has a higher yield potential. The stability of Inrat 69 is good and better than that of Bedri because of the latter's disease susceptibility.

The variety demonstrations serve to introduce new varieties and a package of practices to the farmer. They also provide information on varietal adaptation.

SEED PRODUCTION AND TECHNOLOGY

Superior varieties developed by research must move from the breeder to the farmer. The production and marketing of good quality seed of these varieties supplies this need. At the request of the Tunisian government, CIMMYT agreed to help strengthen the seed production program by adding a seed production specialist to its North African staff in 1973.

The objectives of this program include improving the quality and ensuring an adequate quantity of seed of the major crops to the farmers, providing special training for key personnel, and achieving greater uniformity among the countries of North Africa in seed standards and seed laws and procedures to facilitate seed movement from country to country.

Assistance was provided in developing national seed legislation under which a national seed advisory committee is to be formed. This should have a significant impact on seed quality control. New certification standards have been established with stress on the quality of seed sold while attempting to leave some flexibility to ensure that seed moves rapidly from research to production.

Seed enterprises and seed multipliers are being helped in production, processing, and quality control. Training programs are planned for seed technologists for the Maghreb region. The emphasis is on seed production, certification, testing, and other seed technology measures. This activity should provide a cadre of trained technicians and leaders in seed production.

The CIMMYT scientist also spends a portion of his time outside Tunisia assisting with seed production development in the region.

The Federal Republic of Germany has helped Tunisia establish an official seed testing laboratory. The U.S. Agency for International Development has provided short-term consultants and anticipates supporting training abroad for key personnel. These joint activities should strengthen seed programs in Tunisia and the region as a whole.

Table 50. **Yield results of practical demonstration of improved varieties and practices. Tunisia, 1972/73.**

Variety [a]	Sites, no.	Yield, t/ha Regular practices	Yield, t/ha Recommended practices
	Bread wheat		
Soltane	10	1.59	2.66
INIA 66	9	1.70	2.45
Florence Aurore	25	1.38	1.93
	Durum		
Inrat 69	17	1.25	2.02
Mahmoudi	9	1.05	1.47

a/ Varieties in less than nine sites not shown.

EXTENSION

The extension activities of the cereal project were conducted by Tunisian personnel. Recommendations for varieties and practices for the different regions of the country were developed.

Practical demonstrations were conducted at 33 locations. The results clearly show the advantage of improved variety, good fertility, and weed control (Table 50).

Several hundred farmers attended the nine pre-sowing meetings held in October. Although the impact of these meetings cannot be measured directly, 105,000 quintals of seed, enough to sow 10 percent of the wheat area, were sold in 1972/73 and of this about 50 percent was of improved varieties. Six meetings were held in the early part of the year to discuss fertilizer and weed control measures. During the year about 60,000 hectares were sprayed with herbicides, predominantly 2,4-D. This was about half the expected area. The persistent rains prevented spraying. In the small-farmer program about 9000 quintals of seed of new varieties were distributed.

The emphasis of the cereal project has been to increase production of wheat in the major higher rainfall wheat area of the north. About 41 percent of this area is now sown to the new higher yielding bread wheats. The new Tunisian durum varieties cover approximately 10 percent of this area. On the whole, high yielding varieties now cover about 10 percent of the total wheat area of Tunisia and are estimated to be contributing about 20 percent of total production.

The Ford Foundation, the U.S. Agency for International Development, and CIMMYT are assisting the government of Tunisia in its cereal research and production activities.

EGYPT

The government of Egypt has been assisted in recent years by the Arid Lands Agricultural Development Program (ALAD) of the Ford Foundation in its wheat research, as well as in a number of other crops. Dr. Gordon McLean is assigned by ALAD as a specialist in certain cereal crops including wheat. He works with the Egyptian scientists in the further development of their wheat program. Dr. Abdul Hafiz of FAO, Regional Consultant for FAO on cereals, has helped the Egyptian scientists for many years with guidance, encouragement, supply of genetic materials, and training of personnel. CIMMYT has been associated with the Egyptian program for some years through its supply of genetic materials and by training of young scientists and senior research personnel at its headquarters in Mexico. In 1972/73, Dr. M.M. Sadek, in charge of the wheat research program, and Dr. A.H. Kamel, senior plant pathologist at Giza, visited CIMMYT in Mexico for nearly 3 months. In addition, CIMMYT provided training for Mr. Hamdy Nagib in production and Mr. Moussa G. Mosaad in breeding technology.

Egypt consumes about 4 million tons of wheat and flour. Per capita consumption is a little less than 100 kilograms per year. Thus the annual increase in requirements should be about 100,000 tons, but, in fact, it is about 300,000 tons. That may reflect a high income elasticity for wheat and wheat products. Or, the high rate of urbanization may be increasing bread consumption. Of its total requirement, Egypt produces about 1.8 million tons, so about 2.2 million tons in wheat or flour equivalent must be imported. This is a heavy drain on foreign exchange especially since wheat prices have risen so rapidly recently. Thus it is imperative that wheat production be increased to meet as much of the shortfall in wheat production as is possible.

Egypt produces no durum wheat although it consumes about 80,000 tons a year. Demand is expected to grow more rapidly than population since most of the durum is used in urban centers.

In the 1972/73 season wheat yield and production were above average. This was the first season in which farmers planted semi-dwarf wheats. Prior to this year, the semi-dwarfs had been confined to the research fields except for modest seed production in the 1972/72 season. In 1972/73, of the 550,000 hectares of wheat produced, 28,000 hectares were devoted to the semi-dwarf varieties Super X and Mexipak 69. Yields of these varieties were 1.5 t/ha higher than yields of the traditional improved varieties. Foundation seed of the variety Chenab 70, which was donated by the government of Pakistan, was sown on 51 hectares at Sakha and produced 7.0 t/ha. The early variety SA42 was grown on 0.7 hectare for seed increase. Because of its earliness, bird damage was severe.

The success of the high yielding varieties has prompted the government of Egypt to increase the sowings of Mexipak 69, Super X, and Chenab 70 to 250,000 hectares for the 1973/74 season.

Rust was limited and where it did appear it was too late to have any material effect on yield. The bird problem, however, is increasing each year, particularly on early maturing varieties. The presently grown semi-dwarf varieties did not respond as well in the Upper Nile Valley as in the delta region. While this is to be expected because of higher temperatures and a shorter growing season, other earlier maturing semidwarfs should be selected which will provide a better yield in the Upper Nile. The present medium-maturing types are not fully suited to the prevailing conditions.

Table 51 shows some of the results obtained with varieties of durum grown at Sids in Middle Egypt, in comparison with a number of bread wheats. It was surprising that

Table 51. **Yield of improved durum and bread wheat varieties. Sids, Egypt, 1972/73.**

Variety	Yield, t/ha
Jori 69	7.50
Brant S	6.25
Cocorit 71	6.07
Mexipak	5.36
Cajeme 71	5.36
Chenab 70	5.00
SA 42	4.64
Yecora 70	4.46
Giza 156 (local check)	5.18

Jori 69, a semi-dwarf variety of Mexican origin, produced 7.5 t/ha in this region. These yields are from seed production fields ranging from 0.4 to 10.4 hectares. Although durum wheat has not been grown in Egypt for several decades because of danger of rust, this result has encouraged the governments to consider introducing high-yielding, rust-resistant durums into the central and southern Nile areas.

At Sakha, at the heading stage, several lines in the International Bread Wheat Screening Nursery were promising:

Potam 70	Nor 67 - Tordo
Y50-Kalyan[3]	Pato-Cal X 7C/Bb-Cno
Cno "S" - Gallo	Jar-Cno X N066
Chanate No. 1	Cno-Inia "S" X Bb-Cal
Mexipak "S" - 5640	Bb-Sonalika
Nor 67 - 7C	Sta Mta Barbella X Bb
	Bb-HD832

"Hybrid necrosis" is a problem in crosses between many of the Mexican varieties with Egyptian varieties. It may arise from the Hindi 62 background of the latter since the same difficulties arise in crosses with Indian varieties.

In the summer of 1973, nursery materials were sown in Tanzania at Arusha and at Njoro in Kenya. This should speed development of materials in the off season and permit screening materials for the rusts.

LEBANON

Lebanese cereal production was severely restricted in 1972/73 by an extended period of dry weather early in 1973. Rainfed locations in central and northeastern Lebanon received about half the normal rainfall, and grain production was low. In the irrigated and high rainfall areas of the coast, Mexipak produced high yields. Mexipak was grown on a wider area of the northern coastal plain which is predominantly rainfed, and yields as high as 5 t/ha were recorded. Diseases were not of economic importance in the north because of low rainfall. The main irrigation districts produced an estimated average yield of 2.8 t/ha on 10,000 hectares. In spite of this, the poor rainfall reduced the Lebanese crop by about half. Mexipak has established itself as the leading variety of bread wheat and now covers about a third of the entire wheat area. A limited area of Jori 69 durum gave good results and it is expected that this variety will expand into the area now planted to Senatore Capelli.

Varietal testing has been extensive and a number of superior lines have been identified. These lines compare in yield to Mexipak and are being placed under small scale increase in 1973/74.

ETHIOPIA

Wheat imports in Ethiopia reached 50,000 tons in 1972. By July 1973, about 9500 tons were imported largely through food aid programs. The production of wheat for 1973 has been estimated at 800,000 metric tons from 1,100,000 hectares for an average yield of 740 kg/ha. Approximately 20 percent of the crop is bread wheat, grown primarily in Arusi, Southern Shoa, and Bale provinces. The rest of the crop consists of local durums suitable for unleavened bread and pasta products.

Estimates of the 1973 wheat crop in the Arusi Province —a main wheat growing area under rainfed conditions—have been provided by the CADU Project. About 50 percent of the agricultural area (150,000 hectares) was sown to wheat; within this area, 18 percent is under mechanized farming. Yields for the nonmechanized farms were estimated at 1.5 t/ha and yields for the mechanized farms at 2.0 t/ha. Total production is about 256,000 tons, which is an increase of

Mr. Felix Pinto, right, FAO expert at Holleta Station, Ethiopia, shows a method of ridging developed to overcome waterlogging effects on wheat production.

57,000 hectares and 86,000 tons in production over the 1972/73 crop season.

The use of improved varieties rose from 14 percent in 1969 to about 75 percent in 1973. The principal improved varieties sown are Kenya Kanga, Laketch (white grain, Siete Cerros derivative), and the line Supremo-Kenya x Yaqui 48. Romany and Salmayo were grown only on a limited area because of their susceptibility to current races of stem rust.

The 1973 crop season was generally favorable for wheat production. There was little rain in the February-April period which is called the short rainy season; the main rainy season began in June and continued into early October. A heavy early infestation of barley fly severely reduced stands of barley in most of the country. Wheat, however, was only slightly affected. *Septoria tritici* was common on wheat and high readings were recorded on Laketch. The disease caused grain shrivelling. A light infection of stem rust which appeared late in the season caused little damage to the crop. Desiccating winds and early frost which sometimes produce widespread damage did not develop until the crop matured.

New varieties. New varieties under advanced multiplication are INIA 66, K4500, Kenya Mamba, and K4135. Although INIA 66 is susceptible to *Septoria tritici*, its earliness allows late seeding so it can escape serious infection. K4135 and Kenya Mamba have good resistance to diseases, however their weak straw is a drawback in the better watered and more fertile areas. Other varieties such as K4970, L10A5C, and K4958 are under multiplication for use in the highlands where a longer season prevails.

The more promising varieties from earlier multiplication plots include Romany Backcross (white grain) and Inrat 69, a durum wheat from Tunisia. The latter is the first improved durum variety introduced in the rainfed areas.

In addition to the varieties included in international trials, 69 bread wheats, 24 durums, and 23 triticales were grown as part of the National Trial Program. There is also a wealth of promising material in the indigenous types being tested in national observation plots and nurseries.

A large number of introductions drawn mainly from CIMMYT nurseries and from other international programs are screened yearly. Segregating populations of wheat and triticale are selected, and a limited local crossing program in wheat was recently initiated. Some of the outstanding new genotypes in the national trials:

Bread wheat
Cno "S" - Gallo 27829-19Y-2M-4Y-0M
LR64^2-Son64xCC 27941-8Y-2M-2Y-1M-0Y
Y50-Kal^3 37188-F$_2$-4M-16Y-1M-0Y
Nor67-7Cerros 30367-1M-1Y-3M-0Y
Bb-Cal 30877-17M-1Y-1M-0Y
Tob66-B.Man x Bb 25998-5B-3J-101J-14-0M

Durum wheat
Cr "S" - BYE^2-Tc^2/Z-BxW D28984-20Y-6Y-0Y-2KDZ-0GDZ
LD 357E - Tc^{2}xJo "S" D27534-3M-1Y-3M-1Y-0M

Triticale
Arm "S" x -308-7Y-4M-100Y-100M-0Y-114N
Beaver "S" E1-68B-5N
Kangaroo x MTE20-Per X-284-100N-)M
UM940 "S" - Kangaroo X - 1029-37M-1Y-1M-1Y-0M

Even though data have not been compiled, several varieties grown at CADU yielded well over 5 t/ha.

Agronomy. Increases of 550 kg/ha over control plots (a 64% increase) were demonstrated in trials of the national fertilizer program using a low level of phosphate (46 kg/ha P_2O_5). When such a practice was combined with improved varieties and better cultural practices, yields were 80 percent higher than those of control plots. A Minimum Package Program initiated recently aims to increase wheat production by 26,000 tons by 1978.

Agricultural policy. Increased production of bread wheat is being emphasized to attain self-sufficiency. Thus, the proportion of bread wheat varieties to indigenous durum types will expand until imports of grain are no longer required. Once this is accomplished the remaining wheat area will be planted to improved durums, triticales, oil crops, and pulses rather than attempting to export surplus wheat.

Staff development. Six Ethiopian scientists have received training at CIMMYT-Mexico under the FAO/Rockefeller Foundation training program or the International Development Research Center training program. Wheat research is now coordinated by one of these graduates who recently obtained a Ph.D. degree from Oklahoma State University (USA). Another scientist who is expected to return shortly with a M.Sc. degree from the University of Manitoba (Canada) will head the triticale program.

TURKEY

In contrast to the previous 2 years, wheat yields in Turkey during the 1972/73 season were relatively low. Wheat production was estimated at about 9 million tons from about 8.5 million hectares. Thus yield was only marginally above 1 t/ha. Turkey's annual wheat requirement is about 10 million tons. Because of the availability of carry-over stocks, however, imports are likely to be held to 300,000 tons. Unfortunately, Turkey exported several hundred thousand tons last year and is now faced with importing at a much higher price in the world market.

The lower yields of 1972/73, resulted from a spring drought that affected nearly all of Turkey, but especially the southern part of the Anatolian plateau (Konya region) and southeastern Turkey. In these areas poor yields and crop failure were common. The coastal areas and Thrace province in European Turkey enjoyed relatively good weather and produced near normal crops. The drought has continued throughout the summer and fall resulting in late germination of the 1973/74 crop.

In 1972/73, Bezostaya, a Russian winter bread wheat variety spread very rapidly throughout Thrace and covers 80 percent of the wheat area. In this region, which has relatively high rainfall, Bezoataya performed very well. Penjamo 62 remains the principal variety of the coastal zone, but several new varieties are being considered for release and are presently under increase.

The tillage research conducted over the past 3 years, has resulted in the recommendation of a package of cultural practices, which should provide a basis for higher yields in the low rainfall areas. Researchers believe that this package, which can be effected with a minimum of extra inputs, will enable the farmer to produce yields that are twice the national average. The government of Turkey is bringing these findings directly to the farmer in an accelerated production program.

BREEDING AND VARIETAL RESEARCH

Wheat research in Turkey is conducted by the government of Turkey with technical assistance from The Rockefeller Foundation, U.S. Agency for International Development, Oregon State University, FAO, and CIMMYT.

Spring wheat program. Improved varieties are now grown on about 60 percent of the coastal area. Of this, Penjamo 62 occupies nearly 90 percent making the region a near mono-variety culture. To correct this situation, the spring wheat breeding program, centered at Izmir, has been conducting an extensive breeding and selection program over the past 4 years. In 1972/73, seven outstanding lines were identified which will be considered for release as new varieties in the near future:

Ciguena
    21406-6-2-0Y
Ciguena "S"
    21406-6-2-300Y-0S
Robin "S"
    26787-300Y-300M-302Y-3M-0Y
Robin "S"
    26787-300Y-300M-302Y-1M-0Y
Robin "S"
    26787-300Y-300M-302Y-2M-0Y-500Y-0Y
Cocorit 71
LD 357_E-Tc^2xAA "S"
    27524-12M-1Y-1M-0Y

These varieties represent two germ plasm groups for the bread wheats and, in the case of the latter two varieties, two diverse groups in durum wheats. Multiplication and testing of these lines will continue in the 1973/74 season, and they probably will be released for growing in the following season.

Several other lines including Cno-Gallo, Nuri "S", and Son 64 [(WF51/Md x N - Th x KT17A) 6134-Dirk] are promising but are being more extensively tested before a final decision on their release. The best line from this group will be considered for release in 1976.

During 1972/73, the spring durum program identified additional lines with promise. These include several Gaviota and Pelicano sibs: Anhinga "S" 22234-52M-3Y-1M-0Y, 21564-Cr "S" 32929-1Y-1M-1Y-0M, 21563-Gr "S" 31543-8M-3Y-2M-0Y, and AA "S" - (CP^3_E-Gz x Tc^3/BY_E-Tc)-31733-4M-6Y-2M-0Y. These lines will be tested further and multiplied for possible release in 1976.

Gem, a USA spring barley variety, was multiplied for release in the Aegean region this year. Gem has wide adaptation within the region. In 2 years of testing it has consistently out-produced the local varieties by 40 to 50 percent and frequently by 100 percent.

The plans for 1973/74 include the start of a spring wheat screening nursery and a uniform yield nursery for regions growing spring wheat. The screening nursery will contain the promising lines selected at each of the spring wheat research stations. Fifteen sets of this nursery will be prepared at Izmir and distributed to all the cooperators. The uniform spring wheat yield nursery will have approximately 20 superior entries drawn from the breeding programs of the cooperating stations. This trial will be conducted at 5 to 10 locations in each of the spring wheat regions of Turkey. The best lines will be considered for release as new varieties. Efforts are continuing to expand the off-station trials but shortage of personnel and equipment limit this effort.

Program of the southeastern region. The breeding program of the southeastern region, centered at Diyarbakir, is developing rapidly. In the past season Dicle 74 (Cocorit 71) was recommended for release. In 3 years of trials it consistently outyielded local durums by more than 25 percent. Its quality and grain type equal those of the varieties grown. In a 1-hectare multiplication plot in 1972/73 it produced slightly over 3 t/ha. The seed is again being multiplied and the seed should be available for 1974/75 sowings in farmers' fields. This new variety could rapidly make an impact since more than 60 percent of the wheat area of the region is in durum wheat.

Many other promising durum and bread wheat lines have been identified. Among the durums are several sister lines of Cocorit which appear superior to Dicle 74, several Crane "S" lines, lines from 21563-AA "S", Anhinga "S"-22234-52M-3Y-1M-0Y, and Stork "S" CM470-1M-3Y-0M. These lines are being tested throughout the region.

The winter wheat program. In Thrace the varietal picture has changed dramatically in the past 2 years. Before 1970, several bread and durum wheat varieties were grown. But in 1969 Bezostaya was introduced, and by 1972/73 adoption was an estimated 70 percent. Adoption is likely to rise to 80 to 85 percent in 1973/74. Although Etoile de Choisy was recommended for release this year, little has been planted so far.

The breeding program in Thrace has identified other promising lines including several lines received from Pakistan, a few French varieties (FD 2813, Heima, FD-2915, Capitole, Splendeur), Kavkaz (from Russia), and several lines arising from the cross Kenya sel 2657/Fr x KAD-Gabo. These lines are under extensive tests.

The breeding stations for the Anatolian Plateau of Turkey, where 5 million hectares of winter wheat are grown each year, are located at Eskisehir and near Ankara. In 1972/73 these stations conducted an extensive testing program on farmers' fields. Twenty-eight locations with normally two yield trials at each were used. This wide scale testing should reduce the time required to identify superior varieties for the Central Plateau.

Two new varieties, 4/11 and Bolal, have been released for farmers' use following large-scale multiplication in 1972/73. These varieties, are expected to have an impact on the wheat production in 2 years. Bolal is widely adapted and showed high yield potential and good drought resistance in 3 years of testing. It has the potential to raise yields significantly, but because of its red grain, which is less acceptable than white grain in Turkey, it may encounter some opposition. Its high yield should offset this disadvantage.

Kirac 66, a bread wheat variety with good yield potential, is now in the final stages of multiplication. Cumhuriyet 50 (P 661), a new barley variety, with better yield than those presently grown, is also ready for release. These two varieties should be available to the farmers in 1974/75.

In addition to these, several outstanding lines were identified:

(FnxK58-N/Tmp 64) Yy 305	P195-8
F1 "S" (FnxK58-N/Tmp)	P211-6
093/44 (FnxK58-N/tmp)	P206-40
T54-01-25-3-7 (Local)-7 Cerros	M6418-6-1A-6A-1A-0A
T54-01-25-3-7 (Local)-7 Cerros	M6418-6-3A-101A-1A-0A
Fr-TmxTx580-405/908-Fn	M6405-2-1A-101A-1A-0A
Fr-TmxTx580-405/908-Fn	M6405-11-12A-101A-1A-0A
14/53-P 101	B7911 (Aric 175-69)
C59287-P101x6538	B7912 (Aric 176-69)
V64058-1-8	B7845 (Aric 109-69)
$BY_E{}^2$-Tc (durum)	22252-15A-2A-2A-0A
$BY_E{}^2$-Tc (durum)	22252-15A-2A-8A-0A
61-130-LeedsxCapras Bug 1018 (durum)	C29/13
61-130-414/44 (durum)	C25/6

All of these lines will enter preliminary multiplication and extensive tests in 1973/74. The two lines $BY_E{}^2$-Tc performed well in the durum areas of the Anatolian Plateau in 1972/73. Although neither of these lines have outstanding winterhardiness, they have enough for the main durum areas.

The first international winter wheat and winter durum screening nurseries (IWWSN and IWDSN) were distributed for the 1972/73 growing season. The aim of these nurseries is to evaluate winter bread and durum lines and varieties for disease resistance and adaptation in several winter wheat regions of the world. They also serve as a vehicle to distribute superior germ plasm to cooperators. Nineteen sets were grown. Distribution of the first set was made to Romania, Hungary, Mexico, Iran, Algeria, and Turkey. The IWWSN and IWDSN contained 862 and 323 entries respectively. Lines were selected from the winter wheat stations in Turkey. In the future the number of locations outside Turkey will be increased and the number of entries decreased as lines with insufficient winterhardiness are eliminated. Foreign cooperators will be encouraged to submit advanced lines and varieties for the second and succeeding nurseries.

The winter wheat breeding programs plan to begin a winter barley breeding program in Ankara in 1973/74. Winter barley varieties are being collected and will be screened for adaptation on the Anatolian plateau. The breeding of winter durums is also being strengthened to incorporate a greater degree of winterhardiness in types with high yield and adaptation.

The off-station testing begun in 1972/73 will be expanded to other regions of Turkey, and it is hoped to increase the number of locations in the western transitional and central plateau trials. The off-station trials are often associated with tillage experiments to demonstrate the value of a complete package.

Pathology. Stripe and stem rust, common bunt, and loose smut are the principal diseases of winter wheat in Turkey. Common bunt and loose smut were responsible for the greatest losses in the past year because the prolonged drought precluded the development of the rusts. In the spring wheat regions, stripe rust, septoria leaf blotch, and loose smut are of greatest importance. Powdery mildew can also be damaging in the Marmara - Black Sea areas. Because of dry conditions most of these diseases did not cause serious damage. In all, disease incidence in 1972/73 was much below normal.

The disease surveillance program comprises three activities: Growing a network of trap nurseries, conducting an extensive mobile disease survey, identifying races and virulences of rust collections.

The Turkish Trap Nursery is made up of 60 commercial varieties of wheat and barley. It was sown at 60 locations in 1972/73. The disease survey was a joint undertaking of the Plant Protection Directorate and Wheat Research and Training Center. On the basis of previous experience, fewer fields were visited, but this proved quite satisfactory since the incidence of diseases was low.

Race and virulence identification was started in 1972. Based on a few samples, the results indicated that stripe rust races 2E16, 6E0, 6B16,and 38E144 were present in Turkey in 1973. Additional samples were submitted to Dr. R.W. Stubbs at Wageningen, Netherlands, for identification and verification. According to adult plant response, virulence for only the YR-6, YR-7, and YR-8 resistance genes plus Bezostaya and cross 8156 was present in inoculated nurseries. More collections were found capable of attacking Bezostaya than in previous years. In stem rust, the same races as those found in previous years are important. Races 11, 17, 34, 100, 111, 136, 189, 264, and 274 were identified. Data are not yet available for distribution and virulence in leaf rust. Leaf rust collections were also submitted to Dr. Boskoviç in Yugoslavia for analysis.

Analysis of collections will be strengthened by the forthcoming transfer of well-trained personnel to Ankara.

A common bunt nursery was started at Ankara and grown at two locations. In all, 739 varieties and lines were tested. Approximately 15 percent showed less than 10 percent bunt, indicating a considerable availability of resistance genes. A few varieties were immune. These varieties will be used to incorporate resistance in the wheat breeding gene pool. The 739 varieties are also under test for resistance to prevalent soil-borne diseases. Varieties showing good tolerance or resistance will be used in variety improvement. This, like the bunt trial, is a joint project of the Plant Protection Directorate and the Wheat Research and Training Center.

Greenhouse tests were conducted for the seedling rust resistance of varieties in the winter wheat crossing block. Comparing greenhouse seedling and adult plant field reactions reveals which varieties have adult plant resistance but not necessarily which have both. Those tests will help the breeders identify varieties to use in incorporating resistance.

Research is being continued on septoria leaf blotch. An artificial epidemic was created in the Izmir nursery in spite of unfavorable environmental conditions. Studies of losses in yield and nutrition due to attacks of this disease are being conducted. Screening for sources of resistance is being emphasized at Izmir.

Since airborne pathogens are dispersed by weather systems over several countries, these diseases must be monitored on a regional basis. For this reason a regional disease surveillance program was set up in 1971. CIMMYT, ALAD, FAO, and the Turkey program together with 100 cooperators in 32 countries were involved in the current year. The program involves the growing of a Regional Disease and Insect Screening Nursery and a Regional Trap Nursery. The former is administered by the ALAD program in Lebanon and the latter by the Turkey program. The Regional Trap Nursery includes the principal commercial varieties of the region and may forewarn of the breakdrown of resistance in a country before the race reaches the commercial crop. With time and collection of data, the distribution and movement of such races can be mapped.

To illustrate the change in virulence and establish the endemic virulence or resistance trends, a comparison of average coefficient of infection for the rusts among local, improved, and dwarf wheat varieties in five geographical zones is presented in Table 52. A coefficient of infection greater than 10 suggests that the wheat varieties in this class have less than adequate resistance and should be replaced. A value between 5 and 10 indicates that the variety is reasonably resistant but new resistance will be needed shortly. A coefficient of less than 5 indicates that resistance is still adequate. Thus local varieties are in danger of attack by all three rusts in each region. As a class improved varieties that are not semi-dwarf are also in danger of attack by all three rusts in each region. The dwarf varieties, as a class, have adequate resistance in most regions. Necessarily there are exceptions. For example, in East Africa, particularly in Kenya, the rusts have a broad virulence base, hence there is little difference in the three classes and most varieties are susceptible. On the whole, however, the dwarf varieties in the region have much better resistance than the taller varieties. This does not mean that some dwarf varieties are not susceptible. They are, and they will continue to become, susceptible and they will have to be replaced with others that are resistant. While considerable progress has been made, there can be no slackening of effort if yields and production are to be stabilized.

Table 52. **Average coefficient of rust infection of local, improved, and dwarf wheat varieties in five regions. 1971/72-72/73.**

Variety group[a]	Indian subcontinent	Middle East	North Africa	East Africa	South Europe	Avg
		Stem rust[b]				
Local	29	22	24	50	24	34
Improved	8.5	14	14	42	11	16
Dwarf	0.57	4.7	4.4	41	4.2	8.5
		Stripe rust[c]				
Local	26	20	8.9	21	13	16
Improved	11	12	2.6	11	9.9	11
Dwarf	5.1	6.0	0.59	4.8	3.0	6.2
		Leaf rust[d]				
Local	49	18	44	22	17	32
Improved	32	15	23	8.2	11	20
Dwarf	20	8.9	6.9	1.4	1.8	8.8

a/ 7 local, 12 improved and 12 dwarf varieties in 1971/72, and 7 local, 31 improved and 14 dwarf varieties in 1972/73. b/ Puccinia graminis tritici. c/ P. striiformis tritici. d/ P. recondita tritici.

AGRONOMY

Soil tillage management and agronomic research trials have been conducted on the Anatolian plateau for the past three fallow-crop cycles by Dr. F.E. Bolton and his colleagues. Dr. Bolton returned to Oregon State University in 1973 and was replaced by Dr. M.J. Lindstrom. The work has demonstrated the importance of proper fallow management. Research was conducted in cooperation with OSU/AID and the Soil and Fertilizer Research Institute, Toprak ve Gubre Arastirma Enstitusu. In four experiments, conducted in farmers' fields by the OSU/AID team, average yields of 1.97 t/ha were obtained in comparison with 1.17 t/ha in adjacent farm fields—a gain of 67 percent. The average yield of the best treatment in each trial was 2.36 t/ha—a gain of 102 percent.

Fallow tillage. No yield benefits or improved water penetration appear to accrue from fall chiseling or subsoiling, although the friability and ease of tilling in subsequent spring operations was improved. Use of the moldboard plow in the fall increased yields at Altinova State Farm. The system has several advantages. First, time and labor are more available in the slack periods in the fall. Second, soils remain friable and weed-free longer in the spring allowing a 2 to 4 week delay before spring tillage. Third, a wider choice of initial spring tillage implements is possible. Fourth, initial spring tillage operations are faster and easier to perform so that they can be more timely.

The best type of spring tillage appears to be the moldboard plow with attached spike-tooth harrow used in late March or early April. This is particularly beneficial where grassy weeds are a problem. The disadvantage of using the moldboard plow in the spring is the time and power requirement. The time factor is critical.

The offset disc gives only slightly lower yield results and is faster and probably more economical. The use of a sweep plow with the grassy weeds has consistently given lower yields. For secondary tillage, however, the sweep plow appears to work well. The use of a rod weeder on the heavy clay soils created compaction problems which were quite evident in late summer.

The best method for summer weed control appears to be the sweep coupled with spike harrow. These implements consistently gave good yields over the 3 years. The sweep with a rod weeder also appeared good, but field speed was reduced. The spike-tooth harrow pulled behind the sweep-rod weeder combination leveled the furrows left behind. The sweep-harrow combination has the advantage of being useful for follow-up spring tillage and summer weed control.

Although the rodweeder creates compaction problems particularly when the soils are wet, for middle or late summer weed control the rodweeder works well. Table 53 shows the best fallow management systems in the order of their performance.

Drill seeding. The recommendations for drill seeding based on previous years' research vary with the type of drill used and the moisture status at seeding time. Ideally, seeding should be done into moisture conserved during the fallow period, but this is not common at present.

For early seeding, the shovel press drill with 30 to 35 cm spacing and 15 cm runner shovels has given the best results. The seed should be placed at least 2 cm into moist soil. The total depth of seeding will vary with the depth of moisture and it will usually be 12 to 15 cm below the original soil moisture with seed covered with 6 to 10 cm of soil in the furrow. Seeding should be done September 12 to 20. The best results are obtained from 90 to 120 kg/ha seed. For varieties with low tillering capacity, 110 to 120 kg/ha should be used.

Fertilizer should be applied at 40 to 60 kg/ha N and 50 to 60 kg/ha P_2O_5. If di-ammonium phosphate (DAP 18-46-0) is used, 110 to 130 kg/ha can be applied in the furrow but not in direct contact with the seed. When a

Table 53. **Best equipment and timing of operations for seasonal cultivations in Turkey.**

System	Initial spring operations	Follow-up operations	Summer operations
1.	Moldboard plow and spike harrow. 18-20 cm depth. Late March to early April.	Sweep and harrow 14-16 cm depth, 3-5 weeks after initial tillage depending on soil moisture and weed conditions.	1st. Sweep and harrow 12-14 cm depth. Time depends on soil moisture and weed growth: usually late May or early June. Mulch of 9-11 cm depth should be well established by 10 June. 2nd. Subsequent operations are required for weed control with same implement, 10 cm depth until seeding time.
2.	Sweep plow, 12-14 cm depth. Early April or when soil moisture at surface at proper level.	Sweep and harrow 14-16 cm depth. 3-4 weeks after initial tillage depending on soil moisture and weed conditions.	1st. Sweep and harrow 12-14 cm depth. 2nd. Sweep and harrow 10-12 cm depth. Other instructions same as above.
3.	Off-set disk 16-18 cm early April when soil moisture is low enough that soil will shed from disks.	Sweep and harrow 14-16 cm depth. Time same as above.	Same as above. Note: Sweep-rodweeder and harrow combination may be substituted for one of the above operations if weed conditions warrant.

10 to 15 cm shovel is used, seed and fertilizer can be placed together in the 3 to 5 cm band furrow. If P_2O_5 fertilizers are used, 50 to 60 kg/ha can be applied directly with seed. An application of 40 kg/ha N can be broadcast before the last tillage and worked into the soil. Additional nitrogen (20 to 30 kg/ha) can be applied in the spring if soil moisture is good in March or early April.

For late seeding with a disc drill, additional tillage may be needed to control late summer weeds and to smooth and firm the seedbed. The disc drill needs a better seedbed than the deep furrow drill. Excellent results were obtained in 2 years using a double disc opener drill at 17.5 cm row spacing where press wheels followed the opener. Press wheels do a better job than drag chains. When surface soils are moist, seed should be placed at least 2 cm into moist soil. The depth will depend on depth of moist layer but will normally be 5 to 7 cm deep. If surface soils are dry, seeds should be covered by 3 to 5 cm of soil. Seeding should be done October 10 to 15. If fall rains are inadequate for seeding into moisture by October 15, seeding should be done into dry soil to take advantage of the first moisture. The seeding rate should be 120 to 150 kg/ha. For varieties which tiller less, 140 to 150 kg/ha should be used.

Apply 40 to 60 kg/ha N and 50 to 60 kg/ha P_2O_5. The same application as described for deep furrow drilling can be used except that DAP can be applied directly with the seed without damage to germination since the concentration of fertilizer with seed is one half that with the deep furrow drill because of narrower spacing. The amount of nitrogen to apply in the spring depends on the availability of moisture in the profile.

For weed control, 2,4-D and 2,4,5-T are effective when used properly and at the correct date. In Turkey, applications from April 1 to 10 kill the weeds when they are small and before they have competed for nitrogen. Several weed species are resistant to these chemicals and are becoming a serious problem. Bromoxynil Plus or Brominal mixed with 2,4-D and 2,4,5-T show good results but these chemicals are not yet registered for use in Turkey.

TRAINING

In the past year eight Iranian scientists received agronomic training in the Turkey program. In addition two Iranian wheat breeders spent some time in the program.

IRAN

In 1972/73 the wheat production of Iran was 4.17 million tons compared with the long time average of 4.50 million tons. Barley production also fell below the average and is estimated at 800,000 tons. The shortfall in both crops can be attributed to below-average precipitation particularly in the south and west of the country. In addition a warm early spring which shortened the season interferred with full plant development and yield. Because of the generally dry conditions, disease did not play an important role. Rust developed in a few areas but even there it did not affect production materially. As a result of the short crop, Iran is importing about 1 million tons of wheat to make up the deficit and provide a small buffer stock.

The 1972/73 season was marked by a shortage of moisture which could affect the next year's yields and total production in the areas of limited rainfall. The crop results will depend on the rainfall of the coming season. To encourage wheat production and make it more competitive with cash crops such as cotton, the government is considering raising the price of wheat by 40 percent or more to about US$120 to $134 per ton depending on the quality. In addition, it proposes to issue free fertilizer, mainly urea, to those who sell wheat to government agencies.

In spite of the small number of experienced wheat scientists, Iran has an aggressive wheat improvement program. In 1972/73 five varieties were named for release.

Karaj 1, (200H-Vilafen)Roshan1-44-792, was derived from a cross of an introduced hybrid with the Iranian variety Roshan. Karaj 1 has been in yield trials since 1967/68 and the average yield under good moisture has been 4.37 t/ha, an advantage of 39 percent in yield over the check variety Omid, and comparable to the yield of Bezostaya. It is a winter wheat. The kernel color is white, it is moderately susceptible to stripe rust and stem rust and moderately resistant to leaf rust.

Karaj 2, Florence Aurore x Thatcher-ET/Omid1-44-21863, is a cross between a Mexican hybrid and the Iranian variety Omid. It has been in yield trials since 1968/69 and gave an average yield of 4.93 t/ha over the last 4 years which is 40 percent above the yield of Omid and 8 percent above Bezostaya. The kernel color is white and its resistance to the three rusts is somewhat above that of Omid. It is a winter variety.

Arvani 1, Roshan/Mentana-Kenya x Mayo 48, is a cross between Roshan and a Mexican line made at Karaj and selected at Ahwaz. It has been tested since 1969-70 and averages more than 4 t/ha. This is an advantage of 77 percent over the local check Sholeh and 17 percent above INIA 66. It has a large red kernel and shows resistance to yellow rust and septoria. It is moderately susceptible to stem rust. It is a spring wheat.

Khazar 1, P4160$_E$-Narino 59 x Lerma Rojo 64, is a selection from a hybrid Mexican population sent to Gorgan Station in 1964. In replicated trials since 1968/69 it has shown an average yield 20 percent above Akova, the variety it is designed to replace. Its yield is 9 percent above that of INIA 66. Its kernels are slightly smaller than those of INIA 66 but are lighter in color. It has resistance to yellow and stem rust but is moderately susceptible to mildew and leaf rust.

Moghan 1, Lerma Rojo 64 x Norin 10-Brevor/Andes$_E$, is a selection from Mexican germ plasm made at Moghan and Gorgan Stations. In replicated yield trials conducted since 1968/69 it has averaged more than 4 t/ha in Gorgan and 4.9 t/ha at Moghan. Compared with INIA 66 and Akova, this variety has given superior yields at Moghan. It is resistant to stem rust, but moderately susceptible to leaf rust.

About 200 tons of seed of Moghan 1 were available for distribution this season. The other varieties are still in an early stage of seed multiplication with 1 to 2 tons of each available.

A large breeding and selection program is conducted at Karaj the central station. Significant programs are also being conducted at several other Iranian centers. Iran is stepping up its training of scientists with one taking a Ph.D. and five training at CIMMYT. Five other scientists have been sponsored in visits to the Turkey national program at Ankara.

The Iranian improvement program has been strengthened by the appointment of an agricultural engineer engaged in station development and a breeder-agronomist to assist in the further development of the improvement production program. These expatriates are supplied by the ALAD-FF group.

Adaptive research and production agronomy is being strengthened. Detailed plans have been made for improved irrigation, field layout, and landshaping for Karaj and Kelardasht and considerable development work was accomplished in the current year. Kelardasht is the new summer nursery station located in the mountains between Karaj and the Caspian Sea.

Land and some equipment have been purchased for a dryland center at Kermanshah.

The Iranian government is developing an integrated research program for wheat and barley and plans a phased training program which over a 10-year period should equip all the research stations with trained staff. There is a need to accelerate seed production to move materials from the research stations to the farmer rapidly.

AFGHANISTAN

In the 1972/73 season Afghanistan had a bumper wheat crop which can be attributed largely to an increase in the use of fertilizers, increased area sown to improved varieties, and above-average precipitation. Farmers planted about 1.5 million hectares on irrigated land and 1.2 million hectares on rainfed land. Production has been estimated at slightly above 3 million tons with an average yield of 1.72 t/ha in the irrigated area and 0.52 t/ha in the rainfed area.

Throughout the year rainfall was above average and well distributed; in addition, snowfall was much above that normally expected. The only exceptions to these conditions occurred in the southwest in Helmand, Kandahar, and Zabul provinces. Here the precipitation was below average. However, since much of the production in this area is under irrigation its effect was minimized.

Scientists at the Ministry of Agriculture consider Strampelli, Golden Valley, Dacia, and Victory No. 1 the best-adapted varieties for the winter wheat areas. Among the spring wheat varieties, Chenab, Khushal, INIA 66, and Ephrat appear the most promising. In 1973 the government imported 500 tons of seed of the winter wheat variety Kavkaz from the USSR, to be distributed to farmers under contract for growing in the 1973/74 season.

The research department has continued to screen several international nurseries for suitable varieties. These nurseries include the screening and yield test nurseries distributed by CIMMYT from Mexico, the International Winter Wheat Yield Trial from Nebraska, and some other trials issued by FAO-ALAD from Beirut and the Turkey-Rockefeller Foundation Program from Ankara.

The increased wheat production in 1972/73 made available about 170 kg/capita of wheat as compared with 161 kg in the previous season.

The wheat improvement program in Afghanistan is being assisted by the U.S. Agency for International Development and by a plant breeder supported by the government of India. Other organizations including FAO are helping in the extension of new techniques.

PAKISTAN

A target of 6.7 million tons of wheat production was set prior to the 1972/73 wheat season. This was met. Throughout the growing season weather conditions were favorable, and it had been expected that considerably more than the target would be achieved. The crop sown at the optimum time yielded well, for the most part, but a substantial part of the area which was sown late was damaged for a variety of reasons. Wheat plantings were continued up to mid-January which places all present varieties out of their proper growing period. The earliest variety available should not have been sown later than the end of December. This meant that the late crop was subjected to dry hot winds which brought on premature ripening in the late stages. In addition a new race of leaf rust, race 158, attacked all varieties severely except Blue Silver (Sonalika). Late sown fields were affected most because of the earlier attack and longer exposure to the pathogen.

Yields generally were below expected levels because of inadequate use of fertilizer. Not only was insufficient fertilizer applied, but the balance between N and P_2O_5 continued to deteriorate. The soils of Pakistan are now very deficient in phosphorus because of the drain on reserves caused by the high cropping intensity. This year the ratio of N to P_2O_5 was 9:1 instead of 2:1 which is considered optimum.

Seed quality has also become a major problem. The high yielding varieties Mexipak and Chenab have become mixed with increasingly higher percentages of low yielding varieties. This caused some yield reduction. The country needs a strong seed production organization.

There was considerable comment that the yield potential of Mexipak is degenerating. While it has become susceptible to leaf rust, fertilizer imbalance and unseasonable sowing dates were responsible for much of its lower yield. Genetically, of course, it has the same constitution.

The improvement program. The cereal sections of the provincial research centers are conducting research on breeding, quality, and agronomy. Pathology is largely conducted at the national level by the plant pathology section.

An excellent cadre of scientists has been built up over the years. Some dislocations occurred in reorganizing agricultural work from federal lines to provincial lines. The adverse effects, however, are being mitigated by training for those centers whose staffs were depleted. Pakistani scientists are willing and enthusiastic in their endeavors to provide a sound research base for the country's wheat production. Research activities have continued to expand and have become more diversified.

New varieties. Following the release of Chenab 70 and SA42, other varieties had to be developed which would carry different patterns of disease resistance. In Punjab, four varieties may be released before the next planting season.

The locally made cross 114B-35xNad63 yields better under low moisture and low fertility than any released variety. Its root system apparently allows it to exploit ground moisture better than most varieties. It can be sown in late October. Bb-Norteno, II-27100-307M-100, is a CIMMYT cross that equals Chenab 70 in yield. It is suitable for November sowing in average to well-fertilized soils. Sandal is a Bb "S" selection which equals Mexipak in yield. It can be planted from mid- to late November on average to well fertilized soils. Cno-SonxKl.Rend/Mexipak V1325 is another Bb "S" selection. It has yields equal to those of Chenab 70, but stronger straw and better quality. It is suitable for highly fertile soil where lodging is a problem. All four varieties are resistant to leaf rust, stem rust, and stripe rust.

Several upcoming varieties which are disease resistant and have good quality are now in an advanced stage of testing:

Variety	Principal characteristics
Nai 60-CB151 x 5948-Mpk PK 3563-4-0A-0G-0Aut Bulk IV	Short duration, disease resistance, high quality
Mangla - Inia PK 3551-1a-2a-0a	Mid- to late-November sowing, disease resistant, Prot. 13.1%
TN15-Nor 67 x Cno 67 Pk 3580-1a-1a-0a	Mid- to late-November sowing, disease resistant, Prot. 14.3%
Cno "S" - HD832 Pk 3567-1a-2a-0a	Optimum sowing date: mid-November, slightly shorter than Mexipak, high resistance to rusts Prot. 13.2 %
Mangla x S948-Inia "S" Pk 3352-4a-2a-0a	Optimum sowing date: first half of November, fair rust resistance, Prot 12.9%
Pi62-Frond x Pi62-Mazoe/Mpk Pk 2858-7a-3a-4a-0a	Resistant to rusts, suitable for limited water regime, Prot. 11.9%
Milam - HD832 Pk 3483-9a-3a-0a	Mid- to late-November planting, resistant to rusts, good for low water Prot. 13.2%
SA42 - Nayab Pk 6208-16a-7a-0K	Mid-November optimum for sowing, resistant to rusts
Inia-Cal x Inia "S" - CC II28647-67Y-1M-1Y-0M	Mid-November planting, resistant to rusts, strong straw, red grain.

About six will be entered in the province-wide micro-plot tests in the coming year. Some are expected to be entered in international yield trials. Seed of these varieties will be made available to the other provincial centers.

Among the varieties in early stages of testing more than three dozen outyielded Mexipak and Chenab 70 in station trials. These have been advanced to the new trial series.

Segregating materials. Nearly 1600 F_2 populations were grown, plus nearly 4300 lines in advanced generations. This material was selected for yield potential, disease resistance, and high quality. In addition, certain groups were selected on the basis of suitability to low moisture regimes,

Drs. Bjawa and Qureshi show the excellent plots of the Bahawalpur station, Pakistan.

early maturity (particularly for rotation with cotton), and better efficiency for low levels of irrigation and fertility.

In addition to the regular breeding material, many international nurseries were evaluated. Yecora 70, Tobari 66 - 8156, Meng - 8156, Cocorit (durum), and Vicam 71 showed greatest potential to become varieties or be used in further crossing.

Quality is important in Pakistan both as to color of grain and protein content. The latter is particularly important since wheat is the major food of 80 percent of the people. In the early generations, Pelshenke values, 1000-kernel weight, and color and hardiness of grain are determined. In the advanced material, milling and baking properties are determined. The four varieties being considered for release, were tested, including assay for amino acid content, at the Nuclear Institute for Biology and Agriculture. All four varieties have lysine contents slightly superior to those of existing commercial varieties.

In the North West Frontier, frost affected some of the research plots but it provided an opportunity to select for greater frost resistance. One of the varieties which was outstanding in yield was Tarnab 19. It is being increased but because of its disease susceptibility it can only be a stop-gap variety. Another variety, Tarnab 957, has high resistance to all three rusts.

Baluchistan is increasing four lines for possible release in that province. They include a cold-resistant selection of the cross 114B-35 x Nad. 63, a line from Sonora 64 x H 68, line 299 x Qt 115, and 6134 x C 271. These are the highest yielding lines developed in the Quetta program.

Table 54. **Wheat varieties resistant to various pathogens in tests 1967-71 by the Plant Pathology Institute, Pakistan.**

Resistant to leaf rust races 12, 57, 77, and 184 and stem rust races, 11, 15, 17, 21, 24, 40, and 42 in seedling and adult stages.

Rush-Sup.	F6-M 30
FKN	F6-M 35
T. Timopheevi	LR64 x Son 64
Le Prevision	5840-S64 x Mpk PK 2367-1a
Kafue F45-A-Lee/Selk 1T-1T-2T	Cno "S" x Inia "S"
F430-Lee-ND74	Cno "S" -No66
F334-I	Tzpp x Sk-LR64
C273-Wt$_e$ x Son 64	Bb "S"
723-PK-1659	Bb "S"
Son 64 x P41603$_e$/Son 64 II-1980-1T-1T-2T	Bb "S"
Tobari 66	Bb "S"
1261	F$_5$-520
1590	CII-23

Resistant to field collections of partial bunt (Neovissia indica)

Wanken	Preska	Saratovskaja	Noroeste^{8}x Transfer
T. Timopheevi	Anniversario	Kirghizskaja-16	Noroeste^{7}xWebster
Nainari 60	Wardal	Dika 9/14	Noroeste^{10}xMediterranean
Nadadores	Lancer	Jafazi	Noroeste^{8}xDemocrat
Cougar	Trader	Melanopus	Thatcher (K22/63)
Gala	Bowie	Sinvalocho	Rushmore-Supreza
Dular	Selkirk	Lee	Kenya Farmer
Waban	Yuma	Lerma Rojo	Sonora 64-A
Exchange	F.K.N.	Wichita^{6}xMalakof	
Agent	Gage	Wichita^{8}x Loros	
Agatha	3255	Noroeste 66	

Resistant to races L8, L9, and L33, and field collections of Tilletia foetida

T. Timopheevi	IRN-1416	A-IV-19
299	IRN-1421	Deka 41/61
Bk-7	Mpk 65x5840	A-VII-3
Bk-9	Kalyan	Sonalika
Cougar	WB149xBk6-1B47	Red River
IRN-1147	2242	Son 64-Y50 5_e x Gto/Inia "S"
Dular	Carstens V	Jar-Napo LR64 x Tzpp-An$_e$^{3}
Waban	P.I. 178383	Cno"S" x Son 64-K1-Rend/8156 (Bb) sel
Selkirk	Yuma	F$_5$-517
Jafazi	Redman	F$_5$-728
6331	Deri-113	NP852-Son64xMayo 48
6332	3255	
Yayla-305	Mpk 69	

Resistant to races 1, 2, 10, and 12, and field collections of loose smut

Andes	Ch53 N10BxY54	Narino 59	744 PK/1660 [a]
Cajeme	Y50 ^{6} x 46-4M [a]	Frontana	Mpk-G155x5840
Indus 66	PW-Th ^{6} x a43-Selk	Veranopolis	H-23-YZ
Inia 66 [a]	FKN	Gala	1943 [a]
Huamantla Rojo [a]	Wanken [a]	Ment-Kenya	2077
Mexipak-65	3255	F430-LeexND74	2809
Mexipak-69	T. Timopheevi	F334-1	3207
Tobari 66 [a]	P-556 [a]	Hindi-Giza 139	5034
Norteño-67 [a]	Sr-5 (Marquis) [a]	FAO-RN9-63/64	F6-M.8
Penjamo-62	Sr-6 (Marquis) [a]	FAO-W-68	F7-1
Fn-K58xMD/Y54 ^{4}	Sr9-B (Marquis) [a]	Rachna 65 [a]	BK-7
2190 x Y54 ^{4}	Sr10 (Marq.) [a]	Au-44	
Wt x N112B-2A	Sr11 (Marq.) [a]	723 PK/1659	

a/ Only moderately resistant.

In the Sind, seven varieties show promise and are likely to be available for increase in the next year.

Breeders and government-level officials hope to reinstitute a coordinated wheat program at the national level. Plans are well advanced to bring this program into being under the Agricultural Research Council of Pakistan.

Plant pathology. The plant pathology section has introduced a national screening nursery for screening the advanced materials arising from the breeding programs on a country-wide basis. They have also begun a national trap nursery.

Over the past several years wheat varieties have been screened for resistance to various pathogens. These are shown in Table 54 to help breeders in other countries in selecting crossing materials.

Assistance. Assistance to the Pakistan wheat program is being provided by U.S. Agency for International Development and the Ford Foundation.

INDIA

The multidisciplinary coordinated wheat research program began in 1964. Since then, research has been intensified in breeding, genetics, agronomy, pathology, quality, physiology, and entomology. As a result of the cultivation of superior wheat varieties developed or identified in the program, the keen interest of the farmers in adopting new technology, extensive and efficient seed multiplication and distribution, government action on establishing floor prices with economic incentive and other measures, wheat production was raised from the record 1964/65 crop of 12.3 million tons to a high of 26.4 million tons in 1972. The yields over this period increased from 0.9 t/ha to 1.4 t/ha. Thus, in less than a decade, wheat production was raised by 115 percent and average yield by 51 percent.

In 1973, however, production received a set-back because of a shortage of fertilizers, electric power, and water in the canals. The last two stemmed from the low rainfall in the monsoon period of 1972. The temperature during the ripening period was abnormally high in several major wheat growing states resulting in some grain shrivelling. In addition, new races of leaf rust, to which Kalyansona has become increasingly susceptible, appeared in epidemic form in the northern plains. Recently, somewhat later maturing rice varieties such as IR8 have been grown in rotation with wheat. The late maturity of the rice varieties has set back much of the wheat plantings by about 2 weeks. In addition to the lower yields caused by this out-of-season growing period, the grain filling period occurs when heat damage is most likely and leaf rust has built to its highest intensity. This late seeding must be rectified to place the crop in its proper growing period. Only early maturing varieties such as Sonalika should be grown where seeding is late.

The result of these deficiencies was somewhat reduced production of wheat in 1972/73, now estimated to be 24.5 to 25.0 million tons.

Breeding research. To identify better wheat varieties with resistance to the prevalent races of disease for commercial production under the varying cultural and climatic conditions, 690 new strains of wheat developed by the Indian wheat breeding centers were tested in the All-India Coordinated Wheat Varietal Trials during the 1972/73 season. In all, 384 bread and durum wheat trials were conducted. In addition to these yield trials these new strains were evaluated for reaction to major diseases and pests and for quality characteristics. Based on results of these and previous trials and district large-scale trials, the 12th All-India Wheat Workers Workshop, held in 1973, recommended five varieties for release (Table 55).

In addition, wheat workers identified several new strains considered worthy of multiplication and extensive testing before possibly recommending them for release in 1974 (Table 56).

All of the varieties in Tables 55 and 56 are now under extensive multiplication Some are expected to replace Kalyansona and other dwarf varieties released earlier and in commercial production. The earlier released dwarf varieties have become susceptible to new strains of the rusts in recent years.

Table 55. **Wheat varieties identified for release. India, 1973.**

Variety	Parentage	Recommended area	Conditions for which recommended	Features
		Bread wheats		
HD1982	E5557*xHD845	Eastern UP, Bihar, Assam, Orissa, West Bengal.	High and medium fertility when timely sown. High fertility in late seeding.	A double dwarf with a high resistance to leaf rust. Amber hard, large, lustrous grains.
UP215	TzppxSon64	Maharastra, UP part of Rajasthan Madhya Pradesh and Gujarat.	High fertility and timely sowing.	A single dwarf with good resistance to rust. Amber, hard, lustrous grains.
Shera (HD1925)	LR64AxSon64	Central UP, part of Rajasthan Madhya Pradesh and Gujarat.	High fertility and late sowing.	A double dwarf with good resistance to stem rust. Amber, hard, medium, large, lustrous grains.
		Durum wheats		
MACS 9	T. Durum x T. pol.	Maharastra, Andhra Pradesh, Karnatka.	Low fertility and rainfed.	A tall conventional variety with good resistance to stem rust. Excellent grain.
HD4502	Pi "S"-BY^{2}xTc /Z-B x Wells.	Maharastra, Andhra Pradesh, Karnatka, Tamilnadu.	High fertility and timely sowing.	Triple dwarf with high resistance to stem and leaf rust. Amber, hard, large grains.

A number of backcross lines of Kalyansona, Sonalika, and Sharbati Sonora, the most popular and widely grown commercial varieties, have been developed with different sources of rust resistance. Some of these lines were tested at 14 locations scattered over the five zones of the country in 1972/73. Several appear promising and have been included in a special coordinated trial for 1973/74. Multilines representing individual mixtures of Kalyansona, Sonalika, and Sharbati, were included in this trial along with the single backcross lines. Material of these lines were sent to CIMMYT. Those which are backcross lines of Kalyansona have been placed with a large number of similar lines developed at CIMMYT in the 8156 background for testing at a number of locations world-wide for 1973/74.

Under the cooperative multilocation testing program conducted for the National Wheat Genetic Stock Nursery, which is grown at all wheat breeding stations in India, some very promising genetic stocks were identified and used by the breeders in their wheat breeding programs. This nursery comprises promising Indian material along with material selected from various international nurseries.

The project also cooperates with international and regional programs. During 1972/73, a large number of yield, screening, and breeding nurseries of bread, durum, and triticale varieties were obtained from such agencies as CIMMYT, Arid Lands Agricultural Development Program, FAO, and the U.S. Department of Agriculture. These nurseries were evaluated at many centers, and the project selected many lines for inclusion in the Genetic Stock Nursery, station trials, and for extensive testing in national and special regional trials in 1973/74. Some of the more promising strains:

Bread wheat	Durum wheat
Tanori 71	Pelicano "S"
Zaafrane	Anhinga "S"
Torim 73	Jori "S" - Crane "S"
Jupateco 73	
Ciano - INIA x Bluebird	

Agronomic research. Agronomy work in the last year focused on developing suitable packages of practices for rainfed wheat. Close spacing (15 to 20 cm between rows), high seed rate (125 kg/ha), and deep placement of nitrogen (10 cm) at 40 kg/ha N was the best combination found for growing rainfed wheat. Where the crop was sown late, closer row spacing and higher seed rate were very beneficial.

Pathology research. Several chemicals were tested for control of rusts. RH124, applied at 0.5 liter/ha, gave complete control of leaf rust which is perhaps the most damaging of the three rusts in India. Disease surveillance was continued throughout the country and the pathology group organized screening nurseries of the plant breeders' materials which were evaluated for disease resistance.

A study in which weather movements and wind directions determined by satellite pictures were correlated with a known center of stem rust correctly forecasted the appearance of stem rust near Hoshangabad in Madyha Pradesh.

The disease surveillance program is vital to India where the occurrence of an epidemic could cause wholesale famine. It deserves further support. New advanced lines should be screened nationally to ensure that the resistant strains are rapidly multiplied.

Quality. Many new strains were screened for chapati,-bread-, and biscuit-making properties. UP310, UP319, K65, K68, and Hira were very good for bread-making. Chhoti Lerma, Safed Lerma, and NP809 were suitable for biscuit flours. Many strains from the coordinated trials appear to have good protein level.

Summer nurseries. The summer nurseries at Wellington in Tamilnadu in the south and Keylong in the Himalayas in the north were sown with wheat and triticale material deeloped by various breeders. A heavy epidemic of rusts permitted critical screening of the materials. Mildew and septoria present at Wellington gave a further selection pressure.

Triticale program. Work on the triticales is being conducted at four locations: Indian Agricultural Research Institute at New Delhi, Punjab Agricultural University at Ludhiana, G.B. Pant University of Agriculture and Technology at Pantnagar, and J.N.K.V. University at Indore. Preliminary trials conducted in the hills of north India by Pantnagar University during 1972/73 indicated that triticales are superior to wheat in yield. Although the reasons are unclear, the triticales may be better adapted to soils of lower pH. Systematic All-India Coordinated Trials of triticales are being organized for the first time in 1973/74. Decisions on the future of triticales in the different agro-climatic zones of India will be taken on the basis of these trials. Although present triticales are narrowly based genetically, new variation being developed may lead to much wider adaptation. Strains that have well-filled grain and good yield potential are now in preliminary yield trials.

Conclusion. New varieties with superior rust resistance must be increased as rapidly as possible. It is particularly important that satisfactory multilines of 8156 be selected, bulked, and increased. These lines can be expected to yield comparably to Kalyansona which has wide adaptability in India. Introduction of a multiline of this genotype on a fairly broad scale can greatly reduce the danger from disease epidemics. The growing of the wheat crop in North India out of season because of late rice harvest requires a hard look on the part of both rice and wheat programs to determine whether this can be remedied by the introduction of an earlier maturing rice variety. The deteriorating situation in fertilizer supply is alarming. India has suffered a further reduction in fertilizer supply for the coming season. It is generally conceded that stocks are 40 percent

Table 56. **New strains advanced to pre-release multiplication. India, 1973.**

Variety	Parentage
	Northwest plains zone
HD 2009	LR 64 "S" - Nainari 60
HD 2028	(LR-Son64/Son64-Tzpp x Nainari 60) Ciano
Raj 821	NP875-HD (M) 1508
WL 334	HD (M) 1508 - S308 (Sonalika)
HD 1981	E 5557 (Pi "S") - HD 845
UP 319	Ciano "S" x Son 64-Kl. Rendidor/8156 = Bb "S"
	Northeast plains zone
HP 916	S227 (Kalyansona) - S308 (Sonalika)
K 852	Sel. from S 308 (Sonalika)
HD 2037	NP 875-C303 x S310/S331 (Chhoti Lerma)
	Central zone
Raj 911	Var 0229 (CIMMYT)
HI 7747	Sel from Mex cross 1633
HD 4519	HI, 35-196-Pi "S" x Bel 116/Tc^2 (durum)
WL 208	NP 887 - V18 (SuperX) x Kalyan
MP 112	C306 - Hybrid 65
J-1-7	Sel from C 273 x NP 835
J 24	S 308 (Sonalika) - WS 217
	Peninsular zone
HD 2012	S 307 (Safed Lerma) -NP875xHD1592 (Kalyansona "S")
HD 1739	Hybrid 65-1 x C306
HD 4513	(Barrigon Yaqui ^{2}- Tc) ^{2} /Z-B x Wells (durum)
HW 124	NP 881-E4928 x S331 (Chhoti Lerma)
NI 5749	G-4-48-N59
	Northern hills zone
HB 117-107	E 4717 x Kiran
HS 1138-6-4	E4870 x S308 (Sonalika)

below demand. This situation must be amended if the forward momentum in wheat production is to be maintained.

NEPAL

Wheat is the third most important crop in Nepal following rice and maize. Approximately 259,000 hectares are planted to wheat—about 11 percent of the cultivated area of the country.

Wheat is grown from the lowland Terai plains near the Indian border to 3000 meter elevation in the Himalayas. It is sown in November or December and harvested in March or April in the lowlands. Between 2000 and 3000 meters it requires 7 to 10 months to mature, and when sown in September and October it is harvested from May to July. At elevations above 3000 meters, wheat is grown as a summer crop, planted in May and harvested in October or November.

The wheat area in the Terai region has doubled in the last 7 years. With expansion of the irrigation in the Terai, wheat production is expected to increase further. Wheat production for Nepal 1965/66-72/73:

Year	Area 000 ha	Production 000 t	Yield t/ha	Area under improved varieties %
65/66	117.7	147	1.25	4
66/67	125.0	159	1.27	9
67/68	192.3	205	1.07	14
68/69	207.9	233	1.12	25
69/70	225.5	265	1.17	33
70/71	228.4	193	0.84	43
71/72	239.0	223	0.93	40
72/73	259.0	312	1.20	66

Sonalika is the most widely grown variety in the Terai. Kalyansona has declined in popularity because of lower yield caused by leaf rust. S331 (Chhoti Lerma) is also high yielding and is resistant to the rusts. Its acceptance, however, has been slow because of its small grain. In the hill areas, Lerma Rojo 64 remains the principal variety. Lerma 52 which preceded Lerma Rojo 64 still maintains its popularity with the hill farmers of the interior where it does well on soils of low fertility. Local wheats are still grown in many high altitude areas. Difficult road communication has hindered adaptive research and as a result improved varieties have not yet been introduced.

A blanket NPK recommendation of 100-60-50, has been adopted because of limited knowledge of soil fertility. In such areas as the Kathmandu Valley, farmers have been convinced of the value of the recommended application. In most other areas, however, farmers use about half the recommended rate. In 1972/73, phosphorus was in short supply for wheat sowings and as a result farmers applied only nitrogen and potassium.

Following sowing in the fall of 1972, excessive rainfall damaged the crop in many areas. It also delayed weeding and topdressing. In the Terai region the winter was warm and a prolonged drought during the grain filling period reduced grain size and yield. In some areas, strong winds just after flowering caused even the three-gene dwarf varieties to lodge. The lodged crop produced shrivelled grain.

The leaf rust was serious in the Terai and all three rusts were present in the hill regions. As usual, bunt on susceptible varieties caused damage in the hills. Wireworms did some damage in the Terai and *Heliothis armigera* damaged crops near maturity in localized areas of the hills.

In the forested area of lower elevations, unexplained sterility of the grain occurred. In the northern forest area of Rupandehi District near Bhairawa, 50 hectares of UP 301 was almost completely sterile. Sonalika and Kalyansona were not affected in nearby fields although in 1970 all varieties at one location near Biratnagar were similarly affected.

It is now nearly 15 years since improved varieties of wheat were first introduced in Nepal. The adaptive wheat research program was expanded 3 years ago and was further expanded in 1972/73 with the development of a wheat team. The team consists of four members located at the research station near Kathmandu. Efforts are being made to increase the staff and facilities. The wheat program is conducting adaptive research at 12 experiment stations, six of which are located in the Terai and six in the hills. These 12 stations provide representative sites for the different agroclimatic regions. Staffing of these centers is moving forward.

The wheat program is developing a working relationship with CIMMYT, the All-India Coordinated Wheat Improvement Program, FAO, and other organizations. Breeding materials, varietal nurseries, and disease nurseries provided by these organizations are being evaluated each year. Two Indian varieties, HD 1962 and HD 1982, look promising in the yield trials. NS30 and NS31 look promising in initial trials. The more promising varieties are being further tested in farmers' field trials. These are being expanded to give farmers an opportunity to help select suitable varieties.

The U.S. Agency for International Development and CIMMYT are helping Nepal in the development and conduct of the wheat program.

BRAZIL

The 1972 wheat harvest was one of the worst in Brazil's history. Frost, excessive rain, and disease reduced the production from an expected 2.2 million tons to 683,000 tons (or 800,000 tons according to some estimates). Wheat production moved up sharply in 1973 (Table 57) to 1.9 million tons.

Wheat prices rose from US$98 a ton in 1972 to $112 a ton in 1973. Prices undoubtedly would have gone much higher in view of world prices up to $250 a ton had it not been for a government ceiling established to hold domestic inflation to 12 percent per year.

Two thirds of the 1972 soybean crop was sold in the world market at over US$500 a ton. This encouraged the farmers to switch from wheat to soybeans resulting in a reduced wheat area in 1973 in the main wheat belt of the South. A similar pattern is forecast for 1974 sowings, since wheat prices are held well below world price and most of the soybeans will be sold into an expected firm world market.

Table 57. **Brazilian wheat area, production, imports, prices, and yields.**

Year	Area million ha	Production million t	Imports million t	Price US$/t	Yield t/ha
1971	1.90	2.02	1.57	97	1.08
1972	2.08	0.68	3.02	98	0.31
1973	1.75	1.88	1.88 [a]	122	1.07

a/ Estimated.

The northern region. In the northern wheat region, the states of Parana, Sao Paulo, and Mato Grosso, disease in general was reported less severe in 1973 although there were late attacks of septoria, helminthosporium, and scab in certain areas which reduced yields somewhat. In this region production was estimated at 200,000 tons: 140,000 tons from Northern Parana, 50,000 tons from Sao Paulo, and 10,000 tons from southern Mato Grosso.

In the traditional wheat area south of the Tropic of Capricorn, yields were expected to average about 1 t/ha although around San Borja where the soil is essentially aluminum-free, a better yield was expected. In the non-traditional wheat region, north of the Tropic, average yields were considered to be above 1.5 t/ha although many farmers of Northern Parana State harvested more than 2.5 t/ha.

For the third consecutive year a summer nursery was grown in the January-May period at the experiment station at Brasilia. No irrigation is required to give an average yield of 0.6 t/ha and, with best varieties, good fertility, and soil corrected for low pH (aluminum toxicity), yields of 1.2 t/ha have been recorded. These yields contrast with 2 to 3 t/ha obtained for May-September crops in the same area. The summer nursery permitted growing two generations per year.

At the Siete Lagoas Station in the central-west part of the region, yields of 3 to 4 t/ha were obtained under irrigation and high fertility. In the San Francisco Valley yields of 2 to 3 t/ha were harvested in yield tests. One problem associated with extending wheat cultivation under irrigation in this area is the high cost of sub-structuring the land for irrigation. Costs per hectare range from US$1800 to $2000. About 18,000 hectares have been developed, but

Table 58. **Yields from 10 locations in southern Brazil for outstanding lines. 1973.**

Entry	Yield, t/ha All sites	Sites with aluminum toxicity	Sites without aluminum toxicity	IAS 59 check
PAT 1	2.0	1.9	2.3	–
PAT 10	1.9	1.7	2.2	1.8
PAT 19	2.2	2.0	2.7	–
PAT 43	2.1	–	2.1	1.9
PAT 46	2.3	–	2.3	1.9
PAT 8	1.8	1.5	2.3	1.8
PAT 9	1.9	1.5	2.1	–
PAT 54	1.9	–	1.9	1.9

because of costs, hence scarcity of land, only 2 hectares are allotted per family. Although perhaps 3 million hectares could be developed, the cost would be US$5 to $6 billion.

CIMMYT materials have been tested in the region for some years. Although some have shown promise, no direct information was available for specific materials.

The southern region. In the southern region, data have been received only from Cruz Alta. Fifty-four varieties, PAT 1 to PAT 54, were included in the 1973 Southern Brazil Regional Yield Trials. Of these, five will be reincluded in all zones in 1974:

PAT 1	(Colotana 824/N-ArditoxFrontana^2-Kenya 324)Norin 72 = Sel of S67
PAT 10	Skemer-Toropi^2, B2742-1C-2A-0C
PAT 19	(S12xVernapolis-1WRN1960 line 218) Desc. B530-0c-52C-1C-0C
PAT 43	Crim (Colo 824-Yt54xCzho/Tp), B5081-2c-3A-0C
PAT 46	Nor 67-C25, B1994-4c-4A-0C

Three other varieties will be reincluded only in the aluminum-free regions:

PAT 8	Tp-1AS 16xCrim B422
PAT 9	Tp-1AS 16xCrim B422
PAT 54	Lagoa Vermelha-Angola 118,B615-1c-1J-201J-0C

Table 58 gives yield data for these eight varieties.

Thirty lines have been selected at Cruz Alta from preliminary trials as the best in yield under aluminum toxicity or aluminum-free conditions. The best line on high aluminum was PAT 7268, a sib of PAT 10, with a yield of 2.8 t/ha. It was third best on soil limed to reduce aluminum toxicity with a yield of 2.6 t/ha. Another sib, PAT 7284, was highest in yield on limed soil with 2.7 t/ha. PAT 72133, from the cross INIA x 1AS20-Angola 106, was second on limed soil. About 900 entries were selected from the advanced lines for preliminary yield trials. Because of the interest for other countries with low pH soil and the likelihood of aluminum toxicity, the parentage of the best F_4 and F_5 advanced lines at Cruz Alta are listed in Table 59.

The performance of the triticales was surprising. Only rarely have aluminum-tolerant lines been encountered with any introduced cereal. Yet, some of the F_3 and F_4 Armadillo sibs introduced from CIMMYT and then reselected in Brazil yielded over 3 t/ha which was more than any wheat line or variety in any trial. Unfortunately, grain quality was poor. Hopefully, triticales from CIMMYT with good grain can be obtained to cross with these aluminum tolerant selections in 1974.

The high yielding triticales will also be included in the crossing block to cross with wheat in an attempt to improve aluminum-tolerance in wheat. The increased tolerance is presumably derived from rye since the durum parent shows none.

The San Borja region is essentially aluminum-free so some CIMMYT wheats may have sufficient disease resistance to be used directly. Because of their earliness it may be possible to seed late and escape a part of the septoria and scab attack.

COLOMBIA

Wheat is sown in Colombia in March and harvested in July or August. In 1973 about 56,000 hectares of wheat were grown, and production was about 60,000 tons. Colombia imports about 400,000 tons annually. This is a large foreign-exchange drain since the cost for imports is 7000 pesos per ton (US$280). The farmer is paid about 5000 pesos per ton. The contrast in price indicates the strong desire of millers for imported wheat.

About 80 percent of the wheat is grown at 2200 to 2800 meters elevation. Early varieties with better quality and responsiveness to fertilizers are needed. At high elevations varieties are needed which yield relatively well under low fertility conditions. The principal diseases include stripe rust, scab, and the smuts.

Moisture levels at seeding were good in 1973, but a period of below-normal rains followed, and then from flowering to maturity rains were much above normal leading to severe fusarium infection (scab).

About 60 to 70 percent of the fertilizer needs are produced domestically. Various formulations including 10-30-10, 8-30-10, 13-26-4, 15-15-15, and 14-14-14 are produced amounting to about 400,000 tons of fertilizer (not nutrients). In addition some 150,000 tons of urea are used, and about half of this is imported. The import price of urea in 1973 was US$160 per ton. Like so many other countries, Colombia is feeling the pinch of high wheat prices and high fertilizer prices on imported materials.

Colombia could produce the greater part of its wheat needs by increasing the area devoted to wheat cultivation.

Table 59. **Superior advanced lines. Cruz Alta, Brazil, 1973.**

Parentage	Cross
F4	
IAS50-JixYr70	B8240
IAS50-GbxS60	B7921
Amz "S" - L.V.	B7376
Amz "S" - J14710 69	B7374
Aobak-TpxCd1	B7386
Bb-Anh	B7391
Bb-B25	B7393
Bb-Cpa	B7394
Bb-Mis	B7402
Bb-Nor67xPAT7285	B7419
Bna-BH1146xBb	B7428
(Chig285-Gto/KlPet-RafxSon64) C279-67	B7444
(Chig285-Gto/KlPet-RafxSon64) NPr-Pj	B7446
(Chig285-Gto/KlPet-RafxSon64) Pel 13214-65	B6401
Cno-Inia^{2}xS12-SA3502	B7464
Cno-IniaxIAS57	B7991
Nai60-JnxTzpp-Son64/PAT7285	B7691
Nor 67-Pel A403-65	B6979
Pato-CnoxB15	B7723
Pato-Mga	B8072
IAS59xBb-Nor 67	B7027
IAS59-Son64	B7031
Pe113214-65(Cno-Y/TT-Son64xCh)	B7040
Pe1 13214-65/Tob-CfnxBb	B8062
Pe113394-65xCia-Son64^2	B8067
Ptf-Cno/Fn-IAS50xJ9280-67	B7729
Pato B-C371-67	B8053
Pato B-L.V.	B8055
Pato R-Pe1 13214-65	B8056
Rq-Np63xMga	B7750
Rq-Pa1 No. 2xIAS58	B7742
SA3423-Anh	B7761
SA3423-IAS57	B7165
SA3423-Son64	B7106
SA3423-Tp	B7766
Sam-Pel 13395-65	B7102

continued

Table 59 continued

Parentage	Cross
Son64-An64xIA0-10	B7797
(Son64-An64AxNad/Jar) Iv	B7192
(Son64-An64AxNad/Jar) IAS59	B8102
(Son64-An64AxNad/Jar)S61	B8101
Son64-KI.RendxBb/S55	B8092
(Son64-KIRend/CiaxLR64^2-Son64)S12-B8xJ9280-67	B7814
Son64-KIRendxIAS55	B7800
Son64-KttAxTp/Sam	B7826
(Son64xTzpp-Y54/PalNo.2)Cno	B7808
(Son64xTzpp-Y54/PalNo.2)IAS7	B7809
Sta Barb (12300xLR64A-7C/Nor67)	B7775
Super X-J14477-69	B7830
S12-B8xJ9280-67/DrcA-Desc	B7791
S12 x Cno-Inia ^{2}	B7780
S12-SA3502xSon64-KttNo.2	B7794
S42/Tob-CfnxBb	B8025
S43/Tob-CnfxBb	B6700
S53-II-60-216	B5579
S62-Jar	B6255
S64-CC	B7531
Tob-PurxCno/S55	B7848
Tob-Cgt	B7852
Tp-Anz 106xCno-Inia ^{2}	B7871
Xe66/S12-B8xJ9280-67	B8177
F5	
S62-Jar	B6255
Bb-B19	B6303
Ji-L.V.	B6506
(DrcA/Tzpp-Son64xNp63)C33	B6632
AMz "S"-ND81	B7373
Bb-Anh	B7391
Bb-Nor67xAnh	B7422
Pato (B)-C371-67	B8053
Pato (R)-Pel 13214-65	B8056
Rq "S"-Np63xMga	B7750
S42-II-60-216	B8026
F6	
Fn-K58-NxN10B/Pel 21414-66	B1589

Table 60. **Yield of some wheat varieties in regions of the Department of Cundinamarca, Colombia, 1972.**

Variety	Yield, t/ha Centro Occ Savannah [a]	Simijaca Ubate	Zipacon	Soacha	Norte Savannah [b]	Avg [c]	Percent of Tiba 67.
9	3.2	4.2	2.5	2.5	1.5	2.8	123
21	4.2	4.9	3.1	2.1	1.9	3.3	146
12	3.9	4.5	3.0	2.2	1.5	3.0	133
14	3.8	4.5	3.8	2.1	1.8	3.2	140
22	3.8	5.0	2.9	2.2	1.2	3.0	133
19	3.7	4.5	2.6	2.1	1.2	2.8	124
18	3.6	3.5	3.7	2.6	1.3	2.9	129
24	3.6	3.5	3.2	2.3	1.5	2.8	124
3	3.2	3.5	3.3	2.5	1.1	2.7	120
11	3.2	4.2	3.2	2.3	1.3	2.8	124
Avg	3.6	4.2	3.2	2.3	1.4		
Tiba 67 [d]	3.0	3.4	2.5	1.8	1.5	2.3	100

a/ Average of five locations. b/ Average of three locations. c/ Average of 12 centers. d/ Check variety.

This would call for an integrated production program in which technology, technical assistance, credit, and marketing services and support prices should play their part.

The native varieties are late, tall-strawed and susceptible to such diseases as stripe rust, black rust, and mildew. They generally have low yield potential (0.8 to 1.2 t/ha), but are otherwise reasonably well adapted to the areas above 3000 meters.

The Instituto Colombiano Agropecuario (ICA), has developed superior varieties with earliness, good plant type, resistance to diseases, and good quality. These are quite capable of producing 2.5 t/ha at 2400 to 2800 meters elevation. All varieties are subjected to yield testing for 3 years at experiment stations, and the most promising are then grown in regional and farm demonstration plots to determine their yield, yield stability, and adaptation within the wheat zones of the country. On the basis of these tests, varieties are recommended for the different zones. The demonstrations also serve as centers for farmer field days.

Table 61. **Yield of seven promising wheat varieties in replicated trials, multiplication plots, and semi-commercial plantings in comparison with the commercial variety Bonza 63. Tibaitata, Colombia, 1973.**

Variety	Replicated trials Yield, t/ha	Replicated trials Percent of Bonza 63	Multiplication plots [a] Yield, t/ha	Multiplication plots [a] Percent of Bonza 63	Semi-commercial trials Area, ha	Semi-commercial trials Yield, t/ha
16	5.6	135	5.9	183	4.4	3.5
21	5.5	134	5.0	156	–	–
7	5.4	133	5.8	178	–	–
19	5.4	131	5.4	167	–	–
11	5.1	125	5.2	161	–	–
8	4.5	110	5.8	178	4.9	3.3
41	4.4	108	4.5	139	3.4	3.5
Bonza 63	4.1	100	3.2	100	6.1	3.0
Samaca	3.9	96	3.9	119	5.5	2.9

a/ Plots of 37 rows, 5 m long separated by 30 cm.

Table 60 shows the yield of the 10 best varieties grown in 1972 in several regions. The data show that in any region, at least six varieties could replace the existing varieties. From these tests, zones of high, medium, and low production, can be mapped. Regions of optimum wheat yield are the valley of Ubate and the central and western part of the Bogota savannah. The yield potential is 3.0 to 3.5 t/ha. Regions of intermediate wheat yield are the semiparano and region of Soacha. The yield potential is 2.3 to 2.5 t/ha. Regions of low wheat yield are parts of the north of the Bogota savannah, Sopo, Tocancipa, and Gachancipa. The yield potential is below 2 t/ha.

Varietal improvement. In 1973, 450 varieties of bread wheats were tested at Tibaitata and Surbata for yield, disease resistance, and general performance. More than 5 percent of these varieties showed characters superior to those of the commercial varieties Bonza 63, Tiba, Tota, Samaca, and Sugamuxi previously distributed by ICA. Table 61 compares the more promising varieties slated for possible distribution in 1975 with Bonza 63. A genetic yield potential of 5 t/ha possessed by some of the varieties surely points to a possibility of raising the national yield average from 1.2 t/ha to 2.0 t/ha, provided that varieties are grown with good cultural practices.

In addition to excellent yield, these varieties have good quality, adaptation, and resistance to the principal limiting diseases. They have strong straw which will allow them to be sown at high seed rate (130 to 150 kg/ha) and with above 300 kg/ha of fertilizer. This will assure a good population of well-formed spikes, the factor most directly involved in final yield. These varieties are under pre-release multiplication.

During the 1973 season, 90 crosses were made; 585 F_1 plants and 6593 F_3-F_7 lines were grown. Of 9520 individual plants selected, 2197 were discarded because of poor grain quality, leaving 7323 lines for sowing in 1974.

International nurseries. In 1973, 4848 lines and varieties of wheat and triticales were received from Mexico, USA, Netherlands, Italy, Israel, and Lebanon. This material was observed and selected for yield, quality and disease resistance.

From material received in previous years, eight varieties of wheat and 15 varieties of triticale having yields over 7 t/ha were isolated (Table 62). These yields should be taken with discretion since they represent only single-row plots. In spite of this the wheat and triticale material selected shows good yield potential. These varieties plus 184 others will be tested in replicated plots in 1974 in order to give a better test of the genetic potential for yield. This preliminary information, however, indicates that many of these varieties received from international sources are adapted to Colombian conditions and should prove useful in raising yields.

Table 62. **Wheat and triticale varieties with yields in single rows [a] above 7 t/ha. Tibaitata, Colombia, 1973.**

Var. no.	Yield t/ha	Origin
	Wheat	
173	8.5	6 th IBWSN
229	7.6	6th IBWSN
25	7.5	6th IBWSN
308	7.5	6th IBWSN
211	7.3	6th IBWSN
130	7.2	6th IBWSN
185	7.2	6th IBWSN
260	7.1	6th IBWSN
	Triticale	
69	9.9	3rd. ITSN Group A
24	9.7	3rd. ITSN Group A
57	8.5	3rd. ITSN Group A
4	8.5	3rd. ITSN Group A
13	8.4	3rd. ITSN Group A
8	7.6	3rd. ITSN Group A
37	7.3	3rd. ITSN Group A
113	7.3	3rd. ITSN Group A
11	7.1	3rd. ITSN Group A
58	8.0	4th ITSN Group B
11	7.9	4th ITSN Group B
25	7.8	4th ITSN Group B
6	7.1	4th ITSN Group B
33	7.4	4th ITSN Group C
107	7.1	4th ITSN Group C

a/ 5 m long, for a plot size of 1.5 sq.m.

At Tibaitata triticale yielded 5.7 t/ha compared with 4.3 t/ha for rye and 5.2 t/ha for wheat (Bonza 63). Attention must be paid to this new man-made species. The chief problem with the triticales is low grain weight. This is due to the high frequency of shrivelled grains. The grain also germinates very easily in the field. For these reasons its first use in Colombia is likely to be as a feed grain. Once a solution is found to the problem of grain formation, it should be possible to obtain a triticale with high yield and good quality for bread making.

Regional trials. In 1973, 12 regional trials were conducted to determine which varieties are best adapted to the major wheat regions. On the basis of such trials, recommendations will be made for varietal release in 1974/75. Twenty-five varieties were tested at each site, and the best performing ones are shown in Table 63. These varieties yielded above 3.5 t/ha with normal rainfall. Thus it should be easy to surpass the national average of 1.2 tons with

Table 63. **Best yielding varieties in regional adaptation trials under normal rainfall or drought. Colombia, 1973.**

Location	Yield, t/ha PM21	PM7	PM13	PM16	PM19	PM8	Bonza 63[a]
	Locations with normal rainfall						
Mosquera	5.9	5.8	5.4	6.2	5.7	5.1	4.9
Madrid	4.6	4.2	4.0	4.1	3.8	3.9	3.3
Simijaca Aposentos	4.1	4.5	5.0	3.6	3.9	3.8	4.7
Simijaca Corcega	5.4	5.1	4.2	3.9	4.3	3.3	4.9
Sopo	2.3	1.7	1.7	1.5	1.3	1.6	0.8
Avg	4.5	4.2	4.1	3.9	3.8	3.6	3.7
	Locations with 2 months of drought						
Ubate	2.6	1.9	1.6	1.3	1.4	1.3	—
Cajica	0.7	0.6	0.6	0.7	0.4	0.4	—
Tausa Paramo	1.0	0.7	0.9	0.4	0.6	0.4	—
Choconta Paramo	0.1	0.4	0.7	0.1	0.2	0.2	—
Subachoque Semiparamo	1.1	0.7	0.9	0.4	0.6	0.5	—
Avg	1.1	0.9	0.9	0.6	0.8	0.6	—

these varieties and good management and in this way improve production and the farm income.

At stations where a prolonged drought during March and April prevailed, yields fell below the national average of 1.2 t/ha. PM21, in spite of the adverse conditions, produced 1.1 t/ha (Table 63). Since it also was highest yielding at good locations, this variety evidently has yield stability under various conditions. Special attention will be given to PM21 in 1974 as a possible new variety for distribution in 1975.

Agronomy. Adequate fertilization is essential for increasing yields. Experiments were conducted to determine optimum fertility level and seed rate for the dwarf variety ICATA-2 (Table 64). Due to a high incidence of fusarium head blight, yields were relatively low, but the observed differences offered valuable information about yield and farmer income. The best treatment was a seed rate of

Table 64. **Yields of the dwarf wheat variety ICATA-2 with 0-0-0, 20-60-20, 40-120-40, or 60-180-60 NPK and various seeding rates. Tibaitata, Colombia, 1973.**

Seed rate kg/ha	Yield, t/ha 0-0-0	20-60-20	40-120-40	60-180-60
100	2.8	3.0	3.5	3.2
120	2.6	2.8	3.2	3.1
140	2.9	3.1	3.5	3.2

100 kg/ha and 40N:120P:40K, and it yielded 0.73 t/ha more than the same seed rate but zero fertilizer. At the 1973 support price, 4000 pesos a ton, the value of this extra grain is 2915 pesos. The cost of fertilizer was 1680 pesos giving a gain of 1235 pesos a hectare from applying fertilizer.

Quality. The milling and baking industry wants good quality in wheat varieties. In the experimental work, the ICA milling and baking laboratory provides quality data on high yielding lines in order to select ones with quality similar to imported hard red winter types.

In 1973, tests were conducted on more than 100 varieties grown at the Bogota and Cundinmarca stations. Loaf volume and water absorption are two of the main quality factors. A loaf volume of 750 cc or more is considered satisfactory. The loaf volume of many of the advanced lines exceeded 800 cc and one variety gave a loaf volume of 940 cc as compared with 890 cc for the hard red winter check. From this standpoint a considerable number of varieties are quite acceptable.

Water absorption of 70 percent is considered desirable. The hard red winter check registered 78 percent. The water absorption of two varieties was rated at 104 percent. The advanced lines of Colombian wheats have excellent water absorption in general.

Flour extraction percentage of the advanced wheat lines is generally somewhat low. In part, at least, this is due to the use of a 20-year-old mill which provided poor separation of flour so that 5 to 10 percent of the flour passed through with bran and shorts.

Over 7300 Pelshenke tests were conducted to provide a rapid evaluation of dough strength. About 300 new lines gave a Pelshenke value greater than 100 minutes as compared with an acceptable level of 60 under the conditions of the Colombian test.

OTHER ACTIVITIES

ECONOMICS

The program in economics, in its second full year of operation, focused on supporting CIMMYT's efforts to help national programs develop and diffuse new maize and wheat technologies. The economics section contributes to these efforts through its collaboration with others in making data and analysis available to agricultural scientists and policy makers and by adding the economists' perspectives to efforts to introduce change into agriculture.

Activities in 1973. The major activity in 1973 was collaboration in a series of adoption studies. Eight studies are now under way. Studies on Plan Puebla (Mexico), El Salvador, Colombia, and Turkey were started in 1972. Studies on India, Tunisia, Kenya (west of Rift Valley), and Iran were launched in 1973. These studies are aimed at (1) ascertaining how farmers classified by agro-climatic regions and farm size used the technology, (2) establishing how the adoption of new technology was influenced by characteristics of the farmer such as education and off-farm work, by characteristics of the farm such as nearness to markets and importance of cereals, and by agricultural policy such as price policy and support for the extension program, (3) augmenting various countries' capacities to do social science research at the farm and market level, and (4) enhancing CIMMYT's capacity to counsel national programs on the diffusion of new technology.

Each study accents close cooperation between agricultural scientists and economists along with collaboration between the CIMMYT staff and indigenous researchers. In each study an attempt was made to involve a national program. For example, in Tunisia the national cereals program is cooperating closely with the study, in Turkey the extension service is helping, and in Colombia and Iran the national research services are actively involved. The contributions of national governments have ranged from substantial to minimal.

Field surveys were carried out for all but two of the studies, India and Plan Puebla, where sufficient field data already existed. For the most part, these surveys have involved substantial efforts in training personnel. Some results of the studies are discussed later.

Another activity of the economics section relates to our view that where technologies and policies are consistent with the goals and the constraints of farmers they are most likely to be judged successful. An important function of the economist is to collaborate with agricultural scientists to identify farmers' circumstances and to interpret their implications for technology and for policy. This point of view emphasizes the importance of data from the farm and market level. In many countries where maize or wheat is important, little reliable information at the micro-level is available. Moreover, they have little capacity to get such data. For these reasons CIMMYT will hold a series of three international workshops in 1974 involving participants skilled in data collection in rural areas of developing countries.

In collaboration with physiologists in the maize and wheat programs, the economics section began a project which will enlarge CIMMYT's knowledge of the agro-climatic conditions characterizing the world's maize and wheat producing areas. An improved data base will help both programs set research priorities.

Finally, the economics section also took part in several meetings: the International Wheat Seminar, a conference with the Technical Advisory Committee of the Consultative Group on International Agricultural Research (CGIAR) on the role of social scientists in the international centers, a workshop at Iowa State University on technology and social change in foreign cultures, a CGIAR seminar on socio-economic research, a conference on nitrogen consumption and use, and a conference on the world food perspective. Attendance at these sessions was motivated by our responsibility to help keep others apprised of CIMMYT's programs as well as in keeping CIMMYT abreast of current thinking on agricultural development.

Selected results from adoption studies. When completed, the adoption studies will include background information, a description of the patterns of adoption of the various components of the new technology, detailed analysis of what influences farmers' decisions to adopt recommended practices, and a discussion of agricultural policy and its implications for the diffusion of new technology. At this time some results on the pattern of adoption are available for a limited number of programs.

Tables 1 to 4 emphasize seed and fertilizer use, relating these to agro-climatic regions and to farm size. The pattern of adoption is described in terms of agro-climatic regions and farm size because these are the two factors emphasized by development assistance agencies as they consider the development and diffusion of new technology.

In each of the agro-climatic regions most observes felt that the new technology was profitable. Some contradictions to this view have emerged from the studies.

In summarizing the many existing studies on the adoption of new wheat technology in India, V.S. Vyas reports that the principal influence on the adoption of new wheat varieties is an assured water supply. While farm size has played a role, its role is at times confounded by access to water. That is, in certain regions, a greater proportion of large farms have irrigation than do small farms and more large farms follow, albeit not strictly, the new technologies. In areas where virtually all farms are adequately irrigated, for example in the Punjab, virtually all farmers, irrespective of size, have adopted new varieties. Even so, Vyas points out, the larger farmers tend to adopt first with the smaller farmers catching up within a few (2 to 4) years.

From the Indian data it might be concluded that agro-climatic factors have played the dominant role in the adoption of new wheats and, to a lesser extent, in the use of fertilizer. Farm size appears to be markedly influential in some regions, less in others, and only marginally in still others.

Preliminary observations on the adoption studies. While final comments await a detailed analysis of the data, Tables 1 to 4 plus the remarks on India permit some preliminary observations. One of the clearest implications is the overriding importance of the characteristics of the agro-climatic region on the use of improved varieties and fertilizer. Looking first at varieties, climate's role is most evident in Kenya and Turkey (Tables 1 and 2) where some regions report virtually complete adoption of improved seeds while other regions report quite low rates of use. In Kenya and Turkey the difference between regions with high adoption rates and those with low rates exceeds 50 percentage points, e.g. for Kenya 83 percent in the two high elevation regions compared with 14 percent in the low elevation region. While not as marked, the influence of agro-climatic factors is still evident in El Salvador (Table 3) where over 20 percentage points separate the adoption rate of hillside farmers from that of valley farmers. A slightly larger spread separates Plan Puebla's Region A from Region B in terms of percentages of farmers adopting recommended planting densities (Table 4). The Vyas study also maintains the importance of agro-climatic factors in India's experience with improved varieties.

Fertilizer use also reflects the impact of agro-climatic factors. For each of the programs represented in the tables, the regions manifesting greatest fertilizer use exceed the lowest regions by over 50 percent. This is also true for the areas in India include in the Vyas summary.

All this indicates that agro-climatic factors, with their implications for the attainment of such farmer goals as

Table 1. **Kenya: Proportion of sampled farmers in the maize growing area west of the Rift Valley divided by farm size, who planted hybrid maize, and proportion using fertilizer on maize or maize mixed with other crops.** [a] **1973.**

Region	Elevation [b]	Annual rainfall [c]	Farm size [d] ha			Farmers, % adopting hybrid maize			using fertilizer		
			smallest	largest	special	smallest	largest	special	smallest	largest	special
A	high	high	under 3.2	3.2 +	—	80	86	—	47	72	—
B	high	medium	under 4.5	4.5-20	20 +	77	79	94	67	93	98
C	low	low	under 2.4	2.4 +	—	6	23	—	0	6	—

a/ Source: Survey of 350 farmers sponsored by CIMMYT and carried out by John Gerhart with the support of agricultural scientists at Kitale Station. b/ High elevation is above 1500 m; low elevation is below 1500 m. c/ High rainfall is over 150 cm/year; medium rainfall is 100 to 150 cm; low rainfall is less than 100 cm. d/ For Regions A and C, observations were arrayed by size and divided into two groups based on size. The same procedure was followed for Region B excluding farms over 20 hectares. Farms over 20 hectares in Region B made up the "special group; nearly all once were part of European-owned farms.

profits or risk aversion, significantly shape the pattern of adoption of new technology.

This finding has important implications for economics research in developing countries. For most problems, such research must examine each agro-climatic region separately, if it is to be useful. Table 1 suggests, for example, that Kenya's policy makers accent development of new varieties for the low elevation, low rainfall region. If the regions were combined, resulting in an adoption rate of some 60 percent for improved seed, the inference would almost surely be that credit and extension services should be accented. By basing the analysis on agro-climatic regions, completely different policy implications may emerge.

Table 2. **Turkey: Proportion of sampled farmers divided by farm size who planted wheat of Mexican or Russian origin, and average fertilizer use.** [a] **1972**

Region [b]	Farm size, [c] ha smallest	largest	Farmers (%) adopting new wheats smallest	largest	Use of fertilizer [d], kg/ha smallest	largest
Mediterranean						
valleys	under 8.1	8.1-150	87	94	113	122
hillsides	under 6.1	6.1-125	91	90	125	143
Aegean						
valleys	under 4.6	4.6-22	61	78	33	57
hillsides	under 3.9	3.9-37	2	20	26	59
S. Marmara						
valleys	under 3.4	3.4-14.5	3	10	57	53
hillsides	under 4.4	4.5-108	6	21	44	60
N. Marmara	under 8	8-128	61	83	91	106

a/ Source: Study of 800 farmers sponsored by the Turkish Ministry of Agriculture and CIMMYT directed by Rechat Aktan and with subsequent analysis in collaboration with Nazmi Demir. b/ Mediterranean region is centered on Adana, Aegean region is centered on Izmir, S. Marmara region is north of Izmir and along the Marmara Sea, N. Marmara is north of the Bosphorus in European Turkey. "Valleys" includes flat land. c/ For each subregion, e.g. Aegean valleys, the observations were arrayed by farm size and then divided evenly into two groups based on size. d/ Nitrogen plus phosphorus.

This in turn points up the advantages from incorporating the knowledge and perspectives of agricultural scientists in work on economics. Their special knowledge of the relationships between plants and environments and of alternative farmer practices can be critical to effective research.

Looking now at the influence of farm size on adoption of varieties, a pattern again emerges. Larger farms have higher adoption rates than smaller farms in each of the agro-climatic regions. Usually the differences are small, under 15 percentage points, e.g. hillside farmers in El Salvador (Table 3) and Turkey's Mediterranean farmers (Table 2). Such differences are probably not large enough to warrant special agricultural policy.

Table 3. **El Salvador: Proportion of sampled farmers, divided by farm size** [a] **who planted hybrid maize, and nitrogen use on maize.** [b] **1972**

Region	Farmers (%) adopting hybrid maize small	medium	large	Nitrogen use, kg/ha small	medium	large
Hillsides	16	28	30	21	38	51
Valleys	37	37	67	41	53	67

a/ Small farms: under 1.4 ha; medium farms: 1.4-3.1 ha; large farms: 3.2-31.5 ha. b/ Source: Study of 350 farmers sponsored by CIMMYT and undertaken by Jesus Cutie in 1973.

But in some areas differences between smaller and larger farmers in the adoption of improved varieties are more notable, as for example among El Salvador's valley farmers or Turkey's North Marmara farmers. Such differences are also reported for some of the regions studied in India.

In general, farm size has the most impact where adoption rates of improved varieties are intermediate. Larger farmers are usually among the first to adopt new technologies and seldom have lower adoption rates than smaller farmers. The data cited here suggest that when virtually all of the larger farmers of an agro-climatic region adopt new varieties, then virtually all of the smaller farmers also adopt, e.g. Turkey's Mediterranean region (Table 2). When a region's larger farmers have low rates of adoption, under 30 to 35 percent, the smaller farmers also have low rates of adoption, e.g. valley farmers in Turkey's South Marmara region (Table 2).

When, however, larger farmers have an intermediate adoption rate, between 35 and 85 percent, the differences among the size groups become larger, as they are among El Salvador's valley farmers (Table 3). There is one exception to this--Turkey's Aegean valley farmers where the difference is but 17 percentage points (Table 2). This region will be studied more intensively in 1974.

Thus it appears that where improved varieties are very attractive to the bulk of the large farmers, small farmers will also adopt. Similarly, when the varieties are not attractive to the large farmers, they are not attractive to small farmers. But when a large but not overwhelming group does accept, the smaller farmers tend to lag well behind.

Table 4. **Plan Puebla (Mexico): Nitrogen use on non-irrigated maize by sampled farmers (1970), and proportion of farmers reporting at least one field of non-irrigated maize with recommended planting density (1972), divided by farm size.**[a,b]

Region[c]	Nitrogen use, kg/ha		Farmers (%) with at least one field at proper planting density	
	smallest	largest	smallest	largest
A	37	52	21	33
B	58	99	0	0

a/ Smallest farms: 0.5 to 3.89 ha; Largest farms: 3.9 to 32.5 ha. b/ Source: A survey of 270 farmers in 1970 and a survey of 221 parcels in 1972, by Plan Puebla. c/ Region A: The part of Plan Puebla area in which farmers must wait for spring rains before planting. Region B: The part of the Plan area in which farmers commonly have residual moisture into which they can plant before the rains start.

One explanation is that, while all farmers are attracted by the higher average incomes promised by improved varieties, some are inhibited by their perception of higher risk. The risks perceived tend to influence small farmers more than large farmers. In regions like Kenya's high elevation, high rainfall area, farmers perceive little risk and virtually all adopt new varieties. In regions like the low elevations area in Kenya, small profits are promised and virtually no one, regardless of farm size, adopts new varieties. In regions like El Salvador's valleys, perceived risks keep many large farmers from adopting, but an even greater proportion of small farmers fail to adopt.

Other explanations come to mind, for example, access to credit or to the services of extension agents. While such access almost certainly favors large farmers, the contrasts among farm size groups between regions within countries make it unlikely that it plays a critical role.

Until detailed analysis of each study--including such factors as education, tenure, distance to markets, and access to extension services--is in hand, we think profit and risk best explain the emerging patterns of adoption. Some comments from agricultural scientists on the suitability of new varieties for different regions support this view. For example, the hybrids for western Kenya include a heavy admixture of high altitude germ plasm from South America. They lose their relative advantage over local maizes as altitude declines, hence their relative profitability declines. Agricultural scientists also report that the first versions of new wheats showed marked sensitivity to septoria. So, in regions like Turkey's Aegean where septoria occurs, it seems likely that farmers viewed the new wheats as more risky than local varieties.

For fertilizer use, farm size seems to be a more important influence on adoption. With few exceptions, measures of fertilizer use are appreciably higher for larger farms than for smaller farms. The exceptions occur in Turkey (Table

2) and are also reported by Vyas for regions included in his survey of India. Even in Turkey, however, the pattern is consistent although the differences in fertilizer use are not so marked.

This pattern of fertilizer use reflects differences between large and small farmers in risk-averting behavior, access to credit, and access to information. Each of these motivating considerations would give rise to the pattern evidenced. More complete analysis on the role of a wide range of variables on each of several practices will be available during 1974.

SERVICE LABORATORIES

Chemical research on maize. Several chemical methods for identifying and selecting maize that has high protein quality have appeared recently in the literature. We evaluated these methods in the laboratory to see if any have advantages over the ones used at CIMMYT. Most did not provide better information about quality than our present techniques.

One method, however, which was developed by Dr. E.T. Mertz of Purdue University, seems useful for identifying material of high quality. The test is simple and inexpensive. It measures the excess levels of free amino acids in opaque-2 kernels with ninhydrin. Opaque-2 endosperm has much higher levels of free amino acids than the normal endosperm (Cer. Chem. 51:304 - 307, 1974).

At present we are trying this test to identify high quality protein in single kernels without damaging the germ. This procedure would permit planting of the selected seeds. Also, potentially, the breeder might use it for selecting materials growing in the field. He could identify segregating ears such as opaque-2 in a floury-1 background or hard endosperm opaque-2 in a normal vitreous background.

If this test proves satisfactory for selecting in the field, the material selected would be evaluated in the laboratory with CIMMYT's usual technique which gives more complete information about protein, tryptophan, and lysine content.

Analytical service for maize. During 1973 approximately 8400 maize endosperm or whole kernel samples provided by the breeding program were evaluated using the screening procedure previously reported. The samples analyzed were from the opaque-2 conversion program and from the opaque-2 soft or hard endosperm composites under improvement.

Approximately 1000 of the samples were submitted for analysis by national breeding programs in Africa and Latin America.

Biological evaluation of maize. Since the usefulness of the meadow vole (*Microtus pennsylvanicus*) as an experimental animal for evaluation of cereal protein quality was doubtful in our early bioassays, attempts were made in 1973 to learn more about the requirements and physiological behavior of the vole.

We compared the effects of dietary protein sources on grain, feed consumption, and protein efficiency ratios (PER) of weanling voles, considering group size, acceptability of diet, and reproducibility of growth responses. We also compared the effect of different levels of lysine, tryptophan and methionine supplementation to "normal maize" diets for the growing meadow vole. These supplementation trials were important since no information on quantitative requirements for essential amino acids by the growing vole was available. The supplementation trials were intended to reveal if the voles respond to the different levels of lysine and tryptophan, the first limiting amino acids for maize protein, in order to properly evaluate the quality of this cereal grain. Normal and opaque maize, wheat, and triticale were compared as protein sources for growing voles. No significant differences were apparent between PER values for normal and opaque-2 maize, wheat and triticale. The individual PER values within each feeding trial varied remarkably.

Normal and opaque-2 maize were supplemented with lysine, tryptophan, and methionine to different levels. PER values of all treatments did not differ significantly from each other, not even from normal maize without supplementation. The type of maize as well as the amino acid levels had no effect on growth responses. Data were also collected on acceptability of maize diets as well as on vole caecal accumulation.

Based on the data from these tests CIMMYT decided to discontinue the evaluation of protein quality with voles.

Chemical analyses (protein and amino acids) will be the criteria for screening and selecting of materials of high quality in the future. Biological assays of advanced breeding material with another experimental animal—rats or swine—will be considered, but under contract with other institutions working in this field.

Laboratory training and assistance. During 1973, practical training was provided to seven trainees from seven countries in the protein quality laboratory at CIMMYT. They spent 1 to 4 months learning the techniques used in maize quality evaluation.

Assistance with equipment necessary for the installation of a service protein quality laboratory has been provided to different countries. CIMMYT has insisted that the equipment be installed and used in a laboratory to be devoted to give service to a maize breeding program.

Barley. About 2600 barley samples were evaluated for high protein and for high lysine using the screening procedure of dye binding capacity (DBC), a simple but effective method.

Triticale. Approximately 3000 triticale samples were screened for protein quantity and quality using the DBC technique. In lines with high DBC values, lysine content also was determined.

Data of analyses are reported under corresponding sections (maize, triticale, etc.).

Soils and plant nutrition. The laboratory analyzed 874 soil samples for pH, nitrogen, assimilable ions, etc., and 25 samples of water for soluble ions and pH. For the wheat physiology program, 3955 samples were analyzed for nitrogen. To check our soil analysis results, the same samples were tested both at CIMMYT and at the Instituto Nacional de Investigaciones Agricolas soils laboratory. The results obtained were comparable, with an experimental error that can be accepted.

EXPERIMENT STATIONS

The main improvement during the year at El Batan was the construction of a new set of buildings on recently purchased land. This new area was leveled, fenced, and the irrigation system was extended into it.

At Atizapan a new building to be used as a lecture hall and dining room and an isolated store for fertilizers and chemicals were constructed. Improvements were made to the office and several roofs changed from tiles to asbestos cement. The reservoir was completed, as well as a concrete aqueduct on the north and south sides to reduce water losses and to improve irrigation methods.

At Poza Rica an all-weather road was constructed between the buildings and down to the fields. Further improvements were made to the office block. The house for the station superintendent was renovated.

Periods of heavy rains caused the river to flood on various occasions, but the river breaks again proved their worth in preventing serious erosion. Due to the construction of the pumping station for Poza Rica's public water supply on the river bank opposite the experiment station and imposition of antipollution regulations, a new system of inlets for pumping water from the river to our reservoir had to be made.

At Tlaltizapan a new house for the station superintendent and a building for the trainees' use were nearly completed. Improvements were made to the office buildings. Permission was received to construct a level crossing over the railway, so fencing of the station was completed.

Silos were constructed on all stations for handling the excess grain not required by the programs. More of our required machinery and equipment was purchased.

Table 1. **Weather at CIMMYT experiment stations. Mexico, 1973.**

Month	Temperature, °C Max	Min	Avg	Rain Amt (mm)	Days
		El Batan			
Jan	20.6	2.6	11.6	––	––
Feb	22.6	2.7	12.6	3.3	1
Mar	26.1	4.7	15.4	0.6	1
Apr	25.9	6.3	16.1	60.0	7
May	25.8	8.5	17.1	72.7	13
Jun	23.7	9.7	16.7	46.0	12
Jul	22.0	8.6	15.3	106.8	23
Aug	21.4	9.0	15.2	209.3	24
Sep	23.0	8.8	15.9	115.8	11
Oct	22.0	7.3	14.6	81.5	10
Nov	22.3	2.7	12.5	11.9	3
Dec	19.7	0.8	9.4	6.2	3
		Poza Rica			
Jan	22.8	12.7	17.7	12.4	9
Feb	23.6	14.1	18.8	44.5	10
Mar	30.7	19.5	25.1	6.5	4
Apr	30.3	19.5	24.9	21.3	11
May	33.9	22.2	28.0	61.7	10
Jun	32.3	23.4	27.9	417.3	13
Jul	31.8	22.7	27.2	189.3	14
Aug	30.9	21.8	26.4	331.0	17
Sep	32.9	22.5	27.7	324.0	11
Oct	34.5	27.7	25.6	145.2	12
Nov	30.3	19.5	24.6	26.7	18
Dec	24.6	13.8	19.2	101.8	12
		Atizapan			
Jan	5.4	–4.3	0.5	––	––
Feb	7.0	–3.7	1.6	4.5	1
Mar	12.0	–1.2	5.3	2.5	1
Apr	11.9	0.0	5.9	32.6	5
May	13.0	5.6	9.3	67.9	13
Jun	13.1	7.4	10.2	63.8	6
Jul	13.2	8.2	10.7	188.2	19
Aug	17.9	5.8	11.8	166.4	16
Sep	20.1	6.9	13.5	161.8	11
Oct	20.5	5.5	13.0	50.2	6
Nov	19.9	–0.7	9.6	16.8	3
Dec	18.1	–4.5	6.8	––	––
		Tlaltizapan			
Jan	30.5	7.5	19.3	––	––
Feb	32.6	10.4	20.7	2.1	1
Mar	35.7	12.8	24.6	––	––
Apr	30.7	15.9	25.8	15.0	6
May	36.3	19.1	27.7	38.3	10
Jun	32.1	19.1	25.5	245.9	19
Jul	31.0	18.0	23.9	210.7	13
Aug	30.3	17.8	24.1	162.6	20
Sep	31.0	17.3	24.1	110.5	17
Oct	30.5	10.5	20.3	69.3	13
Nov	30.9	10.8	20.8	19.7	2
Dec	29.2	7.6	17.3	––	––

Table 2. **Effect of herbicide treatment and cultivation on maize yield (unshelled, 33% moisture avg. of four replications). El Batan, Mexico, 1973.**

Herbicide	Rate, kg/ha a. i.	Yield, t/ha No cultivation	Cultivated
Igran 50H [a]	2	9.0	8.3
	3	9.0	8.4
Gesaprim Combi 50H [b]	2	8.7	7.8
	3	8.7	7.8
Gesaprim 50H [c]	2	9.3	8.4
Check		7.3	8.7

a/ Terbutrine 50% *b/* Atrazine 25% + Terbutrine 25% *c/* Atrazine 50%

Emergency power plants were delivered for Atizapan, Poza Rica, and Tlaltizapan, where interruptions of the power supply had been troublesome.

Metereological observations for 1973 are given in Table 1.

A trial of several herbicides for pre-emergence weed control in maize was conducted at El Batan. The aim of the trial was to compare effectiveness of herbicides with and without mechanical cultivation and to determine the residual effects of the herbicides on crops following maize.

The herbicides were sprayed on the soil (a sandy clay) 1 day after the maize was planted. Half of the plots were cultivated with a tractor 35 days after planting.

Gesaprim combi gave very good control of *Galinsoga parviflora* and *Eleusine indica* up to 87 days after planting. Igran 50 was not satisfactory at 2 or 3 kg/ha a.i. Herbicide activity seemed to be the same in both cultivated and uncultivated plots. Yields of the uncultivated plots, however, were 15 to 30 percent higher than yields of the

Table 3. **Yield of alfalfa and wheat as affect by herbicides applied to previous maize crop (avg. of four replications). El Batan, Mexico, 1973.**

Chemical applied previously to maize	Rate, kg/ha a. i.	Yield, t/ha Alfalfa	Wheat
Igran 50H	2	9.4	6.8
	3	9.6	8.1
Gesaprim Combi 50H	2	9.0	8.3
	3	8.7	8.3
Gesaprim 50H	2	8.4	7.0
Check	––	9.8	8.1

cultivated plots (Table 2). Cultivation may have reduced the vigor of the crop through damage to the roots.

Wheat or alfalfa was sown in all plots right after the maize was harvested. None of the herbicide treatments had significant residual effects on these crops. (Table 3).

INFORMATION SERVICES

The information services continued processing, producing, and distributing information based on CIMMYT research findings to the network of collaborating scientists, field technicians, researchers, and administrators interested in maize and wheat; preparing audiovisual materials for CIMMYT meetings and conferences; providing library services for CIMMYT headquarters and outreach staff; and helping CIMMYT visitors both at headquarters and experiment stations in Mexico.

New publications. Publications issued during 1973 are shown in the table.

In addition, a working copy of the Puebla Project terminal report was prepared in Spanish for the International Seminar on Regional Agricultural Development Projects (sponsored by the Post-Graduate College, Chapingo, and International Development Research Centre, Canada), held at Chapingo. The final version of this publication will be published in English and Spanish in 1974.

Cooperation was given to International Development Research Centre, Canada, which co-sponsored the International Triticale Seminar, at El Batan, in the preparation of materials for the proceedings. The proceedings will be published in English by IDRC in 1974.

The information services staff also helped get materials ready for the CIMMYT-Purdue Symposium on High Protein Maize. This involved the compilation and editing of the documents which will be published in English by a commercial publisher in 1974. The materials are being translated into Spanish and will be published in 1974. In this task, the help of Dr. Jim Bemis, an editor hired temporarily, has been very useful.

Publications issued in 1973

Title	Language		
	English	French	Spanish
Chemical screening methods for maize protein quality at CIMMYT. Evangelina Villegas and Edwin T. Mertz. (Research bulletin 20)		X	
Triticale breeding and research at CIMMYT F.J. Zillinsky (Research bulletin 24)	X	(summary)	X
Results of the seventh international spring wheat yield nursery (Research bulletin 25)	X	X	X
Treatment design for fertilizer use experimentation. Foster B. Cady and Reggie J. Laird. (Research bulletin 26)	X	(summary)	X
What is CIMMYT? (Information bulletin 8)	X	X	X
Results of the Second and Third International Triticale Yield Nurseries 1970-71, 1971-72. (Information bulletin 10)	X	X	X
Maize training booklet and program	X		X
Publications and audiovisuals at CIMMYT	X		X
CIMMYT Annual Report 1972	X		X
Proceedings: Wheat, Triticale and Barley Seminar, January 22-26, 1973.	X		
The Puebla Project, 1967-69 (5th printing)	X		X
Strategies for Increasing Agricultural Production in Small Holdings (4th printing)	X		X

Translations. CIMMYT has continued publishing materials in English and Spanish. In 1973 several bulletins were published fully in French; some others had a French summary. Translations to Spanish and French are done by a group of translators, including CIMMYT staff, Chapingo staff, and other qualified people.

In addition to translating materials for publications within CIMMYT series, other documents are also translated (letters, documents, pieces for El Batan Informa, research documents for staff use, etc.)

Translations and reprints. As in previous years, the communications program acquired and distributed, upon request, reprints of several papers by CIMMYT scientists, published in journals outside the CIMMYT series:

Genetic analysis of stem rust resistance in three cultivars of wheat. S. Rajaram, N.H. Luig, and I.A. Watson. 1971. Euphytica 20: 441-452.

The inheritance of leaf rust resistance in four varieties of common wheat. S. Rajaram, N.H. Lüig, and I.A. Watson. 1971. Euphytica 20: 574-585.

The inheritance of resistance to *Puccinia recondita* in hexaploid triticale. M.A. Quinones, E.N. Larter, and D.J. Samborski. 1972. Can J. Genet. Cytol. 14: 495-505.

Sources of adult leaf rust resistance in triticale. S. Rajaram, F.J. Zillinsky, and N.E. Borlaug. 1972. Indian Phytopath. 25: 442-448.

Crop production and the world food problem. R.J. Laird. Proceedings, I Latinoamerican and V. Mexican Congress of Botany, Sociedad Botanica de Mexico, pp. 562-607.

Audiovisuals. Audiovisual section work in 1973 included: (a) Art: charts and graphs, both in color and black and white; lettering, diplomas, maps, emblems, and maps of experiment stations. (b) Photography work: both in the field and in the lab, including negatives for printshop, taking and developing black and white and color pictures, plates, prints, enlargement of pictures, photomurals, and taking and mounting color slides. (c) Mailings of photos and other audiovisual materials. In 1973, 24 copies of CIMMYT movies were mailed to different countries; 24 slide sets, 430 incidental slides, and 158 black and white pictures were sent to different countries which required them. (d) Answering requests for movies, slide sets, black and white pictures and color transparencies. These requests generally comes from extension, research, and academic institutions. (e) Answering requests for pictures from the media, both commercial and non-commercial. (f) Exhibits: In 1973 two exhibits were prepared by the audiovisual section. One was for the Wheat, Triticale, and Barley Seminar held at El Batan. This exhibit had 12 presentations. The other was for the International Triticale Symposium. This had 23 presentations. (g) Miscellaneous work: The audiovisual staff is in charge of selecting and exhibiting the commercial movies for trainees on Saturdays. (h) Visitors: The audiovisual staff collaborates with the visitors and seminars services. A special slide set was prepared in 1973 for visitors: "This is CIMMYT," consisting of about 40 slides, which show CIMMYT activities. The staff also helps take care of visitors to CIANO Experiment Station during April, the most busy month there.

Visitors and Seminar Services. Approximately 3000 visitors were registered by the visitors service at CIMMYT in 1973, half of them individually, half in groups. In addition, a large number of visitors were received by Plan Puebla and the CIMMYT research stations where no record is kept.

Library services. CIMMYT's headquarters library now has 2200 bound books, 5000 pamphlets, and 1100 periodical subscriptions.

During 1973 the library loaned out 4700 books, pamphlets, and periodicals, and received approximately 7200 readers in the library. Trainees make up more than half the library users. CIMMYT continues to look upon the National Agricultural Library at Chapingo, 10 kilometers from CIMMYT, as CIMMYT's comprehensive reservoir of books. The CIMMYT library is only a working collection. During 1973 CIMMYT borrowed 664 books from Chapingo, and sent 11 books on loan to Chapingo.

The staff of the CIMMYT library gives about one-quarter on their time to preparation of bibliographies for the staff, and conducting searches for requested information.

APPENDIX

Appendix table 1A-1. **Varieties of the Third RDISN with generally low infection of stem rust 1972/73.**

No. of Entry	Pedigree	South Asia**	North Africa (Egypt)	East Africa (Kenya)	Mexico	Seeding Race 113 U.S.A.***
205	Pato R-Cal/7CxBb-Cno	5MR	-	20MS	TS	23
543	Magnif 41	5MR	-	30MR	TMR	25
783	TT-Son 64 x Cno	10S	TR	20MS	TMR	34
892	On-Tob 66	10MR	-	-	TMR	33
897	Np 63- Tob "S" x 8156	5MR	TR	-	10MR	23
898	"	5R	-	-	TMR	34
906	Jar "S"	10MR	TR	40MS	TMR	00
918	II-62-3 Minn	5MR	0	20S	TR	33
*988	Burgas 2 (Sort 12-13	5S	0	-	TS	23
*993	Aurora	0	0	-	-	01
1055	Kenya Kudei	TR	-	60MS-S	5MR	12
1057	Kenya Hunter	TS	0	50S	TS	00
*1059	Kenya Sungura	TR	-	40S	0	23
1061	Kenya Kanga	TMR	-	60MS-S	TR	00
1062	Kenya Leopard	5S	0	50S	0	00
1067	Kenya Grange	5MS	20R	90S	TMS	33
1073	Kenya Mamba	TS	0	40MS-S	-	01
1074	K4689-1	TMR	0	50MS	0	00
1077	4500-2	TR	0	70S	0	00
1079	4500-4	0	0	50S	TR	00
1082	Np 63 - Bot "S"	TR	20R	-	TR	33
*1083	4500-1	TR	0	40S	TR	00
1085	4500-3	TR	0	30S	0	00
1093	Kenya Kiboko = (6106-1)	TMR	TR	30MR	TR	23
1094	6106-2 = C18154-Fr^{2}xGb54/II-53-526	0	10R	50MR-MS	TMR	33
1095	Cno-Crespo	5R	10R	50MS	0	33
1097	Bb	TMR	10R	40MS	TMS	33
1098	Bb	TMR	20R	50MS	5MR	23
1104	CC-Inia	5MR	2-MR	-	TR	23
1107	Rom^2 x Af-Mg = 6290-9	0	0	20MR-MS	0	22
1108	CC-Inia"S"	TMS	10R	60S	TR	34
1109	Inia"S"-CC^2	TMR	TR	70S	5MR	23
1115	Rom^2 x Af-My 6290-12	20MS	TR	30MR	0	34
1121	Ment-Rom^2 = 6296-20	0	0	30MS	0	00
1122	" = 6296-23	0	0	20MS	TR	00
1125	Tzpp-Wte x Nar 59/Jar"S"	TMR	0	80S	TR	00
1126	Rom^2 x Ag-My 6290-30	0	0	40MS	TR	01
*1127	Menco	0	0	50S	0	01
1158	Kenya Kiboko "S" =6106-3	TR	0	30MR	0	34
1159	Kenya Kiboko "S" =6106-8	TR	-	50MS	5MS	12
1162	Tob^2(Wisc6145xKF/C18154xFr^2) =6461-8	5R	TR	30MR	5MR	12
1169	Ment-Rom^2 = 6290-30	0	0	40MS	TR	12
1183	Fanfare	10MR	10R	20S	TR	34
1238	DP 869 B3B5	5MS	0	20MS	0	23
1243	CI 14479	5S	10R	20MS	0	33
1261	Chhoti Lerma	0	20R	40MS	5MS	33
1272	Provence	0	20MR	40MS	TR	23
1291	Bb-Inia	5MR	0	-	TR	34
1302	Wren	5MR	10R	30MS	0	45
1307	Tordo	0	0	30MS	5S	45
1316	K4526 L10 A5	10S	0	30MS	0	00
1345	Tob x Kl Pet-Raf.	5MR	10R	20MS	TMS	43
1349	Inia-Bb	10MR	Tr	-	TMS	33
1362	Aust. Line	0	10R	20MS	TS	33
1370	Rom x Wisc-Sup(Fr-FnxY)^2 = 6297-2	0	0	30MS	0	00
1388	Ment-Rom^2 = 6296-9	0	10R	40MS	0	00
1577	Soty - 8156	15S	20MR	20MS	0	45
1589	Gallo "S"	0	0	50MS	TR	23
1604	L.R. (amber)	0	20R	30MS	5S	12
1613	Pi62-Chris"S"xSon64-Cno"S"	5MR	10R	40MS	TR	12
1735	Giza 156 x Giza 155	0	0	30MS	5MS	45
1747	Giza 148 x Giza 155	TR	10R	20MS	TS	34
1762	Cal-Cno"S"xCno-Son64	10MR	40S	30MS	TMS	12
1765	Cno-No 66 x Gto	10MR	10R	40S	20MR	12
1766	Cno"S"-No 66/C273xNp875-E-353-58	5MR	10R	40MS	10S	33
1772	Tob S - 8156	10MR	40R	90S	5MR	23

Continued

Appendix table 1A-1 continued

1773	Inia"S"-Np63(Son64-Kl Red/Cnox LR64^2 - Son 64	5MR	0	60S	TMR	23
1777	Gavilan "S"	TR	20R	Seg	10MS-S	23
1781	CC x Cno-Son 64	TR	-	70S	TMR	01
1783	Cno"S"-7C	TR	20R	20MS	5MR	12

* Also resistant to yellow rust
** Based on South India, Central India and Pakistan
*** Based on Browder, L.E. 1971. A proposed system for coding infection types of the cereal rusts. Plant Disease Reporter, 55: 319-322.

Appendix table 1A-2. **Bread wheat lines of the Third RDISN resistant to stem rust at Njoro, Kenya 1972/73 (Coefficient of infection < 10).**

No. of Entry	Pedigree	South Asia **	North Africa (Egypt)	East Africa (Kenya)	Mexico	Seedling 113 U. S. A. ***
50	Inia 66-RL4220 x 7C	5MR	0	10MS	TMR	23
195	Ron-Cha x Bb-Nor 67	TR	10R	20MR	TR	23
*210	Bj67-CalxTob-8156/7CxBb-Cno	5R	-	10MS	0	34
329	(Fr-Fn/Y-Nar"S"xVg8058)Af-My)^2	20S	20S	10MS	TR	44
401	(Fr-FnxY-Nar"S")^{2}T.tin/Idead^{2}xPfn	10MS	10S	15MR	TR	34
414	Lee-Ptfz	0	TMS	10MS	10S	23
419	Ptf x Vg8058 (Af-My)^2	40S	40S	10MS	TR	23
446	Ptf x Qfn-K338 AA/Mfo	10MS	40S	10MS	5MS	23
453	Nar"S"^{2}-Pj"S" x (Frth)^2-Y50	20S	-	10MS	TR	00
797	Pato-Cno	40S	-	10MR	-	23
799	Nad x T238-1-5-8-17-10	-	-	TMR	TMR	01
*869	Pato x Cno"S"-Tob 66	10S	-	5MS	TS	23
914	(Frth)^2-K184PxT.vulg-Ae orata	-	0	10MR	-	00
1052	Kenya Timga	20S	0	5S	0	34
1081	II-60-218	5MR	5S	10MR	0	23
1106	Rom^{2}xAf-My 6290/1	0	TR	20MR	TR	23
1113	K. Nyati "S" 6290/10	TR	TS	20MR	0	33
1114	" 6290/11	-	0	TMR	0	23
1116	" 6290/13	10MS	10R	5MR	0	23
1161	Tob66^2(Wisc245xII-50-17)^2/CI 8154 -Fr^2 6661-113	10R	TR	10MR	0	12
1163	" 6661-21	TR	TR	20MR	TR	12
1168	Ment-Rom^2 6296-23	0	10R	10MR	0	01
1176	Gb54^2-36896xGb56/II-53	20MS	TR	20MR	0	22
1239	CI 14378	5MR	10R	10MS	0	23
1319	Pb^2 x Mg$_{E_2}$= RL4219	5S	0	10MS	0	44
1342	Ptf x Rfn^2 - Pj62	5MR	TR	10MS	TR	33
1749	G148-G155	TR	TR	10MS	5S	34
1868	Azteca-Chanote	-	10MS	10R	10MR	-

* Also resistant to yellow rust
** Based on South India, Central India and Pakistan
*** Based on Browder, L.E. 1971. A proposed system for coding infection types of the cereal rusts. Plant Diseas Reporter, 55: 319-322.

Appendix table 1B. **Stem rust reaction of selected durum lines from Third RDISN 1972/73.**

No of Entry	Pedigree	South Asia *	North Africa (Egypt)	East Africa (Kenya)	Mexico	Seedling race 113 U. S. A**
1802	Tehuacan	10MR	-	80S	0	12
1805	Wells	10MR	0	80S	0	01
1809	Hercules	10MR	0	70S	0	01
1811	Jori 69	20MR	30K	40MS	0	33
1812	Cocorit 71	10MR	-	50S	0	01
1818	Flamingo	0	20R	-	0	22
1822	Durum var. 24	5MR	10R	49MR-S	TR	11
1823	Pinguino"S"	20MR	TS	40S	TMR	00
1826	Anhinga	30MR	40MR	70S	5MR	02
1836	21563 x Brant "S"	10MR	40R	40S	TMR	11
1837	T. dur leve x Gll-AA"S"	10MR	10R	60S	0	12
1839	Jori "S"	5MR	40R	50MS	TMS	01
1847	Gll-Jori x F3 Tunisia	10MR	20R	40MS	0	23
1858	Gll-By$_E$-Tc^4	-	40R	50MS	TMR	02
1867	VZ324-Cpx Ve 156/Hour	60S	60S	20MS	TMR	12
1871	Brant"S"-Al"S"	50S	60S	20MS	TS	23
1892	T. dur Th. 790L	20MR	TR	60S	0	34
1898	Maliani 11C	0	0	-	20S	01
1904	Pelicano"S"-Crane"S"	20MR	60S	30MS	0	12
1912	21563-Jo"S"	0	20R	70S	TMS	33
1927	D. Dwarf S-15 x Jo"S"	30MR	20MR	60S	5MS	33
1928	D. Dwarf S-15 x Cr"S"	20MR	20MR	60S	5MR	12
1947	Flamingo"S"	10MR	20R	80S	TMR	11
1988	Gerardo 584	15MR	TR	20MS	TMR	02
1991	Valnova (Gerardo 598)	15MR	TMR	40MS	TS	12

* Based on three sites - South India, Central India and Pakistan
** Based on Browder, L.E. 1971. A proposed system for coding infection types of the cereal rusts. Plant Disease Reporter 55: 319-322.

Appendix table 1C. **Stem rust reaction of selected barley lines from Third RDISN, 1972/73.**

No. of Entry	Pedigree	South Asia *	North Africa (Egypt)	East Africa (Kenya)	Mexico
2045	CR 113-Por	0	20MR	20MS	20S
2046	Cyprus Black A	0	0	30S	30S
2048	Gizeh 134	TS	TMR	70S	40S
2050	Beladi 16	10S	10MR	30S	50S
2054	Cheoror CI 1111	0	TMS	40S	-
2055	Cheoror CI 9185	0	TMS	30S	10S
2059	Jordan 3	0	TMR	70S	-
2067	Beecher Mut 5Kr M5	5S	-	30MS	40S
2073	II 258/L21 71-74	0	30S	40S	30S
2083	Giza 120	TS	0	60S	40S
2088	Chevalier	0	TMS	60S	50S
2091	Mor-BURF9xPro/Tol^2/Cer/Apm	0	0	20MS	-
2092	Por-C58-1-4407-19	TMS	-	30MS	20S
2093	"	0	10S	40MS	30S

* Based on three sites - South India, Central India and Pakistan

Appendix table 2A. **Yellow rust resistant lines of bread wheat in the Third Regional Disease and Insect Screening Nursery. 1972/73 (Coefficient of infection < 10).**

No. of Entry	Pedigree	South Asia *	West Asia **	North Africa (Egypt)	East Africa (Kenya)	Mexico
9	Tanori 71	10R	TR	0	5MS	20MR
46	Inia-NP710xCno"S"	5R	TS	0	5MS	10MR
71	Wren "S"	TR	TMS	0	5S	TMR
77	Tob"S"-Np63xCno/We	TR	5S/8	0	5MS	TR
106	$Y50_E$-Kal^3	5R	TMR	0	10MS	10MR
108	Bb (Son64-An64xNad/Jar"S")	0	TMR	0	10MS	20MR
112	Inia"S"-Np 63xCal^2	TR	10MS	0	TMS	10R
113	"	0	TR	0	TMS	5MR
130	Bv-Nor 67	5R	10MS	0	10MS	10MS
136	Pato	5R, 20S	0	0	TMS	0
210	Bj67-CalxTob-8156/7CxBb-Cno	TR	TMR	10MS	TMS	10MR
218	Pato B(Jar-Np63/LR64xTzpp-An_E)	0	5S	0	TMS	20MR
224	Cal-Lv	0	5S	0	TMR	20MR
229	Fury-Bb	0	TR	0	5MS	10MR
248	Inia"S"-OnxInia-Bb	0	5S	0	5MS	10MR
252	Pato-7C/CC-8156xCno"S"	0	5MS	0	5MS	20MR
289	Bb-Pato	0	TS	0	5MS	TR
311	Inia-Np63 x Cal^2	20R	TS	0	0	10MS
312	"	10MS	TR	0	0	10MR
321	Nar"S"-Pj"S"	5MS	5R	0	TMR	TR
322	Collafen	0	TR	0	TMR	10MR
327	(T/Chin166-KFxL-N/M^2-ME)Fr-Nar"S"^{2} (Pj "S")	0	5MR	0	5MS	10MR
328	(T/Chin 166-KFxL-N/M^2-ME)Fr_E-Yt54^3	TR	10MS	0	10MR	10MR
338	(Yt54/N10BxLR)Mfo^2 K338AAxFF-KAD/66	0	10MS	0	5MS	10R
347	LAC 173 (67A)	0	10MR	0	10MS	-
348	LAC 638 (67A)	TR	10MR	0	TMR	-
361	(T/Chin166-KFxL-N/M^2-ME)Fr-NarS^2 (PJ"S")	0	10MS/5	0	5MS	10MR
388	(Fn x MD/N-Y50) Fr x MCM/Kt-Y	TR	TMR	0	10MR	TR
406	ND4-Lee x PFn^4	TR	5MS	0	0	20MR
408	Fr^2 - 1829 x Pfn^4	5R	TMS	0	5MS	10MR
425	(FnxMcM/Kt-Y)Nar"S"^{2}-Pj"S"	10R,10S	0	0	10MR	TMR
467	Chir. x Mh-Ind Arg.	0	5R	0	TMS	5MR
473	(Y48-K58/NxFr-KAD/Gb) Coutiches	0	TR	0	0	TR
474	Poncheau x Kt54^2-Nar 59	0	5S	0	0	TR
487	(Pfn/$Yt54^E$ x LR-MfO) SpWt467/Gb-LR x Vg 9052	0	TR	0	0	TMR
495	$Kt54^2_E$-Nar 59 x HnIV^2	5R	TMR	0	10MS	TR
498	"	10MR	0	0	10MS	TMR
499	"	10R	TR	0	1)MR	TMR
503	Car 557-PJ62 x HnIV	TR	TR	0	5MS	10MR
505	Nar"S"-Fr x Ci-My54/Fr	TR	10MS	0	10MS	20MR
508	Hua R^2 - $My54_E$	10R	TR	0	10MS	10MR
528	Fec28-No.293xNo.885	10R	TMS	0	TMS	10MR
530	P.I. 297027(K)	TR	TR	0	TMS	TMR
566	LR x N10B/An_E	0	TR	0	TMS	10MR
574	Kenya Kanga = $K4496L5A_2$	0	TR	0	-0	TMR
606	Samaca	0	TR	0	0	TMR
607	Opal	0	5R	0	0	10MR
617	Andes 56	TR	TS	0	5MS	5MR
630	Bb-Nar"S"	TR	10MS	0	0	10MR
647	Pato"S"-Tob"S"	10MS	TR	0	10MR	5R
655	Gallo-Nar 59	5MS	10MS	0	0	20MR
676	Nova Prata	0	5R	0	0	10MS
690	Red River 68	0	5S	0	TMS	5MR
698	CI 14324 Sel. 13C	0	TR	0	TMR	5MR
699	CI 14361	0	10MR	0	10MS	10MR
728	CC-Crespo	0	0	0	10MS	TR
741	Soty x Nad-Chris	20S	TR	0	10MR	5MR
753	Kt/Bag_E-Fn/U x Bza	0	10MS	0	0	5MR
754	Nar 59^2(1088-KtxFr-Fn/Y)	TMS	TS	0	0	10MR
778	NP875-Pj62xCal	0	0	0	10MS	10MS
869	Pato x Cno"S"-Tob 66	0	TS	0	0	TMR
876	Ariana 66	0	0	0	TMR	TR
922	PI 231312	0	10MS	0	TMR	-
945	CC-Inia/CnoxEl Gau-Son64	0	0	0	0	10MS
946	"	0	0	0	0	10MS
963	Gte-TR215	0	TR	0	10MR	5R
986	Sort 11-32-1145	0	0	0	0	-
987	Sort 315-16	0	0	0	0	-

Continued

988	Burgas[2] (Sort 12-13)	TR	0	0	0	-
993	Aurora	5R	0	0	0	-
994	Kankaz	10R	0	0	0	-
1016	JO-03045	0	TR	0	0	-
1017	JO-03021	0	TR	0	0	-
1021	Strampello	10MR	0	0	10MS	-
1024	Car 12	5R	0	0	TMS	-
1030	Diplomat	5R	20R	0	0	-
1031	Blueboy	20R	10MS	0	0	-
1041	Zenith	0	0	0	10MS	-
1042	Clarior	TR	0	0	0	-
1047	Moldova	0	10MS	0	10MS	-
1050	Starke	0	10MS	0	0	-
1059	Kenya Sungura	TR	TR	0	TMS	10MR
1070	Bonny	5R	TR	0	TR	5R
1083	4500-5	0	10MS	0	TS	10MR
1084	4500-1	0	TS	0	TS	10MR
1088	Rom xGb-Gya=(6295-4A)	0	10MS	0	TMS	20MR
1092	Rom x Wis Sup (Fr-Fn/Y2A-(6297-2)	0	TR	0	TMS	10MR
1113	K. Nyati "S" = (6290-10)	TR	10MS	0	20MR	20MR
1127	Menco	TMR	5R	0	20MR	10MS
1175	4500-4	5MS	10MS	0	5S	TMR
1212	Resistente (T61)	0	10MS	0	5R	-
1215	Constante (Magnif 11)	0	10MS	0	10R	-
1216	Fulgero	0	10MS	0	5R	-
1217	Fontarronco A	TR	10MS	0	TR	-
1283	Libellula'	TR	TS	-	TR	-
1323	Np63-Tob"S"x8156	TR	10MS	0	5R	10MS
1350	Bb-Tob 66	5R	10MS	-	10MS	10MR
1358	Cardenal "S"	TS	TR	0	TR	10MR
1367	K4573 L3D2	10MS	5MS	0	5R	20MR
1376	Lilifen	TMR	10MS	0	5MS	20MR
1377	CD/Yt54ExKt54B(Nar59-DrCxSoty)	TMR	0	0	5S	10MS
1379	CD/Yt54ExKt54B(Nar59-DrCx8156-Pj62)	0	TR	0	TR	5R
1381	NP876xPJ-Cal	0	0	0	TS	10MR
1386	PD Kenya	0	10MS	0	TR	10R
1395	Mildress	0	0	-	-	-
1396	Ardent	TR	5R	0	0	20MR
1398	Fr/KAD-Gb-Bza	5R	TR	0	5MS	-
1414	PI 293993 (UK)	0	TR	0	0	TR
1415	TP114/207-208	TR	TMR	0	0	-
1417	Saunders-E.de Ch28	TR	TR	0	0	5R
1418	E. de Choisy 28	TR	TR	0	0	5MR
1422	Horizon	TR	TR	0	TR	TR
1424	NP 818	20R	TR	-	0	20R
1426	Bol Bugday	TR	0	5MS	-	-
1427	N.S. 314	5R	TS	0	10R	-
1428	Svenno	TR	5MS	-	20MR	-
1474	CI 7800-Bza(MdxMcMar-E/Af-My)	0	TMS	0	20MR	5MR
1484	CI 7800-Bza x3Tob"S"	0	5MS	0	10MS	10MR
1491	K133-BtxYE/Fr3/(Sa-McMxMy/MdxK117A-Fn)Fnth/	0	10R	0	10MS	20MR
1512	Sel 5 x K58-N/Desc	TR	TR	0	10MS	20MR
1513	"	5R	0	0	TR	20MR
1514	/(Sa-McMxMy/MdxK117A-Fn)Fnth/Frth-Bza3	TR	TMS	0	0	10MR
1521	/ " / Rz"S"	TR	TR	0	TMS	10MS
1523	" "	10MS	0	0	10MS	20MR
1556	Son 64-Gn	TMR	TR	0	TMR	20MR
1616	CC-Inia x Tob "S"	0	5S	0	TR	5MR
1647	NS 11-34	0	10MS	0	0	-
1649	Brkulja 4	TR	0	0	10R	-
1650	Cruena Zvezda	TR	5S	0	10R	-
1651	18 NS 984/1	0	TR	-	5R	-
1652	21NS-622	0	0	0	10R	-
1653	22NS-10-79	0	TS	0	10R	-
1654	VH 70774	0	0	0	0	-
1668	CD/101/Drc	TR	5R	0	TR	-
1674	Sturdy	5S	10MS	0	TR	-
1734	L1439 - Goza 155	TR	10MS	0	TR	10MR
1750	Giza 148 - Giza 155	TR	5MR	0	5R	10MR
1797	Arezu	10R	10MS	0	0	TR
1798	K-E. de Choisy x MxP	TR	TR	0	5S	TMR
1799	"	TR	TR	0	5R	TMR

* South Asia - Includes data from Afghanistan, India, Nepal and Pakistan
** West Asia - Includes data from Iran, Lebanon and Turkey.

Appendix table 2B. **Yellow rust reaction of selected durum lines from the Third RDISN, 1972/73.**

No. of Entry	Pedigree	South Asia *	West Asia**	East Africa (Kenya)	Mexico
1802	Tehuacan 60	-	10MR	0	30MS
1803	Sneatore Capelli	-	TR	5R	20MR
1804	Capeiti	10MS	25S	10MS	30MR
1807	Gerardo Vz 466	-	10MS	TMR	30MS
1811	Jori 69	-	10MR	TR	-
1813	Sincape 9	-	10S	5R	30MR
1814	Alex 281	-	10S	10MR	10R
1818	Flamingo	-	10S	10MR	10MR
1822	Durum Var 24	10S	TMS	20MS	10MR-MS
1823	Pinguino"S"	0	25S	10R	20MR
1829	Cr"S"-Ganso"S"	TR	10MS	5MR	5MR
1849	Gll-JnixRD3-6/Stw 63	TR	10S	10MR	40MS
1856	Cr"S"/(Stw^6-G.Bull)Stw^6-St464	10R	10S	5MS	5MR
1869	Lob-Mal^2 x Oviachic	30S	0	10R	5R
1870	Preto Cimarelo-Oviachic	-	5S	20MS	20MR
1874	Vz 360-CpxVz 156	-	0	5MR	30MR-MS
1875	Flamingo"S"	0	0	5MR	10MR
1877	Jori-AA"S"	0	5MS	10MS	30MS
1887	Albatross"S"	-	5S	0	20MR-MS
1890	<u>T</u>. <u>turgidum</u>	5S	0	TR	20MR
1807	Maliani 8D	TR	10MS	5R	-
1898	Maliani 11C	0	10MS	5R	-
1907	Cocorit "S"	10MS	5MR	5R	10MS
1908	"	10MS	Tr	10MR	10MS
1912	D-21563-Jq"S"$_2$	-	TR	10MR	20MR-MS
1913	Cr"S" (<u>T pol</u>.^{2}-Tc^2/Gll"S")	TMR	TR	10MR	20MR
1914	Flamingo"S"	TR	TR	0	20MR
1915	Crane"S.				
1919	Jo"S"(LD357$_E$-Tc^{2}xGll"S"	-	0	5MR	20MR-MS
1922	Cocorit"S"	TR	0	5MR	10MS
1947	Flamingo"S"	TMR	TS	5R	10MR
1948	"	TMS	5S	TR	10MR
1951	Giorgio 446R	TR	0	20MR	10MR
1965	Gerardo 650	-	10MR	10MR	10MS
1970	" 655	-	5MR	30MR	20MR
1971	" 656	TMR	-	5R	10MR
1985	" 580	-	10S	10MR	10MR
1988	" 584	-	10S	10MR	20MR
1992	Jucci	TR	10MS	5R	-
1993	Raineri	TR	10S	10MR	10MR
2001	Mohamed Ben Bashir	50S	5S	TR	20MR
2002	Zenati Bouteille	TR	0	30MR	30MS
2016	Chile931	-	10MS	20MR	10MR
2019	Greece 46049	0	5MR	TR	30MR
2035	14647	-	0	0	10MR
2038	HDH-7	10MS	0	0	10R-MR

Appendix table 2C. **Yellow rust reaction of selected barley lines from Third RDISN 1972/73.**

No. of Entry	Pedigree	South(1) Asia	West(2) Asia	East Africa (Kenya)	Mexico
2046	Cyprus Black A	10MS	0	30S	TMR
2047	Edda	0	0	30MS	0
2054	Cheoron CI 1111	30S	0	TR	0
2055	Cheoron CI 9185	10S	0	TR	0
2058	Himalaya	75S	0	5R	0
2062	Hiproly	10S	0	0	0
2070	II 254/L 1971-74	10S	0	30S	0
2071	II 257/L 2041-44	0	0	60S	TMS
2088	Chevalier	20S	0	TR	0

(1) All Barley lines at Ludhiana, India were susceptible and data omitted. Data presented list the highest reading from Afghanistan, Nepal and Pakistan

(2) Data from Iran, Lebanon and Turkey

Appendix table 3A. **Bread wheat lines with resistance to two or more species of the major diseases. (Data from the Third RDISN, 1972/73).**

Entry No.	Pedigree	Stem Rust	Stripe Rust	Leaf Rust	S. tritici
46	Inia - NP710 x Cno "S"		R	R	
108	Bb(Son64-An64 x Nad/Jar "S")		R	R	
113	Inia "S"-Np63xCal^2		R	R	
136	Pato		R		R
210	Bj67-CalxTob-8156/7CxBb-Cno	R	R		
224	Cal - Lu		R	R	
248	Inia "S"-OnxInia-Bb		R	R	
311	Inia "S"-Np63xCal^2		R	R	
312	"		R	R	
467	Champ x Mh-Ind Arg.		R		R
472	Vg8881 (Fn-Th^{3}xII-44-99/Th^2			R	R
473	(Y48-K58/NxFr-KAD/Gb)Coutiches		R	R	R
479	Hqn/Fn-ThxYt 54$_E$			R	R
494	Kt 54$_E$^{2} - Nar59 x Hn IV^2			R	R
495	"		R		R
498	"		R	R	R
499	"		R	R	R
503	Car 557-Pj62 x Hn IV		R		R
508	Hua R^2 - My 54$_E$		R	R	
530	PI 297027 (K)		R		R
534	Romany		R	R	R
536	CI 8155-Nar59^2			R	R
543	Magnif 41	R			R
546	C29			R	R
548	S2			R	R
574	Kenya Kanga		R	R	R
575	K4497 = L14B1			R	R
593	S-11			R	R
595	Czho-KF			R	R
602	Tob-B-Man x Bb			R	R
605	Rafael Mag			R	R
606	Samaca		R		R
607	Opal		R		R
610	Pato/Son64-Pdue x Cno-Inia			R	R
611	Piamontes			R	R
612	Iassul			R	R
617	Andes 56		R	R	
676	Nova Prata		R	R	R
682	Fronthatch (Minn-II-50-18)			R	R
698	Sel 13C = CI 14324(K)		R	R	R
699	CI 14361 (Chile)		R	R	
753	Kt/Bg-Fn/UxBza		R	R	R
756	7756 Mex = CI 14302			R	R
769	Zaafrane			R	R
808	Agatha			R	R
869	Pato x Cno "S"-Tob "S"	R	R		
915	SANo43xWis-Sup$_2$			R	R
916	TT-1673 x Kt48^2			R	R
918	Minn II-62-3 = Fletcher "S"			R	R
922	76R = PI 231312 (Chile)		R		R
945	CC-Inia/Cno x El Gau-Son64		R	R	
946	"		R	R	
987	Sort 315-16		R		R
988	Burga 2 = Sort 12-13		R		R
993	Aurora		R		R
994	Kavkaz		R		R
997	SP 69103			R	R
1011	NE 701147				
1012	NE 701137			R	R
1016	Jo-03021		R		R
1017	Jo-03057		R		R
1025	Caribou		R		R
1041	Zenith		R		R

Continued

Appendix table 3A continued

1050	Starke		R		R
1070	Bonny		R		R
1071	K. Blume			R	R
1072	K4853 = PB/1970			R	R
1077	K4500-2			R	R
1079	K4500-4			R	R
1081	II-60-218 Minn. R6	R		R	R
1083	K4500-5		R		R
1084	K4500-1		R		R
1085	K4500-3			R	R
1092	K6297-2		R		R
1106	K6290-1 = K Nyati "S"	R			R
1107	Kenya Nyati "S"			R	R
1113	K6290-10 = K Nyaty "S"	R	R	R	R
1114	K6290-11 = "	R		R	R
1116	K6290-13 = "	R			R
1127	Menco	R	R		R
1168	K6290-13 = K Nyati "S"			R	R
1215	Constante = Madif 11		R		R
1216	Fulgero		R		R
1217	Fontarronco		R		R
1225	RL4110 = CI 14254			R	R
1239	CI 14378	R		R	
1283	Libellula		R		R
1316	K4526 L10 A5	R			R
1319	Pb^2 x Mg_{2E}	R		R	
1342	$PtfxRfn^2$-Pj62	R		R	
1345	Tob66 x KlPet-Raf	R		R	
1367	K4573 L3D2		R		R
1372	Chris			R	R
1373	IRN 63-409			R	R
1379	$CD/Yt54_E$ x Kt54(Nari59-Drcx8156-Pj62		R		R
1386	PD Kenya		R		R
1390	Rarniaja 12			R	R
1395	Mildress		R		R
1396	Ardent		R		R
1398	Fr/KAD-Gb-Bza		R		R
1402	Anniversario			R	R
1414	PI 293003 (UK)		R		R
1415	TP 114/207-208		R		R
1417	Saunders - E. de Choisy 28		R		R
1422	Horizon		R		R
1426	Bol Bugday		R		R
1427	NS314		R		R
1428	Svenno		R		R
1447	S12 - J9280-67			R	R
1512	Sel 5 x K58-N/Desc		R		R
1513	"		R		R
1647	NS 11-34		R		R
1650	Cruena Zvesda		R		R
1651	18NS 984/1		R		R
1653	22NS 10-79		R		R
1654	VH 70774		R		R
1668	CD/101/Drc		R		R
1674	Sturdy		R		R
1799	Kenya - E de Choisy BxMpk		R		R

R = Resistant at all test sites

Appendix table 3B. **Durum wheat varieties with resistance to two or more species of the major diseases (Data from Third RDISN, 1972/73).**

Entry No.	Pedigree	Stem Rust	Stripe Rust	Leaf Rust	Septoria tritici
812	PI 94587-1 (Hessian fly R)			R	R
1802	Tehuacan 60	R	R		
1807	Gerardo VZ 466		R	R	
1811	Jori 69	R	R		
1818	Flamingo	R	R		
1822	Durum Var 24	R	R		
1823	Pinguino	R	R		
1849	GII-Jori x RD 3-6/Stw63		R	R	
1890	T. turgidum		R		R
1897	Maliani 8D		R	R	
1898	Maliani 11C	R	R	R	
1912	D21563-Jo "S"	R	R		
1947	Flamingo "S"	R	R		
1988	Gerardo 584	R	R		
1991	Gerardo 598	R		R	
1992	Jucci		R		R
1993	Ranieri		R		R

R denotes some degree of resistance at all test sites.

Appendix table 3C. **Barley lines with resistance to two or more species of the major diseases (Data from Third RDISN, 1972/73).**

Entry No.	Pedigree	Stem Rust	Yellow Rust	Leaf Rust
2046	Cyprus Block	R	R	
2047	Edda		R	R
2054	Chevron CI IIII	R	R	
2055	Chevron CJ 9185	R	R	R
2059	Jordan 3	R		R
2070	II 254/L1971-7Y		R	R
2073	II 258/L2171-7Y	R		R
2088	Chevalier	R	R	

Note: All varieties S to yellow rust in North India
In Morocco all lines moderately susceptible to leaf rust. R above indicates some degree of resistance at other sites.

Appendix table 4A. **Winter and semi-winter wheats with apparent resistance to Septoria tritici in the Middle East. (Second RDISN 1971/72)***

Entry No.	Variety or Line	Ave. Score	High Score
1002	Nebraska Line	1.8	4
646	Felix	2.0	3
677	Flamingo	2.0	3
1007	Knox 62	2.0	4
1012	Indiana Line	2.0	3
40	Blueboy	2.3	4
936	Romania F89/63	2.3	4
1010	Indiana Line	2.4	3
1013	"	2.4	4
1017	Michigan Line	2.4	3
1085	Sonora x Chancellor[8]	2.4	-
1087	Michigan Ambar x Chan[8]	2.4	-
638	Flevina	2.5	4
641	Manella	2.5	3
642	Tadorna	2.5	3
644	Stuibes Dickkopf	2.5	3
645	Mildress	2.5	3
911	Ommid	2.5	3
1622	Jubilar	2.5	4
1623	Demar 4	2.5	3
655	NS 314	2.7	3
1005	Nebraska line	2.7	4
1008	Arthur	2.7	5
1009	Indiana line	2.7	4
1083	Asosan x Chancellor[8]	2.7	-
1683	NS 12-60	2.7	-
929	Spring x Cheyenne	2.8	4
639	Heines VII	3.0	4
643	Cleo	3.0	3
912	Bezostaya	3.0	4
939	F. Awrore x Th-Mt/Omd	3.0	4
1082	Ulka x Chancellor[8]	3.0	-
1638	Nebraska line	3.0	5
1649	Nisu	3.0	5
2293	Wanser	3.0	4
2295	Libellula	3.0	5
2296	Aurora	3.0	4
2298	Capitole Vilmorin	3.0	4

* Data limited because of lack of vernalization at some locations.

1973 CIMMYT sources and application of funds

The following date are taken from the 1973 CIMMYT Audit Report of Price Waterhouse y Cia., S.C., Mexico.

US$5,253,000		**Core unrestricted income** [a]
	US$1,500,000	U.S. Agency for International Development
	1,334,000	International Bank for Reconstruction and Development
	750,000	Ford Foundation
	750,000	The Rockefeller Foundation
	451,000	Government of West Germany
	468,000	Administrative charges and miscellaneous income
954,000		**Core restricted income** [b]
	493,000	United Nations Development Programme Research and training in the development of quality protein maize
	331,000	Canadian International Development Agency Triticale research project
	118,000	The Rockefeller Foundation Puebla Project
	12,000	International Development Research Centre (Canada) Research on low temperature tolerant sorghums
1,805,000		**Special projects income** [b]
	997,000	Ford Foundation Projects in Algeria, Argentina, Egypt, Lebanon, Pakistan, Tanzania, Tunisia, and miscellaneous training
	248,000	U.S. Agency for International Development Projects in Morocco and Nepal, and miscellaneous training
	219,000	Government of Zaire Programme National Mais, Zaire
	154,000	The Rockefeller Foundation Projects in Central America, Mexico, Pakistan and Turkey and miscellaneous training
	56,000	International Development Research Centre (Canada) International triticale workshop in Mexico, computer equipment, and miscellaneous training
	55,000	Inter-American Development Bank Training in wheat and maize
	14,000	Purdue University Maize-symposium in Mexico and meteorological stations established in Mexico
	7,000	International Institute of Tropical Agriculture Project in Tanzania and miscellaneous training
	55,000	Training grants from seven donors
8,012,000		**TOTAL INCOME**
5,146,000		**Unrestricted expenses**
	1,009,000	Wheat
	712,000	Maize
	170,000	Puebla Project
	139,000	Economics
	436,000	Experiment stations
	74,000	General service laboratories
	279,000	Information services and library
	419,000	General operations
	610,000	Administration
	1,298,000	Capital acquisitions
1,178,000		**Restricted expenses**
	1,014,000	Direct expenses
	164,000	Administrative charges
1,358,000		**Special projects expenses**
	1,170,000	Direct expenses
	188,000	Administrative charges
7,682,000		**TOTAL EXPENSES**
330,000		**Reimbursements to donors and unexpended balances**
	330,000	For restricted and special grants and working capital
8,012,000		**TOTAL EXPENSES, REIMBURSEMENTS, AND BALANCES**

a/ Funds available for core operations without restriction for use within the budget approved by CIMMYT Trustees.
b/ Funds available only for the activity specified by the donor.