CIMMYT
Report on Wheat Improvement
1981

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Londres 40 Apartado Postal 6-641 06600 México, D. F, México

Correct Citation: CIMMYT Report on Wheat Improvement 1981. 1984

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

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

CIMMYT
Report on Wheat Improvement
1981

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Londres 40 Apartado Postal 6-641 06600 México, D. F, México

Cover design: Miguel Mellado E.

Layout: Miguel Mellado E.; José Manuel F.; Adriana Leal

Typesetting: Silvia Bistrain R.; Maricela A. de Ramos

Typing: Ma. Dolores Mir; Leticia González; Rosa Isela Magaña; Carmen Alatorre de Fernández

Contents

	Page
CIMMYT Trustees	iv
Wheat Program Personnel	v
Directors' Introduction	vi
Bread Wheat Improvement	1
Durum Wheat Improvement	17
Triticale Improvement	29
Barley Improvement	39
Base Support Programs	
Pathology	45
Germplasm Development	57
Germplasm Bank	67
Wide Crosses	69
Agronomy	77
Training	87
International Nurseries	93
Regional and In-Country Activities	
Disease Surveillance Program	96
Andean Region	102
Southern Cone Region	105
Southern Cone Agronomy Program	110
North and West Africa and Iberian Peninsula	118
Eastern and Southern Africa	121
South and Southeast Asia	124
Pakistan	130
CIMMYT/ICARDA Cooperative Wheat Breeding Program	132
Glossary	134

CIMMYT Trustees

(as of April 1, 1982)

FRANCISCO MERINO RABAGO
President, CIMMYT Asamblea
Secretary of Agriculture and Wheat Resources
Mexico

VIRGILIO BARCO
Chairman, Board of Trustees
The Ambassador of Colombia to USA
Colombia

JESUS MONCADA DE LA FUENTE
Vice-Chairman, Board of Trustees
Director General
Instituto Nacional de Investigaciones Agrícolas
Mexico

ENRIQUE AMPUERO P.
Director General
Instituto Nacional de Investigaciones Agropecuarias
Ecuador

WALTER P. FALCON
Director
Food Research Institute
Stanford University
USA

ROBERT D. HAVENER
Director General
CIMMYT
USA

PHAITOON INGKASUWAN
Rector
Kasetsart University
Thailand

H.K. JAIN
Director
Indian Agricultural Research Institute
India

W.A.C. MATHIESON
Consultant, UNDP
United Kingdom

JAMES R. McWILLIAM
Professor of Agronomy
University of New England
Australia

KAN-ICHI MURAKAMI
Professor of Agriculture
University of Tsukuba
Japan

STACHYS NJAGI MUTURI
Deputy Permanent Secretary
Ministry of Energy
Kenya

W. GERHARD POLLMER
Professor of Plant Breeding
University of Hohenheim
Germany

ABDOULAYE SAWADOGO
Professor of Economic Geography
University of Abidjan
Ivory Coast

O. M. SOLANDT
Consultant
Canada

Wheat Program Personnel

Director — Byrd C. Curtis, USA

Associate Director — Arthur R. Klatt, USA

Senior Consultant — Norman E. Borlaug, USA

Bread Wheat Breeding — Sanjaya Rajaram, India

Durum Wheat Breeding — Gregorio Vazquez, Mexico

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

Barley Breeding — Enrique Rodríguez, Mexico

Pathology — Santiago Fuentes, Mexico
Enrique Torres, Colombia
Girma Bekele, Ethiopia

Germplasm Development — Ricardo Rodriguez, Mexico

Germplasm Bank — Ayla Sencer, Turkey

Milling and Baking Laboratory — Arnoldo Amaya, Mexico

Agronomy — Patrick Wall, Ireland
Peter R. Hobbs, United Kingdom
David A. Saunders, Australia

Training — Hugo Vivar, Ecuador

Wide Crosses — A. Mujeeb Kazi, USA

International Nurseries — Maximino Alcala, Mexico

Postdoctoral Fellows
Pedro Brajcich G., Mexico
Larry Butler, USA
Edwin Knapp, USA
Pierre Malvoisin, France
Christopher E. Mann, Federal Republic of Germany
Johann-Peter Neuhaus-Steinmetz, Federal Republic of Germany
Guillermo Ortiz F., Mexico
Reynoldo L. Villareal, Philippines

International Cooperative Programs
Andean Region, South America — H. Jesse Dubin, USA (based in Ecuador)
Southern Cone Region, South America — Man Mohan Kohli, India (based in Chile)
Matthew A. McMahon, Ireland (based in Chile)
Eastern and Southern Africa — Gerbrand Kingma, Netherlands (based in Kenya)
Henk Bonthuis, Netherlands (Dutch Associate, based in Kenya)
North and West Africa and Iberian Peninsula — George Varughese, India (based in Portugal)
Disease Surveillance Project — J. Michael Prescott, USA (based in Turkey)
Maarten Van Ginkel, Netherlands, (Dutch Associate, based in Turkey)
CIMMYT/ICARDA Cooperative Wheat Breeding Program — Walter Nelson, USA (based in Syria)
Pakistan — Homer Hepworth, USA (based in Pakistan)
South and Southeast Asia — E. E. Saari, USA (based in Thailand)

Directors' Introduction

The global wheat situation in 1981 was characterized by a continuation of trends noted in our introduction to the 1980 CIMMYT Report on Wheat Improvement. Wheat production in the developing countries of the world again approached record levels, nearly 158 million tons (Mt) in total. This high level of production was largely due to continuing progress in improving yields in South and East Asia; India, Pakistan, Bangladesh and Nepal all harvested bumper crops, together producing about 50 Mt (some 14 percent above the 1978-80 combined average for these countries). In the Middle East, little change over the previous 3-year average was recorded, despite a slightly higher level of production in Turkey (about 17 Mt). Results in Latin America were mixed, with above average production levels in Mexico and Argentina, and reductions in output by the remaining wheat-growing countries in the region.

Despite near record levels of production in the Third World, global trade in wheat achieved a new high in 1980/81, approximately 91 Mt. Developing countries continued their rapid increase in wheat imports, reaching a level of over 53 Mt (a 16 percent rise over the 1978-80 average). The geographic pattern of Third World imports was similar to that of the 1970s and coincides with those countries and regions in the developing world where the consumption of wheat is rapidly expanding: the North Africa/Middle East regions and the tropical countries of sub-Saharan Africa and Southeast Asia. China also raised its imports of wheat to nearly 13 Mt, some 32 percent above its previous 2-year average.

Wheat Program Objectives for the 1980s

Even though tremendous progress has been made in raising the wheat production capacity of many developing countries, the fact that Third World wheat imports continue to increase rapidly indicates that CIMMYT's job is far from complete. Careful analyses of production constraints and consumption trends in the developing world guide the establishment of CIMMYT's Wheat Program objectives and priorities for the 1980s.

Wheat is increasingly being grown in marginal environments, in "nontraditional" areas and/or on problem soils. To improve the dependability of yields in these diverse environments means placing greater emphasis in our breeding programs on incorporating (1) resistance to various diseases, (2) tolerance to such soil problems as salt and toxic levels of aluminum, and (3) tolerance to drought and heat. Of special interest in this regard are our expanding efforts to improve resistance to the so-called "minor" diseases of wheat, such as those caused by *Septoria, Helminthosporium* and *Fusarium* species. Moreover, our cooperative work with Brazil to enhance wheat's tolerance to toxic levels of aluminum is showing impressive results. Highlights of these and other efforts are provided in this report.

Our work on improving genetic yield potential, *per se*, is not being neglected. All four crop programs continue to strive for maximum genetic yield potential in advanced materials. Yet given the real-world conditions noted above, yield dependability criteria have necessarily moved to the forefront of our overall breeding efforts. We will, of course, continue to report on our progress toward improving the yield potential of CIMMYT materials.

Regional and Cooperative Programs

Most CIMMYT wheat staff posted outside Mexico are assigned to regional programs. Only one staff member was working in 1981 in a bilateral national program assignment—in Pakistan. His work focused mainly on production agronomy research. In total, the Wheat Program had staff assigned to seven regional programs in 1981. Reports from these staff members are contained herein.

It is through our regional and cooperative programs that we have been able to multiply tremendously the impact of our crop improvement activities. We take pride in our warm associations with scientists and agricultural leaders all over the world, and we consider ourselves to be full partners with national program scientists in our efforts to improve wheat, triticale and barley.

Special mention must be made here of CIMMYT's unique relationship with the National Institute of Agricultural Research (INIA) of the Government of Mexico. INIA has a strong and independent research program, and germplasm flows freely between INIA and CIMMYT. We operate the summer cycle nurseries at El Batan and Toluca, but benefit from regular input by INIA scientists. In the winter cycle, CIMMYT is privileged to work with the Northwest Center for Agricultural Investigations (CIANO), a branch of INIA, on the CIANO station near Ciudad Obregon. The farmers' organization of the area, known as the PATRONATO, provides half the operating costs needed for these winter nurseries. CIMMYT greatly appreciates this support; it is our hope for the future, as in the past, that our joint efforts will continue to supply superior varieties to the farmers of Mexico.

New and/or expanding programs

While all of our support units continúe to provide excellent service to the breeding programs, two support activities deserve special mention here: the new CIMMYT wheat germpalsm bank and our expanding wide crosses program. Special funding from the Government of Japan enabled the construction of a new seed house and germplasm bank facilities during 1980-81. In addition to the two cold chambers previously used for short-term storage of about 70,000 entries, the facilities for the germplasm bank now include three new cold rooms (two of which are equiped for medium-term storage of about 90,000 entries), a seed drying room, a seed preparation room, a machine room and offices. These new facilities have expanded considerably our ability to maintain active collections of germplasm for use in our breeding efforts, and the financial support of the Government of Japan is greatly appreciated.

Our work in wide crosses (intergeneric hybridization) has shown remarkable progress since its inception in mid-1979. The program continues to stress the incorporation into wheat of disease and environmental stress tolerance charcteristics from alien genera. Crosses are made between *Triticum aestivum* and *Aegilops, Agropyron, Elymus, Haynaldia* and *Secale* species, as well as with *T. turgidum*. Several hybrids were produced in 1981 and cytologically verified on the basis of their F_1 chromosome number. Backcross progenies of these hybrids are showing promising resistance to rust and helminthosporium diseases, and may in some cases prove useful in developing salt tolerance in wheat.

A closing note

As many of you know, 1981 was a sad year for CIMMYT. Glenn Anderson, Director of the Wheat Improvement Program, died of a sudden illness. He is sorely missed by all who knew him, but his life's work continues. The current Directors intend to follow through on the work begun by Dr. Anderson and his predecessor, Dr. Norman E. Borlaug. Efforts are underway to strengthen activities at CIMMYT Headquarters as well as in our regional programs: we are striving to increase the efficiency of our operations by adopting the latest scientific technologies and management techniques appropriate to CIMMYT's activities. We also recognize the fundamental importance of training national program staff and are seeking ways to complement and further extend the impact of our training efforts. As noted earlier, the job of the CIMMYT Wheat Program is far from complete. However, we have a clear sense of the challenges and problems before us and are optimistic about their eventual resolution.

Byrd C. Curtis
Director

Arthur R. Klatt
Associate Director

Bread Wheat Improvement

S. Rajaram, Head, Bread Wheat Program
P. Brajcich, Wheat Breeder
L. Butler, Wheat Breeder/Pathologist

Introduction

World wheat production averaged about 440 million metric tons from 1978 to 1980. (FAO, *Food Balance Sheets*, 1980). Roughly one-third of this total was produced in developing countries. Significantly, the total area sown to semidwarf varieties in developing countries now exceeds 35 million hectares.

Wheat is an important source of food to three-fourths of the population in developing countries, and production in these areas continues to expand at rates higher than those in developed countries and as compared to other major cereals. As a spectacular example, the relatively new effort by Bangladesh to produce wheat has resulted in more than a 100 percent gain in production in the period between 1978 and 1980; a 40 percent gain was achieved in 1981 over the previous year. It is expected that the area devoted to wheat will expand from about 1.8 million acres in 1981, to between 3 and 4 million acres by 1985. It is largely through the use of semidwarf wheats that progress such as this has been and will be achieved.

The expansion of wheat production into such areas as Bangladesh places new demands on breeding bread wheat for specific adaptations and stresses (e.g. for the highlands of the tropics, for drought stress and for resistance to *Helminthosporium* spp., *Septoria* spp. and aluminum toxicity). Further, as varieties gain in farmer acceptance and preference, and are thus sown over extensive areas, changes in rust race virulences and the consequent instability of resistance present a recurrent challenge to breeders.

Expanding wheat production in developing countries where wheat is not a traditional crop, such as in Bangladesh, is placing new demands on breeding bread wheats for specific adaptations and stresses. Here, Dr. S. Rajaram, head of the bread wheat program, examines some materials with potential usefulness in the more tropical areas of the world. (Photo: T. Harris)

CIMMYT believes, however, that the necessary germplasm can be successfully developed. Support for this belief comes from several important sources: 1) data derived routinely from screening nurseries and yield trials in problem areas, 2) the identification of resistance in nurseries both artificially inoculated and naturally infected in Mexico and, 3) the development of new breeding strategies to deal with changes in rust virulences. For example, significant progress has been achieved toward incorporating tolerance to toxic levels of aluminum into germplasm of improved agronomic type. An additional attribute observed in this germplasm was the apparent incorporation of resistance not only to rusts but also to other important foliar diseases.

CIMMYT's concern for combining specific genetic characteristics (for disease resistance, environmental tolerances, and agronomic type) with wide adaptation is reflected in the categories of germplasm included in the spring and winter crossing blocks of 1981 (Tables 1 and 2).

Breeding and testing locations

Breeding and evaluation of segregating and advanced materials are conducted during two cycles per year at two alternate locations: Ciudad Obregon in northwest Mexico (elevation: 40 meters; 27.4°N latitude; growing season: November-May), and Toluca in the State of Mexico (elevation: 2640 meters; 19°N latitude; growing season: May-October). Certain nurseries are also evaluated at El Batan, site of CIMMYT Headquarters. Yield potential is evaluated in Cd. Obregon, where irrigation, good land preparation, and high levels of fertilizer and sunlight ensure maximum genetic expression. However, conditions at Cd. Obregon do vary and mean yields fluctuate accordingly. Figure 1 illustrates the mean, maximum and minimum temperatures in the period 1960 to 1981 and 1980-81 cycles. The yields experienced in the 1980-81 cycle were not as high and were probably due to higher minimum and mean temperatures from November to February and in April.

Resistance to various diseases is evaluated at several locations in Mexico, such as Patzcuaro, Rio Bravo, El Refugio, and Los Mochis. Increasingly, we are artificially inoculating nurseries with a variety of "minor" pathogens, in addition to the rusts. As a part of a recently initiated program to select wheats for tropical areas, various nurseries at El Batan were inoculated with *Helminthosporium sativum* and *H. tritici-repentis*. Also, all nurseries in Toluca (except seed multiplication plots) were inoculated with *Septoria tritici*. Segregating and advanced materials are also subjected to severe selection pressures each year at many international locations. Thus, we have been able to develop widely adapted, high yielding, disease resistant germplasm through the use of this unique breeding and testing system.

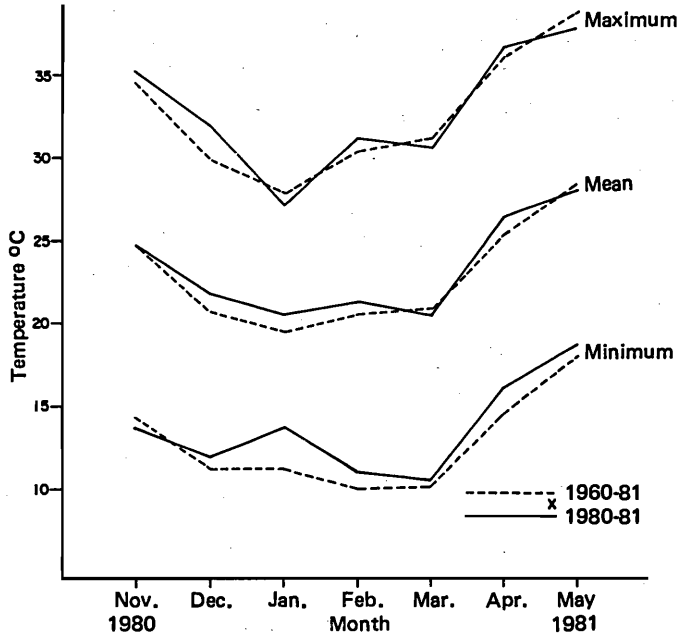


Figure 1. Temperature variations, Cd. Obregón, México

Table 1. Classification of entries in the spring wheat crossing block, 1981

Group (number)	Classification	Entries (number)
I	High yielding lines or varieties	30
II	High yielding lines in highland areas	54
III	High yielding lines in dryland areas	13
IV	East African lines	17
V	Middle East lines	12
VI	Southern Cone lines or varieties	12
VII	Aluminum toxicity resistant lines or varieties	16
VIII	Septoria leaf blotch resistant lines or varieties	81
IX	Scab resistant lines or varieties	19
X	Helminthosporium spp. resistant lines or varieties	27
XI	Leaf rust slow rusting lines	10
XII	Industrial quality lines	3
XIII	Early maturity lines or varieties	4
XIV	Australian, USA and Canadian lines or varieties	3

Yield and adaptation

The process of developing spring wheat germplasm for international use is a dynamic one in which the necessary genetic variability, wide adaptation and/or disease resistances are tapped from numerous and diverse sources. Contributions come from the winter wheat germplasm pool, from varieties developed in other countries, and from selections made among CIMMYT's own segregating and advanced international nurseries. After intensive assessment through several growing cycles, promising lines are crossed to germplasm considered to be high yielding, widely adapted and rust resistant. Advanced, yield-tested progeny resulting from these crosses are initially made available to international cooperators through the International Bread Wheat Screening Nursery (IBWSN).

In 1981, fifty-six replicated yield trials at Cd. Obregon were used to determine the yield potential of 1450 advanced lines. The resistance of these lines to leaf rust was observed in small multiplication plots (PCs) attendant to yield trials. Small sets of PCs were also planted at Los Mochis and Rio Bravo for visual assessment of resistance to leaf rust. As a result of these evaluations, 206 lines were selected for inclusion in the 15th IBWSN. In Mexico,

Table 2. Varietal distribution by region and country of entries in the winter wheat crossing block, 1981

Region and country	Number of entries	
WESTERN EUROPE		32
France	20	
England	8	
Holland	3	
Austria	1	
EASTERN EUROPE		29
Hungary	4	
Poland	3	
Bulgaria	2	
Rumania	8	
Yugoslavia	12	
UNION OF SOVIET SOCIALIST REPUBLIC		2
FAR EAST		13
South Korea	2	
Peoples Republic of China	11	
SOUTH AMERICA		9
Argentina	1	
Chile	8	
TURKEY		10
UNITED STATES OF AMERICA		82
Oregon	62	
Indiana	3	
Colorado	6	
Kansas	2	
Nebraska	4	
Oklahoma	2	
Texas	3	

the 15th IBWSN was observed for resistance to leaf rust and *H. tritici-repentis* at El Batan, to leaf rust at El Refugio, and to stripe rust and *Septoria tritici* at Toluca. The yields of selected lines in the 15th IBWSN are presented in Table 3.

Wide adaptation and stability of yield

Preliminary international results of the 14th IBWSN and the 17th International Spring Wheat Yield Nursery (ISWYN) indicate that various selections of advanced lines of Veery"S" are showing top yield performance in both trials. The 14th IBWSN and 17th ISWYN were tested at 38

Table 3. Yields of promising advanced lines from the 15th IBWSN at Cd. Obregon, Sonora, Mexico, 1980-81

Entry number	Cross	Yield/Yield of best check variety (kg/ha)
2	KVZ-CJ71	5819/5514(NAC)
10	F12.71-COC 75	6007/5921(VEE#1)
30	BUC"S"	6447/5921(VEE#1)
32	BUC"S"	6106/5921(VEE#1)
33	BUC"S"	6367/6304(VEE#3)
37	PSN"S"	5850/5618(NAC)
41	KOEL"S"	5800/5724(NAC)
42	SNB"S"	5860/5519(NAC)
57	VEE"S"	5776/5618(NAC)
63	CHAT"S"	5682/5618(NAC)
64	CHAT"S"	6342/6022(CN079)
65	CHAT"S"	6214/6022(CN079)
66	CHAT"S"	6083/6022(CN079)
70	BOW"S"	6050/6382(CN079)
73	BOW"S"	6008/6382(CN079)
75	Ti-TOB66xALD"S"	6111/6022(CN079)
76	Ti-TOB66xALD"S"	6147/6022(CN079)
81	HAHN"S"	6114/6201(CN079)
82	HAHN"S"	6083/6201(CN079)
83	HAHN"S"	6129/6201(CN079)
85	HAHN"S"	6324/6201(CN079)
92	MNV"S"	5768/5724(NAC)
94	MAYA"S"-NAC76	5594/5538(NAC)
95	WRB"S"	6135/6201(CN079)
96	JUP73-BJY	6422/6461(CN079)
97	BJY"S"-JUP73	6064/6461(CN079)
101	SAP"S"-HUAC"S"	6001/6461(CN079)
102	SAP"S"-HUAC"S"	6026/6461(CN079)
103	NKT"S"	6271/6461(CN079)
*104	NKT"S"	6593/6461(CN079)
108	CROW"S"	6143/6461(CN079)
*109	CROW"S"	6493/6460(MOR"S")
126	(CHR-S948xCHR(4)/8156(B))JUP73	6061/6118(CAR-ANA)
*127	BEZ-ZA75xCAR"S"	6674/6118(CAR-ANA)
131	CMT-MO73xTRM	6138/6815(MOR"S")
154	TES76-MUS"S"	6131/6240(VEE#2)
195	BUC"S"xKAL-BB	5781/5682(NAC)
196	BUC"S"xKAL-BB	5857/5682(NAC)
197	BUC"S"xKAL-BB	5919/5793(VEE#1)

and 33 locations, respectively. The average yield performance of 5 Veery selections in the 14th IBWSN was 4636 kg/ha, compared to 4266 kg/ha for Pavon 76, a high yielding variety known for its wide adaptation. Similarly, the average yield of 5 Veery selections in the 17th ISWYN is 4404 kg/ha compared to 4287 kg/ha for Pavon 76, reported as the highest yielding released variety in Mexico.

CIMMYT-INIA cooperative breeding and testing program

The experiment station at Ciudad Obregon is jointly managed by the scientists of CIMMYT and CIANO (Centro de Investigaciones Agrícolas del Noroeste) of INIA (Instituto Nacional de Investigación Agrícola). CIMMYT also collaborates with other research centers of INIA, such as CIAB in El Bajio, CIAPAN in Los Mochis and CIANE in Tampico. A list of varieties released by these centers is given in Table 4.

The assessment and multiplication of germplasm preparatory to varietal release is a laborious process. As practiced by CIANO, it is a very sophisticated and cautious one. Disease resistance assessments are needed before multiplication of foundation seed begins. Results of yield testing and disease resistance assessments of varieties released in Mexico in 1981 for the Ciudad Obregon area are presented in Table 5. Three varieties derived by CIMMYT-INIA, Nacozari 76, Pavon 76, CIANO 79, occupied respectively about 60 percent, 20 percent and 10 percent of the bread wheat growing areas near Cd. Obregon in the 1980-81 cycles. It became obvious during this cycle that, due to an apparent change of the virulences of the leaf rust population, the resistance of Nacozari 76 was no longer adequate. In the 1981-82 cycle, CIANO 79 will probably occupy about 50 percent of the bread wheat growing area, with lesser amounts occupied by Imuris 79, Tesia 79 and others. Newer varieties, such as Glennson 81 and others listed in Table 5, are in an early stage of general cropping and have yet to be assessed as to farmer acceptance. Note that three new varieties are sister selections of

Table 4. List of varieties developed cooperatively by CIMMYT/INIA and released recently in Mexico

Name	Cross and pedigree	Location of release
GLENNSON M81	KVZ-BUHO"S"xKAL-BB = VEERY"S" CM33027-F-8M-1Y-2M-0Y	Cd. Obregon, Sonora
URES T81	KVZ-BUHO"S"xKAL-BB = VEERY"S" CM33027-F-12M-1Y-4M-2Y-2M-0Y	Cd. Obregon, Sonora
GENARO F81	KVZ-BUHO"S"xKAL-BB = VEERY"S" CM33027-F-12M-1Y-6M-0Y	Cd. Obregon, Sonora
TONICHI S81	CAR422-ANA75 SWM4610-2Y-20M-1Y-0M	Cd. Obregon, Sonora
SONOITA F81	TRM73xKAL-BB CM37130-15Y-1M-3Y-0M	Cd. Obregon, Sonora
GUASAVE F81	KVZxKAL-BB/BON CM33202-E-1M-2Y-0M	Los Mochis, Sinaloa
MULEGE F81	(TOB66-B.MANxBB/CDL)SX66 CM8972-9M-1M-5Y-0M	Los Mochis, Sinaloa
MAHONE F81	(TOB66-B.MANxBB/CDL)SX66 CM8972-9M-1M-1Y-0M-(1-53B)	Los Mochis, Sinaloa
HUASTECO M81	HOPPS-RONxKAL CM8874-K-1M-1Y-1M-0M	Huasteca, Tamaulipas
VICTORIA M81	YR70(B)-TRF"S"xRSK-TRM73 CM36064-A-1M-5Y-0M	Huasteca, Tamaulipas
CELAYA F81	YD"S"-ZZ"S" CM35048-33Y-2M-1Y-0M	Roque, Guanajuato

Table 5. Yield (kg/ha), leaf rust reaction, and agronomic characteristics of the five new varieties released (1981) for the Northwest of Mexico compared to standard varieties Nacozari 76 and CIANO 79

Name and pedigree	Yield kg/ha			Leaf rust reaction			Days to flowering	Days to maturity	Plant height (cm)
	Y78-79	Y79-80	Y80-81	Cd. Obregon	Mochis	R.Bravo			
CAR422-ANA75=TONICHI 81 SWM4610-2Y-20M-1Y-0M	6583	7050	5958	5MS-S	5R	5MS	87	129	95
VEERY #1=GLENNSON 81 CM33027-F-8M-1Y-2M-0Y	7867	8367	5843	TMR-R	TMR	10R-MR	84	129	90
VEERY #2=URES 81 CM33027-F-12M-1Y-4M-2Y-2M-0Y	8778	7946	5510	TS	TMR	10MR-MS	87	132	90
VEERY #3=GENARO 81 CM33027-F-12M-1Y-6M-0Y	6452	7733	5820	5MS	0	5MR-MS	87	132	100
MOR"S"=SONOITA 81 CM37130-15Y-1M-3Y-0M	6237	5713	5584	5X	10MR-MS	5MS	80	132	70
NACOZARI 76			5637	20MS-S	50S-MS	10MR-MS	84	129	90
CIANO 79			6055	10MS-MR	5MR	5MS-MR	82	132	90

Veery; selections of Veery are performing well and have gained acceptance in such diverse locations as Pakistan, Paraguay and Spain. In fact, a Veery selection was also released in Pakistan as PAK 81.

The authors would like to take this opportunity to thank officials of CIANO, INIA and the Mexican Government for the fitting and timely tribute paid to the late Director of the CIMMYT Wheat Improvement Program, Dr. Glenn Anderson, by naming Veery No. 1 as the variety "Glennson." We also wish to reaffirm our gratitude for the cooperation received from various personnel of CIANO who have greatly facilitated the development of CIMMYT germplasm.

Breeding for stress conditions

In addition to high yield and wide adaptation, very strong emphasis is given to producing:

- wheats with resistance to many foliar diseases, intended for highland areas;
- wheats resistant to aluminum toxicity, intended for acid soils;
- wheats for drought-prone areas;
- wheats resistant to juvenile heat tolerance and foliar diseases, intended for warmer subtropical areas.

These stress environments comprise millions of hectares the world over, and thus merit special attention in our breeding program. Progress in some of these environments has already been achieved, and is expected in others in the near future. A brief summary of advances in each category is provided below.

Wheats for highland areas

The breeding of bread wheats for highland areas presents many challenges, particularly for the incorporation of needed resistance to prevalent diseases. In such areas (the Andean region, East Africa and Central America) diseases due to *Fusarium nivale, Septoria* spp., *Xanthomonas translucens*, and *Puccinia striiformis* frequently occur together in high intensity. Stable resistance for *P. striiformis* is available in CIMMYT materials. However, easily identifiable and transferrable resistance, such as that used for stem and leaf rusts, apparently does not occur (at least in readily usable forms) for the complex of foliar diseases caused by nonobligate pathogens.

The CIMMYT/Brazil cooperative shuttle-breeding program for improving the tolerance of HYVs to high levels of free aluminum is showing impressive results. An important aspect of this program is laboratory screening of germplasm at the seedling stage. (Photo: J. L. Castillo)

Resistance that does occur appears to be cumulative in nature and stems from as yet undefined resistance factors that separately do not impart high levels of resistance. The identification of resistance factors in usable germplasm is often made difficult if inoculum pressure is excessive; the resistance is simply overwhelmed by the disease. Progress has been made, however, and several lines of wheat with good yields and disease resistance have been developed (Table 6). All lines presented in Table 6 were selected from replicated yield trials at Toluca in 1981. An acceleration in the development of wheats with the necessary resistance to foliar diseases is expected, due to the progressively easier identification and availability of new sources of resistance.

Table 6. Yield response of selected lines from highland yield trials conducted in Toluca 1981

Cross and pedigree	Yield (kg/ha)
KEA"S" CM21335-9Y-3M-1Y-1Y-1Y-0B	4674
TAN"S" CM30697-2M-8Y-1M-1Y-1B-0Y	4833
TAN"S" CM30697-2M-14Y-0M-97B-0Y	4882
TAN"S" CM30697-10M-1Y-10M-1Y-1B-0Y	4750
KVZxBB-CHA/TRM73 CM30832-Z-3Y-1M-4Y-1M-0Y-1PTZ-0Y	4542
BOW"S" CM33203-F-4M-4Y-1M-1Y-0M	4833
PJ62xZA75-BBT CM35855-E-3M-500Y-502M-500Y-501M-500Y-500B-500Y-0Y	4715
/JUP73(7C-PATO(R)/LR64-INIA66-BB)/ANA75 CM37760-C-21Y-2M-1Y-3M-0Y	4729
PATO-0NxMAYA"S"(2) CM39440-1Y-2M-2Y-1M-1Y-2M-0Y	4681
JUP73-BJY"S" CM39992-12M-1Y-1M-1Y-0M	4667
JUP73-BJY"S" CM39992-12M-1Y-1M-1Y-1M-1Y-0B	4674
BJY"S"-JUP73 CM40078-6M-4Y-2M-1Y-2M-1Y-0B	5063
SUP"S"-MON"S" CM40392-17M-1Y-1M-0Y	5063
DGA-BJY"S" CM40610-22Y-3M-2Y-1M-1Y-2M-0Y	4660
ERAF-YR70/PATO-0NxMAYA"S" CM40732-5Y-3M-1Y-2M-2Y-1M-0Y	5257
PAT7768-HORK"S" CM40803-2M-2Y-1M-0Y	4853
YACO"S" CM41195-A-13M-2Y-3M-1Y-1M-0Y	5625
PC "S"-PVN"S" CM42889-11Y-1M-2Y-1M-1Y-1M-0Y	5278
PC "S"-PVN"S" CM42889-11Y-1M-2Y-1M-1Y-2M-0Y	5333

Table 6. (continued)

Cross and pedigree	Yield (kg/ha)
MRS-INIA66xTRM73 CM43259-A-1Y-1M-1Y-1M-1Y-2M-0Y	4938
F35.70-MO73xNAC76 CM43367-E-3Y-6M-1Y-2M-0Y	5729
JUP73-EMU''S''xGJO''S'' CM43598-II-8Y-1M-1Y-1M-2Y-1M-0Y	5347
JUP73-EMU''S''xGJO''S'' CM43598-II-8Y-1M-2Y-1M-1Y-2M-0Y	5174
JUP73-EMU''S''xGJO''S'' CM43598-II-8Y-1M-2Y-2M-2Y-2M-0Y	5292
JUP73-EMU''S''xGJO''S'' CM43598-II-8Y-1M-2Y-4M-1Y-1M-0Y	5292
JUP73-EMU''S''xGJO CM43598-II-8Y-1M-2Y-5M-2Y-1M-0Y	5236
JUP73-EMU''S''xGJO CM43598-II-8Y-1M-2Y-5M-2Y-1M-0Y	5236
JUP73-EMU''S''xGJO CM43598-II-8Y-1M-5Y-1M-2Y-0B	5146
7C-ALD''S''xCAN''S'' CM43713-H-1Y-3M-2Y-6M-1Y-1M-0Y	5028
Lira''S'' CM43903-H-2Y-1M-5Y-1M-1Y-1M-0Y	5000
MAYA''S''-MON''S''xKVZ-TRM73 CM44083-N-2Y-2M-1Y-1M-1Y-2M-0Y	5132
JUP73-FURYxSIS''S'' CM44599-EE-3Y-3M-1Y-1M-1Y-0B	5174
MUS''S''-PTM70xMAYA''S''-ALD''S'' CM44740-A-3Y-1M-1Y-2M-1Y-2M-0Y	5639
BBxTOB66-8156/SX CM45661-1M-3Y-3M-1Y-0Y	5069
TES76-VID''S'' CM45992-38M-1Y-3M-2Y-0Y	5451
COQ''S''-NAC76 CM46767-6M-2Y-3M-2Y-0Y	5229
/(KT-BGxFN-U/BZA)TRM73/ALDAN''S'' CM47941-EE-5M-2Y-1M-1Y-0Y	4903
/(KT-BGxFN-U/BZA)TRM73/ALDAN''S'' CM47941-EE-5M-2Y-1M-1Y-0Y	5070
/(KT-BGxFN-U/BZA)TRM73/ALDAN''S'' CM47941-Q-2M-1Y-4M-1Y-0Y	5208
MRH50-TRM73/HORK''S''xCN)67-7C CM47942-K-1M-1Y-1M-2Y-0Y	4861
CI14227-TRM73xMAD''S'' CM47943-V-5M-3Y-1M-1Y-0Y	5326
{/CNO-8150xTOB-CNO(NO/12300xLR64-8156)/PLO}R37-Gh11xYr CM48732-A-1M-3Y-1M-2Y-0Y	5028
BUC''S''-BJY''S'' CM49641-32Y-4M-2Y-0Y	5021

Previous to 1981, certain advanced nurseries were planted in Patzcuaro, Mexico, during the summer cycles for screening against naturally occurring strains of *Septoria tritici*. Progenitors with good resistance were thus identified, and results from Patzcuaro correlated well with those obtained through the International Septoria Observation Nursery (ISEPTON) and also from such cooperators as Dr. Eyal at the University of Tel Aviv, Israel. A list of promising progenitors for septoria resistance is presented in Table 7. Note the high incidence of lines of Bobwhite (Bow"S") and Sunbird (Snb"S").

In 1981, members of the CIMMYT pathology program successfully inoculated all segregating and most advanced nurseries at the Toluca station, using inoculum prepared from Patzcuaro isolates that were increased in the laboratory. Selection pressure was raised to such an extent that only about one-half the number of individual plants were selected from segregating nurseries in 1981 as were selected in 1980.

Regarding new sources of resistance, a genuine breakthrough was achieved against the complex of foliar diseases via the continued development of aluminum toxicity resistance. Progress in aluminum toxicity resistance, *per se,* will be discussed in the following section; however, a particularly important by-product of the aluminum toxicity nursery has been the detection of lines possessing an apparent resistance to a number of nonobligate foliar pathogens, such as *Septoria* spp. and *Fusarium nivale*. The quality of resistance was dramatically highlighted at the national research station in Quito, Ecuador, and at Njoro, Kenya, where favorable conditions for disease development resulted in the virtual destruction of most bread wheat lines, except those in the CIMMYT Aluminum Screening Nursery.

Wheats for acid soils

Since 1974, when cooperative agreements were formalized between CIMMYT and three Brazilian research institutions (EMBRAPA, FECOTRIGO and OCEPAR), shuttle breeding for tolerance to aluminum toxicity has shown remarkable progress. Agronomic characteristics of varieties with field and/or laboratory tolerance to toxic levels of aluminum have substantially improved and continue to do so. In fact, progress in this regard has been such that a number of selections from the Aluminum Screening Nursery were included in the conventional yield trials during the Cd. Obregon cycle of 1981-82.

Table 7. Lines from the 15th IBWSN with *Septoria tritici* reaction lower than 5.3 (0-9 scale) at Patzcuaro, Mexico, 1981

Entry Number	Cross and pedigree
57	VEE"S" CM33027-F-15M-500Y-0M-89B-0Y
61	VEE"S" CM33027-F-15M-500Y-0M-126B-0Y
73	BOW"S" CM33203-K-10M-7Y-3M-1Y-2M-0Y
11	F12.71-C0C75 SWM5784-17Y-2M-2Y-2M-1Y-1M-0Y
62	CHAT"S" CM33090-N-1M-1Y-0M-121Y-0B
10	F12.71-C0C75 SWM5784-17Y-1M-5Y-1M-1Y-0B
45	VEE"S" CM33027-F-1M-9Y-0M-86Y-0B
46	VEE"S" CM33027-F-1M-9Y-0M-97Y-0B
70	BOW"S" CM33203-K-9M-9Y-4M-4Y-1M-0Y
72	BOW"S" CM33203-K-9M-19Y-3M-3Y-2M-1Y-0M
74	BOW"S" CM33203-K-10M-7Y-3M-2Y-1M-0Y
68	BOW"S" CM33203-K-9M-2Y-1M-1Y-1M-0Y
12	F12.71-C0C75 SWM5784-17Y-2M-2Y-2M-1Y-2M-0Y
14	MON"S" CM8288-A-3M-6Y-5M-1Y-1M-0Y
64	CHAT"S" CM33090-T-1M-4Y-0M-1B-0Y
71	BOW"S" CM33203-K-9M-9Y-4M-4Y-1M-1Y-0M
78	BOW"S" CM33203-K-9M-24Y-0M-15Y-0B
42	SNB"S" CM34630-D-3M-3Y-1M-1Y-0M
152	PVN76"S"-7C66 CM45470-8M-1Y-2M-1Y-1Y-0M
2	KVZ-CJ71 SWM1430-4Y-3Y-0Y
55	VEE"S" CM33027-F-15M-500Y-0M-76B-0Y
59	VEE"S" CM33027-F-15M-500Y-0M-110B-0Y
69	BOW"S" CM33203-K-9M-2Y-1M-1Y-2M-0Y
199	ALD"S"-MN72130 CM50361-8Y-6M-1Y-2Y-0M

Such progress could not have been achieved without the close cooperation of the Brazilian organizations, whose field and laboratory observations provide the basis for establishing the populations from which individual plants are selected in Toluca and Cd. Obregon .

Field evaluations of populations involving crosses with the CIMMYT line "Alondra" have proven more useful than laboratory analyses of these lines. Alondra, a "resistant" line under certain field conditions, has no true tolerance to aluminum toxicity, *per se,* as attested by negative laboratory results. However, this line apparently has the inherent capacity for increased and/or more efficient uptake of phosphorus, which is relatively immobile in the soil and becomes particularly limiting to plants with reduced root growth resulting from aluminum toxicity. Development of rapid laboratory testing procedures to determine which populations/plants have both increased uptake of phosphorus and tolerance to toxic levels of aluminum would be particularly useful at this juncture.

Wheats for drought-prone areas

Screening—Increasingly more emphasis is being directed toward breeding wheats adapted for rainfed conditions or areas of high drought risk. It is impractical, if not impossible, to attempt to breed for all drought conditions, since the time of stress occurrence differs widely from one area to another and tolerances of cultivars vary accordingly. However, it is useful to identify germplasm with apparent tolerance to at least a defined set of water stress conditions. Since 1980, selected materials have been routinely evaluated by replicated yield trials conducted under rainfed conditions at El Batan, as well as reduced irrigation (2 irrigations) at Cd. Obregon.

Yield responses of selected lines tested under reduced irrigation (Cd. Obregon, 1980-81) and rainfed conditions (El Batan, 1981) are presented in Table 8. Note the predominance of Veery, Bobwhite and Lira lines. The reduced irrigation regime at Cd. Obregon consisted of two irrigations: the first immediately after planting (November) to produce a stand and the second soon after flowering. Significant moisture stress was observed. The mean yield of the Nacozari checks under the reduced irrigation regime was 3943 kg/ha, but 5616 kg/ha under the normal irrigation regime (5 irrigations) of conventional yield trials. More stress was apparently produced under the reduced irrigation regime than under rainfed conditions at El Batan, where yields of identical lines were, without exception, considerably higher. Ciudad Obregon is expected to prove particularly useful for assessing moisture stress tolerance, since the amount of water and the stage at which plants receive water can be controlled with reasonable precision. Selected lines, in the form of dryland sets, were also grown in the rainfed areas of Celaya and Zacatecas, as well as at El Batan. Selected lines will be included in the dryland trials at Cd. Obregon in the 1981-82 cycle.

Selection—CIMMYT is also exploring spring x winter combinations for drought resistance/tolerance in Cd. Obregon. These populations are planted in mid-October, when soil temperatures are relatively high. Irrigation is applied to facilitate germination and establish the nursery. Eighty-five days later (in January), the second irrigation is applied. The selection of individual plants and lines is made in March. This process has now been followed for three years and considerable progress is evident. The lines being selected should combine drought tolerance with the ability to withstand heat early in the growth cycle because of increased tillering capacity. In 1982, CIMMYT should be able to assemble a drought screening nursery for distribution to countries with drought-prone production environments.

Wheats for tropical areas

Traditionally, wheat cultivation has been confined to subtropical and subtemperate climatic areas. Recently, interest has grown in promoting wheat cultivation in the warmer tropical areas (during the coolest time of the year). While it is recognized that yields equal to those achieved in subtemperate and subtropical climatic zones cannot be attained, CIMMYT believes wheat to be a viable crop for some countries in the tropical belt. These countries/regions include Southeast Asia, Western Africa, Southern Africa, Central America, Chaco of Bolivia and the Cerrados of Brazil. The potential wheat area of these countries/regions constitutes millions of hectares, and thus merits special attention in CIMMYT's bread wheat breeding program.

Table 8. Yield response of selected lines under reduced irrigation (2 irrigations) in Cd. Obregon and rainfed conditions in El Batan

Cross and pedigree	Yield*		Days to flowering	Height
	Dryland Batan 1980	Obregon 1980-81		
TTM"S" CM30136-3Y-1Y-0M-100B-0Y	4882/(4553)	3869/(3594)	81	74
TAN"S" CM30697-2M-10Y-1M-2Y-2B-0Y	5903/(4553)	-	82	92
TAN"S" CM30697-2M-10Y-1M-2Y-2B-0Y	5368/(4553)	-	90	92
BUC"S" CM31678-R-4Y-2M-21Y-0M	4805/(4553)	3925/(3594)	83	78
ALD"S"/CALxBB-CNO CM32595-5Y-2M-1Y-1M-1Y-0M	4777/(4553)	4181/(3594)	87	87
VEE"S" CM33027-F-15M-4Y-4M-3Y-2M-1Y-0M	6021/(4553)	4038/(3594)	92	102
VEE#5 CM33077-F-15M-500Y-0M	4903/(4553)	4003/(3594)	84	88
VEE#5 CM33027-F-15M-500Y-0M-98B-0B	6083/(4553)	3866/(3594)	86	85
VEE#5 CM33027-F-15M-500Y-0M-110B-0Y	5326/(4553)	4253/(3594)	86	82
VEE#5 CM33027-F-15M-500Y-0M-115B-0Y	5694/(4553)	3819/(3594)	86	83
VEE"S" CM33027-I-2M-1Y-1M-1Y-3M-0Y	5694/(4553)	3809/(3594)	86	83
BOW"S" CM33203-H-4M-1Y-0M-81B-0Y	5028/(4553)	4256/(3859)	79	75
BOW"S" CM33203-H-4M-1Y-0M-167B-0Y	5430/(4553)	4003/(3859)	79	77
BOW"S" CM33203-H-4M-1Y-0M-190B-0Y	5097/(4553)	4188/(3859)	80	72
CHOVA CM34603-A-1M-3Y-1M-5Y-3M-0Y	5629/(4554)		83	90
NKT"S" CM40454-11M-4Y-1M-1Y-4M-1Y-0B	5861/(4553)	4741/(4200)	81	78
LIRA"S" CM43903-H-4Y-1M-1Y-3M-2Y-0B	5062/(4493)	4406/(4119)	84	89
LIRA"S" CM43903-H-4Y-1M-1Y-3M-3Y-0B	5604/(4493)	4338/(4119)	83	87
LIRA"S" CM43903-H-4Y-2M-1Y-2M-1Y-0B	4757/(4493)	4441/(4119)	82	82

*Figure in parenthesis is the yield of best check variety in the same trial.

These geographic areas can be classified into two general categories:

- Dry and warm, without any serious disease problems (eg., Nigeria and Sudan);
- Wet and warm, where leaf rust and helminthosporium diseases are prevalent (e.g., Zambia and Brazil).

A successful breeding program will require germplasm evaluation and selection for the following characters, either individually or in various combinations:

- Heat tolerance
- Profuse tillering capacity
- Resistance to leaf rust
- Resistance to *H. sativum*
- Resistance to *H. tritici-repentis*
- Resistance to scab

Not all of the disease resistances listed above would be required in the same cultivar; selections could be made with site-specific requirements in mind. To date, preliminary screening for *Helminthosporium* spp., in Mexico, Brazil, Bangladesh and Zambia has enabled identification of certain resistant varieties (Table 9).

Wheat production appears to be technically feasible in some countries of the tropical belt (during the coolest time of the year). Here, Dr. E.E. Saari (left) and Dr. S. Rajaram examine trials grown in the Bangladesh. (Photo: B. C. Curtis)

Table 9. Lines included in the 1981-82 spring crossing block with good resistance to *Helminthosporium sativum* and/or *H. tritici repentis*

Cross and pedigree	*H. sativum*	*H. tritici repentis*
KVZ-HD2009 SWM2984-1M-1Y-1M-2Y-0M-0M	X	
CRT-ALD''S'' I114055-0M-7LD-5LD-1LD-0Y	X	
CRT-ALD''S'' I114055-0M-7LD-5LD-2LD-0Y	X	
CRT-ALD''S'' I114055-0M-7LD-1LD-0Y	X	
CRT-ALD''S'' I114055-0M-19LD-25LD-1LD-0Y	X	
TOB''S''/CN067-JARxKVZ CM20707-A-1Y-8M-1Y-0Y-2PTZ-0Y	X	X
TOB''S''/CN067-JARxKVZ CM20707-A-1Y-8M-1Y-0Y-4PTZ-0Y	X	X
(TOB''S''-NP0xCC-INIA/CN0-N066)SJ''S'' CM30633-3M-3Y-1M-0Y		X
TAN''S'' CM30697-16Y-7M-1Y-0M		X
PEW''S'' CM31630-H-3Y-1M-6Y-0M		X
KAL-BBxCJ''S''/ALD''S'' CM32421-4M-1Y-2M-2Y-0M		X
BN0''S'' CM32556-3M-501Y-519M-0Y		X
HAR''S'' CM33435-P-1M-1Y-0M		X
<CEB148/(INIA/LR64(2)-SN64xCC)CC-INIA667>VID''S'' CM33683-A-4M-1Y-1M-0Y		X
TOW''S'' CM34709-B-3M-1Y-1M-1Y-0M		X
BJY''S''-GJ0''S''(LR64-SN64xTZPP-AN64/BBxTOB-CN0) CM34742-E-2M-9Y-0M		X
FURY-M073 CM36732-16Y-15M-4Y-0M		X
OLN-TRM CM36820-10Y-1M-1Y-0M		X
BON-JUP73 CM36872-27Y-3M-2Y-0M		X
BRL74.72-C0C75 CM36889-31Y-10M-0Y		X
GOV-AZ67xMUS''S'' CM41257-I-8M-3Y-0M	X	X

Table 9. (continued)

Cross and pedigree	*H. sativum*	*H. tritici repentis*
ERA-MN69.146xPVN76 CM52349-1MM-0MM	X	
BH1146		X
L2000.731		X
MN72135		X
PF69129		X
PF71131		X
PF7339		X

Durum Wheat Improvement

G. Vázquez, Head, Durum Wheat Program

Improving the yield dependability of durum wheats across a range of environments in the developing world is a major objective of CIMMYT's durum wheat program. Dr. G. Vazquez, head of the program, here compares two potentially useful plant types.

Introduction

The majority of cultivated wheat varieties belong to four main species of the genus *Triticum*. These are the hexaploid, *T. aestivum* (bread wheat), the tetraploids, *T. turgidum* var. *durum* and *T. timopheevii,* and the diploid, *T. monococcum.*

Globally, *T. aestivum* is by far the most important economically, and its numerous cultivars are adapted to a wide range of environmental conditions. Durum wheat is the second most important species, and is currently grown on about 8 million hectares scattered throughout the dryland areas of the developing world.

Durum wheat is the primary cereal grain crop grown in the countries of the Middle East and Mediterranean Basin. Even so, the consumption of durum wheat in such countries as Algeria, Italy, Tunisia and Morocco outstrips current production; these countries, together with France and Spain, accounted for nearly two-thirds of total 1981 durum wheat imports for the region.

Low yields are observed in many countries where durum wheat is of primary importance as a basic food grain. Algeria, for example, with a durum area double that of bread wheat, reports an average yield of about 540 kg/ha.

For this reason, improving the genetic yield potential of CIMMYT durums continues to be an important breeding objective. However, it should be noted that some of CIMMYT's advanced durum lines yield above 8 t/ha under optimum conditions.

Thus, other objectives designed to enhance yield dependability across a range of environments are now guiding CIMMYT's durum wheat breeding program. Data from the 11th (1979-80) and 12th (1980-81) International Durum Yield Nurseries (IDYNs) indicate significant progress regarding yield dependability; a number of CIMMYT lines had average yields of about 4.5 t/ha across *all* locations. In particular, the advanced lines Yavaros "S", Frigate "S", Cormorant "S" and Mallard "S" all demonstrated high and dependable yields. Highlighted below is the progress made in 1981 toward the durum wheat program objectives.

Yield potential

An analysis of yield data obtained from durum yield trials planted in Mexico under excellent cropping conditions in the Yaqui Valley during the season 1980-1981, shows that new semidwarf durum lines outyielded the best durum checks by 2 to 14 percent (Table 1). Results of durum yield trials planted at El Batan (site of CIMMYT Headquarters) under very good rainfall conditions in 1981 indicate that some advanced durum lines possess yield potential superior to commercial durum checks. Performance of these lines ranged from 96 to 111 percent of the best commercial checks (Table 2). Some lines developed by CIMMYT have performed very well in international tests, with yields superior to the CIMMYT checks included in the trials, as well as to the adapted local cultivars. Seventeen locations scattered around the world report in the 11th International Durum Screening Nursery (IDSN) an average yield of 4634 kg/ha for durum line Waha "S", CM-17904-B-3M-1Y-1Y. The durum line, Winged "S", CM-18577-11Y-7Y-1Y-1M-0Y-OKE, also performed well at 4569 kg/ha.

The IDSN, which includes over 200 entries of new durum lines developed by CIMMYT, is distributed each year to about one hundred locations around the world. Although the nursery is generally replicated only once at each location, the numerous locations reporting data provide a representative sampling of the performance of CIMMYT durums under diverse environmental conditions.

Table 1. Yield performance, agronomic and disease data of advanced durum lines, compared with checks, Y80-81

Var. No.	Cross and pedigree	Yield kg/ha	Rank in trial	%best check	Days to flower	Plnt Ht	Disease reaction: Yellow Rust	Leaf rust	Stem rust	Sept trit (0-9)	Fus. nivale
220	Stifftall"S" CD-16677-A-7M-1Y-3M-0Y	6776	1	102	76	95	30MS-S	TS	0	6.5	20
504	Mexl"S"-Mag"S" x Scar"S"-GdoVZ579 CD-26795-5B-2Y-1Y-0M	6805	8	102	71	85	TR	20MR	0	5.4	30
589	Sco"S"-Rabl"S" x Mexl75 CD-28164-B-2M-1Y-1Y-0M	7129	4	102	82	85	0	10MS	0	5.3	30
702	Sapl"S"-Teal"S" CD-23739-11Y-2M-1Y-1Y-0M	7698	1	102	84	100	TR	10S	0	5.3	10
80	Shwa"S"-Yav"S" CD-20626-5M-2Y-1M-0Y	7701	3	103	79	85	0	TMS	0	6.5	20
81	Shwa"S"-Yav"S" CD-20626-6M-2Y-1M-0Y	7758	2	103	78	80	0	TMS	0	6.6	20
487	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun-Cr"S")Gs"S"/}	6903	7	103	77	100	0	0	0	4.3	30
	CD-26593--3B-2Y-5Y-0M										
526	Pln"S"-Memo"S"(S15-Cr"S"/Clt"S"-AA"S" x Fg"S") CD-27313-F-1M-1Y-1Y-0M	7253	1	103	75	95	-	-	-	-	-
534	USDA.595-Dack"S" x Rok"S" CD-27402-D-2M-1Y-2Y-0M	7211	2	103	78	90	TMS	0	0	6.5	5
590	Sco"S"-Rabl"S" x Mexl75 CD-28164-B-2M-1Y-2M-0M	7173	3	103	82	80	0	10MS-S	0	5.4	40
613	Frlg"S"-Ren"S" x Ruff"S"-Gta"S"/Ren"S" CD-28376-D-2M-2Y-1Y-0M	7508	1	103	66	80	T-30MS	5MR-MS	0	5.3	20
666	Clt"S"-Mexl"S" x Shwa"S"/Mal"S" CD-25095-A-2Y-1M-1Y-1Y-0M	7347	3	103	66	95	0	TS	0	6.5	30
673	Qfn-AA"S" x Gta"S"-Pg"S"/Boy"S" CD-25241-A-3Y-1M-1Y-1Y-0M	7333	4	103	83	90	0	5MR-R	0	5.3	20
401	Gre"S"-Corm"S" x Shwa"S" CD-22237-C-2M-6Y-1M-1Y-0Y	7388	1	104	80	90	0	5S-MS	0	5.3	30
495	Alf"S"/Ptl"S"xS15-Cr"S"(.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/ CD-26662-7B-1Y-1Y-0M	6943	6	104	66	85	TR	5-30MS	0	6.4	20
587	{/(Cp-St464 x Ibls"S"/Coot"S")Oyca"S"/Sooo"S"}Rabl"S" CD-28146-D-4M-1Y-4Y-0M	7256	2	104	79	90	TMS	30MS-MR	0	5.4	20
649	Shwa"S"-Mexl75 x Yav"S" CD-24831-A-1Y-3M-1Y-2Y-0M	7323	6	104	76	95	TMS	TMR	0	5.5	20
323	P66.270-Ptl"S" x Dom"S"/Yav"S" CD-25031-A-1Y-3M-2Y-0Y	7600	3	105	78	85	0	TS	0	6.4	20
482	Shwa"S"-Yav"S" CD-26406-3B-2Y-9Y-0M	6995	5	105	79	80	-	-	-	-	-
485	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/} CD-26593-3B-1Y-2Y-0M	7038	3	105	71	85	0	0	0	4.3	40

Table 1. (continued)

Var. No.	Cross and pedigree	Yield kg/ha	Rank in trial	%best check	Days to flower	Plnt Ht	Disease reaction: Yellow Rust	Leaf rust	Stem rust	Sept trit (0-9)	Fus. nivale
490	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF3Tun/Cr"S")Gs"S"/7} CD-26593-3B-2Y-8Y-0M	7018	4	105	81	90	TR	TR	0	4.2	30
648	Shwa"S"-Mexl75 x Yav"S" CD-24831-A-1Y-3M-1Y-1Y-0M	7461	4	105	76	95	TMS	TMR	0	6.5	30
651	Shwa"S"-Mexl75-Yav"S" CD-24831-A-1Y-3M-1Y-4M-0M	7394	5	105	77	90	0	TMS	0	5.3	20
593	Boy"S"-Clt71/(Cr"S"-Gs"S"xMarte"S"/Tllo"S")Memo"S"/7 CD-28166-F-1M-1Y-3Y-0M	7400	1	106	76	85	TMS	5S	0	5.4	20
652	Shwa"S"-Mexl75 x Yav"S" CD-24831-A-1Y-3M-2Y-1Y-0M	7485	3	106	78	95	0	5S	0	5.4	30
657	Duro5-Ibis"S" x Ren"S"/Snipe"S" CD-24842-A-3Y-1M-1Y-1Y-0M	7490	2	106	78	110	0	5MS	0	5.3	5
669	(S.0179-PH158 x Gta"S"-S.0195/JNK)Yav"S" CD-25126-A-1Y-3M-1Y-1Y-0M	7587	2	106	85	85	TMS	TMS	0	6.5	10
73	Gull"S"-Snipe"S" x Gdo VZ449 CD-19711-D-1Y-3M-0Y	8017	1	108	79	90	0	0	-	-	-
304	Yavaros"S" CM-9799-126M-1M-5Y-0M-8AU	7834	2	108	76	90	0	TS	0	5.4	5
339	Yav"S"-Gedlz"S" CD-20095-2M-1Y-1M-1Y-0Y	7783	1	108	75	105	40S-MS	20MS-MR	0	6.6	30
670	(S.0179-PH159xGta"S"-S0195/JNK)Yav"S" CD-25186-A-1Y-3M-2Y-2Y-0M	7758	1	108	85	90	TMS	5MS	0	5.4	30
321	Shwa"S"-Mexl75 x Yav"S" CD-24831-B-2Y-1M-1Y-0Y	7917	1	109	76	90	0	TMR	0	5.4	5
481	Shwa"S"-Yav"S" CD-26406-3B-2Y-7Y-0M	7369	1	110	79	85	-	-	-	-	-
486	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF3Tun/Cr"S")Gs"S"/7} CD-26593-3B-2Y-1Y-0M	7344	2	110	78	95	0	0	0	4.3	40
638	(Mexl75-Chumpi 2 x Fab"S"/P66.270)Goose"S" CD-27137-1M-1Y-4M-0M	8049	1	114	75	90	TMR	TMS	0	1.1	10
26	Mexicali 75 (Check)	6229	21	-	66	90	0	5-30MS-S	0	6.4	20
27	Yavaros 79 (check)	7495	2	-	77	95	0	TMS	0	6.4	20

Yield and agronomic data taken from Y 80-81. Plnt Ht: Height (cm). Yell rust: Yellow rust.
Disease reaction represents highest reading from several locations in Mexico.
R= resistant, MR= moderately resistant, S= Susceptible, MS= Moderately susceptible, T= Trace reaction to *Septoria tritici* and Fusarium nivale given in percentage.

Data from the 8th-11th IDSN nurseries indicate an average yield increase for the top 10 durum lines of 19.7 percent (Table 3). Under high productivity conditions and/or when excellent cultural practices are used to encourage maximum genetic expression (such as in northwest Mexico), individual durum lines have yielded as much as 10,850 kg/ha. Moreover, data from the 10th IDYN report some very good average yields under dry conditions in Pakistan, Argentina and Turkey: Frigate "S" yielded 4933 kg/ha, Yavaros "S" 5244 kg/ha, and Cfn5-Fg "S" x Ptl "S" 5306 kg/ha.

Results from the 11th IDYN, which includes durum lines and varieties developed and released by national programs around the world, show some CIMMYT durum lines consistently placing among the top five positions (Table 4). Performance such as this, over 133 locations, indicates the wide adaptation of these high-yielding durum lines.

Table 2. Top five durum lines of the 13th IDYN, compared with checks, El Batan, 1981

Variety or cross	% Durum check	Ht cm	Flow days	Strp rust	Leaf rust
Rockel"S" CD-1895-12Y-0Y-2E-6B-0Y	111	85	62	TMS	0
Cinc"S" CD-4465-E-4Y-5M-0Y-0KE-1B	109	110	64	0	TMR-MS
BD1543-Inrat69 x Coot"S"/Gta"S" CD-13557-J-3Y-1M-0M	99	110	66	0	TR
Cyus"S"-Sincape9xYel"S"/Cnf5-Fg"S"xPtl"S" CM-19981-I-3Y-3M-2Y-3M-1Y-0M	96	115	67	0	TMR
DWL5023	96	80	65	TMS	TMR-MS
Cananea 79(Tcl check)	117	115	58	0	TMR
Mexicali 75 (Durum check)	100.0	85	58	0	60MS-MR
Pavon 76 (BW check)	99	100	63	0	T-10S

Reactions: R-Resistant, S=Susceptible, T=Trace, MS=Moderately Susceptible

MR=Moderately Resistant.

Ht cm = Height in centimeters

Flow days= Days to flowering

Strp rust= Stripe rust

Table 3. Mean of top ten lines for different characters of the 8-11th IDSN, Durum wheat, 1976-1979

IDSN	Yield Kg/ha	Flow Days	Mat. Days	Strp rust	Leaf rust	Stem rust	Powd %	Sept trit (0-9)	Yellow Berry (%)
8	3650	95.7	140.0	0.7	6.9	4.5	20.1	2.0	7.0
9	4137	97.2	135.5	0.4	8.8	11.9	9.1	2.9	0.0
10	4027	97.4	150.4	0.0	1.0	1.6	0.0	3.7	-
11	4369	93.4	132.7	0.0	5.8	4.0	0.5	0.9	4.3
% improv.	19.7								

Table 4. Top ranked durum lines and varieties for yield, agronomic characteristics, and disease resistance of the 11th IDYN 1979-80

Var. No.	Variety or cross and pedigree	Origen	Yield Kg/ha	Flow days	Lodg %	Strp RT.L	Leaf rust	Stem rust	Powd %	Sept trit (0-9)	Sept nod (0-9)	BYDV (0-9)	Helm (0-9)	Test Wt	1000 G.W.
1	Eider"S" CD-10535-D-1M-1Y-4M-0Y	Mexico				0									
2	Gerardo VZ394	Italy							29						
3	Gs"S"-AA"S" x Pg"S"/Fg"S"-Cit"S" CM-14587-501Y-1M-0Y-1B	Mexico				0				2.4	4.4		4.2		
4	Harlequin"S" II-18001-B-3M-7Y	Mexico					8			2.2					50
5	Shearwater"S" HRL-861-2B-0Y-2B-100Y-7M-0Y	Mexico			1		8					1.0			
6	Magh 72-Ch67 x Gad"S" CD-16819-E-6M-3Y-0M	Mexico							18						
7	Candealfen	Chile													
8	68111/Rugby x Ward	U.S.A.									4.3				
9	68112/Ward D72114	U.S.A.											4.1	78	
10	A63040/Sentry D66058-81T-1T-2T-2T-0T	U.S.A.								1.8			3.8		
11	Wakooma	Canada								1.7	4.3		4.0		
12	Cfn5-Fg"S" x Ptl"S" CM-17780-A-7M-1Y-1Y-0M	Mexico										1.0			
13	Bittern"S" CM-9799-126M-1M-5Y-0Y	Mexico													
14	Gta"S"-USA0445 D-31-1B-2Y-2B	Mexico			4							.9			
15	Ch67-Jo"S" D-25665-6M-2Y-1M-0Y	Mexico													
16	Cr"S"-Gs"S" D-28980-28Y-13M-500Y-0M	Mexico				0				2.3					
17	Avocat"S" CD-1074-1Y-3Y	Mexico					7	7							
18	Mallard"S" CD-1894-3Y-1Y-5M-2Y-0M	Mexico	4709												50
19	Rokel"S" CD-1895-12Y-1Y	Mexico		87											
20	Tc60-Cit"S" x Rabl"S" CD-4360-A-3Y-1M-1Y-0M	Mexico			7										
21	Bo"S"-Gs"S" x Coot"S"/Ruff"S"-Fg"S" CD-10454-5M-3Y-2M-2Y-1M-0Y	Mexico						4							
22	Goldfinch"S" CD-12736-1Y-6M-0Y	Mexico							22						
23	Dack"S"-Kiwi"S" CD-12499-8Y-1M-4Y-1M-0Y	Mexico													
24	BD1543-Inrat 69 x Coot"S"/Gta"S" CD-135557-J-3Y-3M-1Y-0M	Mexico				0									50
25	Gs"S"-Tag.B.B. x Pg"S"-Ralle"S" CD-14234-G-2Y-1M-1Y-0M	Mexico				0									
26	Stifftail"S" CD-16677-A-7M-9Y-QM	Mexico										.9	4.2		53
27	Swan"S" CD-16707-H-3M-3Y-0M	Mexico				0						.8			

(Table 4 continued next page)

Table 4. (continued)

Var. No.	Variety or cross and pedigree	Origen	Yield Kg/ha	Flow days	Lodg %	Strp RT.L	Leaf rust	Stem rust	Powd %	Sept trit (0-9)	Sept nod (0-9)	BYDV (0-9)	Helm (0-9)	Test wt	1000 G.W.
28	Oyca"S" x Gdo VZ394-Cit"S" CD-17717-6Y-1M-0Y	Mexico			6	0									51
29	Ruff"S"-Fg"S" CM-9880-20M-1Y-1M-1Y-1B	Mexico					8								
30	(Inrat69-gr"S"xBo"S"/Rabi"S")T.dic Vern.-Gll"S" CM-9924-2SK-0SK	Mexico													
31	Fulmer"S" CM-10200-9BK-1BK-2Y	Mexico												78	
32	Dackiye"S" CM-13919-11Y-2M-2Y-0Y	Mexico					6								
33	Oystercatcher"S" CM-14562-J-600Y-1M-2Y	Mexico			7	0									
34	Frigate"S" CM-17904-B-3M-1Y-0M	Mexico		89		0									
35	Winged"S" CM-185-11Y-6Y-2Y-0Y	Mexico				0									
36	Cfn x Lan Dwarf-F2 Lan A4590-51P-4P-2P-2P	Chile				0								78	
37	Creso	Italy			5									78	
38	Tito	Italy					7								
39	Essaip	Tunisia							14					79	
40	Algerian 88	Algeria													
41	D6811	Tunisia													
42	D6	Tunisia													
43	Guillemot"S" CM-14646-C-1Y-1M-1Y-0Y	Mexico													
44	Bittern"S" CM-9799-126M-1M-4Y-0Y-0M	Mexico	4684						29					79	
45	Cocorit 71 (Durum check)	Mexico		89											
29	Ruff"S"-Fg"S" CM-9880-20M-1Y-1M-1Y-1B	Mexico					8								
30	(Inrat69-gr"S"xBo"S"/Rabi"S")T.dic Vern.-Gll"S" CM-9924-2SK-0SK	Mexico													
31	Fulmer"S" CM-10200-9BK-1BK-2Y	Mexico												78	
32	Dackiye"S" CM-13919-11Y-2M-2Y-0Y	Mexico					6								
33	Oystercatcher"S" CM-14562-J-600Y-1M-2Y	Mexico			7	0									
34	Frigate"S" CM-17904-B-3M-1Y-0M	Mexico		89		0									
35	Winged"S" CM-185-11Y-6Y-2Y-0Y	Mexico				0									
36	Cfn x Lan Dwarf-F2 Lan A4590-51P-4P-2P-2P	Chile				0								78	
37	Creso	Italy			5									78	
38	Tito	Italy					7								
39	Essaip	Tunisia							14					79	
40	Algerian 88	Algeria													
41	D6811	Tunisia													
42	D6	Tunisia													
43	Guillemot"S" CM-14646-C-1Y-1M-1Y-0Y	Mexico													
44	Bittern"S" CM-9799-126M-1M-4Y-0Y-0M	Mexico	4684						29					79	
45	Cocorit 71 (Durum check)	Mexico		89											
46	Mexicali 75 (Durum check)	Mexico		85											
47	Pavon 76 (Bread wheat check)	Mexico	4674					3						79	
48	Nacozari 76 (Bread wheat check)	Mexico	4675	89				6							
49	Mapache (Triticale check)	Mexico	5220	87			0	0	6	2.3	2.4	.9	4.3		
50	Local check	-	4526	93	22	4	31	13	22	2.1	3.6	1.1	5.6	77	43
	Number of observations	-	133	88	42	9	14	17	24	.9	.4	.6	.7	62	60

Reaction to rusts given 25 coefficient of infection, other diseases as percent

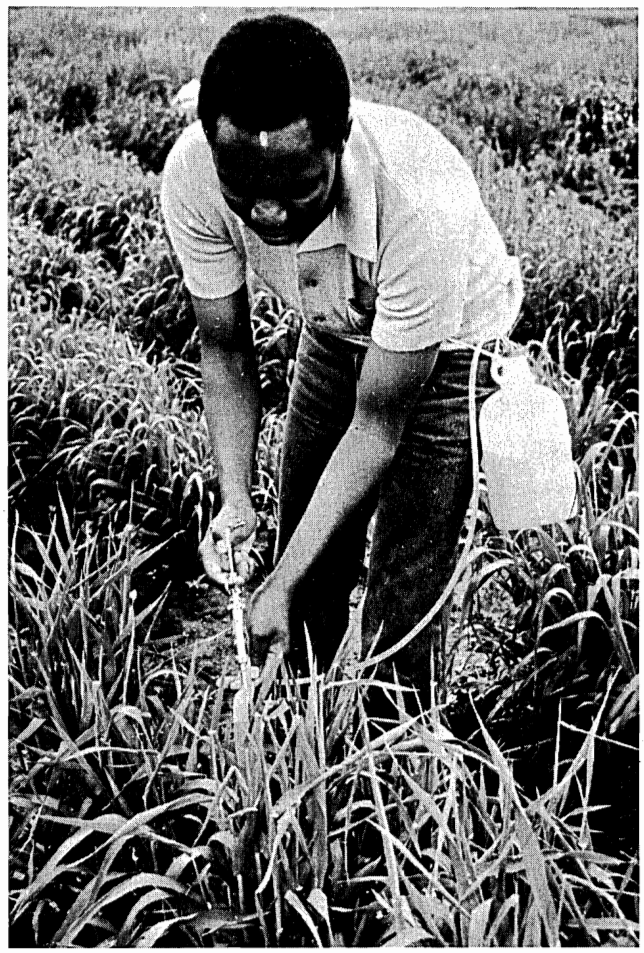
Flow days= Days to flower
Lodg% = Lodging percent
Strp. Rt.L.= Stripe rust on leaves
Powd = Powdery mildew
100 G.W.= Weight of 1000 grains given in grams

Resistance to diseases

Despite the artificial inoculations made for leaf rust (*Puccinia recondita*) at Ciudad Obregón, and for leaf rust and stem rust (*Puccinia graminis* f. sp. *tritici*) at El Batan and Toluca during the summer season of 1981, heavy and uniform disease pressure was not achieved. However, materials planted at Toluca and other locations of the high plateau of Central Mexico were heavily attacked by *Septoria tritici, Fusarium nivale, Puccinia striiformis* and, in some places, by *Puccinia recondita,* head scab (*Fusarium* spp.) and *Puccinia graminis* f. sp. *tritici.* Table 1 summarizes disease notes taken at various locations in Mexico during 1981.

Data from screening and yield nurseries distributed throughout the world indicate that better resistance to stem rust and leaf rust is needed for the principal growing areas, and that more resistance to *Septoria nodorum,* powdery mildew, *Septoria tritici, Helminthosporium* spp. and *Fusarium* spp. would be desirable for some specific durum environments (Tables 3 and 4).

A new F_2 group of stem rust-resistant crosses was assembled in 1981, including resistant materials from Ethiopia, the U.S.A. and Canada, as well as other good materials previously screened in locations noted for heavy stem rust infections. Similar F_2 nurseries will be developed for *Septoria tritici, Helminthosporium* spp. and some other important diseases in the future.



Durum materials are artificially inoculated at various stages in the crop cycle in an effort to create heavy and uniform stem and leaf rust epidemics. Despite these inoculations, however, environmental conditions at the CIANO, Toluca and El Batan stations were such that adequate stem and leaf rust epidemics were not achieved in 1981. (Photos: T. Luba-left; J. L. Castillo-right)

Tolerance to environmental extremes
Drought tolerance is being incorporated in CIMMYT durums by utilizing various durum lines from India and the U.S.S.R., as well as materials from the CIMMYT nurseries. Early durum lines, such as Cocorit 71 and Mexicali 75, are performing as well as drought resistant cultivars (e.g. Deir Allah 2), when grown under extremely dry conditions. This suggests the need to develop earlier materials for those areas receiving very low amounts of rainfall.

New durum lines are showing promise in certain dryland areas. Preliminary reports from the 10th EDYT and 12th IDYN show yields of 2721 kg/ha (with 173 mm of rain) for Gta"S"-Tc_{60} x Mexi "S" in Joydebpur, Bangladesh, and of 4877 kg/ha for Yavaros 79 grown under 437 mm of rain in Jamalpur, Bangladesh. The same data show a yield of 3974 kg/ha for the durum line Lds Mut-Teal "S" grown under 220 mm of rainfall in Alentejo, Portugal. Materials with good grain-filling characteristics, as estimated by the hectolitric weight (PH) and 1000 kernel weight (1000 KW), are being crossed with materials that yield well.

Certain agronomic characteristics (e.g., strong straw in medium-tall to tall materials and reduced foliage), as well as tolerance to cold, are being sought in the durum wheat program. A new F_2-bulk nursery is being assembled with segregating types of medium-tall to tall stature; it is expected that lines from this nursery will perform better in hilly areas and low input environments, where shallow soils, competition with weeds, and various other constraints exist.

Durum wheat macaroni quality
Developed countries generally use durum wheat to produce semolina, from which macaroni and other highly industrialized products are produced. A large amount of durum wheat, however, is consumed directly in the form of various home-made foods. Thus, new high-yielding lines must also meet a range of quality requirements and early generation and advanced lines are routinely screened for high vitreousness, hectolitric weight, 1000 grain weight, acceptable pigment and protein content, and medium to strong gluten strength.

Numerous high-yielding lines with satisfactory quality characteristics are included in the IDSN and EDYT nurseries each year. Those materials having high and stable quality are selected and used in new crosses in the Mexico-based durum breeding program. Tables 5 and 6 describe some of the quality factors of high-yielding durum lines observed in trials in 1980-81. Hectolitric weights of 80 kilograms or more and 1000 grain weights of 60-70 grams are common in the program; the majority of these lines also maintain a pigment content of 5 or better going from grain to macaroni.

The development of durums having good bread-making characteristics is currently being explored, and a series of new crosses have been observed during the 1980 and 1981 seasons. For this purpose, crosses of CIMMYT durums with materials from the U.S.A. and Canada are being made and screened at appropriate stages for the type of gluten strength required.

International nurseries
Little or no variation has occurred in the number of international durum nurseries distributed by CIMMYT during the last five years (Table 7). There has been, however, a tendency to assemble F_2 nurseries for more specifically defined durum wheat environments. In addition to the traditional F_2 dryland and F_2 irrigated nurseries, CIMMYT has been distributing other F_2 nurseries over the last three years. These nurseries include germplasm with tolerance to cold temperatures, semidwarf and medium-tall to tall crosses, and F_2 bulks incorporating resistance to stem rust. Distribution of these F_2 bulks are by request, and are generally directed to those places where the possibility of producing useful segregates is highest.

Data from international nurseries are summarized and analyzed every year, which helps identify outstanding lines for different characteristics. These lines are then used for various crossing objectives. About 1500 single crosses and about the same number of top and double crosses are made each winter and summer cycle in Mexico.

Table 5. Quality data of high yielding durum lines from yield trials: Cd. Obregon, Sonora México, 1980-81

Var. No.	Cross and pedigree	pH	1000 GW	% Yell berr	% black point	Prot %	Car Cont	Gluten color	Gluten Strength
220	Stifftail"S" CD-16677-A-7M-1Y-3M-0Y	81.4	68.7	5	5	9.5	5.2	5	F
504	Mexi"S"-Mag"S" x Scar"S"-GdoVZ579 CD-26795-5B-2Y-1Y-0M	80.5	62.2	0	T	10.6	3.4	5	F
589	Sco"S"-Rabi"S" x Mexi75 CD-28164-B-2M-1Y-1Y-0M	80.7	54.2	5	10	9.3	3.3	5	F
702	Sapi"S"-Teal"S" CD-23739-11Y-2M-1Y-1Y-0M	80.9	69.7	0	T	11.2	4.8	6	F
80	Shwa"S"-Yav"S" CD-20626-5M-2Y-1M-0Y	80.4	53.9	0	5	10.7	7.6	8	F
81	Shwa"S"-Yav"S" CD-20626-6M-2Y-1M-0Y	80.9	53.4	0	5	11.4	6.6	5	F
487	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun-Cr"S")Gs"S"/} CD-26593--3B-2Y-5Y-0M	81.8	60.6	0	T	11.1	5.2	6	F
526	Pin"S"-Memo"S"(S15-Cr"S"/Clt"S"-AA"S" x Fg"S") CD-27313-F-1M-1Y-1Y-0M	-	-	-	-	-	-	-	-
534	USDA.595-Dack"S" x Rok"S" CD-27402-D-2M-1Y-2Y-0M	75.6	53.6	0	10	10.0	1.8	2	F
590	Sco"S"-Rabi"S" x Mexi75 CD-28164-B-2M-1Y-2M-0M	80.6	54.7	0	10	9.4	3.4	4	F
613	Frig"S"-Ren"S" x Ruff"S"-Gta"S"/Ren"S" CD-28376-D-2M-2Y-1Y-0M	79.1	55.2	T	5	9.6	3.9	3	F
666	Clt"S"-Mexi"S" x Shwa"S"/Mal"S" CD-25095-A-2Y-1M-1Y-1Y-0M	80.3	63.7	0	10	10.0	4.4	6	F
673	Qfn-AA"S" x Gta"S"-Pg"S"/Boy"S" CD-25241-A-3Y-1M-1Y-1Y-0M	77.8	59.6	T	10	9.8	4.8	7	1/2F
401	Gre"S"-Corm"S" x Shwa"S" CD-22237-C-2M-6Y-1M-1Y-0Y	81.6	57.6	10	5	9.5	1.8	3	F
495	Alf"S"/Ptl"S"xS15-Cr"S"(.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/ CD-26662-7B-1Y-1Y-0M	78.9	61.7	0	20	9.9	6.2	6	F
587	{/(Cp-St464 x Ibis"S"/Coot"S")Oyca"S"/Sooo"S"}Rabi"S" CD-28146-D-4M-1Y-4Y-0M	79.7	56.5	0	T	10.5	5.2	5	F
649	Shwa"S"-Mexi75 x Yav"S" CD-24831-A-1Y-3M-1Y-2Y-0M	81.8	55.5	T	10	11.6	3.8	5	F
323	P66.270-Ptl"S" x Dom"S"/Yav"S" CD-25031-A-1Y-3M-2Y-0Y	80.7	56.5	0	5	11.2	4.5	5	F
482	Shwa"S"-Yav"S" CD-26406-3B-2Y-9Y-0M	-	-	-	-	-	-	-	-
485	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/} CD-26593-3B-1Y-2Y-0M	80.3	64.7	0	10	10.8	4.5	7	F

(Table 5 continued next page)

Table 5. (continued)

Var. No.	Cross and pedigree	pH	1000 GW	% Yell berr	% black point	Prot %	Car Cont	Gluten color	Gluten Strength
490	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/} CD-26593-3B-2Y-8Y-0M	80.8	54.8	T	T	10.5	5.6	7	F
648	Shwa"S"-Mexi75 x Yav"S" CD-24831-A-1Y-3M-1Y-1Y-0M	81.8	56.3	0	10	11.6	3.8	4	1/2F
651	Shwa"S"-Mexi75-Yav"S" CD-24831-A-1Y-3M-1Y-4M-0M	83.0	57.7	0	5	11.2	3.4	4	F
593	Boy"S"-Cit71/(Cr"S"-Gs"S"xMarte"S"/Tllo"S")Memo"S"/ CD-28166-F-1M-1Y-3Y-0M	82.1	54.8	10	T	9.1	4.8	5	F
652	Shwa"S"-Mexi75 x Yav"S" CD-24831-A-1Y-3M-2Y-1Y-0M	82.2	56.7	0	5	11.2	3.2	5	F
657	Duro5-Ibis"S" x Ren"S"/Snipe"S" CD-24842-A-3Y-1M-1Y-1Y-0M	80.0	61.2	T	10	10.7	2.6	4	F
669	(S.0179-PH158 x Gta"S"-S.0195/JNK)Yav"S" CD-25126-A-1Y-3M-1Y-1Y-0M	82.0	51.4	T	5	10.1	7.5	7	F
73	Gvil"S"-Snipe"S" x Gdo VZ449 CD-19711-D-1Y-3M-0Y	80.0	50.7	5	T	9.2	4.8	7	F
304	Yavaros"S" CM-9799-126M-1M-5Y-0M-8AU	82.7	58.0	5	5	8.7	5.4	5	F
339	Yav"S"-Gediz"S" CD-20095-2M-1Y-1M-1Y-0Y	81.3	60.9	T	20	10.6	3.6	5	S
670	(S.0179-PH159xGta"S"-S0195/JNK)Yav"S" CD-25186-A-1Y-3M-2Y-2Y-0M	81.9	51.6	T	10	9.6	8.1	6	F
321	Shwa"S"-Mexi75 x Yav"S" CD-24831-B-2Y-1M-1Y-0Y	81.6	68.1	10	5	9.2	4.5	5	F
481	Shwa"S"-Yav"S" CD-26406-3B-2Y-7Y-0M	-	-	-	-	-	-	-	-
486	Ful"S"{Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/} CD-26593-3B-2Y-1Y-0M	82.2	62.1	0	T	10.9	5.2	6	F
638	(Mexi75-Chumpi 2 x Fab"S"/P66.270)Goose"S" CD-27137-1M-1Y-4M-0M	80.4	50.2	0	10	10.1	4.5	7	F
26	Mexicali 75 (Check)	77.6	62.2	0	10	9.4	5.7	6	F
27	Yavaros 79 (check)	82.7	58.0	5	5	8.7	5.4	5	F

P.H: Hectolitric weight in kilograms. 1000 KW: 1000 grain weight in grams. %Yell Berr: Yellow berry percentage.
Prot %: Protein percentage
Car cont: Carotene content in parts per 1000. Gluten color: scale 1-10, ten the best. Gluten strength: F=strong, 1/2F=medium strong

Table 6. Durum wheat lines having good performance and good quality Y80-81

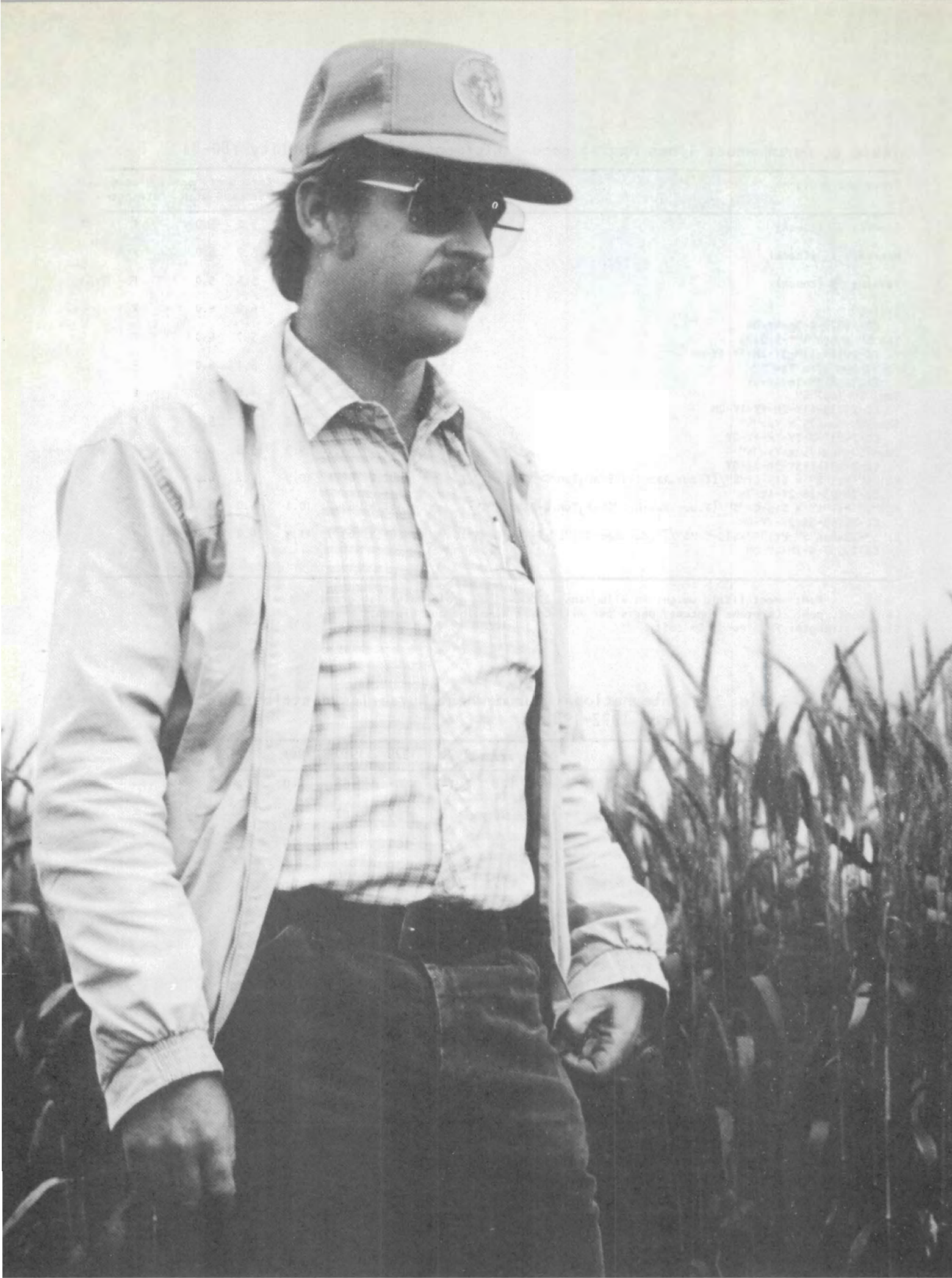
Cross and pedigree	PH	1000 KW	Prot %	Car. Cont. ppm Semol	Car. Cont. ppm Gluten	Gluten strength
Cocorit 71 (Check)	78.4	53.0	9.0	3.2	5.0	F
Mexicali 75 (Check)	77.6	62.2	9.4	5.7	6.0	F
Yavaros 79 (check)	82.7	58.0	8.7	5.4	5.0	F
Stil"S" CD-16677-A-3M-4Y-OM	82.0	64.3	9.5	6.0	6.0	F
Yav"S" x Gta"S"2-S.0179 CD-20124-11M-3Y-2M-1Y-1Y-OM	82.7	68.1	10.4	5.7	6.0	F
Fg"S"-Dom"S" x Yav"S" CD23598-2Y-1M-1Y-OY	81.3	64.0	9.8	5.1	6.0	F
Sapi"S"-Teal"S" CD-23739-11Y-2M-1Y-1Y-OM	80.9	69.7	11.2	4.8	6.0	F
Shwa"S"-Mexi75 x Yav"S" CD-24831-B-2Y-1M-1Y-OY	81.6	68.1	9.2	4.5	5.0	F
Shwa"S"-Mexi75 x Yav"S" CD-24831-E-3Y-3M-1Y-OY	81.8	64.1	9.3	5.8	6.0	F
Ful"S"{Ptl"S" x S15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/} CD-26593-3B-2Y-1Y-OM	82.2	62.1	10.9	5.2	6.0	F
Ful"S"{Ptl"S" x S15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/} CD-26593-3B-2Y-7Y-OM	81.4	63.7	10.1	6.0	6.0	F
Br"S"-ZBxRen"S" Ptl"S"xS15-Cr"S"/(T.dur.Ram-Gll"S"xF_3Tun/Cr"S")Gs"S"/ Cd-27537-G-2M-1Y-OM	81.7	63.7	11.9	4.2	5.0	F

P.H: Hectolitric weight in kilograms: 1000KW=1000 grain weight in grams.
Car. Cont. ppm: Carotene content, parts per million in semoline and gluten.
Gluten strength: F= strong, S= soft

Table 7 . International Durum Wheat Nurseries distributed from 1977-1981

	1977	1978	1979	1980	1981
EDYT	28	14	-	68	40
IDYN	77	76	96	82	70
IDSN	98	79	101	94	70
CB	28	29	42	36	30
PC	-	-	10	10	15
F_2 Dryland	46	50	52	50	40
F_2 Irrigated	50	49	45	36	35
F_2 Cold Tolerant	16	55	46	47	40
F_2 Semi-Tall-to Tall	-	-	10	-	10
F_2 Resistant to Stem Tall	-	-	-	-	5
TOTALS	343	352	402	423	355

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



Triticale Improvement

B. Skovmand, Head, Triticale Program

Introduction
The primary objectives of the triticale program have changed little over the past few years; efforts continue toward improving yield potential and wide adaptation, toward maintaining and improving resistance to various diseases, toward improved testweights and better endosperm development, and toward improved industrial (milling and baking) quality. The introduction of new germplasm to broaden the genetic base was maintained at 1980 levels for primary hexaploid triticales, but was intensified for the octoploid triticales. In attempting to widen further the adaptation of triticales, a special effort is being made to develop lines with approximately the same maturity as the early wheat variety "Sonalika."

Yield potential and wide adaptation
Increasing the yield potential and adaptation of triticales remain two of the most important objectives of the breeding program. To guide the crossing efforts, results from yield and screening tests conducted in Mexico are combined with data obtained from the International Triticale Yield Nursery (ITYN) and International Triticale Screening Nursery (ITSN). During the 1980-81 crop cycle in Ciudad Obregon, Sonora (Northwest Mexico), about 700 advanced triticale lines underwent replicated yield testing; 172 of these lines were selected for the 13th ITSN, based upon their yield performance, test weight and endosperm development, disease resistance and agronomic type. The 13th ITSN was then distributed to 125 locations around the world.

The 13th ITYN (1981-82) was expanded to 50 entries, rather than the usual 25 that comprised the entries in the first 12 ITYNs. This expansion was merited due to the increase in the number of triticale varieties being released around the world over the last few years. Prior to the 13th ITYN, almost all entries in this nursery were advanced lines from CIMMYT's breeding program. The 13th ITYN includes CIMMYT's advanced lines, as well as officially released varieties and advanced lines being considered for release in certain countries. Many of these newly released (or about-to-be released) triticale varieties have been introduced through CIMMYT's international nurseries; in-country testing led to identification of advanced materials having potential under local growing conditions, and reselection among these materials by national program cooperators produced the lines chosen for release as varieties.

Table 1 gives yields and test weights of the ten highest yielding lines in the 12th ITYN (based on results from 35 locations). The line "Juanillo 97" yielded about 5 percent higher than the check (Beagle) and also had a somewhat better test weight, as did some of the other newer lines.

Table 2 shows the actual yield and yield as a percentage of the best check, Cananea, of the top 22 lines from the 12th ITSN (based on results from 30 locations). Some of the newer triticales are out-yielding the best check by as much as 14 percent; ten lines from four crosses are out-yielding the sisters of Juanillo (the top yielder in the 12th ITYN) by 1 to 6 percent.

The triticale Mapache (Cananea 79) was included as a check in the 14th, 15th and 16th International Spring Wheat Yield Nurseries. Table 3 compares the ranking in each of these nurseries of Mapache and Nacozari 76, a widely adapted spring wheat. Mapache performs as well as Nacozari 76 and, as can be seen in Tables 1 and 2, there are a number of triticales that out-yield Mapache. Thus, it seems safe to state that the newer triticales now have very close to the same adaptation to diverse environments as the more widely adapted bread wheats.

Results from yield and disease screening trials conducted in Mexico, in combination with data obtained from CIMMYT's international testing network, help guide the crossing activities of the triticale improvement program. Here Dr. B. Skovmand, head of the program, looks over disease-screening plots near Patzcuaro, Mexico, an area conducive to natural epidemics of *Septoria* and *Fusarium* species. (Photo: T. Harris)

Table 1. The highest yielding lines from the 12th International Triticale Yield Nursery (ITYN), giving average yield and test weight over 35 locations

Rank	Entry number	Variety or strain	Average yield Kg/ha	Test weight Kg/hl
1	17	Juanillo 97	4179	68
2	2	Beagle	3914	65
3	16	Ram	3871	63
4	9	M_2A	3859	67
5	25	Local check	3840	71
6	18	Muskox"s"	3763	69
7	7	Coorong	3710	63
8	3	Caborca 79	3707	66
9	1	Cananea 79 (Mapache)	3702	64
10	14	PFT 7717	3644	67

Table 2. The highest yielding lines* from the 12th International Triticale Screening Nursery (ITSN), averaged over 30 locations and in percent of Cananea 79

12th ITSN entry number	Cross and pedigree	Yield Kg/ha	Yield % of Cananea 79
30	Tejon-Bgl"S" (3 sisters) X-16134-35Y-1Y-1M-1Y-2B-0Y	4882	114
285	(Cml-Pato x Kiss DWF/Bgl) Bgl BB-823	4817	112
269	Drira x Kiss - Arm"S" (2 sisters) X-21295	4744	111
169	W 74.103-Addax/Bgl"S"-M_2A x Ira (4 sisters) X-33470-C-1Y-3M-2Y-2M-0Y	4680	109
46	Juanillo 207	4627	108

Table 2. (continued)

12th ITSN entry number	Cross and pedigree	Yield Kg/ha	Yield % of Cananea 79
45	Juanillo 100	4626	108
122	Bcm"S"-IA X-31186-6Y-4M-1Y-2M-0Y	4601	107
44	Juanillo 90	4595	107
34	IA-M_2A x Pi62/Bgl X-T6304-500B-501Y-506B-0Y	4588	107
63	Bvr"S"-Abn"S" X-24560-9Y-3M-1Y-0M	4452	104
281	Ira-Drira (2 sisters)	4438	104
280	M_2A-Ktz 12 x Bgl B-175	4424	103
24	Topo 1418	4397	103
106	M_4-Fs 1795 x Bgl"S" (2 sisters) X-29755-B-1M-2Y-5M-2Y-1M-0Y	4394	103
74	Bgl"S"-Addax X-27407-1H-1Y-1M-1Y-1M-0Y	4390	102
116	Navojoa-Lince X-31100-5Y-1M-2Y-0M	4380	102
250	Beagle	4375	102
15	Delfin 205	4347	101
264	(IA/Tcl E_3 Arm"S" x 1229-100B)NV"S"-Fs 1045 X-38330-A-5M-1Y-4M-0Y	4328	101
60	Fs 1795 - Lince X-24369-4H-1Y-1M-1Y-0M	4319	101
28	Topo 1419	4309	101
101	Cananea 79 (Mapache)	4286	100

* Best 10% are reported and only highest sister included, number of sisters given in parenthesis

In attempting to increase the yield potential of triticales it became important to shorten their stature, as was done with bread wheats. Several years of selection pressure for plant height are now showing results, as can be seen in Table 4, which gives yield, yield as a percentage of best check, test weight, and plant height for selected lines in two elite triticale yield trials (ETYTs) planted at four test sites in Mexico. The first experiment (ETYT 1) includes only substituted triticales, those with one or more rye chromosomes substituted by D-genome wheat chromosomes; ETYT 1 demonstrates that some of the newer lines possess better yields, better test weights, and are up to 13 cm shorter than the check Cananea. The second experiment (ETYT 2) primarily included complete triticales, those with all seven rye chromosomes, which are generally taller than substituted triticales; ETYT 2 shows the same trend, i.e., that there are complete triticales which are better yielding and up to 14 cm shorter than the check Juanillo.

Test weights and endosperm development

Significant progress in test weights and endosperm development has been made and further improvements are expected. The objective is one of raising triticale test weights to an equivalency with the market requirement for wheat (76 kg/hl), and some of CIMMYT's lines have already reached this level. In fact, under ideal growing conditions at Ciudad Obregon, Sonora (northwest Mexico), a few advanced triticales have produced 80 kg/hl test weights. The best bread wheats range from 82 to 85 kg/hl.

Table 5 lists some of the triticale lines with the highest average test weights from the 12th ITSN (based on information from 6 locations). These data show that there are now triticales with almost the same test weight as the bread wheat Pavon 76, and that some lines have better test weights than the bread wheat Nacozari 76. However, at two of the test sites Nacozari 76 was heavily attacked by disease, which of course lowered its test weight.

Table 3. Performance of Mapache *(triticale) and Nacozari 76 (bread wheat) in the 14th, 15th, and 16th ISWYN (1977-78, 1978-79, and 1979-80)

	14th ISWYN 69 locations		15th ISWYN 74 locations		16th ISWYN 66 locations	
	Mapache	Nacozari76	Mapache	Nacozari76	Mapache	Nacozari76
Average Rank over all Locations						
No. of appearances in top 10 places	39	27	36	30	28	28
No. of appearances from 11th to 20th place	9	22	14	19	14	17
No. of appearances from 21st to 30th place	14	11	11	17	12	9
No. of appearances from 31st to 40th place	6	5	8	7	8	8
No. of appearances from 41st to 50th place	1	4	5	1	4	4

* Also known as Cananea 79

Table 4. A summary of results of selected triticale lines tested at four locations in Mexico: Cd. Obregon, Toluca, El Batan, and Huamantla

Strain identify	Average yield Kg/ha	Yield % of best check	Test weight Kg/hl	Height in cm
ETYT I				
Cananea 79 (check)	5685	100	64.2	110
Ptr"S"-MA 106 X-39860-2Y-7M-1Y-0Y	6175	109	69.4	99
Ptr"S" x Cin-FS 658 X-39597-4Y-2M-1Y-2M-0H	6085	107	70.2	97
Vaca"S" X-36437-7M-2Y-3M-0Y	6076	107	66.8	105
ETYT II				
Juanillo 159 (check)	6467	100	66.7	139
IRA-Drira 32 B-507	6998	108	67.4	129
IRA-Bgl x Drira-Kang B-2658	6782	105	70.7	125
IRA-Drira 37 B-507	6426	99	68.3	125

Significant advances in endosperm development and test weights have been achieved. On the left is seed of Armadillo "S," the first improved CIMMYT triticale (test weight: 56.4 kg/hl at Toluca station); on the right is seed of Dingo "S," one of CIMMYT's new lines (test weight: 73 kg/hl at Toluca). (Photos: L. Terpan)

Table 5. Lines from the 12th ITSN with highest average test weight over 6 locations as a percent of Pavon 76 (bread wheat check)

12th ITSN entry number	Cross and pedigree	Test weight Kg/hl	Pavon 76 %	Yield kg/ha
226	Pavon 76 (bread wheat check)	76.8	100	3357
219	Panther"S"-M_1A X-36471-22M-2Y-2M-0Y	74.3	97	3748
222	Panda"S"-RM X-36517-5H-1Y-1M-0Y	73.1	95	3555
172	Bcm x Ira-Cal X-34485-A-1M-1Y-1M-0Y	72.7	95	4219
273	IA-Kla x Cal-Bgl B-199	72.7	95	4019
86	M_2A-M_1A X-27947-24M-1Y-1M-1Y-1M-0Y	72.7	95	3751
198	Panda"R"-Mastiff"S" X-35783-17H-2Y-1M-0Y	72.6	95	3713
177	Nacozari 76 (bread wheat check)	72.3	94	3438
224	Panda"S"-RM X-36517-176H-1Y-2M-0Y	72.3	94	3807
199	Panda"S"-Bcm"S" X-35784-423H-1Y-2M-0Y	72.3	94	3729
278	IA-Kla x Cal-Bgl B-199	72.3	94	3713
60	Fs 1795-Lince X-24369-4H-1Y-1M-1Y-0M	72.1	94	4319
2	Caborca 79 (triticale check)	68.0	89	4039
1	Cananea 79 (triticale check)	64.9	85	3608
27	Beagle (triticale check)	64.3	84	4227

For a number of years it has been easy to obtain fairly high triticale test weights under the best growing conditions. It is much more difficult to get good test weights at locations with poorer growing conditions. Therefore, more attention is now being given to selection for good test weight at less than ideal locations in Mexico, such as the Toluca and El Batan stations. Table 6 gives the test weights of the best yielding lines from the 13th ITSN grown at three highland sites in Mexico. These lines yielded more than 30 percent higher than the checks, and they also had up to 13 percent higher test weights.

Broadening the genetic base

To introduce new germplasm into the triticale program, more than 1000 crosses were made in 1981 between ryes and hexaploid wheats, ryes and tetraploid wheats, between various triticales and hexaploid wheats, between triticales and ryes and between triticales and tetraploid wheats (see Table 7).

Greater emphasis is currently being placed on hexaploid wheat x rye crosses. These crosses produce octoploid triticales, which were previously used mainly in the improvement of the hexaploid triticales. It now appears, however, that primary octoploid triticales may have some desirable characteristics, such as dwarfness, improved seed type and earliness, as compared to the primary hexaploids. At present, however, none of the octoploid triticales can compare with the improved hexaploids with regard to these traits. Extensive crosses are being made between octoploids to explore the potential of these materials.

Just as octoploid triticales have played a major role in the improvement of hexaploid types, improved hexaploids are being used to improve octoploids. CIMMYT is crossing octoploid x hexaploid germplasm and then top-crossing again with octoploids to determine whether such characters as yield and adaptation can be transferred from the improved hexaploid triticales to the octoploids.

Earliness

In general, triticales are later maturing than bread wheats. Since there are a number of locations where triticales could be grown with advantage if not for their relatively long growth cycles, the triticale program is now giving special attention to selection for earliness. Some advanced lines have a maturity very close to that of the early wheat variety Sonalika. These are, however, preliminary results from only one location and they need to be confirmed over a range of environments. Several of these promising lines will be in yield tests in the next two crop cycles in Mexico.

Ryes that mature earlier are also being selected for use in producing primary triticales. The program now has populations of rye that are three weeks earlier than ryes in general. These populations are being used in crosses to both tetraploid and hexaploid wheats, and the results of these crosses will be included in subsequent reports.

Disease resistance

Most wheat and rye diseases also occur on triticale. In comparison to wheat, triticale continues to display superior resistance to the more common wheat diseases, such as the rusts (*Puccinia* spp.), smuts (*Ustilago* and *Urocystis* spp.), bunts (*Tilletia* and *Neovossia* spp.) and powdery mildew (*Erysiphe graminis*). However, it has a greater susceptibility to some of the less common diseases of wheat, such as those caused by *Helminthosporium sativum* (spot blotch) and *Fusarium* species (head scab) (see the 1980 CIMMYT Annual Report on Wheat Improvement).

While the levels of resistance in triticale to many disease-causing organisms are adequate at present, this may be due as much to the limited extent of commercial production (compared to wheat) as it is a function of the crop's inherently high resistance. As larger areas are devoted to production, particularly in locations characterized by a high incidence of disease, there will likely be a corresponding increase in selection pressure for pathogens with specific virulence on triticale.

Quality

In 1981, CIMMYT's Industrial Quality Laboratory evaluated the seed of 681 triticale lines and varieties from the crossing block, the 13th ITSN, the 13th ITYN and some miscellaneous groups. The material was ground in a Bühler mill and the flour was tested for protein content, falling number, mixing characteristics and baking and cookie quality.

Table 6. Yield and test weight averaged from Toluca, El Batan, and Huamantla of certain lines from the 13th International Triticale Screening Nursery (ITSN) that had both high yield and high test weight in comparison to the standard check varieties

Yield Rank	13th ITSN entry no.	Cross and pedigree	Yield Kg/ha	Yield % of Caborca 79	Test wt Kg/hl	Test wt % of Caborca 79
1	49	W.74.103-Adx/Bgl"S"-M_2AxIRA X-33470-C-1Y-3M-2Y-2M-0Y	5462	137	69.6	109
2	158	IRA-Bgl x Juanillo B-2671	5426	136	70.8	111
3	157	Bgl deriv.(Cin-Pi62xPato/Bgl) B-2824	5353	135	67.1	105
4	154	IRA-Bgl x Juanillo B-2659	5325	134	69.7	109
5	165	Cin-Cno x Bgl/Merino"S" B-2700	5282	133	72.5	113
6	167	Cin-Cno x Bgl/Merino"S" B-2700	5252	132	71.3	112
7	55	Castor"S" x IRA-Cal X-34727-1M-1Y-1M-1Y-1Y-0H	5243	132	66.9	105
8	149	IRA-Bgl x Drira-Kang B-2658	5234	132	70.9	111
9	148	Juanillo-M_1A B-2637	5215	131	68.7	108
10	136	Welsh x Kal-Bb X-46937-5B-1Y-7B-0Y	5151	130	64.6	101
11	139	Lt338.75-Gpr X-51544-120C-0B	5142	129	67.0	105
12	130	IRA^2 x M_2A-CML/IA-Trr X-41312-H-1Y-1M-1Y-0Y	5132	129	67.3	105
13	153	IRA-Bgl x Juanillo B-2659	5096	128	70.1	110
	3	Caborca 79 (check)	3962	100	63.9	100
	1	Cananea 79 (check)	3815	96	61.2	96
	2	Beagle (check)	3459	87	61.6	96

Crossing block quality— The test weights of the crossing block materials have improved, with some lines reaching 77.2 kg/hl. This reflects improvements in grain quality. There were very few lines with a test weight lower than 70 kg/hl and none lower than 65 kg/hl. Flour extraction rates have also improved, with values up to 74.1 percent and none lower than 60 percent.

13th ITSN quality— The 172 lines from the 13th International Triticale Screening Nursery had an average test weight of 73.8 kg/hl; only 7 lines were lower than 70 kg/hl. The flour extraction rates averaged 65.5 percent and 57 percent of the lines had a loaf volume greater than 600 cc, while 32 lines exceeded 700 cc.

No notable changes were observed in the other materials tested regarding such quality traits as protein content, sedimentation and loaf volume.

Table 7. Introduction of new germplasm -- number and kind of interspecific crosses made in Cd. Obregon 1980-81 and El Batan 1981 cycles

Interspecific cross			Number of crosses made
Durum wheat	x	Rye	49
Bread wheat	x	Rye	133
Triticale	x	Bread wheat	528
Triticale	x	Rye	266
Triticale	x	Durum wheat	50

BEST AVAILABLE COPY

Barley Improvement

E. Rodríguez, Head, Barley Program

Introduction

CIMMYT's barley breeding program operated during 1981 according to much the same basic objectives as laid down when the program was initiated. These encompass the development of improved germplasm with high yield potential, wide adaptation, high nutritional qualitiy, lodging resistance and hull-less grain. CIMMYT shares a barley-improvement mandate with the International Center for Agricultural Research in the Dry Areas, (ICARDA), a sister CGIAR institute. ICARDA currently focuses its barley research on the semiarid regions of the Middle East, and close coordination and collaboration exists between the two centers. As indicated in the 1980 CIMMYT Annual Report on Wheat Improvement, however, our efforts toward raising the level of disease resistance have been sharply increased, and now constitute the primary objective of CIMMYT's barley program.

New breeding approaches

To achieve these objectives, and to improve the usefulness of the germplasm developed for certain areas, two new breeding approaches were adopted in 1981: first, a more intensive use of spring x winter crosses, and second, the establishment of a shuttle breeding method similar to the Brazil/CIMMYT aluminum toxicity shuttle breeding program that has been operating in the bread wheat program for several years. The first approach has been designed and implemented almost exclusively to meet the needs of Mediterranean and North African countries; the second approach was adopted primarily for countries in the Andean region.

Spring x winter crosses have been distributed as F_2 bulks since 1976. The F_2 bulks specifically bred for the Andean region have also been distributed for several years, but 1981 was the first year during which a shuttle breeding strategy was used to produce germplasm with such characteristics as resistance to stripe rust (*Puccinia striiformis*), barley yellow dwarf virus (BYDV), scald (*Rhynchosporium secalis*) and leaf rust (*P. hordei*).

Yield potential

During the 1980-81 winter cycle at Ciudad Obregon, Sonora (northwest Mexico), a total of 350 advanced lines were tested in replicated yield trials. To avoid bias in the yield comparisons, the trials were divided into hulled, hulless, normal and early types. Tables 1 to 4 show the yields of some selected lines and their corresponding checks.

Disease resistance

During the summer cycle of 1981 at El Batan, artificial epidemics were created for both leaf rust (*Puccinia hordei*) and scald (*Rhynchosporium secalis*). Using suspensions of urediospores of *P. hordei* and conidial suspensions of *R. secalis*, the breeding nurseries were artificially inoculated. The two diseases developed uniformly and it was possible to make selections of materials resistant to one and, in many instances, to both diseases.

Over the last two years, a considerable number of lines have been placed into the disease resistance crossing block. At the present time, a total of 372 entries have been assembled, and they are being heavily used in crosses. The resistance crossing block contains, in addition to lines resistant to *P. hordei* and *R. secalis*, lines with resistance to such diseases as *P. striiformis, Helminthosporium sativum* and BYDV.

Some of the entries in the resistance crossing block have maintained their resistance at several locations in Mexico. Table 5 lists some of the lines that have proven to be resistant to *P. hordei* at 4 locations.

The CIMMYT barley program is attempting to increase the disease resistance of its advanced lines. Here, Dr. E. Rodriguez, head of the program, examines some early maturing material for the effects of leaf rust (*Puccinia hordei*).

Table 1. Comparative yields of normal hulless barley lines from trials grown at Cd. Obregon, Sonora, Mexico in 1980-81 cycle

Entry No.	Variety or cross and pedigree	Yield kg/ha	Percent of best check	Days to maturity
161	Ore"S" x Emir-Nackta, Ast9071 CMB76A-427-1Y-1Y-1B-1Y-1B-0Y	5356	110	130
157	Sibiri"S" CMB76A-383-1H-1Y-1B-1Y-1B-0Y	5296	108	130
158	(Por-EB1053 x CM67/M64.76)BDGC-Gas CMB76A-387-1Y-1Y-1B-1Y-2B-0Y	5179	106	130
176	Ore"S"-Mz1 x Huiz-CI08985 CMB76A-1145-A-6B-3Y-1B-3Y-2B-0Y	5095	104	126
173	Apm-RL x Api-CM67/Ore"S" CMB76A-970-C-5B-1Y-1B-1Y-1B-0Y	5039	103	116
197	CM67-GvaxApi-EB489.8.2.15.4/Cal.MrxDs-Apro(Pro-Tol IxCer^2-Tol I/5106)7 CMB77-1267-B-1Y-1B-1Y-1B-1Y-0B	5264	108	127
181	11012.2-CM67 x Por-U.Sask.1800/Apm-HC1905 CMB76-265-30Y-1B-1Y-1B-3Y-0B	5216	107	125
186	Bco.Mr-MzqxP71318-M66.85/BDGC-Gas CMB77-149-8Y-1B-1Y-3B-1Y-0B	5135	106	120
248	BDGC-Gas(Apm-IB65 x 11012.2/Api-CM67 x Ds-Apro) CMB77-538-3Y-3B-2Y-1B-2Y-0B	5349	109	120
	Api-CM67xOre (Best check)	4886	100	126

Table 2. Comparative yields of Normal, Hulled Barley lines from trials grown at Cd. Obregon, Sonora, Mexico in 1980-81 cycle

Entry No.	Variety or cross and pedigree	Yield Kg/ha	Percent of best check	Days to maturity
8	CI3909.2 x M66.151-Manker(Apm-IB65/Api-CM67 x Ds-Apro) CMB76A-384-6M-1Y-1B-1Y-2B-0Y	5941	112	120
28	10876.1 x Avt-LocalD8/D171-Strain 205 CMB76A-1015-H-5B-1Y-1B-1Y-1B-0Y	5757	109	124
54	DL69-Bahtim 10 x H251 CMB76-765-A-1M-2Y-1B-1Y-1B-0Y	6100	115	108
35	Nopal(Api-CM67 x Apm-IB65/Api-CM67 x I1266 L2966.69 CMB77-136-10Y-1B-1Y-2B-2Y-0B	5883	111	108
37	/Nopal(Mor-BuRF9 x Pro-Tol I/Api)/CI12125/Api-CM67 x Mzq CMB76A-1173-B-2B-1Y-2B-2Y-1B-0Y	5855	110	110
47	(70.22101 x Olli-M64.69/Gas)M69.69-Hja C4715 x Cllo CMB76A-1315-A-1B-1Y-1B-1Y-1B-0Y	5806	110	110
55	(Beacon/CM67-U.Sask1800 x Pro-CM67) Centinela CMB77-241-5Y-1B-1Y-1B-1Y-0B	5635	106	112
87	Min480-Gvn x11012-Tern CMB77-192-17Y-1B-1Y-1B-2Y-0B	6614	135	121
98	NP842-ApmxCM67-U.Sask 1800/Avt-11012.2 CMB77-449-3Y-2B-2Y-1B-2Y-0B	5646	107	111
103	Bal 16-11012.2 x Celaya-CI3909.2 CMB77-465-5Y-1B-2Y-1B-1Y-0B	5682	107	128
144	Api-CM67x11012.2%SMAI.35.6W/(CM67-AproxSY02109-Mari)Ensenada/ CMB77-1585-E-2Y-1B-1Y-1B-2Y-0B	5534	104	115
128	Pyo-UMN Barley Ras309 CMB77-1140-3Y-1B-1Y-1B-1Y-0B	5168	97	116
	Ensenada (check)	5282	100	124

In addition to the El Batan station, a second screening site (Huamantla) located in the high plateau of Mexico was used. Even though no artificial epidemics were created, the natural infections of both *P. hordei* and *R. secalis* were high enough to permit the selection of resistant materials in segregating populations.

For diseases not present in Mexico, we continuously depend upon the help of national and regional programs in order to evaluate CIMMYT barley germplasm. It is hoped that this assistance will grow as more cooperating national programs place a greater emphasis on the improvement of barley.

Table 3. Comparative yields of Early Hulled lines from trials grown at Cd. Obregon, Sonora in 1980-81 cycle

Entry No.	Variety or cross and pedigree	Yield Kg/ha	Percent of best check	Days to maturity
289	M64.69-M65.211 x Apm-RL/Api CMB76-579-5Y-1B-1Y-1B-5Y-0B	4219	113	94
307	Mona-Gateway/63 x B1 CMB77-302-7Y-1B-1Y-2B-1Y-0B	4355	117	90
314	Mona x Mzq-DL71 CMB77-383-3Y-1B-2Y-1B-3Y-0B	4157	111	88
319	Manker x Apm-RL/Musard"S" CMB77-564-1Y-1B-2Y-1B-1Y-0B	4142	111	92
	Mona (Early Hulled check)	3732	100	95

Table 4. Comparative yields of Early Hulless lines from trials grown at Cd. Obregon, Sonora in 1980-81 cycle

Entry No.	Variety or cross and pedigree	Yield kg/ha	Percent of best check	Days to maturity
379	Mari-Coho x Sultan-Nacta CMB76-613-12Y-3B-1Y-1B-2Y-0B	3100	98	94
405	Apm-RL x Bco.Mr-Gva CMB75-38-16Y-1M-1Y-2B-1Y-0B	3814	120	88
	Mona (Early Hulled check)	3168	100	95

Table 5. Lines from the 1981 resistance crossing block showing resistance to *Puccinia hordei* at four locations in Mexico in 1981

Entry No.	Variety or cross and pedigree	Reaction at location			
		Roque	Toluca	Patzcuaro	Refugio
4	Emir-Shabet x CM67/F8 HB.854.23-121x148.221 CMB78.440-500Y-500B-501Y	10R	0	0	10MR
5	Pro-Beacon CMB72A-11-1L-1B-0Y	TMR	5MR	0	10R
6	Egypt 20	TrR	0	0	TrR
9	WI 2231	0	10MR	0	0
11	USDA 11122	0	5MR-MS	0	0
46	Por x C58.1-4407.19/Bra CMB74A-108-3B-1Y-1B-1Y-0B	0	5MS.S	0	0
47	Tunis	TrR	0	TMS	TrR
48	Giza 119	TrMR	0	0	TrMR
49	Deir Ala 105	0	0	0	0
50	Saida	0	5MR-MS	TrS	0
51	Nadja	0	0	0	0
52	Trinf	0	0	TMS	5MR
53	CI 4977 x Line 58	5MR	TrR	0	0
54	Bigo	0	10MR-MS	10MS	0
55	Mari-Aths CYB-4-2A-3A-1A-0A	0	10MR-MS	0	0
58	Nopal x Api-CM67 x Mzq CMB76-288-16Y-1B-1T-1B-2Y-0B	TrR	10MR	0	TrR
74	CM67-U.Sask 1800 x Pro-CM67 CMB72A-160-I-1B-7Y-500B-0Y	TrR	1-MR	10MS	TrR
77	Peru	10MR	0	0	10MR

CIMMYT
WHEAT
PROGRAM

Pathology

S. Fuentes, Head, Pathology Program
E. Torres, Pathologist
G. Bekele, Pathologist

Introduction

The effects of plant disease constitute a dynamic biological process. These effects follow discernable patterns and change from place to place. Assessing these effects becomes difficult as land mass (geography), climate, and vegetation change from one continental region to another. Disease effects accumulate as the amount of inoculum increases due to the contiguous or non-rotational nature of modern agriculture. The situation is further complicated as areas are reclaimed for agriculture and/or new crops are introduced.

To confront the complicated nature of worldwide disease problems CIMMYT has employed methods designed to develop a wide germplasm base with diverse genetic pools containing wheats resistant to specific diseases and to combinations of diseases. Although the approach is to develop a wide germplasm base resistant to a large number of pathogens of economic importance, priority is given to the cereal rusts because they are a global problem. In the past, CIMMYT, in conjunction with the Government of the Royal Netherlands, has conducted a number of workshops to teach various methodologies used for creating artificial rust disease epidemics. The workshops were held in the national research program centers of many countries: Chile, Kenya, Turkey, Tunisia, Syria, Bangladesh, Portugal, Pakistan, India and Nepal. In addition to host country scientists, large numbers of the workshop participants came from surrounding countries. These workshops have provided many scientists with knowledge of rust spore collecting equipment and methods to facilitate a disease management program. The training included an effort to standardize field disease recording procedures, thereby enabling participating scientists to increase their collaborative research with CIMMYT toward a common goal.

Other foliar wheat diseases, such as septoria leaf and glume blotch, powdery mildew, helminthosporium leaf and glume blotches, scab, and some viruses are also important. However, these diseases are more location and climatic specific than the rusts. Even so, the process of searching for and developing resistant plants is the same as that employed against the rusts.

To fully exploit potential collaborative disease research opportunities, CIMMYT pathologists and breeders send out large numbers of advanced lines of wheat, barley and triticale to cooperators around the world. Disease data are sent back by cooperators and analyses are made to determine which lines have the lowest disease severity worldwide. Reports that specify the best performing lines are sent to collaborators for use in their breeding programs. Meanwhile, breeders at CIMMYT make further crosses between lines with the best disease performance and lines possessing desirable agronomic and quality characteristics.

This constant flow of germplasm and performance data between CIMMYT and its collaborators is the fastest and most effective means of dealing with the biologically dynamic nature of diseases, which cause yield and quality reductions everywhere.

The rusts

Leaf, stem and stripe rust are cereal diseases of high economic importance on a global scale. In 1980-81, the 13th International Bread Wheat Screening Nursery (IBWSN) generated reports from 40, 23 and 21 locations for leaf, stem and stripe rust, respectively. There are numerous resistant cultivars among CIMMYT's materials with infection coefficients as low as 0.3 for stem and stripe rust, and 0.9 for leaf rust. Information about these cultivars is available upon request. Eleven cultivars with low average coefficients of infection for all three rusts are presented in Table 1.

Each year the CIMMYT pathology program screens the wheat, triticale and barley crossing blocks for resistance to numerous diseases, including the smuts and bunts. Here, Dr. S. Fuentes, head of the pathology group, explains the effects of loose smut on wheat to a group of visitors to the Toluca, Mexico, experiment station. (Photo: T. Harris)

Table 1. Spring wheat cultivars from the 13th IBWSN with coefficient of infection not greater than 2.6 for stem rust, 2.4 for leaf rust, and 2.0 for stripe rust in 40, 23, and 21 locations, respectively

Variety No.	Name and Pedigree	Highly tolerant to other diseases
194	Veery"S" CM-33027-1-2M-1Y-1M-3Y-1M-1Y-0M	
195	KVZ/Tob-CFN x BB) Bolillo"S" CM-33028-1-1M-3Y-1M-1Y-1M-1Y-0M	b
203	Bobwhite"S" CM-33203-G-5M-6Y-3M-1Y-1M-1Y-0M	
210	Bobwhite"S" CM-33203-K-9M-2Y-1M-1Y-2M-0Y	ac
212	Bobwhite"S" CM-33203-K-9M-9Y-4M-1Y-1M-1Y-0M	ac
215	Bobwhite"S" CM-33203-K-9M-9Y-4M-4Y-1M-1Y-0M	c
221	Bobwhite"S" CM-33203-K-9M-14Y-4M-1Y-2M-0Y	bc
225	Bobwhite"S" CM-33203-K-9M-19Y-3M-3Y-0M	abc
227	Bobwhite"S" CM-33203-K-9M-19Y-3M-3Y-2M-1Y-0M	ab
233	Bobwhite"S" CM-33203-K-9M-24Y-1M-1Y-1M-2Y-0M	c
237	Bobwhite"S" CM-33203-K-10M-7Y-3M-1Y-2M-0Y	ab

a- Indicates tolerance to *Septoria tritici* in various locations

b- Indicates tolerance to *S. nodorum* in various locations

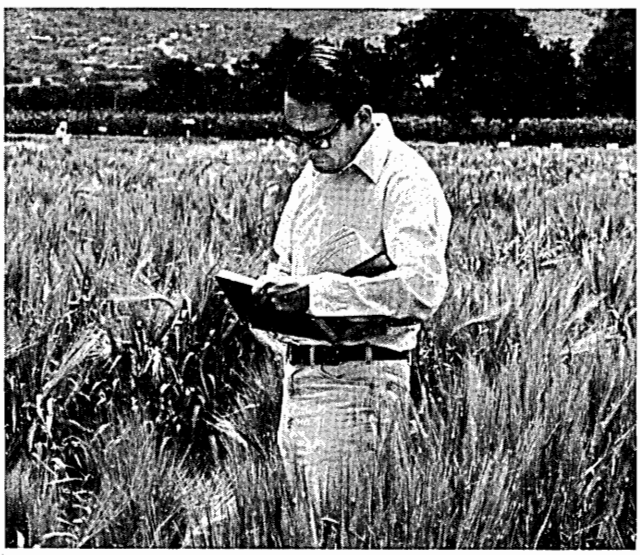
c- Indicates tolerance to powdery mildew in various locations

Many of the rust "hot spots" that were used to screen the IBWSN material in 1981 are located in South America and East Africa. Reports from cooperators in North America, Eastern and Western Europe and the Indian Subcontinent indicate moderate to low incidences of the three rusts. The low levels of rust in the North American countries can probably be attributed to the fact that the materials grown there have been intensively bred and screened for resistance (using crosses of spring and winter material from around the world). The long term resistance achieved, especially against stem rust, is important to note. Low rust levels are possibly due to a low turnover of new rust races, which results in less severe and more infrequent epidemics in North America.

Virulence survey of leaf rust

In breeding crops for resistance to the rust fungi, some knowledge of the genetic composition of local rust populations is necessary. Relevant descriptors are the virulence genes that occur in a given local rust population.

Pathologists of INIA and CIMMYT-Mexico coordinate a national system of rust nurseries. These nurseries consist of isogenic lines, selected CIMMYT advanced lines that have maintained resistance to the rust fungi over the last five years, and a selection of widely grown Mexican commercial varieties. During 1981, these nurseries were planted throughout Mexico at: Ciudad Obregon, Sonora; Los Mochis, Sinaloa; Rio Bravo, Tamaulipas; Toluca and El Batan, Mexico; and El Refugio, Guanajuato. Leaf rust occurred abundantly in these nurseries during 1981.



In 1981, CIMMYT's advanced barley materials were effectively screened for scald (*Rynchosporium secalis*). Dr. E. Torres here evaluates disease severity in the late stages of development.

Infection data for the monogenic lines (Table 2) confirm previously observed differences in the range of virulence among populations of the leaf rust fungus across Mexico. Data from Ciudad Obregon describe mainly the inoculum used to induce leaf rust epidemics on segregating populations. The rather narrow range of virulence observed there suggests the need to enrich the bulk inoculum with local isolates that carry virulence genes for resistance genes Lr 3-ka, -21, -22, -23, and -30. Populations from El Refugio possess the widest range of virulence. Thus, El Refugio continues to be a very good site for testing materials for leaf rust resistance.

Rust fungicide evaluations

CIMMYT continues to evaluate modern fungicides for the control of leaf rust. The 1981 test on fungicide efficacy included seven new treatments, as well as Bayleton, which is regarded as the standard chemical for use against wheat rusts. Rust infection was assessed at heading. Bayleton (at 800 g/ha) conferred the best protection to experimental varieties Inia 66 and Yecora 70. Bayleton was followed in effectiveness by Tilt (at 1300 and 800 ml/ha). The highest intensity of infection corresponded to Plantvax EC, Plantvax WP and BAS-421-00F (Table 3). Average yield (calculated from four replicated plots of four 4.50 meter rows) ranged from 4310 kg/ha (Inia 66 sprayed with Vigil at 150 ml/ha) to 5088 kg/ha (Yecora 70 sprayed with Tilt at 800 ml/ha). Data are given in Table 3. All fungicides except Vigil resulted in yields slightly higher than with Bayleton. However, differences in yield were not statistically significant.

Septoria tritici and S. nodorum

Septoria tritici is present in areas with a relatively wet, cool climate. Epidemics are fairly easy to create artificially under field conditions. In 1981, *Septoria tritici* cultures were grown at CIMMYT in large volume on a specific culture medium in the laboratory. Spore suspensions in distilled water were applied with ultra-low volume sprayers on various nurseries of segregating and advanced bread wheats, durum wheats and triticales at Toluca, Mexico. A heavy disease epidemic ensued and it was easy to discard a large amount of susceptible material, both in the segregating and highly advanced lines.

Table 2. Virulence patterns of leaf rust populations from six locations in Mexico during 1980-81, identified by the ability to overcome each of 21 leaf rust resistance genes (Lr-) + = Susceptible interaction
- = Resistant interaction

Resistance Source		Locations					
Lr-gene	Source Cultivar or species	Ciudad Obregon	Los Mochis	Río Bravo	Toluca	El Batan	El Refugio
1	Centenario	+	+	+	-	+	+
2a	Webster	+	+	+	-	+	+
2b	Carina	+	+	+	+	+	+
2c	Loros	+	+	+	+	+	+
3	Democrat	+	+	+	+	+	+
3ka	Aniversario	-	-	+	-	+	+
9	Transfer	-	-	-	-	-	-
10	Exchange	+	+	+	+	+	+
11	El Gaucho	+	+	+	-	+	+
13	Manitou	+	+	+	+	+	+
14a	Selkirk	+	+	+	+	+	+
14b	Maria Escobar	+	+	+	+	+	+
16	Exchange	+	+	+	+	+	+
17	Lucero	+	-	+	+	+	+
19	Agatha	-	-	-	-	-	-
20	Thew	-	-	-	-	-	-
21	*Aegilops squarrosa* v. *meyeri*	-	+	+	-	+	+
22	*Ae. squarrosa* v. *strangulata*	+	-	-	-	+	+
23	Lee	-	-	+	+	+	+
24	Agent	-	-	+	-	-	-
30	Terenzio	-	-	-	-	+	+

Table 3. Average coefficient of leaf rust infection and average yield (kg/ha) obtained on Inia 66 and Yecora 70 in a fungicide test during the 1980-81 wheat season in Ciudad Obregón (means of 4 replications)

Treatment		Average coefficient of infection		Average yields		
Fungicide	dose/ha	Inia 66	Yecora 70	Overall	Inia 66	Yecora 70
Tilt	800 ml	35.0	10.0	4805	4523	5088
BAS-421-00F	1000 ml	62.5	22.5	4757	4523	4991
Tilt	1300 ml	32.5	6.3	4697	4370	5023
Plantvax EC	2000 ml	72.5	30.0	4678	4380	4977
Plantvax WP	1000 g	45.5	17.5	4678	4444	4912
Bayleton	800 g	17.5	7.5	4634	4435	4833
Vigil	250 ml	32.5	11.3	4591	4528	4653
Vigil	150 ml	47.5	10.0	4516	4310	4722
Varietal means		43.2	14.4		4439	4900

The 1981 wheat and triticale crossing blocks were inoculated by Dr. G. Bekele with water suspensions of *Fusarium graminearum;* glassine envelopes were used to enhance mycelial development of the fungus. (Photo: J.L. Castillo)

Septoria nodorum is the causal agent of glume blotch, and is sometimes confused with *S. tritici*. In Table 1, some CIMMYT materials from the 13th IBSWN showing less than 4.0 (on the 0-9 scale) for *S. nodorum* and *S. tritici* are listed. The 11th ISEPTON was also summarized both for resistance to *S. nodorum* and *S. tritici*. Results are given in Tables 4 and 5. As in previous years, Brazilian lines are among the list of most resistant materials: IAS.20, IAS.58, Maringá, PAT. 7253, and the cross Pelotas 72380-Arthur 71 have proven useful as sources of resistance in single crosses (e.g. Maringá-Aldan, cross 46961; Maringá-Valdivia, cross CM46962; IAS.20-H567.71, cross CMH 76.480) or in backcrosses with high yielding germplasm (entries 128, 137, 138 and 142). The winter wheat line Kavkaz (as well as Aurora, a sister line) is another good source of resistance to both septorias, especially in combinations with Cigueña, or with the advanced lines Bobwhite, Chat and Musala.

The Patzcuaro site in the State of Michoacan, Mexico, continues to be a good location for preliminary screening of basic nurseries and advanced materials from CIMMYT's small grains breeding programs. Although severe epidemics of *S. tritici* have been experienced there year after year, the virulence of the fungus seems confined to hexaploid wheats; durums and triticales are highly

resistant, showing few spots with scarce pycnidia formation in the lower leaves of the plant. This potential bias is corrected by the screening and shuttle breeding performed by CIMMYT's collaborators in areas of the world where *S. tritici* is severe on bread wheats, durums and triticales (the Middle East, Ethiopia, and southern Brazil).

Powdery mildew

Severe powdery mildew epidemics occurred in 13 countries of Eastern and Western Europe and the Middle East in 1980-81. In this case, the presence of powdery mildew at the early crop stages highly restricted infection by or development of rusts or any other pathogens. Personal communication with many scientists visiting CIMMYT revealed that powdery mildew appearing early in the season sharply reduces the leaf area available to infection by other pathogens. There is resistance in the CIMMYT germplasm, however; some of the lines listed in Table 1 showed less than a 1.5 coefficient of infection for this disease.

Helminthosporium leaf spot diseases

These diseases are often severe in the hot, humid low-lands of the world. The major wheat pathogens under such conditions are *Helminthosporium sativum,* the causal agent of spot blotch and *Helminthosporium tritici repentis,* the cause of tan spot. In 1980-81 an infection rating of 2.5 to 3.0 (0-9 scale) for *H. sativum* was reported from 8 locations around the world. As the production of wheat increases in the warmer environments, the incidence and severity of spot blotch is expected to rise. Consequently, CIMMYT is increasing its breeding efforts for resistance.

Scab

Also known as ear rot of wheat, scab is caused by *Fusarium* spp. and is one of the major diseases in those parts of the world characterized by a cool, rainy and/or humid climate. The disease is of high incidence where maize (or rice) and wheat are interchangably cultivated. The fungus occurs in southern China and in Korea, and is very prevalent in the high plains of such South American countries as Brazil, Paraguay and Argentina. It also occurs in the Pacific Northwest of the United States.

In the Mexican highlands at Toluca in the State of Mexico and at Patzcuaro in the State of Michoacan, and to a lesser degree at El Batan, scab is observed naturally on wheat, even though the major commercially cultivated crop in these areas is maize. When the wheat grown at these locations is artificially inoculated, adequate screening for scab resistance is nearly assured.

In 1981, CIMMYT selected the El Batan and Toluca sites for intensified scab screening efforts. An inoculation technique frequently used under Brazilian conditions was adopted, with some modifications. The modified technique involves using a No. 10 hypodermic needle to place a tiny drop of water suspension of fusarium spores under the glumes of two oppositely located spikelets at the mid-section of a spike. Drops are placed after gently opening the glumes to prevent tissue injury from the sharp needle. The inoculation is done once flowering is complete. Then the disease development up and down the spike from the site of injection is visually observed and rated according to scale.

In 1981, crossing block materials consisting of 303 bread wheats, 318 durum wheats and 209 triticales were planted at Toluca and El Batan. Four spikes in each line were inoculated using water suspensions of *Fusarium gramineum.* Two of the spikes in each line were covered with pollinating glassine envelopes to conserve humidity and ensure mycelial development of the fungus. The other two spikes were left uncovered. Covering the inoculated spikes with glassine envelopes helped a great deal in assessing the disease during disease note-taking. At both locations, covered spikes showed the highest incidence of infection. Covering the spikes had two advantages at El Batan: 1) it seems the envelope helped conserve moisture and thus mycelial development was enhanced, and 2) spikes covered with glassine were protected from rain and wind blown dust, thereby permitting easy detection of the fungus mycelia. At Toluca, spikes were well protected from frequent and heavy rains and dew. Thus, disease development could be evaluated with speed and certainty during note-taking.

A scale to assess scab development was designed that consisted of three stages or degrees of expression: 1) fusarium spores failed to develop or they merely produced mycelia and ceased to spread from the point of inoculation, 2) the fungus produced mycelia at the point of inoculation and spread up and/or down the spike, and 3) spikes and peduncles were killed from toxin probably produced by the fungus.

Table 4. Bread wheat genotypes in the XI-ISEPTON most resistant to *Septoria tritici* in 8 locations*. Maximum average infection=5.0 (0-9 scale)

Entry number	Variety or cross and pedigree		Average rating of infection
20	IAS-20		3.5
120**	PAT-7253		3.8
121	Maringa-Aldan"S"	CM46961-13M-1Y-2M-001Y-9Ptz-0Y	4.0
127	Maringa-Valdivia"S"	CM46962-3M01Y-1M-002Y-1Ptz-0Y	4.0
137	IAS.20^2-H567.71 x Pel 72380-Arthur 71	CMH77.197-7Y-5B-1Y-5Ptz-0Y	4.0
4**	Bobwhite "S"	CM33203-K-8M-1Y-0M-0Ptz	4.2
122**	Maringa-Aldan"S"	CM46961-13M-1Y-2M-001Y-3Ptz-0Y	4.2
123**	Maringa-Aldan"S"	CM46961-13M-1Y-2M-001Y-4Ptz-0Y	4.2
31	Chat"S"	CM33090-T-1M-4Y-0M-51B-0Y-2Ptz-0Y	4.4
87	Carifen x Kal-Bb/Nacozari 76	CM41182-K-9M-1Y-2M-1Y-1M-0Y-0Ptz	4.4
134	IAS 20-H567.71	CMH76.480-13Y-5B-1Y-1Ptz-0Y	4.4
119	Maringa-Aldan"S"	CM46961-12M-3Y-1M-001Y-3Ptz-0Y	4.6
33	Junco"S"	CM33483-C-7M-1Y-0M-15B-0Y-1Ptz-0Y	4.6
34	Junco"S"	CM33483-C-7M-1Y-0M-15B-0Y-2Ptz-0Y	4.6
77	Kvz-GV x Tito"S"	CM30817-C-10Y-2M-1Y-0M-1Ptz-0Y	4.6
138	IAS.20^2-H567.71 x IAS.58	CMH77.213-2Y-1B-1Y-2Ptz-0Y	4.6
141	IAS.20-H567.71	CMH76.480-13Y-5B-0Y-2B-0Y-3Ptz-0Y	4.6
142	H570.71-IAS.20^2 x Pelotas 72380-Arthur 71	CMH76A.977-1B-10Y-6B-0Y-2Ptz-0Y	4.6
44	Trifon"S"	F4-5Y-0M-2Y-0Y-1Ptz-0Y	4.8
94	Golden Valley-Azteca 67 x Musala"S"	CM41257-I-8M-2Y-1M-2Y-4M-0Y-Ptz	4.8

(Table 4 continued next page)

Table 4. (continued)

Entry number	Variety or cross and pedigree		Average rating of infection
128	IAS.58-IAS.55 x Aldan"S"-Maringa	B19789-C-502M-501Y-503M-002Y-2Ptz-0Y	4.8
2**	Alondra"S"	CM1683-A-1Y-1M-3Y-11M-0Y-0PTZ	5.0
18	Bobwhite"S"	CM33203-K-12M-14Y-3M-0Y-1Ptz-0Y-0Ptz	5.0
59**	Kvz-Cgñ	SE1006-9S-4S-0S-1Ptz-0Y	5.0
78	Kvz-GV x Tito"S"	CM30817-C-10Y-2M-1Y-0M-2Ptz-0Y	5.0
89**	Golden Valley-Azteca 67 x Musala"S"	CM41257-I-8M-1Y-1M-2Y-2M-0Y-0Ptz	5.0
90	Golden Valley-Azteca 67 x Musala"S"	CM41257-I-8M-1Y-1M-3Y-3M-0Y-1Ptz-0Y	5.0
104	(Bb-Kal(Tp x Cno-No66/Bb-Cno))Kal-Bb x Mildress	CM38796-E-3Y-500M-500Y-500M-500Y-500B-0Y-1Ptz-0Y	5.0

*Locations rated:

1. Mexico. Patzcuaro, Michoacan State.
2. USA. Davis, California
3. USA. Corvallis, Oregon. Hyslop Farm.
4. Italy, Rieti.
5. Poland, Cracow.
6. Poland, Blonie.
7. Tanzania. Iringa Region.
8. Ethiopia, Shoa

**Genotypes resistant also to *Septoria nodorum*.

Table 5. Spring wheat entries from the XI-ISEPTON highly resistant to *Septoria nodorum* in 6 locations*. Maximum average infection rating = 3.5 (0-9 scale)

Entry number	Variety or cross and pedigree		Average rating of infection
29	Chat"S"	CM33090-T-1M-4Y-0M-25B-0Y-2Ptz-0Y	2.2
27	Chat"S"	CM33090-T-1M-4Y-0M-7B-0Y-1Ptz-0Y	2.7
32	Chat"S"	CM33090-T-1M-4Y-0M-176B-0Y-1Ptz-0Y	2.8
61	Kvz-Cgn	SE1006-9S-3S-4S-0S-1Ptz-0Y	2.8
97	Tob"S"/Cno-Jar x Kvz	CM20707-A-1Y-8M-1Y-0Y-0Ptz	2.8
123	Maringa-Aldan"S"	CM46961-13M-1Y-2M-001Y-4Ptz-0Y	2.8
4	Bobwhite"S"	CM33203-K-8M-1Y-0M-0Ptz	3.0
28	Chat"S"	CM33090-T-1M-4Y-0M-7B-0Y-3Ptz-0Y	3.1
57	Kvz-Cgñ	SE1006-9S-1S-7S-0S-1Ptz-0Y	3.1
124	Maringa-Aldan"S"	CM46961-13M-1Y-7M-003Y-1Ptz-0Y	3.1
8	Bobwhite"S"	CM33203-K-9M-24Y-0M-0Ptz	3.2
59	Kvz-Cgñ	SE1006-9S-1S-4S-0S-1Ptz-0Y	3.2
89	Golden Valley-Azteca 67 x Musala"S"	CM41257-I-8M-1Y-1M-2Y-2M-0Y-0Ptz	3.2
120	PAT.7253		3.2
122	Maringa-Aldan"S"	CM46961-13M-1Y-2M-001Y-3Ptz-0Y	3.2
2	Alondra"S"	CM11683-A-1Y-1M-3Y-11M-0Y-0Ptz	3.3
53	MN72131		3.3
58	Kvz-Cgñ	SE1006-9S-1S-7S-0S-2Ptz-0Y	3.3
83	Ti71-Tob66 x Alondra"S"	CM33217-Q-4M-1Y-0M-133B-0Y-1Ptz-0Y	3.3
23	Buck Buck"S"	CM31678-R-4Y-2M-21Y-0M-3Ptz-0Y	3.5
116	Maringa-Aldan"S"	CM46961-1M-9Y-2M-001Y-2Ptz-0Y	3.5

*Locations rated:

1. USA. Bozeman, Montana
2. Canada. Charlottetown, PEI.
3. Ireland. UCD, Lyons.
4. Poland. Blonie, Rabzikow.
5. Sweden. Svalof, AB.
6. Kenya. Rift Valley, Eldoret, LSFTC.

The third disease expression was much more frequent under El Batan weather conditions in all crops; the same was observed in triticales at Toluca. Thus, El Batan was found to be a less desirable site than Toluca, but tests conducted there definitely helped to identify resistant materials.

At the end of the 1981 cycle, 58 bread wheats and 27 triticales had been identified as highly tolerant or resistant to scab. These lines were then sent to two locations each in China and Brazil for further testing and verification of resistance under local conditions.

Loose smut

Wheat, triticale and barley lines in crossing blocks and screening nurseries are screened each year for resistance to loose smut. Since 1976, inoculation has been done using Moore's partial vacuum method. Generally, durum wheats and triticales are much more resistant than bread wheats and barleys. In the latter two crops, resistant lines are retained for subsequent testing. Table 6 lists 25 bread wheat lines that have shown resistance to loose smut in three or more testings. Seed from these lines is available upon request in limited supply.

Table 6. Bread wheat lines resistant to loose smut in two or more tests carried out by CIMMYT in Mexico, and suggested sources of seed

Variety or cross and pedigree	Seed source: CB bread wheat Y79-80 Entry No.	Seed source: 13th IBWSN Entry No.
Au-UP301 SWM 485-500Y-0D-501Y-2B-500Y-501M-500Y-500M 500Y-0M		1
Wq-RM x Kal-Bb SWM 1445-8Y-2M-500Y-502M-500Y-502M-500Y-0M	514	6
(NdD-WW x Lee-Fn/N)Ti71 Resel SWM 4589-7Y-2M-0Y		26
Car 422-Ana 75 SWM 4610-2Y-20M-1Y-0M	140	30
Chr-S 948.A1 x Chr^5 CMH 73.489-2Y-0B	209	
Pato(R)-Cal/7C x Bb-Cno CM 5746-G-3Y-6M-2Y-5M-0Y	298	
Mon"S" CM 8288-A-3M-6Y-5M-8Y-0M	17	
Chiroca"S" CM8963-A-1M-1Y-1M-5Y-6M-0Y	160	
Cno"S"-PjxOn-II 60.147/Bb-G11 CM 31026-Q-1Y-1M-4Y-1M-0Y	332	
Kal-Bb x Cj71"S"/Hork"S" CM 32418-1M-1Y-6M-1Y-0M		149

Table 6. (continued)

Variety or cross and pedigree	Seed source: CB bread wheat Y79-80 Entry No.	Seed source: 13th IBWSN Entry No.
Bnq"S" CM 32556-3M-1Y-3M-1Y-1B-1Y-0M	61	61
Mad"S" CM 32586-79M-1Y-2M-0Y	465	167
Bow"S" CM 33203-K-9M-24Y-1M-1Y-1M-2Y-0M	80	233
Mai"S"-Pj x Emu"S" CM 33254-T-1M-1Y-6M-500Y-0M	336	249
Vul"S" CM 36064-A-1M-1Y-0M	40	
C22-Trm73 CM 36834-25Y-1M-8Y-1M-0Y	510	354
Mon"S"-Cndr"S" CM 36925-3Y-3M-4Y-0M	319	
Yd"S" x Kal-Bb/Hork"S"-Mo CM 38558-A-7Y-9M-1Y-0M	338	
Chiroca"S"-Hork"S" CM 39812-8M-5Y-0M	114	414
Sap"S"-Mon"S" CM 40392-17M-1Y-2M-0Y	117	430
HD 1220-Kal^3 x Nac CM 40454-11M-4Y-2M-3Y-0M	122	436
Yd"S"-Bjy"S" CM 40456-12Y-1M-1Y-0M	124	445
Pato-On x Maya 74/Bb-Ron x Maya 74 CM 40739-30M-1Y-1M-0Y	500	467
Him-Coc x Nac CM 41195-J-7M-1Y-0M	340	
Golden Valley-AZ67 x Mus"S" CM 41257-I-8M-3Y-0M		478

Germplasm Development

R. Rodríguez, Head, Germplasm Development

Introduction
Efforts to improve bread wheat, durum wheat, triticale and, to a lesser extent, barley and rye germplasm continued throughout 1981. In cooperation with CIMMYT's wheat wide cross program, some interspecific and intergeneric crosses were also made. Some of the germplasm development projects were modified in 1981 based on results obtained in 1980. This report will discuss these activities and results of the more important aspects of the program.

Bread wheat
Protein content—In 1981, the number of crosses made for improvements in protein content was reduced by nearly half as compared to previous years. This was done because the high protein content materials yield significantly less than the commercial varieties in common use today. Although the high protein lines possess early maturity and good agronomic type in general, their low yields make them commercially non-competitive since there is no special price for high protein wheats. However, the potential of these lines has not been completely explored, and it is still necessary to determine their possible value by means of yield trials and protein content analyses.

Table 1 provides a comparison of two high yielding lines, Pavon "S" (Var. 25) and a line derived from the cross CMH75A.66 (Var. 11). This latter line produced 436 kg/ha of protein with a yield of 4355 kg/ha, while Pavon "S" produced 370 kg/ha of protein from a total yield of 5581 kg/ha. Ciano 67 produced only 296 kg/ha of protein with a total yield of 3409 kg/ha.

Materials with higher numbers of spikelets per spike (s/S) and grains per spikelet (G/s) tend to produce fewer tillers and have poor grain-filling ability. Ing. R. Rodriguez is working to break this inverse relationship, and here explains to a visitor the various components of yield. (Photo: J. L. Castillo)

Extensive yield testing and protein analyses are now being carried out to determine which lines have both high protein content and higher grain yields. The number of these tests has increased as more lines with uniform agronomic characteristics have been obtained. Results to date indicate some potential for lines derived from the cross CMH75A.66, in combination with various high grain yielding lines. The focus of this work, however, has changed since the inception of the project, for we are now more interested in the potential commercial payoff of the high protein materials than in further increases in protein content, *per se*.

Aluminum tolerance—At the beginning of this project, the objective was to improve some of the agronomic characteristics of aluminum tolerant Brazilian wheats so as to facilitate the addition of this tolerance to the high-yielding wheats being developed by CIMMYT. The goal has been to improve wheat production in areas where there are toxic levels of aluminum in the soil.

Extensive backcrossing has resulted in aluminum tolerant lines with improved agronomic characteristics. Short-straw types were developed rather quickly and have been tested in Brazil over the last four years (see CIMMYT Report on Wheat Improvement, 1980). Significant progress has also been made toward increasing the number of spikelets/spike (s/S) and the number of grains/spikelet (G/s). However, of greater interest to the CIMMYT program is the resistance carried by some Brazilian wheats to various disease-causing organisms, such as *Fusarium* spp., *Septoria* spp. and *Helminthosporium* spp. We now have materials being tested by phytopathologists to determine the extent to which expected resistances are being recovered in backcross progeny.

Rust resistance—Lines developed from such rust resistant wheats as Chris, Bonza 55, Andes 56, Selkirk and Era are being crossed with high-yielding wheats in an effort to incorporate the rust resistance of these varieties to wheats with higher productive capacity. At the same time, these resistant lines are being used in crosses designed to pyramid

TABLE 1. Performance of 23 high protein content lines, observed in a yield trial grown at CIANO (Cd. Obregón), Sonora, Mexico, 1980-81

Rank by Yield	Var. No.	Variety or cross and pedigree		Yield (kg/ha)	Protein in Flour (percent)	Protein in Flour (kg/ha)	Days to flowering	Height (cm)	Leaf rust
1	25	Pavon"S"		5581	10.2	370	73	90	30MS
2	11	Fnd-Con67[2] x Ron#2-Fnd	CMH75A.66-8B-1Y-4B-1Y-0B	4355	15.1	436	76	75	TMR
3	10	Fnd-Cno67[2] x Ron#2-Fnd	CMH75A.66-8B-1Y-4B-1Y-5B-1Y-0B	4237	14.9	403	76	75	TMR
4	9	Fnd-Cno67[2] x Ron#2-Fnd	CMH75A.66-8B-1Y-4B-1Y-1B-1Y-1B-0Y	4215	15.1	427	76	80	TMR
5	7	Ron#2-Fnd x SX	CMH77.3-4Y-3B-1Y-0B	4194	12.8	351	75	85	TMR
6	8	Ron#2-Fnd x CHM74A.630	CMH76.33-1Y-1B-1Y-1B-1Y-1B-0Y	4183	11.1	309	78	85	TMR
7	2	Fnd-Cno67[2] x Ron#2-Fnd	CMH75A.66-8B-1Y-4B-1Y-5B-3Y-0B	4108	14.2	376	76	75	TMR
8	1	Fnd-Cno67[2] x Ron#2-Fnd	CMH75A.66-8B-1Y-4B-1Y-1B-1Y-0B	4022	14.9	427	76	75	TMR
9	3	Fnd-Maya"S"[2]	CMH73A.634-4B-1Y-1B-1Y-4B-1Y-1B-0Y	3946	12.9	338	70	85	TR-MR
10	5	Ron#2-Fnd x Za.75	CMH76.28-3Y-1B-2Y-5B-1Y-2B-0Y	3806	11.9	289	78	70	TMR
11	16	Fnd-Cno67[2] x Ron#2-Fnd	CMH75A.66-8B-1Y-1B-0Y	3806	14.2	378	76	85	TR
12	6	Ron#2-Fnd x Za.75	CMH76.28-3Y-1B-2Y-1B-1Y-0B	3763	12.5	296	78	75	TMR-MS
13	4	Ron#2-Fnd x Za.75	CMH76.28-3Y-1B-2Y-4B-3Y-2B-0Y	3731			78	65	TMR
14	15	Ron#2-Fnd x PaBo/Ron#2-Fnd	CMH77.134-9Y-1B-0Y	3527	13.7	316	73	70	TMR
15	21	CMH76.173	CMH76.173-7Y-4B-3Y-1B-0Y	3495	13.9	291	66	75	TMR
16	13	Ron#2-Fnd[3]	CMH77A.16-4B-1Y-3B-0Y	3462	12.9	276	78	75	TR-MR
17	24	Ciano 67		3409	12.2	296	70	80	20MS-S
18	22	CMH76.173	CMH76.173-4Y-3B-6Y-7B-0Y	3366	14.2	295	66	70	TR-MR
19	20	CMH76.173	CMH76.173-4Y-3B-6Y-5B-0Y	3344	14.1	282	66	65	5R-MR
20	19	CMH76.173	CMH76.173-4Y-1B-2Y-1B-1Y-0B	3258			66	80	5MR
21	12	Ron#2-Fnd[3]	CMH76.35-1Y-1B-1Y-1B-1Y-0B	3108			70	75	TMR-MS
22	18	CMH76.217	CMH76.217-3Y-1B-2Y-1B-0Y	3043			73	75	TMR
23	17	CMH76.217	CMH76.217-3Y-1B-1Y-1B-1Y-0B	2892			70	75	10MR-MS
24	14	Ron#2-Fnd[3]	CMH77A.16-4B-1Y-3B-4Y-0B	2882			78	85	TR
25	23	CMH76.207	CMH76.207-3Y-7B-4Y-2B-0Y	2742			75	70	5R-MR

CV = 11% DMS 5% = 678kg/ha 1% = 907kg/ha

the leaf rust resistance genes (Lr.9 and Lr.19) of the parental material. Some uniform lines obtained from these crosses will be selected during the 1981-82 cycle, and then will undergo evaluation for disease resistance and yield.

Some important results have been obtained regarding the management of the simple genes Lr.9, Lr.19, Lr.21 and Lr.24. As shown in Tables 2 and 3, some lines with excellent agronomic type carry the specific resistances conferred by these genes, and some of these lines also have a high yield capacity. Agatha-Yecora 70 produces higher yields than RL6010-Yecora (Table 2); this was also observed in the 1979-80 cycle and it would be helpful to know whether this is always true. If so, then it must be taken into account when planning future crosses involving Agatha and RL6010. A few new lines with the Lr.9, and Lr.19 genes are now being evaluated for resistance and yield. The material with Lr.21 and Lr.24 genes is less advanced and will require additional attention in subsequent cycles.

We now have advanced generation material derived from RL6010 that carries the Lr.19 gene with the plant types of Yecora 70, Sonalika, Jupateco 73 and Potam 70. Uniform lines have also been developed via backcrosses of Agatha and RL6040—both of which carry the Lr.19 gene—with Yecora 70, Inia 66, Cajeme 71, Tanori 71, Potam 70 and Zaragoza 75. Also, some uniform lines have been developed that carry the Lr.24 gene (which is found in Agent) in the types of Yecora 70, Inia 66 and Sonalika. Little work and few materials have been applied toward transferring the Lr.21 gene carried by RL6043. However, we think that this gene will be useful in widening the spectrum of leaf rust resistance.

Yield components—It has been reported previously that materials with higher numbers of spikelets per spike (s/S) and grains per spikelet (G/s) tend to have less tillering and poor grain-filling ability. In an effort to break this inverse relationship, the better agronomic types with higher numbers of s/S and G/s from the cross CMH77A.917 are being crossed to good grain quality and/or high-yielding wheats. As an example of improvement in this area, F_4 segregates of the cross CMH79A.955 possess larger spikes with better filled grain than those of CMH77A.917.

Regarding the development of the large grain character, some crosses have been made between materials carrying this trait (derived from Buitre) and durum wheats that also have large grains. Some lines phenotypically similar to bread wheat, but with larger grains than those of Buitre, have been obtained.

Durum wheat

Dwarfism—Several tall durum wheats, including Zenati-Boutille (Z-B), Tehuacan, Candealfen, Senatore Capelli, Iumillo and Reichenbachii, were included in the germplasm improvement program to shorten their straw. At present, the material derived from Z-B is the most advanced; uniform lines 60 cm tall and five backcrosses to Z-B are currently available. In addition, Cocorit 71, Mexicali 75, Tehuacan 60 and Z-B are being used as recurrent parents to incorporate in them the dwarfism of the hexaploid S948A1, which is 35 cm tall. After several backcrosses, a few uniform dwarf lines are now in hand and consist primarily of materials derived from Z-B and Tehuacan 60.

Stem characteristics—The thickness and strength of straw are two characteristics being added to such conventional durum wheat lines as Mexicali 75, Cocorit 71, and Yavaros 79. Shearwater is the donor parent for thickness of straw, and some of the segregates from crosses with Mexicali 75 possess good agronomic type and thicker straw. Some of these lines will be available for the 1981-82 cycle.

In addition, some advanced strong-strawed durum lines have been developed. The most advanced material is from CMH80.890, whose parents are (Fortuna-Maya "s" x Fortuna/$S_{10}B_3$) Mexicali 75^2. There are also some advanced lines from the cross CMH80.980, whose parents are H149.69-ZB^2 x D69.2/ZB^6. Segregating lines from these crosses possess strong straw from the base of the plant to the superior part of the peduncule. These lines are also short strawed, early maturing, and have good fertility, but their grain does not fill completely.

Table 2. Performance of 23 lines resistant to leaf rust, observed in a yield trial grown at CIANO (Cd. Obregon), Sonora, Mexico, 1980-81

Rank by Yield	Var. No.	Variety or cross and pedigree		Yield (kg/ha)	Days to flowering	Height (cm)	Leaf rust
1	172	Agatha-Yec 70^4	CMH78.610-5Y-6B-0Y	7256	78	60	TR
2	165	Agatha-Yec 70^2	CMH77.490-2Y-2B-10Y-1B-0Y	7156	78	75	TR
3	163	Agatha-Yec 70^4	CMH78.610-5Y-0B	7056	78	65	TR
4	166	Agatha-Yec 70^3	CMH77A.485-4B-3Y-1B-0Y	6711	78	65	TR
5	170	Agatha-Yec 70^3	CMH77A.485-8B-5Y-1B-0Y	6578	78	70	TR
6	171	Agatha-Yec 70^3	CMH77A.485-8B-3Y-1B-0Y	6456	78	65	TMR
7	168	Agatha-Yec 70^3	CMH77A.485-8B-2Y-1B-0Y	6233	75	70	TR-MR
8	173	Agatha-Yec 70^4	CMH78.610-5Y-1B-0Y	6222	78	65	TMR
9	160	RL6010-Yec 70^4	CMH78A.669-9B-4Y-0B	6111	68	70	TR
10	164	Agatha-Yec 70^3	CMH77A.485-8B-2Y-1B-3Y-0B	6067	75	70	TR-MR
11	161	Agatha-Yec 70^3	CMH77A.485-8B-3Y-0B	6000	78	70	TMR
12	162	Agatha-Yec 70^3	CMH77A.485-8B-4Y-0B	6000	78	70	TR-MR
13	169	Agatha-Yec 70^3	CMH77A.485-8B-4Y-1B-0Y	5989	75	70	TR-MR
14	167	Agatha-Yec 70^3	CMH77A.485-4B-3Y-7B-0Y	5744	75	65	TR
15	157	RL6010-Yec 70^2	CMH77.478-1Y-2B-5Y-1B-0Y	5688	68	70	TR
16	152	RL6010-Yec 70^2	CMH77A.466-8B-5Y-0B	5444	68	60	TR-MR
17	175	Tesia 79		5444	75	80	30MS
18	155	RL6010-Yec 70^4	CMH78A.669-11B-0Y	5389	68	65	TR
19	174	Yecora 70		5278	70	60	50S
20	153	RL6010-Yec 70^2	CMH77A.466-8B-5Y-1B-0Y	5244	68	60	TMR
21	154	RL6010-Yec 70^4	CMH78A.669-9B-0Y	5144	68	70	TR
22	159	RL6010-Yec 70^3	CMH78.620-3Y-1B-3Y-0B	5000	68	70	TR
23	156	RL6010-Yec 70^2	CMH77.478-1Y-2B-1Y-1B-0Y	4878	68	65	TR
24	158	RL6010-Yec 70^2	CMH77A.466-8B-5Y-3B-0Y	4756	68	65	TR
25	151	RL6010-Yec 70^2	CMH77A.466-8B-3Y-0B	3956	68	60	TR

CV = 11%

DMS 5% = 1081 kg/ha
1% = 1445 kg/ha

Agatha carries the Lr.19 gene and LR6010 carries the Lr. 9 gene

Table 3. Performance of 20 lines resistant to leaf rust, observed in a yield trial grown at CIANO (Cd. Obregon), Sonora, Mexico, 1980-81

Rank by Yield	Var. No.	Variety or cross and pedigree		Yield (kg/ha)	Days to flowering	Height (cm)	Leaf rust
1	200	Ciano 79		6356	76	85	20MR-MS
2	191	RL6040-Cj 71^3	CMH78A.674-3B-1Y-0B	6167	66		TR
3	189	RL6010-Jup 73^4	CMH78A.668-15B-3Y-0B	5789	73	85	TR
4	182	Jupateco 73		5644	68	90	60S
5	198	Agatha-Ti 71^5	CMH78A.657-6B-5Y-0B	5633	68	85	TR
6	179	RL6010-Inia 66^4	CMH78.616-6Y-7B-0Y	5522	68	85	TR
7	193	Agatha-Cj 71^3	CMH78.606-16Y-1B-1Y-0B	5478	83	70	TR/50S
8	185	RL6010-Jup 73^3	CMH78.619-14Y-1B-0Y	5456	68	80	0
9	194	Agatha-Cj 71^3	CMH78.606-16Y-1B-6Y-0B	5356	78	65	0
10	187	RL6010-Jup 73^4	CMH78A.668-4B-1Y-0B	5344	68	90	TR
11	197	Agatha-Ti 71^5	CMH78A.657-6B-1Y-0B	5344	68	80	TMR
12	196	Agatha-Ti 71^4	CMH78.609-1Y-1B-4Y-0B	5311	68	85	TR-MR
13	190	Cajeme 71		5222	78	70	40S
14	192	RL6040-Cj 71^3	CMH78A.674-1B-5Y-0B	5133	66		TR
15	195	Tanori 71		5067	68	80	60S
16	186	RL6010-Jup 73^3	CMH78.619-14Y-8B-0Y	4944	68	85	0
17	177	RL6010-Inia 66^4	CMH78.616-6Y-2B-2Y-0B	4911	70	95	TR
18	176	Inia 66		4878	68	85	50S
19	183	RL6010-Jup 73^2	CMH77A.464-10B-1Y-1B-0Y	4878	70	80	TR
20	188	RL6010-Jup 73^4	CMH78A.668-12B-0Y	4878	70	90	0
21	184	RL6010-Jup 73^2	CMH77A.464-10B-1Y-4B-0Y	4867	70	85	0
22	199	Agatha-Ti 71^5	CMH78A.657-10B-0Y	4678	68	80	TR
23	178	RL6010-Inia 66^4	CMH78.616-6Y-2B-0Y	4322	75	90	TR
24	181	RL6010-Inia 66^5	CMH78A.666-4B-4Y-0B	4178	68	85	TR
25	180	RL6010-Inia 66^5	CMH78A.666-1B-3Y-0B	4144	68	80	TR

CV = 11% DMS 5% = 909 kg/ha
1% =1214 kg/ha

Agatha and RL6040 carry the Lr. 19 gene. RL6010 carries the Lr. 9 gene

Yield components—Uniform lines of durum wheat with 7 to 9 flowers per spikelet (F/s) and 4 to 6 grains per spikelet (G/s) will be harvested in the 1981-82 cycle. These lines are short strawed and early maturing, but their fertility and grain filling characteristics are deficient. In addition to the development of large-spike durum wheats, some lines with 12 to 15 s/S and 5 to 7 G/s have been found, mainly among materials derived from wide crosses of bread wheats with durum wheats. Poor grain filling is the main limiting factor in the durum progeny from these crosses, just as it is in the bread wheat progeny.

Definite advances have been made toward obtaining tetraploid wheats with large grain. Short-strawed, early maturing and large-grain lines are now available, and were derived from *Triticum polonicum, T. turanicum, T. pyramidale* and the Camel tooth type. We have two major objectives in working with this material: one is to improve the agronomic type, and the second is to combine several grain types. With regard to grain type, for example, the *T. polonicum* type (thick and large grain) is being combined with the Camel tooth type (slim and very long grain). Rapid progress is expected and will be evaluated in the 1981-82 cycle.

Early maturity—Recently, a crossing program designed to add early maturity to durum wheats was initiated. With the same objective in mind, wide crosses have also been made with various early maturing bread wheats. Evaluation of the potential for transferring this early maturity characteristic to durum wheats is now underway.

Triticale

Several years ago a small triticale germplasm improvement program was established. Initially, the objective was to develop short-strawed triticales; additional objectives were defined later, and include the improvement of such characteristics as leaf type, number of spikelets per spike, number of grains per spikelet, grain size and grain-filling ability. Plant height and early maturity are the highest priority improvement objectives at this time, and the triticale crop improvement program is now using several improved lines with earlier maturity and short straw. In 1982, lines that show one or several of following characteristics will be available from the germplasm improvement unit:

- short straw
- spikes with more spikelets
- spikes with more flowers per spikelet
- spikes with more grains per spikelet
- shorter growing cycle
- large grain

Triticale x wheat—Triticale x wheat crosses were initiated to determine the extent to which the genetic components of wheat germplasm can be transferred to triticale and vice versa. It has so far been possible to transfer dwarfism from wheat to triticale, and experimental results indicate that it is also possible to improve triticale grain quality by means of these crosses. On the wheat side, lines with larger spikes than those of conventional wheats have been recovered, and there are also segregates that show better resistance to the rusts than the wheat parent.

Triticale x wheat crosses have produced the following materials:

- short-strawed, early maturing triticales
- short-strawed triticales with good grain
- intermediate types between wheat and triticale with large and well-filled grains
- wheats more resistant to the rusts than their wheat parents
- wheats with larger spikes
- wheats with larger grain
- wheats with pubescent necks

Both the triticales and wheats are phenotypically similar to the triticale or wheat parent, respectively; their cytological composition, however, has not been analyzed.

Results obtained to date indicate potential usefulness of the progeny from these crosses in regions/countries with certain soil or disease problems, such as Brazil. For this reason the Brazilian germplasm is being used in these crosses.

Rye

The improvement of rye germplasm is potentially very important to the production of new primary triticales. With this ultimate use in mind, we selected individual plants among the conventional rye varieties, but mainly within the variety Snoopy. A number of unifrom lines have now been obtained that possess one or several of the following characteristics:

- short straw
- early maturity
- good fertility
- rust resistance
- large spikes
- more than two grains per spikelet

We have also selected a mutant, multifloral type with a spike very similar to that of the canary-seed type (see Figures 1, 2 and 3).

Crosses have been made within the rye population to improve agronomic type and grain characteristics. A few superior lines that represent an improvement over their parents have been obtained. Among those improved characteristics is a better ability to cross with wheat.

Figure 1. A rye line from a normal population of the variety Snoopy. Note the similarity of the spike to that of canary-seed, and the variations in plant height and tillering.

Figure 2. A group of canary-seed-type spikes from Snoopy. These spikes have a high number of flowers, but they are very sterile and show a marked basal atrophy.

Figure 3. Rye spikes similar to those of canary-seed. Note the grain formation.

Interspecific crosses

A number of bread and durum wheats were crossed with *Triticum monococcum, T. dicoccoides* and *T. timopheevi*. Some of the F_1 progenies were treated with colchicine, and the rest received no treatment. Selections were made in the segregating lines for plant height, rust resistance and general agronomic type. However, some undesirable traits have also been observed among the selected materials, such as rachis fragility and poor filling of the grain.

In the 1981-82 cycle, a number of uniform lines derived from these wide crosses will be harvested. These materials will require analyses for their disease resistance and also for their flour characteristics. They should also undergo cytological examination to help determine their best uses.

Germplasm Bank

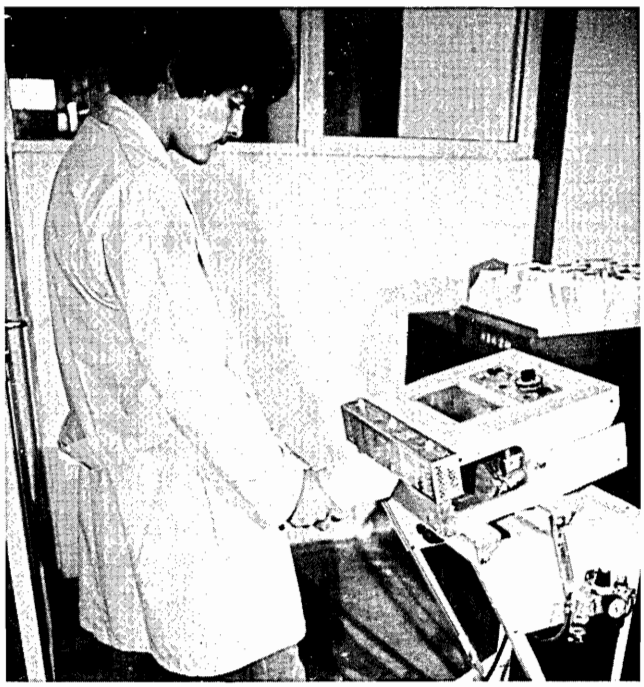
A. Sencer, Curator, Germplasm Bank

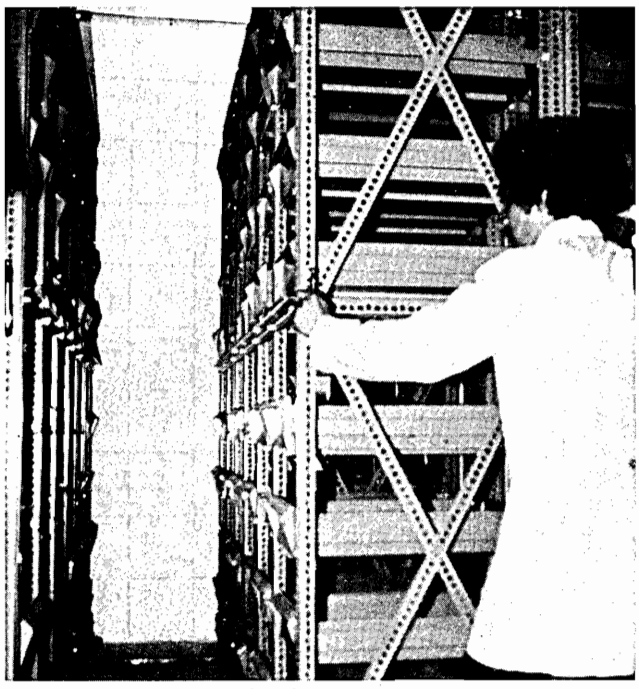
An active collection (about 70,000 entries) consisting of small samples of bread wheat, durum wheat, triticale and barley lines that have been improved in CIMMYT nurseries, as well as those received from the related nurseries and gene banks, has been maintained by CIMMYT under short-term storage conditions since 1972-73. During 1981, additional nursery material was received from the various crop programs within the Wheat Improvement Program.

During 1980-1981, a new seed house containing physical facilities for the germplasm bank was constructed. In addition to the two cold chambers previously used for short-term storage, which have a capacity of 100,000 entries (50-100g each), the facilities for the germplasm bank include three new cold rooms (two of which are furnished for medium-term storage of about 90,000 entries), a seed drying room, a seed preparation room, a machine room and offices. These facilities are expected to become fully operational during early 1982.

An inventory of the entries in the existing active collection has been started. The best entries and varieties from CIMMYT nurseries have been identified. Some of the nursery material and duplications are being eliminated from the active collection. Along with the inventory, introduction and storage data are being recorded. The descriptors for morphologic, agronomic, disease and quality characteristics have been developed.

One part of the existing active collection (about 10,000 entries) was sown at the CIANO station in northwest Mexico for seed increase, rejuvenation and evaluation purposes during the 1981-82 winter cycle. Entries in the nurseries of the bread wheat, durum wheat, triticale and barley programs (from which seed samples will be received at the end of the winter cycle at Cd. Obregon, Hermosillo and Toluca) have been identified and evaluation data is being collected jointly by the germplasm bank and other programs.





Dr. A. Sencer, curator of the CIMMYT germplasm bank, evaluates entries in the field (left), and manages the day-to-day operation of the bank's new facilities. Entries are being readied for medium-term storage (above left) in the new cold rooms (above right). (Photos this page: J.L. Castillo)

Wide Crosses

A. Mujeeb-Kazi, Head, Wide Crosses Program

Introduction

Wide cross, or "intergeneric hybridization," research efforts continued in 1981 to stress incorporation of disease and environmental stress tolerance characteristics into wheat (*Triticum aestivum*) from other genera. The alien genera are comprised of *Aegilops, Agropyron, Elymus, Haynaldia,* and *Secale* species; crosses are also made with *T. turgidum*.

Several intergeneric hybrids have been produced. These are cytologically verified as hybrids on the basis of their F_1 chromosome number, which is the sum of half the chromosome complement of each genus forming the hybrid. The F_1 hybrids are self-sterile and often do not form fertile doubled plants (i.e., amphidiploids) when treated with colchicine. The schematic shown in Figure 1 outlines the stepwise procedures for advancing germplasm through the wide crosses program, using *T. aestivum x E. giganteus* as the hybrid combination for demonstration purposes.

Hybrid combinations

A number of hybrid combinations are produced and maintained by the CIMMYT wheat wide cross program (Table 1). Those receiving greater emphasis in 1981 are as follows:

- *Triticum aestivum* (2n=6x=42) x *E. giganteus* (2n=4x=28). The advanced backcross (BC) progenies have been cytologically determined to carry addition or substitution chromosomes of *Elymus giganteus*. These progenies have selectively expressed resistance to leaf rust, stem rust and helminthosporium diseases. Meiosis in the BC progenies is normal and the alien *Elymus* chromosomes show no recombination with wheat chromosomes. In addition to developing alien addition or substitution lines of *Elymus*, efforts are being directed toward incorporating the alien genes into *T. aestivum* through a genetic manipulation mechanism present in certain wheat varieties.

- *Triticum aestivum* (2n=6x=42) x *A. elongatum* (2n=10x=70). The *Agropyron* source is used primarily for salt tolerance. Several BC_I plants (*T. aestivum-A. elongatum x T. aestivum*) were self-fertile and expressed rust resistance. Cytological variations in BC_I thwart a systematic cytological advance of this combination. Consequently, the material after BC_I will be field tested directly. When desirable plant types are identified, a cytological analysis of the selections will be conducted.

- *Triticum aestivum* (2n=6x=42) x *A. distichum* (2n=4x=28) [amphiploid and BC_I seed source: R. Pienaar]. The BC_I progenies (2n=8x=56, $AABBDDX_1X_2$) were directly advanced by selfing or by producing BC_{II} seeds via crosses of the BC_I progenies to the varieties Inia 66, Veery"S" and Zaragoza 75. Selection for leaf and stem rust resistance has also led to selection of several individual plants that possess satisfactory plant habit. The material will now be tested for salt tolerance through a cooperative research effort (presently in a developmental stage). Cytological analyses will be curtailed on later generation and on elite material.

- *Elymus canadensis* (2n=4x=28) x *T. aestivum* (2n=6x=42). The F_1 hybrid (2n=5x=35, SHABD) backcrossed twice to *T. aestivum* varieties produced BC_{II} progenies that included self-fertile segregants. BC_{III} seed set was also obtained on several BC_{II} plants. Based on initial testing, *E. canadensis* appears to be a potential source of resistance to helmintho-

A number of intergeneric hybrids have been produced by the CIMMYT wide crosses program. Dr. Mujeeb-Kazi, head of the program, will be moving many of the advanced backcross progenies of these hybrids from the greenhouse to the field in 1982. (Photo: J. L. Castillo)

sporium diseases, as are *E. patagonicus* and some JX-genome *Elymus* species (exemplified by *E. giganteus*). Somatic variations prevalent in the BC progenies necessitate field testing for disease resistance prior to critical cytological analyses.

- *Triticum aestivum* (2n=6x=42) x *A. junceum* (2n=6x=42). The progenies in BC_{II}, as well as those advanced from the amphiploid (2n=12x=84), will soon be tested for disease and salt tolerance. The BC progenies are cytologically highly complex with chromosome variations occurring frequently. Fertility is poor in the selfed BC_{II} and amphiploid progenies, and limited seed availability has prevented field testing until recently.

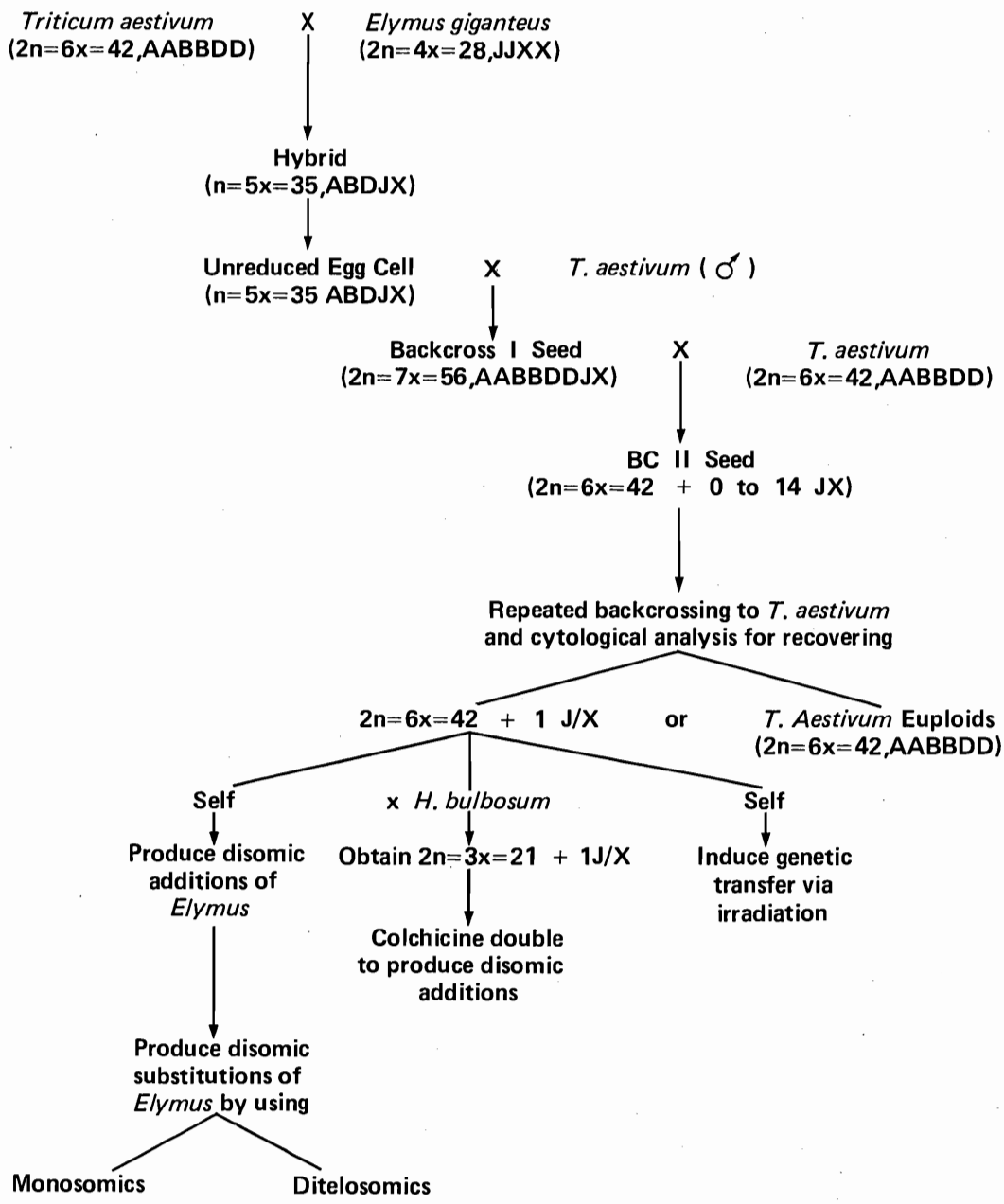


Figure 1. Schematic of steps involved in synthesizing *E. giganteus* addition lines, substitution lines, obtaining genetic transfers, and for recovering *T. aestivum* euploids.

Table 1. List of intergeneric hybrids maintained in CIMMYT, Mexico

Hybrid combination detail	F_1 chromosome number	F_1	BCI	BCII	BCIII	BCIV	C-1
Barley x wheat hybrids							
H.vulgare (14) x *T.turgidum* (28)*	21	*	*				
H.vulgare (14) x *T.aestivum* (42)*	28	*	*	*	*		
T.aestivum (42)* x *H.vulgare* (14)	28	*	*				
Barley x *Elymus* hybrids							
H.vulgare (14) x *E.patagonicus* (42)	21	*					
H.vulgare (14) x *E.canadensis* (28)	28	*					
E.canadensis (28) x *H.vulgare* (14)	21	*					
Agropyron x Barley hybrid							
A.elongatum (28) x *H.vulgare* (14)	21	*					
Wheat x *Elymus* hybrids							
E.agropyroides (42) x *T.aestivum* (42)*	42	*	*	*			
E.canadensis (28) x *T.aestivum* (42)*	35	*	*	*			
E.dahuricus (42) x *T.aestivum* (42)*	42	*	*	*			
E.virginicus (28) x *T.turgidum* (28)	28	*					
T.aestivum (42) x *E.condensatus* (28)	21	POLYHAPLOID					
T.aestivum (42)* x *E.giganteus* (28)	35	*	*	*	*	*	
Wheat x *Agropyron* hybrids							
A.elongatum (14) x *T.turgidum* (28)	21	*					
A.elongatum (70) x *T.aestivum* (42)*	56	*	*	*			
T.aestivum (42) x *A.distichum* (28)*†[1]	-		*	*			*†
T.aestivum (42) x *A.distichum* (28)*†[1]	-		*	*			*†
A.fibrosum (28) x *T.aestivum* (42)*	35	*	*	*			
A.fibrosum (28) x *T.aestivum* (42)*	14	POLYHAPLOID					
A.fibrosum (28) x *T.turgidum* (28)*	28	*	*	*			
A.scabrifolium - x *T.turgidum* (28)	-	*					
A.sibericum (28) x *T.turgidum* (28)	28	*					
A.trachycaulum (28) x *T.turgidum* (28)*	28	*	*				
A.trachycaulum (28) x *T.aestivum* (42)*	35	*	*	*			
T.turgidum (28) x *A.elongatum* (70)	49	*	*	*			

(Table 1 continued next page)

Table 1. (continued)

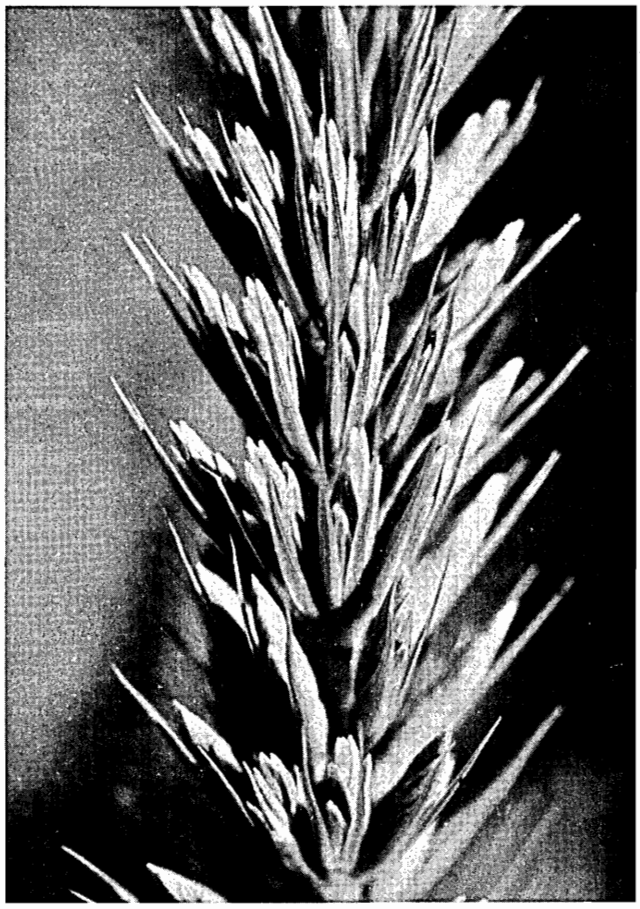
Hybrid combination detail	F_1 chromosome number	F_1	BCI	BCII	BCIII	BCIV	C-1
T.timopheevii (28) x *A.elongatum* (70)	49	*	*	*			
T.aestivum (42)* x *A.elongatum* (70)	56	*	*	*			
T.turgidum (28) x *A.junceum* (42)	35	*					
T.aestivum (42)* x *A.junceum* (42)	42	*	*	*			*
T.aestivum (42)* x *A.repens* (42)	42	*	*				
T.aestivum (42)* x *A.scythicum* (28)	35	*	*				
T.turgidum (28)* x *A.scythicum* (28)	28	*	*				
T.aestivum (42)* x *A.podperae* (42)	42	*	*				
T.turgidum (28)* x *A.podperae* (42)	35	*	*				
T.aestivum (42)* x *A.trichophorum* (42)	42	*	*				
Agropyron x Rye hybrids							
A.elongatum (28) x *S.cereale* (14)*	21	*	*				
Trigeneric hybrids							
A.fibrosum/T.turgidum//S.cereale	35 with 7 rye						
A.fibrosum/T.aestivum//S.cereale	42 with 7 rye						
*H.vulgare/*2T.aestivum//S.cereale*	21_W 7 rye 4 barley						
T.timopheevii/H.bogdanii(†2)*//S.cereale*	14_W 7 barley and 7 rye						
T.aestivum/E.giganteus//S.cereale	21_W 14_E 7 rye						
T.aestivum/E.giganteus//A.elongatum	21_W 14_E						
T.aestivum/E.giganteus//T.aestivum/3/A.elongatum	$21_W 35_{Ag}$ + 3 to 9 E						
Miscellaneous							
A.trachycaulum (28) x *E.giganteus* (28)	F_1 = 28						
E.agropyroides (42) x *E.giganteus* (28)	F_1 = 35						
Elymus sp. (28) x *S.cereale* (28)	F_1 = 28						
T.aestivum-A.elongatum (C-1) 56 x *T.aestivum* (42)	F_1 = 49 (42_W 7 *A.elongatum*)						
T.aestivum-A.elongatum (C-1) 56 x *T.turgidum* (28)	F_1 = 42 (35_W 7 *A.elongatum*)						
T.turgidum-A.elongatum (C-1) 42 x *T.aestivum* (42)	F_1 = 42 (35_W 7 *A.elongatum*)						

* Indicates backcross parent
†1 Source: Dr. Pienaar
†2 Source: Dr. Kimber

Chromosomal variation and complexities in alien genetic transfers

Lack of genetic recombination—Meiotic associations in the F_1 hybrid indicate genetic recombination between genomes. In a great majority of the F_1 hybrids obtained, intergenomic chromosomal relationships as observed via meiotic analyses are lacking, which precludes the possibility of alien gene transfers through F_1 recombinations. The options being explored by CIMMYT are to 1) develop addition lines, 2) develop substitution lines, 3) achieve transfers from irradiation of the addition lines, 4) produce trigeneric hybrids, 5) use tissue culture techniques, or 6) utilize the genetic stocks of *T. aestivum* that will permit enhanced and rapid practical (field) agricultural research.

Chromosome variations in BC_1—It is generally anticipated that BC_1 progenies will have the complete chromosome complement of one parent plus half the complement of the alien genera. Table 2 shows the variations that occur in BC_1 for several intergeneric combinations. Such variations require cytological analyses at least through the BC_1 progenies. Where the deviation in chromosome numbers is greater than expected (Table 2), progenies can be immediately field tested, delaying cytology until the field-selected plants show phenotypic stability and express tolerance characteristics (this is the case with *T. aestivum x A. elongatum* and *T. aestivum x A. junceum* BC_1 progeny). When the BC_1 progenies are generally normal, critical cytological analyses will be a continuous and integrated aspect of germplasm advancement, e.g., as with *T. aestivum x E. giganteus*.



A spike of *Elymus giganteus* (left) and a closer view of its florets (right). Advanced BC progenies of *T. aestivum* x *E. giganteus* have selectively expressed resistance to leaf rust, stem rust and helminthosporium diseases. (Photos: T. Harris)

Table 2. Some intergeneric F_1 hybrids and backcross I (BCI) combinations, with somatic cytological constitutions and variations in BCI.

Serial number	Intergeneric hybrid combination (F_1)			(F_1)or(C-1) chromosome number	Backcross I combination (BCI)		Expected BCI chromosome number	Observed BCI chromosome number or range
1	*T.aestivum*	× *A.junceum*		42	(F_1)× *T.aestivum*		63	42 and 63
2	*T.aestivum*	× *A.junceum*		84	(C_1)× *T.aestivum*		63	59 to 63*†
3	*T.aestivum*	× *E.giganteus*		35	(F_1)× *T.aestivum*		56	55 to 56
4	*A.elongatum*	× *T.aestivum*	cv. Jupateco	35	(F_1)× *T.aestivum*		56	49 to 56
5	*A.elongatum*	× *T.aestivum*	cv. C.Spring	35	(F_1)× *T.aestivum*		56	56
6	*A.trachycaulum*	× *T.turgidum*		28	(F_1)× *T.turgidum*		42	41
7	*A.fibrosum*	× *T.aestivum*	cv. Pavon	35	(F_1)× *T.aestivum*		56	55 to 56*
8	*A.fibrosum*	× *T.turgidum*		28	(F_1)× *T.turgidum*	cv. Cocorit 71	42	39
9	*A.fibrosum*	× *T.turgidum*	cv. Mexicali	28	(F_1)× *T.turgidum*	cv. Grano Grande	42	43
10	*A.fibrosum*	× *T.turgidum*	cv. Mexicali	28	(F_1)× *T.turgidum*	cv. Mexicali	42	40 to 42†
11	*A.fibrosum*	× *T.turgidum*	cv. Quilafen	28	(F_1)× *T.turgidum*	cv. Mexicali	42	56
12	*E.dahuricus*	× *T.aestivum*	cv. Pitic	42	(F_1)× *T.aestivum*	cv. Pavon	63	42,61 to 65*†
13	*E.canadensis*	× *T.aestivum*	cv. C.Spring	35	(F_1)× *T.aestivum*	cv. C.Spring	56	57 to 61*†
14	*E.canadensis*	× *T.aestivum*	cv. C.Spring	35	(F_1)× *T.aestivum*	cv. Veery	56	54 to 59*†
15	*E.canadensis*	× *T.aestivum*	cv. C.Spring	35	(F_1)× *T.aestivum*	cv. Zaragoza	56	54 to 59
16	*T.aestivum*	× *A.elongatum*		56	(F_1)× *T.aestivum*		77	42 to 61*†
17	*A.elongatum*	× *S.cereale*		21	(F_1)× *S.cereale*		28	49
18	*T.timopheevii*	× *A.elongatum*		49	(F_1)× *T.timopheevii*		63	38 to 42*

*: With telocentrics

†: With dicentrics

Publications

MUJEEB-KAZI, A. "Apomictic progeny derived from intergeneric *Hordeum-Triticum* hybrids." *Journal of Heredity* 72:284-285. (1981).

MUJEEB-KAZI, A. "A cytogenetic analysis of the complexities of combining diverse genera with *Triticum aestivum L. "Agronomy Abstracts* p. 68. (1981).

MUJEEB-KAZI, A. and RODRIGUEZ, R. "Cytogenetics of intergeneric hybrids involving genera within the *Triticeae*." *Cereal Research Communication* 9:39:45. (1981).

MUJEEB-KAZI, A. and RODRIGUEZ, R. "An intergeneric hybrid of *Triticum aestivum L. x Elymus giganteus*." *Journal of Heredity* 72: 253-256. (1981).

RODRIGUEZ R., and MUJEEB-KAZI, A. "Cytological variations in intergeneric hybrids involving *Agropyron* species, *Secale cereale, Triticum turgidum* and *T. aestivum*." *Agronomic Abstracts* p. 71 (1981).

Agronomy

P. Wall, Head, Agronomy Program
P. Hobbs, Agronomist

Introduction

The agronomy program is involved in three main activities: training, agronomic recommendations for the breeding nurseries, and some agronomic studies that are not highly site specific. In training, the program works closely with the 6-month wheat production agronomy training program and is involved with preparation of agronomists for regional CIMMYT staff positions. The latter is accomplished through the direct involvement of potential regional agronomists with the 6-month training program, as well as their work toward resolving the wide range of agronomic problems addressed by the program. The production agronomy trainees place trials in farmers' fields and on the experiment stations, but only those conducted on the various stations are reported here.

Research is conducted in two distinct regions of Mexico. In the winter, from November to May, the program moves to the irrigated desert-type environment of the CIANO station in the Yaqui Valley, near Ciudad Obregon in the northwestern state of Sonora, Mexico. This is an ideal environment for studies on yield, drought and weed control (of *Avena fatua* and *Phalaris minor*). In the summer, studies are conducted on the upper plateau near Mexico City at the El Batan and Toluca stations. In these rainfed environments, studies concentrate on weed control (mainly broadleaf weeds) and fertilizer recommendations.

Weed control

On all three stations, weed control studies in 1981 tested individual chemicals and mixtures for possible use in the breeders' nurseries, as well as those that could potentially be used on farmers' fields. The trials ranged from an initial screening (using logarithmic sprayers), through a more critical testing of the effects of different rates and times of chemical application on phytotoxicity and weed control. This was followed by tests for varietal sensitivity to the most promising chemicals before using them in farmers' fields.

Some results from the 1980-81 season in Cd. Obregon are shown in Tables 1 and 2. Mataven (flamprop-methyl) is the most effective herbicide for both wild oat and phalaris control in bread wheats; good control was obtained from applications at 21 to 35 days after crop emergence. This herbicide stunts weed growth and allows the crop to shade out the weeds. Although weed control is more variable, Illoxan (diclofop) applied from 7 to 28 days post-emergence is used in the breeders' nurseries where wide spacing between rows reduces effective control with Mataven. Early applications of Illoxan effectively controlled phalaris (Table 2), but because of the temperature sensitivity for germination of wild oats, later applications were better for wild oat control in fields with earlier planting dates.

Some results from El Batan are shown in Tables 3 and 4. Illoxan effectively controlled the grasses, even at the 0.5 kg/ha rate. Dicuran (chlortoluron) and DPX 4189 look promising for control of broadleaf weeds. *Oxalis latifolia* persisted through all the treatments, however, and has become a nuisance weed on the El Batan station. The growth of this weed is stunted by DPX4189, especially at higher doses, but treatment does not eliminate it. Table 4 shows the phytotoxic effect of 2,4D on wheat. Yield reductions became increasingly severe as the time of application departed from the optimum 40-day post-emergence date.

Results from Toluca are shown in Table 5, and DPX4189 and Dicuran look promising for weed control. As an early post-emergent herbicide, Dicuran gave longer control of *Poa annua* than did the present recommendation of Tribunil (methabenzthiazuron) and Brominal (bromoxynil).

One of the major activities of the agronomy program is the development of information useful to breeders in creating desired conditions for screening germplasm. Here, Dr. Pat Wall, head of the program, describes an experiment to assess water infiltration rates at the CIANO station; data from this experiment will help breeders simulate desired moisture-stress conditions for screening for drought tolerance. (Photo C.R. Dowswell)

Table 1. The effect of different herbicides on the yield of wheat and the control of wild oats and *Phalaris minor* at CIANO (Cd. Obregon), Sonora, Mexico, 1980-81

Treatment	Yield kg/ha	Weed rating[1] oats	Weed rating[1] phalaris	Lodging[3] Score
Unweeded check	3105 d[2]	0	0	27.9
Hand weeded check	5470 a	10	10	0.0
2,4D 1 kg, 35 days post	5125 ab	2	6	0.0
Brominal 0.24 kg, 21 days	3981 c	0	0	3.3
Finaven 0.5 kg, 42 days*	5102 ab	9	5	0.0
Finaven 0.75 kg , 42 days*	4832 ab	10	5	0.0
Finaven 0.75 kg, 14 days*	4959 ab	9	0	1.9
Tribunil 1 kg, premerge**	4629 bc	10	4	0.0
Suffix 1 kg, 35 days*	5090 ab	9	9	2.8
Suffix 0.5 kg + Carbyne 0.3 kg, 35 days*	5245 ab	8	9	11.7
Illoxan 0.75 kg + Surfactant 0.5%, 4 days*	4755 ab	5	9	0.6
Illoxan 0.75 kg + Surfactant 0.5%, 14 days*	4974 ab	7	6	0.1
Illoxan 1.00 kg, 14 days*	4755 ab	7	9	0.0
Illoxan 0.75 kg + Surfactant 0.5%, 21 days*	5192 ab	8	9	0.0
Illoxan 0.75 kg + Surfactant 0.5%, 35 days*	4951 ab	6	9	0.0
Illoxan 0.5 kg, premerge + 0.75 kg, 35 days*	4946 ab	8	10	0.0
Illoxan 0.5 kg, 4 days + 0.5 kg, 35 days*	5084 ab	7	10	8.3
Illoxan 0.75 kg, 4 days + 0.75 kg, 35 days*	5176 ab	9	10	24.7
Mataven 0.45 kg, 14 days*	5075 ab	5	5	0.0
Mataven 0.45 kg, 21 days*	5112 ab	10	10	0.0
Mataven 0.45 kg, 35 days*	5072 ab	10	10	0.0
Mataven 0.60 kg, 35 days*	5091 ab	10	10	1.4
Mataven 0.60 kg, 35 days	4582 bc	10	10	0.0
Illoxan 0.75 kg, 4 days + Finaven 0.75, 42 days*	4886 ab	10	10	0.0

* 1 kg 2,4D applied 35 days post-emergence or 42 days following Suffix

** 1 kg 2,4D + 0.75 kg Finaven applied 35 days post-emergence

1 0 = no weed control 10 = complete weed control

2 Figures followed by the same letter are not significant using DMRT at 95% confidence

3 Percentage of plot lodged x angle to the vertical/90°

It also produced acceptably low levels of phytotoxicity when tested across a wide range of materials from the four crop programs.

Long-term weed control

A trial was started in 1979 at CIANO to determine the long-term (3-year) effects of various cultural and chemical control practices on *Avena fatua* and *Phalaris minor* populations. The treatments included the methods by which wheat stubble is incorporated, presence or absence of a summer soybean crop, irrigation before or after sowing, wheat seeding density, and with and without chemical grass weed control for one, two or three seasons.

Chemical control of grass weeds with Mataven at 0.6 kg/ha gave complete control and an average yield of 4.9 t/ha meaned over all cultural treatments. However, this report focuses on those treatments where grass weeds were not controlled chemically in the 1980/81 season. Yields in these treatments ranged from 0.5 to 5.3 t/ha. The mean yields and weed populations of each factor are shown in Table 6.

Pre-irrigation, followed by a discing to incorporate germinated weeds, and then seeding into moist soil was the most favorable cultural practice for controlling weeds (Table 6). Yields averaged 1.3 t/ha higher using this practice than seeding into dry soil and then irrigating, reflecting an overall 90 percent reduction in wild oat populations. It is interesting to note that neither this nor the other treatments caused large differences in phalaris populations. This is presumably because phalaris is less competitive than wild oats, and therefore even when cultural weed control is poor, phalaris populations are low due to the competitive effect of wild oats. Counts of germinated weeds after the pre-irrigation and prior to discing showed that more phalaris plants (115/m^2) than wild oats (32/m^2) had germinated and were thus destroyed by discing. Many farmers in the Yaqui Valley are now practicing pre-irrigation for weed control even though this practice delays seeding and increases the difficulty of seedbed preparation.

Table 2. The effect of date of seedling and timing of Illoxan application on the yield of bread wheat and the control of wild oats and phalaris at CIANO (Cd. Obregon), Sonora, Mexico, 1980-81

	November 12th			December 23th			
Treatment	Yield kg/ha	wild[1] oats	phalaris	Yield kg/ha	wild oats	phalaris	Mean Yield
Unweeded check	4388 b[2]	0	0	4843 b	0	0	4616 b
Illoxan pre-emerge	4746 ab	3	5	4864 b	0	3	4805 b
Illoxan 7 days	4707 ab	2	8	5793 a	8	10	5250 a
Illoxan 14 days	5038 a	8	6	6041 a	8	9	5540 a
Illoxan 21 days	5066 a	10	8	5928 a	10	7	5497 a
Illoxan 28 days	5037 a	10	7	5794 a	9	6	5416 a
Mean	4829 b			5543 a			5186

[1] Weed score where 0 = check population and 10 = no weeds

[2] Figures followed by the same letter are not significantly different using the DMRT test at the 5% level of confidence

Table 3. The effect of herbicides on the yield and control of broadleaf weeds and grasses in block B2, El Batan, 1981

Treatment	Yield kg/ha	Phyto-toxicity[1]	*Sicyos*	*Tithonia*	*Amaranthus*	*Galinsoga*	*Grasses*	*Oxalis*	*Acalypha*
1kg Tribunil + 0.24 Brominal 10d	4518 a	0	10	10	10	10	9	2	10
0.75kg Illoxan + 20g DPX 2d	4485 a	0	10	10	10	10	10	5	9
1kg Dicuran 10d + 0.24 Brominal 20d	4368 ab	0	10	10	10	10	10	5	10
Hand weeded check	4346 abc	0	10	10	10	10	10	10	10
1kg Karme x premerge wet	4289 abc	0.5	10	10	10	9	9.5	1	10
0.75 Illoxan + 1kg Basagran 2d + 0.24 Brominal 20d	4272 abc	0	10	10	9	10	10	0	5
0.75 Illoxan 2d + 1kg Basagran 6d + 0.24 Brominal 20d	3952 abcd	0	10	10	9	10	10	0	6
20g DPX 2 days	3527 bcd	0	8	8	10	10	3	2	10
1kg Basagran 2d + 0.24 Brominal 20d	3458 bcde	0	10	10	10	10	0	0	2
1kg Karmex 10 days	3438 cde	1	10	10	10	10	10	6	9.5
20g DPX premerge dry	3156 de	0	8	7	10	6	1	2	6
0.75kg Illoxan 2 days	2634 ef	0	3	2	3	2	10	0	2
1kg Treflan preplant incorporated	1837 fg	0.3	4	1	5	0	9	0	3
Non weeded check	1686 g	0	0	3	5	0	0	0	0
Mean	3569								
LSD 0.05	780								

[1] 0 = no phytotoxicity or weed control, 10 = dead plants or no weeds.

Table 4. The effect of 2,4D on the yield and yield components of Pavon bread wheat, when applied at different times after emergence at El Batan, 1981

Treatment	Yield kg/ha	Spikes /m^2	Grains /spike	1000 grain wt	Height cm	Grains /m^2 x 10^3
No 2,4D	4154 a[1]	351	28.5	36.8 bc	100	9.99 a
2 kg 2,4D 10 days	2288 d	328	22.3	27.8 d	82	7.27 bc
2 kg 2,4D 20 days	3011 bc	250	32.2	33.0 c	77	8.04 bc
2 kg 2,4D 30 days	3405 b	350	24.5	35.3 bc	83	8.49 ab
2 kg 2,4D 40 days	4068 a	362	27.7	36.2 bc	98	9.93 a
2 kg 2,4D 50 days	3046 bc	278	24.4	39.7 ab	94	6.75 bcd
2 kg 2,4D 60 days	3095 bc	262	25.1	42.0 a	96	6.51 cd
2 kg 2,4D 70 days	2548 cd	354	15.5	43.2 a	100	5.23 d
Mean	3202	317	25.0	36.7	91	7.77
LSD 0.05	555			4.4		1.65

[1] Figures followed by the same letter are statistically different at the 5% level of confidence using DMRT.

Table 5. The effect of various herbicides on weed control and the yield of Pavon 76 at breeders' spacing at Toluca, Mexico, in 1981

Treatment	Yield kg/ha	Phyto-toxicity	Weed control - 53 days *Poa*	*Galinsoga*	*Commelina*	*Veronica*
1 kg Tribunil + 0.24 Brominal 10d	2149	0	8	9.5	5	9
1 kg Karmex 10 days	2069	0.3	10	8	9	9
0.1 Goal premerge wet	1796	0.3	3	2	3	8
1 kg Dicuran 10 days	1767	0	10	9	9	8
1 kg Karmex + 0.24 Brominal 20d	1669	1.3	9.5	10	9.5	3
1 kg Karmex premerge wet	1654	0	8.5	9	4	1
0.5 Dicuran + 0.24 Brominal 20d	1627	0	7	10	10	0
1 kg Dicuran + 0.24 Brominal 20d	1624	0	9.5	10	10	2
20 g DPX 4189 premerge wet	1614	0	9.5	4	8	10
0.5 Karmex + 0.24 Brominal 20d	1551	1.0	9	10	10	0
1 kg Dicuran 20 days	1521	0	9.5	9	8	2
20 g DPX 4189 premerge dry	1325	0	10	6	8	10
20 g DPX 4189 10 days	1184	0	10	9.5	9	10
Tribunil + Brominal 10d + weedwiper	1131	0	8	8	6	9
No weed control	1081	0	0	0	0	0
1 kg Treflan pre-plant incorporated	931	0	4	0	0	4
Mean	1543					

Table 6. Mean yields, wild oat and *Phalaris minor* populations with various cultural factors after two wheat crops

		Yield t/ha	wild oats panicles/m^2	*P. minor* spikes/m^2
Wheat stubble treatment:	Plough-disc harrow	3.8	59	24
	Disc harrow	3.6	97	26
	Burn-disc harrow	4.2	48	19
	No incorporation	3.9	31	30
	PF [a]	*	***	*
Summer treatments:	Fallow	3.4	96	28
	Soyabeans	4.4	21	21
	PF	***	***	*
Sowing irrigation:	Pre-irrigate-disc harrow-seed	4.5	12	20
	Seed-irrigate	3.2	105	29
	PF	***	***	*
Seedling density:	100 kg/ha seed	3.9	69	34
	200 kg/ha seed	3.8	49	16
	PF	N.S.	*	*
Chemical control:	No chemical control	3.6	88	21
	Chemical control 1979/80	4.1	30	29
	PF	***	***	*

[a] PF = Significance of F test

The effect of a summer soybean crop on weed populations and yields was surprising. Neither weed has been observed to germinate during the hot summer. The irrigation or herbicide used during the summer must be affecting the viability of the dormant weed seeds. Moisture is the most logical reason and this hypothesis must be tested experimentally. Figure 1 shows the effect of various treatments and combinations of treatments on the yield of wheat in the disced treatment. This shows the important contribution to yield of both soybeans and pre-irrigation. However, even though yields are not significantly different, weed control was better with pre-irrigation.

Chemical control of weeds in one year reduced weed populations in the following year, resulting in an overall 0.5 t/ha yield increase. However, the next-year gain from controlling weeds chemically is not as great as that of the above two cultural practices (Figure 1). The above cultural practices are also more economic.

Although seeding density and the method of stubble incorporation did have effects on weed populations, the effects on yields were small (Table 6, Figure 1), except in the case of stubble burning. Stubble burning gave a sizeable effect on weed populations and on yield compared to the unburned treatment, which was also disc harrowed. The lack of a yield effect in the case of seeding rate was due to increased lodging at the higher seedrate in the variety used, Pavon 76.

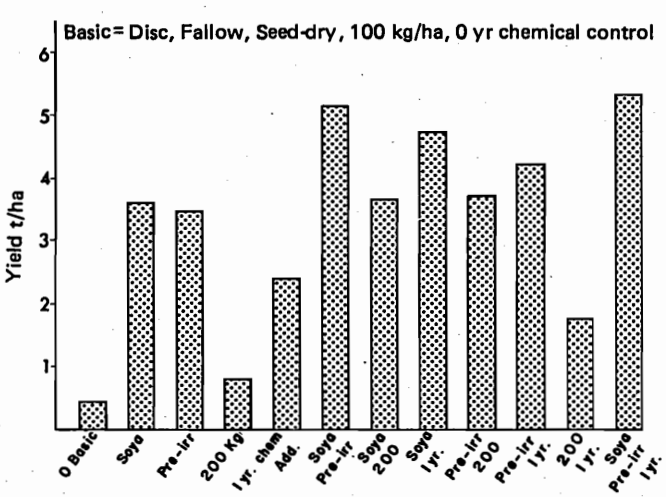


Figure 1. The effect of various treatments and combinations of treatments on the yield of wheat in an integrated weed control experiment at Ciano in 1981

There were several interactions between factors that affected both yield and weed population. For example, both pre-irrigation and soybeans resulted in good weed control and higher yields, but together their effects were not completely additive.

The most striking treatment comparison is that between the best and worst treatments on plots having no history of chemical control. The best treatment was ploughed, disced, seeded to summer soybeans, pre-irrigated and the wheat seeded at 100 kg/ha. This treatment yielded 5.2 t/ha with 9 oat panicles and 12 phalaris spikes per square meter. The worst treatment was disced, left fallow in the summer, and the wheat seeded into dry soil at 100 kg of seed/ha. Here the yield was 0.45 t/ha with 518 oat panicles and 2 phalaris spikes per square meter.

Fertilizer application

Fertilizer studies at CIANO demonstrated the effects of splitting nitrogen dressings, the effects of applying nitrogen fertilizer before as opposed to after an irrigation, the response curves of varieties released between 1950 and 1979 to nitrogen (Figure 2), and the effects of row spacing on nitrogen responses and uptake efficiencies.

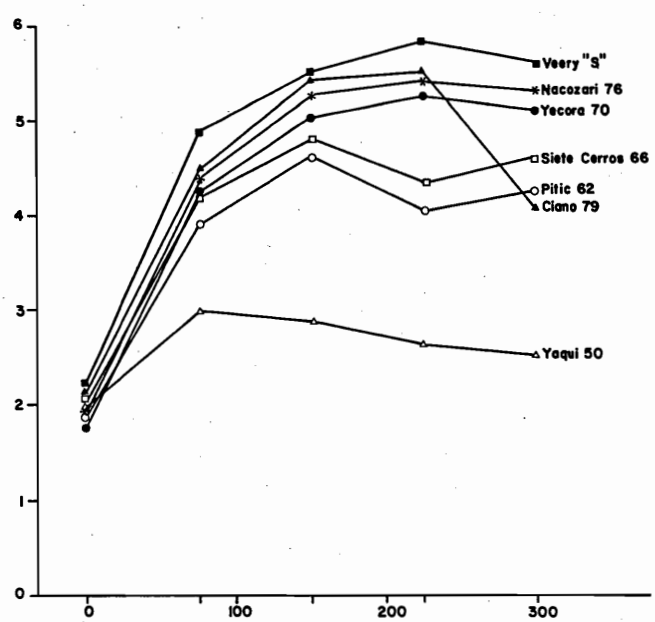


Figure 2. Nitrogen response curves of various wheat varieties released over the last 30 years

At El Batan, nitrogen response curves for barley and bread wheat under different moisture regimes were determined, although nitrogen responses this year were low and restricted to the first 50 kg of nitrogen. At all three stations, longer term fertility studies were initiated to investigate optimum fertilizer applications for the breeders' nurseries. Initial results indicate that nitrogen and phosphorus levels could be reduced without affecting yield.

Irrigation trials on the CIANO station demonstrated different methods of irrigation scheduling, critical stages for moisture stress in the small grain cereal crops, and fertility x moisture interactions. Field evaluations of ridge and furrow irrigation systems were also conducted. However, substantial rainfall in this normally dry environment reduced the usefulness of some of these results.

A variety trial was conducted at CIANO for three different planting dates. The December 23rd date was best because of lodging (caused by rain and wind) in the earlier planting dates. At El Batan, various bread wheat varieties and advanced lines were compared under irrigated and rainfed conditions. Pavon was the best variety under both conditions.

Longer term fertility studies were initiated in 1981 at the CIANO, Toluca and El Batan experiment stations to determine optimum fertilizer applications for the breeders' nurseries. Initial results indicate that nitrogen and phosphorus levels could be reduced without affecting yield. (Photo: R. Knapp)

Training

H. Vivar, Breeding and Pathology Training Officer
R. Knapp, Production Agronomy Training Officer

Introduction
CIMMYT wheat improvement training efforts during 1981 continued to focus on the strengthening of national program research capabilities in plant breeding, wheat pathology, cereal quality, agronomy and experiment station management.

The basic principle underlying CIMMYT training remains that of a team approach to identifying and solving problems, with a strong emphasis on field work. Many of our trainees have previously spent little or no time in the field; we believe there is no substitute for this field time when it comes to developing the confidence of young trainees and instilling them with a willingness to work.

Trainees from "new" countries
Uganda, Mozambique, Transkei and Thailand sent trainees to CIMMYT for the first time, adding to the list of countries that have not traditionally produced wheat, but are increasingly interested in growing small grains (especially wheat) in suitable areas as a way of reducing expenditures on wheat imports.

Bangladesh is a prime example of a "non-traditional" wheat-producing country. A decade ago, very little wheat was produced in Bangladesh. Today, this small country (in area, at least) produces nearly a million tons of wheat. Several factors, among them a strong government commitment and a core of CIMMYT-trained wheat scientists, influenced the wide adoption and increase of wheat production in the country. The largest single group of countries that currently produce very little wheat (or none at all), but are interested in doing so, are found in Africa. There is a critical need for trained personnel in these countries, and CIMMYT is responding to this need by committing a larger portion of core training funds to the region (Table 1).

CIMMYT in-service training courses continue to advocate a team approach to identifying and solving problems, with a strong emphasis on field work. Dr. H. Vivar, breeding and pathology training officer, here discusses leaf disease symptoms with pathology trainees. (Photo: J. L. Castillo)

Table 1. Funding of CIMMYT wheat trainees in 1981, expressed as a percentage of total funds expended

	CIMMYT core funds	Other sources
Latin America	6.7	8.9
Africa	20.0	13.3
Middle East	6.7	2.2
Far East	11.1	26.7
Europe	2.2	2.2
Total	46.7	53.3

Breeding and pathology training
Trainees in breeding and pathology learn CIMMYT's methodologies by working in daily contact with crop and pathology program personnel. Many of the skills developed during the training period will be applied in their national programs after returning home.

In pathology training, heavy emphasis is placed on teaching trainees how to artificially create epidemics that permit a more efficient selection of resistant materials. Diseases other than the rusts tend to be important in countries where wheat is a new crop, creating the need for training people in disease diagnosis, as well as how to evaluate and screen parental material. In 1981, *Septoria tritici, Helminthosporium tritici repentis, H. sativum,* and *Rhynchosporium secalis* epidemics were created in the field plots. Trainees learned how to identify and evaluate various disease reactions, and these skills will help them to better evaluate 1) the germplasm developed by their national programs and 2) CIMMYT international nurseries.

Wheat production training

The demand for CIMMYT-trained wheat production specialists has increased dramatically since the inception of the in-service production training course in 1969. Presently, training resources are stretched to the limit, thus prompting a restructuring of the production courses in order to maximize the effectiveness of staff time and increase cost effectiveness. Wheat production courses will now operate concurrently from the beginning of May until the beginning of November and will be headquartered at El Batan. Ways of augmenting the Mexican-based training—e.g., with in-country short courses and consultation with national programs, ex-trainees and CIMMYT outreach agronomists—are being attempted and evaluated. The field-oriented approach to training at CIMMYT, however, has not changed.

Visiting scientists

CIMMYT nurseries growing in the Yaqui Valley (CIANO station, near Ciudad Obregon) are a big attraction to wheat scientists around the world.

Table 2. Visiting Scientists, 1981

From developing countries:			
Argentina	5	Nepal	2
Bangladesh	3	Nigeria	1
Brazil	5	Pakistan	3
Chile	1	Peru	4
China	1	Portugal	2
Ecuador	2	Rwanda	1
Guatemala	2	Sudan	2
Korea	1	Thailand	1
Lebanon	1	Turkey	1
Mexico	5	Zambia	1
Mozambique	2	**Total individuals:**	**46**
		Total countries:	**21**
Others:			
Norway	3	Sweden	2
Poland	1	USA	11
Spain	5	USSR	3
Total number of individuals:			**25**
Total number of countries:			**6**

A total of seventy-one visiting scientists from 27 countries came to CIMMYT during 1981 (Table 2). Sixty of those went to Cd. Obregon during March and April, and eleven went to El Batan and Toluca stations during the summer.

By financing the visits of thirty-five scientists each year, most of whom come from the developing world, CIMMYT encourages this personal interaction among wheat researchers. While visiting CIMMYT, they have a unique opportunity to trade ideas among themselves and with our staff, discuss research results, and generally strengthen the interpersonal and professional bonds that hold the international network of wheat scientists together. Visiting scientists are also free to select wheat, triticale and barley germplasm and, after the seed has been appropriately treated with fungicides and other chemicals, to take it to their home countries for use in their crop improvement efforts.

Number of national origin of wheat trainees, 1981

Latin America	6	**Africa, South of the Sahara**	13
Bolivia	1	Cameroon	2
Chile	1	Ethiopia	2
Peru	4	Kenya	1
		Madagascar	1
North Africa and Mideast	6	Mali	1
Algeria	2	Mozambique	1
Cyprus	1	Senegal	1
Jordan	1	Tanzania	1
Turkey	2	Transkei	1
		Uganda	1
South, Southeast and East Asia	17	Zambia	1
Bangladesh	7		
Korea	1	**Other Countries**	2
Nepal	3	Portugal	1
Pakistan	4	USSR	1
Philippines	1		
Thailand	1		
		Total Countries	**26**
		Individuals	**44**

Southern Cone Region

M.M. Kohli, Breeder/Pathologist

Introduction

Total wheat area and production in the Southern Cone region of South America remained at roughly the same levels in 1981 as in 1980 (see Table 1). Argentina and Uruguay were able to increase production somewhat, but these gains were offset by declines of 10 to 40 percent in wheat area in Brazil, Chile and Paraguay.

Table 1. Wheat area and production, 1981

Country	Area 1000 Ha		Production 1000 Tons	
	1980	1981	1980	1981
Argentina	5023	6000*	7780	8000*
Brazil	3319	2064	2682	2203
Chile	432	373	686	600*
Paraguay	55	50	45	55*
Uruguay	250	400*	370	500*
Total	8843	9035	11577	11358

* Estimated

Crop Status

Argentina increased its wheat area by 20 percent and enjoyed excellent moisture conditions at seeding time. However, financial difficulties at the farm level and the high cost of fertilizers (a fertilizer-to-grain ratio of 10:1 or higher prevailed) were primarily responsible for a sharp decline in fertilizer usage. Another prolonged drought during most of the crop cycle further reduced expected gains from the increased area.

Brazil's wheat area is at its lowest level since 1973, having suffered a sharp decline (38 percent) over 1980. This decline was expected, since farmers strongly disagreed with the wheat price established by the government. In certain cases, the per hectare cost of production was estimated to be 90 percent of the potential returns. In addition, the government decided to loan farmers only a portion of the cost of production and provide a 70 percent coverage of costs in the form of crop insurance. This was an abrupt change in wheat policy that required a significant economic compromise by farmers. Many preferred to let their land lie idle during the winter and seed to soybeans in the spring, an attractive alternative given cost and price differentials.

In Chile, a reduction in wheat area in 1981 reflected the general trend in the country toward decreasing production of traditional crops. A lack of interest by millers in purchasing small quantities of domestically produced wheat with different grades was partially responsible for fluctuating internal commercial prices. At the same time, government policies that place no restrictions on imports, as well as the availability of wheat in the international market at lower prices, dissipated all concern regarding shortages. These factors, added to the high cost of production at the present yield level, are primarily responsible for the decline in area.

In Paraguay, approximately 70 percent of the wheat area is concentrated in the southern state of Itapua. Severe frost damage in 1980, which caused a loss of about 40 percent, was a major deterrent to any increase in seeded area in spite of a very favorable government price support for wheat. National campaigns designed to encourage wheat production were probably responsible for limiting the cuts in area. The crop suffered from drought in some locations, but a lack of disease problems and insect pests resulted in good yields, which may regenerate farmers' faith in the crop.

In 1980, Uruguay announced a favorable price support for wheat at harvest time. A continuation of this favorable price in 1981 was responsible for an excellent increase (60 percent) in wheat area. All early and normal seedings produced a good crop. However, a large proportion of the late crop, especially in the south, suffered seriously from drought. Thus, the total increase in production in Uruguay was lower than expected.

Germplasm development

Spring x winter wheat crosses—The adaptation of CIMMYT germplasm, especially that derived from spring x winter crosses, has been outstanding in the region. Some countries (e.g., Argentina, Chile and Uruguay) need longer cycle wheats for certain areas.

Pages 89 - 104 Missing

Unfortunately, a majority of the advanced winter material received through international nurseries is severely susceptible to one or more diseases in the Southern Cone. Severe stem and leaf rust epidemics in Argentina and Uruguay, and leaf and stripe rust in Chile, destroyed over 95 percent of the winter material in spite of its excellent adaptation. This indicates an urgent need for a concentrated effort to widen the disease resistance in the spring x winter wheats so as to fully exploit their potential.

Those spring x winter crosses involving Aurora, Kavkaz and Weique are of special interest, considering the large number of advanced CIMMYT lines (e.g., Alondra, Bobwhite, Chat, Veery, etc.) being tested throughout the region. The cross Kvz x Cno-Pj, SWM 1285, is being considered for release in Argentina, and is used in the breeding programs of several other countries in the region.

Brazilian x CIMMYT wheat crosses—Recently, the germplasm developed from crosses between Brazilian and CIMMYT wheats have added another dimension to yield and adaptation. The majority of this material (selected alternately in Brazil and Mexico) combines the high yield potential and good agronomic type of the CIMMYT wheats with the tolerance to acid soils (and high levels of free aluminum) and resistance to a wide range of foliar diseases that characterizes the Brazilian germplasm. Some of this material was evaluated in the first Aluminum Screening Nursery at several locations in Brazil and Paraguay. These tests confirm the superiority of this germplasm, and it is projected that these materials will soon replace the traditional types. Some outstanding lines now undergoing multiplication in Brazil come from the following crosses:

IAS 63 - Ald x Gto - Lv	F 11915-A-502M-1Y-3F-701Y
IAC 5 - Aldan	CM 46961
PF 70354 - Alondra "S"	CM 47090
(IAS58-IAS55 x Ald/IAC5)Ald"S"-IAS58 x Ald"S"	CM 55517
[(IAS60-Pel A 394.65 x IAS55/Ald"S") IAS56-IAS55]Ald"S"-Hork"S"	CM 55539

LACOS regional nursery—The Advanced Lines of the Southern Cone (LACOS) regional wheat nursery was seeded at approximately 20 sites throughout the Southern Cone and another 10 sites outside the region. Even though all results are not back at the time of this reporting, some general observations can be made.

It seems that most of the advanced wheat lines developed within the region are intended for a very specific set of production conditions. The result has been that a large number of lines fail to adapt to other locations, sometimes even within the same country, which indicates a very narrow germplasm base in the nursery. In and of itself, this narrowness is not very important, considering the size and extreme agroclimatic variation of the region. It does explain, however, the limited movement of wheat varieties from one country to another. Advanced lines from Marcos Juarez, Argentina, performed adequately in most locations, making this location an important testing site within the region. Material from southern Chile and Bolivia was too late and too early, respectively, for most of the testing sites. Durum lines included in the LACOS nursery performed poorly throughout the region. A list of the wheat varieties released in the region during 1981 is given in Table 2.

Triticale—In several parts of the region, triticales continued to demonstrate their excellent adaptation. Farmers who have seen triticale in demonstrations or semi-commercial fields tend to be very impressed, but varietal releases are still being withheld pending the establishment of a market for the grain. Brazil is in the process of developing information about milling and baking quality, and also has experience in growing triticales under farmers' conditions. A commercial variety has still not been released, but the increasing interest and involvement of the commercial milling and baking sector should help facilitate this eventuality.

The unstable grain quality of the present material, when grown under farmers' conditions, may be partially responsible for the delay in varietal release. Pre-harvest sprouting, as well as spike diseases that cause poor grain development, require more attention. However, it is very clear that the rye chromosomes, whether in triticales or in wheats, are demonstrating the adaptive advantages they impart in the Southern Cone region.

Barley—The area devoted to barley production in the region has also gone down in recent years. Most of the barley grown is done so on contract. Regional production meets only a third of the regional demand, but economic considerations keep a tight control on area. Various disease problems, such as BYD, leaf rust, stripe rust and net blotch, have kept the breeding programs under pressure for the last several years. However, the benefits of a concentrated

effort toward incorporating greater disease resistance into high-yielding types should become apparent over the next few years.

Disease Screening

Disease screening pressure was excellent throughout the region in 1981, and many susceptible materials were discarded. All the breeding nurseries were affected by one or more of the major endemic diseases; the impacts of these diseases on commercial farms was variable. Several changes in the existing rust populations were observed that may be of lasting consequence.

A new race of stem rust (Isolate 17/80), identified in Brazil, attacks Pato resistance. In addition, Sr 25 (Agatha), which was effective throughout the region (except in Chile), became susceptible during 1981. These changes have caused great concern among the wheat breeders in Brazil, since a majority of their advanced lines and multiplications have become susceptible to stem rust for the first time.

Another stem rust virulence on Brazilian wheat varieties CNT 8 and BR 4 (carrying resistance from ND 81 and Sinvalocho Gamma, respectively) was detected in "La Estanzuela," Uruguay, a hot spot

Table 2. Wheat varieties released in the Southern Cone region, 1981

Country	Variety	Line	Cross and Pedigree	Institution
Argentina	La Paz INTA	P77/5450	Son 64-VIL 23 x JAR"S"/PPI 2:71-74T-1T-1T-1T	INTA
	Klein Atalaya*		N066-Bb x CC-We CM 12263	Klein Seeds
Brazil	Xavantes	IAC 18	BH 1146^{4}- S12	IAC
	Marcai	IAC 17	IAS 20 - IRN 526.63	IAC
	Aracatu	IAPAR 3	Unknown Pedigree	IAPAR
	Jandaia	OC 73124	Unknown Pedigree	OCEPAR
	Anahuac*		II 12300 x LR64 - 8156/NOR 67	IAPAR/OCEPAR
	Cocoraque*		II 12300 x LR64 - 8156/NOR 67 II 30842-58R-1M-4Y-OM	IAPAR/OCEPAR
	BR 7	PF 72206	IAS 20 - Toropi	EMBRAPA
Chile	Ancoa INIA	Q 10-063	(T/Chin 166-KF x L/N/M^{2}-ME)NOR 10-YT54 A 2602-1p-1p-1p	INIA, Chillán
	Labriego INIA	Q 5-71	HdB-Vg 8881/(Fn-K58/N x N10 B)Y54/ N 1674-2C-1C-1C	INIA, Chillán
	Carolina		Collafen Mutant	Catholic Univ.
	Victoria*		Pavon "S" CM 8399-D-4M-3Y-OM	Catholic Univ.
Paraguay	C 7659	Pel 72214	Unknown Pedigree	IAN
Uruguay	E. Hornero	LE 805	Novafen - Kl. Impacto	La Estanzuela
	Trigal 800		$Scout^{5}$- Agent x NAD 63-CO 652643	Cargill

* CIMMYT origin.

for stem rust infection. Its spread to Argentina and Brazil will take but a short time and should be carefully monitored.

Trigal 800 (Argentina) and Tifton (Brazil) wheat varieties carry leaf rust resistance from Agent (*Agropyron elongatum*, Lr 24). They were released in 1980 and became susceptible in 1981. However, the new virulence provided a good screening measure for the breeding materials. Fortunately, a low inoculum build-up during the first year prevented widespread damage in commercial fields, but 1982 may be critical.

Breeding for stripe rust resistance in Brazil has traditionally been of lesser importance. However, for two consecutive years farmers in Rio Grande do Sul State have had to protect their wheat crops through chemical control. This may be a temporary manifestation of very favorable conditions for the parasite, but if inoculum continues to build up over the years, it may cause serious epidemics on the present varieties.

In Chile, a further build-up of stripe rust race 236 E 141 (which attacks Clement) and/or a new race, 238 E 143, identified on a new variety (Manquefen), caused serious concern among wheat farmers in the south. A prolonged drought and higher than normal spring temperatures controlled the spread of the disease and reduced losses. However, the potential danger is likely to change the varietal mix; the area planted to an older resistant variety (Manella) may well increase significantly in the next cycle.

Stripe rust race 24 of barley kept moving southward in Chile and seriously infected the barley crop in the south-central and coastal regions. Although its presence in the southern region has been noted at the experimental station, it still has not affected farmers. This may eventually happen in 1982, since all presently cultivated varieties are severely susceptible. In the meantime, traces of susceptible reactions have been observed on Emir, thus far resistant, in Ovalle (northern Chile). This potential susceptibility needs to be checked further.

Septoria leaf blotch attacks vast areas of wheat in the region and causes an undetermined amount of damage every year. Septoria glume blotch is severe only in certain years. There was little damage due to *Septoria* spp. in farmers fields during 1981, but heavy infections at several experiment stations provided a good screening of materials. Some new

Dr. M.M. Kohli, breeder/pathologist, coordinates CIMMYT's breeding and pathology activities in the Southern Cone.

lines included in the 11th ISEPTON provided a good level of resistance. Some of the outstanding lines are listed here:

Bobwhite"S"	CM 33203-K-8M-1Y-0M-0Ptz
Junco"S"	CM 33483-C-7M-1Y-0M-20B-0Y-2Ptz-0Y
Trifon"S"	F4-5Y-0M-2Y-0Y-1Ptz-0Y
Veery"S"	CM 33027-F-15M-500Y-0M-6B-0Y-1Ptz-0Y
Aepoglom - II 64.27	MN 72131 0Ptz
Kvz - K 4500 L-A.4	SWO 176-3M-1Y-4M-1Y-0Y-1Ptz-0Y-1Ptz-0Y
Bage - Hork"S" x Aldan "S"	CM 48016-P-2M-1Y-1M-0Y-1Ptz-0Y
GV-Azt 67 x Mu"S"	CM 41257-I-8M-1Y-1M-2Y-2M-0Y-0Ptz
Maringa - Aldan"S"	CM 46961-13M-1Y-2M-001Y-4Ptz-0Y
IAS 20 - H 567-71	CMH 76.480-13Y-5B-1Y-2B-2Y-1Ptz-0Y
IAS 20^2- H 567.71 x IAS58	CMH 77.213-2Y-1B-1Y-2Ptz-0Y

A severe head scab (*Gibberella zeae*) infection in southern Brazil and Uruguay permitted an effective selection among advanced materials. Only five lines (representing three crosses) in the 14th IBWSN demonstrated any appreciable level of resistance at "La Estanzuela." The following lines appear to have some resistance, and need to be checked more carefully through artificial inoculation:

Bobwhite"S"	CM 33203-H-8M-1Y-2M-3Y-1M-0Y
Sparrow"S" - Grajo"S"	CM 35195-1M-3Y-4M-4Y-1B-0Y
Mrs x Kal-Bb/Azt	CM 43429-H-1Y-1M-1Y-1M-1Y-0B
Mrs x Kal-Bb/Azt	CM 43429-H-1Y-1M-2Y-1M-0Y
Mrs x Kal-Bb/Azt	CM 43429-H-1Y-1M-2Y-3M-1Y-0B

Using a backcross breeding procedure and a needle inoculation technique, EMBRAPA—Brazil has developed some advanced materials with good plant type that carry scab resistance. A collection of scab resistant sources from Brazil was distributed through CIMMYT to Argentina, Hungary and China for field screening, but results are not yet back. Identification of additional scab resistant materials will be of immense importance to the whole Southern Cone region, possibly reducing the need for investments in chemical control.

Three years of field screening in southern Chile against take-all and root rot provided data with many inconsistancies. Artificial inoculation seems to be required to effectively screen for these diseases. A small amount of material that was artificially inoculated in Chillan provided no useful resistance information. Thus, it may be necessary to expand the scale of innoculation efforts to get any worthwhile results.

The near absence of BYD in the region (except on a drought affected crop in Balcarce, Argentina) added further uncertainty to the effectiveness of selections made under field conditions. Artificial inoculations of advanced wheat lines and F_2 populations in Santiago, Chile, proved to be very effective in the identification of field resistant types.

As to loose smut, some problems have been recently reported in Argentina and Uruguay regarding the effectiveness of *Vitavax* as a control. These reports need to be checked and the necessary steps taken to reduce an already high level of infection.

Training and regional visits

Seven wheat scientists from the region visited CIMMYT, Mexico, for a month or more to participate in various program activities. Periodic contact with CIMMYT researchers in Mexico provides regional scientists with an opportunity to learn about the objectives and orientation of CIMMYT's base program. It also enables the modification of certain activities at CIMMYT headquarters to meet regional needs. This two-way flow of scientific information, as well as the active participation of national program scientists in the identification of needed research, leads to more effective cooperation on an international level.

Providing support to national programs and acting as a permanent contact with them, especially at the critical stages of crop development, is an integral part of CIMMYT's regional activities. Over 160 man-days were spent with the national research programs within the Southern Cone region during 1981, participating in the planning and excecution of various research activities.

Seminars and conferences

CIMMYT staff participated in three technical and two planning meetings on wheat research coordination held in the region through cooperation with IICA Cono Sur/BID Project. In addition, regional staff attended a seminar held in Argentina on the Breeding and Physiology of Yield.

Southern Cone Agronomy Program

M.A. McMahon, Agronomist

The Southern Cone wheat agronomy program completed its third year in 1981. The activities established in 1979 and 1980 were continued, with field work occurring both in Argentina and Chile. Contact was also maintained with the ongoing activities in Brazil, Paraguay and Uruguay. To complement to this field work, support was also given to national prgorams by providing material (machinery, etc.) and by sending visiting scientists to the base program in Mexico.

Chile (Central Coastal Area)
Evaluations of the limitations to yield under farmer conditions were continued in 1981 on the marine terraces of the 5th and 6th Regions in collaboration with INIA (Instituto de Investigaciones Agropecuarias). These experiments are not designed nor intended for economic evaluation. Rather, the objective is to determine which factors are limiting wheat yields and their relative importance. The agronomic treatments were changed from the previous year. Results from 1980 indicated that the application of phosphorus alone did not affect yields, hence this factor was not included in the experiment in 1981. The herbicide treatment was also dropped for the same reason. Bayleton was applied as a fungicide treatment to control *Septoria tritici*, as this is the main diseasecausing organism in the area. Bayleton is also active against the rusts (*Puccinia* spp).

The following six treatments were superimposed on the farmers' sowing as soon after sowing as possible:

1. Check
2. Check and Bayleton
3. Nitrogen (N)
4. N plus Bayleton
5. N plus phosporous (NP)
6. NP plus Bayleton

The dosage of each factor was as follows:

N: 150 kg/ha, applied as urea in two applications each of 75 kg/ha at sowing and 75 kg/ha at tillering;

P: 90 kg/ha as triple superphosphate applied (broadcast method) at sowing;

Bayleton: Two applications of 500 g/ha of the commercial product were made to keep the flag leaf free of disease.

All experiments received a general application of herbicide, MCPA 750 Amine (1 lt/ha) and Illoxan (1 lt/ha). All sowings were done in late May and early June, which is normal for the area. The harvest was completed between December 10 and December 23.

The soil and variety data for each site are presented in Table 1. Six sites were planted to improved varieties and four were sown to traditional varieties. The soil data pertain to the top 20 cm of soil surface. All soils were low in inorganic nitrogen and only one soil (site 2) had a high level of P (Olsen). A very wide variation in the exchangeable potassium (K) content was noted, ranging from 670 ppm to 43 ppm. Results are presented in Tables 2 and 3.

Dr. M.A. McMahon, agronomist, coordinates CIMMYT's Southern Cone agronomy program.

As can be seen from Table 2, there was a considerable variation in yield levels across sites. The range for the NP+Bayleton treatment was from 1360 kg/ha to 7540 kg/ha. As might be expected, this was due to site differences. However, it appears that the most important site variable for achieving maximum yields was the exchangeable K content (Table 1); there was a significant correlation ($r^2 = 0.71^*$) between exchangeable K and maximum yields. This makes it difficult to assess the relative contribution of the improved varieties.

Table 1. Soil analysis and variety data for each site in the V and VI Regions of Chile, 1981

Location	pH	$N(NO_3^- + NH_4^-)$ ppm	P(Olsen) ppm	Exch. K ppm	Variety
1	6.9	29	6	670	Aurifen (Improved)
2	6.3	15	14	148	Andifen (Improved)
3	6.2	12	4	60	Lucero (Improved)
4	6.7	8	7	48	Libun (Traditional)
5	6.8	11	6	309	Menflo (Traditional)
6	6.2	70	7	43	SNA-2 (Improved)
7	6.8	21	6	340	Aurifen (Improved)
8	6.4	9	5	64	SNA-2 (Improved)
9	6.5	1	3	48	Libun (Traditional)
10	6.1	4	5	64	Libun (Traditional)

Table 2. Yield data (kg/ha) for each site in the V and VI Regions of Chile, 1981

Site	1	2	3	4	5	6	7	8	9	10	$\bar{x}$
Treatment											
NP + Bayleton	7540	4220	5380	1360	5140	3000	6590	3280	3240	2430	4220
NP	7280	4400	5330	1590	5180	2700	6530	2940	2230	2280	4050
N + Bayleton	6420	4400	4580	740	4100	2710	6710	2700	1050	2090	3550
N	6290	4420	4520	960	3970	2700	6580	2850	1190	2260	3570
Check + Bayleton	4160	3860	2080	640	4080	1300	5540	1950	960	1500	2610
Check	4940	3010	2470	440	3730	1230	4980	1780	900	1610	2510

There were substantial yield gaps (Check minus NP+ Bayleton) at all sites, which ranged from 815 kg/ha to 2910 kg/ha and averaged 1710 kg/ha. Nitrogen was the principle factor contributing to these gaps, making an average contribution of 1000 kg/ha. The NP treatment also made a significant contribution, averaging 1580 kg/ha, and was significantly higher than the N contribution at six of the the sites. Bayleton did not make a significant contribution, which was an expected result because of the dry spring experienced in 1981. The incidence of disease was therefore very low.

Thus, results of these experiments have shown that (1) there is a high correlation between maximum yields and exchangeable K content, (2) a large yield gap exists even in the absence of K and the most important factor contributing to this yield gap is nitrogen, and (3) the NP treatment also made a significant contribution at the majority of sites.

Chile (South Central Area)

Four productivity trials were conducted in this region, two in red granitic soils and two in volcanic soils (trumao). The treatments in this area were:

1. Check
2. Nitrogen (N)
3. Phosphorus (P)
4. Nitrogen and phosphorus (NP)
5. Weed control (WC)
6. Nitrogen and weed control (N+WC)
7. Phosphorus and weed control (P+WC)
8. Nitrogen and phosphorus plus weed control (NP+WC)

In the granitic soils, the fertilizer applications were 70 kg/ha of N and 70 kg/ha of P_2O_5. Weeds were controlled with a mixture of MCPA and Dicamba (1 lt + 0.25 lt, commercial product). Wherever wild oats (*Avena fatua*) posed a potential problem, they were controlled with Mataven (4 lts/ha, commercial product). At the two sites on volcanic soils, a treatment of Bayleton was added (500 cc/ha, commercial product) to control leaf rust (*Puccinia recondita*) on the susceptible variety Manquefen. Results for the granitic soils are presented in Tables 4 and 5. As is shown, actual yield levels are quite low on these soils. However, site 1 produced higher yields than site 2, which may be due to varietal differences; at site 1 an improved variety, Antufen, was used while at site 2 the old traditional variety, 1500, was used. A substantial yield gap existed at both sites, most of which was accounted for by a joint application of nitrogen and phosphorus. Neither of these elements alone accounted for much of the yield gap. Weed control made a very small individual contribution, but there was a nitrogen-weed control interaction.

Table 3. Yield gap (kg/ha) and the contribution of each factor (kg/ha) for each site in the V and VI Regions of Chile, 1981

Site	1	2	3	4	5	6	7	8	9	10	$\bar{x}$
Factor											
Yield Gap	2600	1210	2910	920	1410	1770	1610	1500	2340	815	1710
Bayleton	-130	220	-90	-80	150	130	250	120	310	-50	80
N	1800	980	2270	310	140	1440	1380	910	190	620	1000
NP	2860	880	3080	930	1260	1580	1300	1250	1810	800	1580

Table 4. Yield (kg/ha) in granitic soils at two sites in South Central Chile, 1981

Treatment	Site 1 Var. Antufen	Site 2 Var. 1500
Check	810	700
N	1390	800
P	890	800
N + P	2560	1340
WC	880	750
N + WC	1380	930
P + WC	1070	950
N + P + WC	3150	1600

Table 5. Yield gap and the individual and joint contributions (kg/ha) of the different factors in granitic soils at two sites in South Central Chile, 1981

	Site 1 Var. Antufen	Site 2 Var. 1500
Actual Yield	810	700
Potential Yield	3150	1600
Yield gap	2340	900
Individual Contributions		
Weed Control	70	50
Nitrogen	580	100
Phosphorus	80	100
Joint Contributions		
Weed Control + Nitrogen	570	230
Weed Control + Phosphorus	260	250
Nitrogen + Phosphorus	1750	640

At the same time these experiments were being carried out, a survey of thirty wheat producers was conducted in the area. An evaluation was made of their fields and a questionnaire was filled out at each farm. The general results of the survey area are as follows:

Tenacy — The majority of the wheat in the survey area is produced under a share-cropping system. The landowner supplies land and half of the production inputs. The sharecropper supplies labor and the other half of the inputs. The resulting crop is evenly divided (50-50) between the farmer and sharecropper.

Access to new varieties — All farmers surveyed were unaware of the new varieties released by the experimental stations.

Power — All power for land preparation and sowing is supplied by horses and bulloks. This limits the area sown, which usually does not exceed 3 hectares per sharecropper.

Method of sowing — All seed is broadcasted and covered with a plough, leading to a very uneven depth distribution of seed.

Seed treatment — All farmers used seed treatment.

Source of seed — Certified seed is never used and only 15 per cent of the farmers select their seed. They usually keep seed grain from the previous harvest or interchange seed with neighbors.

Seed rate — The seed rate used by farmers in the area is between 110 kg/ha and 140 kg/ha.

Date of sowing — Sowing is done after the rains in May. Later sowing is not possible because the soils become saturated.

Varieties — About 93 per cent of the farmers interviewed sow varieties that mature too late for these condidtions. Newer, earlier varieties are apparently unknown in the area.

Fertilization — Some 53 per cent of the farmers interviewed do not use fertilizer. The remaining 47 per cent only apply nitrogen at tillering and in very small quantities (less than 20 kg/ha). Phosphorus is not used as a fertilizer.

Weed control — Of the farmers interviewed, 65 per cent have never applied herbicide, and the rest do so late when the weeds are in flower.

Wheat use — Seventy-five per cent of the farmers surveyed are able to meet their own consumption needs with the wheat they produce. The remaining 25 per cent must buy wheat to meet their needs.

Table 6. Yield (kg/ha) in volcanic soils at two sites in South Central Chile, 1981

	Site 1		Site 2	
Treatment		+ Bayleton		+ Bayleton
Check	5060		3750	
N	4790		1540	
P	5630		3830	
N + P	4530		2700	
WC	4710	5350	5250	5740
N + WC	4970	5580	4200	4690
P + WC	5230	5780	5150	6610
N + P + WC	5370	5790	4490	5690

The results of the productivity trials carried out in the volcanic soils are shown in Table 6 and 7. Manquefen was the variety used in both cases. Site 1 was very fertile, having had a subterranean clover pasture for the previous five years. The only factor that made a significant contribution was phosphorus; nitrogen and weed control made negative but non-significant contributions. The average response to Bayleton at this site was 580 kg/ha.

Site 2 had a yield gap of 1500 kg/ha, all of which was accounted for by weed control. Nitrogen made a negative and a very significant contribution of 2210 kg/ha, which was due to enhanced growth and competition of wild oats. The nitrogen and weed control treatments did not make a significant contribution. It seems that the wild oat vigor induced by the application of nitrogen was only partially reduced by weed control, and this was evident wherever N was applied. The average yield increase due to Bayleton at this site was 910 kg/ha.

Argentina

INTA Pergamino continued its work on the exploration of nutrient deficiencies in wheat in the Pampa Humeda. A nitrogen-phosphorus trial was carried out at twenty locations. Even though it was a dry year (rainfall between sowing and tillering ranged from 3 to 71 mm and averaged 39 mm across sites), there were strong responses to nitrogen and phosphorus throughout the area. The data are summarized in Tables 8 and 9.

The average check yield was 2260 kg/ha and the average maximum yield was 3310 kg/ha (Table 8). To reach maximum yields, nitrogen was needed at all twenty sites; phosphorus was required at eighteen sites. In Table 9, the optimum economic yields are calculated for two cost: price ratios (cost of fertilizer: price of wheat). At a ratio of 5:1, nitrogen gave an economic response at 80 percent of the sites while phosphorus gave an economic response in 50 percent of the trials. When the ratio changed to 8:1, the percentages were 65 percent and 35 percent, respectively. Across those sites showing a response, the average economic response was 1000 kg/ha when the ratio was 5:1 and 915 kg/ha when the ratio was 8:1.

These data show that nitrogen is almost universally deficient in the area and that economic responses can be achieved, even under dry conditions such as those experienced in 1981. Phosphorus is also widely deficient. As shown in the 1980 Southern Cone Agronomy report, the deficiency of phosphorus can be accurately diagnosed through soil tests. Efforts to better characterize the response to both N and P will continue.

Table 7. Yield gap and the individual and joint contributions (kg/ha) of the different factors in volcanic soils at two sites in South Central Chile, 1981

	Site 1	Site 2
Actual Yield	5060	3750
Potential Yield	5630	5250
Yield Gap	570	1500
Individual Contributions		
Weed Control	-350	1500
Nitrogen	-270	-2210
Phosphorus	570	80
Joint Contributions		
Weed Control + Nitrogen	-90	450
Weed Control + Phosphorus	170	1400
Nitrogen + Phosphorus	-530	-950

Table 8. Check yields (kg/ha), maximum yields (kg/ha) and doses of N and P_2O_5 (kg/ha) necessary for maximum yields, Pampa Humeda, Argentina, 1981

Site	Yt	Y max	Y max-Yt	N	P_2O_5
1	1260	2450	1190	90	79
2	1460	2060	600	81	9
3	1750	3290	1540	119	52
4	1570	2410	840	86	35
5	1120	2910	1790	52	142
6	2970	4120	1150	140	79
7	2300	3400	1100	82	66
8	2300	3560	1260	112	9
9	2760	3550	790	145	0
10	2480	4060	1580	170	69
11	3460	3700	240	44	26
12	2120	2350	230	77	35
13	2810	4550	1740	100	66
14	1890	2890	1000	61	80
15	2010	3060	1050	93	57
16	2230	3980	1750	93	0
17	2750	3630	880	84	56
18	2770	3950	1180	107	106
19	2990	3760	770	98	97
20	2240	2590	350	74	57
$\overline{X}$	2260	3310	1050		

Yt = Check yield

Y max = Maximum yield

Table 9. Check yields (kg/ha), optimum economic yields (kg/ha) and the optimum economic rates (kg/ha) of N and P_2O_5 under two different price regimes, Pampa Humeda, Argentina, 1981

Site	Yt	$Y_{o.e.}$		$N_{o.e.}$		$P_2O_{5o.e.}$		$Y_{o.e.}-Y_t$	
		a	b	a	b	a	b	a	b
1	1260	2280	2060	57	38	50	35	1020	800
2	1460	1620	-	12	-	-	-	160	-
3	1750	3140	2930	90	73	23	8	1390	1180
4	1570	2270	2120	56	38	-	-	700	550
5	1120	2770	2560	50	48	88	58	1650	1440
6	2970	3760	3450	68	26	41	24	790	480
7	2300	3230	2900	33	-	47	31	930	600
8	2300	3560	3500	97	89	-	-	1260	1200
9	2760	3390	3040	87	32	-	-	630	280
10	2480	3810	3600	118	87	-	-	1330	1120
11	3460	-	-	-	-	-	-	-	-
12	2120	-	-	-	-	-	-	-	-
13	2810	4460	4290	75	59	52	42	1650	1480
14	1890	2700	-	-	-	67	-	810	-
15	2010	3010	2910	68	54	-	-	1000	900
16	2230	3960	3890	85	74	-	-	1730	1660
17	2750	3400	3210	49	28	5	-	650	460
18	2770	3640	3440	57	36	69	54	870	670
19	2990	3420	-	25	-	40	-	430	-
20	2240	2330	-	-	-	-	-	-	-

Y_t = Check yield

$Y_{o.e.}$ = Optimum economic yield

$N_{o.e.}$ and $P_2O_{5o.e.}$ = Rate of N and P_2O_5 to produce optimum economic yields

a = When $\frac{\text{Price N}}{\text{Price Wheat}}$ and $\frac{\text{Price } P_2O_5}{\text{Price Wheat}} = 5$

b = $\frac{\text{Price N}}{\text{Price Wheat}}$ and $\frac{\text{Price } P_2O_5}{\text{Price Wheat}} = 8$

North and West Africa and Iberian Peninsula

G. Varughese, Breeder/Pathologist

Introduction
The CIMMYT wheat, barley and triticale regional program for North and West Africa and the Iberian Peninsula is based at the National Plant Breeding Station at Elvas, Portugal. The Portugese Ministry of Agriculture and Fisheries provides facilities for program personnel, whose offices are located at the Ministry headquarters in Lisbon.

The basic objective of this regional effort remains one of strengthening national research programs (1) by supplying germplasm, (2) through short term training, (3) by supplying some critical equipment, and (4) through technical consultancy by CIMMYT's regional staff and staff from the base program in Mexico. The program also strives to provide an active linkage between the various research programs and institutions of the different countries within the region.

Wheat area
A total of about 16 million hectares of winter cereals are grown each year in the North African and Iberian regions. In North Africa, durum wheats are predominant (48 percent of the total winter cereal area) and are closely followed by barley (38 percent of the total). Bread wheats occupy only about 20 percent of the area. However, in Morocco barley is a more important crop and is grown on a little over 50 percent of the area. In contrast, durum wheat occupies a negligible portion of the total winter cereal area of the Iberian Peninsula (some 2 percent). In Spain, barley is the main crop (53 percent of area), closely followed by bread wheat (45 percent), while in Portugal bread wheat is the predominant crop (58 percent) followed by rye (28 percent) and barley (12 percent).

Wheat is a relatively new crop in West Africa. Technical advice is being provided to nine West African countries in which wheat is, at present, grown on a limited area or in which wheat production experiments are either underway or being planned. In this regard, Nigeria is the most advanced among these nine countries with about 13.8 thousand hectares of bread wheat. Smaller areas in Mali, Niger, Chad, Cameroon and Mauritania are devoted to bread wheat.

Production conditions
Nearly all of the wheat areas in North Africa and the Iberian Peninsula are rainfed environments. The 1981-82 season was probably the driest of the last 100 years for Portugal, Spain and Morocco. As a result, in many places within these three countries the crop completely failed. In those locations where it survived, production was less than half that expected. Algeria had an average crop, while in northern Tunisia the crop was good. Central and southern Tunisia were very dry and production was correspondingly reduced.

In West Africa, the entire wheat crop is irrigated. The season is very short, extending only from November 15 to about the beginning of March. Soils in many West African countries have a high clay content and, as a result, water penetration is very low. Since temperatures during most of the growth cycle are high, evapotranspiration rates are also very high. Thus, the crop requires relatively frequent but light irrigations.

Diseases and stresses
Drought, coming at various stages of the crop, is a major limiting production factor in the region of North Africa and Iberia. During wet years, septoria diseases and stripe rust can be very damaging. Next in importance is leaf rust. Some stem rust, helminthosporium, fusarium and powdery mildew are also found.

In general, there are no serious wheat disease problems in West Africa, except in Cameroon where the crop is grown on the high plateau during the end of the rainy season. Septoria, fusarium and helminthosporium diseases are the major problems in Cameroon; in all the other West African countries, heat tolerance is the overriding requirement.

Varietal status

In the Andaluzian region of Spain, more than 80 percent of the cereals area is devoted to varieties with CIMMYT germplasm in their pedigrees. Anza is the predominant variety, followed by Cajeme 71 and Yecora 76. Pavon 76 and Nacozari 76 soon will be entering in market. The crosses Veery, Bobwhite, Car-Ana, Dove and many others are in the advanced stages of varietal register trials and are likely to be released in 1983. Mexicali, although not yet registered, is grown on a sizable area.

In Portugal, Anza is the leading variety, followed by some Italian and French varieties. Three new bread wheats and three new durum wheats are proposed for registration trials this year:

VOGA (bread wheat)	Npo-Cdl x Zbz CM8935-D-5M-3Y-3M-2Y-OM
LIMA.1 (bread wheat)	Veery No. 3 CM33027-F-12M-1Y-6M-0Y
ALMANSOR (bread wheat)	E4870-C306 x M5392-666.5/Bb x CC-INIA CM22099
TIMPANAS (durum wheat)	Gerardo 469-Gr"S" CM362-21M-2Y-7M-0Y
HELVIO (durum wheat)	Jo"S"-AA"S" x Flg"S" CM9799-126M-1M-5Y-0Y
CELTA (durum wheat)	Plc"S"-Ruff"S" x Gta"S"-Rlte CM17904-B 3M-1Y-0M

Dr. G. Varughese (far right), breeder/phathologist, coordinates CIMMYT's regional program in North and West Africa and the Iberian Peninsula. Here he explains to a group of Disease Methodology Workshop participants the workings of an ultra-low volume sprayer. (Photo: C. R. Dowswell)

In North Africa there was no significant change from the varietal situation that prevailed in 1980, except that in Morocco a sizable quantity of Inrat 69 was imported from Tunisia because of the shortage of seed due to the drought.

In West Africa, Siete Cerros and its derivatives are the predominant varieties. Since foliar diseases are not very important, varietal improvement efforts for this region should focus on incorporating better heat tolerance. The plant breeding department of the Ahmed Bellow University of Zaria, Nigeria, is the only national institute currently capable of doing any varietal screening for this region.

Triticales

Portugal grows about 150 thousand hectares of rye in its northeastern hilly regions. The soils in this region are acidic and of very poor quality. The winters tend to be very harsh. Trials conducted by the University of Vila Real shows that some of the selections from the winter triticales of France do very well. The best selections are 532-4 and 532-8. Where the winters are not harsh, Beagle also looks very promising. In the Alentejo, which is the main wheat area of Portugal, triticales also perform well. Armadillo, Beagle, Mapachi, Arabian and Bacum are on the official list of varieties in Portugal. Eight new lines are proposed for registration trials this year by the National Plant Breeding Station of Elvas:

Borba 1	Bgl"S"xM_2A-Cin	X15673-A-1Y-2Y-1M-0Y
Borba 2	Bgl"S"xM_2A-Cin	X15673-A-1Y-2Y-6M-0Y
Pantera 1	Tejon-IRA	X13895-B-100Y-101B-100Y-1M-2Y-0M
Pantera 2	Tejon-IRA	X13895-B-100Y-101B-100Y-1M-2Y-0M-0Y
Terrugem	M_2A^2-Cin	X7272-14M-1Y-100M-0Y
Vedor	M_2A-IA	X12677-40Y-1Y-1M-0Y
Avis	Inia-Arm"S"	X1648-9N-0M
Monsanto	Maya II-Arm"S"	X2802-70N-3M-1N-2M-0Y

Cereal trade in Portugal is controlled by the government and the price offered for the triticales is very attractive. It has been set at a level equal to that of the number two grade wheat. Since triticales yield better than wheat in many locations, the triticale area in Portugal is likely to increase in the near future.

In Spain, triticales are performing well in many locations and a number of varieties are available (Cachirulo, Mahissa 26, Cirro, Manigero, Torote and Yoreme). Mapachi is likely to be released in 1982 under the name Balboa. Since there is no definite governmental policy at present regarding triticales, the increase in commercial production will probably be slow.

Tunisia currently has about one thousand hectares devoted to seed multiplication of different selections of M_2A. Production of triticale as a feed grain is being encouraged by the government, but as yet no price for the triticales has been set. It is anticipated that triticale will receive a price slightly higher than barley, which currently commands about 20 percent less than bread wheat.

Disease methodology workshop

The seventh wheat disease methodology workshop was held at the National Plant Breeding Station, Elvas, from April 27 to May 7, 1981. It was jointly organized by the INIA of Portugal, IPO of the Netherlands, and CIMMYT. Twenty people representing nine countries participated in this training effort. As part of the workshop, each of the countries represented received a complete set of the equipment demonstrated and used by workshop participants. This equipment was a donation by the Royal Government of the Netherlands. As a result of this training and equipment, it is anticipated that the programs of the region will be able to better screen their breeding materials against prevalent diseases.

Eastern and Southern Africa

G. Kingma, Breeder/Pathologist
H. Bonthuis, Pathologist

Introduction
Improved distribution of germplasm was the main focus of wheat research cooperation in the region during 1981. Follow-up visits to selected countries (such as Ethiopia and Zambia) helped in identifying promising material. Intensive preliminary disease screening in Kenya reduced the number of introduced materials by 99 percent. The best remaining lines were then distributed to 16 national programs in the region.

Germplasm resources in the region
Bread wheat—Romany and Romany Backcross bread wheats perform very well under acid soil conditions and are grown widely in Eastern Africa. This type is found in Ethiopia, Tanzania, Rwanda, Burundi, Madagascar and Zaire. Cultivation was banned in Kenya about a decade ago due to stem rust risk.

A second bread wheat type with wide adaptation is the Kenyan cross K 4500, known in Ethiopia as Enkoy, in Tanzania as W 3697 and in Zambia as Tai. It was not released in Kenya because it did not meet Kenyan bread-making quality standards. In recent years, several varieties with Tobari 66 and CI 8154-Frocor2 in their pedigrees have been widely grown in Kenya. The use of these varieties is expanding in Tanzania, Uganda and elsewhere. The largest acreage to date has been occupied by K Fahari and K Tembo. Commercial use of the K 6290 cross is also expanding; it is known as K Nyati in Kenya and Malawi and other selections in Ethiopia, Tanzania, North Zambia and possibly Mozambique.

Dr. G. Kingma, breeder/pathologist, coordinates CIMMYT's regional activities in Eastern and Southern Africa.

Such Mexican semidwarf wheat types as Inia 66, Yecora 70 and other Bluebird varieties have been widely used in Southern Africa. Under dryland conditions, the semi-winter wheat Scheepers 69 has occupied many thousands of hectares. Intensive management of Bluebird has resulted in yields of over 10 tons. In Zimbabwe, Gwebi is widely used; in Mozambique, Helene S 13 and Yecora are promising; T4 Resel, an Anza type, is also widely grown in Southern Africa.

Durum wheat—Ethiopia primarily grows durum wheats. The local types are well adapted to difficult soil conditions and to water logging. A major requirement for new durum varieties in Ethiopia is stem rust resistance, as that will allow planting earlier in the rainy season.

Barley—Barleys are a major food crop in Ethiopia, and it has been difficult to replace well-adapted local barleys with such varieties as IAR/H/485 and Composite 29. Malting barleys are grown in Kenya and Ethiopia. The varieties Proctor and Research have been widely used, and in Ethiopia the use of Beka and more recently Holker, is expanding. In Kenya, Tumaini is replacing the older varieties.

Triticale—During the 1970s the potential for this crop was rapidly established in the region. Ethiopia led the way in reporting 30 percent higher yields than bread wheat. Maya 2-Armadillo selections were especially good. In Kenya, this was confirmed and, after several years of testing, Tcl 65 was released. This line was the top yielder in five years of yield tests in the whole region. Triticale is in the advanced stages of testing in several countries, e.g., Uganda, Rwanda, Zaire and Burundi. In Rwanda, three triticales have been released (Moshi, T 65 and T 74).

Beagle triticales have also been tested in the region with encouraging results. The full complement of rye chromosomes in these types has helped them to better adapt to acid soil conditions.

Germplasm evaluation in Kenya
In 1981, the Off-Season Nursery (5000 entries) was harvested in Njoro and selections were made on the basis of stem and stripe rust resistance. Over 350 lines were included in the 1981 Repeat Nursery. In the main season, most of the new introductions were planted in mid-May, and after some initial rains they were exposed to prolonged drought. The 20,000 lines developed very heavy *Helminthosporium tritici-repentis* and fair stripe rust. Also stem rust was heavy in durums and quite serious in triticales. Late in the season bread wheats also suffered from stem rust.

In Eldoret and Molo, special groups were screened for septoria and stripe rust, respectively. These locations are hot spots for these diseases. The selections made at each site will be included in the 1982 Repeat Nursery. In November, 1981, the new Off-Season Nursery was planted, which was partly made up of entries that are under multiplication from the latest Screening Nursery for the African Cooperative Wheat Yield Trial (SNACWYT) and the African Coopertive Wheat Yield Trial (ACWYT). New introductions were also planted, such as the Parcelas Chicas from CIMMYT, Mexico, and the observation nurseries from the Near East.

The best-performing bread wheats, durums, triticales, barleys and oats under 1981 conditions in Kenya were distributed to 20 locations in the region. Larger seed quantities of SNACWYT entries were provided for preliminary yield testing during 1982 in Kenya.

Regional yield trials and screening nurseries
The 1981 ACWYT included 15 entries and a local check. Results obtained in 10 locations clearly indicated again the top performance of T65 and Beaver-Armadillo triticales. Among the bread wheats, Veery was excellent. Also DZ1-Tob(Nad-Lr64xBb/Bb-Nor 67) proved to be a high yielder in 5 of the 10 reporting locations. The good adaptation of the triticales in the region has now been demonstrated in the ACWYT trials for five years, including 66 station years and covering 50 carefully selected bread wheats, durums and triticales. The varieties already in full use in the region have often been used as checks, and the introduced triticales and bread wheats were generally superior.

The varieties included in the yield tests were selected from the regionally conducted screening nursery, SNACWYT. This group of bread wheats, durums, triticales and barleys constitute the top one percent of the materials that passed through at least two crop cycles in Kenya under heavy stripe and stem rust pressure. In 1981, some 225 bread wheat lines were included, many with Kavkaz and Alondra as one of the parents. Others from Mexico, Turkey, Lebanon, Brazil and Ecuador were also selected and frequently reselected in Kenya. Cooperators in Botswana, Burundi, Ecuador, Egypt, Ethiopia, Swaziland, Syria, Tanzania and Zaire reported on the performance of these lines.

Thirty-three lines were identified as important candidates for further evaluation, based on all the cooperators' reports, as well as field inspections in 10 locations. Finally, 11 entries were chosen for the 1982 ACWYT:

3	Kavkaz-K4500	SW0176-3M-1Y-4Y-1Y-1M-0Y-1Ptz-0Y
21	Golden Valley-Az67xMus	CM41257-I-8M-3Y-0M
37	Kavkaz Cno-Pj62	SWM1285-2Y-3M-1Y-0M-3Ke-0Ke
48	Kavkaz-Ciquena	SE1066-95-1S-6S-0S-6Ke-0Ke
64	Veery	CM33027-F-12M-1Y-5M-1Y-0M-2Ke-0Ke
70	Bobwhite	CM33203-G-9M-2Y-501M-500Y-0M-1Ke-0Ke
179	Hahn	CM33682-L-1Y-12M-500Y-0M
220	Yamhill-TobxRon	SE1756-7S-2S-5S-0S-3Ke-0Ke
142	Pichihuila-HD2206	CM40655-5M-3Y-3Y-3M-2Y-0M
106	Gyrak = Chova	CM34603-A-1M-6Y-4M-1Y-2M-0Y
13	KavkazxBb-Cha/Torim	CM30832-Z-3Y-1M-4Y-1M-0Y-1PtZ-0Y

Durums included in the 4th SNACWYT (1981) comprised many lines from Ethiopia, where they were selected under heavy stem rust pressure at Debre Zeit. Some reselections from Mexican crosses proved quite resistant in Kenya, e.g., P66/253-FgxPg-Cit, CM18040; Heron, CM17747;

and Frigate, CM17904. In Ethiopia the cross Gerardo VZ512-Cit x Ruff-Fg was free from stem rust in 1979. It was renamed Hora at Debre Zeit, and Tezontle in Mexico. The cross Gdo-VZ471-BrxPg, CM13919, was also scored low for stem rust. Important sources of stem rust resistance are Iumillo and Reichenbachii. It appears that crosses with Argentinian and some Italian parents contribute considerable amounts of resistance to stem rust, i.e., P66/253, Candeal II and Gerardo numbers. In 1982, F_2 populations that have several of the above parents will be evaluated in Ethiopia and Kenya.

Triticales in the 4th SNACWYT included many lines with Panda in their parentage. Panda had shown improved seed type and higher test weights than earlier developed triticales, but evaluations in the region showed that the plant type is not as good as Bgl-M_2A, Delfin or Ram. Beagel-M_2A and Ocelot are also showing promise for the region.

International yield trials and screening nurseries
The main yield trials sent by CIMMYT were again tested in the region. The highest yielding bread wheat in the 17th ISWYN was Veery No. 2, both in Kenya and in the world wide average. Four other Veery selections were also among the best 10 in Kenya, surpassing the triticale Cananea. In 1981, stripe rust has been observed on the leaves of most Veery selections, which will limit its use in the region to the lower elevations. This demonstrates again how difficult it is to combine high yields and good rust resistance for places like Kenya. The chances of identifying a new variety through these yield trials are small when the rusts are so aggressive. Thus, the much slower and more laborious way of introducing screening materials and making selections from thousands of lines must continue as the main approach.

CIMMYT's Aluminum Tolerance Screening Nursery (bread wheats) is providing some potentially useful germplasm. In 1980, the shuttle breeding program between Brazil and Mexico had advanced far enough so that 420 lines could be distributed for screening in the region. Tests in Zambia, Tanzania and Kenya, with severe soil acidity at several of the sites, have helped to identify crosses with good levels of stripe and stem rust resistance in addition to tolerance of acid soils. Foliar diseases were much less of a problem for some entries. Combinations of IAS 63 and IAS 64 with Aldan were particularly encouraging. It may be expected that varieties can be identified to replace Romany.

Summary
Most of the cooperation engendered in 1981 among the 16 countries in the region was achieved with the distribution of the African Cooperative Wheat Yield Trial (ACWYT) and regional screening nurseries. Country visits also strengthened regional understanding.

Disease screening of introduced bread wheats, durums and triticales is very intensive in Kenya. Triticales are showing high levels of disease resistance and adaptation to many soils in the region. International yield tests and screening nurseries again provided promising material for further use in the region.

South and Southeast Asia

E. E. Saari, Breeder/Pathologist

Introduction
During 1981 the CIMMYT South and Southeast Asia regional wheat program (based in Bangkok, Thailand) completed its first year of activities in the region. The major wheat growing countries in the region are Pakistan, Nepal, India and Bangladesh. From the Bangkok base, it is easier to respond to requests and attend to program activities on regular basis. The distant location of CIMMYT headquarters in Mexico precludes the possibility of trips to the region on short notice.

The other main purpose for the regional office in Bangkok is to facilitate CIMMYT's response to increasingly frequent inquires from countries that are not "traditional" wheat-growing nations. The countries of Thailand, Burma, The Philippines, Indonesia and Sri Lanka are interested in exploring their potential for growing wheat. Wheat imports represent a major foreign exchange outlay for most of these countries (Table 1). There is relatively little information regarding the potential for wheat cultivation in these areas, and it will be part of the regional program's function to evaluate the prospects.

In South Asia, wheat is a major crop, surpassed only by rice in area and production. The production gains and increases in wheat over the last decade have been dramatic. Acreage has increased, but more importantly the average yields per hectare have gone up dramatically. In some cases, such as Bangladesh, total food production has risen as a result of increased cropping intensity.

Disease constraints to production
In the entire region, leaf rust is the number one constraint to production. This is a particularly significant problem in light of the fact that Sonalika, which is susceptible to leaf rust, is the dominant variety in the region. The national programs in the region, in cooperation with CIMMYT, are seeking alternative short-season varieties that fit into the prevailing rice/wheat rotation cropping pattern.

The second most important disease problem in the region is yellow (stripe) rust, which is of particular importance in the northern parts of Pakistan and India, as well as in portions of Nepal. The release of varieties in Pakistan with inadequate levels of resistance has created a situation that might make yellow rust a more dangerous disease problem than leaf rust.

The problem of helminthosporium blights has existed in the region for a long time. This is a chronic problem that reduces yields by as much as 30 percent in a serious year. Efforts to identify sources of resistance and to develop varieties with higher levels of resistance continue, but progress has been slow.

Pakistan
In 1981, Pakistan recorded a record wheat crop of 11.5 million tons. It was also a rust-free year, so no serious losses were encountered due to these diseases. There is still a pressing need to diversify the wheat varieties grown in Pakistan. The varieties currently being grown are highly susceptible to yellow rust, and this is becoming an increasingly dangerous situation. If conditions favorable to disease development and spread prevail and if inoculum arrived early, yellow rust could cause serious losses.

Leaf rust also constitutes a significant problem in Pakistan, and most of the varieties currently being grown do not possess adequate resistance. The need to change varieties as soon as possible to diminish the potential for a rust epidemic such as occurred in 1978 must be recognized. A number of varieties appear promising and possess adequate resistance to both leaf rust and yellow rust. These lines should be given top priority in Pakistan's seed multiplication program. The Veery "S" selection from CIMMYT material is being released as Pak 81.

Table 1. Estimated trade in wheat grain and flour, including durum, in 1981-82 compared with 1980-81 (From World Wheat Council Estimates 1982 and CIMMYT)

Country/Region	Imports - Millions of Tons 1980-81	1981-82	Production 1981
Bangladesh	0.7	1.0	1.6
China	13.7	13.0	57.0
India	0.3	2.5	36.5
Indonesia	1.3	1.5	-
Japan	5.9	5.5	-
Korea, Rep. of	2.1	2.0	-
Korea, Dem. Rep.	0.5	0.5	0.4
Malaysia	0.5	0.5	-
Mongolia	0.1	0.1	0.3
Nepal	-	-	0.4
Pakistan	0.2	0.5	11.5
Philippines	0.9	0.8	-
Singapore	0.3	0.4	-
Sri Lanka	0.5	0.5	-
Taiwan	0.6	0.6	-
Thailand	0.2	0.2	-
Vietnam, Soc. Rep.	1.0	1.0	-
Far East Asia	29.0	31.0	107.7
Near East Asia	7.0	8.0	28.9
Africa	15.6	16.5	8.9
World	93.0	99.0	456.8

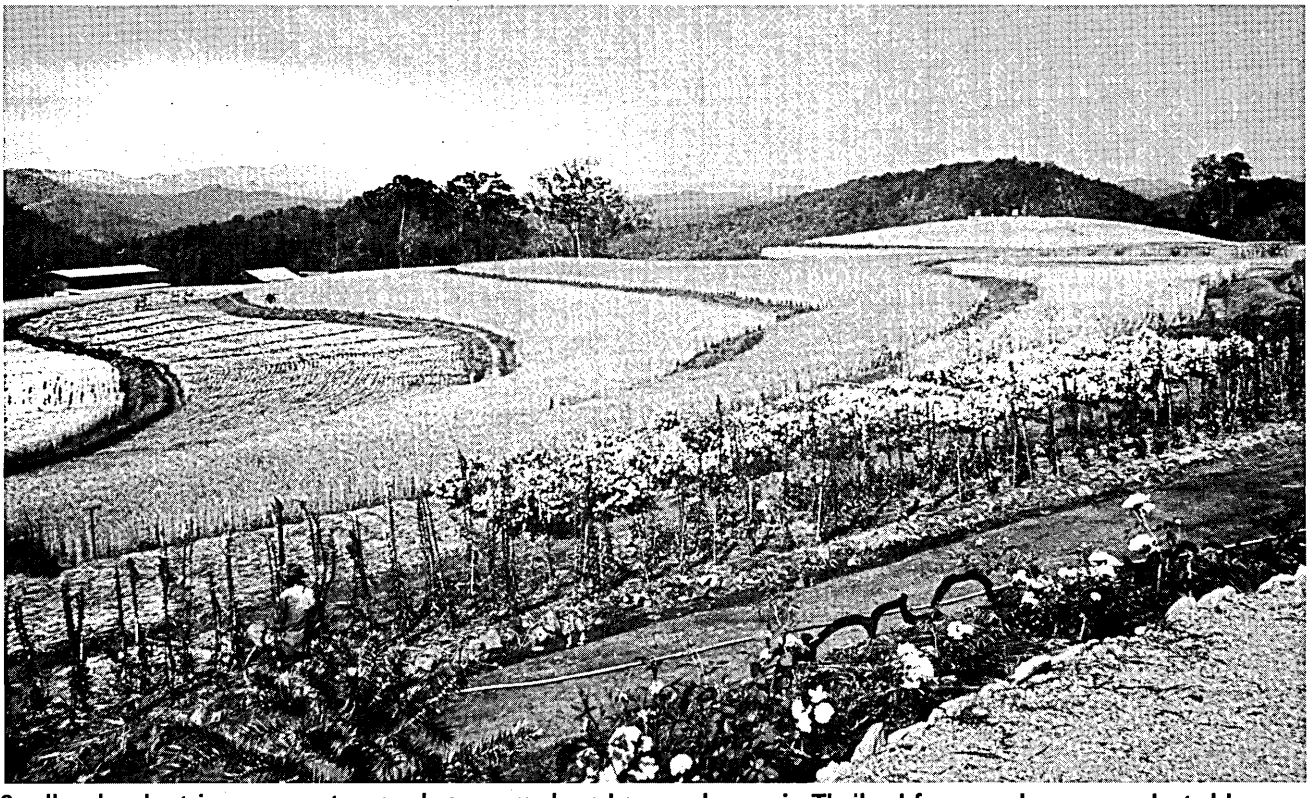
This variety is resistant to both leaf rust and yellow rust, and is one of the top yielding lines at all locations in international yield tests. Punjab 81 was also released this past year, but it lacks adequate resistance to yellow rust. If grown over an extensive area, Punjab 81 could suffer significant damage from this disease.

India

The 1981 official production estimate for India was 36.5 million tons. Even so, the Indian government decided to import three million tons of wheat to build up buffer stocks. A very severe drought the previous year forced India to use nearly all of the 22 million tons of wheat that had been stored for such emergency situations. The increasing demand for food by its rapidly growing population remains one of India's major preoccupations. It is estimated that India will need approximately an additional three million tons of food grains each year just to satisfy the needs of its growing population.

One serious problem confronting India's wheat production efforts is the susceptibility to leaf rust of the variety Sonalika. This is a recent development and presents a very serious threat, since Sonalika is the most widely grown variety in India. Sonalika is rather unique because it is the earliest maturing variety available with yields in the range of 3 to 4 tons, and the amber grain color is favored by the subcontinent peoples. Because it requires a short growing season, this variety fits into double- or even triple-cropping situations. Normally, wheat is sown after the rice crop is harvested in October or November. By the time land preparation has been completed, the sowing date for wheat is later than would be optimum for medium term varieties. Consequently, Sonalika has become the favorite variety of farmers who have irrigation and practice multiple-cropping.

The Indian national wheat research program is the largest national level effort in the world and probably the most diverse. They have an extensive varietal testing program and it should be possible to find a substitute variety for Sonalika in the near future.



Small-scale wheat improvement research programs have been underway in Thailand for several years, conducted by Thailand's Department of Agriculture and Chiang Mai University. This highland research station is located near Chiang Mai in Northern Thailand. (Photo: T. Harris)

Nepal
For its size, Nepal grows a great deal of wheat (350,000 hectares). The majority of this area is adjacent to North India and, not surprisingly, the variety Sonalika also predominates here because of the rice-wheat rotation cropping pattern. Consequently, the breakdown of Sonalika's resistance to leaf rust presents Nepal with the same problem faced by India.

Bangladesh
In 1981, the wheat acreage in Bangladesh approached one million acres and the total production was 1.6 million tons. Yet Bangladesh is relatively new to the production of wheat; in 1973 the total area was only 120,000 acres. Many people thought wheat production was not technically feasible on a large scale in Bangladesh. However, the selection of short-season varieties like Sonalika has made wheat the second most important crop in the country.

The environment in Bangladesh is subtropical, but wheat grows and yields well in spite of this. Here, too, the variety Sonalika predominates, accounting for approximately 70 percent of the total area sown to wheat. Thus, Bangladesh faces the same problem as India and Nepal regarding Sonalika's susceptibility to leaf rust. However, several new varieties look promising and are being increased. The variety Balaka has been released and it is hoped that it will supplant some of the acreage currently being sown to Sonalika.

Wheat production in non-traditional areas
Thailand—There is a history of wheat experimentation in Thailand, with the Department of Agriculture and Chiang Mai University conducting small research programs on wheat for several years. Based on this experience, a Thailand National Program was outlined at a wheat workshop help in Chiang Mai in August of 1981. During this meeting, a Thailand Observation Nursery (TON) was organized, which will facilitate screening of wheat, barley and triticale selections. In addition, a Thailand Yield Nursery was established, which will include the highest yielding lines available. Initially, a total of 40 lines were identified and two yield nurseries of 20 varieties each were prepared and distributed.

A preliminary analysis of the 1980-81 wheat, barely and triticale trials indicated that the earlier lines generally mature in 90 to 100 days in Thailand. The best yields approached three tons (or slightly more with irrigation). These yields are not as high as in temperate climates, but are adequate given the short growing season. Under rainfed conditions, yields of 1.0 to 1.5 tons per hectare have been achieved.

There are two distinct wheat-cropping situations in Thailand. The first is the rice-wheat rotation in which wheat is sown in November and December after the rice crop has been harvested. The wheat matures in 90 to 100 days and irrigation is required. Rising temperatures begin to force maturity in early March.

The second situation is that of the upland crop-wheat rotation. In this case, the cycle is approximately 120-140 days and, since this is strictly a rainfed environment, each crop must be grown on residual moisture alone. Consequently, the moisture holding capacity of the soil becomes critically important.

In both cases good crop management is essential. The date and method of sowing, as well as varietal selection, are critical for crop establishment under Thailand's conditions. The widespread use of wheat in the Thai cropping system would reflect crop intensification rather than a substitution. There are large areas of land that remain fallow after the rainy season crop is harvested. A crop could be taken in the cooler, dry period after the rainy season without competition with other crops.

In areas with shallow soils or low moisture holding capacity, barley may be a reasonable crop. In initial experiments with barley, some of the earliest varieties matured in 60-70 days with yields of 1.0 to 1.5 tons per hectare.

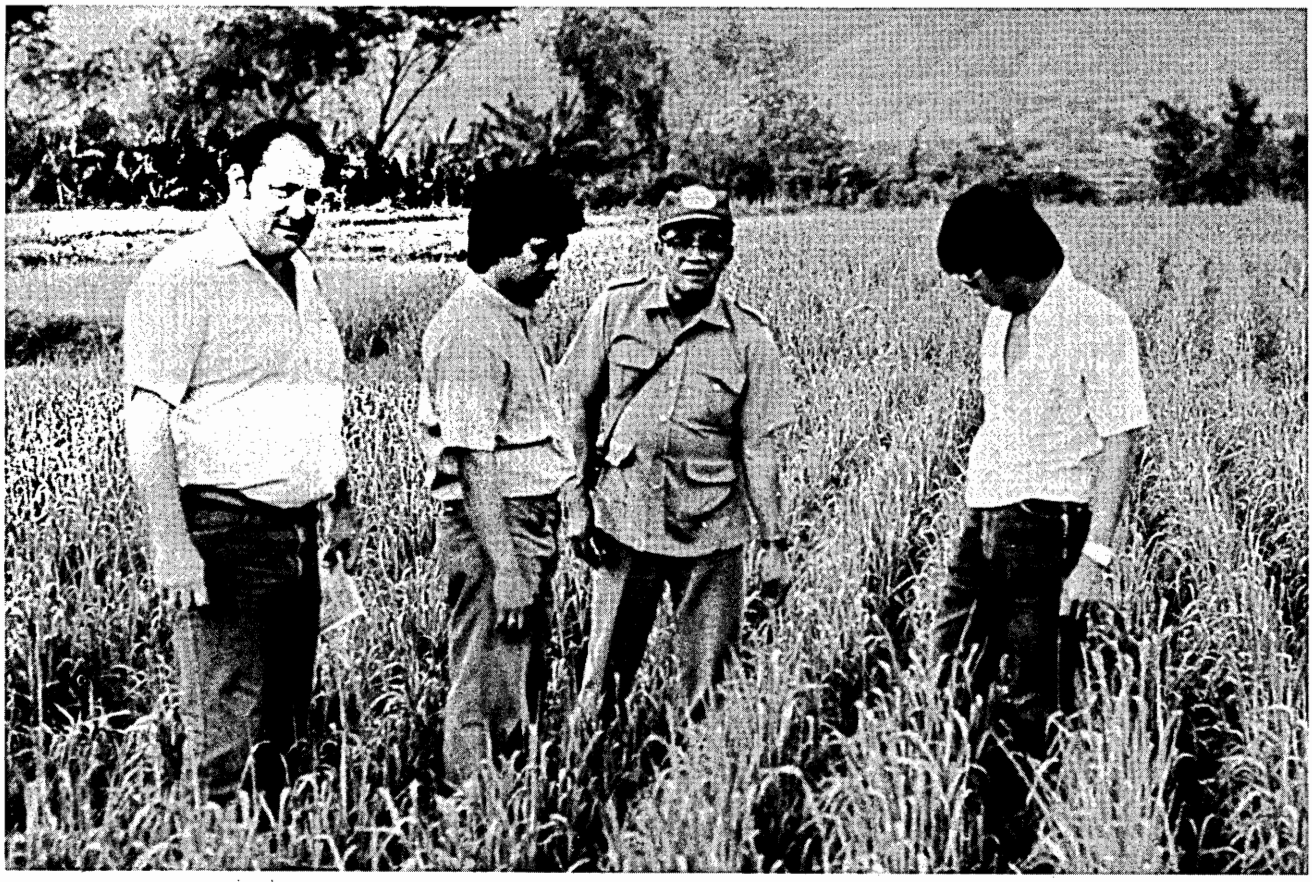
Triticale has been doing well in terms of yield, but requires a longer cropping cycle, usually 110 to 130 days. There are no early maturing triticales to compare with the early maturing wheats or barleys. The best triticale yields have approached 3 to 4 tons in small experimental plots.

There is a growing awareness and interest in wheat and wheat products in Thailand. Most of the wheat products produced are convenience consumer items for the urban population. Wheat is imported (up to 200,000 tons per year) and milled in Bangkok. The wheat products used are similar to those of traditional wheat growing areas. Loaf bread is common, as are cakes, cookies and biscuits. In the rural areas, flat breads and donut-type products are common. One of the fastest growing uses of wheat is in the manufacture of noodles.

In the case of barley, there are prospects for its utilization as feed or for malting. There is a substantial animal industry in Thailand (poultry and pigs) and the use of barley as feed appears promising. There is also a lack of winter forages, which presents opportunities for using some of the forage type barleys, and possibly triticale.

Burma—The Burmese government has expressed an interest in increasing wheat production. Currently, they cultivate about 80,000 hectares of wheat in environments similar to those found in Bangladesh. Yields tend to be quite low. Although there is a shortage of trained manpower and facilities it is apparent that the potential for the expansion (and improvement) of wheat production in Burma is great.

The Philippines—In 1981, a meeting was held in The Philippines to plan for wheat experimentation and the testing of small-scale production potential. It was decided to design a more highly coordinated and extended wheat trial system along with the initiation of preliminary seed multiplications. The Philippines, like Thailand, has been conducting small-scale experiments with wheat for many years. The major difference is that the typhoon season in The Philippines tends to make the date of planting somewhat variable. Late typhoons and flooding can prevent the timely sowing of wheat.



The Philippines, like Thailand, has been conducting small-scale experiments with wheat for several years. Here, Dr. E. E. Saari (far left) examines experimental plots with cooperating Filipino wheat researchers. (Photo: B. C. Curtis)

Indonesia—Small-scale experiments in wheat production, particularly on the island of West Java, have been conducted by Indonesia over the past few years. It is not clear at this time whether wheat could be economically produced on West Java because of competition with the alternative crops. There are possibilities in other highland areas, however, where competing crops are not present. In addition, the frequent rains result in numerous disease problems, which increase the risk of growing wheat. Head scab (*Fusarium* spp.) in West Java is particularly severe because of the wheat-maize rotation and the moisture conditions.

Sri Lanka—About 3,000 small-scale demonstration plots have been established in Sri Lanka and seeded to the variety Sonalika. There will be a multiplication of seed and a limited production campaign next fall (1982). The prospects for a successful dry season winter crop of wheat in Sri Lanka are increased by the fact that the country receives some winter rains, particularly at elevations above 300 meters.

Obstacles to production

In all of these non-traditional wheat areas, there is a need to develop plant types or identify varieties that possess tolerance to high temperature at the juvenile plant stage. This characteristic is definitely required; otherwise wheat in this environment tends to "bolt" and flower at a very early date. Soil-borne diseases are another problem confronting wheat in the tropical climates. The seedling blight caused by *Sclerotium rolfsii* is also a major problem. Damping off of young seedlings often occurs where temperatures are high and the soil is saturated with moisture. It is questionable whether we will be able to identify resistance to this particular disease, and development of a chemical seed treatment technique may be required.

Helminthosporium sativum is a significant production constraint in tropical environments. Only relatively small differences in resistance in wheat have been recorded. Barley seems to possess greater variation, and the development of resistant varieties should be possible. Leaf rust will undoubtedly become a major concern in non-traditional wheat production environments. It has already been found in areas where one would not expect. The races identified are primitive and do not attack most of the current varieties, but the expansion of wheat cultivation will undoubtedly result in the evolution of new races capable of attacking the cultivated varieties.

In barley and, to some extent, in wheat severe aphid attacks have been recorded, and losses have been attributed to what appears to be barley yellow dwarf. This could present a serious obstacle to production because the cooler dry period favors the build up of aphids.

Another difficulty encountered in growing wheat and barley in the off-season are birds and rats. Since no other green crops are being grown at the time, these pests migrate to the green crop in the field. This can only be alleviated when the acreage is sufficiently large to disperse the problem, or campaigns for bird and rat control are adequate to minimize damage.

In many tropical environments, soils are frequently low in pH and high in free aluminum, resulting in aluminum toxicity in plants. This has not so far been a limiting factor, except at certain locations. Triticale tends to perform well in these locations and presents an opportunity for an alternative crop. Triticale for direct human consumption, or as feed for poultry and pigs, offers a good utilization of the crop.

During the first year of the South and Southeast Asia regional program, a high degree of variability within and among the species of bread wheat, durum wheat, barley and triticale was observed. Durum wheats seem to be the most poorly adapted of the four to tropical environments. It is evident that selection of materials that are much better adapted than the current varieties will be possible. It also appears that breeding programs can effectively concentrate characters for adaptation to these environments. To date, research on the tropical adaptation of wheat, barley and triticale has been almost non-existent. However, prospects are very good for the development of germplasm that will exceed in performance the materials currently available.

Pakistan

H. M. Hepworth, Agronomist
N. I. Hashmi, National Wheat Coordinator

Introduction

Wheat remains the most important food crop in Pakistan, occupying 6.9 million hectares. Barley covers about 170,000 hectares. Triticale is not produced commercially, but appers to hold promise for some areas.

In 1980-81, the Government of Pakistan made a strong and successful effort to increase wheat production. Crop prices were increased, as were supplies of fertilizer. The weather was nearly perfect; rainfall came at the optimal time vis-a-vis the crop cycle. Diseases were present, particularly leaf rust and stripe rust, but fortunately did not mature into damaging epidemics. The crop was officially estimated at 11.34 million tons, establising a new production record for the third successive year. Pakistan was virtually self-sufficient in wheat for the year. Even so, the country remains far below the estimated potential yield for wheat.

Production constraints

Varietal development—Pakistan developed and released several varieties with excellent agronomic characteristics and high yield potential. However, lack of disease resistance remains a serious problem. The varieties now in widespread production are known to lack the disease resistance needed to adequately protect the crop, hence the country remains vulnerable, particularly to leaf rust and stripe rust. Pakistan also needs some early maturing varieties to replace Sonalika (Blue Silver), which has become susceptible to the rusts. Several varieties are being monitored very closely and have either been withdrawn from the list of recommended varieties or should be replaced. Among these are Sonalika, Yecora, Nuri 70, WL 711, Sandal, Pari 73 and Bahawalpur 79. During 1981, two varieties were approved for release: Veery "S" (CM33027 - F - 15M-500 Y-OM) was released as PAK-81 and variety 1360 (Inia/Son64-P4160ExSon64, PK6841-2a-2a-1a-0a) was released as Punjab 81.

In 1981, wheat scientists from all over Pakistan joined together with several CIMMYT personnel in a tour of the country's major wheat research stations and production areas. Here the group visits triticale experimental plots at the Nuclear Institute of Agriculture and Biology in Faislabad.

Weeds—Pakistán has severe weed problems in certain areas. *Phalaris minor*, Retz. is spreading rapidly and appears to be causing major yield reductions. Other species causing damage are *Chanopodium album* Linn, *Carthamus oxycantha* Bieb and the common mustard, *Brassica* spp., which is grown as a crop in many cases.

Research to date has shown that several herbicides are very effective in controlling these weeds. A strong educational effort will be required, however, to successfully introduce herbicide use on a broad scale.

Cultural practices—Fertilizer application continues to increase, but is still far from adequate. The N-P rates must be decreased from the current ratio of 5 to 1 down to 2 to 1 or lower for optimum results.

Poor seedbed preparation and seeding methods that result in very thin stands are still major constraints to production. With cropping intensity increasing, late seeding into poorly prepared seedbeds becomes more and more of a problem. Improved management that will allow the high-yielding varieties to express more of their genetic potential is the key to further increasing wheat production in Pakistan.

CIMMYT assistance

CIMMYT works with Pakistan in several ways. Pakistan receives more CIMMYT nurseries and breeding material than any other country, an interchange that strengthens both the Pakistan and CIMMYT breeding programs. Each year several trainees from Pakistan participate in the various Wheat Improvement Program training courses at CIMMYT headquarters in Mexico. CIMMYT has also provided assistance in weed control and is participating in a cooperative soil moisture management research effort. This program will develop methods for improving cultural operations to increase wheat yields.

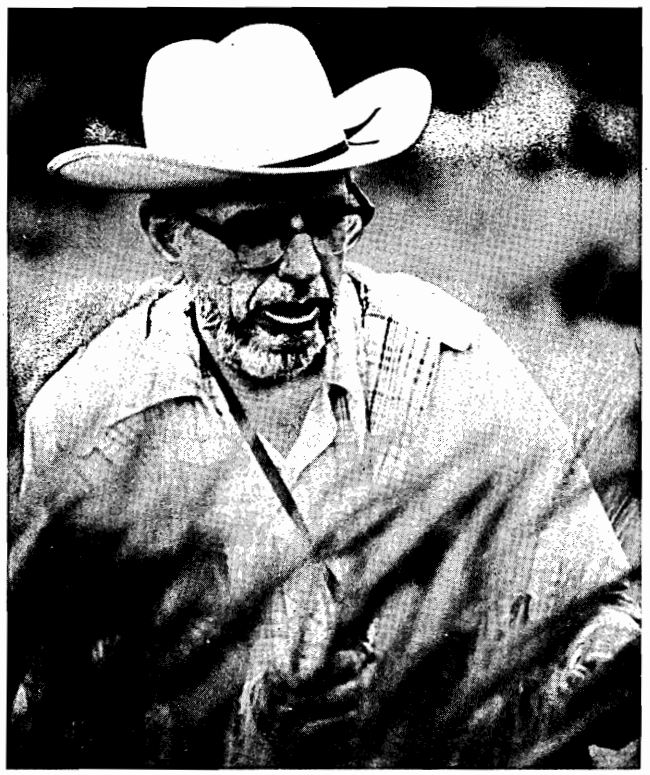
CIMMYT/ICARDA Cooperative Wheat Breeding Program

W. Nelson, CIMMYT Wheat Breeder

Introduction

Beginning with the 1980-81 season, CIMMYT and the International Center for Agricultural Research in Dry Areas (ICARDA) established a cooperative bread wheat breeding program. A CIMMYT wheat breeder was stationed at ICARDA to coordinate bread wheat breeding efforts. This joint program pools the resources of both centers to develop germplasm adapted to rainfed conditions in the ICARDA region, as well as other similar rainfed areas.

The specific objectives of the program are to develop widely adapted germplasm that 1) expresses high yield potential under both low and high rainfall conditions, 2) is capable of withstanding environmental variations in heat, drought and cold, and 3) is resistant to the insects and diseases of the region. Attention is given to developing materials that possess the quality characteristics necessary to accomodate the uses of bread wheat in the region.



Dr. Walt Nelson, wheat breeder, coordinates the CIMMYT/ICARDA cooperative bread wheat breeding program.

The main breeding location is near Aleppo, Syria (Tel Hadya), with additional sites at Trebol and Kfardan, Lebanon. All of the material is grown at Tel Hadya, and selected F_2 populations, observation nurseries and yield trials are grown at the two Lebanon locations. All advanced lines are grown in the Key Location Disease Nursery at 10 or more known disease "hot spots" within the region. Disease evaluations are made in cooperation with the ICARDA cereal pathology program. Other locations within Syria are used for drought and salt tolerance evaluations.

Production conditions

The 1980-81 cycle was delayed somewhat by the late-starting rains (December 11), but a good distribution of above average precipitation during the rest of the season (through May) was favorable for good plant development. Severe frost damage on early lines was caused by—5°C temperatures on April 1. Later maturing lines were in a less vulnerable stage at that time and escaped damage. Below normal temperature in April and May, combined with above normal rainfall, favored the later maturing lines. Good selection pressure occurred for plant type, stripe rust and late leaf rust infection.

Germplasm development

Potentially useful parental germplasm is identified through the CIMMYT and ICARDA base and outreach programs. Each center concentrates on developing and selecting materials according to their respective advantages. For example, breeding for sawfly and bunt resistance can be more easily done at ICARDA than at CIMMYT. Similarly, breeding for resistance to the rusts and other foliar diseases can be accomplished more easily at CIMMYT. By exchanging germplasm at each stage in the breeding process, both centers facilitate their common objective of broadening the germplasm base of winter sown spring wheat.

In the 1980-81 season, 1150 bread wheat crosses were made at Tel Hadya to high-yielding adapted parents. These crosses focused on improving resistance to sawfly, common bunt, *Septoria* spp., stripe and leaf rusts, and drought tolerance. Of the 9000 plant selections made, roughly half were from F_2 populations. Over 500 new selections from F_6 to F_8 segregating populations were advanced to yield trials.

Of special interest are the advanced lines from the crosses between winter and spring wheat germplasm pools. Chat"S", Bobwhite"S", Veery"S", Hahn"S", Koel"S", Kinglet"S" and other spring x winter crosses displayed high yield potential and good disease resistance in the region. It appears likely that increased tolerance to heat, drought and cold may be obtained from the winter wheat germplasm. The program will exploit this apparent contribution to the fullest extent possible.

Varietal releases

Two selections identified by the program were named and released by Syria and placed into seed multiplication. The line S311-Norteño was named Golan, and is intended for rainfed areas. The line HD2172, named Bloudan, may be recommended for the irrigated area of Syria. Both varieties have adequate resistance to the stripe and leaf rust races present in the region; their yields are equal or superior to that of Mexipak.

While progress is being made, it must be recognized that breeding alone will not bring massive increases in bread wheat production in the region. Breeding is an important and integral part of the improvement program, and a continuous effort to breed for insect and disease resistance, as well as overall adaptation and yield potential, is required. However, equally important (if not more so) is the development and adaption of improved agronomic and production practices for cereal production. Wheat breeders must work closely with agronomists if cereal production in the region is to realize its potential.

Glossary

ACI	Average Coefficient of Infection (rust)
ACWYT	African Cooperative Wheat Yield Trial
a.i.	Active ingredient
BYDV	Barley yellow dwarf virus
CB	Crossing block
cm^3	Cubic centimeter
CI	Coefficient of infection (rust)
CIANO	Centro de Inestigaciones Agrícolas del Noroeste (Cd. Obregón, México)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
cm	Centimeter
CRL	Cereal Rust Laboratory, USDA, St. Paul, Minnesota
CV	Coefficient of variation
EDYT	Elite Durum Yield Trial
ELAR	Ensayo Latino Americano de las Royas
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agency for Agricultural Research)
FAO	Food and Agriculture Organization of the United Nations
g	Gram
ha	Hectare
hl	Hectoliter
HYVs	Yigh yielding varieties
IBON	International Barley Observation Nursery
IBWSN	International Bread Wheat Screening Nursery
IBYT	International Barley Yield Trial
IC	Index of quality
ICARDA	International Center for Agricultural Research in the Dry Areas (Aleppo, Syria)
IDRC	International Development Research Center (Ottawa, Canada)
IDSN	International Durum Screening Nursery
IDYN	International Durum Yield Nursery
INAT	Institut National Agricole Tunisienne
INIA	Instituto Nacional de Investigaciones Agrícolas (The Mexican Natinoal Institute of Agricultural Research)
INIAP	Instituto Nacional de Investigaciones Agropecuarias (Ecuador)
IPO	Institut Voor Plantenziektenkundig Onderzoek (Research Institute for Plant Protection, Netherlands)
ISEPTON	International Septoria Observation Nursery
ISWYN	Interantional Spring Wheat Yield Nursery
ITSN	International Triticale Screening Nursery
ITYN	International Triticale Yield Nursery
kg	Kilogram
kg/ha	Kilogram per hectare
kg/hl	Kilogram per hectoliter
LR	Leaf rust
LSD	Least significant difference
m	Meter

m^2	Square meter
PC	Small plot multiplication for pure seed
PMC	Small increase plot
PMI	International multiplication plots
ppm	Parts per million
ppt	Parts per thousand
RDISN	Regional Disease and Insect Screening Nursery
RDTN	Regional Disease Trap Nursery
SNACWYT	Screening Nursery for the African Cooperative Wheat Yield Trial
SR	Stripe rust
t	Ton (= 1000 kg)
t/ha	Tons/hectare
USAID	United States Agency for international Developemtn
USDA	United States Department of Agriculture
VEOLA	Vivero de Enfermedades y Observación de Latino America
YR	Yellow rust
Y80-81	Yaqui, México, 1980-81