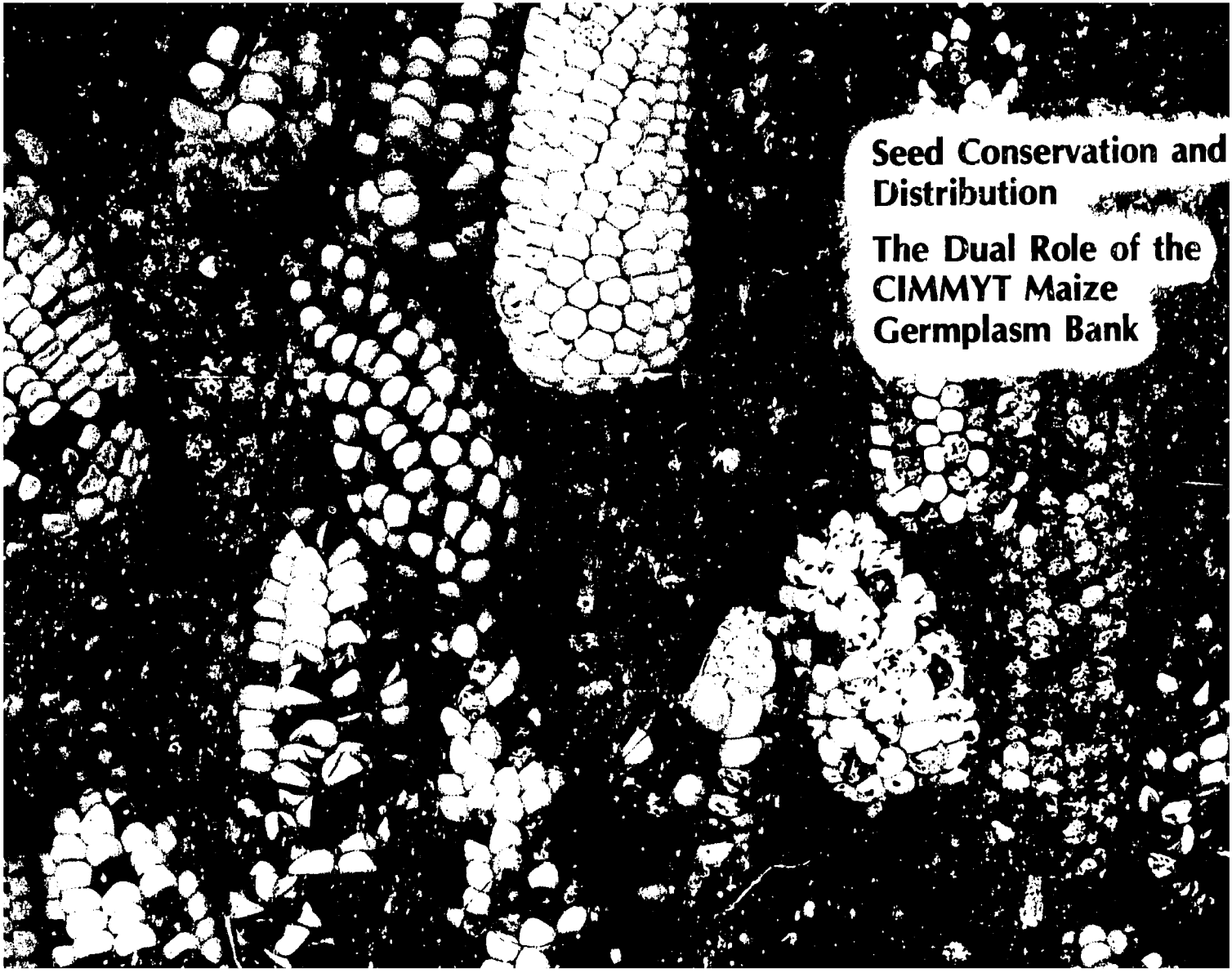

Seed Conservation and Distribution

The Dual Role of the CIMMYT Maize Germplasm Bank

The International Maize and Wheat Improvement Center (CIMMYT) is an internationally funded, nonprofit scientific research and training organization. Headquartered in Mexico, CIMMYT is engaged in a worldwide research program for maize, wheat, and triticale, with emphasis on food production in developing countries. CIMMYT is one of 13 nonprofit international agricultural research and training centers supported by the Consultative Group for International Agricultural Research (CGIAR). The CGIAR is sponsored by the Food and Agriculture Organization (FAO) of the United Nations, the International Bank for Reconstruction and Development (World Bank), and the United Nations Development Programme (UNDP). The CGIAR consists of 40 donor countries, international and regional organizations, and private foundations.

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Seed Conservation and Distribution The Dual Role of the CIMMYT Maize Germplasm Bank

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Introduction

The CIMMYT Maize Germplasm Bank contains a wealth of genetic diversity, mostly in the form of landraces. Through creative work by many plant breeders around the world, this variability has made possible significant advances in maize improvement during recent years and promises to be of even greater service as advances in biotechnology open up new possibilities for bringing about beneficial change in maize germplasm.

In order for scientists to realize the potential of the genetic resources contained in the Bank, however, two essential requirements have to be met: (1) careful conservation of the germplasm and (2) efficient distribution of seed that has been fully characterized and documented to researchers around the world. Over the past 20 years, the Bank has performed both those functions as well as resources permitted, maintaining a large collection of maize landraces and distributing seed of hundreds of accessions each year.

A more ambitious program of germplasm conservation and distribution has been made possible by extra funding given to the Maize Program for improvement of the Bank's facilities. As described in CIMMYT's *Research Highlights 1984* (pages 42-43), those funds are being used to increase storage capacity and to implement a computerized data management system. The latter innovation enables the Bank to produce an accurate and complete catalog of its holdings (with characterization and passport data for all accessions) that will give researchers throughout the world a more precise idea of what is in the Bank.

This booklet is intended to accomplish the next and equally important step of making sure that cooperators know how to acquire seed from the Bank. Early sections of the publication give a general idea of the composition of Bank holdings and the conditions of their storage and management. Succeeding sections:

- Offer advice to help you decide what type of germplasm will be most useful
- List items of information to include in your letter that will enable us to fill your seed request specifically and accurately

Rolf Rosenberg

Compilation of data for characterization of Germplasm Bank accessions.

- Explain some aspects of the handling of accessions acquired from the Bank
- Describe how you can assist us and other researchers by supplying information about your work with Bank accessions

The final section explains the numerous precautions taken by Maize Program staff to ensure the health of seed received and distributed by CIMMYT.

Composition of Bank Holdings

The Center's Maize Germplasm Bank is the world's oldest and largest international collection of maize seed. Currently, it consists of over 12,500 collections, of which 10,174 have been successfully regenerated and accessioned. Collections are seed samples sent to the bank by cooperating research programs and plant collectors. Once a collection has been successfully regenerated by the Bank and preliminary characterization completed, it is given an accession number and only then becomes eligible for long-term maintenance in the Bank.

The Bank's collection was established in the 1940s with materials gathered by breeders who were then sampling the genetic variation of maize in Mexico (1943-1947), the Caribbean (1946-1947), and Guatemala (1948-1949). Since then other collections from all over the Americas, as well as from other countries in the world, have been added to the Bank. The Maize Program assumed responsibility for this germplasm in 1966, when CIMMYT was established.

Landraces—The early collections, those made during the 1940s, were classified into taxa according to genetic and geographical criteria. In the process the concept of the maize landraces was developed and has come to be widely used in work on plant genetic resources.

The two parts of the word *landrace* suggest the geographical and genetic components of this taxonomic concept. *Land* indicates the distinct geographical distribution of each of these maize populations, and *race* refers to the recognizable differences among them. Those differences exist because of the way in which landraces have come

about. Each one is a genetic aggregate that over years of local selection has become adapted to a particular region. That is why, for example, a landrace is highly adapted to the daylength of the area in which it was formed. As one might expect, there is considerable genetic diversity among the many landraces that together make up one of the maize races. Thus, plants found at the extremes of the geographical area in which a race was formed differ from those originating nearer the center, though they still possess to a certain degree the linked characteristics that distinguish the race.

Landraces are probably the best repositories of unique allelic variation. They are not products of modern, scientific breeding programs, but have resulted from selection by farmers for a preferred grain type (one suited to their method of cooking maize) and for adaptation to a particular environment. The landraces held by the Bank (which make up the majority of materials stored in it) were obtained in farmers' fields or from markets, mostly in the Americas. There are more than 250 named races of maize in the New World, representing slightly less than 200 biological races. These can be divided into several groups according to geographical concentration:

- Mexican and Central American
- Andean zone
- Caribbean
- South American coastal tropical flints
- Coroico types of South America
- Northern flints and flours

Once materials of a particular landrace are taken to a location outside their area of origin, they are recognized by

Rolf Rosenberg

Collection of data on Germplasm Bank materials after harvest of a regeneration plot at El Batan, Mexico.

Landraces, the result of selection by farmers for a preferred grain type and adaptation to a certain environment, are probably the best repositiories of unique allelic variation.

the Bank as introductions. For example, an accession of the Mexican race Tuxpeño that is collected in Brazil is considered an introduction because it has long since been taken out of its original environment along the east coast of Mexico. Many of the maize materials found in the Old World are introductions, though distinct landraces have evolved in many regions outside the Americas over the last 400 years. A number of those landraces can be traced back to Caribbean and South American coastal tropical flints. To be successful as an introduction, a landrace generally has to be grown in an environment comparable to its original one. Afterwards, considerable adaptation to local conditions takes place, so that the introductions become genetically unique and are no longer representative of the founding races. If the adaptation has become drastic enough to make the introduction significantly different from the founding population, then it has evolved into a new landrace.

Other samples in the Bank—About 10% of the current holdings consists of various types of samples other than landraces and introductions. There are 629 groups (geographic/racial composites) that were formed during 1959-1961 through consolidation of numerous, very similar collections from a limited geographic area (mainly Mexico, Central America, and the Carribean) and 199 composite varieties from breeding programs. Each accession of those two types was formed from materials gathered at many sites and preserves racial or agronomic adaptation. Such accessions are less likely, however, than the single-population collections (each of which is made up of materials gathered in a farmer's field, as described in the section on landraces) to hold rare allelic variation. The Bank also has some older elite varieties that are now considered obsolete, such as Reid's Yellow Dent and Lancaster Surecropper.

Storage Conditions in the Bank

Some of the collections have been in cold storage since the 1950s. Prior to improvements made in the Bank's facilities during 1984, storage conditions ensured that seed would remain viable for 20-25 years before having to be regenerated for seed renewal. The early collections made during the 1940s have therefore undergone three and in some cases

four cycles of regeneration in nurseries. New ultra-cold storage facilities (already in operation) are expected to lengthen the period between regenerations to 60-100 years.

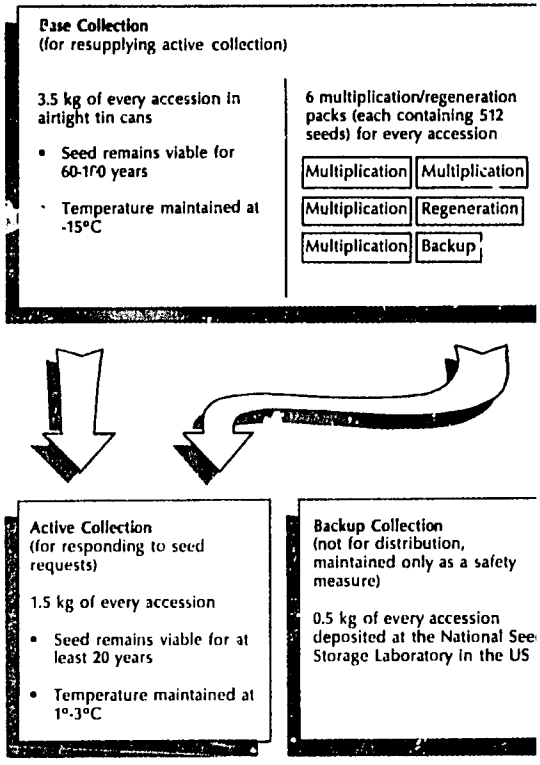
The new facilities include two distinct storage rooms: (1) the active collection and (2) the base collection (see the accompanying figure). In the former, which is kept at about 1°C, a maximum of 1.5 kg of each accession is maintained for 20-25 years. This collection constitutes a working bank from which all seed requests are filled.

In the base collection, which is kept well below freezing (-15°C), seed is maintained in two types of containers: (1) A maximum of 3.5 kg of each accession is stored in airtight tin cans, and (2) for every accession there will eventually be six packs with 512 seeds in each. The packs are sealed, plastic foil, laminate bags and contain seed that has been dried to a low moisture content (6-8%). That seed will be used to regenerate or to multiply accessions. Four packs are intended for increase of accessions whose supply has been depleted through seed requests. In some cases seed increase may not be necessary every 20 years. The fifth pack will be used to regenerate accessions for another 100 years of long-term storage, though regeneration will be carried out sooner (with the fourth pack, for example) if it is determined that the viability of seed in the packs has dropped to an unacceptable level. The sixth pack will serve as a backup for the regeneration (fifth) pack.

To further guarantee the safety of the germplasm, an approximately 0.5-kg sample of every accession is being deposited at the US Department of Agriculture's National Seed Storage Laboratory (NSSL) in Boulder, Colorado. That seed is not for distribution and is on deposit only as a backup for the CIMMYT collection.

As seed is supplied from the active germplasm bank to meet user demand, depleted reserves will either be replaced from the tins in the base collection, or a multiplication nursery will be grown. Note that each multiplication of an accession (from a different seed pack) is only one cycle of meiosis from the preceding cycle of regeneration, as is each subsequent regeneration cycle of the accession

Seed Storage in the CIMMYT Maize Germplasm Bank



The ultimate value of the Bank lies, not so much in the accessions stored, as in the accessions used.

every 100 years or so. Seed will only be regenerated when the percent germination of seed in the multiplication/regeneration packs has declined to an unacceptable level or when demand for the accession has reduced the number of packs to two (packs 5 and 6). Since there will be a much longer period between regenerations than previously (though not between multiplications), fewer regenerations will be required to maintain viable seed in the active collection. As a result, genetic drift, or changes in the genetic composition of the accessions, will be kept to a minimum.

Most regeneration of Bank materials is done in Mexico. Some collections, however, particularly those adapted to high elevations, can be successfully regenerated only at locations outside the country. That work is done in cooperation with national programs. For regeneration or multiplication of an accession, seed is planted in 256 hills at a rate of two per hill with proper spacing in low-density stands to allow for good plant development without excessive environmental stress. The stands are thinned to one plant per hill. Where necessary they are protected against diseases and insect pests. Chain-crossing (with males used only once) is the preferred crossing technique, though for some accessions we have to use bulk sibbing without selfing. The Bank's standard procedure is to base regeneration on a harvest of 100 or more acceptable ears. If fewer than 100 ears are used, it is possible that site-specific selection will affect the sample significantly. That possibility is highly significant if the sample consists of bulks of only 20-40 ears.

Deciding What Type of Germplasm to Request

Though Bank staff expend considerable effort to maintain the germplasm properly, conservation of this material is by no means their only concern. The ultimate value of the Bank lies, not so much in the accessions stored, as in the accessions used. That is why the Bank's policy is to provide seed of its accessions free upon request. The only exception to this policy is that private companies are expected to pay shipping costs.

Our normal practice is to send from 25 to as many as 100 or 200 seeds per accession requested, although we sometimes make special arrangements

to provide a larger quantity if we determine that the research of a cooperator requires extra seed. Even so, in making seed requests, we urge you to be as selective as possible. By doing so you can help us share the seed with a greater number of researchers.

We generally assume that once you have been supplied with seed you will be able to regenerate sufficient quantities for future use. In a few cases, however, we make exceptions to that general rule and will send additional amounts of the accessions you need.

The first step in making a precise and selective seed request is to consider carefully the possible uses of the various types of germplasm available and the work involved in employing that material within your research program.

Among bank accessions the landraces, as mentioned previously, are the major source of unique, low-frequency genetic variation. Tapping that resource, however, is very time-consuming for most breeding programs. The obsolete cultivars and racial composites are easier to work with and often are more appropriate. Very seldom, however, is it possible to fit either those materials or landraces into a breeding program without several cycles of enhancement and selection for adaptation and agronomic characters. Bank materials are not finished varieties ready for release, but rather are samples representing the evolution and racial diversity of maize found in the Americas.

In many cases the Maize Program's gene pools provide a more readily usable source of genetic variation and thus may offer a quicker means of enabling national maize researchers to achieve their breeding objectives. Bank materials have been included in all of the pools, which are divided according to ecological adaptation, time to maturity, grain color, and grain texture. Moreover, superior maize materials from around the world are systematically evaluated and added to the appropriate pools to improve them and extend their genetic variability. As a result, the pools are broadly based and adapted and have a far better agronomic type than most Bank

Rolf Rosenberg

Harvested ears from a regeneration plot at El Batan, Mexico.

Characteristics of CIMMYT Maize Gene Pools

Adaptation	Maturity	Grain texture	Grain color	Pool number
Tropical	Early	White	Dent	16
			Flint	15
		Yellow	Dent	18
			Flint	17
	Late	White	Dent	24
			Flint	23
		Yellow	Dent	26
			Flint	25
Subtropical	Early	White	Dent	28
			Flint	27
		Yellow	Dent	30
			Flint	29
	Inter-mediate	White	Dent	32
			Flint	31
		Yellow	Dent	34
			Flint	33
Transitional*	Late	White	Semident	9a
Highland	Early	White	Floury	1a
			Morocho	5a
			Semident	10a
		Yellow	Floury	3a
			Morocho	6a
			Semident	11a
	Late	White	Floury	2a
			Morocho	7a
			Semident	12a
		Yellow	Floury	4a
			Morocho	8a
			Semident	13a

*Principally for regions of Africa that are transitional between highlands and subtropics.

accessions. For that reason we often recommend that cooperators interested in a certain trait (resistance to a particular disease or insect pest, for example) first screen the appropriate pool. A list and brief description of the main pools are given in the accompanying table. There are also a limited number of special-purpose pools, descriptions of which can be obtained by writing to the CIMMYT Maize Program.

If the desired trait is found in a pool, then it very likely has also been incorporated into an advanced population and into experimental varieties and family lines. Those products include some of the best-performing materials from the pools and could serve even better than the pools as germplasm sources. If the trait is not found, however, the next step is probably to screen bank accessions. Transfer of a trait from those materials to an acceptable background usually takes much longer than with the more refined pools, populations, and other products.

How to Request Seed

A printed catalog of Bank accessions will be kept at all CIMMYT regional maize program offices. If possible, consult this catalog as a first step in making your seed request. Seed request letters should be addressed to: Head of the Maize Germplasm Bank, CIMMYT, Apdo. Postal 6-641, 06600 Mexico, D.F., Mexico. Although some researchers requesting materials from the Bank will know exactly what they want, even down to the accession number, most will have only a general idea. In those cases we will make every effort through further correspondence to determine which accessions are likely to be most useful to the scientists requesting seed.

That process takes extra time but is necessary, as you will gather from the following example. Suppose that we receive a general request for all of the white-seeded material in the Bank. To fill such a request, we would have to send about 3500 packets of seed. Our response in this case would be to write back to the person requesting the seed to obtain a more narrowly defined request, one specifying seed texture, growing conditions, time to maturity, and other requirements. Unfortunately, these letters are sometimes taken as a rejection of the seed request. But in fact, if we were convinced by the

researcher's reply that he or she actually did need all the white-seeded material, we would send the 3500 packets. The recipient would then, however, be faced with the enormous task of growing out 3500 observation rows of fifty plants per accession in a single season, something that is well beyond the capacity of all but a few breeding programs.

By supplying certain items of information in your letter, you can help us keep to a minimum the time required to determine which accessions will be useful to you. In preparing your request, please make sure you include answers to the questions listed below and explained in the following paragraphs:

- How do you plan to use the seed?
- What is the goal of your study?
- How many entries can you handle in a growing season?
- What are the growing conditions where you will plant the seed?

Use of the material—This information is very helpful to us in deciding which accessions are suitable for your work. For example, if you tell us you plan to

CIMMYT Policy on Distribution of Seed From the Maize Germplasm Bank

Seed of Bank accessions is distributed free upon request in small quantities (generally from 25 to as much as 200 seeds per accession according to need) to any bona fide researcher working in the public or private sector in developed or developing countries, with priority given to public sector organizations. Researchers in the private sector are usually asked to pay shipping costs.

By supplying certain items of information, you can help Bank staff keep to a minimum the time required to determine which accessions will be useful to you.

use the seed in a breeding program for lowland, early maturing maize, we will know not to send maize that grows at an elevation of 3900 m in the Andes and takes 11 months to mature. On the other hand, that material would be entirely appropriate if your intention were to measure seed proteins in a biochemical laboratory.

Goal of the study—Be as specific as possible about the objectives of your research. Do you wish, for example, to identify agronomic traits, such as drought or frost tolerance or a particular grain texture, or is your goal to measure racial distance, using isoenzymes, in a laboratory? This information will give us an idea of the amount of seed you require.

Number of entries—To obtain an accurate estimate of the mean and range of a character in an accession, you will need to evaluate a sufficient number of samples. One seed or plant is obviously not truly representative of the material, nor is it practicable to evaluate 10,000. To help us determine what would be a reasonable quantity of seed to send you, indicate how many evaluation rows your program can grow in a season or how many entries your biochemical laboratory can run in a month.

Growing conditions—Sometimes this is obvious from the location indicated in your letterhead, but not always. Please comment in your letter on relevant aspects of the maize-growing environment, such as the length of the growing season, heat units, water availability, disease pressure, and elevation.

Handling of Seed Received From the Bank

There are several features of Bank accessions, particularly the landraces, to bear in mind as you incorporate this material into your research program.

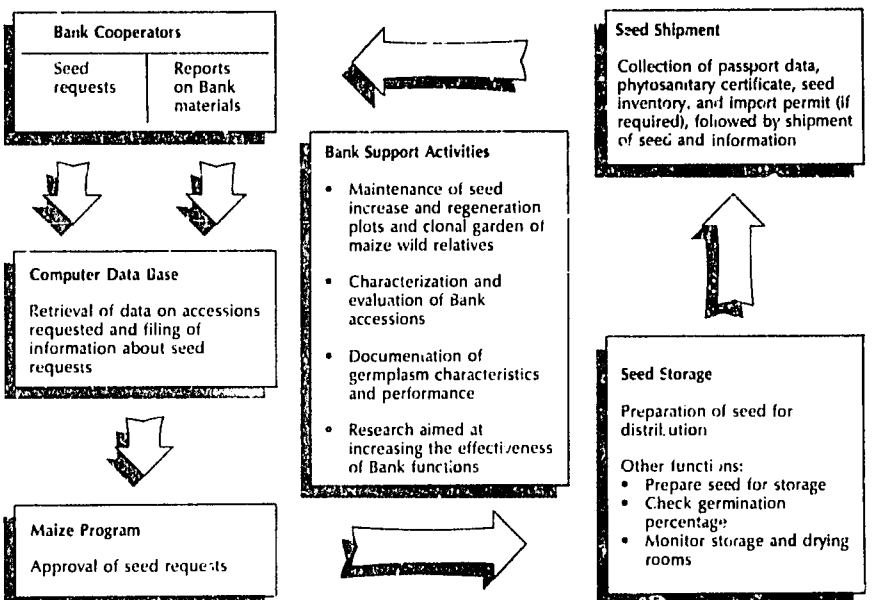
Adaptation to local growing conditions—The first point is that most Bank accessions are highly heterozygous and as such are storehouses of genetic variation. Consequently, the samples we distribute will show considerable variation and will probably not be well adapted to the growing conditions (day length, temperature, soil conditions, pest pressures, etc.) where you are conducting research.

Processing of Seed Requests

The accompanying diagram shows what happens to your seed request from the time it reaches us until your seed is sent out. First, we retrieve information from the computer data base about each accession you have requested. The serial number, name and address of the consignee, materials being sent, and research objective of the person requesting them are entered on a card, which is placed in our files on the distribution and use of Bank accessions. After typing up a formal seed request and getting it approved, Bank staff prepare your seed shipment. Meanwhile, passport and characterization data are obtained and either attached to the seed envelope or mailed to you separately. The envelope, to which are attached a phytosanitary certificate, seed inventory, and import permit, is then sent out from our maize seed shipment office.

If you have requested a small quantity of seed, it is sent by parcel post. Larger seed shipments are airfreighted. We will inform you by telex of the waybill number of the seed shipment and notify you by letter, cable, or telex that your request has been processed. You can expect to receive the seed shipment within 30 days after receiving that notice. Please inform us immediately when your shipment arrives. This information helps us determine whether the shipping process is working efficiently. We will send quarterly reports to all regional staff indicating what materials have been sent to their regions. They will then be able to help us monitor the shipment of seed.

The Path of Seed Requests



To germinate Bank material and obtain good emergence, try to provide the best conditions possible in the laboratory or field.

Many Bank accessions, for example, are short-day materials because of their origin in the tropics. In the temperate zone, those accessions will grow as high as 4-5 or even 6 m and will flower very late. One remedy is to photoinduce the plants when they reach the five-leaf stage. In the field this can be done by covering the plants with light-weight, well-sealed metal garbage cans for enough time to restrict the daily period of light to less than 10 hours. Some materials, however, are so late maturing that the first cycle will have to be grown at a tropical site, where the Bank materials can be crossed with early maturing temperate maize.

Exotic maize germplasm will seldom be easy to handle, but we will do what we can to make sure you are forewarned about any unique requirements of the accessions we send.

Germination and emergence—A second consideration is the effect long-term cold storage will have had on the seed. One consequence is that when brought to ambient temperature the seed will age more rapidly than would seed that has not been in storage. The longevity of the accessions will vary according to type of seed, its moisture content at storage, length of the storage period, and ambient conditions. Regardless of such differences, though, we recommend that you time your seed request such that the seed will arrive no sooner than one month before your planting date.

A second consequence of long-term storage is that the percent germination of the seed (as determined from a paper-towel test) will not correspond to establishment in the field. The germination of most seed in the Bank, after 20-25 years of storage, is still very good under laboratory conditions, but establishment of good stands in the field is sometimes significantly less than predicted by a seed viability test. It is possible to observe 95% germination in the laboratory and 0% emergence in the field. What happens in such cases is that, because of the reduced vigor of the old seed, it produces weak seedlings which are unable to break the soil surface. That problem is especially common in heavy soils and in fields with a crusted soil surface.

In order to germinate Bank materials and obtain good emergence, you should try to provide the best conditions possible in the laboratory or field. One option is to plant the seed in paper cups and then transplant it to the field at the two- to three-leaf stage. Another is to plant the seed in the field at a reduced depth of 2-3 cm and to check the plants frequently until they have reached the five-leaf stage. If we suspect there might be problems with emergence of particular accessions, we will include instructions for starting the seed with your seed shipment.

A third point to remember about seed age is that it can have a dramatic negative effect on yield and yield-related traits. Thus, if you plan to evaluate Bank accessions for those traits, we suggest that you first increase seed of the accessions and then carry out your evaluations with fresh seed during the following cycle. By doing so, not only will you obtain more reliable results, but you will have your own supply of seed and will be less likely to have to obtain more seed of those accessions from the Bank.

Feedback on Use and Performance of Bank Materials

The Bank's function does not end with conservation of seed or even with distribution of that material to researchers around the world. It extends also to promoting the free flow of information about the performance of Bank materials. With all accessions, as mentioned previously, we send passport information (including country of origin, collection site, altitude of site, and other items) and primary characterization data gathered at regeneration of the accession. For selected accessions we can supply more detailed information about special traits. Upon request, we will also supply the regeneration history of any accession.

The information we compile and make available to persons requesting Bank materials is derived mainly from reports we receive from you on how the seed was used and performed. Within 6-12 months after you receive seed from the Bank, we will send a copy of the seed distribution and use file created upon receipt of your seed request. Space is provided for

Adapted and nonadapted (foreground) Germplasm Bank materials in an observation nursery at El Batan, Mexico.

An important function of the Bank is to promote the free flow of information about the performance of its accessions.

information about your research with Bank seed. Even if you can report only that the seed germinated and died or that the accessions were too late in flowering and were not adapted, the information is valuable to us. It is even more useful if you can also inform us about soil temperature, moisture stress, disease or insect pressures, and other factors that might have influenced seed performance.

In addition to a report on seed performance, there are at least two other types of information that would be of use to us and to many of our colleagues in maize research. First, please acknowledge the origin of the seed by CIMMYT Germplasm Bank accession number, so that we can document the use of the material. Accurate records on the use of Bank accessions enable us to make better suggestions to future users about the applicability of the material to various types of research. Second, we encourage you to offer any suggestions about materials that could be added to our collection. Since the Bank's holdings are intended to represent the racial evolution of maize, we are always anxious to acquire new and distinct accessions. If you know of important materials that we are missing, please let us know.

We will very much appreciate your cooperation in accumulating the types of information discussed here. By supplying us with detailed reports, you can help us provide better service to the world community of maize researchers.

Seed Health of Maize Accessions

Every possible precaution is taken to ensure that the seed you receive is alive, healthy, and free of diseases and insects (each seed shipment is accompanied by a phytosanitary certificate). Details about the various safeguards taken and other policies and procedures followed in the handling of Bank materials are provided in the following pages. This information may be of interest, not only to cooperators, but to plant quarantine authorities and other persons concerned with seed health and with preventing the introduction and spread of seedborne disease.

- Upon their arrival at CIMMYT in Mexico, all collections are treated before planting with a combination

of insecticide and fungicide (including ridomil) to ensure that the imported seed does not transmit seedborne diseases. The seed is usually planted more than one year after arrival.

- All maize seed supplied by the Bank is produced at one of the Center's experiment stations in Mexico or elsewhere under collaborative arrangements between the Center and other institutions. The site and year of regeneration are indicated on the front of the envelope in which the seed is sent and on the seed list enclosed in the envelope.

- The sole exception to the rule of distributing only seed grown under the auspices of the Maize Program is that seed of teosinte populations is collected from wild stands in Mexico and Guatemala. Before being stored that seed is treated with insecticide and fungicides. Seed of *Tripsacum* spp., the other maize wild relative on which CIMMYT conducts research, is supplied in very limited amounts from a clonal garden at the Center's Tlaltizapan maize research station in Mexico.

- All of the Center's experimental maize plots and maize-relative gardens are under the supervision of Maize Program staff, including pathologists and entomologists, who monitor the plots from planting to harvest. Plants suspected of having seedborne diseases, including viruses, are immediately rogued.

- To qualify for storage, seed must come from regeneration plots that are free from seedborne diseases of

Regeneration of Germplasm Bank materials at Tlaltizapan, Mexico.

Every precaution is taken to ensure that seed received by cooperators is alive, healthy, and free of disease and insects.

maize, such as *Xanthomonas stewartii*, *Peronosclerospora* spp., and *Helminthosporium carbonum*, as well as virus diseases known to be or suspected of being seedborne.

- Seed is harvested from healthy ears in a Bank introduction nursery, and harvested ears are individually checked by Maize Program scientists. The seed is accessioned if there are more than 100 full ears and if sufficient passport data and information on primary characterization are available. In cases where fewer than 100 ears are harvested, the seed is planted in a regeneration nursery during the next appropriate cycle and then accessioned if more than 100 full ears are produced.

- At harvest all ears are treated in the field with the insecticide Actellic 50 43.2% (a.c.) at a rate of 1 ml/4 l of water; the entire ear is dipped in chemical and then air-dried.

- Ears of all accessions are air-dried without heat to a moisture content of 9-12% before shelling (the moisture percentage varies slightly with endosperm type). After shelling, the seed is further dried to a moisture content of 6-8% for long-term storage in the base collection.

- Only sound seed is shelled for storage. After shelling the seed is carefully examined on light tables. All unhealthy seed is discarded, and chaff and other debris are removed before storage.

- Seed is supplied only in response to specific requests.

- Seed to be sent to a cooperator is taken directly from the active collection (unless special handling or treatment of the seed is required or requested by the consignee) and mailed in paper envelopes.

- For all seed shipments, CIMMYT's Seed Health Laboratory determines the germination percentage and conducts various seed health tests according to the guidelines of the International Seed Testing Association.

These measures, policies, and procedures ensure that seed distributed by CIMMYT is produced under insect- and disease-free

conditions and that it is of the highest quality possible. Treatment of the seed with a mixture of Furadan and Thiram further guarantees that it will remain pathogen and insect free and promotes better stand establishment. The seed treatment currently used by the Maize Program includes 50 ml of Furadan 30% (seed treater), 2 g of Thiram 75% (wettable powder), and 12 ml of water per kilogram of seed.

Furadan (2,3-Dihydro-2, 2-Dimethyl-7-Benzofuranyl N-Methylcarbamate)—The common names or synonyms for the broad-spectrum systemic insecticide/nematicide are Carbofuran and 2,2-Dimethyl-7-Coumaranyl.

Symptoms of poisoning by Furadan are those of cholinesterase inhibition. The manufacturer's recommended antidote for mild intoxication is 2 mg of atropine sulfate administered intramuscularly or sublingually, and for severe intoxication 4 mg of atropine sulfate, preferably administered intravenously as soon as cyanosis disappears. In either case seek medical assistance immediately.

For acute oral toxicity, the LD of Furadan in mammals is 8-14 mg/kg of body weight and for dermal toxicity 3400 mg/kg of body weight.

Thiram (Tetramethylthiuram Disulfate)—The common names of this protective fungicide are Arasan, Tersan, Pomarsol, and Nomersan.

This chemical has low mammalian toxicity; for acute oral toxicity, its LD 50 in mammals is 780 mg/kg of body weight. Since it may cause skin irritation, the manufacturer suggests that you wash your hands after handling treated seed. Do not put seed in your mouth or use it for food or feed.

Rolf Rosenberg

Cleaning seed before it is placed in storage.