

**Wheat Genetic  
Resources at CIMMYT:  
Their Preservation,  
Enrichment, and Distribution**

CIMMYT is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, the Center is engaged in a worldwide research program for maize, wheat, and triticale, with emphasis on improving the productivity of agricultural resources in developing countries. It is one of 16 nonprofit international agricultural research and training centers supported by the Consultative Group on International Agricultural Research (CGIAR), which 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 a combination of 40 donor countries, international and regional organizations, and private foundations.

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**Back cover:** Primitive wheat *Triticum dicoccum*—a source of heat tolerance and resistance to Russian wheat aphid and *Septoria tritici*.

**Cover photos:** Gene Hettel.



Sergio Pastén

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## Introduction

Prior to the late 18th century, agricultural practices were totally dependent on crude handtools, crop landraces, and mixtures of these landraces. Then came the Industrial Revolution with an associated population explosion that transformed the subsistence nature of agriculture and its farming systems forever. In the mid-19th century, Mendel (and later other pioneering plant geneticists) provided a new knowledge of plant genetics and breeding that made it possible to increase dramatically the production and production potential of agriculture. Undeniably, the wonders of crop improvement have resulted in the erosion of genetic diversity of many crops in farmers' fields, including wheat, due to the replacement of landraces and old farmers' varieties with modern high yielding varieties.

Fortunately, our understanding of the sources of genetic diversity and their distribution and interrelationships

between cultivated crops and their wild relatives has rapidly expanded in the latter half of the 20th century. This enhanced awareness has resulted in the present-day concept that genetic resources are our heritage and consequently should be preserved, protected, and made available without restrictions to all who need them.

Clear indications of how important conservation of genetic resources is today include:

- The establishment of the FAO Commission on Plant Genetic Resources;
- Creation of numerous gene banks by the national agricultural research systems;

### What Are Genetic Resources?

The CIMMYT Wheat Program follows the broadest sense of categorizing genetic resources consistent with Frankel (1977) and the FAO Commission on Plant Genetic Resources (FAO, 1983):

- Cultivated varieties—high-yielding ones in current use (advanced varieties) and those they have superseded (obsolete varieties), generally with a known breeding history.
- Primitive varieties or landraces (like those from Tibet in photo at left) with no known breeding history.
- Wild and weedy relatives of the crop species. Twenty-seven species are included in this group for wheat (Kimber and Feldman, 1987).
- Special genetic and cytogenetic stocks.
- Elite and advanced breeding lines— included because they have potential breeding value or special characteristics even though they did not reach cultivar release.

- Ongoing conservation efforts of international agricultural research centers (IARCs) such as IPGRI and commodity centers such as CIMMYT;
- The Keystone International Dialogue on Plant Genetic Resources.

The inclusion, in 1988, of Genetic Resources as one of the Wheat Program's four subprograms (the others being Germplasm Improvement, Crop Protection, and Crop Management and Physiology) demonstrates the Program's conviction that genetic diversity is fundamental to sustaining wheat production in the future. It formalizes our responsibility to preserve genetic resources of wheat and to support the active breeding programs by collecting and/or acquiring germplasm with traits needed by the programs. Further, it demonstrates our commitment to characterize, evaluate, document, and

## Some Definitions

**Active collection**—A collection of accessions maintained for medium-term viability (about 40 years), stored at temperatures close to 0°C, and 3-7% moisture. Ideally, all accessions should be maintained in sufficient quantity to be available on request.

**Base collection**—A collection of accessions kept for long-term (-18°C), secure conservation, which is not used as a routine distribution source.

**Cultivar**—A variety (cultivated variety) of a plant produced by selective breeding, which has been specifically improved for agricultural or horticultural purposes and is grown in cultivated conditions.

**Genetic resources**—Germplasm of plants, animals, or other organisms containing useful characters of actual or potential value. See Box on page 1.

**Germplasm**—1) The genetic material that forms the physical basis of heredity for a species and that is transmitted from one generation to the next by means of the germ cells. 2) An individual or clone representing a type, species or culture, that may be held in a repository for agronomic, historic or other reasons.

**Heterogeneous**—Consisting of genetically dissimilar or diverse individuals; mixed.

**Homogeneous**—Consisting of similar individuals.

**Landrace**—A cultivated form of a crop species, which has evolved over generations of selections by farmers.

**Variety**—A subdivision of a species below subspecies and in classical taxonomy, a heterogeneous grouping, including nongenetic variations of the phenotype, morphs, and races.

**Wild relative**—A relative of a crop species that grows in the wild and is not used for agricultural purposes.

maintain these genetic resources for increased utility in wheat improvement.

The Genetic Resources Subprogram, which is made up of the Wheat Germplasm Bank, the Wide Crosses Section, and Wheat Molecular Biology, supports wheat improvement by:

- Acquiring critical germplasm;
- Maintaining collections of selected germplasm representative of all significant germplasm pools;
- Identifying and documenting useful genetic variability;
- Transferring variability into useful genotypes through pre-breeding and wide crosses;
- Refining appropriate biotechnological tools that will complement the conventional breeding methods used to exploit genetic variation, especially alien introgression;

- Distributing accessions and information freely throughout the world.

This booklet mainly describes activities of the Wheat Germplasm Bank associated with preserving and enriching the potential of wheat genetic resources and making this material available to plant breeders throughout the world, with special emphasis given to developing countries.

### **Intercenter Cooperation**

CIMMYT has signed an agreement with the International Board for Plant Genetic Resources (IBPGR)—in 1992 renamed the International Plant Genetic Resources Institute (IPGRI)—that entails cooperation on the collection, documentation, and evaluation of wheat genetic resources. On technical and practical aspects, we work toward improved planning on plant genetic resources by participating in commodity IARC- and IPGRI-

sponsored meetings that bring together genetic resources staff members. The first of these meetings took place in 1987 at CIMMYT, the second in 1989 at the International Rice Research Institute (IRRI), and the third in 1990 at IPGRI.

In 1988, CIMMYT and the International Center for Agricultural Research in the Dry Areas (ICARDA) reached an agreement through which the two centers now share the responsibilities for genetic resources of *Triticum* spp. ICARDA has the base collection responsibility for tetraploid (durum), diploid wheats, and wild wheat relatives; CIMMYT has base collection responsibilities for hexaploid (bread) wheats and triticales.

Each base collection is being duplicated at the other center for safety. Thus, the CIMMYT Bank is serving as a back-up facility for ICARDA's base collections of spring

durum wheats, the wild relatives of wheat, and barley. In turn, ICARDA backs up CIMMYT's base collection of bread wheats and triticales. Base collection responsibilities for both institutions also include seeking out all commercial varieties and obsolete cultivars as well as maintaining collections of landraces.

Genetic resources staff of CIMMYT and ICARDA will participate in joint evaluation activities since the contrasting environments available to each of the centers are complementary for carrying out germplasm evaluation work.

### **Cooperation with National Programs**

The Wheat Germplasm Bank interacts with national programs by:

- Acting as a backup for national collections;
- Satisfying any request for germplasm and by occasionally requesting

specific germplasm from a national program to be included in the Bank;

- Asking for assistance in verifying the identity of accessions;
- Requesting evaluations that cannot be done in Mexico;
- Participating in joint collection expeditions.

In serving as a backup for national program collections, including working collections, the Bank provides insurance against loss of such germplasm. Such collections can be stored, either as part of the CIMMYT collection or as special holdings that will not be available for distribution. In the first case, the material is available to other programs outside of CIMMYT, in the second case, the material would be available as parental material to CIMMYT breeders. Products of such crosses will be freely available to all our clients. In the future, we anticipate that national programs will become active partners in the evaluation of wheat genetic resources.

### **Germplasm Collection and Acquisition**

Acquisition of new germplasm through active collection is a component of the CIMMYT program that is coordinated with IPGRI and ICARDA (see Box, page 5). The Bank supports and/or actively participates in collection expeditions on a case-by-case basis. Special consideration is given if germplasm in an area is threatened by "genetic wipeout", i.e., the wholesale destruction of a genetic resource (Wilkes, 1983). Of special interest are areas that have material which may not have been collected.

CIMMYT is particularly interested in collecting cultivars from around the world released by breeders in the 20th century that are now obsolete. In view of the history of wheat breeding, these are very important genetic resources. Most of the landrace and hybridization-derived wheat cultivars from South America are now in the CIMMYT collection.

## Recent Expeditions to Acquire Wheat Germplasm

**1984.** Eastern Turkey—Collection of about 750 landrace cultivars.

**1984.** Northern Pakistan—Collection of about 375 landrace cultivars.

**1987.** Southeastern Turkey—Collection of about 500 *Triticum* and *Hordeum* species in the catchment area behind the Ataturk Dam. These are being preserved by the Turkish Program and CIMMYT.

**1989.** Black Sea area of Turkey—Collection of 12 commercially grown

*T. monococcum* and *T. dicoccum* by the Turkey/CIMMYT Program in cooperation with the British Archaeology Institute.

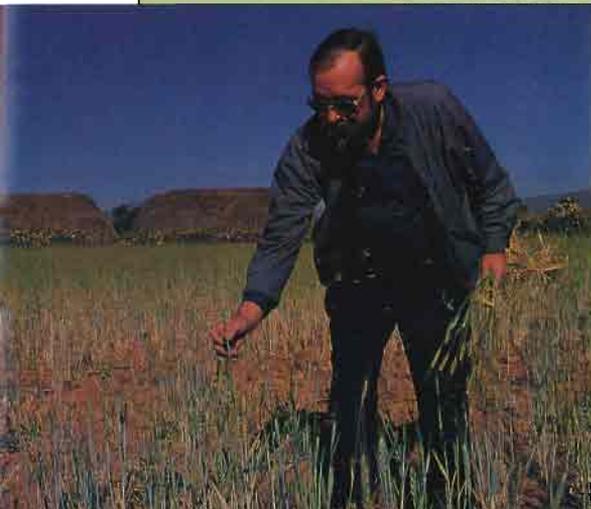
**1989.** State of Michoacan, Mexico—In cooperation with the Mexican national program, collection of commercially grown landrace cultivars of hexaploid wheats introduced in about 1550 from Spain; 216 accessions were obtained (photo).

**1990.** States of Nuevo Leon and Coahuila, Mexico—Collection of 1550 accessions of landrace cultivars in a joint expedition of La Universidad Autonoma Agraria Antonio Narro, INIFAP (Mexican National Institute of Forestry, Agriculture, and Livestock Research), IPGRI, and CIMMYT.

**1990.** Tibet—Collection of *Triticum* and *Hordeum* species during a joint expedition of Canadian, Chinese, ICARDA, and CIMMYT personnel; 250 accessions were obtained.

## Germplasm Preservation

From its inception in 1966 and until 1981, the CIMMYT Wheat Program operated a relatively small germplasm cold storage facility for conserving very small amounts of some materials, usually those used in or resulting from our crossing programs. The Wheat Germplasm Bank, which became operational in 1981, now contains just over 95,000 accessions representing more than 50 years of breeding and collection activities. It is an active collection—stored at -2°C, which should maintain viability of the accessions for a medium-term duration of from 40 to 50 years. Presently, we are in the planning stages of adding a long-term storage facility, which will maintain a temperature of -18°C to extend seed viability to about 100 years. The collection includes various types of genetic resources as shown in Table 1.



Tom Luba

Currently, the entire collection is maintained as an active collection. When our long-term storage facility is completed and when the Wheat Germplasm Bank Information Management System is installed, a base collection of the hexaploid wheat and triticale germplasm will be formed while the rest (durum wheat and wild

**Table 1. Number of accessions contained in the CIMMYT Wheat Bank by species as of January 1992.**

Crop	No. of Accessions
Bread Wheat ( <i>Triticum aestivum</i> )	52,839
Durum Wheat ( <i>Triticum turgidum</i> )	13,448
Triticale (X <i>Triticosecale</i> )	13,268
Barley ( <i>Hordeum vulgare</i> )	7,991
Rye ( <i>Secale cereale</i> )	194
Primitives ( <i>T. monococcum</i> , <i>T. dicoccum</i> )	4,523
Wild relatives ( <i>Triticum</i> spp.)	2,984
<b>Total</b>	<b>95,247</b>

## Conserving Triticale Genetic Resources

Triticale (X *Triticosecale*) is a recently synthesized species, hence there are no landraces of this crop. However, because of intensive plant breeding in several agroecologic zones in North America and Europe, there is a wide array of genotypes in existence. The rye (*Secale cereale*) and wheat (*Triticum* spp.) parents of triticale have been conserved for many years, but even now the genetic resource collections of rye do not fully represent the diversity within cultivated and wild *Secale*.

In 1992, a 3-year collaborative project with the University of California at Davis, was concluded, in which a comprehensive genetic resource collection of triticale was assembled for placing in gene banks. Emphasis was placed on North American germplasm because three prominent triticale breeders, R.J. Metzger, E.N. Larter, and B.C. Jenkins, had retired and the germplasm they accumulated was at

risk of being abandoned or not included in a public collection.

Both winter and spring type triticales were grown at Davis, California, in a common environment. Descriptor data and several evaluation traits were scored. More than 3,000 distinct accessions were multiplied for the National Small Grain Collection in Idaho, the CIMMYT Wheat Germplasm Bank, and for others who may request seeds. This collection is now available from the CIMMYT Bank.



Gene Hettel

relatives) will remain as an active collection. This conforms to the ICARDA-CIMMYT agreement. Barley germplasm is stored at CIMMYT only as a working collection for the joint ICARDA-CIMMYT Barley Program.

## Seed Multiplication and Regeneration

Multiplication and regeneration are two of the most important functions of a germplasm bank because the long-term viability of seed is very much dependent on the quality of the seed being placed in storage. Further, care must be taken to avoid genetic drift, as well as mechanical mixtures and other handling errors.

CIMMYT multiplies wheat seed in a screenhouse at the El Batan headquarters rather than in the field. This facility (photos at right) expedites the production of quality seed for medium- and long-term storage. It also

helps avoid accidental mechanical mixing and other handling errors since the planting for multiplication is programmed year-around instead of being done strictly by the annual crop season. Thus, a limited number of

accessions can be multiplied at any one time by planting weekly or bi-weekly. This is much better than the traditional, simultaneous harvesting of thousands of lines when a single, seasonal planting is made in the field.



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An important consideration in seed multiplication and regeneration is the amount of seed planted. The number of seeds planted or actual number of plants harvested at CIMMYT depends on two factors:

- The homogeneity or heterogeneity of the accessions;
- The size of the seed sample originally received.

As a rule, CIMMYT plants the seed in basic units of 25 plants. If an accession is judged homogeneous or is a very small sample, one basic unit is produced. As heterogeneity increases, one, two, or three units may be included in the planting. The largest number ever employed is 100 plants (four basic units). If there are doubts as to the number of plants to produce, we prefer to err on the high side to be safe. Relative homogeneity is mostly known if the material comes from the CIMMYT programs. Introduced

material is judged for homogeneity when planted in the introduction block for quarantine inspection.

## Seed Health and Quarantine

All introductions are funnelled through CIMMYT's Seed Health Unit (SHU) for inspection before planting. If SHU finds anything of potential danger, the samples are destroyed. If not, the introductions are released for planting in the greenhouse or in designated introduction fields. Bank introductions are inspected periodically and fungicides and insecticides are routinely applied.

SHU conducts an inventory of all pathogens found on seed stored in the Bank. Table 2 provides a typical example of the organisms found in bulked samples of 9206 bread wheat and *T. dicoccum* accessions, showing that only fungi normally endemic in most wheat growing areas were present. We expect that the incidence

**Table 2. Results of physical inspection, surface wash, and blotter incubation tests of more than 9000 bulked samples of bread wheat and *Triticum dicoccum* accessions from the Bank regenerated in Celaya and Papalotla, Mexico.**

	Bread Wheat		<i>T. dicoccum</i>
	CEL1987	PAP1990	PAP1990
<b>Number of Accessions</b>	1264	7616	326
<b>Physical inspection</b>			
Smut balls	0	0	0
Galls	0	0	0
Sclerotia	0	0	0
Insect signs	0	0	0
Weed Seeds	0	0	0
<b>Surface wash</b>			
Karnal bunt teliospores	0	0	0
Common bunt teliospores	0	0	0
<b>Blotter incubation (% infected kernels)</b>			
<i>Cochliobolus sativus</i>	0.3	0	0
<i>D. hawaiiensis</i>	0.3	0.3	0.3
<i>D. tetramara</i>	0	0.3	0
<i>Fusarium</i> sp.	0	0.3	0
<i>F. avenaceum</i>	0	1.3	29.7
<i>F. culmorum</i>	0	0.3	2.8
<i>F. moniliforme</i>	9.3	0.3	0
<i>F. oxysporum</i>	3.0	3.5	0
<i>F. poae</i>	0.3	0.3	0
<i>F. sambucinum</i>	0	0.3	0
<i>Gibberella zeae</i>	1.3	2.3	0

of even these fungi will be greatly decreased with the use of the greenhouse facility. SHU screens each planting in the greenhouse so that a complete record of organisms encountered can be accumulated.

Seed health analysis is useful to indicate potential problems so that prophylactic chemical applications can be planned during seed multiplication to avoid any disease outbreaks. Also, these analyses are used for planning seed treatments prior to shipment.

Presently, the seed treatment utilized for seed shipped from the program is a combination of Vitavax 300 and Daconil (both 2 g/kg seed), applied as a slurry using 3 ml/kg of Pellistac as a sticking agent.

## Evaluation

A major activity of the Bank is to identify useful genetic variability and

make it available to breeders. We expect that variability will be needed to:

- Further increase yield potential;
- Provide new sources of resistance to diseases and pests to maintain the yield level so far achieved;
- Provide adaptation to the more marginal environments;
- Provide improved quality.

Most evaluation work is demand-driven, meaning that evaluations are done for traits or characteristics where the breeding programs lack variability. Evaluations can be requested by CIMMYT and by national program breeders. An example is the request of CIMMYT bread wheat breeders to evaluate Bank accessions for sources of resistance to the Russian Wheat Aphid (RWA). Resistance was identified in both *Triticum aestivum* and *T. dicoccum*

accessions, but not among *T. turgidum* var. *durum* accessions. Additional germplasm in the collection has not been screened for RWA reaction and will be screened only if more sources of resistance are deemed necessary.

Other evaluations which have been undertaken include:

- Bread wheat—*Septoria tritici* resistance, *Helminthosporium sativum* resistance, glume pubescence, and heat tolerance;
- Emmer wheat—Heat tolerance and *S. tritici* resistance;
- Spelt wheat—*S. tritici* resistance;
- Durum wheat—Earliness and *S. tritici* resistance.

Some have proposed the development of a core collection to increase the utility of the collection and ease the evaluation process. However, the CIMMYT genetic resources staff

## Using Wheat's Wild Relatives in the Search for Variability

Most wide crossing efforts focus on two sets of material—one distantly (intergeneric) and the other closely (interspecific) related to wheat. Distant relatives include approximately 325 annual/perennial species. Significant progress has been made in producing complex hybrids, especially in crosses of wheat with *Thinopyrum* (*Agropyron*) *curvifolium*, *A. distichum* (original cross obtained from Dr. R. Pienaar in South Africa), *A. junceum*, *Elymus giganteus*, and several other species derivatives that require additional breeding. After 10 years of crossing and selection following the original cross of *Th. curvifolium* with three susceptible bread wheats, material showing excellent spot blotch (*Helminthosporium sativum*) resistance was turned over to the Bread Wheat Section in 1990 for additional breeding and release of elite germplasm. Advanced derivatives of these hybrids also have resistance to leaf rust, scab, and septoria; prospects

are good for salt tolerance as well. In 1991, Pakistan released two bread wheat varieties derived from CIMMYT-developed *A. distichum* hybrids: Pasban 90 for irrigated areas and saline soils and Rohtas 90 for rainfed areas. Other national programs are evaluating some progeny from this intergeneric work and CIMMYT has incorporated some in its breeding programs.

More recently, the Wheat Wide Crosses Section is incorporating traits into wheat from closely related, mostly *Triticum*, species. One major effort involves crossing durum wheat by *Triticum tauschii* (photo below), which results in lines called synthetic hexaploids. Crosses using 200 different *T. tauschii* accessions



Gene Hettel

in the Bank have been made so far, allowing us to tap into the genetic variability of the wild relative. Disease resistances being sought in these materials are those to helminthosporium, fusarium head blight, septoria, and Karnal bunt. Prospects are also promising for finding good salt tolerance. Another 250 *T. tauschii* accessions in the Bank's working collection await similar crossing with durum wheats.

Genes imparting resistance to wheat leaf and stem rust provide an example of the genetic variability that can be provided by wild wheat relatives. To date, some 20 unique stem rust and 12 leaf rust genes for resistance have been found in eight related wild grasses compared to 21 resistance genes for stem rust and 23 resistance genes for leaf rust found in wheat itself (Skovmand and Rajaram 1990).

considers such a step to be premature and believes more research is needed to determine if a core collection would actually provide better utility.

### **Pre-Breeding**

Pre-breeding is done to develop parental material for the breeding sections and is carried out only when the needed characters are found in accessions that have very poor agronomic type or are super-susceptible to one or several diseases. It normally involves intraspecific or interspecific hybrids where special techniques, such as embryo rescue, are not needed. Pre-breeding will normally be done either to transfer specific genes; or to create source populations based on dominant male-sterile wheats.

Genes transfers will be done using a traditional backcross program where the recurrent parent is an improved semidwarf wheat. If the character is

judged important enough for future use, the production of isogenic stocks will be considered. The following traits are presently under transfer to improved wheats: 1) glume pubescence in bread wheat, 2) flooding tolerance in bread wheat, 3) Russian wheat aphid resistance in spring bread and durum wheats, and 4) earliness in durum wheat.

Creation of genepools is based on dominant male-sterile wheats and will mostly be concerned with biotic and abiotic stresses. Different sources of resistance can be incorporated in a population that can be placed under recurrent selection. These populations will then be made available to breeders. Such populations will be created for various traits when the proper parental material has been identified.

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## An Integrated Wheat Information System

In the past, information generated by different sources, e.g., national trials, international trials, laboratories, and germplasm banks, could not be effectively integrated around the germplasm to which it pertained. For this reason, the Wheat Program resolved to develop an integrated strategy to manage all data pertaining to germplasm in the Program. This strategy, which relies on unique identification of germplasm and features of a relational database, is being implemented in three phases:

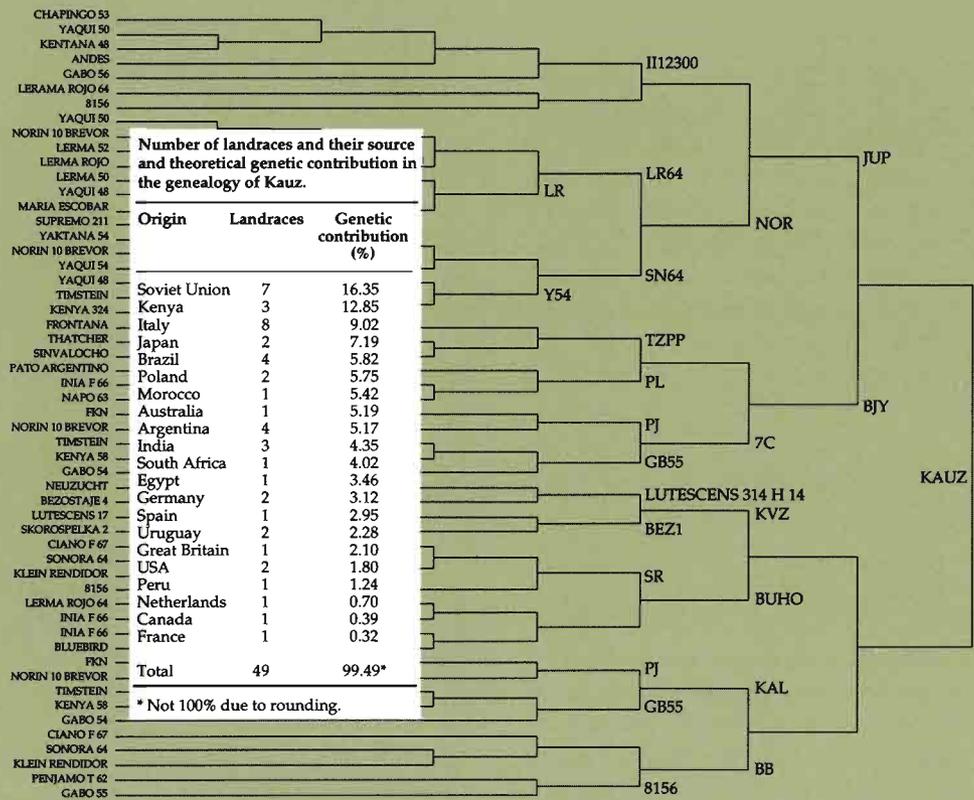
- The unique identification of germplasm by cross identification (CID) and selection identification (SID) numbers. This feature of the Wheat Pedigree Management System (WPMS) has been completed and is on line.
- Germplasm description and information (genotypic or G data). This phase has been partially completed with the installation of the Wheat Germplasm Bank System (WGBS).

- A Wheat Data Management System (WDMS), which will deal with evaluation data of both G and G x E (environment)-type information.

WPMS—This database will be the core of the complete, integrated Wheat Information System. Unique germplasm identification allows systems to share information by recognizing what germplasm is being referred to. In CIMMYT, like most breeding centers, germplasm is identified by cultivar names, breeder names, crosses, cross numbers, and selection histories. A particular line can be identified by one or all of the above, e.g., the notations Seri 82, Veery#5, KVZ/BUHO//KAL/BB, and CM33027-F-15M-500Y-0M identify the same germplasm. WPMS will indicate that all these descriptors refer to the same material.

WPMS, a relational database and repository of information on genealogies

and selection histories, uses the Purdue/USDA system for cross identification and the CIMMYT notation for selection histories (introduced lines can be entered as nonstandard). This repository provides a uniform identification mechanism to store information on germplasm in terms of its relationships to parents, thus potentially serving all aspects of germplasm related research. For example, WPMS can analyze genealogies and the theoretical genetic contribution of any line, variety, or landrace in the tree can be calculated. The complete genealogy of the popular CIMMYT bread wheat, Kauz, indicates 49 landraces from 21 countries contributed to the genetic makeup of this wheat. The Figure/Table shows a partial genealogy of Kauz going back five generations and the theoretical genetic contribution of the parental landraces to Kauz as well as their country of origin. Comparing sets of landraces among the



hierarchical trees of modern varieties will help breeders trace useful traits to specific landraces and identify landraces that have not been used in improvement programs.

Nonredundant storage of pedigree information will provide means to extend individual pedigrees through additional information concerning ancestors. These features can be exploited through the development of tools such as coefficient of parentage. The power of WPMS has already been seen in some unexpected ways. For example, preliminary investigations suggest that cytoplasmic diversity in CIMMYT bread wheats is restricted.

To date, the following WPMS functions have been developed:

- Wheat PMS Fieldbook System (WPFBS)—Generates fieldbooks for

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the breeding sections and prints them with field tags and harvest labels. This system performs rigorous verification of fieldbook data, thus improving data quality. It allows synonyms so different names can be used for identical germplasm in data entry, while the preferred name appears in the fieldbook.



CIMMYT Files

- Wheat PMS Reports—1) Cross expansion, which reports a cultivar based on cross and selection identification. It can expand a cross to include all ancestors. 2) Dendrograms, which permit examination of genealogies of a cultivar and provide a table of theoretical Mendelian genetic contribution of each parent, as provided in the Kauz example. 3) Wheat abbreviations, which create an alphabetically sorted list of wheat cultivar abbreviations. This replaces Special Report 749 from Oregon State University, and is now available for international distribution as CIMMYT Wheat Special Report No. 4, in either electronic or hard copy form. 4) CM Numbers, which report crosses where a given line has been used as a parent.

WGBS—The Wheat Germplasm Bank System manages the Bank's passport, regeneration, and logistical information as described in the text. The WGBS is connected to the other main systems,

WPMS and WDMS, through the unique identifiers and can retrieve and supply information to the complete system. See more about WGBS on page 15.

WDMS—The Wheat Data Management System (WDMS) will provide a secure, flexible system for data storage on wheat, triticale, and barley. It will also provide a set of tools for filtering, transforming, accessing, and exploring data.

WDMS, currently in the planning and design stages, will store original data of three types: 1) environmental, 2) genotype x environment, and 3) genotypic. Tools will be provided to allow basic data manipulation, reporting, and graphic presentations. The ability to query the relational database will provide a powerful research tool. For example, it is envisaged that WDMS could produce a list of sites where international bread wheat, durum wheat, and triticale trials have been grown in the same season with less than 350 mm of

available water. WDMS will be able to list instances where line X, to be released by a national program, occurs in the database and a second sub-list in which all instances of susceptible reactions to specified diseases for the line are reported. The system will extract files for downloading to personal computers for further analysis using standard packages.

Putting it all together—The WPMS, WGBS, WDMS, and associated functions have been developed in System 1032 on a VAX computer under the VMS operating system. We plan to add the User Data Management System, which is a data access tool kit for VAX systems and which facilitates reporting, querying, and exporting. The efficient use of this integrated network will be an invaluable tool for tapping and distributing information on accessions in the Bank.

## **Wheat Wide Crosses**

The Wheat Wide Crosses Section of the Genetic Resources Subprogram adds new variability to the cultivated wheat gene pool by introducing alien genetic material through intergeneric and interspecific hybrids where, in all cases, special techniques such as embryo rescue are required. The products are passed on to the mainstream breeding program of CIMMYT and national programs. The Section also assists in various basic research projects underway at CIMMYT. See the Box on page 10 about the use of distant and close relatives of wheat in the search for genetic variability.

## **Wheat Molecular Biology**

Wheat Molecular Biology is involved in mapping specific genes, i.e., resistance genes or gene complexes for certain diseases, photoperiod response, vernalization, and drought. The Section is also looking at genomic

variability as well as evaluating and investigating other new methodologies with applications in wheat improvement.

In the near future, it is expected that Wheat Molecular Biology, through the use of molecular markers, will assist the Bank in transferring to improved wheats some of the genes identified through its evaluations. In the more distant future, the Section is anticipated to become involved in identifying genomic variation in the Bank's collection, isolating the genes themselves, and applying novel methods of alien gene transfer and gene expression modification.

## **Documentation Using the Wheat Germplasm Bank System**

The Wheat Germplasm Bank System (WGBS) is a software system that electronically manages data (i.e., passport, characterization, evaluation, and logistical information) in the Bank

## CIMMYT Policies on Germplasm Distribution and Cultivar Release

Bank accessions are considered a collection held in trust for use by the scientific community dealing with wheat improvement. During the 1987-1991 period, almost 41,400 samples were distributed to programs around the world. Seed is available free upon request in small quantities (100 seeds per accession according to need) to any wheat scientist or program in the public or private sector in developing and developed countries if the particular accession is available for distribution. In case of scarcity, priority is given to public sector organizations. Researchers in the private sector are usually asked to pay shipping costs. Amounts larger than 100 seeds may be supplied upon special arrangement and would normally be done after pre-shipment multiplication in Mexico—This would take approximately five months.

### **Breeding Material**

*Germplasm Distribution.* CIMMYT distributes bread wheat, durum wheat, triticale, and barley (ICARDA-CIMMYT) germplasm for the benefit of wheat producers and consumers in developing countries. The CIMMYT philosophy is that germplasm, developed through its breeding programs, should be freely available to all clients. Breeders are encouraged to develop their own varieties from this material.

Germplasm is distributed through:

- Seed requests to the Bank (discussed above) and to other CIMMYT sections.
- CIMMYT's International Wheat Nurseries System, which announces germplasm availability to national programs and to all other interested parties on a regular basis.
- Direct collection from CIMMYT nurseries by visitors to Mexico and outreach locations.

For all forms of distribution, germplasm is classified into the following three categories:

- CIMMYT segregating populations (F2-F5).
- CIMMYT-derived advanced lines (F6 and later generations).
- Non-CIMMYT introductions (originating from outside breeders, experimental stations, private, and public breeding organizations, collecting expeditions, and germplasm banks) of advanced lines, commercial varieties, landraces, and wild relatives.

*Variety Release.* CIMMYT's policy for allowing commercial variety releases originating from the three germplasm categories involves the following:

- CIMMYT segregating populations—Selections can be freely released as varieties under all circumstances, in

which case CIMMYT appreciates notification and acknowledgment.

- CIMMYT-derived advanced lines—When there are no Plant Variety Rights (PVR) involved, CIMMYT requests notification and acknowledgment. However, if a CIMMYT advanced line is to be released under PVR, with or without further selection, permission should be obtained from CIMMYT. While CIMMYT recognizes the validity of PVR, it reserves the right to distribute the germplasm to all clients.
- Non-CIMMYT introductions—When an advanced line and/or commercial variety from non-CIMMYT sources that has been included in CIMMYT nurseries is to be released with or without further selection as a commercial variety, written approval must be obtained through CIMMYT or directly from the source responsible for its development, regardless of whether or not PVR applies.

collection. The WGBS can also generate field books and various reports as needed. This database uses elements of CIMMYT's Maize Germplasm Bank Management System (Rosales and Taba, 1988).

WGBS uses the same pedigree identifiers as does the Wheat Pedigree Management System (WPMS), which will allow for data interchange among the crop breeding sections, the international nursery section, and the Bank collection. When germplasm is submitted to the Bank, existing evaluation data will be immediately available for Bank use.

The functions of the WGBS include:

- Storing and updating of passport data, which allows new material to be accessed;
- Producing field books needed for introductions, regenerations, and characterizations;
- Producing lists for seed shipment;
- Assigning storage location in the active and base collections of present material and new introductions;



- Monitoring storage dates, seed viability, and seed amounts;
- Selecting materials that are at critically low levels and need regeneration;
- Filing data obtained from introduction and regeneration nurseries;
- Facilitating selection of accessions based on passport data and/or specific traits.

In the Bank's base and active collections, accessions are continuously added and sometimes subtracted. Therefore, the publication of a catalog of accessions is not foreseen at this time because of the problems of keeping it current. Some time in the future, Bank information may be published using CD-ROM technology. With the WGBS, we can search the database at any point in time and will do so for any scientist/cooperator upon request. We can supply listings of accessions of particular interest, either on diskette or

as a hard copy. Presently, the collection can be categorized on such attributes as crop, growth habit, species, origin, maturity, height, and grain color. Other attributes will be added to this list when the information has been added to the database.

### Seed Requests

Specific seed requests, i.e., those that indicate name or accession number, are easily filled (if the particular germplasm is in the active collection) and normally mailed within one week. If an import permit is required for seed shipments, the process will be expedited if the permit is included with

#### Where to Write

Requests for seed, listings of accessions, or other information about the Bank should be addressed to: Head, Wheat Germplasm Bank, CIMMYT, Apdo. Postal 6-641, 06600 Mexico D.F., Mexico. FAX: (52) 595-4-1069; Email: DIALCOM 157:CGI201.

the initial request. We make every effort to fill more general requests by determining which material will be most useful through further correspondence. In these types of requests, the following information will help us to identify the appropriate germplasm:

- Crop of interest;
- Growth habit required;
- Goal of investigation;
- How much material can be handled in a growing season;
- Growing conditions.

### Feedback on Use and Performance of Bank Material

Conservation and distribution of seed are important functions of the Bank, but our concerns do not end there. Another important function is to promote free flow of information about the performance of Bank material. The Bank compiles data on each accession and this is utilized to select materials to

satisfy requests. Reports from cooperators are important contributions to our knowledge about each accession and we request a copy of any results obtained on Bank material.

## Conclusion

Genetic diversity is critical in enhancing yield potential and sustaining that potential through new sources of resistances and tolerances to biotic and abiotic stresses. Thus, genetic resources are fundamental to sustaining wheat production in the future.

Modern wheat cultivars are an assembly of genes or gene combinations pyramided over the last century by breeders using, in most cases, well adapted cultivars of their region. The advance of international agriculture has enormously expanded the availability of germplasm with wide adaptation and from more sources, thus significantly changing

patterns of cultivar distribution. Given this scenario, introgression of additional variability found in genetic resources is necessary to increase stability and to add further improvements in wheat.

CIMMYT's major objectives include increasing farm-level productivity while safe-guarding against genetic vulnerability. The preservation, evaluation, documentation, enhancement, and easy availability of genetic resources are central to those ends.

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