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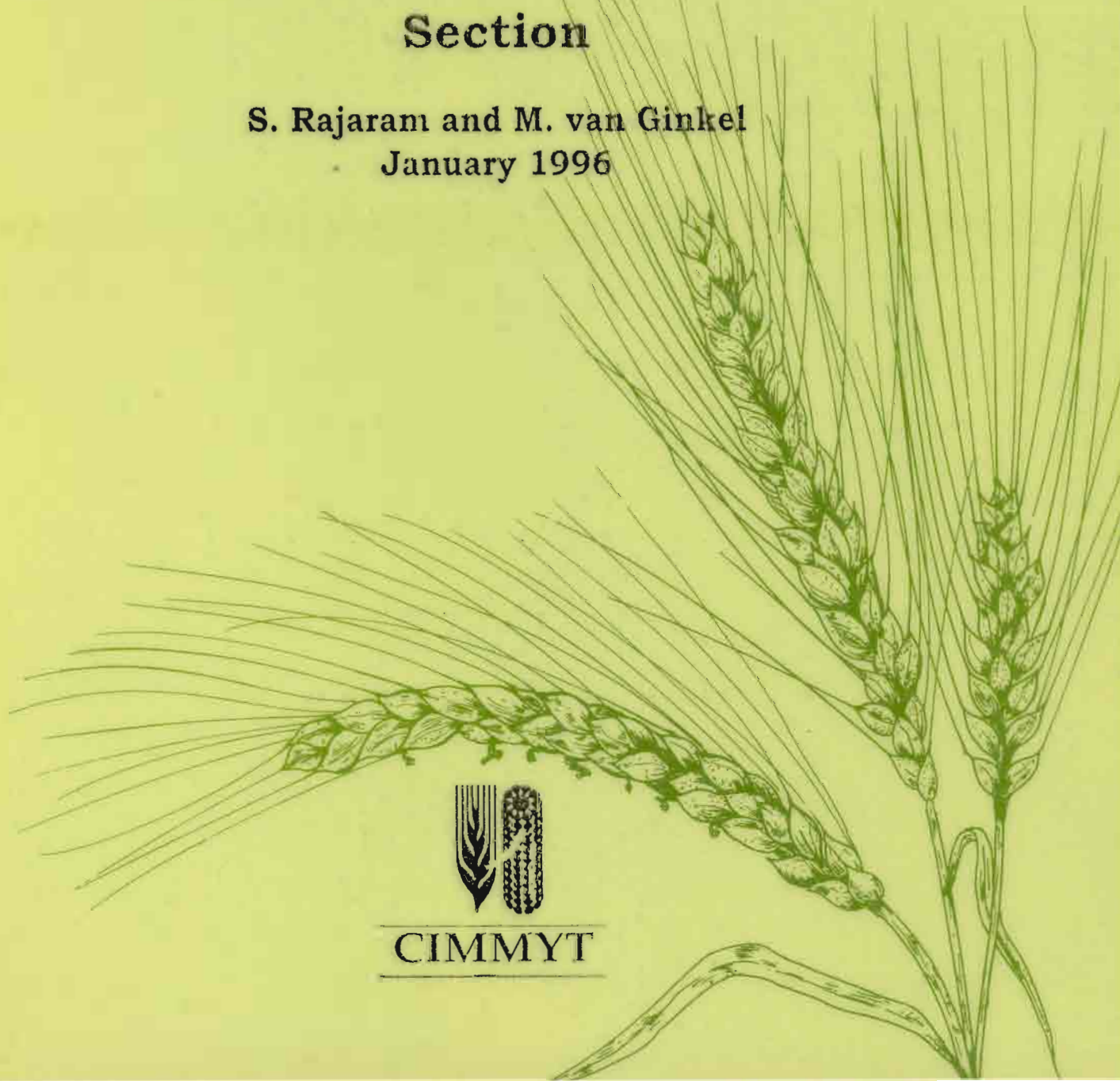
WPSR No. 5

**A Guide to the  
CIMMYT Bread Wheat  
Section**

**S. Rajaram and M. van Ginkel  
January 1996**



**CIMMYT**



**Wheat Special Report No. 5**

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### **Note on Citing This Wheat Special Report**

By sharing research information in this Wheat Special Report on a Guide to the CIMMYT Bread Wheat Section, we hope to contribute to the advancement of wheat breeding and to the importance of shared knowledge. However, the information in this report is shared with the understanding that it is not published in the sense of a refereed journal. Therefore, this report should not be cited in other publications without the specific consent of Dr. S. Rajaram, head of the Bread Wheat Section.

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## **PREFACE**

This special report is an updated introduction to the CIMMYT Wheat Program's Bread Wheat Section. It is designed to help acquaint visiting scientists and other interested persons with the Section's structure, activities, objectives, and philosophies.

We thank Alma McNab for assisting in the preparation of this document.

**S. Rajaram**

Leader, Bread Wheat Section

## **INTRODUCTION**

The precursor of the present CIMMYT Wheat Program originated in 1944 under the sponsorship of the Rockefeller Foundation and the Office of Special Studies of the Mexican Ministry of Agriculture. In 1966, CIMMYT was established as a nonprofit organization responsible to an internationally elected board of trustees. The Ford and Rockefeller Foundations joined Mexico as the initial principal supporters of CIMMYT.

The CIMMYT Wheat Program currently distributes advanced lines to more than 100 countries. Primary clients are the National Agricultural Research Systems (NARSs) of developing countries; germplasm distribution and utilization are dependent upon their close cooperation. The bread wheat breeding section has, therefore, attempted to address the specific problems and limitations associated with wheat production in these countries.

In order to develop effective breeding strategies, various agroecological zones or mega-environments (MEs) have been defined. Germplasm developed for a given ME will withstand the major stresses, but not always the significant secondary stresses. How these products are used and distributed within an ME to address the needs of specific agroecological niches is the responsibility of the NARSs.

The development of broadly adapted, disease resistant, high yielding and stable germplasm within the context of each ME is the Section's primary goal. Although soil and moisture factors influence crop stability and productivity, resistance to biotic factors such as diseases and insects can be critically important in maintaining high yields, thus contributing significantly to the adaptation of a given cultivar across time and environments. Emphasis is also given to maintenance of genetic diversity within each ME to counter the effects of genetic vulnerability.

To breed for wide adaptation and high yield potential, the breeding program shuttles material between alternate sites within Mexico while pyramiding genes that carry resistance to various pathogens. International multilocational testing, through the distribution of International Nurseries and Yield Trials, and the cooperation of the NARSs, provides vital information for use in CIMMYT's Bread Wheat Section's crossing program.

### **CIMMYT BREAD WHEAT (BW) SECTION STAFF**

The breeding program at base (in Mexico) has a current staff of 17 members, comprising 2 research staff and 14 support staff. Nineteen outreach and discipline staff support program activities. Wheat directing staff provide major administrative support. Staff members are listed below:

#### **Core Breeding Staff**

- Sanjaya Rajaram (India): Program Leader/Senior Breeder
- Maarten van Ginkel (The Netherlands): Senior Breeder
- Reynaldo Villareal (Philippines): Head, Training Section

### **Research Assistants**

- Ramon Gil
- Jorge Montoya
- Horacio Vega
- Armando Miranda
- Mario Albarran
- Jose Borja

### **Field Assistants**

- Reyes Colin
- Jose Luis Coss
- Salvador Madrigal
- Leopoldo Salazar
- Valentin Ramirez
- Martin Rodríguez
- Jose Terrazas
- Alfredo Valencia

### **Secretarial Support**

- Lolita Mir

### **Supporting Station Management Staff**

- Toluca: Antonio Miranda and Fernando Delgado
- Cd. Obregon: Rodrigo Rascon

### **Collaborating Pathology Staff**

- Jesse Dubin (USA)
- Ravi Singh (India): Rusts
- Etienne Duveiller (Belgium): *Helminthosporium* and Bacteria
- Guillermo Fuentes-Davila (Mexico): Bunts and Smuts
- Lucy Gilchrist (Chile): Septoria
- Monique Henry (France): BYDV

### **Collaborating Agronomy/Physiology Staff**

- Ken Sayre (USA): Support to Breeding
- Ivan Ortiz-Monasterio (Mexico): N and P Response, Minor Elements
- Matthew Reynolds (Britain): Physiology of Yield and Heat Tolerance



### **Collaborating Genetic Resource Staff**

- A. Mujeeb-Kazi (USA): Wide Crosses

### **Supporting International Nursery Staff**

- Paul Fox (Australia): International Nursery Distribution and Data Analysis

### **Supporting Industrial Quality Staff**

- Javier Peña (Mexico): Industrial Quality

### **Supporting Staff in Outreach**

- Hans Braun (Germany), Breeder, Ankara, Turkey Winter/Facultative Wheat
- Alexei Morgunov (Russia), Breeder, Ankara, Turkey Winter/Facultative Wheat
- Thomas Payne (USA), Breeder, Harare, Zimbabwe
- Mohan Kohli (India), Breeder, Montevideo, Uruguay
- Gene Saari (USA), Pathologist, Kathmandu, Nepal
- Guillermo Ortiz (Mexico), Breeder, Aleppo, Syria
- Douglas Tanner (Canada), Agronomist, Addis Ababa, Ethiopia
- Patrick Wall (Irish), Agronomist, Santa Cruz, Bolivia
- Peter Hobbs (USA), Agronomist, Kathmandu, Nepal
- Craig Meisner (USA), Agronomist, Dhaka, Bangladesh

Recognition is extended to the NARSs of all developing countries for their excellent cooperation. The generous contribution of germplasm from North American universities, in particular Oregon State University (OSU), is gratefully acknowledged.

### **OBJECTIVES WITHIN EACH MEGA-ENVIRONMENT**

The CIMMYT Wheat Program deals with 12 mega-environments (MEs): six define environments for the production of spring wheats and six define the facultative/winter wheat environments. All MEs are based on water availability, soil type, temperature regime, and associated biotic and abiotic stresses. Consumer preferences for grain color and quality are also considered.

## Spring Wheat

### **ME1: Favorable, irrigated, low rainfall environment**

ME1 represents the optimally irrigated, low rainfall areas of the world. The climate during the wheat growing period ranges from temperate to conditions of late heat stress. Representative areas include the Gangetic Valley (India), the Indus Valley (Pakistan), and the Nile Valley (Egypt), and the Yaqui Valley (Mexico). This ME encompasses 36 million hectares spread primarily over Asia and Africa between latitudes 35°S to 35°N. Breeding objectives involve high yield potential, lodging resistance (which includes maintenance of Rht1 and Rht2 dwarfing genes), improved industrial quality, and durable resistance to the three rusts. Greater emphasis will be given to the problem of saline soils, the search for sources of aphid and powdery mildew resistance, and high temperature tolerance for late-sown materials. White-grained types predominate in most areas. Ten million ha are affected by Karnal bunt and hence resistance is being incorporated.

### **ME2: High rainfall environment (>500 mm rainfall during the cropping cycle)**

ME2 is defined by representative locations in the West Asia and North Africa (WANA) Region, the Southern Cone and Andean Highlands of South America, Kulumsa (Ethiopia), Izmir (Turkey), and Toluca (Mexico). Total area exceeds 8 million hectares. Some of these areas are characterized by acidic soils, and for this reason, it has been suggested that ME3 (acid soils) be considered a sub-ME of ME2. Stripe rust, septoria tritici blotch, and sprouting are major production constraints. Resistances to leaf rust, BYDV, fusarium head scab, bacteria, and powdery mildew must also be considered in many parts of ME2. For high yield potential, semidwarf stature is essential. Red grain type is generally preferred throughout ME2, with the exception of Ethiopia. Red grained wheat provides better sprouting tolerance than white grained wheat.

### **ME3: High rainfall, acid soil environment**

Disease and stress problems are similar to ME2, however, phosphorus deficiency and aluminum and manganese toxicities are major constraints to production. Area is estimated at just under 2 million hectares, mostly in Brazil, the Himalayas, and Central Africa. Red grain is generally preferred with the exception of the Himalayas.

### **ME4: Low rainfall environment**

Three distinct types of drought or sub-MEs have been identified based on the stage of plant development at which drought is most severe. These are:

- ME4A: Winter rain or Mediterranean-type drought associated with post flowering moisture and heat stress typical of the WANA region. Also late frosts may occur. Representative locations include Aleppo (Syria) and Settat (Morocco). Total estimated area: 6 million ha.
- ME4B: Winter drought or Southern Cone-type rainfall associated with pre-flowering moisture stress. Marcos Juarez (Argentina) is a representative location. Resistances to leaf and stem rust, septorias, and fusarium are requirements. Total estimated area: 3 million ha.
- ME4C: Stored moisture after monsoon rains results in continuous or Subcontinent-type drought. A representative location is Dharwar (India). Total estimated area: 5 million ha.

The CIMMYT breeding program attempts to combine high yield potential with drought resistance for MEs 4A and 4B. Other, more specifically adapted germplasm is needed for ME4C. This combination of traits is important in drought environments where rainfall is

frequently erratic across years. When rains are sufficient in certain years, the crop must respond appropriately. For MEs 4A and 4C, white grain is a requirement, however, in ME4B red grain is preferred, to avoid sprouting problems.

**ME5: Warmer area environment (areas between 23°N and 23°S below 1000 m altitude)**

The mean minimum temperature of the coolest month in this environment is >17°C. In humid locations, resistances to *Helminthosporium sativum*, leaf rust, and sprouting are major objectives. The estimated area is about 9 million hectares. Representative humid locations are Joydebpur (Bangladesh), Chiangmai (Thailand), Encarnacion (Paraguay) and Poza Rica (Mexico). Kano (Nigeria), and Wad Medani (Sudan) are typically dry locations.

**ME6: High latitude environment (> 45°N or S)**

Wheat is spring-sown in this ME as winters are too severe for survival. Estimated area is 6 million hectares. Resistances to fusarium, *Helminthosporium tritici-repentis*, sprouting, stripe rust, leaf rust, and stem rust are breeding objectives. Photoperiod sensitivity is a consideration and pre-anthesis drought is common. A representative location is Harbin (Heilongjiang, China).

**Facultative Wheat**

**ME7: Favorable, moderate cold (0 to 5°C coolest month), irrigated environment**

Breeding objectives are yield potential and resistances to stripe rust, leaf rust, and powdery mildew. Representative location is Zhenzhou, Henan (China).

**ME8: High rainfall (> 500 mm), moderate cold (0 to 5°C coolest month) environment**

Major diseases are stripe rust, powdery mildew, leaf rust, eye spot. Representative locations are Temuco (Chile) and Corvallis (Oregon).

**ME9: Semi-arid, moderate cold (0 to 5°C coolest month), low rainfall environment**

Drought tolerance and resistance to stripe rust and bunts are requirements. Representative locations are Diyarbakir (Turkey) and Veron (Texas).

**Winter Wheat**

**ME10: Favorable, severe cold (-10 to 0°C coolest month), irrigated environment**

Yield potential and resistances to stripe rust, leaf rust, and powdery mildew are requirements. Beijing (China) is a representative location.

**ME11: High rainfall (> 500 mm), severe cold (-10 to 0°C coolest month) environment**

Major diseases are leaf rust, stripe rust, powdery mildew, and eye spot. Representative locations are Odessa (Ukraine) and Krasnodar (Russia).

**ME12: Semi-arid, low rainfall, severe cold (-10 to 0°C coolest month) environment**

Drought tolerance and resistance to the bunts are needed. Ankara (Turkey) and Kansas (USA) are representative locations.

## NOMENCLATURE OF BREEDING MATERIALS AND ABBREVIATIONS

All genetic materials have been assigned a standardized code, of 7 or 8 spaces, to easily identify the germplasm flow in the Bread Wheat Section.

The first two or three spaces indicate the breeding generation or yield trial stage. In rare cases the initials of the researcher carrying out a special study is used. Some examples are given below:

- CBS: Crossing Block Spring.
- CBW: Crossing Block Winter.
- F1, F2, etc.: Breeding generation.
- F1T: F1 top cross.
- PC: Small plot (*Parcela Chica* in Spanish) of an advanced line bulked in F7 or F8. These lines have entered an unreplicated preliminary yield trial (PYT) for the first time.
- EPC: An Elite PC. These lines have entered replicated yield trials (YT). They have been tested previously as PYTs, and are candidates for International Screening Nurseries and Yield Trials.

The second group of three characters defines the intended target mega-environment, ME1, ME2, etc.:

MEGA-ENVIRONMENT	ABBREVIATION FOR ME ENVIRONMENT	INT. NURSERIES & TRIALS
<b>SPRING WHEAT:</b>		
ME1: FAVORABLE ENVIRONMENT	FE	IBWSN <sup>1</sup> ESWYT
HEAT (late planting)	HT	HTWYT (since 1991)
ME2: HIGH RAINFALL	HR	HRWSN HRWYT (since 1991)
ME3: ACID SOIL	AS	ASWSN
ME4: SEMI-ARID	SA	SAWSN SAWYT (since 1991)
ME5: WARMER AREAS	WA	WAWSN
ME6: HIGH LATITUDE	HL	Germplasm to be distributed as available

<sup>1</sup> Nursery abbreviations are explained below.

**FACULTATIVE WHEAT:**

ME7: FAVORABLE ENVIRONMENT	FE	FAWWON
ME8: HIGH RAINFALL	HR	FAWWON
ME9: SEMI-ARID	SR	FAWWON

**WINTER WHEAT:**

ME10: FAVORABLE ENVIRONMENT	FE	FAWWON
ME11: HIGH RAINFALL	HR	FAWWON
ME12: SEMI-ARID	SA	FAWWON

**Nursery Abbreviations**

- IBWSN: International Bread Wheat Screening Nursery
- ESWYT: Elite Spring Wheat Yield Trial
- HTWYT: High Temperature Wheat Yield Trial
- HRWSN: High Rainfall Wheat Screening Nursery
- ASWSN: Acid Soil Wheat Screening Nursery
- HRWYT: High Rainfall Wheat Yield Trial
- SAWSN: Semi-Arid Wheat Screening Nursery
- SAWYT: Semi-Arid Wheat Yield Trial
- WAWSN: Warmer Areas Wheat Screening Nursery
- FAWWON: Facultative/Winter Observation Nursery (distributed from CIMMYT/Turkey)

**Classifiers**

In some cases, the last two spaces, in positions 6 and 7, or 7 and 8, may provide a "classifier", which further specifies the breeding aim within an ME. Classifiers may be used for segregating populations and advanced lines:

- BD: BW x DW
- KB: KARNAL BUNT
- SY: SYNTHETICS
- SC: SCAB (FUSARIUM)

- DD: DOUBLE DWARF
- HF: HESSIAN FLY
- HQ: HARD WHEAT (QUALITY)
- HT: HEAT TOLERANT
- IQ: INDUSTRIAL QUALITY
- YC: YIELD COMPONENTS
- SL: SALINITY
- SQ: SOFT WHEAT (QUALITY)
- SW: SPRING X WINTER
- WX: WIDE CROSSES
- WC: WEED COMPETITION
- WF: WINTER/FACULTATIVE

### Country-specific Classifiers

Some nurseries have been developed from material outside the program or have been assembled to represent expression of a specific set of traits for a special target area. These, therefore, have been assigned a unique set of classifiers:

- BR: BRAZIL/CIMMYT
- EC: ECUADOR/CIMMYT
- YZ: YANGTZE/CIMMYT (China)
- CH: CHENGDU/CIMMYT (China)
- PA: PARAGUAY/CIMMYT

### Examples

*Basic materials:*

ME1	ME2	ME3	ME4	ME5
CBSME1FE	CBSME2HR	CBSME2AS	CBSME4SA	CBSME5WA

*F1 and segregating populations:*

ME1	ME2	ME3	ME4	ME5
F1ME1FE	F1ME2HR	F1TME3AS	F1ME4SA	F1ME5WA
F1TME1HT	F2ME2EC	F3ME3BR	F1TME4BD	F4ME5PA
F2ME1HQ				
F3ME1KB				
F4ME1SQ				
F6ME1SL				
F7ME1WX				

*Yield trials and corresponding multiplications:*

ME1	ME2	ME3	ME4	ME5
PCME1FE	PCME2HR	PYTME3AS	PYTME4SA	PCME5WA
PYTME1HT EPCME1KB YTME1SQ	EPCME2SC	PYTME3BR	PCME4HF	PYTME5PA

## **PEDIGREE FORMAT**

A standardized recording system is used for crosses made in the Bread Wheat Section. If parent A is crossed with parent B and the F1 is crossed with parent C, its pedigree would be designated as A/B//C. Subsequent crosses with parental material D, E, F, and G are indicated using a number in the following fashion:

A/B//C/3/D/4/E/5/F/6/G

The female is designated by listing it first (on the left) followed by the pollen parent (on the right). Thus, A is the female parent and B the pollen parent in the first cross. The line A/B is the female and C the male parent in cross two, etc.

Backcrosses are designated with an asterisk (\*) and a number indicating the dosage of the recurrent parent. The asterisk and the number are placed next to the crossing symbol that divides the recurrent and donor parents. More than one backcross is rarely practiced in the program. The following are examples involving one backcross:

- A is the recurrent parent: A\*2/B
- B is the recurrent parent: A/2\*B
- A/B is the recurrent parent: A/B\*2//C/D
- C/D is the recurrent parent: A/B//2\*C/D

## **SELECTION HISTORY CODES**

Every segregating and advanced line in the program is assigned a so-called "breeder's cross ID" (BCID) and a selection history. This history records the process of selection, which describes where and how the selection was made and the stage or generation of selection.

Each BCID begins with a letter designation of the cross origin (e.g. CM), followed by a sequential number (e.g. 33027). After this BCID, there is the selection history: the numbers identify the individual plant selected and the letter indicates the location where selection took place, using a selection code. The zero-letter combinations (0Y, 0M, etc.) are reserved for populations harvested in bulk in that generation. A zero followed by a number (05PR, 010M) indicates modified bulk selection, in which a certain number (in the example 5 or 10) of selected heads are bulked.

The following codes indicate Mexican locations of selection (maximum code length is 2 spaces):

- B: EL BATAN
- M: TOLUCA
- PZ: PATZCUARO
- LP: LA PAZ
- Y: YAQUI (optimum)
- SY: YAQUI (reduced irrigation)
- HY: YAQUI (heat, late planting)
- PR: POZA RICA
- FUS: TOLUCA/FUSARIUM
- KBY: YAQUI/KARNAL BUNT

Selection history location codes for other countries are determined by the cooperators in those countries.

Examples of selection histories are presented below:

Type of cross	Breeders Cross ID (BCID)	Selection History (by generation)						
		F1	F2	F3	F4	F5	F6	F7
A/B	CM11897	-	12Y	010M	010SY	1PZ	1Y	0M
A/B//C	CM12456	040Y	10M	05PR	010B	010HY	1M	0Y

For more detailed information regarding selection histories and pedigree abbreviations, see the following CIMMYT publications:

- Semidwarf Bread Wheats. Names, parentages, pedigrees, and origins. Compiled by R.L. Villareal and S. Rajaram. Revised April 1988. Soon to be revised again.
- Wheat Varieties of the Southern Cone Region of South America. Compiled by M. M. Kohli. Soon to be revised.

## DESCRIPTION OF MAJOR BREEDING AND SCREENING LOCATIONS IN MEXICO

### Winter Cycle in North-Western Mexico

- Ciudad Obregon  
27.5°N, 40 masl. Located in the state of Sonora, this is a dry, irrigated, low-altitude site. Yields are high, in the order of 8-9 t/ha in experimental plots and 5-7 t/ha in farmers' fields. This is one of the two most important breeding and screening sites for the CIMMYT Wheat Program. About 60 ha are annually planted to breeding materials. Leaf rust and stem rust are major disease problems, in addition to Karnal bunt.



This location represents ME1 when planted optimally. Reduced irrigation and late planting simulate ME4 and ME5, respectively.

· Poza Rica

20.5°N, 60 masl. Located in the state of Veracruz, this is a hot, humid, low-altitude site. Materials are screened for heat and *Helminthosporium sativum* resistance. The BW program plants about 2 ha.

The site represents ME5.

## Summer Cycle in the Central Mexican Highlands

· Toluca

19°N, 2640 masl. Located west of Mexico City in the state of Mexico, this temperate, high rainfall, high altitude site is the most important summer cycle location for the CIMMYT Wheat Program. The major part of the breeding program including all segregating materials is sown here, totaling about 30 ha. It is a high rainfall environment with good disease expression, especially of stripe rust, *Septoria tritici*, and *Fusarium nivale*. Highest yields in experimental plots are realized in the order of 7-8 t/ha.

In addition to the summer plantings, winter materials are sown in November on about 7 ha.

This site represents ME2 for spring wheat and ME7 (FE) and ME8 (HR) for facultative wheats. Vernalization is sufficient for winter wheats to initiate flowering.

· El Batán, Texcoco

19°N, 2249 masl. This is the administrative center of the CIMMYT Wheat Program, located in the state of Mexico. Irrigation is available during periods of erratic rainfall. Due to land limitations plantings are usually restricted to the crossing block and multiplications of selected advanced materials, not exceeding 5 ha. Leaf rust develops in epidemic proportions.

It represents ME1/ME2/ME4, depending on water availability.

· Patzcuaro

19°N, 2400 masl. Located to the west of Toluca in the state of Michoacán, this rainfed site is used to screen and select for the septorias, head scab and acid soil tolerance. We plant 1-2 ha.

The site represents ME2/ME3.

· El Tigre

21°N, 2300 masl. At this site, located south of Guadalajara in the state of Jalisco, ME2 materials are evaluated for diseases, such as *Septoria* spp., *Fusarium* spp. and leaf rust.

## GERMPLASM DESCRIPTION AND ORGANIZATION IN THE BREAD WHEAT SECTION

### The Crossing Block

The crossing block (CB) is a collection of elite breeding source materials arranged by mega-environment (ME), and within ME by trait. In order to facilitate crossing operations, the CB is sown on four different dates, ten days apart. In all sites spring wheat CBs are planted. In the Toluca winter cycle, also a winter CB is assembled and planted.

### *The Spring CB*

The production of high yielding, widely adapted, stable and “durable” resistant spring germplasm is the primary consideration of the bread wheat section. For this reason, the spring CB is the largest and most diversified of the two CBs. Germplasm has been grouped according to ME. Crossing Block entries include the major varieties released in different countries, elite CIMMYT germplasm identified from international and national testing, or advanced lines exhibiting extreme expression of a specific trait or group of traits (often made available by the germplasm enhancement and wide cross sections within the Wheat Program's Genetic Resources Subprogram).

The specific breeding objectives for each ME were outlined earlier. Genotypes from each section of the CB carry genes specific to their defined ME. For example, ME1 genotypes carry genes or combinations of genes coding for one or more of the following: high yield potential, lodging resistance (dwarfing genes Rht1, Rht2, and Rht8), improved industrial quality, durable resistance to the rusts, tolerance to saline soils, and resistance to aphids and powdery mildew. Within each ME, materials are sub-grouped based on their country of origin or specific character expression. There are five CBs arranged by ME. These are:

- CB for favorable environments (FE),
- CB for the high rainfall areas (HR; containing a ME3 section),
- CB for semi-arid areas (SA),
- CB for the warmer areas (WA),
- CB for the high latitude areas (HL).

The genotypic constitution of the different CBs are given below:

- CB Spring for Favorable Environments (CBSME1FE)
  - A. High Yielding Varieties and Advanced Lines
  - B. Varieties from Major ME1 Countries
    - (i) Afghanistan
    - (ii) Bangladesh
    - (iii) Chile
    - (iv) China
    - (v) Egypt
    - (vi) India
    - (vii) Nepal
    - (viii) Pakistan
    - (ix) Zimbabwe
  - C. High Yielding Under Heat
  - D. Good Industrial Quality
    - (i) Bread Type
    - (ii) Cookie Type
  - E. Synthetics and other Crosses with Wild Relatives

· CB Spring for High Rainfall Environments (CBSME2HR)

A. High Yielding Varieties and Advanced Lines

B. Varieties from Major ME2 Countries

- (i) Andean Region
- (ii) East Africa
- (iii) Mediterranean region
- (iv) Yangtze (China)

C. Disease Resistance

- (i) Stripe rust resistance
- (ii) Septoria resistance
- (iii) Tan spot resistance (*Pyrenophora tritici repentis*)
- (iv) Head Scab Resistance/tolerance (*Fusarium* spp.)

D. Waterlogging Tolerance

E. Aluminum Toxicity Tolerance

F. Good Industrial Quality

- (i) Bread Type
- (ii) Cookie Type

· CB Spring for Semi-Arid Environments (CBSME4SA)

A. High Yielding Varieties and Advanced Lines

B. Varieties from Major ME4 Countries

- (i) India
- (ii) Mexico
- (iii) Southern Cone
- (iv) WANA

C. Hessian Fly Resistance

D. Good Industrial Quality

- (i) Bread Type
- (ii) Cookie Type

· CB Spring for Warmer Area Environments (CBSME5TE)

A. High Yielding Varieties and Advanced Lines

B. Varieties from Major ME5 Countries

- (i) Paraguay
- (ii) Thailand

C. *Helminthosporium sativum* Resistance

D. Heat Tolerance

E. Lines with Rapid Grain Filling

*The Winter/Facultative CB*

A winter/facultative (W/F) CB is sown at Toluca in November. The W/F CB is a collection of the best advanced lines and varieties from breeding programs around the world. Institutions like Oregon State University (OSU) have contributed significantly to this infusion of germplasm. The W/F CB is used primarily as a means of introducing variability into the CIMMYT spring wheat gene pool. CIMMYT/Turkey is involved in the production of winter/facultative types in collaboration with OSU, the Turkish NARS, and the International Center for Agricultural Research in the Dry Areas (ICARDA), which are sent out to NARSs as the FAWWON. CIMMYT base-produced advanced lines are also shared with CIMMYT/Turkey. CIMMYT/Mexico distributes an international W/F Yield Trial, FAWWYT.

The W/F CB consists of varieties from different countries representing the following regions/characteristics:

A. Varieties from Major ME7-12 Countries

- (i) Chile
- (ii) Great Plains of the USA
- (iii) Pacific Northwest of the USA
- (iv) Western, Central and Eastern Europe

B. Stripe rust resistance

C. Early Maturing Dwarf/Semidwarf Lines with Fast Grain Fill

- (i) Hebei
- (ii) Henan
- (iii) Jiangsu
- (iv) Northwestern Plains of Beijing
- (v) Shandong
- (vi) Shanxi

D. Drought-Tolerance

- (i) Afghanistan
- (ii) Iran
- (iii) Turkey

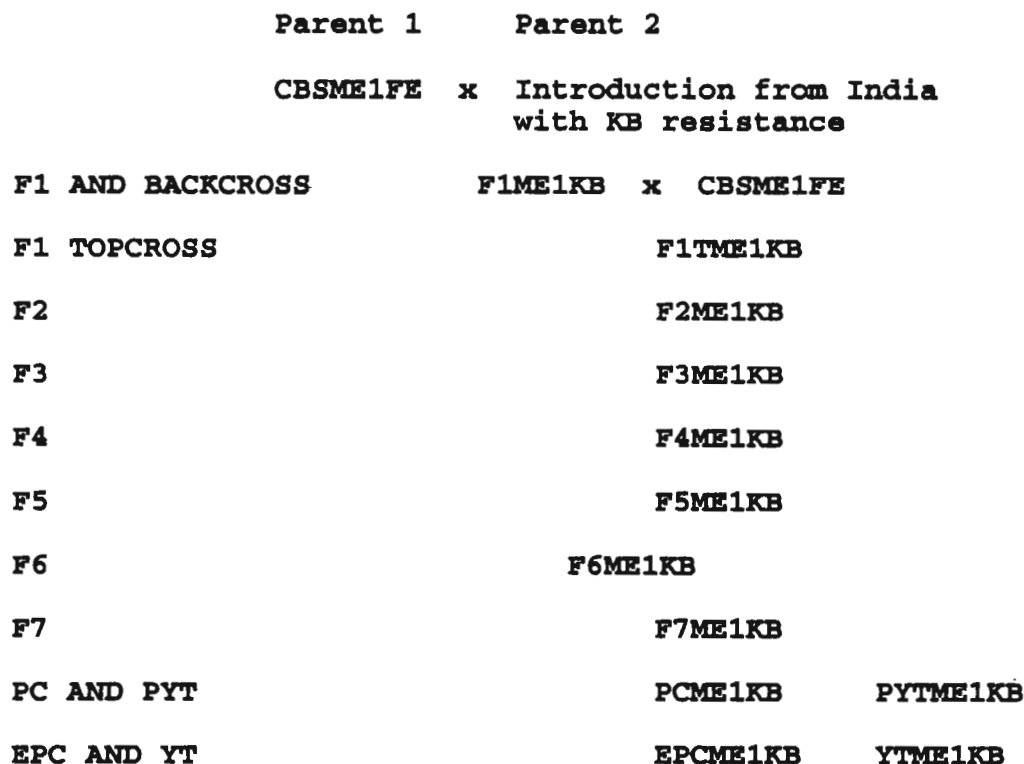
**F1 and Segregating Populations**

Crosses are directed toward specific MEs and the resulting nurseries labeled accordingly (see Nomenclature Section). Many F1 populations are either top- or backcrossed. Topcrosses are used to extend the variability, particularly when parents carry many loci in common, and backcrosses are carried out to stabilize variability as the genetic distance

between parents becomes greater. As a rule, 5-7 spikes are emasculated for simple crosses and 7-10 for top- or backcrosses.

Once a cross has been made and classified, it is selected under the stresses specific to its targeted ME. However, as all elite CIMMYT advanced material is tested over a wide range of environments both in Mexico and internationally, the ME classification may be changed when additional adaptation becomes apparent.

The following diagram is a hypothetical representation of germplasm classification, starting out from parental selection and resulting in replicated yield testing according to the standardized abbreviations in the Nomenclature Section:



If the final product does not have the expected level of KB resistance, is agronomically sound, resistant to the rusts, and high yielding, then it can be reclassified as EPCME1FE. The details of the selection methodology are discussed in the following section.

### **Advanced Lines**

Advanced lines are bulked in the F7 following individual spike selection in the F6, to form small seed multiplication plots or PCs (*Parcela Chica* is "small plot" in Spanish). These PCs are also sown as PYTs (preliminary yield trials) during the Obregon winter cycle, providing information on yield potential, agronomic type (on a large-plot basis), and disease resistance (from PC inoculation).

PYTs are single-replicate yield trials designed to eliminate the bottom end of the yield distribution. Two or three standard checks are included. The trials are either planted on beds (per entry: 2 beds (80cm wide/3m long), with 3 rows/bed,) or in irrigation units (*melga* is "irrigation basin" in Spanish; with 16 plots/melga; per entry: eight-row plot (5 m long), effective harvest area: 5 m<sup>2</sup>).

PCs are sown in small plots for observation and rust and/or KB inoculation. During the summer cycle in Central Mexico, PCs may be sown in many different sites for disease and adaptation evaluation.

Selected PC entries are advanced to EPCs and sown in replicated yield trials during the Obregon cycle. Three replicated (harvest area 5 m<sup>2</sup>), alpha-lattice designs are normally used. Space permitting, an unreplicated trial is sown in another simulated mega-environment (reduced irrigation or late planting) to gauge the performance of materials outside their respective ME.

As with all segregating material, each PC, EPC, PYT, and YT has an assigned ME, depending on its parents and selection history. However, genotypes across MEs can be expected to contain similar linkage blocks. These similarities have arisen through the conceptual belief at CIMMYT that breeding for yield potential is critical in both stressed and stress-free conditions, the former environment in addition requiring specific adaptive traits. This belief has been justified by the consistent demand for CIMMYT germplasm throughout the world. The specific trait requirements necessary for adaptation within defined MEs are included through the process of crossing and selection.

## **BREEDING METHODS AND GERMPLASM FLOW**

The diagrams in this section are schematic representations of the general breeding procedures used in ME1 and ME4. These are by no means rigid structures that must be adhered to under all circumstances. Considerable flexibility exists within the system allowing material to be channeled in different directions. Some segregating material is selected in other countries by CIMMYT staff and/or cooperators and returned to the program. The most important of these international shuttles are listed below:

- CIMMYT/China (*Fusarium* spp.)
- CIMMYT/Ecuador (stripe rust)
- CIMMYT/Ethiopia (stripe rust and *Septoria tritici*)
- CIMMYT/Guatemala (septoria, BYDV, and head scab)
- CIMMYT/Mexico, La Paz (salinity)
- CIMMYT/Turkey (winter and facultative wheat)
- CIMMYT/OSU (USA) (winter and facultative wheat)

In Mexico, segregating material targeted for specific MEs may occasionally be sown outside the regular Obregon/Toluca shuttle. In some instances, yield trials are conducted in the early generations depending on the nature of the material.

The breeding procedures for ME1 and ME4 are described in the following diagrams. FI, RI, and LP indicate full irrigation or moisture stress-free conditions, reduced irrigation, and late planted material, respectively.

The bulk of the winter program is handled by the CIMMYT Program based in Turkey and in collaboration with OSU, although some breeding and selection is conducted in Toluca

during the winter cycle (November to July). Winter x spring crosses are made during the Toluca winter cycle. These crosses contribute specific characters to the spring wheat gene pool and provide extended diversity. A portion of the resulting F1 seed is made available to OSU and CIMMYT/Turkey.

Considerable genetic diversity enters the breeding system in the form of introductions from various countries, including Argentina, Brazil, Paraguay, Chile, Uruguay, Peru, Bolivia, Ecuador, Colombia, Guatemala, USA, Canada, Australia, Russia, UK, France, Germany, South Africa, India, Pakistan, Bangladesh, Syria, China, Thailand, Egypt, Iran, Kenya, Ethiopia, Zimbabwe, Zambia, Japan, and Korea. In addition, the CIMMYT Wide Cross Section within the Genetic Resources Subprogram provides unique gene combinations for inclusion in the breeding program. Once introduced, these materials are classified according to ME in Mexico with regard to agronomic type, disease resistance, and adaptability.

## **PATHOLOGY INTERFACE**

In collaboration with the Crop Protection Unit, all segregating populations are exposed to artificial and natural disease epidemics. The most important diseases for each ME are listed in the following table.

<b>Mega-environment</b>	<b>Major pathogens (in order of importance)</b>
ME1	<i>Puccinia recondita</i> , <i>P. graminis</i> , <i>P. striiformis</i> , <i>Erysiphe graminis</i> <i>Tilletia indica</i>
ME2	<i>P. striiformis</i> , <i>Septoria tritici</i> , <i>P. recondita</i> , BYDV, <i>Fusarium</i> <i>graminearum</i> , <i>Xanthomonas campestris</i> pv. <i>translucens</i> , <i>H. tritici-repentis</i>
ME3	<i>P. recondita</i> , <i>P. graminis</i> , <i>S. tritici</i> , <i>S. nodorum</i> , <i>E. graminis</i> , <i>F. graminearum</i> , <i>Xanthomonas campestris</i> pv. <i>translucens</i>
ME4	<i>P. recondita</i>
ME5	<i>P. recondita</i> , <i>H. sativum</i> , <i>F. graminearum</i> <i>Sclerotium rolfsii</i> , <i>P. graminis</i>
ME6	<i>P. recondita</i> , <i>H. tritici-repentis</i> , <i>F. graminearum</i>
ME7	<i>E. graminis</i> , <i>P. striiformis</i> , <i>P.</i> <i>recondita</i> , BYDV
ME8	<i>E. graminis</i> , <i>P. striiformis</i> , <i>P.</i> <i>recondita</i> , eye spot, BYDV, bunts
ME9	Bunts
ME10	<i>E. graminis</i> , <i>P. striiformis</i> , <i>P.</i> <i>recondita</i> , BYDV
ME11	<i>E. graminis</i> , <i>P. striiformis</i> , <i>P.</i> <i>recondita</i> , BYDV
ME12	Bunts, BYDV, eye spot

The most important diseases for the major breeding/screening environments in Mexico are listed below.

### Obregon

Inoculation of stem rust (*Puccinia graminis tritici*) and leaf rust (*P. recondita-tritici*) by needle and spray applications of susceptible borders ensures adequate infection of the entire targeted fields.

Genotypes targeted for this environment experiencing KB are inoculated with Karnal bunt (*Tilletia indica*) and subjected to thrice daily overhead watering during flowering to optimize conditions for infection and disease spread.

Loose smut (*Ustilago tritici*) and bacterial blight may occur either naturally or artificially.

### Toluca

Needle and spray applications provide stripe rust (*P. striiformis*) and leaf rust infection. Dispersal of infected straw at the tillering stage initiates epidemics of *Septoria tritici* and *Fusarium nivale*.

Individual spikelets are inoculated with *Fusarium graminearum* (200,000 spores/L) to facilitate the ensured expression of head scab in selected entries.

Bacterial and BYDV infections are induced in some populations and occur naturally in many.

### Poza Rica

Materials are screened specifically for spot blotch (*Helminthosporium sativum*) and heat resistance. Infections occur naturally in the form of heavy epidemics.

The following table summarizes the major diseases targeted for each breeding/screening location in Mexico.

Location	Major diseases/insects for selection
Cd. Obregon	<i>Puccinia recondita</i> , <i>P. graminis</i> , <i>Tilletia indica</i> , ( <i>Ustilago tritici</i> )
El Batan	<i>P. recondita</i> , <i>P. graminis</i> , <i>Xanthomonas campestris</i> pv. <i>translucens</i> , BYDV, <i>Diuraphis noxia</i> , ( <i>Ustilago tritici</i> )
El Tigre	<i>S. tritici</i> , <i>S. nodorum</i> , <i>Fusarium graminearum</i> , and <i>P. recondita</i>
Poza Rica	<i>Helminthosporium sativum</i> , <i>P. recondita</i>
Patzcuaro	<i>F. graminearum</i> , <i>S. tritici</i> and <i>S. nodorum</i>
Toluca	<i>P. striiformis</i> , <i>P. recondita</i> , <i>S. tritici</i> , <i>F. graminearum</i> , <i>F. nivale</i> , <i>X. campestris</i> pv. <i>translucens</i> , and BYDV



## **QUALITY INTERFACE**

The Industrial Quality Section evaluates the industrial quality of parents, segregating populations and advanced lines. The Bread Wheat Section aims at producing high yielding, broadly adapted resistant germplasm for a range of quality characteristics. This is important as quality requirements among different countries vary from medium and strong types for the production of leavened breads, to medium but extensible dough for unleavened, flat and steamed breads, to weak dough for cookie and cake production.

While much of the quality assessment is based on advanced materials and lines from international nurseries, increasing emphasis is being given to identifying better quality types in earlier generations, in particular the parental stocks. Electrophoretic techniques allow the identification of specific loci coding for the high molecular weight glutenin subunits. These bands can now be traced and combined more effectively. Sedimentation tests for gluten quality using small grain samples are fast and effective and are used to screen materials in the early generations.

To determine sprouting tolerance advanced lines considered for ME2 and ME3 are planted at Toluca in January, and allowed to ripen during the peak rainy season. Materials are then screened visually in the field for sprouting tolerance. Selected lines are sent to the laboratory and tested for alpha-amylase activity (this enzyme is activated at germination and is involved in the process of starch degradation). Tolerant lines will have low enzymatic activity under rainfall free conditions with a slow rate of change under increasing rainfall.

## **INTERNATIONAL NURSERY SYSTEM**

### **Role of International Nurseries**

The role of international testing as distribution and data collection mechanisms has been dealt with briefly in preceding sections. The collected data are used extensively within the breeding program to help define and fine-tune objectives and make crosses for particular MEs. Each nursery consists of a set of varieties or lines and focuses on the specific requirements of individual MEs. Yield stability and disease resistance are primary objectives within the context of each ME.

### **Operation of International Nurseries**

The operation of international nurseries is the responsibility of the International Nursery Section and can be divided into four major activities:

- Formulation and targeting of nurseries, in conjunction with CIMMYT breeders and national program clients.
- Nursery preparation and distribution.
- Collation and analysis of returned data.
- Distribution of information and reports.

Nursery preparation involves the treatment, packaging, and distribution of healthy, disease-free seed, grouped into mega-environment-oriented nurseries. The system is computerized to facilitate the production of field books and nursery lists. Seed is cleaned and treated with fungicide and insecticide prior to distribution to avoid the introduction of foreign pests and diseases.

Data returned from cooperators are analyzed with the help of CIMMYT's System and Computing Service (SCS). Reports are published from the collated data from many sites and made available to cooperators. The accuracy and the completeness of any report depends heavily on the cooperation of staff in the national programs.

### **IMPACT OF CIMMYT-DERIVED VARIETIES IN DEVELOPING COUNTRIES**

The final output of CIMMYT's bread wheat improvement program is measured by the degree to which it benefits the national programs in different parts of the world, particularly developing countries.

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