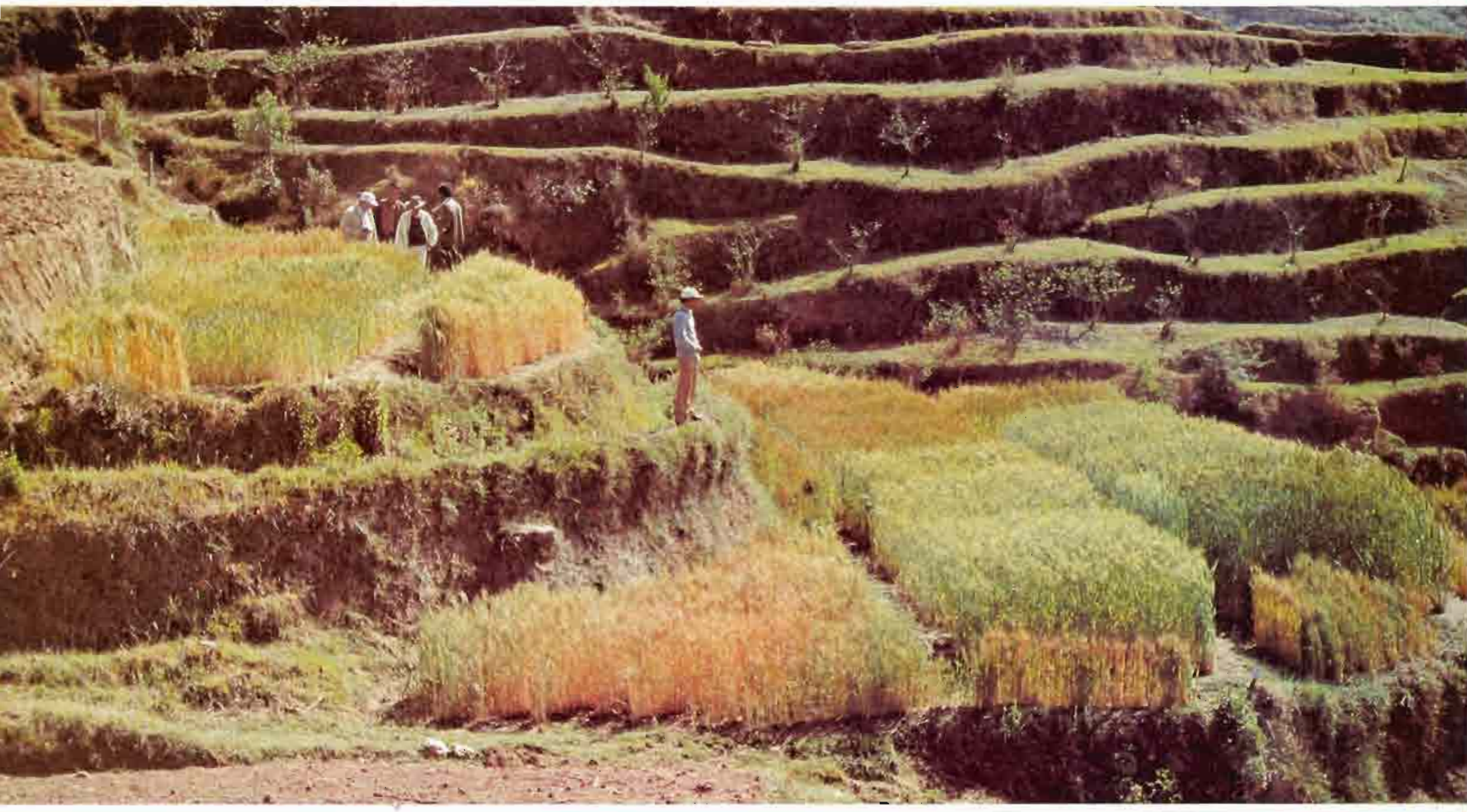
CIMMYT TODAY No. 10

international testing program in wheat, triticale and barley



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CIMMYT TODAY
INTERNATIONAL TESTING PROGRAM IN WHEAT, TRITICALE AND BARLEY

In 1950 a stem rust epidemic struck the wheat crop in the United States and Canada, reaching its greatest destruction in 1954. In 1953 the durum wheat crop of the U.S. was 60 per cent destroyed, and in 1954, 75 per cent. The primary cause of the disease, called race 15B, was capable of destroying any commercial wheat variety then in commercial use. A race similar to 15B was spreading simultaneously in Latin America.

A disaster of this magnitude forced scientists to search for new solutions, and out of this crisis came initiatives which are still benefiting worldwide agriculture. This paper describes one of those benefits.

The standard response to a disease epidemic is the rapid testing of wheat lines to identify resistance to the new race of the pathogen; then to multiply seed of the resistant lines, or to cross the resistant lines to "pyramid the genes" for resistance. A race as virulent as 15B demanded the widest possible testing in the shortest possible time.

In 1950 the U.S. Department of Agriculture* appealed to seven countries to join the U.S. in testing 1,000 lines of wheat selected from the U.S. World Wheat Collection as possible sources of resistance to 15B; the seven countries were Mexico, Colombia, Ecuador, Peru, Chile, Argentina and Canada. CIMMYT's predecessor organization in Mexico was an active participant. These 1,000 wheats were exposed to the stem rust populations in the participating countries. The results of this 1st International Stem Rust Nursery exceeded expectations and today, much of the stem rust resistance in commercial wheats of the U.S. and other countries can be traced to resistant breeding materials identified from those early international trials.

There were other benefits of even greater importance. A new mechanism for widespread distribution and testing of wheat germ plasm was in the process of creation.

New era of plant breeding

International testing opened a modern era in plant breeding. Before the 1st International Rust Nursery many breeders were reluctant to release advanced lines from their breeding programs to fellow scientists for fear the new varieties would be named and released without proper recognition to the breeder and organization responsible. Distribution of materials to other scientists was generally delayed until the variety had been named in the breeder's own state or country. Rarely were early generation materials—lines still undergoing improvement and still "segregating" e.g. expressing genetic variation within the same line—distributed to other scientists.

International testing ushered in a new willingness to share advanced generation un-named lines and early generation materials. This, in turn accelerated the introduction of materials with genetic variability into national breeding programs. It became accepted policy that any line tested internationally could be used by the collaborating scientists for breeding purposes or commercial release, provided acknowledgment of the source of the material was given.

"These developments", said Norman Borlaug, a prime mover of international testing, "broke down a psychological barrier which had tended to keep the efforts of each wheat researcher isolated. The new testing led to an unexpected acceleration of wheat breeding programs around the world".

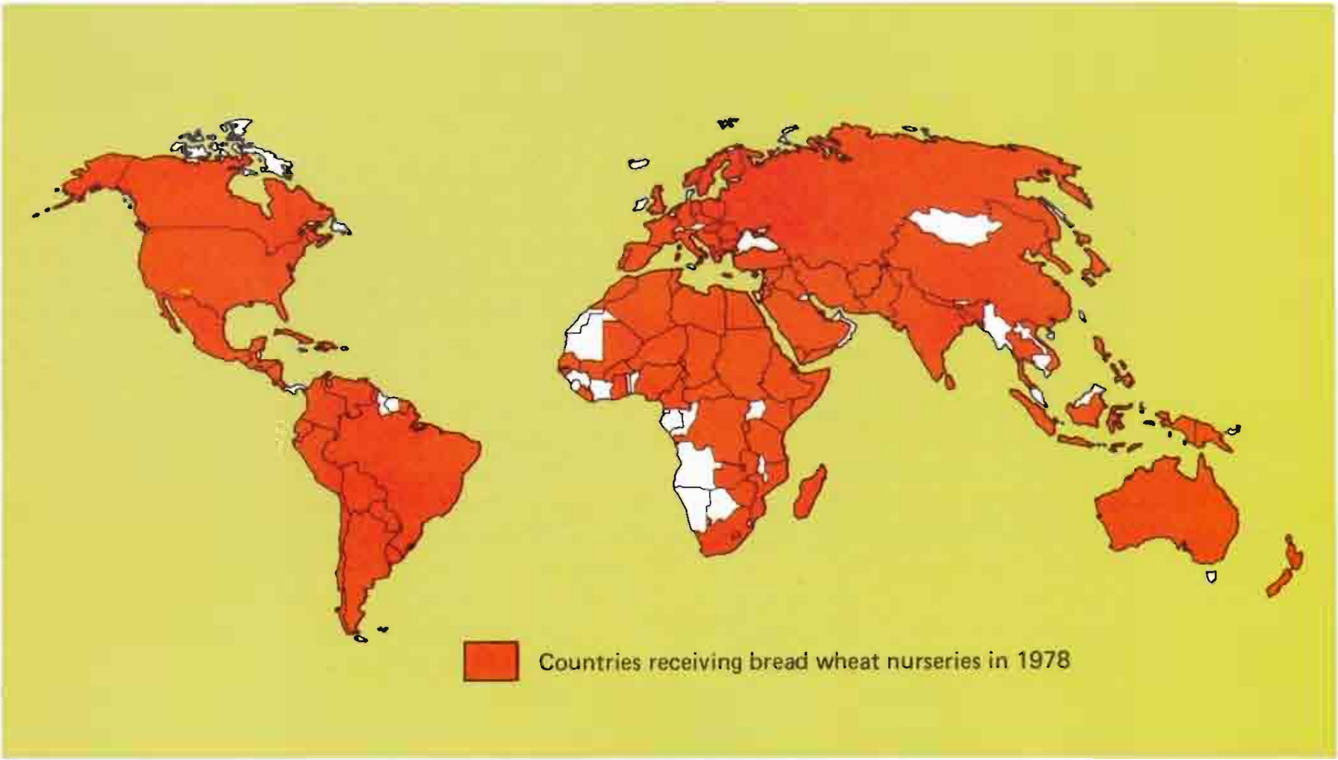
While the initial emphasis of international testing was to identify sources of disease resistance, other benefits also emerged. The inclusion of advanced lines and varieties from all parts of the world afforded cooperators the opportunity to observe the adaptation of materials to widely differing local conditions and served the practical needs of national wheat improvement programs in three ways.

(1) Improvement through New Introductions—International nurseries were particularly useful to countries lacking the resources for large-scale breeding programs. They became the vehicle for distributing advanced lines and commercial varieties for evaluation under local conditions. Such materials were evaluated for disease resistance, adaptation and agronomic characters. Some of the varieties tested were suitable for commercial release without further improvement.

(2) Improvement through Selection—International nurseries also offered national wheat scientists the opportunity for improvement through selection. Many of the experimental lines included in an international nursery, which appeared uniform under local conditions where they were bred, exhibited considerable variation when grown in other parts of the world. Within the best lines of an international nursery grown at one location, wheat scientists had the opportunity to select individual plants which were better adapted to their local conditions than were the bulk populations. National breeding programs thus had an opportunity for crop improvement at minimal time and expense.

(3) Improvement through Hybrid Populations—The international exchange of early generation segregating materials also provided broad sources of genetic diversity, an essential dimension in successful breeding programs. National wheat scientists also received a wealth of germ plasm through international nurseries which could be used as crossing materials to produce offspring that combined more desirable characters than were found in the separate parents.

* Drs. H.A. Rodenheiser, B.B. Bayles, E.C. Stakman and Thorvaldor Johnson played leading roles in conceptualizing and organizing the International Stem Rust Nursery.



International Nurseries Coordinated by CIMMYT

The Cooperative Mexican Government—Rockefeller Foundation Wheat Program (The Office of Special Studies, OEE) and its successor, the Inter-American Wheat Improvement Program, both predecessor organizations to CIMMYT, grew in part out of the success of the International Stem Rust Nursery. But by the time the Inter-American Wheat Program began operation, it had already outgrown its hemispheric boundaries. The interest generated in many Latin American countries by the International Stem Rust Nursery led to the establishment in 1960 of the 1st Inter-American Spring Wheat Yield Nursery, organized and coordinated by CIMMYT's predecessor, the OEE. It included the principal commercial spring wheat varieties of Canada, U.S.A., Mexico, Guatemala, Colombia, Ecuador, Peru, Bolivia, Chile, Argentina, Uruguay, and Brazil. It was originally grown at 15 locations from Canada to Argentina.

The results from this nursery soon clearly established that spring wheat varieties bred at high latitudes (above 40° latitude N or S) in Canada, U.S.A. and Argentina with long day-length requirements were not adapted and produced lower yields when grown in the "semi-tropic" temperate zone short-day belts from 35° N or S of the Equator.

In 1962 upon the request of scientists from a number of North African and Middle East countries, who came to Mexico to participate in the Inter-American—INIA* training program for wheat scientists, a Near East—American Spring Wheat Yield Nursery was organized and coordinated by CIMMYT's predecessor program. The varieties and lines included in this nursery were from low latitude national programs e.g. Mexico, Guatemala, Colombia, Ecuador, Peru, Chile, Tunisia, Egypt, Lebanon, Turkey, Syria, Iraq, Afghanistan, Pakistan, India and Italy. Three "long-day" commercial varieties, from Canada, U.S.A. and Argentina, respectively were included as checks. This nursery was originally grown at 15 locations.

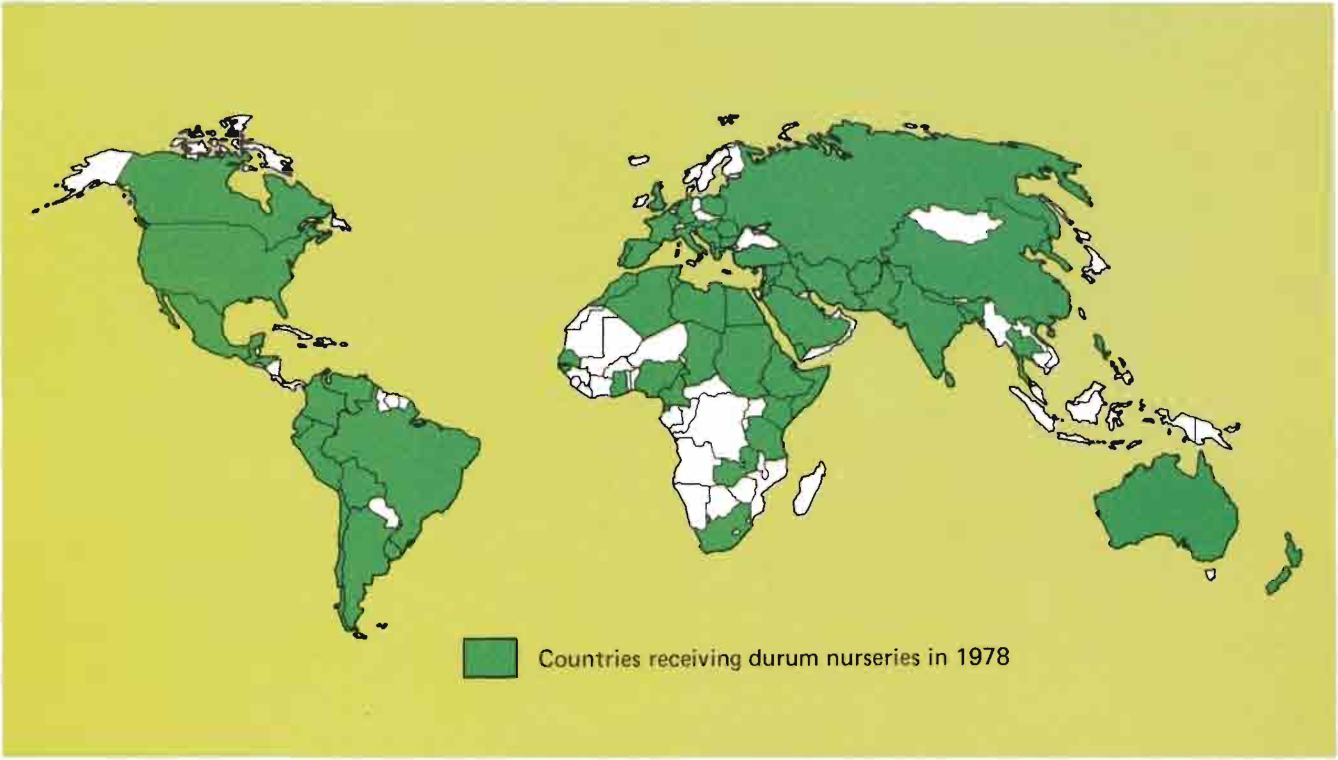
The response from cooperators growing these two nurseries was so great that in 1964 the International Spring Wheat Yield Nursery (ISWYN) was established by CIMMYT to serve spring wheat growing areas worldwide, with particular emphasis on developing countries. It includes varieties adapted to both low latitudes and high latitudes, but with major emphasis given to the former group.

From these origins grew CIMMYT's international testing program which in 1978-1979 includes a total of 31 different nurseries for bread and durum wheats, triticale and barley, sent upon direct request, to more than 110 nations for planting in 1,700 separate trials.

This international testing network is at the heart of CIMMYT's Wheat Program efforts to develop and exchange improved genetic materials carrying the potential for greater yield and higher farm income stability. (See Box: Breeding Wheats). Four general categories describe these nurseries.

(1) crossing blocks
(2) early generation F_2 nurseries (second generation after original cross)
(3) screening nurseries
(4) yield nurseries

* INIA—Instituto Nacional de Investigaciones Agrícolas established in 1960 within the Mexican Ministry of Agriculture to assume the Mexican national wheat research formerly done by OEE.



Crossing Blocks

Each of the four small-grain programs at CIMMYT (bread wheat, durum wheat, triticale and barley) distributes carefully selected lines of potential parents for use in national breeding programs. The lines are classified for grain type, milling and baking quality, resistance to specific diseases, yield potential, good agronomic type, high fertility, etc. As many as 500 lines may be included in a single crossing block.

F_2 Nurseries (segregating populations)

CIMMYT began in the early 1970's—first with bread wheat—to distribute F_2 germ plasm for further evaluation and selection by collaborating national programs. F_2 materials are "segregating", which means that sister plants from the same cross are expressing differences in genetic composition and look quite different one from another. Thus breeders are able to make individual plant selections for desired characteristics to be used in their own breeding programs.

All F_2 bread wheat germ plasm selected and harvested is divided into five categories and shipped to areas whose conditions of climate, soils, moisture, disease spectrum, and cultural practices correspond to the characters of the germ plasm.

This F_2 distribution scheme is also used in durum, triticale and barley following somewhat similar categories as the bread wheats described below.

F_2 Categories (bread wheat)

(1) F2 populations for irrigated conditions

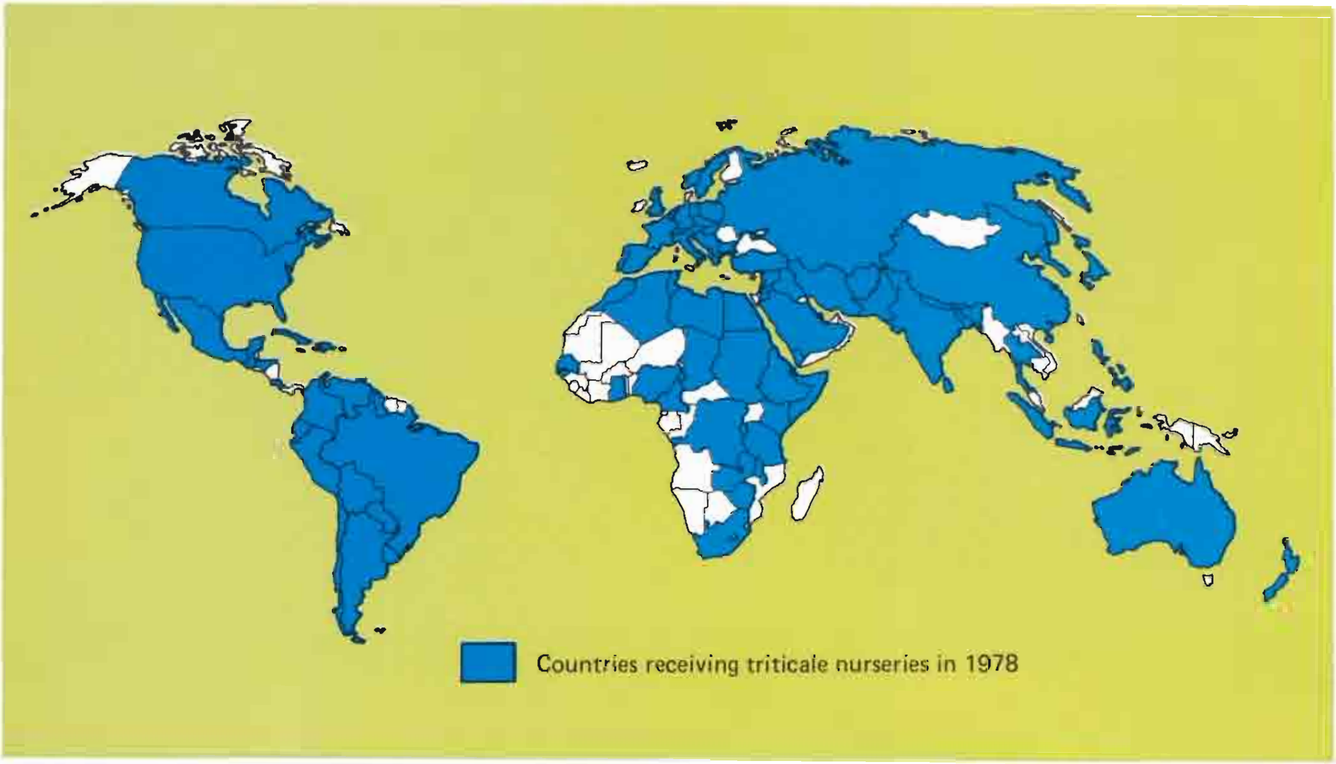
Under irrigated conditions higher yields are obtained

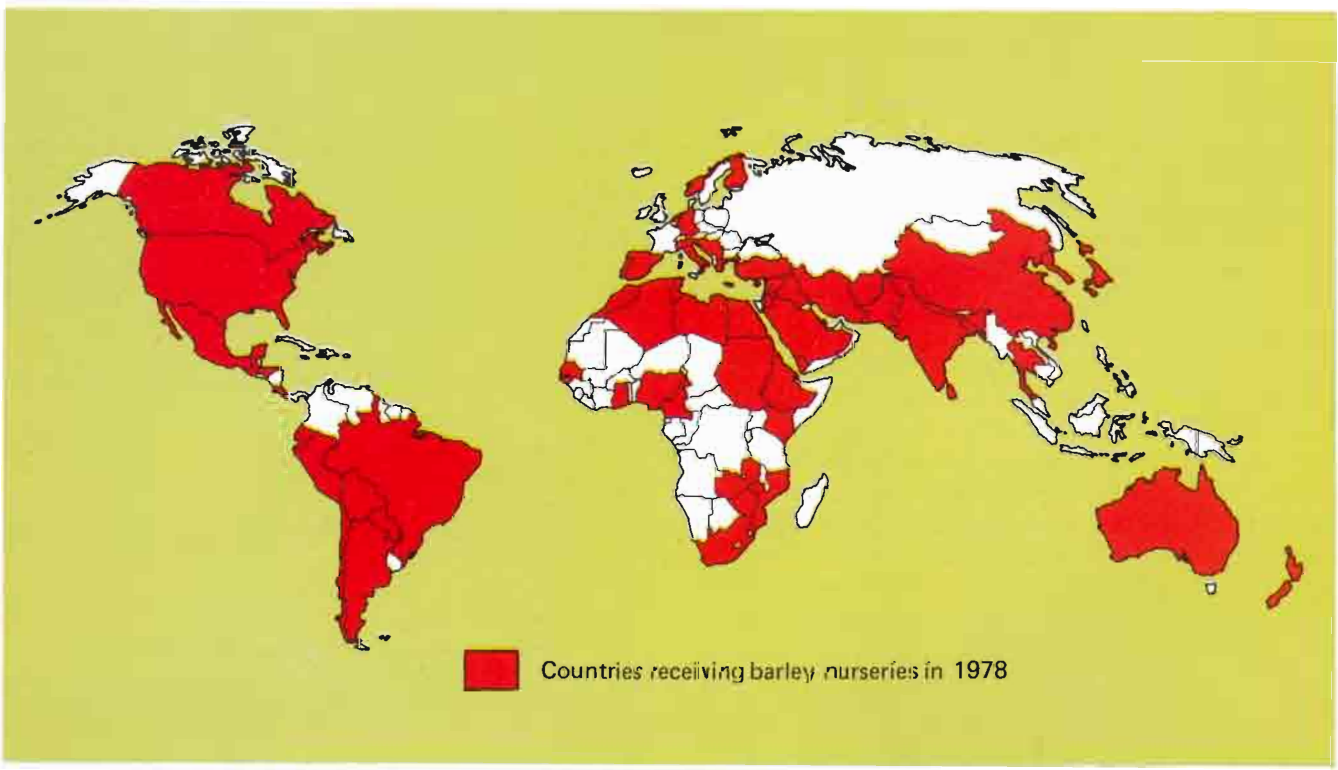
WHEAT BREEDING TERMINOLOGY

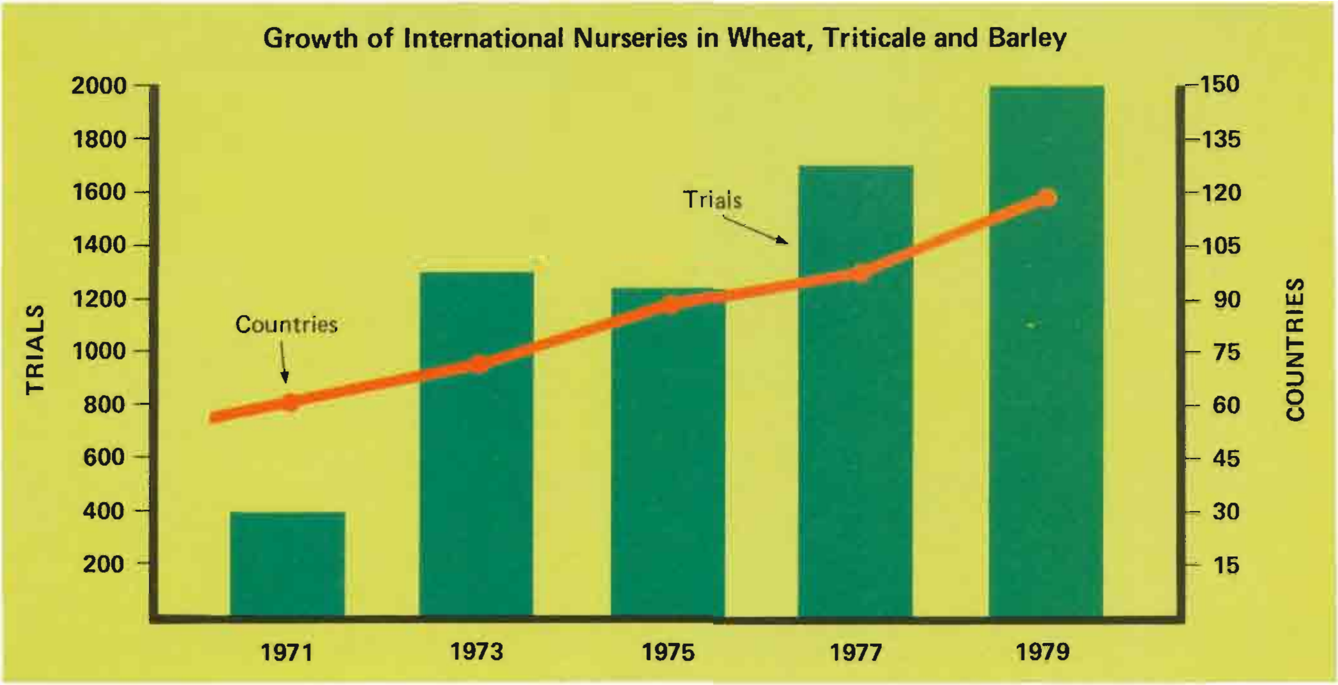
Wheat is normally a *self-pollinating plant.* This means that to combine genes from two separate varieties, a cross must be made between two parents. To execute a cross the breeder must remove the anthers from the plant selected to be the female parent before they are able to shed pollen. The removal of the anthers is called *emasculation.* At flowering time, fresh pollen from the parent chosen as the male for the cross is transferred to the stigmas of the emasculated plant causing fertilization.

The seed produced from this cross will carry the genes of both parents. Subsequent generations planted with the seed derived from this cross are numbered F_1, F_2, F_3... etc. F designates filial generation—and in F_2 the group of plants from a cross are referred to as a population and in F_3 and successing generations, plant progeny rows are referred to as lines.

The early generations exhibit great variations in plant height, maturity, disease resistance, agronomic type, etc. This is termed *segregation,* which is the result of the separation and recombination of different genes. After planting and reselecting the seed of successive generations from the original cross, and allowing self-pollination of these generations, a *pure line* is developed. All plants in the line have reached a state where the genes are the same for all readily recognizable (phenotypic) characters. When plants reach this state they are considered to be an *advanced line or strain.* When released for commercial use, the strain is called a *variety or cultivar,* defined as a group of similar plants which can be identified as unique according to structural characteristics and performance compared to other varieties of wheat. Similar terminology is used in barley and triticale improvement activities.


Countries receiving triticale nurseries in 1978


Countries receiving barley nurseries in 1978



from the shorter, semidwarf plant types. For these environments, CIMMYT distributes F_2 nurseries for irrigated areas on the basis of those crosses where the height of the F_1 plant is less than 100 cm and parental material has a good level of rust resistance.

(2) **F_2 populations for rainfed conditions**
In rainfed wheat areas of developing countries taller varieties perform better because of their superior ability to compete against weeds for sunlight. For dryland areas CIMMYT selects F_2 with a height of more than 100 cm and from parental materials with good rust resistance, and in certain cases, adequate levels of *Septoria* resistance.

(3) **F_2 spring x winter wheat**
Some wheat producing areas of the world—such as Argentina, Chile, Algeria, Iran, Afghanistan, Turkey, South Korea, Peoples Republic of China—require spring wheats with greater cold tolerance to withstand spring frosts; these are called facultative wheats. Crosses between winter and spring varieties are sent to those areas where facultative wheat is desired.

(4) **F_2 8156 type (Siete Cerros) Multiline**
These are the F_2 seeds of crosses in which Siete Cerros is one of the parents. These are sent to areas where Siete Cerros or Super X is or was a major commercial variety such as in the Indian sub-continent and Egypt. (See Box: Multilines).

(5) **F_2 aluminum toxicity resistance**
There are areas of actual or potential wheat production, (for example, Brazil and East Africa) which have acid soils and aluminum toxicity problems. CIMMYT makes crosses between Brazilian lines carrying tolerance to aluminum toxicity and Mexican lines with high yield and good agronomic characteristics. This nursery is distributed to areas where soils are acidic

8156 MULTILINE NURSERY

CIMMYT has long warned of the dangers in growing over large land areas wheat cultivars that are genetically similar. Varieties originating from cross 8156 were grown on millions of hectares in the Indian Subcontinent, the Mideast, and North Africa. In such a situation a new race of rust could spread rapidly through such an area because every plant is genetically similar. Accordingly, CIMMYT began in 1973 to distribute F_2 crosses which had the 8156 line (Siete Cerros) as one common parent in order to develop multiline components which also carried varied sources of genetic resistance from the differing second parents.

A multiline composite is a mechanical mixture of lines which in appearance resemble each other in plant height, maturity period, grain type, agronomic type and yield but differ genetically in disease resistance. With a multiline, when the prevailing race of rust in a region changes, the chances are that only one or two component lines will be rendered susceptible to the disease.

Since a multiline composite must be developed to fit local conditions, CIMMYT produces possible components for multiline composites and distributes the seed through the 8156 F_2 Multiline Nursery to interested collaborators for agronomic and pathological evaluations.

India Multilines

India, with vast land areas previously planted to the 8156 type semidwarf wheat, approved in 1978 three multiline composites based on this variety for commercial release. Each composite contains from 6 to 9 component lines. CIMMYT-derived components, selected through the International 8156 Multiline Nursery, were used as parts of two of the newly released multiline composites. Other components were bred in India. Plans called for the multiline seed to be increased for sale in India during the 1979-80 winter season.

The main breeding station for wheat, barley and triticale used by CIMMYT is located in northwest Mexico at 40 meters above sea level in an irrigated valley. This station is operated by INIA, Mexico's National Agricultural Research Institute as the regional research center, CIANO. During the winter CIMMYT uses nearly 200 hectares of land for its breeding activities and to select lines to be included in the international nursery program.

and aluminum toxicity is a problem. These crosses require parental material with considerable resistance to *Septoria* as well.

Screening Nurseries

The objectives of international screening nurseries are: (1) to introduce new genetic variability which collaborators may use directly or reselect and release to farmers, or use in crosses within their breeding programs; (2) to provide a vehicle to assess the performance of new advanced lines originating from breeding programs; and (3) to provide information on the performance of materials over a broad range of climatic and disease conditions.

The lines distributed have already been tested in Mexico, where they yielded well and showed good resistance to diseases, lodging and shattering (loss of seed before harvest). Each line in a screening nursery is grown in one or two rows with wide spacing to facilitate individual plant evaluation and reselection if desirable. Selection is made on appearance and disease resistance, not on yield.

Anyone collaborating in these nurseries is free to use the materials either as parents for future crosses or as commercial varieties, provided the country of origin is acknowledged upon commercial release. Varieties originating from these nurseries and released for commercial production cannot be protected under patents or plant breeders' rights legislation (described later).

Yield Nurseries

The objectives of yield nurseries are: (1) to provide research workers developing new varieties with an opportunity to assess the performance of their advanced breeding lines over a wide range of climatic, cultural and disease conditions; (2) to serve as a source of information on the basic principles of adaptation; (3) to allow local research and extension workers to compare the performance of new varieties from other countries; and (4) to provide a source of new, valuable genetic variability which the cooperator may use directly or in crosses within his breeding program.

INTERNATIONAL SCREENING AND YIELD NURSERIES

	Date Started	1978 Distribution Countries	Locations	Lines
Screening Nurseries				
International Bread Wheat Screening Nursery (IBWSN)	1967	95	180	465
International Durum Screening Nursery (IDSN)	1969	56	79	228
International Triticale Screening Nursery (ITSN)	1969	77	121	245
International Barley Observation Nursery (IBON)	1973	48	74	354
International Septoria Observation Nursery (ISEPTON)	1970	33	54	235
Yield Nurseries				
International Spring Wheat Yield Nursery (ISWYN)	1964	62	95	50
International Durum Yield Nursery (IDYN)	1969	48	76	25
International Triticale Yield Nursery (ITYN)	1969	52	96	25
International Barley Yield Trial (IBYT)	1978	45	60	25

CIMMYT's main highland small grains breeding station is located west of Mexico City near the provincial capital of Toluca. This station allows CIMMYT to advance its breeding work an extra generation each year. This accelerated breeding approach hastens the development of advanced lines for future testing by national collaborators.

Entries included in yield nurseries come from the CIMMYT—INIA Mexican program or from collaborators in other national programs and usually are either advanced materials (F_5—F_7) or are already released as commercial varieties. When a national collaborator submits varieties for testing in an international yield nursery, they are first grown in Mexico and evaluated by CIMMYT for possible inclusion in an upcoming nursery cycle.

In yield nurseries, lines are grown in six row plots with three replications using commercial planting densities. This design allows breeders to determine reliably the yield potential of each line under the conditions where the trial is planted.

Operation of International Nurseries

"The operation of the international nurseries" says Dr. Maximino Alcala, coordinator of international wheat nurseries, "involves a series of sequential steps which integrates the efforts of CIMMYT scientists and a network of hundreds of collaborating scientists from 110 nations spanning the globe."

Advanced lines and commercial varieties come to be included in the various nurseries through selections made either within CIMMYT or through selections submitted to CIMMYT by national collaborators.

Each year CIMMYT wheat breeders make thousands of crosses and evaluate tens of thousands of segregating lines at each of two alternating sites in Mexico: the first from November sowing, when days are getting shorter at Ciudad Obregon situated in northwest Mexico in an irrigated valley (40 m altitude, 27^{o} latitude); the second from May sowing, when days are getting longer near Toluca in a high, rainfed area of the Central Mexican plateau (2,640 m altitude, 19^{o} latitude). These widely differing growth environments allow CIMMYT scientists to select materials exhibiting good performance—and therefore broad adaptation—at both locations. In fact, only those surviving the rigors of both environments can move forward. This system permits two cycles of selection each year.

At Ciudad Obregon, along with early generation materials, several thousand advanced lines (F_5-F_8 generations) are evaluated each cycle (November-April) for yield, grain color, plant height, and rust reactions. The best 20-30 per cent go into the upcoming cycle of the international screening nurseries in bread wheat, durum, triticale, and barley.

In addition to the distribution of newly developed material, CIMMYT scientists continue their evaluations of material from former screening nurseries. About 20 per cent of the best yielding entries from international screening nurseries planted in the preceding year are re-tested in elite yield trials at four locations in Mexico. Promising materials from these trials may then be included in a subsequent cycle of the international yield nurseries.

In the international yield nurseries, candidate materials from collaborating national programs are planted in Ciudad Obregon in November. In the following spring (April), CIMMYT breeders select 25-50 advanced lines and commercial varieties for inclusion in the upcoming cycle of each yield nursery.

Harvesting at Ciudad Obregon begins in April where rows and plots of selected plants are cut, threshed, selected for grain type and bagged for shipment to CIMMYT's headquarters at El Batan. Here the seed is cleaned, treated, and packaged into sets for shipment to collaborators requesting nurseries.

Each year CIMMYT distributes over 30 different nurseries grown in 1700 trials in 110 countries. Wheat program scientists attempt to visit as many international testing locations as possible each year. Pictured here are two CIMMYT scientists and two Argentinian scientists from INTA, the National Agricultural Research Institute, inspecting a bread wheat trial.

Possible candidates for inclusion in the various nurseries undergo the tests performed by the milling and baking laboratory group. Each year CIMMYT cereal technologists evaluate the grain of thousands of bread wheat, durum and triticale lines for gluten strength and for suitability in making bread, tortillas, chapatis, cookies, spaghetti and other products. Each line which comes to be included in the screening and yield nurseries has been assessed by CIMMYT for grain quality.

"After taking account of requests and the seed available for distribution," notes R. Glenn Anderson, Director of the Wheat Program, "the staff calls a meeting in early July to determine the distribution of nurseries for the upcoming cycle. Usually we don't have enough material to satisfy all requests. First priority goes to collaborators in national research programs and universities in developing countries; second priority to public institutions of developed countries. Bulk seed samples of early generation F_2 materials, depending on availability after satisfying the first two priorities, are also distributed to private seed companies requesting materials".

Nurseries are airfreighted to collaborators in August and September, for planting in November of the same year (Northern Hemisphere) or June of the next year (Southern Hemisphere). Included with each trial are instructions for planting, data recording books, and seed handling certificates. Trials are planted using uniform designs appropriate to the type of nursery.

After harvest, collaborators complete their nursery observations and send their completed data books back to CIMMYT where the data are screened for anomalies and then analyzed on the computer using standardized programs. "Still one of our most serious problems," says Dr. Alcala, "is the lack of standardization in the reports we receive from the collaborators. Most use metric measurements, although some use the English system, and others their indigenous systems of measurement. This variation slows down our data analysis phase considerably."

Preliminary reports on the results from the preceding year's trials at each location are prepared in December and made available to CIMMYT breeders and national collaborators for planning of crosses in the next season of their breeding programs. A final report, which usually includes data from about 75 per cent of the trials sent to collaborators, is mailed to all collaborators within 18 months from the date the nursery was originally shipped.

Many of the national collaborators are former CIMMYT in-service trainees or visiting scientists. These scientists have both learned and shaped the procedures used in the international testing system. Many other collaborators from national or university programs have never visited CIMMYT.

Some 30 in-service trainees a year study and work at CIMMYT to learn to utilize material distributed through international nurseries. These trainees plant in Mexico each of the screening and yield nurseries sent out internationally. The trainees focus their study on two aspects: data recording techniques for evaluating nursery material, and selection criteria for subsequent breeding activities in their home country programs.

Assessing the Impact of the International Nurseries

Varieties containing germ plasm selected from international nursery trials are now grown commercially in

Over the years, CIMMYT has maintained a very close relationship with Indian agricultural scientists. Indian-released varieties, selected and improved from lines distributed through the international nursery program, have led to a tripling in wheat production in India over the last decade. Here, colleagues from Oregon State University, USA and Ludhiana University, Punjab, India, inspect a triticale nursery. This new crop has great promise for the Himalayan hills area.

virtually all spring wheat growing countries. High yielding semidwarf varieties developed by CIMMYT and/or its national collaborators are now grown on more than 30 million hectares in developing countries—48 per cent of the total land area devoted to wheat production.

Germ plasm developed through this cooperative research effort may reach the farmer in three ways:

(1) After appropriate testing, a nation may decide that a CIMMYT selection is suitable for direct release to farmers. (CIMMYT itself never releases a variety; it is the responsibility of national governments to decide when to release a variety and what to name it. For example, when Pakistan decided to release the Mexican variety Siete Cerros to Pakistani farmers it was renamed Mexipak 65. This variety, developed from cross 8156 made in Mexico, has over 20 names around the world and has been grown on as many as 14 million hectares in developing countries in the same year).

(2) Often a national scientist will make individual plant reselections from a population included in CIMMYT nurseries. Future generations of the selection may then become a commercially released variety. For example Mexipak 69 and Kalyansona are names given to reselections from the Siete Cerros population included in an international nursery.

(3) Germ plasm included in the international testing program may also be used by national scientists as parental material in breeding new varieties which require more improvement before they can serve as commercial varieties.

Once good material has either been selected or developed, it will never benefit the farmer until the seed is multiplied, released and distributed to local sales outlets. This phase of the process is often the bottleneck for many good national wheat improvement programs. Sometimes, it means that the country will have to import the desired seed in order to distribute sufficient quantities to the farmer. Other times the experiment stations may multiply a certain amount of the seed which is then sold to selected farmers who have reputations for being good growers. They in turn increase the seed for subsequent sale to other farmers. Government seed production organizations also are involved in increasing new seed for release to farmers. Government seed companies, however, are often plagued by serious bureaucratic constraints.

Expanding Directions

New nurseries are added to the CIMMYT-coordinated international testing program when a sufficiently important requirement is identified for particular types of materials to fit production conditions in developing countries where small grains are important crops.

One expansion during the 1970's has been the emergence of regional nurseries to serve smaller, usually more homogeneous areas. If properly coordinated to avoid unnecessary duplication of germ plasm, such nurseries represent a useful extension of the international testing system.

In 1979, CIMMYT has staff assigned to three regional programs: the Andes, the Southern Cone of Latin America, Eastern Africa, and in addition, cooperates directly with the International Center for Agricultural Research in the Dry Areas (ICARDA) in an area which spans North Africa and West Asia. CIMMYT regional programs are designed to strengthen intra-regional cooperation and collaboration.

CIMMYT has another type of regional program for disease surveillance in the Eastern Hemisphere. "A subject area that is well-served by a regional capacity," says CIMMYT regional pathologist Eugene Saari based in Egypt, "is surveillance activities for diseases and insect pests." Regional nurseries to improve the exchange of useful materials within the region as well as to monitor disease resistance of commercial and experimental varieties and lines are operating in the Eastern and Western Hemispheres. (See Box: Regional Disease and Insect Surveillance and Trap Nurseries).

Other breeding approaches are encouraged by CIMMYT to improve national breeding programs and hasten the development of superior varieties. In one approach, called "shuttle breeding," CIMMYT collaborates directly with a national breeding program to add another growth cycle per year and to add a different climatic situation. For example, Brazilian scientists are working to combine high yield characteristics (from CIMMYT) with aluminum toxicity tolerance (from Brazilian varieties). Such a combination could open up vast areas with acid, aluminium toxic soils for high yielding small grain production. Through shuttle breeding Brazilian scientists are able to plant two selection cycles each year, one in Brazil and one in Mexico. This system has permitted each year the selection for tolerance to aluminum toxicity in the Brazil cycle and for superior agronomic types in the Mexico cycle. It allows for the hybridization of resistant materials with superior agronomic types in the Mexico cycle.

Another form of collaboration involves the utilization of offseason nursery sites to allow national breeding programs to grow an extra breeding selection cycle each year as opposed to what would be possible if only their home climatic zone were used. The operation of several offseason nursery programs is covered in another edition of CIMMYT TODAY.

A Threat to Free Exchanges of Germ Plasm

The contribution to world food production achieved through the network of international nurseries over the last 25 years has far exceeded the dreams of the pioneers. Through these nurseries, high yielding varieties with wide adaptation and stable disease resistance have been developed at an accelerated pace. This progress would not have been possible without this network of international testing and data sharing which has served as a unifying thread to bring together the work of thousands of scientists and hundreds of organizations, worldwide.

The success of this system was built on the free exchange of germ plasm and information with the common goal of increasing world food production. "Today, " says Dr. Borlaug, "there is a concept backed up by legislation developing in some countries called 'Breeder's Rights' which threatens the future of this collaborative effort." Breeder's Rights would place patent restrictions on germ plasm developed by individual scientists whereby free exchange and utilization of such material would no longer be possible. Breeders would, under the Breeder's Rights System, have to pay a user fee to gain access to germ plasm improved by some other scientist. Borlaug believes that if the patent system becomes widespread, the future of international cooperation in the development of improved varieties would be seriously threatened and the release of new commercial varieties with higher yield potential would be slowed down. It would be particularly damaging to developing nations with many small subsistence cultivators.

There is no doubt that the international nurseries will continue as an integral part of the CIMMYT wheat improvement program and will continue to expand to meet the ever-increasing demand for better germ plasm. CIMMYT intends to use its influence and energies to oppose trends which move away from the free exchange of germ plasm and information among nations. We believe that an unfettered system of international cooperation is at the heart of world efforts to produce the needed food to feed present and future generations.

REGIONAL NURSERIES

CIMMYT's oldest regional nursery program is located in an area extending throughout Western Asia and North Africa. Two nurseries are prepared and distributed by regional staff residing in the region in cooperation with ICARDA and FAO as a service to national programs and are designed to gather information on the epidemic diseases affecting mainly wheat. The objective is to predict impending disease epidemics so that new varieties with genetic resistance can be identified and introduced before a new menancing pathogen becomes pandemic.

The Regional Disease and Insect Screening Nursery (RDISN) is primarily a genetic nursery in the sense that it is used principally in plant breeding efforts. This nursery emphasizes the early detection and identification of resistance by screening at locations where new and diverse races of pathogens are present or evolving. The RDISN was sent to 50 locations in 32 countries in 1978.

The Regional Disease Trap Nursery (RDTN) is used for disease monitoring purposes. This trap nursery, sent to 150 locations in 50 countries, is composed of commercial varieties and susceptible and resistant checks. There is no inoculation of this nursery; the intent is to measure the natural levels of disease incidence. Through this nursery (and the RDISN) CIMMYT is beginning to map the origin and spread of new races of rust pathogens from one zone to another.

Information from these nurseries is providing an early warning system which will give additional time to an area facing a high probability of future attack by a disease for which its varieties are susceptible. It is possible, through this nursery, to provide 3-5 years lead time between the first detection of a new race and when it becomes pandemic in the area. This early warning system can provide national breeders with sufficient time to release new varieties and multiply seed with resistance to the new threatening race for introduction in susceptible farming areas to avoid a catastrophe.

A similar pair of nurseries known by their Spanish acronyms, ELAR and VEOLA, are distributed throughout the Western Hemisphere.

INTERNATIONAL NURSERY OPERATIONS

The flow to national collaborators of new advanced lines with constantly improving characters is crucial to the success of the international nursery program. Each spring at the Obregon station, wheat program scientists spend many days carefully evaluating and selecting lines to be included in the various international nurseries.

In April and May, at Ciudad Obregon, lines selected for upcoming international nurseries are harvested and threshed in the field. Seed for some nurseries is cleaned and the grain evaluated in Ciudad Obregon while other seed is shipped directly to CIMMYT headquarters for cleaning and grain evaluation at El Batan near Mexico City.

Seed from lines to be included in most upcoming international nurseries is analyzed in cereal technology laboratories at Ciudad Obregon and El Batan. Data on milling and baking quality for these lines are provided to nursery cooperators, upon request.

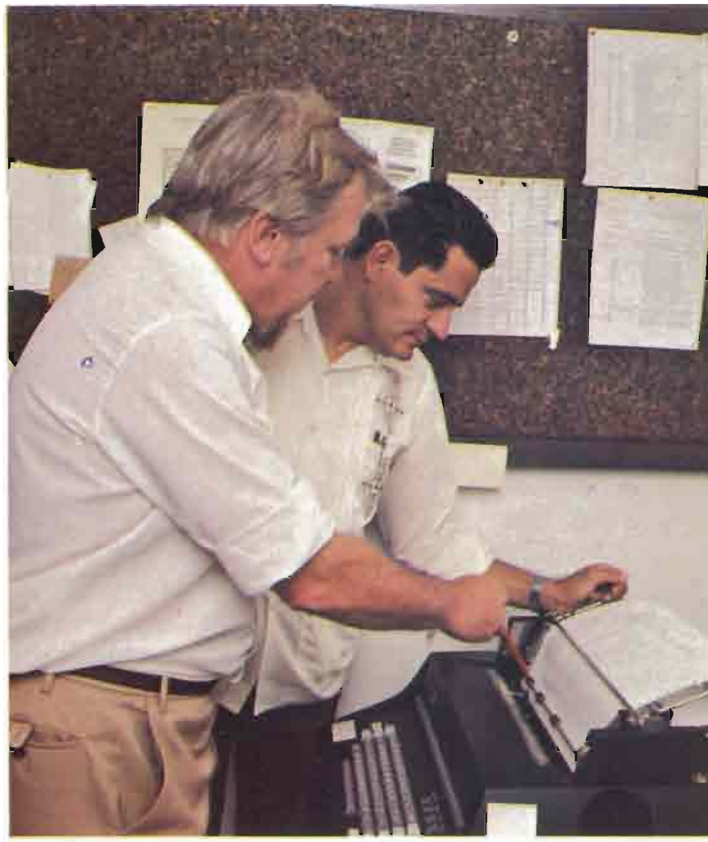
The cleaned seed for different nursery sets is treated with insecticides and fungicides before being packaged. After these chemical treatments, the seed can be shipped safely to national collaborators without the threat of introducing foreign pests and diseases.

The treated seeds of different lines are put into envelopes and grouped into the different nursery sets. In the case of yield nurseries, where three replications of each line are planted, randomizations in the way the lines are planted are necessary to obtain reliable yield information. A randomized plot design is prepared for these yield nursery sets.

Once the seed has been packeted in envelopes and the different nursery sets assembled, those nurseries requested by national collaborators are packed in boxes for final shipment.

Nurseries are shipped airfreight in August and September to national collaborators around the world. Plant quarantine certificates, appropriate uniform nursery design instructions and fieldbooks are included in each nursery box.

National collaborators return their observations from screening and yield nurseries in field books supplied by CIMMYT. Although uniformity in the methods of data recording is the objective, each field book must be reviewed for anomalies and sometimes converted to standard measurements before the computer analysis can be started. Here Dr. Alcala, International Wheat Program Testing Coordinator, gives instructions on data processing to a computer punch card assistant at CIMMYT.



Using standardized computer programs, data from the international screening and yield nurseries are analyzed and presented in tables produced by the computer. These tables are then sent immediately to national collaborators and CIMMYT scientists to help guide future breeding activities. Pictured here are Dr. Alcala and Peter Walker, head of CIMMYT's computer center, reviewing newly produced nursery data.

Once most of the data from national collaborators has been received and analyzed for a particular nursery cycle, CIMMYT prepares and distributes a final report. Currently, formal reports are issued for all CIMMYT-distributed screenina and yield nurseries.

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