

GERMPLASM MOVEMENT IN THE CIMMYT

Colección CIMMYT

WHEAT, TRITICALE AND BARLEY BREEDING PROGRAMS



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Introduction

The CIMMYT Wheat Program is dealing with the germplasm improvement of four crops: bread wheat, durum wheat, triticale, and barley. The following is a brief description of the Wheat Program's major domestic and international breeding and testing nurseries. The purpose here is to acquaint visiting scientists and trainees with the role of each nursery in the overall breeding scheme, how each nursery is planted, and what interrelationships may exist among various wheat, barley, and triticale nurseries, both domestic and international. This is not an attempt to explain CIMMYT breeding philosophies, nor is it a complete listing of all the nurseries or locations with which CIMMYT works.

CIMMYT breeding nurseries generally have Spanish names. Consequently, their abbreviations do not exactly match their English translations. International nurseries are given English names.

Breeding locations

The CIMMYT Wheat Program operates primarily in three Mexican locations. Ciudad Obregon (elevation 40 meters, 29° latitude north) is located in the State of Sonora and is utilized for the winter breeding cycle. Cd. Obregon offers environmental conditions that are conducive to the maximum expression of genetic yield potential. This location also facilitates the screening of breeding material for leaf rust resistance, because a natural leaf rust epidemic occurs annually throughout the Yaqui Valley. Screening for stem rust is accomplished by artificial inoculation of all nurseries. Cd. Obregon is a desert location and therefore is irrigated throughout the cropping season.

Toluca (elevation 2,640 meters, 19° latitude north) is located in the State of Mexico near Mexico City. Natural infections of stripe rust are always heavy, and in addition, a complex of fusarium, helminthosporium, septoria species, and bacteria occur on a regular basis. Toluca is one of the main sites for CIMMYT's summer breeding nursery, which is planted in May and harvested in October. The cold winter temperatures at Toluca also facilitate vernalization of fall-planted winter wheat nurseries that are used in the spring x winter crossing program.

El Batan (elevation 2,240 meters, 19° latitude north) is the location of CIMMYT headquarters, and is the third major site for

CIMMYT's summer breeding nursery.

The rainy season in Toluca and El Batan begins in mid-June, so nurseries at both sites are irrigated to facilitate germination and early seedling growth. However, rainfall is generally sufficient beginning in late June to negate the need for subsequent irrigation.

Nurseries at all three sites are needle-inoculated with stem rust, and oil- and talc-inoculated with leaf and stem rust to supplement natural inoculum.

In addition to the three breeding locations listed above, CIMMYT screening nurseries and crossing blocks are summer planted in Patzcuaro, Michoacan, to evaluate materials for resistance to *Septoria tritici*; Refugio, Guanajuato, to screen for stem rust; and winter planted in Rio Bravo, Tamaulipas, and Los Mochis, Sinaloa, for screening for leaf rust resistance.

CIMMYT pedigrees

Pedigrees in the CIMMYT breeding program begin with an alphabetic designation of cross origin:

- CD = Durum crosses since 1973
- CM = Bread wheat crosses since 1970 and Durum crosses from 1970 to 1973
- CMB = Barley crosses
- CMH = Crosses made for special germplasm improvement
- CT = Triticale crosses after 1981
- D = Durum crosses before 1970

- II = Bread wheat crosses before 1970
SWM = Spring x Winter crosses in bread
wheat
X = Triticale crosses before 1981

These letters are followed by a cross number. For example, 33027 is the numeric designation given to the cross which produced the bread wheat advanced lines called 'Veery'. Following the cross number is either a letter or a number-letter combination. A letter indicates a single plant selection in the F₁ generation from the top and double crosses. In the number-letter combination, the number is used to designate a single plant selection from the F₂ nursery and the letter indicates the location of the selection. These are followed by a series of number-letter combinations which identify individual selections by plant number and location of selection. For example, CM2634 6-B-12Y-3M-1Y-0B indicates that the spring x spring cross, number 26346, was made by the bread wheat program in Mexico as a top or double cross. The letter (B) indicates that it was the second single plant selection made within the F₁ top or double cross population. It was then grown in Cd.Obregon, Yaqui Valley, and was the twelfth selection from the F₂ population (12Y). It was then seeded in Toluca, Edo. de Mexico, where it was the third F₃ selection (3M). The following season it was grown again in the Yaqui Valley where it was the first selection from the F₄ progeny row (1Y). Finally, it was

grown in El Batan where it was harvested in bulk in the F₅ generation (OB).

CIMMYT base nurseries

Unless otherwise stated, the following descriptions apply to nurseries for all four crops: bread wheat, durum wheat, triticale, and barley. These nurseries and their inter-relationships are summarized in Figure 1 (p.10).



CB-Spring (Crossing Block-Spring) contains three hundred to five hundred advanced lines and named cultivars for use as parents in the crossing program. Entries are arranged in the crossing block according to their previously identified genetic superiority for one or more traits. Cultivars and lines are separated into groups, such as high yield and/or wide adaptation, resistance to certain diseases, adaptation to certain regions, tolerance to aluminium toxicity, yield structure characters, and industrial quality. This grouping differs slightly between the four crops according to their respective needs.

CB-Winter (Crossing Block-Winter) is composed of advanced lines and named cultivars of winter materials for use as parents in the spring x winter crossing program. With the exception of the triticale program, entries in the CB-Winter are organized according to origin. The CB-Winter is transplanted in Cd.

Obregon in November after 45 days of artificial vernalization. The same nursery is sown in Toluca in November without artificial vernalization.

Misc. (Miscellaneous) consists of varieties and advanced lines received by CIMMYT from wheat programs outside Mexico, either through responses to requests for seed or as entries from other international nurseries (see Tables 1 and 2, pp. 16, 18). Lines in the Misc. nursery have been evaluated for disease resistance and general agronomic quality for at least one growing cycle in the Observation Lines nursery (LO), or some similar nursery, at one of CIMMYT's Mexico locations. The Misc. nursery is continually examined for possible parents for the crossing program.

LO (Observation Lines) is made up of cultivars and advanced lines that are newly received from various national programs. Cultivars in the LO are evaluated for disease resistance and general agronomic value and, if identified as prospective parents for crossing, are graduated to the Misc. or CB nurseries.

PCs (Small Increase Plots) consist of 600 to 2000 newly bulked F₅ through F₈ lines. They are evaluated for disease resistance and general agronomic performance, and are regularly rogued to produce clean seed-stocks. All entries in the Obregon PC nursery are simultaneously evaluated in replicated

yield trials. Lines that exhibit high yield, resistance to diseases, good grain quality, and resistance to lodging and shattering are made available to cooperators through the International Screening Nurseries.

Experiments (Yield Trials) consist of advanced lines that are potential candidates for the International Screening Nurseries. The Experiments nurseries are yield tests grown only in Ciudad Obregon. Each nursery in the Experiments consists of 30 entries and 3 replications with 2 to 5 check varieties. In addition to yield testing, all lines are evaluated for disease resistance and industrial quality.

International Screening Nurseries include the **IBWSN** (International Bread Wheat Screening Nursery), the **IDSN** (International Durum Screening Nursery), the **ITSN** (International Triticale Screening Nursery), the **IBON** (International Barley Observation Nursery), and the **ISEPTON** (International Septoria Observation Nursery). The first four nurseries are comprised of advanced lines of the respective crop that have been evaluated in Mexico and have exhibited superior yield, disease resistance, acceptable industrial quality, and excellent general agronomic value.

The **ISEPTON** consists of advanced lines of different crops, including entries from the other screening nurseries, PCs, and crossing block nurseries that are tested annually in Patzcuaro, Michoacan, by CIMMYT pathol-

ogists for resistance to *Septoria tritici*. The ISEPTON is distributed internationally to cooperators who regularly report a high incidence of septoria infection. The most highly resistant lines with adequate agronomic characteristics are cycled through the crossing program.

Each screening nursery is composed of 280 to 500 entries that are selected from the best yielding lines of the PCs. The nurseries are sent annually to up to 200 locations throughout the world (the number of locations depends on the crop). The purpose is to make available to cooperators the most recently developed material from the CIMMYT breeding program, as well as to assess the performance of the entries over a wide range of environments. Cooperators may use the material directly in their breeding programs for crossing, may reselect material for further testing and eventual release, or may directly release any entry, provided the country of origin is acknowledged upon commercial release. Because of its high quality, only seed from the PCs grown in Cd.Obregon is used to assemble the screening nurseries.

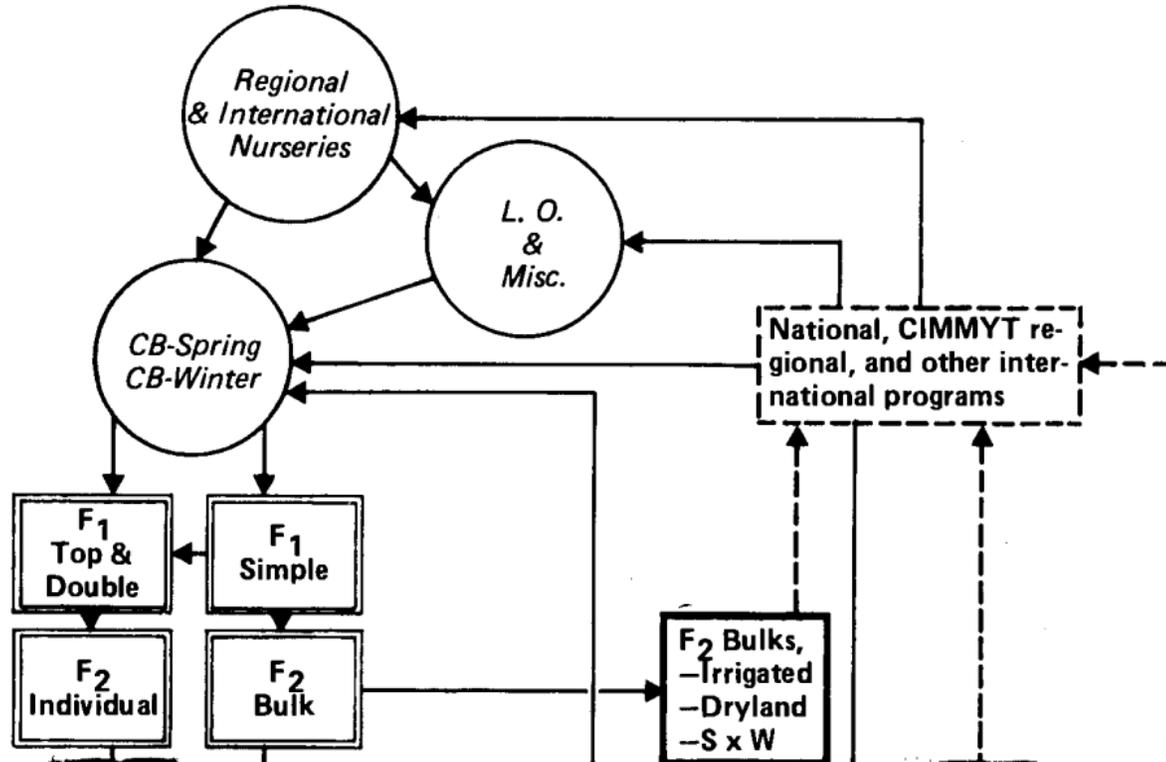
PMIs (International Multiplication Plots) are comprised of seed multiplication plots of advanced lines submitted by cooperators in national breeding programs worldwide. Also included are the best lines of CIMMYT's breeding program that are destined for the international yield nurseries and elite yield

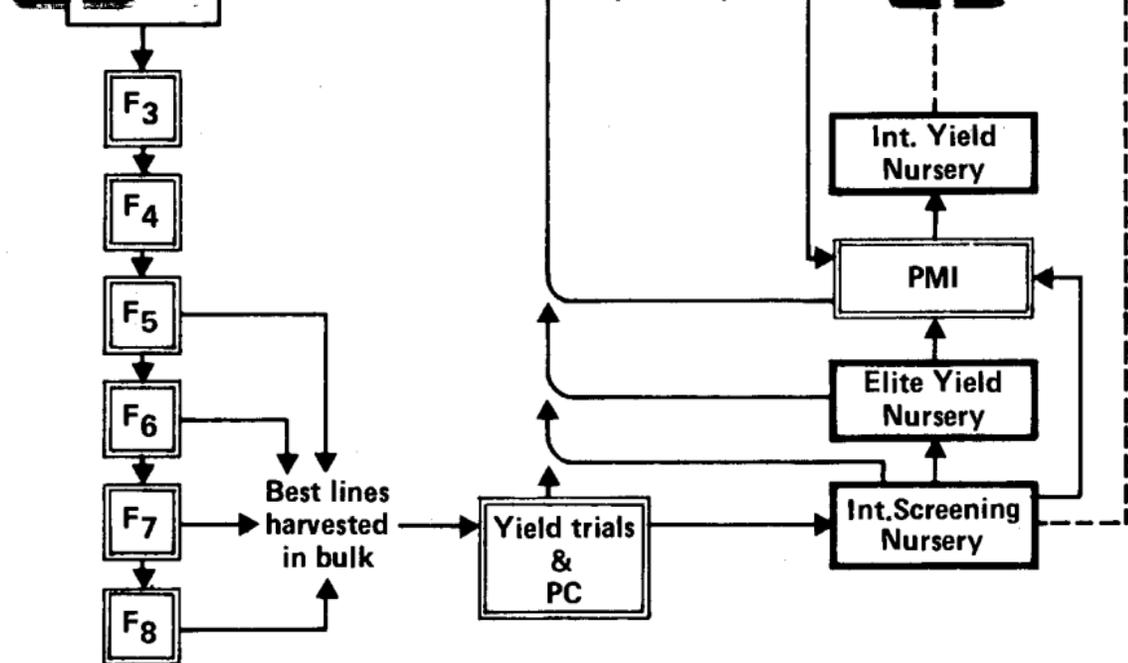
nurseries. From some 100 to 150 candidate cultivars, 49 are selected for the yield nurseries (from durum wheat cultivars, 29 are selected). In addition, seed stocks are produced for lines that have proven potential use as varieties, and these stocks are kept for several years. The PMI nursery is grown only in Cd. Obregon, because of the excellent seed quality that can be achieved there.

International Yield Nurseries include the **ISWYN** (International Spring Wheat Yield Nursery), the **IDYN** (International Durum Yield Nursery), the **ITYN** (International Triticale Yield Nursery), and the **IBYT** (International Barley Yield Trial). Each of these nurseries contain 49 named cultivars and advanced lines (again, the durum wheat nursery contains 29 cultivars), not all of which have been developed by CIMMYT, plus one local check variety. These entries are replicated 3 times. The trials are sent annually to approximately 100 locations throughout the world. Plot size, standardized at all locations, is 6 rows of 2.5 meters with the central 4 rows harvested for yield evaluation. Data is also collected on agronomic and pathologic characteristics and is returned to CIMMYT for analysis and subsequent publication. The ISWYN, begun in 1964, was one of the first international yield nurseries. Its success has helped to provide the impetus necessary for the establishment of international nurseries in every major crop species by various interna-

(Con't Page 12)

10 Figure 1. Movement of Germplasm in CIMMYT's Wheat, Triticale, and Barley Programs.





— Nurseries for use in CIMMYT Crossing program
 = CIMMYT breeding nurseries

— CIMMYT international nurseries
 - - - National, CIMMYT regional, and other international programs

tional agricultural centers and national institutions. These nurseries have played an important role in the dissemination and identification of widely adapted cultivars.

Elite Yield Trials are comprised of the **ESWYT** (Elite Spring Wheat Yield Trial), the **EDYT** (Elite Durum Yield Trial), and the **ETYT** (Elite Triticale Yield Trial). These trials include twenty-nine entries of the most advanced material from the CIMMYT breeding program which have exhibited high-yield potential for two years in Obregon. Each entry is replicated 3 times, and space is reserved for the inclusion of one national check variety. Seed for the Elite Yield Trials comes from the Obregon PMI nursery. These trials are sent annually to 30 to 40 selected cooperators, whose data help to identify suitable varieties for testing in the International Yield Trials. (The ETYT is not distributed for international testing).

F₁ Single is composed of the first generation progeny of single crosses (variety or advanced line x variety or advanced line). F₁ single crosses are advanced as bulks to the F₂ bulk nursery, and/or are used as parents in the production of top and double crosses.

F₁ Top and Double consists of first generation progeny of top crosses (F₁ x variety or advanced line) and double crosses (F₁ x F₁). Individual plant selections are advanced to the F₂ Individual nursery.

F₂ Bulk contains progeny of selected bulk-harvested entries from the F₁ single crosses. For international distribution, entries in the F₂ bulk nursery are categorized according to known or suspected agronomic or pathologic characteristics. Lines in each category comprise a single international nursery which is distributed to cooperators in appropriate locations. Present F₂ bulk categories are, for example, irrigated, dryland, and spring x winter. Progeny of single plant selections are advanced to the F₃.

F₂ Individual is made up of progeny of single plant selections from the F₁ Top and Double nurseries. Selections are made on the basis of plant type and disease resistance. Single plant selections are advanced to the F₃.

F₃ to F₈ breeding nurseries enable evaluation and selection based on plant type, disease resistance, grain type, and preliminary baking quality data. Single plant selections are made in the F₃ through F₇ generations. Bulks are made in F₅-F₈ generations, which become advanced lines and are included in the PC and yield trials.

Special nurseries in the barley program

CB-Quality contains lines with high protein and/or high lysine that come directly from national and regional programs, from the international barley collections (USDA, G.A.



Weibie's, etc.), from mutation breeding programs, and from materials developed within the CIMMYT barley breeding program.

CB-Resistance consists of lines and varieties from regional and national programs, from international collections, and nurseries from international centers (e.g., ICARDA). These lines represent a reservoir of genes for general agronomic improvement and for resistance to diseases such as *Rhynchosporium secalis*, *Puccinia hordei*, *P. striiformis*, *Erysiphe graminis*, and Barley Yellow Dwarf Virus.

Segregating Generations are all nurseries composed of segregating material, from F₂ to F₈, and are split into an early and a normal type nursery.

Yield Trials allow unbiased comparisons to be made among the different types of materials. Advanced lines are tested in separate yield trials that take into account their individual characteristics. These lines are divided into three major groups: covered, naked, and early types.

TN (New Bulls) contains progeny of F₃ through F₈ single plant selections made on the basis of exceptional plant type and disease resistance. New bulls are used as pollen parents in the crossing program.

Special nurseries in the triticales program



Rye Populations are kept for the production of primary triticales. Spring and winter type entries are taken from the World Rye Collection.

Durum x Rye Crosses are made to obtain new primary triticales of the hexaploid type. The crossing is followed by embryo culture in the laboratory and colchicine treatment. The resulting grains are advanced to the hexaploid primary triticales nursery.

Bread Wheat x Rye Crosses are made to obtain octoploid primary triticales. The offspring are treated with colchicine and planted in the next generation in the octoploid primary triticales nursery.

Primary Triticales consists of lines in both the hexaploid and the octoploid primary triticales nurseries, which are observed for their agronomic usefulness in further crosses. Superior lines are crossed with material from the CB. The offspring are advanced to the F₁ single nursery.

Interspecific Crosses are triticales lines that are crossed with rye and bread wheat for recombination of the A-, B-, and R-genomes. Grain resulting from these crosses is planted in the F₁ single interspecific nursery.

F₁ to F₉ Interspecific consists of top and double crosses in the F₁ single interspecific nursery, and then evaluation of lines in all other interspecific nurseries, so that true and stable triticale types can be achieved. Other than that, these nurseries are handled in the same manner as the respective nurseries of the normal breeding program (Figure 1). Good lines from F₅ to F₉ nurseries are

Table 1. CIMMYT regional nurseries

Abbrevia- tion	Name	Crop
RDISN	Regional Disease and Insect Screening Nursery	Bread Wheat, Durum, Triticale, Barley
RDTN	Regional Disease Trap Nursery	Bread Wheat, Durum, Barley
VEOLA	Vivero de Enfermedades y Observaciones de Latinoamérica (Latin American Disease Screening Nursery)	Bread Wheat, Durum, Triticale, Barley
ELAR	Ensayo Latinoamericano de Royas (Latin American Disease Trap Nursery)	Bread Wheat, Durum, Barley
LACOS	Lineas Avanzadas del Cono Sur (Advanced Lines of the Southern Cone)	Bread Wheat, Durum, Triticale
ACWYT	African Cooperative Wheat Yield Trial	Bread Wheat, Triticale, Barley
SNACWYT	Screening Nursery for the African Cooperative Wheat Yield Trial	Bread Wheat, Triticale, Barley

harvested in bulk and advanced to the PCs and yield trials of the normal program.

CIMMYT regional nurseries

CIMMYT regional programs, in cooperation with institutions of the respective region, assemble a number of nurseries (see Table 1). These nurseries consist of varieties



Organization	Purpose	Distribution
CIMMYT Middle East Regional Program/ICARDA	Screening for disease resistance	Eastern Hemisphere
CIMMYT Middle East Regional Program	Surveillance of pathogens	Eastern Hemisphere
INIAP Ecuador/CIMMYT Andean Regional Program	Screening for disease resistance	Latin America
INIAP Ecuador/CIMMYT Andean Regional Program	Surveillance of pathogens	Latin America
INIA Chile/CIMMYT Southern Cone Regional Program	Screening for disease resistance and adaptation	Southern Cone countries
CIMMYT East Africa/Kenya Regional Wheat Program	Yield evaluation of regionally adapted lines	East African countries
CIMMYT East Africa/Kenya Regional Wheat Program	Identification of regionally adapted lines	East African countries

and advanced lines that have shown adaptation to a particular region and should be tested there on a broader basis. Lines or varieties may also be included which are suitable for disease surveillance in certain hot spots. CIMMYT sows these nurseries at its Mexican sites to cycle superior material to the crossing program through the L.O. or Misc. nurseries.

Table 2. Other international nurseries

Abbrevia- tion	Name
ISWRN	International Spring Wheat Rust Nursery
IWWPN	International Winter Wheat Performance Nursery
IWSWSN	International Winter x Spring Wheat Screening Nurseries
IWSWYT	International Winter x Spring Wheat Yield Trial
RWYT	Regional Wheat Yield Trial
RBYT	Regional Barley Yield Trial
RFWYT	Rainfed Wheat Yield Trial
PON	Preliminary Observation Nursery
RCB	Regional Crossing Block
	Ensayo Conosur (Southern Cone Yield Trial)
UMSN	University of Manitoba Screening Nursery
	South African Wheat Yield Trial
AUSEN	Australia Septoria Nursery

Other international nurseries



Other international nurseries that are important to CIMMYT's Wheat Program are listed in Table 2. Most of these nurseries are received by CIMMYT for purposes of screening the material for possible use in the base program.

Crop	Organization
Bread Wheat, Durum, Triticale, Rye	USDA
Bread Wheat	University of Nebraska
Bread Wheat	Oregon State University
Bread Wheat	Oregon State University
Bread Wheat, Durum	ICARDA
Barley	ICARDA
Bread Wheat, Durum	ICARDA
Bread Wheat, Durum, Barley	ICARDA
Bread Wheat, Durum, Barley	ICARDA
Bread Wheat	EMBRAPA
Triticale	University of Manitoba
Wheat	South Africa
Wheat	Wheat Industry Research Council of Australia

