Global Strategy for the *Ex situ* Conservation and Utilization of Maize Germplasm

Photo courtesy of Ing. Mario Fuentes, Maize Genebank Manager, Guatemala. Maize ear drying of highland landraces.

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DISCLAIMER

This document has been developed by the crop experts. The objective of this document is to provide a framework for the efficient and effective *ex situ* conservation of the globally important collections of maize.

The Global Crop Diversity Trust (the Trust) provided support towards this initiative and considers this document as a critical framework for guiding the allocation of its resources. However the Trust does not take responsibilities for the relevance, accuracy or completeness of the information in this document and does not commit to funding any of the priorities identified.

This strategy document is expected to continue evolving and being updated as and when information becomes available. The Trust therefore acknowledges this version dated September 2007.

In case of specific questions and/or comments, please direct them to the strategy coordinator mentioned in the document.

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Summary

The genetic resources of maize constitute an immeasurable treasure for humankind. Conservation of maize germplasm and knowledge about its variation and uses provide (i) resources for agricultural improvement to reduce hunger and poverty and (ii) a solid knowledge base for future generations of researchers and technological users. The variability among maize landraces exceeds that for any other crop. The collection and study of the accessions of the races of maize are unprecedented in man's agricultural heritage; their maintenance and regeneration has been remarkable, and their widespread and open availability to research workers has been unique (Taba, 2005). Nonetheless, problems remain:

1. Integration of maize germplasm resources and maize breeding is challenging; historically, efforts have been inconsistent.
2. Most racial studies of maize have been New-World-oriented.
3. Regeneration of some eco-specific accessions has been difficult.
4. Distribution of individual seed requests via national germplasm banks has generally been ineffective due to resource and/or policy issues.
5. Phytosanitary restrictions are a major bottleneck in distributing germplasm samples.
6. Teosinte populations are endangered and have scattered (and less than complete) representation in the major international germplasm banks.
7. Documentation of the materials held in national collections is inconsistent, and sometimes poor, and is held in multiple databases that are not necessarily well maintained or easily accessible.
8. *Tripsacum* populations are part of the secondary gene pool of maize genetic resources, and some are endangered; some populations should be monitored and conserved.
9. Developing a worldwide strategy for preservation, documentation, distribution, and utilization of maize genetic resources will require attention to these and other, generally less difficult, problems.

1. Introduction

The process of developing the proposed strategic approach began in February 2006 with requesting the expertise of Dr Major Goodman of the Crop Science Department, North Carolina State University, Raleigh, USA to facilitate the development of a global conservation strategy for maize. The process began with data compilation and analysis of the status of existing maize collections complemented through a survey (format in Appendix 1) to the major maize collection managers (listed in Appendix 2). The information on the holdings of maize was obtained from the Bioversity International Database of Germplasm Collections. A summary of the results of the survey is included in Appendices 6 to 9.

Following from the survey, an expert meeting was held at CIMMYT in Mexico, 5-6 May 2006 (Programme in Appendix 3 and list of participants in Appendix 4). The discussions at the meeting guided the development of the approach suggested herein. The strategy consultation meeting was preceded by a workshop, "Latin American Maize Germplasm Conservation: Regeneration, *In situ* Conservation, Core Subsets, and Prebreeding," 2-4 May 2006 at CIMMYT, where worldwide representatives of maize germplasm collections were invited.

A steering committee consisting of Major Goodman (North Carolina State Univ., USA), J. Manuel Hernandez C., (INIFAP, Mexico), J. Jesus Sanchez G. (Univ. Guadalajara, Mexico), Ricardo Sevilla P. (Univ. National Agraria La Molina/INIA, Peru), and Suketoshi Taba (CIMMYT), assisted by Brigitte Laliberté (Global Crop Diversity Trust), gathered opinions from other attendees and made preliminary suggestions for a global maize conservation strategy.

2. Background

Maize was domesticated in southern or southwestern Mexico, most likely from teosinte or some extinct wild maize very closely related to teosinte (Wilkes, 2004; Sluyter and Dominguez, 2006). Maize is highly variable morphologically and is grown from sea level to 3800 m. Maize and the diploid teosintes, both with 2n=20, are interfertile (there is one species of perennial, tetraploid teosinte). While maize covered much of the New World at the time of colonization, the teosintes have a much more restricted geographic distribution; mainly central and southwestern Mexico, with limited populations in northern Mexico, Guatemala, and Nicaragua (see Appendix 5). Maize has been divided into about 300 landraces (summarized in Goodman and Brown, 1988, but recently published in full on searchable CDs by the USDA and the North Central Regional Plant Introduction Station at Iowa State University, 2005 [USDA-ARS, 2005]). The maize of commerce represents only a fraction of the 300 or so landraces. The commercial landraces are the Northern Fints, Southern Dents, and Corn Belt Dents from the US, Tuxpeño and Celaya from Mexico, Cuban Flint from Cuba, Coastal Tropical Flint/Costeno and Tuson/Puya from the Caribbean and northern South America, Cateto and Cristal from Brazil and Argentina. Several early-maturing landraces from the Caribbean area probably were responsible for the early spread of maize into southern Europe; these were most likely Early Caribbean from the islands and Nal-tel de Tierra Baja from Guatemala. These few commercial landraces, which represent perhaps 5 to 10% of the landraces of the New World, were the sources of the bulk of the maize germplasm that reached and spread throughout the Old World. Teosinte was originally divided into 6 races by Wilkes (1967), but since the discovery of *Zea diploperennis*, species and subspecies names have come into favor (Wilkes, 2004; Appendix 5 of this document) for teosinte. While some races of maize (mostly lowland and mid-elevation races in areas where modern commerce prevails) have been displaced by modern cultivars, and others are threatened, virtually all the teosintes are endangered as a result of modern farming and ranching practices. In areas where populations of Native Americans predominate, their landraces of maize are still being cultivated and can still be collected today. However, economic forces, such as the North America Free Trade Agreement (NAFTA), are seriously eroding the well being of the small farmers in Mexico with a resulting serious reduction in the number of landraces being grown and a reduction of land area devoted to most races. In addition to maize and teosinte, there is one other genus of consequence related to maize. Some species of the genus *Tripsacum* (suggested base chromosome number 2n=18 (Anderson, 1944; Stebbins, 1950), but actually represented by a polyploid series with some apomixis) can be crossed with maize (with difficulty), usually resulting in sterile progeny, but backcrosses to maize are possible. *Tripsacum*'s range is somewhat less than maize, but much greater than teosinte. There are at least 16 species of *Tripsacum*, ranging from the USA to Bolivia (de Wet *et al*., 1983). Some species are widespread, but others have very restricted distributions (Appendix 5).

3. Networks

While there are numerous regional germplasm networks in the Americas, Africa, Asia, and Europe, most of the networks are more concerned with general information exchange rather than regeneration and active germplasm exchange. Most have budgets suitable only for holding occasional meetings and have had relatively little influence on active national or regional germplasm exchange, except for sometimes setting policies. The networks that have been most effective for maize are LAMP (Latin American Maize Project) and the Latin America Maize Regeneration Project. LAMP was funded in the mid-1980s with a US $1.5 million contribution to the US Department of Agriculture (USDA) from Pioneer Hi-Bred International. Their CEO at that time was William L. Brown, who had been instrumental in collecting and studying the accessions of the races of maize in the 1950s and early 1960s. The regeneration project was initiated as a result of a unanimous recommendation of the National Plant Germplasm Resources Board of the USDA in 1983 (Brown was vice-chair). In many ways, the two projects worked together. Over 12,000 Latin American accessions were evaluated through LAMP, sequentially identifying the more promising ones for further breeding work, and eventually identifying an elite set of about 300 accessions. An executive committee worked with a director to distribute funds to the collaborating national projects. This was probably the most extensive evaluation project ever carried out for a set of germplasm accessions. While it covered only 50% of the “available” accessions, it quickly demonstrated the sad status of the remaining 50%, for which there were not adequate viable seed to even have two replications at two locations. The regeneration project was coordinated at various times by North Carolina State University, Ft. Collins (then NSSL, now NCGRP), and CIMMYT. It eventually regenerated most of the maize accessions of Latin America, including those of LAMP, starting at a time when many were on the verge of loss due to limited funding and understaffing of national programs. The project director was responsible for the purchase and distribution of supplies and allotment of monies to the collaborating programs. This project has been quite successful, but a number of “difficult” accessions remain to be regenerated, while other accessions still need safety backup. Additional funding and some careful decisions on appropriate regeneration sites need to be made to complete this important project.

The LAMP project eventually led to the GEM (Germplasm Enhancement of Maize) project in the USA, a cooperative public/private endeavor to quickly expand the germplasm base of commercial maize. Elite germplasm accessions are crossed to private lines from US or foreign companies (or to public lines from foreign countries), families are derived by selfing, and top crosses are tested cooperatively to identify superior families. These superior families are first distributed to cooperators (US and international) and then, with a year's delay, to the general public anywhere in the world via the NCRPIS at Ames, Iowa. GEM is effectively governed by an elected Technical Steering Committee which oversees the efforts of the project directors at Ames and Raleigh; funding is through USDA-ARS and results from direct Congressional appropriations. GEM would be more effective with more international participation; at present there is little encouragement from the USDA (which has traditionally had a minimal interest in international collaboration) to do this. Together, these three projects represent much of the current leadership for protection, promotion, and utilization of maize germplasm resources.

4. Overview of ‘major’ collections

4.1 Germplasm Collections

The total number of unique New World maize germplasm accessions exceeds 27,000 (Taba survey, 2006; see Appendices 6 and 7). Accession as used herein excludes inbred lines, synthetics, and other breeding materials and, unless otherwise noted, excludes teosinte and tripsacum). These accessions have been classified into some 300 races (Goodman and Brown, 1988). Major New World collections are listed in Table 1.

Table 1. Major New World Collections

Location	Size of own collection	Importance (9 = most important - 1= least important)	International seed distribution**	Duplicate stocks from elsewhere	Wild species stocks
Argentina	2,400	5	S-MTA		
Bolivia	1,500	8	N	23	1
Brazil	3,200	6	S-MTA	288	7
Chile	950	7	S-MTA		
Colombia*	1,800	7	N	1,800	
Ecuador	1,100	7	S-MTA	168	
Guatemala	900	8	N		
Mexico*	12,000	9	S-MTA	1,800	136
Paraguay	478	7	N		
Peru	3,000	7	S-MTA	37	
USA- NCGRP*	200	9	S	39,000	354
USA- NCRPIS*	1,300	8	Y	13,500	238
Uruguay	852	5	S		
Venezuela	1,200	6	N		
CIMMYT*	7,311	9	Y	17,632	308
TOTAL	**38,191**			**74,248**	**1,044**

* Hold regional or international accessions
** Y=Yes; N=No; S=Some; U=Uncertain MTA requires a Material Transfer Agreement

The relative importance of the various collections includes the uniqueness of their holdings, the expertise and historical documentation held by the banks and their collaborators, and the degree to which their holdings are available through the active international distribution centers (CIMMYT and NCRPIS). Historically, the original strains of maize in Latin America collected in 1950-60's with the National Research Council-Rockefeller collection missions were preserved in four national centers (Brazil, Colombia, Mexico, and Peru). Later (see Section 3), most were duplicated at CIMMYT and USDA germplasm banks.

Not all accessions have been classified by race, and not all can be classified. The latter include some that are mixtures of races; some that are descendants of hybrids; some that are mixtures of hybrids and races, or descendants of such mixtures. Documentation for some accessions requires improvement. Most New World accessions have been regenerated recently, most have duplicate preservation for safety, and most are available for distribution, either from CIMMYT or from the USDA's North Central Regional Plant Introduction Station at Ames, Iowa (NCRPIS), or from both. The number of Old World accessions is somewhat smaller (perhaps 20,000; based on Taba's survey; 40,000, if regional reports are included, but some of the latter may include breeding materials and accessions from other countries). More Old World accessions probably represent descendants of widely-distributed, open-pollinated varieties or hybrids, and sample duplication may be more of an issue with Old World accessions. Major Old World collections are listed in Table 2. Their regeneration status, safety backup status, and general availability are much less certain than for New World accessions. Actual availability of accessions governed by MTAs is uncertain. Past experience with seed requests to many of the germplasm banks requiring MTAs suggests that seeds might actually be available from less than half of them.

Table 2. Major Old World Collections

Location	Size of own collection	Importance (9 = most important - 1= least important)	International seed distribution**	Duplicate stocks from elsewhere
Angola*	600	2	U	
China	13,000	4	N	1,200
Ghana*	500	2	N	
India	1,300	3	S-MTA	
Indonesia	500	3	N	14
Japan*	6,000	2	U	
Kenya	1,100	3	S-MTA	
Korea, North*	7,000	1	N	
Korea, South*	7,000	1	U	
Morocco*	1,100	2	U	
Nepal*	500	4	U	
Pakistan	500	3	N	
Philippines*	2,000	4	U	
Romania	4,500	3	Y	800
Serbia	1,200	3	Y	4,600
South Africa*	900	3	S	
Sri Lanka	350	1	U	350
Turkey	1,500	4	S-MTA	
Nigeria (IITA)***	11	4	S-MTA	765
Total	**42,061**			

* From Regional Reports; may include accessions from other countries or breeding stocks
** Y=Yes; N=No; S=Some; U=Uncertain , MTA requires a Material Transfer Agreement
*** International

4.2 Genetic Stock Collections

In addition to the major germplasm collections, there is one primary maize bank specifically for genes, the Maize Genetic Cooperation Stock Center. The maize stock center has conserved and annotated the maize mutant stocks and made them available to maize geneticists worldwide for 74 years. It is located in the Department of Crop Sciences of the University of Illinois (123 Turner Hall, 1102 S. Goodwin Avenue Urbana, IL 61801-4798, USA). The center's expertise and service to the worldwide users of maize genetic stocks are well known. Approximately 85% of its core holdings currently have safety backup at NCGRP (Ft. Collins), but it also houses tens of thousands of "terminal" segregating families generated by recent multimillion dollar National Science Foundation (NSF) genomics grants as well. In addition, some of these same NSF grants are producing thousands of Recombinant Inbred (RI) populations that are really beyond the scope of the maize stock center's core mission, the study and preservation of stocks containing specific mutant alleles.

5. The importance - and the uniqueness – of the individual collections

The reasons for the differing rates among them are the extent of unique holding of the accessions or races of maize either from own country only or those including the adjacent countries. The original strains of maize in Latin America collected in 1950-60’s with the National Research Council-Rockfeller collection missions were preserved in the four national centers. Later they were duplicated at CIMMYT and USDA gene banks.

The key collections are basically the international collections of the Americas, found at four sites:

1. CIMMYT
2. NCGRP (Ft. Collins)
3. NCRPIS (Ames)
4. Genetic Stock Center (Urbana)

CIMMYT houses most of the Latin American accessions, both for medium and long-term storage. There are low and high-elevation Bolivian accessions, intermediate and high elevation Guatemalan accessions, and some Caribbean accessions that are missing from CIMMYT's bank or lack regeneration. In addition, despite being THE world center for public maize breeding, for historical reasons, CIMMYT's germplasm bank has a very poor representation of public, tropical, inbred lines, and even lacks a few CIMMYT (CML) inbreds in its current inventory. Its representation of other important breeding materials is rather haphazard due to the long-term concept that the germplasm bank was for accessions, not breeding materials. However, the recent organizational reform of CIMMYT has streamlined integration of its maize breeding and maize genetic resources units. CIMMYT is widely regarded for its international collaboration and its willingness to share germplasm. Only recently has it even instituted shipping charges. It also now has a separate unit from the germplasm banks that handles shipping of both maize and wheat germplasm (the jury is still out on whether this is functioning well). CIMMYT houses many teosinte accessions, and it also monitors the existence of stands of wild and weedy teosintes, especially those in Mexico. The other three germplasm banks with large numbers of teosinte accessions are those of INIFAP (the Mexican national program), the University of Guadalajara, and NCGRP (FT. Collins). CIMMYT houses one of three major tripsacum gardens in the world; the others are at the USDA-ARS Subtropical Horticulture Research Station in Miami, Florida, and a USDA-ARS facility at Woodward, Oklahoma (see Appendix 5 for more detail about teosinte and tripsacum).

NCGRP (Ft. Collins) is the long-term storage center for the US, and it houses even more Latin American maize than does CIMMYT. It generally does not provide seeds directly, but works in conjunction with NCRPIS at Ames, IA, the medium-term storage facility and the regeneration branch for the USA. NCRPIS is renowned world-wide for promptly sending seed of its holdings postage-free to any location in the world that does not have extremely restrictive phytosanitary requirements. NCRPIS and NCGRP (Ft. Collins) hold many, perhaps most extant, public US inbreds, many breeding populations, and distribute patented and Plant Variety Protection (PVP) inbreds as their protection expires. NCRPIS is the first choice for most germplasm requests, as its holdings are extensive, its shipping is prompt and free, and there are no charges for the seeds. The major drawback is that there is a large backlog of materials that need regeneration and limited funding and facilities for regeneration.

The Genetic Stock Center at the University of Illinois is unique in the world. It houses virtually all of the mutants of maize, various chromosomal stocks, multiple mutant stocks, and various other stocks of interest to the maize genetics community. It provides these upon request to anyone, anywhere in the world, free of charge. It is short of space, but is currently expanding.

The national centers are important for various reasons. The most important are those of Brazil, Colombia, Mexico, and Peru. They were the original stock centers holding the NRC-Rockefeller collections of the 1940s-1960s, upon which the races of maize were defined and described. The national centers are not nearly as critical as the international centers for *ex-situ* seed storage, however. Almost all of the national New World germplasm banks have donated samples of their holdings to either CIMMYT or NCGRP (Ft. Collins), or both. What the national centers have to offer is their knowledge of, and experience with, their national accessions.
For the most part, the Old World maize germplasm banks hold materials that are distinctly less

important than those of the New World. Most Old World materials represent maize of commerce, which represents only a small segment of the variation found in the Americas, perhaps 10% or less. The bulk of it represents US and Caribbean materials; the remainder is mostly low-elevation Mexican Tuxpeños and Brazilian/Argentine Catetos. These jointly account for about 10 of the 300 races of maize of the Americas. Perhaps the most unique Old World populations are the waxy maizes of South East Asia that are currently threatened by the expansion of hybrid maize.

What's missing from *all* of the germplasm banks are samples of important hybrids and private inbred lines (except recently expired PVP and patented ones which are available from NCRPIS).

6. Conservation status

6.1 Storage facilities, seed exchange and database management

The four major maize germplasm banks are well managed, with access to, and use of, appropriate medium and long-term facilities. Almost all Latin American accessions are stored at a minimum of two locations; many are stored at three. The storage conditions for all facilities surveyed are summarized in Appendix 8, and seed exchange and database policies are summarized in Appendix 9.

6.2 Sample sizes

Sample sizes are more than adequate at the 4 major locations, except the genetics stock center at Urbana, where sample sizes are deliberately small, to accommodate the large number of mutant stocks. The mutant stocks are virtually always homozygous, and cooperators know that they will usually receive few (often 15) kernels that they will need to increase themselves.

6.3 Regeneration status

Regeneration has proceeded well at CIMMYT, the accessions lacking regeneration there are usually "difficult" accessions, poorly adapted to the experimental facilities available. The status of regeneration at NCGRP (Ft. Collins)/NCRPIS is more problematic. The number of accessions is larger, the regeneration budget has been tighter, and the facilities (mostly on Puerto Rico and Saint Croix) more limited. In recent years, all regeneration has been conducted with a goal of 100 sib-mated ears per growout; that is probably an excessively high number, given the numbers of ears originally collected (usually 5 to 20, rarely more). In some cases it may be possible and efficient to combine regeneration efforts with *in-situ* conservation/farmer-assisted-breeding efforts.

6.4 Duplication status

Almost all accessions at CIMMYT are duplicated in national collections (although most national programs have very limited budgets and often have badly worn and outdated storage facilities); most have a long-term safety backup at NCGRP (Ft. Collins). Virtually all NCRPIS accessions have long-term backup at NCGRP (Ft. Collins). Most of the accessions at NCGRP (Ft. Collins) that are not at NCRPIS are backed up at CIMMYT, in fact that is where many of them came from. Many of these are also in the appropriate national collections.

6.5 Data available

Passport data are available for almost all maize germplasm bank accessions. However, there is little uniformity in its management. CIMMYT seems to prefer its own accession numbers; NCGRP (Ft. Collins) and NCRPIS use PI numbers almost exclusively; and only the national programs use the original accession numbers initiated with the remarkable National Research Council-Rockefeller studies upon which all the American Races of Maize bulletins were based. Evaluation data are available from both CIMMYT and NCRPIS. The quantity of data is fairly directly correlated with the year of last regeneration. Recently regenerated accessions tend to have more data. Many of the data are descriptive and morphological. Only the US GRIN system is web-accessible, and it can be difficult to go from GRIN's PI numbers to original collection numbers.

National programs use either databases or spreadsheets of their own choosing (Appendix 9). There is little standardization, despite published international protocols. Many of the data collected beyond standard passport data consist of morphological data that are highly subject to genotype-by-environment interactions.

7. Collections that fail to meet accepted guidelines concerning conservation standards

Appendix 8 lists standards for both medium and long term storage for maize accessions. The national collections of Latin America are virtually all stored under medium-term conditions (a few have long-term storage), at approximately 5°C and 50% relative humidity (RH). The national banks have been under funded, sometimes unfunded, for the past 50 years (this funding shortcoming basically began with the withdrawal of the Rockefeller Foundation support for such activities in the late 1950s and early 1960s). In the mid 1950s, virtually all Latin American maize was stored in three major germplasm banks: Brazil, Colombia, and Mexico. Once CIMMYT was functional, Brazil shipped its holdings (which included the collections from Argentina, Uruguay, eastern Bolivia, and the Guianas, as well as Brazil) to CIMMYT, and they formed the heart of the then newly-formed CIMMYT germplasm bank. Colombia initially held the collections for the Andean and northern regions of South America, from Chile to Venezuela. Peru took responsibility for its collections in the late 1950s, and since that time Colombia has slowly transferred most of the responsibility for the collections of other nations to either CIMMYT (Venezuela, Ecuador, and Bolivia) or the US germplasm system (Chile). As countries developed functional germplasm systems of their own, duplicate sets of the materials have been transferred back to the country-of-origin. The USDA Germplasm Regeneration Project and LAMP have led to renewal and backup of most accessions in recent years

The national collections of Africa, Asia, and Europe vary widely in size and scope, but virtually all are based upon the races of maize of commerce, which represent at most about 10% of the races of maize of the Americas. Thus, the materials housed in these banks represent secondary centers of diversity, but diversity of commercial maize that is often overlooked. Some of these banks – China and India, for example – are extremely well designed and managed; some are little more than refrigeration chambers, usually operated at about 5°C and 50% RH (unfortunately the tales of beef and more exotic fare being stored in seed cold rooms are sometimes true).

7.1 Development of core subsets

There is a real need to identify core subsets of the races, but this requires expertise not only in statistical procedures (of which there are many), but more critically, expertise on racial and accession classification and the availability of the type of data needed to develop reasonable classification decisions. There are few scientists with this sort of expertise and very little data that are really appropriate for the task (Sanchez *et al*, 1993). The races were originally defined largely on the basis of a combination of ecogeographical and morphological variation. Accessions typical of the races were chosen on the basis of field studies. These typical accessions have been used for most of the subsequent molecular marker work that has followed (*e.g.,* Sanchez *et al*, 2000; Matsuoka *et al*, 2002) and have basically served as core collections for more than 50 years. The need for core subsets rests on two anchors (1) the germplasm banks' needs to focus on specific accessions for regeneration, storage, and distribution; and (2) the users' needs for a rational sampling scheme to facilitate selection of materials to meet their objectives (Franco *et al*, 2006). While the typical accessions provide an initial, if perhaps slightly dated core, additional collections have been made since they were identified, and molecular techniques have been developed, applied, and have finally started to become economically feasible. Development of core collections is critical, but they must be based on good phenotypic and ecogeographic data (where possible, GIS-based, consistent with the collection's passport data), as well as molecular data. Poorly developed sets of core collections can do real harm, not only by misleading potential users, but also by causing the neglect of important materials omitted from such cores.

7.2 Molecular data

While molecular data are useful, many of them are largely random with respect to meaningful interpretation. Experience has shown that a very large number of markers are needed. Even Liu *et al*, 2003, working with 94 micro-satellite (SSR) markers on a very diverse set of 260 inbred lines (which are much easier to classify than are panmictic populations) had problems grouping a few lines with their close relatives (by pedigree). Attempting to use even fewer markers with open-pollinated populations, as has occasionally been done, clearly will lead to even more errors in classification. While costs per datapoint have finally fallen, the current favorite, single-nucleotide polymorphism (SNP) markers, unlike SSRs, restriction fragment-length polymorphisms (RFLPs), or isozymes, often require a two-step procedure (i) grouping SNPs into haplotypes and (ii) using haplotype frequencies for grouping accessions or landraces. Molecular data represent just one piece of the relationship puzzle; genotype-by-environment interaction often rules trait-application expression or performance, and ultimately performance determines value for application. The most useful data for racial classification for both maize and teosinte are latitude, longitude, and altitude, if the 10 or so races of maize of commerce are excluded, and the same conclusion applies to many species of tripsacum.

7.3 Distribution of DNA samples

One area that has not been greatly explored by maize germplasm banks is the possibility of distributing DNA samples, rather than seed, to the growing number of molecular labs interested in germplasm. This would be particularly important when seed availability is low. Certainly this would be feasible for core collections, as the samples could be cheaply collected during regeneration or germination testing. Feasibility is, of course, dependent on required financial and human resources to collect and distribute DNA or tissues for DNA extraction relative to other priorities, such as regeneration. An efficient system for distribution of tissue or DNA is likely 10 to 100X less costly than the regeneration activities to produce seed and could satisfy a large segment of the research community. Distribution of DNA would not be subject to phytosanitary restrictions that sometimes impede germplasm exchange.

7.4 Germplasm management and breeding

The integration of breeding with germplasm management is much too broad an area to develop a complete plan here; however, there are segments that could and should readily be implemented. One example is the addition of materials with superior traits or research value, such as released inbred lines, significant breeding populations, and important commercial hybrids (or advanced generations thereof) to germplasm collections. With adequate safeguards of intellectual property rights, including required time-delays for public release of materials governed by PVP or plant patents, there is no obvious reason that private as well as public materials should not be included. In addition, collecting and providing basic data from germplasm increases (yield, standability, maturity, adaptation) would greatly increase the value of accessions to breeders and others interested in utilizing such materials. User-friendly, internet-access to such data, along with passport data, is long overdue and should encompass data held in all national and international collections.

7.5 Maize races in the regions

There is a need to extend the "Races of Maize" studies (summarized in Goodman and Brown, 1988) to other parts of the world. Such studies exist for Spain, India, Italy (Brandolini, 2006), and several East European countries. Limited studies exist for certain regions of the Himalayas and Japan. However, few studies like them exist for such maize-rich regions as China, Indonesia, and Turkey or for the entire

African continent. Notably absent is an equivalent study for the USA.

7.6 Regeneration vs. re-collection

There are a number of regions in the Americas where accessions have lain dormant in germplasm banks without regeneration due to lack of appropriate experimental facilities or lack of knowledge about where to grow "difficult" materials (Goodman, 1984). There have also been cases where regeneration was not possible due to limited funding for germplasm conservation, characterization and distribution. For example, several landrace accessions were collected in Ghana and Burkina Faso but largely lost due to the lack of adequate storage facilities and limited funding. In some cases, recollection of adequate samples makes more sense than regeneration, particularly for high-elevation landraces growing in areas unaffected by improvement programs (much of Oaxaca and Chiapas in Mexico, many Central American highlands, much of Andean Argentina, Bolivia, Chile, Ecuador, Colombia, and Peru). These are cases where national programs should have the knowledge and expertise to recollect. In other cases, appropriate environments for regeneration have been identified (for example, many Bolivian races and all the Amazonian races can be regenerated in winter nurseries in Florida), but have been under- or unused. In almost all cases, however, key accessions exist within these "difficult" sets that demand regeneration due to their historical importance (the typical accessions, for example). National programs should be able to assist with these efforts, some of which could readily be coordinated with farmer-assisted selection/*in-situ* conservation efforts. Much progress has been made on regeneration since the 1980s; many collections were regenerated in collaboration with CIMMYT in the 1990s. CIMMYT does not have duplicates of many national collections that North Carolina State helped regenerate in the 1980s. CIMMYT has received some 500 national accessions of Colombia from Ames, but many accessions from Bolivia as well as some from African countries remain to be regenerated for safety back-ups.

8. Distribution status

8.1 Availability of seedstocks

The availability of seedstocks of accessions of maize in the New World has changed from dismal (in 1980) to quite good today. Most accessions are stored in reasonable quantities (usually > 1 kg) in both national and international centers. The international centers (CIMMYT and NCRPIS) have functioning programs in place for phytosanitary inspections, packaging, and shipping. The situation for much of the Old World is much less clear, some countries (much of Europe, China, India, and Japan) appear to have adequate stocks and personnel, others may have large numbers of stocks, but quantity and availability are less clear (Appendix 9 has some relevant information).

8.2 Accessibility

The maize of the Americas is generally accessible through either CIMMYT or NCRPIS or both. Perhaps 10% of the accessions lack regeneration. The status of accessibility of Old World accessions is much more questionable.

8.3 Phytosanitary requirements

The limitations that current phytosanitary requirements place on germplasm exchange are often prohibitive, even for well-funded programs. For poorly funded programs, they form an immense barrier. Many of these limitations are of economic origin, designed to act as limiting or prohibiting tariffs to inhibit large-scale commerce (conceptually, at least, this is prohibited or at least limited by the SPS [Sanitary and Phytosanitary] Agreement of the WTO; Jensen, 2002). Examples: requiring freedom from southern leaf blight for seeds sent to countries where the disease is endemic (Argentina, South Africa, etc.) or limiting the percent of seeds with the common fungus *Fusarium* to 5% (Serbia). Many countries (including Mexico) restrict seeds containing any sign of Stewart's wilt, a minor disease of little real pathological significance. Others require certification of freedom from diseases that do not occur in the regions where the seeds are produced (HPV [High Plains Virus] does not occur in Florida or North Carolina, yet seeds produced in those states sometimes require field inspections or laboratory testing to be shipped to some countries). Some countries require freedom from diseases that are highly unlikely to be seed transmitted (*Cercospora zeae-maydis*, *Kabatiella zeae*, and *Phyllostica maydis*, for example in maize; similar lists exist for soybean and other crops). Others simply greatly hinder or slow usage of materials, for example Australia and Brazil require that all new genetic materials must pass though a post-entry quarantine process with few seeds that require several subsequent increases before any real experimentation can take place. There are legitimate reasons to screen maize seeds from certain areas where important seed-borne diseases occur, but these are often the exception. In many cases, boatloads of maize enter a country more freely than a packet of 50 insect-free kernels of an important germplasm accession. These problems are severe, and they are not restricted to maize, either in their severity or their inappropriateness. Current concerns over the presence of GMOs and related import restrictions simply add to already-existing problems.

8.4 Past experience

Both CIMMYT and NCRPIS ship several hundred kernels of an accession to most locations in the world within a few days or weeks (unless unreasonable phytosanitary restrictions exist in the recipient country – see above). To some degree, the general ineffectiveness of national maize germplasm banks in international seed distribution can be attributed to minimal budgets combined with unreasonable phytosanitary requirements restricting seed distribution. Almost none exchange seed freely, although bank to bank interchange is not unusual. Some are better than others at responding to individual international requests. Some of the reasons for the failure to freely participate in international seed exchange are budgetary. However, some of the reasons are political and bureaucratic, occasionally based on overestimates of the potential commercial value of germplasm. Fears associated with patenting genes or germplasm have tended to paralyze seed interchange in recent years. Still, the distribution efforts and policies of the NCRPIS at Ames, Iowa, USA, stand in stark contrast to those of all other national New World maize germplasm banks. Only the maize germplasm bank at CIMMYT compares well with the efforts made at Ames, a bank that has often had severe budget limitations (although rarely as limited as most Latin American national banks). Unless these problems, which are sometimes political, sometimes legal, occasionally nationalistic, and almost always budgetary, can be met head-on, the role of national germplasm banks in global efforts will be severely constrained. The resulting loss of genetic diversity and capacity in the form of expertise and research networks will be felt internationally and will be irreversible. As there has been less interest in Old World accessions, there is little past experience with which to judge actual availability.

9. Analysis of which collection holders are unable to readily make material available internationally

In Latin America, Argentina, Chile, Paraguay, Uruguay, and Colombia lack funding for international exchange. Bolivia, Ecuador, Peru, Venezuela, Guatemala, and Mexico lack funding and also have legal restrictions.

In the Old World, there are funding restrictions, political restrictions, and phytosanitary restrictions for much of Africa and Asia. China has political restrictions, while the situations with India, Japan, and South Korea are currently uncertain (see Table 2).

10. Synthesis of conservation and distribution

The collections of CIMMYT and the combination of NCRPIS (Ames)/NCGRP (Ft. Collins) generally meet expected international standards for maintenance and distribution. Both do have backlogs for regeneration; CIMMYT's are smaller, but perhaps more troubling, as their backlogs represent difficult ecologies for which regeneration policies have yet to be established. The genetic stocks of the Maize Cooperation Stock Center at the University of Illinois also generally meet such standards, except for lack of on-site, long-term storage. Like NCRPIS, the Urbana center relies upon NCGRP (Ft. Collins) for long term storage, but about 15% of their stocks lack such a backup.

11. Major collections not meeting standards

11.1 Extent to which the diversity within the collection is, or is not, already represented within a collection that meets the standards for conservation and distribution

For the New World, virtually all the diversity housed in the national centers, which generally fail to meet international standards (for lack of long term storage, lack of resources for meeting international seed requests, and/or legal limitations on seed shipments), is found at CIMMYT and NCRPIS (Ames) / NCGRP (Ft. Collins). The accessions housed in the national collections of the Old World are another story altogether. Few of these are backed up at the international centers; many are essentially unavailable to non-national (and sometimes even to national) users; and assurance of periodic regeneration is often uncertain. The loose-knit European maize network (Lipman, *et al*., 1997) is one exception to this, but even there long-term storage and secure backup seem not to be well-defined.

11.2 Importance of any diversity not already represented

There are a few areas where adequate collections were never made (portions of the Amazon basin, parts of Central America, waxy maize in SE Asia). The original collections from the island of Dominica (*not* the Dominican Republic) were completely lost. While France has sampled the maize germplasm from the French Caribbean islands and deposited it in their germplasm collections, no samples have been deposited in the international banks and no published studies of the sampled variation exist. The original collections from Dominica included the typical collections of the important commercial race, Coastal Tropical Flint. Many of the collections sponsored by IBPGR in the 1970s were lost, as there was not an effective germplasm maintenance program active at that time, at CIMMYT or elsewhere. Neither public nor private tropical inbred lines are well represented, nor are important hybrids (or their bulk increases).

11.3 Specific requirements for collections to be able to meet the standards for conservation and distribution

This information is simply not readily available for many national collections. It is often possible to determine the nominal conditions for seed storage, but if backup generators are not available, not fueled, or not maintained, the end result is many packages of non- or poorly-germinating seed. Simply signing agreements and treaties does not guarantee seed distribution. The restrictions may simply be monetary, but the more severe ones are political/legal. One could send out surveys asking about these points, but there are often limits on what technical staff may say (and such restrictions are not limited to under-developed countries). Even visiting the germplasm bank sites might not be sufficient, although it would greatly increase our present knowledge.

12. Identify any other collection that was not included among the original set of 'major' collections but that nevertheless has important genetic diversity

The Vavilov Center in St. Petersburg (Russia) once held worldwide accessions of maize. The many years of restricted budgets, poor or non-existent facilities for regeneration, and deteriorating facilities appear to have greatly reduced the integrity of these collections. There may still be important accessions held at the National Seed Storage in Kuban, near the city of Krasnodar. This would require further investigation to verify.

13. Potential improvements for collections that meet standards

13.1 Specific actions that could be undertaken in the short term to increase the efficiency and effectiveness of conservation collectively

CIMMYT needs support to finish up the Latin American Maize Regeneration Project at a rate of about US $ 300,000/year, for a period of 5 years. CIMMYT may be able to raise some of this money itself, but given the misery that currently hovers over all the international centers, it probably cannot raise more than half. If outside funds are not available, this project may well cease.

NCGRP (Ft. Collins) is in the same boat with NCRPIS, both need funds for a backlog of regeneration needs. Those needs are in the US$ 250,000/year range for the indefinite future, certainly 10 years or more. In addition, NCRPIS is the likely site for initiating the metadatabase for maize. They currently provide the only web-accessible database, the often maligned GRIN system, which more or less works, but not in a user-friendly way. The initial costs for that would be fairly high, at least US$ 250,000/year for 2 years, and US$125,000/year for 2 more years to clean things up. While the US germplasm system might match half or more of the regeneration costs, they would be unwilling to foot very much of the costs for an international database network, perhaps at most 15 to 20% of the overall costs. If outside funds are not forthcoming, the regeneration will proceed at a very slow rate; the metadatabase for maize will not happen.

The Genetic Stock Center's major needs are additional cold storage space at perhaps US$ 100,000 (particularly if they are to house the increasing number of recombinant inbred populations) and added technical support at US $60,000/year. This center probably has enough political clout to raise most of these monies from USDA sources (they have recently received a modest increase in cold storage space). US$ 10,000 to 20,000 of seed money might raise it much sooner.

13.2 A process to be followed for identifying other potential areas of need or improved efficiency

A small international committee (or indeed a single person) needs to solicit suggestions for maize germplasm banks worth visiting, then visit them (or have a proxy visit) and report on what needs to be done next. Clearly, there is a need for CIMMYT and INIFAP to collaborate more directly on the 10,000+ Mexican accessions. CIMMYT and NCRPIS could collaborate on germplasm regeneration. National programs could be tapped for more regeneration and more information on the accessions. Until a metadatabase for maize is placed in operation, many of the needs and much of the duplication will go unrecognized.

13.3 Ways in which cooperation per se might be enhanced, e.g. through a strengthening a specific crop or other network.

The Latin American Regeneration Project and the LAMP Project should both be extended to other important collections; the LAMP project covered only about 50% of the potentially available Latin American accessions. The maize metadatabase and the international committee should be able to pinpoint such collections. This cost may be about US$ 2 million. The GEM project should be extended to include additional international collaborators at a cost of US$ 500,000 annually for a period of 15 to 20 years; the USA might cover a substantial portion of this, perhaps 50%, but would be unlikely to shoulder the entire burden.

14. PLAN OF ACTION

14.1 Global Accessions Management: Identifiers, Essential Metadata, and Standardization

The most reasonable starting point is to develop a plan for generating downloadable information lists of all consequential maize germplasm bank holdings available over the internet. A comprehensive, easily-used, metadatabase *solely for maize* germplasm is needed that could retrieve base data from individual maize germplasm banks (which may each have different types of lists and different, perfectly functional, software programs). Users must have the ability to download Excel-compatible spreadsheets on sets of accessions circumscribed by geographical origin, race, germplasm type (accession, breeding stock, population, inbred, etc.), core membership (where available), seed availability, and safety backup information. Most existing databases are sound, but even the most accessible of them are not user-friendly, even for knowledgeable users. Minimum data needed would be passport data, but much more would be feasible, including digital photographs. This should be done in collaboration with MaizeGDB (http://www.maizegdb.org/), which already lists inbred lines held in the US germplasm system, and possibly with Gramene. CIMMYT and IRRI are collaborating to develop a germplasm bank management system, and that needs to be coordinated with other maize genetic resource efforts. For the past few years, efforts have been made within the CGIAR centers to establish a system-wide information network for genetic resources (SINGER). This global information system is accessible via the internet (http://singer.grinfo.net/) and is aimed at implementing a one-stop entry point for information on, and access to, the in-trust collections of the CGIAR centers. At this point, SINGER is even less user-friendly than GRIN. The challenges in using information compiled from various database sources are significant. The most pressing problem is to resolve the various acronyms and numbering systems used for the same accessions (*e.g.*, Chs30 = CHS 30 = CHIS 30 = Chiapas 30 = CHIAPAS 0030, a simple example), and allow a user to access the material using *any* of these (or other reasonable) codes. (For a challenge, try standardizing the collections of Guatemala or Peru or those of the states of Chihuahua or Oaxaca on the CIMMYT database on the CD of the 2006 Maize Germplasm Network Meeting; the NPGS database provided has no real collection names to standardize). Inclusion of digital photos of at least ears and kernels with the passport and field data is critical. Potential users need to know, at a minimum, information on adaptation, relative maturity, plant height, and susceptibility to lodging in order to select materials that can be successfully grown and utilized. Evaluation data - agronomic, phenotypic or biochemical - need to be end-user, trait-oriented, while being aware that (unlike self-pollinated crops) the variation within accessions is often as large as the variation among accessions within a specific region. Resolving these issues needs to involve not only current expertise of both germplasm and database authorities, but the education of a new generation of maize germplasm specialists. Funds are needed immediately to provide resources and expertise to resolve the differences among identifiers of the accessions between various maize databases and to standardize the identifiers; *a maize database Swat Team is needed NOW*. It must be recognized that accessions with common identifiers but different seed sources may not be exactly (and, occasionally, not even approximately) identical. The CIMMYT maize bank has placed CIMMYT ID numbers on accessions of in-trust collections received from cooperators. The cooperator banks' identifiers of the accessions are registered as associated identifiers. NCGRP (Ft. Collins) has used CIMMYT ID numbers for its inventory in the safety back up collection. This type of labeling system is widespread; the PI numbers in the US follow the same pattern. While CIMMYT ID numbers or US PI numbers are very helpful to curators and other insiders, virtually all outside researchers use the original accession numbers. Neither a CIMMYT ID nor a US PI number has much meaning to users outside their respective systems. While GRIN can be (sometimes) used on line to decipher a PI number, there is currently no web access to CIMMYT ID numbers. As an example of the iterations one can encounter, consider Lim 13, a well-known Peruvian accession. It has been assigned at least five identifiers over the past 50 years. First, the Colombian bank assigned it a PER number; then the NAS-NRC assigned it a NRC number; then Peru assigned it "Lim 13," then the USDA assigned it a PI number, and, finally, CIMMYT assigned it a CIMMYT ID number. Along the way, it is quite possible that EMBRAPA assigned it a Brazilian number, and it may have acquired Chinese, Russian, and Yugoslavian numbers as well. And of course we have not considered the various iterations of Lim, LIM, Lima, and LIMA or 0013, 013, 13, 13, etc. Thus, a single accession can acquire a plethora of labels, many of which would be meaningless even to the authors of *The Races of Maize in Peru*.

14.2 Global and Regional Cooperative Networks and Availability of Seed Accessions

The next priority would be:

(1) to use the maize database, in conjunction with national germplasm bank expertise, to determine which accessions exist but for which viable seeds are NOT available for current distribution
(2) to determine which ecogeographic areas are under- or unrepresented in the collections and in need of collection or re-collection, and
(3) to establish which existing accessions are most in need of immediate regeneration (based on age and quantity of seed, significance of the accession, etc.).

Identification of needs must be followed by prioritization and by immediate action to remedy the problems identified. Resources are critically needed for the recollection of rare, endangered, and non-adapted races, including those landraces that are soon to be replaced by improved maize. Collecting broader-based samples than was done originally would be helpful. The current goal is to obtain regenerations of 100 sib-pollinated ears each from accessions that most often were originally collected as five to ten open-pollinated ears. Thus, most often, the initial effective population size was less than 20; at least a few were based on single ears and some were collected as bulk seed at local markets. While recollecting, collection of indigenous knowledge must be a priority (particularly for utilization and cultural uses), and agronomic and phenotypic evaluation data need to be collected during regeneration. These are excellent opportunities for training the next generation of specialists and for international collaboration.

One potential strategy suggested for enhancing regional collaboration in sub-Saharan Africa is through the establishment/strengthening of a regional network of maize germplasm conservation. The network needs to bring together germplasm conservation specialists from the various National Agricultural Research Systems (NARS) to design appropriate strategies for germplasm collection, conservation and distribution. This network could facilitate the development of collaborative projects for germplasm collection, evaluation, distribution, and information exchange. The network could request that scientists in the NARS from different countries in Africa that need to carry out critical maize germplasm collection expeditions develop project proposals and submit them for funding. Panels could be formed to review proposals and approve those that are well conceived. As a requirement for conducting the collaborative project, the network could insure sharing of the collected germplasm with CIMMYT, IITA, and/or NCGRP for long-term storage. Similar plans might work elsewhere.

14.3 Global and Regional Ex-situ Conservation Network: Regeneration and Safety Backup

Safety backup for all accessions should be possible once a comprehensive maize metadatabase is operational. All maize accessions should be backed up for long term storage at NCGRP (Ft. Collins) and at CIMMYT in quantities of at least 1 kg each at each location. Typical accessions and/or core accessions should have 3 kg each. It is far more expensive to regenerate an accession multiple times than to do it right the first time. Current medium term storage conditions (+5° C, 25% RH) easily allow for 20 years storage. At the current distribution rate of the US NPGS, almost 40% of the collection (sans cores) needs regeneration every 10 years. Current long-term storage (-20° C) requires regeneration at intervals of over 100 years (exact statements are not possible, but excellent germination has persisted for well over 50 years). Safety backup is particularly critical for non-New-World accessions; Asian and African accessions appear particularly vulnerable to loss. Even those countries for which routine seed exchange is impossible for political or phytosanitary reasons must make provision for safety backups.

In addition, core subsets of maize germplasm should be sent to Svalbard, the international high security seed-vault now under construction in Norway, provided that its temperature and relative humidity conditions meet standards for long term storage of maize.

14.4 Collaboration on Maize Germplasm Conservation and Capacity Building of Maize Germplasm Specialists

The roles of national versus international germplasm banks must be clarified; each type of germplasm bank needs to determine its role in a global germplasm system and focus its resources and activities accordingly. National germplasm banks that are inactive in terms of fulfilling individual seed requests may have other, equally important, roles to play in terms of germplasm collection, regeneration, maintenance, education, and knowledge. Those maize germplasm banks actively filling international seed requests appear to be largely limited to NCRPIS and CIMMYT at present. While IITA serves as a regional maize germplasm bank for much of Africa, quarantine restrictions (fear of spreading *Striga*, downy mildew or maize streak are at least some of the causes) limit its role on the wider international stage. IITA's active involvement in the Phytosanitary Council and the establishment of seed regulatory mechanisms should facilitate the distribution of maize germplasm accessions from its bank across countries in sub-Saharan Africa. IITA needs to assess and coordinate maize germplasm collection in West and Central African and cooperate with other germplasm banks in East and South African regional efforts. CIMMYT is willing to provide safety backup for all African accessions and is willing to house, maintain, and distribute core collections, once these are identified, and important breeding stocks, including released African inbred lines. CIMMYT and the NCRPIS (Ames) will remain the main distributors of seeds of germplasm accessions, with CIMMYT and NCGRP (Ft. Collins) sharing long-term storage. For the most part, national programs need to concentrate on local maintenance, education, and within-country distribution and utilization. National collections are important; each country has an obligation to provide its people with their own genetic resources. The contributions of national germplasm banks toward understanding the nature of the accessions, their current and historic uses, particularly for human food, and toward educating the next generation of curators are essential. National banks can also identify those areas that have never had good collections, where it is still possible to do reasonable collecting. For an international system to function, there simply must be cooperative use of resources - for documentation, regeneration, data collection, and preservation of accession history and uses. No single institution can do everything. Germplasm bank managers and curators are the resource experts for users, and a web-based, maize database will greatly help users, but will generate still more questions and requests for information from the national banks, even with seed shipments being handled globally or continentally.

14.4 Germplasm conservation and management need to be integrated to improve agricultural productivity

While increased maize production is one goal of genetic resources programs, enhancing food security, reducing poverty and protecting the environment are at least equally important goals, particularly in Sub-Saharan Africa and in Indigenous areas of the Americas. Strategic evaluation of maize germplasm accessions combined with genetic enhancement will be important to achieve this. Maize germplasm accessions must be evaluated systematically in order to search for desirable traits needed in the prevailing production systems, identify sources of resistance to diseases, pests and parasitic plants, as well as to locate sources of tolerance to abiotic stresses. Novel traits identified from the results of evaluations will be invaluable raw materials for supporting genetic enhancement for increasing productivity. The lack of extensive genetic enhancement research activities is considered to be one of the major factors limiting the use of landrace collections maintained in germplasm banks. This is particularly true for maize breeders in sub-Saharan Africa and elsewhere, who face substantial pressure to generate improved varieties adapted for their particular countries with limited resources and thus cannot afford to invest these resources in long-term genetic enhancement projects. Genetic enhancement will be carried out at IITA to transfer the required traits into suitable genetic backgrounds that can be distributed as breeding materials for use by NARS in Sub-Saharan Africa and elsewhere for their maize breeding programs.

14.5 Improved Access to Conserved Germplasm

To address the phytosanitary restrictions on germplasm quantities of seed, a united front with other crops will probably be necessary. The use of seed quarantines solely to limit commerce is indefensible; the impositions of phytosanitary rules that are in conflict with common sense is self-defeating and not in a country's own best interests.

14.6 Conservation of Wild Relatives of Maize: Teosinte and *Tripsacum*

Seed collections of the teosintes need to be safely duplicated at NCGRP and CIMMYT. National/International Reserves need to be established to protect the remaining fragments of the Balsas, Guatemala, Huehuetenango, and Nicaraguan races of teosinte. International collaboration of teosinte experts from the Colegio de Postgraduados, ICTA (Guatemala), INIFAP, the University of Guadalajara, the University of Massachusetts, and the USDA-ARS is vital (see Appendix 5). CIMMYT's current *ex-situ* tripsacum garden at Tlaltizapan, Morelos, should continue to be maintained, with a duplicate garden established in Veracruz (or some equivalent lowland, tropical environment). Seed samples collected from the clones should be conserved in the bank and made available for requests. Another tripsacum garden could be established near IITA headquarters in Africa. IITA has experience in utilizing teosinte, and thus can exploit the available wealth of diversity in both teosinte and tripsacum for genetic enhancement of maize germplasm in different parts of Africa. *In-situ* monitoring of tripsacum populations should be conducted in Mexico and Guatemala, the center of diversity for the genus, and in other countries in Central and South America, where both widespread and endemic species are found. *Ex-situ* tripsacum gardens at CIMMYT and USDA in Florida should be enriched with the diversity found in *in-situ,* and more collaboration should occur between these two unique sites. Unless there is some mechanism to establish who is responsible for the wild relatives of maize, they will continue to fall through the cracks. The most reasonable solution to this problem is to place the responsibility for teosinte and tripsacum conservation with the maize germplasm banks. Until now, collection – and much of the maintenance – of teosinte and tripsacum has been conducted by botanists and geneticists who do not have proper facilities or budgets for such long-term endeavors.

15. Conclusions and consequences

The major conclusions are that for maize there are really three major international-level collections: (1) CIMMYT (Texcoco, Mexico), (2) NCRPIS (Ames, USA)/NCGRP (Ft. Collins, USA), (3) Maize Cooperative Genetic Stock Center (Urbana, USA). The national collections are primarily – and vitally - important as knowledge and training bases. The collections of the Americas are generally of much greater consequence than the accessions from the Old World.

There is a need for financial support of a metadatabase for maize germplasm that is user-friendly and web-accessible, and there is still a need for support of regeneration (or re-collection where it is more efficient and effective than regeneration) in critical regions.

There is a serious need to train a new generation of maize germplasm specialists, and that training should include experience at the national centers with the new maize metadatabase. A small, forceful international committee needs to examine the needs of the entire maize germplasm community and be willing to fight to make it more effective and more responsible.

15.1 Access to improved material and crop improvement

The application of projects such as GEM (Germplasm Enhancement of Maize) and CIMMYT's germplasm enhancement efforts would certainly be assisted by having basic agronomic data available for accessions. These and similar germplasm enhancement-type projects would also be greatly aided by having ready access to released international inbreds and elite breeding populations. Various molecular association studies and most disease- and insect-screening trials for molecular or field studies would also greatly benefit from ready access to such materials.

While IITA has made some efforts to utilize landrace accessions for combating downy mildew, maize streak virus, *Striga hermonthica*, southern corn rust and stem borers, the number of accessions used has been very limited. Furthermore, most studies of races, pests, or pathogens have not included a broad spectrum of African or Asian materials, as they have simply been generally unavailable. Comprehensive racial studies of such materials would allow systematic sampling, and safety backups of such materials are imperative. Regional interchange among China, India, Indonesia, the Koreas, Japan, and the Philippines would accomplish a minimal safety backup network for East Asia, although current political realities may present insurmountable temporary barriers to some of this.

15.2 Safety duplication

China, India, and Japan are certainly capable of doing their own collecting, conservation, and maintenance, but safety maintenance and seed availability on an international level are concerns. For example, seed of Southeast Asian waxy germplasm is not held by any of the international germplasm banks. Core collections and important breeding materials need to be sent to CIMMYT or NCGRP (Ft. Collins), depending upon the ease of exchange and latitude of the accession. CIMMYT is willing to maintain and distribute the core collections (including inbreds and important breeding materials) of Southern China and other tropical and semitropical countries of the region.

IITA can serve as coordinator for Africa, facilitating germplasm transfer. It should also house the African core collections and advanced breeding materials, which should be shared with CIMMYT. Regional exchange among Turkey and the countries of East Europe would accomplish safety backups for these important accessions, and such materials would most appropriately be housed at NCGRP (Ft. Collins) for permanent protection. Such activities would obviously need to involve the Ministries of Agriculture and, where appropriate, the Agricultural Science Academies. European accessions from both eastern and western Europe need to be incorporated into a unified network, and their accessions need to be permanently stored at NCGRP (Ft. Collins) or some other suitable site, with safety backups in more than one European country. At present, only NCGRP (Ft. Collins) appears to be willing to accept maintenance of all Old World accessions. The database efforts of SINGER, Zemun Polje, and other European systems (Lipman *et al*., 1997) need to be incorporated into a worldwide web-friendly, metadatabase for maize germplasm. Certainly other options for the backup storage sites, such as the nearly-operational germplasm bank at Svalbard, Norway, will emerge and should be considered in terms of duration of seed viability, institutional policies, shipment costs, and access possibilities.

15.3 Filling gaps in collections

With a relatively small amount of intelligent re-collection and a stronger focus on the most important "difficult" accessions, the ecogeographic sampling for maize in the New World will be essentially complete. It is extremely important to act now, as economic and demographic changes are eroding the genetic diversity of maize in many areas that were once untouched by modern agricultural, horticultural, forestry, and industrial practices. Perhaps the greatest problems to be overcome are the various barriers to seed exchange ranging from phytosanitary infelicities to political embargoes. The Global Public Good Project, a World Bank-funded project aimed at improving the operations of CGIAR germplasm banks, may help in optimizing the maize global strategy.

15.4 Training in maize genetic resources

Along with the will to provide resources for the regeneration of accessions non-adapted to the ecology of the germplasm banks, and the resources to recollect material, we need to address the depth of expertise in maize genetic resources. It is important to rapidly identify suitable candidates for training in the field of maize conservation and use in the next five years. At least twelve young scientists need to be employed globally in this area within the next 10 years; more would be much better. This training should be in conjunction with both national germplasm resources programs and with allied breeding programs in order to facilitate collaboration between the two. Experience with *in-situ* conservation efforts would also be desirable. There is an obligation of each nation to train its own essential personnel, but germplasm expertise has international value as well. The training of future maize genetic resource experts, breeders, entomologists, pathologists, and agronomists capable of focusing on the practical aspects of agricultural production challenges is critical. Without these people, most of the potential to apply the genetic discoveries and technologies resulting from use of plant genetic resources will be lost.

15.5 Maize wild relatives

Opportunities for contributions from the wild relatives of maize to maize breeding challenges may increase in the future as current molecular breeding technologies advance. Social and environmental changes threaten stability of long-term conservation *in-situ*, and necessitate *ex-situ* backup. Evolutionary bottlenecks from teosinte to maize and from indigenous maize to commercial maize have occurred. The genetic diversity of teosinte and tripsacum is relevant to maize research and breeding efforts for maize productivity, nutritional quality, bio-energy production, and other uses.

15.6 Global maize genetic resources registry

The time for holding additional maize germplasm meetings and for writing extensive papers on the woeful status of the maize germplasm system has long past. Had as much effort gone into developing a user-friendly database for maize germplasm as has gone into organizing meetings about the status of maize germplasm, we would be able to Google "Lim 13" or "Chs 30" and acquire useful information about their racial assignments, agronomic characteristics, and seed availability in a matter of seconds. Much effort toward maize germplasm conservation and utilization has been made over the past 20 years, but many of the fruits of those efforts will remain elusive until a user-friendly maize database is deployed.

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Appendices

APPENDIX 1: Survey of the maize collection information in Maize Crop Strategy Development

A. Questionnaire on organizational information and legal status of the maize collection:

1. 1. Organizational information

Name and address of organization holding/maintaining the (crop name) collection	
Address:	
City:	
Postal code:	
Country:	
Web site:	
Curator in charge of the (crop name) collection	
Name:	
Address:	
City:	
Telephone:	
Fax:	
Email:	
Name of respondent to this questionnaire, if different than above	
Contact details:	
Date of response:	

1.2 Additional key contact persons for the above germplasm collections

Name	Title/Function	Email address

1.3 Please describe the organization

ı Governmental organization
ı University
ı Private organization
ı Other: please describe: _______________

1.4 Is the institution in charge of the (crop name) collection the legal owner of the collection?

Yes ı No ı
If no, who is the owner (including no owner identified)? ________________

1.5 Is the collection subject to the terms and conditions of the International Treaty on Plant Genetic Resources for Food and Agriculture?

Yes ı No ı
If no, please indicate if it is expected that the collection will come under the International Treaty, and if so when
If it is not expected to come under the International Treaty, please indicate whether or not the material is available for international distribution, and if so under what terms and conditions

B. Questionnaire for the maize collection manager for the global maize crop strategy coordinated by CIMMYT

Table 1. Unique characteristics of the maize collection

Institution name:
Country:
Collection manager name:
Email:

Accession category	Country of origin	No. of accessions	No. of introductions [1]	
			Own country	Other countries
Landrace accessions				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Improved populations/synthetics				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Open pollinated varieties				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Inbreds				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Teosintes				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				
Tripsacum				
Own country .-				
Other country 1.-				
Other country 2.-				
Other country n.-				

1. Accessions that are included in the collection from own country or other countries.

C. Questionnaire for the maize collection manager for the global maize crop strategy coordinated by CIMMYT

Table 2. Seed storage conditions

Institution name:	**0**
Country:	**0**
Collection manager name:	**0**
Email:	**0**

Seed storage category	Storage temp. (°C)	Storage humidity (%RH)	Type of container [1]	Initial storage quantity [2]	Seed viability (%)	Storage size (m^3)
Long- term collection (30+ years)						
Medium-term collection (until 30 years)						
Short-term collection (until 10 years)						

1: Please describe if aluminum laminate or other types of bags are used.
2: Initial number of seeds or inicial seed weight when the accession is deposited.

D. Questionnaire for the maize collection manager for the global maize crop strategy coordinated by CIMMYT

Table 3. Seed exchange policy and use of information databases

Institution name:	**0**
Country:	**0**
Collection manager name:	**0**
Email:	**0**

Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
An accession database	Used ( ) Not used ( )	Updated ( ) Not updated ( )
Who authorizes the shipment?	Collection manager ( ) Other* ( ):	
Name 1 and title:		
Name 2 and title:		
Are accessions duplicated elsewhere	Yes[3] ( ) No ( ) If yes, where:	
Seed shipment	Seed accessions available( ) Not available ( )	
- No. of landrace accessions for which seed are available upon request	No.:	
- Seed quantity available for a single routine request	Number or weight (g):	
- Cost of seed	Free ( ) Charge ( )	
- Cost of shipment	Free ( ) Charge ( )	
MTA[1] used/required	Used ( ) Not used ( )	MLS[2] ( ) Bilaterlal ( ) Other ( ) specify:

* Please, specify who authorizes the shipments and what position(s) he/she/they hold.
[1] Material Transfer Agreement.
[2] Multilateral System of Seed Exchange.
[3] Please, specify where the duplicates are sent.

APPENDIX 2: List of collection managers contacted through a survey

	Country	Full Name	Institute's name	Email - main
1.	GLOBAL	Suketoshi Taba	CIMMYT, Int.	s.taba@cgiar.org
2.	GLOBAL	Dominique Dumet	IITA, Nigeria	ddumet@cgiar.org
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4.	Australia	Peter Lawrence	Australian Tropical Crops & Forages Germpasm Collection	peter.lawrence@dpi.qld.gov.au
5.	Austria	Paul Freudenthaler	Austrian Agency for Health and Food Safety	genetische.ressourcen@ages.at
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39.	Yugoslavia		Maize Research Institute	

APPENDIX 3. Global Maize Genetic Resources Conservation meeting, 5-6 May 2006

Sponsored by the Global Crop Diversity Trust, Word Bank and CIMMYT, Int.
PROGRAM

Friday May 5, 2006: Consultation on development of a global strategy for the effective and efficient ex-situ conservation of maize genetic resources

08:00-08:20	Dr. Dave Ellis. USDA, Plant Genetic Resources Preservation Program - Maize collections at the National Center for Genetic Resources Preservation	Suketoshi Taba
08:20-08:40	Sara Hearne, IITA, Nigeria, West Africa Region Maize germplasm conservation, utilization and management in the West African Region	
08:40-09:30	Brigitte Laliberté, Global Crop Diversity Trust, Rome, Italy Global MAIZE conservation system and the role of the Trust	
09:30-10:10	Discussion on a global TEOSINTE strategy: conservation, management, and networking: Identification of most important populations How to management through a network	J. Sanchez / S. Taba
10:10-10:40	Discussion on a global TRIPSACUM strategy: conservation, management, and networking: Who are the partners, where is the expertise on collecting and conservation? How to produce seeds for conservation and use?	D. Costich / S. Hearne
10:40-11:00	Coffee break	
11:00-11:30	Discussion on global MAIZE strategy: conservation, management, and networking	Goodman / Sanchez
11:30-13:30	Development of the global maize genetic resources strategy for ex-situ conservation – small groups:	
	National / Regional / Global Collaboration: Sharing of responsibilities Safety-duplication Role of international and regional centers/networks	Costich / Zanetta / Ellis / Perales
	Role of National Germplasm Banks: Participation in a global system in conservation, regeneration, characterization, documentation, distribution and access	Sevilla / Has / Jampatong / Muthamia
	Information on accessions and sharing of databases: Challenges and opportunities for collaboration	Hernandez / Teixeira / Gardner / Rincon
	Teosinte and *Tripsacum* conservation: Components into a global maize conservation strategy	Sanchez / Hearne / Gonzalez / Fuentes
13:30-14:30	Lunch in CIMMYT Cafeteria	
14:30-16:00	Group reports	Goodman / Taba
16:00-16:30	Coffee break	
16:30-17:00	Future perspectives from the consultation on the global maize strategy for ex-situ conservation and networking	
17:00-18:00	Further comments, discussions, ordering of priorities and adjourn	
18:00-21:00	Farewell cocktail and dinner for participants in the Guest House.	

Saturday May 6, 2006: Small group expert committee meeting on the global maize strategy of ex-situ conservation

08:00-10:00	Expert committee meeting on the results of the consultation on development of maize crop strategy	Goodman
	Suketoshi Taba, Jesus Sanchez, Ricardo Sevilla, Juan Manuel Hernandez, Dave Ellis, Candice Garder, Sarah Hearne, Denise Costich, Anne Zanetto and any other interested partner	
10:00-10:30	Coffee break	
10:30-12:30	Elaboration of conclusions and recommendations	

APPENDIX 4 Participants in the Maize Germplasm Network Meeting, CIMMYT, May 2006

	Coutry/Organisation	Name and contact details
1.	Argentina	***Ing. Agr. (MSc) Marcelo Edmundo Ferrer,*** Recursos Genéticos EEA INTA Pergamino, Ruta 32 Km. 4.5, 2700 Pergamino (Buenos Aires), Argentina Tel. 54 2477 431250 Ext. 132, Fax 54 2477 432553 e-mail: mferrer@pergamino.inta.gov.ar
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	Participation unable to attend	
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APPENDIX 5: The wild relatives of maize

A3.1 Teosinte genetic resources

Teosinte, the closest relative of maize, is considered to have greatly influenced the high genetic variability and development of the principal Mesoamerican maize landraces. After several decades of studies, the hypothesis of teosinte as the wild ancestor of maize has become widely accepted. Despite profound differences in ear and plant morphology, teosinte and maize are very close genetically; they hybridize and produce viable, fully fertile hybrids. The inheritance of key traits distinguishing maize and teosinte has been under study by Doebley and co-workers for the last two decades. Several of the morphological traits are under the control of multiple genes and exhibit quantitative inheritance; there are five or six regions of the genome that have very strong effects on the observed differences between maize and teosinte (Doebley, 2004). However, a key event in maize domestication, the liberation of the kernel from the hardened, protective casing that envelops the kernel in teosinte is controlled by a single gene (Wang *et al*., 2005).

Teosinte is represented by annual and perennial diploid species (2n = 20) and by a tetraploid species (2n = 40). They are found within the tropical and subtropical areas of Mexico, Guatemala, Honduras, and Nicaragua as isolated populations of variable population sizes, occupying from less than one ha to several hundreds of square kilometers. The distribution of teosinte extends from the southern part of the cultural region known as Arid America, in the Western Sierra Madre of the State of Chihuahua and the Guadiana Valley in Durango, to the western part of Nicaragua, including practically the entire western part of Mesoamerica. A point worth highlighting with regard to the geographic distribution of teosinte is that populations have specific climate, soil, and human circumstances under which they can be found (Sanchez *et al*., 1998).

Teosintes comprise seven taxa (Appendix 5, Table 1) divided into two sections and five species: section *Luxuriantes* Doebley & Iltis comprises *Zea perennis* (Hitch.) Reeves & Mangelsdorf, *Zea diploperennis* Iltis, Doebley & Guzmán*, Zea luxurians* (Durieu & Ascherson) Bird and *Zea nicaraguensis* Iltis & Benz. Section *Zea* contains three subspecies of *Zea mays* , *Zea mays* ssp. *parviglumis* Iltis and Doebley (race Balsas), *Zea mays* ssp. *mexicana* (Schrader) Iltis (races Chalco, Central Plateau and Nobogame), and *Zea mays* ssp. *huehuetenangensis* (Iltis and Doebley) Doebley (race Huehuetenango). Over the last 25 years, great advances have been made in knowledge of genetic diversity, phylogenetic relationships and the natural distribution of teosinte in Mexico, Guatemala and Nicaragua (Doebley et al., 1984; Sánchez et al., 1998; Matsuoka et al., 2002; Doebley, 2004; Fukunaga et al., 2005).

The major teosinte collections in germplasm banks are those of INIFAP, CIMMYT, USDA-ARS and Universidad de Guadalajara (Appendix 5, Table 2). Only CIMMYT and USDA-ARS have long-term storage facilities. Of the 805 accessions reported by the above institutions, only partial data are available for users: 40% have passport data and only 25% have inventory data. On average, 750g are stored per accession at the Universidad de Guadalajara and about 600g at INIFAP. It is important to stress that most populations have been sampled in small seed quantities, mostly for genetic and morphological studies. Sampling for long-term conservation will be required for most populations.

Although the samples on hand may generally represent the variation known and expected in Mexico and Central America, it has not been possible to verify many existing reports of teosinte in the field, due to the difficulties of reaching sites, budget constraints and lack of equipment for exploring and collecting. It is difficult to estimate the danger of extinction for teosinte with precision, however, based on observations over the last 25 years, all populations are threatened. Several populations have practically disappeared, except, until recently, for some populations in the Balsas Basin, which includes many populations from the states of Guerrero, Michoacán, and Mexico (Sánchez et al., 2004; Wilkes, 2006). However, a recent survey (Dr. G. Wilkes, Dr. S.Taba and Dr. J. Sanchez; December, 2004) of southern and northern Guatemala teosinte populations found them nearing extinction. Over the last 500 years, human activities such as deforestation, urbanization (road building) and cattle grazing have been identified as the major threats to teosinte. However, according to Dr. G. Wilkes, the most important threat is when the cultivation of maize landraces is abandoned. Because of these threats, permanent monitoring programs and in-situ conservation projects with participation of local farmer communities are critically needed. For the short term, collecting and ex-situ conservation activities are urgent in Guatemala, Nicaragua and several sites in Mexico.

A3.1.1 Recommendations for teosinte preservation and use

Ex-situ teosinte seed conservation

- When collecting existing populations, use appropriate sample size for seed distribution of duplicates and for users.
- Monitor seed viability of accessions in the banks.
- Upgrade seed storage facilities.

In-situ teosinte conservation

- Designate in-situ sites or populations for protection in Mexico, Guatemala, and Nicaragua.
- Monitor the in-situ populations for changes in demography and genetic diversity.

Characterization/evaluation and use

- Characterize with minimum phenotypic descriptors.
- Characterize with molecular markers.
- Develop a database characterizing teosinte populations and races.
- Compile information on characterization, use, and prebreeding with teosinte.
- Make data web-accessible.
- Teosinte database
- Compile passport data of the accessions at all banks.
- Make seed increases, and inventory the accessions as necessary.
- Compile in-situ monitoring data.
- Make seed distribution records available.

A3.2 Tripsacum genetic resources

The genus *Tripsacum* is the genus most closely related to *Zea*. Two easily discerned morphological features distinguish *Tripsacum* species from *Zea* species. First, *Tripsacum* inflorescences have both distal male spikelets and basal female spikelets, unlike *Zea* in which there are separate male and female inflorescences (although teosinte, and more rarely maize, do form some mixed inflorescences). Second, tripsacum fruitcases are less indurate, more cylindrical in cross section, and rectangular-trapezoidal in outline.
Tripsacum L. is a genus of nearly 20 recognized taxa (Appendix 5, Table 3), all of which are native to the New World. They are distributed from central and eastern United States to Paraguay; growing from sea level to nearly 2,700 meters in tropical and subtropical forests, savannas, grasslands, dry scrubland, and temperate forests. Systematic treatment is difficult because hybridization, polyploidy, and apomixis occur throughout the genus. In addition, there is insufficient herbarium material, especially from South America, for a comprehensive study. *Tripsacum* and *Zea* comprise subtribe Tripsacinae, tribe Andropogoneae, subfamily Panicoideae of family Poaceae (GPWG, 2001). *Tripsacum* is a more distant and diverse American relative of maize than the teosintes. Mexico and Guatemala are the centers of diversity for both genera.

Tripsacum is widely distributed in the Americas, however, it is not a very common plant. The species are perennial forage grasses, but even the more widely spread T. dactyloides is not common enough to be of importance. Populations of various size exist, but their colonizing ability is inferior to that of more aggressive grasses, such as Panicum maximum. One species, T. andersonii, is a natural *Tripsacum* x *Zea* hybrid (Talbert et al. 1990; Larson and Doebley 1994; Berthaud et al. 1997). *Zea* luxurians (an n=10 teosinte) was identified as the *Zea* parent, while triploid T. latifolium (2n=3x=54), the result of a hybridization between T. latifolium (2x) and T. maizar (2x), is proposed to be the *Tripsacum* parent (Berthaud et al. 1997) This species has been introduced as a forage grass throughout the tropics.

Tripsacum species display considerable variation in ploidy level, with a haploid chromosome number of n=18 (Table 3): a few are strictly diploid, others show a range from diploid to tetraploid, and in some cases, pentaploid and hexaploid, while still others are strictly tetraploid. Our imperfect knowledge in this area is highlighted by the results of a population study of Mexican *Tripsacum* species: in a survey of ploidy levels (2x, 3x, 4x, 5-6x) in 174 populations, 15 out of 37 ploidy level-taxon combinations (41%) had never been reported before, and in more than half of the cases, the "new" ploidy was triploid (Berthaud et al. 1997).

With respect to reproductive biology, all of the diploids are sexual, while the polyploids exhibit facultative diplosporic, pseudogamous apomixis. This signifies a complete breakdown of meiosis in the embryo sac, and the development of embryos that are genetically identical to the maternal plant. Endosperm development does require fertilization by a reduced or unreduced sperm cell. Male meiosis is also disrupted, resulting in 25% of the pollen grains with variable ploidy (Farquharson 1955; Burson et al. 1990; Leblanc et al. 1995). Despite this dysfunction, sexual offspring are produced on rare occasions by the apomictic polyploids (Grimanelli et al. 2003). This low level of sexual reproduction allows for gene flow among diploid and polyploid species in areas of sympatry, perhaps underlying the complex pattern of overlapping and highly variable morphology seen in the centers of species diversity in Mexico and Guatemala (Randolph 1970; Li et al. 1999; Springer and Dewald 2004).

The most important collections of *Tripsacum* are the field collection at the CIMMYT experiment station at Tlaltizapan, Morelos, Mexico, and the USDA live germplasm collections at Miami, FL, and Woodward, OK, USA.

Maize and *Tripsacum* have been hybridized; de Wet and Harlan (1978), among others, have reported successful crosses with diploid and tetrapoid species; however, no spontaneous hybrids have been confirmed. (other than T. andersonii). Maize breeding programs using *Tripsacum* germplasm are not common; the more alien nature of *Tripsacum* germplasm makes its transfer into maize extremely complex. A transfer program for apomixis was underway at CIMMYT during the late 1990's and a program for resistance to Striga hermonthica, started at CIMMYT, is underway at IITA (Gurney et al., 2003). Utilizing *Tripsacum*-introgressed maize lines developed at the Crop Evolution Laboratory of the University of Illinois in the 1970s by Harlan, De Wet and coworkers (salvaged by Brian Kindiger), Duvick et al. (2006) are successfully altering the fatty acid composition of maize.

Tripsacum, as a close relative to maize, is an obvious source of genes for the improvement of this important crop plant, one that is critical to the world food supply. Past efforts have focused solely on T. dactyloides. A thorough study of the genus *Tripsacum* in its entirety will provide a "roadmap" for plant breeders and geneticists to expand their search to all of the natural diversity available in the genus. As the agronomic potential of *Tripsacum* itself is starting to be realized through its increasing use for pasture, forage, and soil erosion control throughout the world (Springer and Dewald 2004), continued improvement and development of the genus is predicated upon a strong commitment to the preservation of natural populations and the development of germplasm resources.

A3.2.1 Recommendations for Tripsacum preservation and use

- Coordinate all *Tripsacum* preservation, collection and research efforts with those of the teosinte project.
- Complete inventory of germplasm in *ex situ* collections at CIMMYT and at USDA stations in Miami and Woodward, characterizing the accessions with phenotypic descriptors and molecular markers in one web-accessible database.
- Establish priorities for collection from natural populations based on representation of taxa in existing *ex situ* collections.
- Identify a core collection that could be replicated at other sites, including IITA.
- Revisit and monitor the Mexican *Tripsacum* populations included in the original survey carried out by The Apomixis Research Project (co-sponsored by IRD [Institute of Research for Development, France] and CIMMYT) from 1989 to 1994.
- Increase seed available for distribution through CIMMYT.

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Appendix 5, Table 1. Nomenclature for maize and teosinte

Wilkes, 1967; 2004	Doebley, 1990; Iltis and Benz, 2000
Section: *Euchlaena* (Schrader) Kuntze	**Section: *Zea***
Zea mexicana (Schrader) Kuntze	-
Chalco	*Zea mays* L. subsp. *Mexicana* (Schrader) Iltis
Central Plateau	*Zea mays* L. subsp. *Mexicana* (Schrader) Iltis
Nobogame	*Zea mays* L. subsp. *Mexicana* (Schrader) Iltis
Balsas	*Zea mays* L. subsp. *Parviglumis* Iltis & Doebley
Huehuetenango	*Zea mays* L subsp. *Huehuetenangensis* (Iltis & Doebley) Doebley
Section: *Luxuriantes* (Durieu)	**Section: *Luxuriantes***
Guatemala	*Zea luxurians* (Durieu & Ascherson) Bird
Zea perennis (Hitch.) Reeves & Mangelsdorf	*Zea perennis* (Hitch.) Reeves & Mangelsdorf
Zea diploperennis Iltis, Doebley & Guzmán	*Zea diploperennis* Iltis, Doebley & Guzmán
	Zea nicaraguensis Iltis & Benz
Maize	
Section: Mays L.	Section: Zea
Zea mays L.	*Zea mays* L. subsp. *Mays* Iltis & Doebley

Appendix 5, Table 2. Teosinte collections in Mexico and the United States

Race / species	**UdeG**	**INIFAP**	**CIMMYT**	**USDA (GRIN)[b]**
Balsas	96	135	50	120
Chalco	18	44	45	16
Central Plateau	37	55	18	12
Nobogame	2	4	2	6
Zea diploperennis	2	7	2	14
Zea perennis	1	4	2	10
Huehuetenango			1	7
Zea luxurians			1	21
Zea nicaraguensis			1	2
Unknown			40	1
Total accessions	156	249[a]	162	209

[a] Includes 100 accessions from Universidad de Guadalajara, 2004
[b](www.ars-grin.gov) and Plant Inventory No. 173, 174, 176, 177, 179, 181 (USDA).

Appendix 5, Table 3. Genus Tripsacum in the Americas

Species	**Species Distribution***	**Ploidy**
SECTION: *Tripsacum*		
andersonii J.R.Gray (1976) [*Tripsacum* 3X (54) + *Zea* 1X (10)]	Beli, Boli, Braz, Cari, Colo, CoRi, Ecua, ElSa, FrGu, Guat, Guya, Hond, Mexi, Nica, Pana, Peru, Suri, Vene.	2n=64
australe H.C. Cutler & E.S. Anderson (1941)	Boli, Braz, Colo, Ecua, FrGu, Guya, Para, Peru, Suri, Vene.	2x, 4x
bravum J.R. Gray (1976)	Mexi	2x, 3x, 4x, 6x
cundinamarce de Wet & Timothy (1981)	Colo	2x
dactyloides (L.) L. (1759)	Beli, Boli, Braz, Cari, Colo, CoRi, Ecua, FrGu, Guat, Guya, Hond, Mexi, Pana, Para, Suri, USA, Vene.	2x, 3x, 4x
floridanum Porter ex Vasey (1892)	USA (Fl), Cuba	2x
intermedium de Wet & J.R. Harlan (1982)	Guat, Hond, Mexi.	4x, 5x
latifolium Hitchcock (1906)	Beli, Boli, Cari, CoRi, Guat, Hond, Mexi, Nica, Pana, Suri.	2x, 4x
manisuroides de Wet & J.R. Harlan (1982)	Mexi.	2x
peruvianum de Wet & Timothy (1981)	Ecua, Peru.	4x, 5x
zopilotense Hern.-Xol. & Randolph (1950)	Guat, Mexi.	2x, 3x, 4x
SECTION: *Fasciculata*		
jalapense deWet & Brink (1983)	ElSa, Guat, Mexi	4x
lanceolatum Rupr. ex E. Fourn. (1881)	Guat, Hond, Mexi, Pana, USA.	4x
laxum Nash (1909)	Beli, Cari, Colo, CoRi, ElSa, FrGu, Guat, Mexi.	2x
maizar Hern.-Xol. & Randolph (1950)	CoRi, Guat, Mexi.	2x, 3x, 4x
pilosum Scribn. & Merr. (1901)	Guat, Hond, Mexi, USA.	2x, 3x, 4x

- Sources: Species names, author(s), year of publication (The International Plant Names Index (IPNI) 2005 [http://www.ipni.org] with corroboration from original literature); Species Distributions (Zuloaga et al. 2003); all other information (Berthaud et al. 1997; de Wet et al. 1983a; de Wet et al. 1983b; de Wet et al. 1976; de Wet et al. 1982; de Wet et al. 1981; Wilkes 2004).
- Beli=Belize, Boli=Bolivia, Braz=Brazil, Cari=Caribbean, Colo=Colombia, CoRi=Costa Rica, Ecua=Ecuador, ElSa=El Salvador, Fl=Florida(USA), FrGu=French Guiana, Guat=Guatemala, Guya=Guyana, Hond=Honduras, Mexi=Mexico, Nica=Nicaragua, Pana=Panama, Para=Paraguay, Suri=Surinam, USA=United States of America, Vene=Venezuela.

APPENDIX 6: Summary of the questionnaire on the maize collections

Country	Institution	Collection Manager data	Accession category: Type accession	Accession category: Country of origin	No. of accessions	No. of introductions[1]: Own country	No. of introductions[1]: Other countries
Argentina	INTA	MSc. Marcelo Edmundo Ferrer	**Landraces**	Argentina	2,430	2,430	
		mferrer@pergamino.inta.gov.ar		**Total**	**2,430**	**2,430**	**0**
			Improved populations and synthetics	Argentina*	15	15	
				Total	**15**	**15**	**0**
* Maybe available under MTA.							
			Open pollinated varieties	Argentina	3	3	
				Total	**3**	**3**	**0**
			Inbreds	Argentina	55	55	
				Total	**55**	**55**	**0**
				GRAND TOTAL	**2,503**	**2,503**	**0**
Australia	Australian Tropical Crops & Forages Germplasm Collection	Peter Lawrence	**Landraces**	Others Countries	103		103
		peter.lawrence@dpi.qld.gov.au		**Total**	**103**	**0**	**103**
			Improved populations and synthetics	Australia	76	76	
				Others Countries	26		26
				Total	**102**	**76**	**26**
			Open pollinated varieties	Australia	20	20	
				Others Countries	75		75
				Total	**95**	**20**	**75**
			Inbreds	Australia	90	90	
				Others Countries	319		319
				Total	**409**	**90**	**319**
				GRAND TOTAL	**709**	**186**	**523**
Austria	Austrian Agency for Health and Food Safety	Dr. Paul Freudenthaler	**Landraces**	Austria	16	16	
		genetische.ressourcen@ages.at		Bosnia and Herzegowina	1		1
				China	1		1
				Slovakia	1		1
				USA	3		3
				Yugoslavia	1		1
				Total	**23**	**16**	**7**
			Improved populations and synthetics	Brazil	1		1
				Netherland	1		1
				Nepal	2		2
				Total	**4**	**0**	**4**
				GRAND TOTAL	**27**	**16**	**11**
Bolivia	Centro de Invest. Fitoecogenéticas de Pairumani	Lic. Lorena Guzmán	**Landraces**	Bolivia	1,478	1,478	
		fitogen@fundacionpatino.org		Chile	23		23
				Total	**1,501**	**1,478**	**23**
			Improved populations and synthetics	Bolivia	2	2	
				Total	**2**	**2**	**0**
			Open pollinated varieties	Bolivia	10	10	
				Total	**10**	**10**	**0**
			Inbreds	Bolivia	50	50	
				CIMMYT	20		20
				Total	**70**	**50**	**20**
			Teosinte	Mexico	1		1
				Total	**1**	**0**	**1**
				GRAND TOTAL	**1,584**	**1,540**	**44**
Brazil	Embrapa Milho e Sorgo	Flavia França Teixeira	**Landraces**	Brazil	3,153	3,153	
		flavia@cnpms.embrapa.br		Others countries*	288		288
				Total	**3,441**	**3,153**	**288**
*Mexico, USA, Guatemala, Hondura, El Salvador, Rep Dominicana, Cuba, France, Holland, Italy							
			Improved populations and synthetics	Brazil	222	222	
				Total	**222**	**222**	**0**
			Teosinte	Mexico	6		6
				Total	**6**	**0**	**6**
			Tripsacum	Unknown	**1**		**1**
				Total	**1**	**0**	**1**
				GRAND TOTAL	**3,670**	**3,375**	**295**
Chile	Instituto de Investigaciones Agropecuarias	Erika Salazar Suazo	**Landraces**	Chile	949	949	
		esalazar@inia.cl		**Total**	**949**	**949**	**0**
			Open pollinated varieties	Chile	2	2	
				Bolivia	2		2
				Others countries	16		16
				Total	**20**	**2**	**18**
* Uruguay, Argentina USA							
			Inbreds	Chile	506	506	
				Total	**506**	**506**	**0**
				GRAND TOTAL	**1,475**	**1,457**	**18**

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China	Institute of Crop Science _ CAAS	Xinxiong Lu xxlu@caas.net.cn	**Landraces**	China	13,415	13,415	
				Israel	6		6
				Albania	17		17
				Argentina	12		12
				Australia	12		12
				Belgium	5		5
				Brazil	4		4
				Bulgaria	21		21
				Canada	13		13
				Chile	10		10
				Czech Republic	3		3
				Egypt	18		18
				England	12		12
				Ethiopia	2		2
				France	23		23
				Germany	34		34
				Guatemala	1		1
				Hungary	120		120
				India	1		1
				Indonesia	3		3
				Iran	9		9
				Italy	37		37
				Japan	48		48
				Malaysia	1		1
				Mexico	177		177
				Mongolia	4		4
				Netherlands	6		6
				Pakistan	6		6
				People's Republic of Korea	32		32
				Peru	1		1
				Philippines	1		1
				Poland	12		12
				Puerto Rico	7		7
				Republic of Yemen	2		2
				Romania	18		18
				Russia	44		44
				Somali	2		2
				Thailand	16		16
				Turkey	8		8
				Ukraine	10		10
				Unknown	233		233
				USA	238		238
				Vietnam	9		9
				Yugoslavia	78		78
				Zaire	3		3
				Total	**14,734**	**13,415**	**1,319**
			Improved populations and synthetics	China	61	61	
				Total	**61**	**61**	**0**
			Inbreds	China	2,791	2,791	
				Australia	3		3
				Austria	3		3
				Bulgaria	6		6
				Canada	38		38
				Czech Republic	3		3
				Egypt	1		1
				France	44		44
				Germany	1		1
				Hungary	5		5
				Italy	57		57
				Japan	12		12
				Mexico	238		238
				Nigeria	8		8
				People's Republic of Korea	16		16
				Poland	4		4
				Portugal	1		1
				Republic of Yemen	4		4
				Romania	14		14
				Russia	18		18
				South Africa	2		2
				Spain	2		2
				Unknown	52		52
				USA	511		511
				Yugoslavia	95		95
				Total	**3.929**	**2.791**	**0**
				GRAND TOTAL	**18,724**	**16,267**	**1,319**
Colombia	CORPOICA	Alejandro Alberto Navas Arboleda anavasa@corpoica.org.co	**Landraces**	Colombia	1,768	1,768	
				Africa	2		2
				Antigua	8		8
				Argentina	10		10
				Barbados	12		12
				Bolivia	376		376
				Brazil	1		1
				Chile	33		33
				CIMMYT	27		27
				Cuba	37		37
				Ecuador	395		395
				Grenada	16		16
				Guadalupe	16		16
				Guatemala	13		13
				Haiti	26		26
				India	3		3
				Indonesia	2		2
				Jamaica	2		2
				Martinique	1		1
				Mexico	225		225
				Panama	90		90
				Peru	113		113
				Puerto Rico	14		14
				Republic dominicana	68		68
				Santa Croix	3		3
				Santa Lucia	4		4
				Thailand	2		2
				Trinidad y Tobago	30		30
				USA	14		14
				Venezuela	435		435
				Total	**3.746**	**1.768**	**1.978**
			Improved populations and synthetics	Colombia	406	406	
				Total	**406**	**406**	**0**
				GRAND TOTAL	**4.152**	**2.174**	**1.978**

Country	Institution	Collection Manager data	Accession category: Type accession	Accession category: Country of origin	No. of accessions	No. of introductions[1]: Own country	No. of introductions[1]: Other countries
Costa Rica	CATIE	Dr. Andreas W. Ebert	**Landraces**	Costa Rica	60	60	
		awebert@catie.ac.cr		El Salvador	6		6
				Guatemala	54		54
				Honduras	6		6
				Mexico	26		26
				Nicaragua	3		3
				Panama	15		15
				Russia	5		5
				USA*	244		244
				Total	**419**	**60**	**359**
				GRAND TOTAL	**419**	**60**	**361**

*** These 244 accessions have been donated by USDA and are registered in the GRIN database. Countries of origin are Argentina, Turkey, Chechoslowakia, USA, Canada, Russia, Afghanistan, Philippines, Bolivia, Brazil, Syria, Spain, Chile, Yugoslavia, and Ecuador.**

Country	Institution	Collection Manager data	Type accession	Country of origin	No. of accessions	Own country	Other countries
Czech Republic	RICP Prague-Ruzyne	Vera Chytilova	**Improved populations and synthetics**	USA	7		7
		chytilova@genobanka.cz		**Total**	**7**	**0**	**7**
			Open pollinated varieties	Czech Republic	1	1	
				Germany	1		1
				Hungary	2		2
				Poland	1		1
				unknown	8		8
				USA	36		36
				Total	**49**	**1**	**48**
				GRAND TOTAL	**56**	**1**	**55**
Czech Republic	Research Institute of Crop Production of Prague	Zdenek Stehno	**Landraces**	Czech Republic	94	94	
		stehno@vurv.cz		Bulgary	1		1
				Total	**95**	**94**	**1**
			Open pollinated varieties	Czech Republic	3	3	
				Germany	1		1
				Hungary	5		5
				Poland	4		4
				URSS	2		2
				Unknown	25		25
				USA	44		44
				Yugoslavia	3		3
				Total	**87**	**3**	**84**
			Inbreds	Czech Republic	413	413	
				Austria	2		2
				Bulgaria	5		5
				Canada	35		35
				France	28		28
				Hungary	8		8
				Italy	3		3
				Netherland	3		3
				Poland	11		11
				Portugal	2		2
				Romania	2	;	2
				URSS	4		4
				Unknown	10		10
				USA	77		77
				Yugoslavia	3		3
				Total	**606**	**413**	**193**
				GRAND TOTAL	**788**	**510**	**278**
Ecuador	INIAP-DENAREF	Cesar Tapia	**Landraces**	Ecuador	1,055	1,055	
		Alvaro Monteros		Argentina	2		2
		denaref@ecnet.ec		Brazil	1		1
				Colombia	16		16
				Cuba	2		2
				Mexico	9		9
				Peru	133		133
				Rep. Dominicana	2		2
				USA	3		3
				Total	**1,223**	**1,055**	**168**
			Improved populations and synthetics	Ecuador	10	10	
				Total	**10**	**10**	**0**
			Open pollinated varieties	Ecuador	9	9	
				Total	**9**	**9**	**0**
				GRAND TOTAL	**1,242**	**1,074**	**168**

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions [1]	
			Type accession	Country of origin		Own country	Other countries
France	Inst. Nat. de la Recherche Agronomique	Anne ZANETTO	**Landraces**	France	546	546	
		zanetto@ensam.inra.fr		Algeria			4
				Argentina			43
				Austria			2
				Bulgaria			85
				Canada			4
				Chile			87
				China			18
				former Czechoslovakia			21
				former USSR			9
				Germany			5
				Hungary			87
				India			1
				Italy			23
				Japan			30
				Korea, Republic of			2
				Mexico			3
				Morocco			2
				Pakistan			1
				Poland			18
				Portugal			7
				Romania			58
				Spain			71
				Switzerland			1
				Thailand			1
				Turkey			1
				USA			38
				Yemen			1
				Yugoslavia			35
				Total	**546**	**546**	**658**
			Improved populations and synthetics	France	71	71	
				Afghanistan			2
				Argentina			13
				Australia			1
				Austria			6
				Bulgaria			13
				Canada			23
				Hungary			10
				Italy			15
				Japan			23
				Mexico			5
				Poland			3
				Romania			17
				USA			142
				Yugoslavia			3
				Total	**71**	**71**	**276**
			Inbreds	France	859	859	
				Argentina			36
				Australia			6
				Austria			30
				Belgium			2
				Brasil			1
				Bulgaria			212
				Canada			325
				China			44
				Dominican Republic			4
				Egypt			9
				former Czechoslovakia			124
				former Yugoslavia			129
				Germany			13
				Greece			22
				Hungria			73
				India			2
				Israël			8
				Italy			67
				Japan			13
				Marocco			28
				Mexico			4
				Nigeria			39
				Poland			66
				Portugal			65
				Romania			133
				Russia			27
				South Africa			25
				Spain			95
				Switzerland			21
				Turkey			4
				United Kingdom			2
				Unknown			24
				Uruguay			6
				USA			852
				Total	**859**	**859**	**2,511**
				GRAND TOTAL	**1,476**	**1,476**	**3,445**
Georgia	Non specified	Zurab Jinjikhadze	**Landraces**	Georgia	89	89	
		tamrikoj@yahoo.com		**Total**	**89**	**89**	**0**
			Improved populations and synthetics	Georgia	10	10	
				Total	**10**	**10**	**0**
			Inbreds	Georgia	63	63	
				Total	**63**	**63**	**0**
				GRAND TOTAL	**162**	**162**	**0**
Guatemala	Instituto de Ciencia y Tecnología Agrícolas (ICTA)	Mario Roberto Fuentes López	**Landraces**	Guatemala	914	914	
		mfuentes@icta.gob.gt		**Total**	**914**	**914**	**0**
				GRAND TOTAL	**914**	**914**	**0**
India	National Bureau of Plant Genetic Resources	Dr. Kalyani Srinivasan	**Landraces**	India	1,285	NS*	NS*
		aksingh@nbpgr.ernet.in+E9		**Total**	**1,285**	**0**	**0**
***Non specified**				**GRAND TOTAL**	**1,285**	**0**	**0**
Indonesia	ICABIOGRAD	Ir. Sri Gajatri Budiarti, MS	**Landraces**	Indonesia	529	529	
		sdg_balitbio@bogor.indo.net.id		Malaysia	2		2
				Philippines	1		1
				Tanzania	1		1
				Thailand	2		2
				USA	3		3
				Vietnam	5		5
				Total	**543**	**529**	**14**
			Improved populations and synthetics	Indonesia	29	29	
				Total	**29**	**29**	**0**
			Inbreds	Indonesia	30	30	
				CIMMYT	34		34
				Total	**64**	**30**	**34**
				GRAND TOTAL	**636**	**588**	**48**

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Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	Mr. Z.K Muthamia	**Landraces**	Kenya	1,116	NS*	NS
		ngbk@wananchi.com		**Total**	**1,116**	**0**	**0**
*NS Non Specified							
			Improved populations and synthetics	Kenya	4	4	
				Bulgaria	4		4
				Ethiopia	2		2
				France	5		5
				Iran	1		1
				Mexico	3		3
				Senegal	2		2
				South Africa	1		1
				USA	13		13
				Yugoslavia	1		1
				Zimbabwe	2		2
				Total	**38**	**4**	**34**
			Inbreds	Kenya	74	74	
				Total	**74**	**74**	**0**
				GRAND TOTAL	**1,228**	**78**	**34**
Mexico	CIMMYT, INT	Dr. Suketoshi Taba	**Landraces**	Mexico	8,925	8,925	
		staba@cgiar.org		Afghanistan	19		19
				Angola	9		9
				Antigua	18		18
				Argentina	1,153		1,153
				Austria	7		7
				Bahamas	1		1
				Barbados	26		26
				Belize	7		7
				Bolivia	841		841
				Brazil	3,137		3,137
				British Virgin Island	54		54
				Chile	451		451
				China	26		26
				Colombia	349		349
				Congo	1		1
				Costa Rica	392		392
				Cuba	301		301
				Ecuador	1,001		1,001
				Egypt	1		1
				El Salvador	105		105
				Ethiopia	29		29
				GRANDada	35		35
				Guadalupe	34		34
				Guatemala	1,029		1,029
				Guiana Fr.	11		11
				Guinea	1		1
				Guyana	15		15
				Haiti	59		59
				Honduras	178		178
				India	4		4
				Israel	4		4
				Jamaica	8		8
				Kenya	2		2
				Lebannon	7		7
				Mali	58		58
				Martinica	10		10
				Morocco	52		52
				Nepal	212		212
				Nicaragua	74		74
				Niger	1		1
				Pakistan	2		2
				Panama	195		195
				Paraguay	567		567
				Peru	1,219		1,219
				Puerto Rico	42		42
				Rep. Dominicana	216		216
				St. Croix	15		15
				St. Vincent	20		20
				Sta. Lucia	8		8
				Surinam	13		13
				Thailand	1		1
				Trinidad y Tobago	72		72
				Uganda	4		4
				Uruguay	977		977
				USA	31		31
				Venezuela	630		630
				Yemen	2		2
				Total	**22,661**	**8,925**	**13,736**
			Improved populations and synthetics	CIMMYT	1,190	1,190	
				Total	**1,190**	**1,190**	**0**
			Open pollinated varieties	CIMMYT	1,092	1,092	
				Total	**1,092**	**1,092**	**0**
			Inbreds	CIMMYT	358	358	
				Total	**358**	**358**	**0**
			Teosinte	Mexico	159	159	0
				Guatemala	26		26
				Nicaragua	1		1
				Total	**186**	**159**	**27**
			Tripsacum	Mexico	91	91	0
				Belize	1		1
				Brazil	1		1
				CIMMYT	5		5
				Colombia	13		13
				Ecuador	1		1
				Honduras	1		1
				Peru	2		2
				Trinidad y Tobago	1		1
				USA	1		1
				Venezuela	5		5
				Total	**122**	**91**	**31**
				GRAND TOTAL	**25,609**	**11,815**	**13,794**

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Mexico	INIFAP - Mexico	Dr , Juan Manuel Hernández Casillas hernandez_casillas@hotmail.com	**Landraces**	México	10,444	10,444	
				Africa	24		24
				Argentina	4		4
				Belice	14		14
				Bolivia	1		1
				Brasil	24		24
				China	2		2
				Colombia	6		6
				Costa Rica	34		34
				Cuba	75		75
				E. U.	18		18
				Ecuador	18		18
				El Salvador	75		75
				Guatemala	956		956
				Guyana Holandesa	1		1
				Haiti	15		15
				Hawaii	5		5
				Honduras	134		134
				Islas Virgenes	4		4
				Israel	4		4
				Jamaica	4		4
				Martinica	10		10
				Nicaragua	50		50
				Panamá	25		25
				Paraguay	1		1
				Perú	36		36
				R. Dominicana	235		235
				Rumania	10		10
				Trinidad y Tobago	19		19
				Venezuela	5		5
				Total	**12.253**	**10.444**	**1.809**
			Teosinte	México	136	136	
				Total	**136**	**136**	**0**
				GRAND TOTAL	**12,389**	**10,580**	**1,809**
Mexico	INIFAP - Oaxaca	Flavio Aragón Cuevas faragoncuevas@yahoo.com.mx aragon.flavio@inifap.gob.mx	**Landraces**	Oaxaca . México	1.250	1.250	
				Total	**1.250**	**1.250**	**0**
			Open pollinated varieties	Oaxaca , México	25	25	
				Total	**25**	**25**	**0**
			Teosinte	Oaxaca . México	2	2	
				Total	**2**	**2**	**0**
				GRAND TOTAL	**1,277**	**1,277**	**0**
Netherland	Centre for Genetic Resources the Netherlands	Noor Bas noortje.bas@wur.nl	**Landraces**	Netherlands	1	1	
				Pakistan	179		179
				Portugal	42		42
				Russia	18		18
				USA	11		11
				France	9		9
				Canada	8		8
				Greece	5		5
				(former) Yugoslavia	3		3
				Spain	2		2
				Mexico	2		2
				Ethiopia	1		1
				Romania	1		1
				Bolivia	1		1
				Unknown	2		2
				Total	**285**	**1**	**284**
			Improved populations and synthetics	USA	5	5	
				Canada	3		3
				France	2		2
				Spain	1		1
				Unknown	8		8
				Total	**19**	**5**	**14**
			Open pollinated varieties	Netherlands	5	5	
				Germany	3		3
				Unknown	4		4
				USA	1		1
				Total	**13**	**5**	**8**
			Population type unknown	Netherlands	10	10	
				Asian Countries*	5		5
				Canada	7		7
				European countries**	13		13
				France	5		5
				Mexico	25		25
				Pakistan	9		9
				Russia	8		8
				Sudamerican countries***	3		3
				Unknown	62		62
				USA	17		17
				Yugoslavia	8		8
				Total	**172**	**10**	**162**
				GRAND TOTAL	**489**	**21**	**468**
Nigeria	IITA	Dumet (interim) ddumet@cgiar.org	**Landraces**	Nigeria	11	11	
				Benin	145		145
				Cameroon	4		4
				Congo	31		31
				Equatorial Guinea	5		5
				Ghana	12		12
				IBPGR	166		166
				Kenya	29		29
				Malawi	66		66
				Somalia	35		35
				Tanzania	50		50
				Tchad	76		76
				Togo	64		64
				Upper Volta	25		25
				Zambia	28		28
				Zimbabwe	29		29
				Total	**776**	**11**	**765**
				GRAND TOTAL	**776**	**11**	**765**

*Japan, turkey & Israel
**Austria, Germany, Czech republic, Greek, Hungary, Italy, Portugal, Spain
***Bolivia & Peru

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Pakistan	Plant Genetic Resources Programme Nat Agric Res Center	Dr Zahoor Ahmad zahmad51@hotmail.com	Landraces	Pakistan	507	507	
				Total	507	507	0
			Improved populations and synthetics	Pakistan	74	74	
				Others countries	86		86
				Total	160	74	86
				GRAND TOTAL	667	581	86
Paraguay	CRIA	Orlando J Noldin orlandonoldin@gmail.com	Landraces	Paraguay	478	478	
			Improved populations and synthetics	Paraguay	15	15	
				GRAND TOTAL	493	493	0
Peru	Universidad Nacional Agraria La Molina	Julián Chura Chuquija Ricardo Sevilla Panizo chura@lamolina.edu.pe stc_ccipr@infocipe	Landraces	Peru	3000	3000	
				Brazil	10		10
				Colombia	5		5
				Guatemala	6		6
				Mexico	12		12
				Venezuela	4		4
				Total	3037	3000	37
			Improved populations and synthetics	Peru	21	21	
				Total	21	21	0
			Open pollinated varieties	Peru	24	24	
				Total	24	24	0
			Hybrids	Peru	1361	1361	
				Total	1361	1361	0
				GRAND TOTAL	4443	4406	37
Romania	Agricultural Research and Development Institute	Dr. Ion Antohe fundulea@ricic.ro	Landraces	Romania	234	234	
				Different countries	31		31
				Total	265	234	31
			Improved populations and synthetics	Romania	20	20	
				Different countries	64		64
				Total	84	20	64
			Open pollinated varieties	Romania	19	19	
				Different countries	5		5
				Total	24	19	5
			Hybrids	Romania	671	671	
				Different countries	368		368
				Total	1039	671	368
				GRAND TOTAL	1412	944	468
Romania	Suceava Genebank	Dr Eng Danela Murariu dmurariu@suceava.astral.ro	Landraces	Romania	3227	3227	
				Canada	1		1
				Italy	1		1
				Unknown	15		15
				Total	3244	3227	17
			Improved populations and synthetics	Canada	5		5
				France	2		2
				Italy	2		2
				Unknown	118		118
				URSS	1		1
				USA	16		16
				Total	144	0	144
			Open pollinated varieties	Romania	126	126	
				Canada	1		1
				Unknown	6		6
				Total	133	126	7
			Hybrids	Romania	834	834	
				Argentina	4		4
				Canada	38		38
				Germany	9		9
				France	31		31
				Italy	7		7
				Mexic	10		10
				Netherland	10		10
				Peru	1		1
				Poland	24		24
				Union of Soviet Socialist Republics	7		7
				Turkey	5		5
				Ukraine	2		2
				USA	33		33
				Russian Federation	33		33
				Unknown	187		187
				Total	1235	834	401
				GRAND TOTAL	4756	4187	569
Romania	Agricultural Research and Station TURDA	Dr Ioan Has ioanhas@yahoo.com	Landraces	Romania	1,160	1,160	
				Austria	8		8
				Bulgaria	11		11
				Canada	107		107
				France	150		150
				Germany	115		115
				Hungary	22		22
				Italy	20		20
				Poland	49		49
				R Czech	16		16
				R Moldova	69		69
				Rusia	15		15
				Spain	24		24
				Swiss	1		1
				USA	136		136
				Yugoslavia	17		17
				Total	1,920	1,160	760
			Improved populations and synthetics	Romania	33	33	
				Germany	20		20
				Spain	8		8
				Total	61	33	28
			Open pollinated varieties	Romania	267	267	
				Germany	9		9
				Spain	2		2
				Total	278	267	11
			Hybrids	Romania	860	860	
				Austria	8		8
				Bulgaria	11		11
				Canada	107		107
				France	150		150
				Germany	86		86
				Hungary	22		22
				Italy	20		20
				Poland	49		49
				R Czech	16		16
				R Moldova	69		69
				Rusia	15		15
				Spain	14		14
				Swiss	1		1
				USA	136		136
				Yugoslavia	17		17
				Total	1,581	860	721
				GRAND TOTAL	3,840	2,320	1,520

Country	Institution	Collection Manager data	Accession category: Type accession	Accession category: Country of origin	No. of accessions	No. of introductions [1]: Own country	No. of introductions [1]: Other countries
Slovak Republic	Gene Bank, Research Inst. of Plant Production	Dr. Daniela Benedikova benedikova@vurv.sk	**Landraces**	Slovakia	204	204	
				Bulgaria	1		1
				Ukraina	2		2
				Total	**207**	**204**	**3**
			Improved populations and synthetics	Slovakia	219	219	
				Australia	2		2
				Austria	1		1
				Bulgaria	6		6
				Canada	47		47
				Czech Republic	5		5
				France	35		35
				Germany	5		5
				Hungary	14		14
				Italy	3		3
				Japan	1		1
				Netherland	3		3
				Poland	26		26
				Portugal	1		1
				Romania	6		6
				Spain	1		1
				URSS	16		16
				Unknown	18		18
				USA	132		132
				Yugoslavia	11		11
				Total	**552**	**219**	**333**
			Open pollinated varieties	Slovakia	11	11	
				Albania	1		1
				Czech Republic	5		5
				Hungary	8		8
				Korea	1		1
				Poland	7		7
				URSS	10		10
				Unknown	51		51
				Yugoslavia	8		8
				Total	**102**	**11**	**91**
			Inbreds	Slovakia (SVK)	37		37
				Total	**37**	**0**	**37**
				GRAND TOTAL	**898**	**434**	**464**
Spain	Misión Biológica de Galicia (CSIC)	Dr. Amando Ordás aordas@mbg.cesga.es	**Landraces**	Spain	165	165	
				Portugal	17		17
				Total	**182**	**165**	**17**
			Improved populations and synthetics	Spain	28	28	
				USA	30		30
				Total	**58**	**28**	**30**
			Open pollinated varieties	USA	22		22
				Total	**22**	**0**	**22**
			Inbreds	Spain	59	59	
				Canada	15		15
				Portugal	7		7
				USA	114		114
				Total	**195**	**59**	**136**
				GRAND TOTAL	**457**	**252**	**205**
Sri Lanka	Plant Genetic Resources Centre	Non specified pgrc@sl.lk	**Landraces**	Sri Lanka	350	350	
				India	3		3
				Italy	3		3
				Mexico	200		200
				Nigeria	2		2
				Pakistan	3		3
				Philippines	4		4
				Thailand	50		50
				Unknown	72		72
				USA	3		3
				Vietnam	4		4
				Total	**694**	**350**	**344**
			Improved populations and synthetics	Sri Lanka	4	4	
				Total	**4**	**4**	**0**
			Open pollinated varieties	Sri Lanka	350	350	
				CIMMYT	15		15
				Total	**365**	**350**	**15**
			Inbreds	Sri Lanka	90	90	
				CIMMYT	160		160
				Total	**250**	**90**	**160**
				GRAND TOTAL	**1,313**	**794**	**519**
Sweden	Nordic Gene Bank	Katarina Wedelsbäck Bladh katarina.wedelsback.bladh@nordgen.org	**Improved populations and synthetics**	Sweden	1	1	
				France	6		6
				Total	**7**	**1**	**6**
				GRAND TOTAL	**7**	**1**	**6**
Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.	Sansern Jampatong snjpt@korat.loxinfo.co.th	**Landraces**	South and Central America	408		408
				Total	**408**	**0**	**408**
			Improved populations and synthetics	Thailand	153	153	
				CIMMYT	141		141
				USA	18		18
				Other countries*	289		289
				Total	**601**	**153**	**448**
			Open pollinated varieties	USA	63		63
				Total	**63**	**0**	**63**
			Teosinte	CIMMYT	3		3
				Total	**3**	**0**	**3**
				GRAND TOTAL	**1,075**	**153**	**922**
Turkey	Aegean Agricultural Research Institute	Dr. A. Ertug Firat etae@aari.gov.tr	**Landraces**	Turkey	1,574	1,574	
				Total	**1,574**	**1,574**	**0**
			Improved populations and synthetics	Turkey	7	7	
				Total	**7**	**7**	**0**
			Inbreds	Turkey	6	6	
				Total	**6**	**6**	**0**
				GRAND TOTAL	**1,587**	**1,587**	**0**

*Asian, South American, African and European countries

Country	Institution	Collection Manager data	Accession category: Type of accession	Accession category: Country of origin	No of accessions	No of introductions[1]: Own country	No of introductions[1]: Other countries
Ukraine	NCPGRU	Dr. Victor K. Ryabchoun ncpgru@kharkov.ukrtel.net	Improved populations and synthetics	Ukraine	894	894	
				Canada	16		16
				France	4		4
				Germany	12		12
				Serbia and Montenegro	24		24
				USA	50		50
				Total	**1,000**	**894**	**106**
			Inbreds	Ukraine	1,430	1,430	
				Canada	100		100
				France	91		91
				Germany	86		86
				Serbia and Montenegro	112		112
				USA	400		400
				Total	**2,219**	**1,430**	**789**
				GRAND TOTAL	**3,219**	**2,324**	**895**
Uruguay	N/A	Dr Federico Condon fcondon@inia.org.uy	Landraces	Uruguay	852	852	0
				Total	**852**	**852**	**0**
				GRAND TOTAL	**852**	**852**	**0**
USA	North Central Regional Plant Introduction Station, ARS, USDA (NC-7)	Mr Mark Millard mjmillar@iastate.edu	Landraces	United States	1,320	1,320	
				Afghanistan	21		21
				Albania	6		6
				Algeria	23		23
				Angola	19		19
				Anguilla	1		1
				Antigua and Barbuda	8		8
				Argentina	317		317
				Australia	17		17
				Austria	29		29
				Azerbaijan	4		4
				Barbados	7		7
				Belarus	1		1
				Belize	4		4
				Benin	1		1
				Bhutan	6		6
				Bolivia	464		464
				Botswana	2		2
				Brazil	512		512
				Bulgaria	33		33
				Burkina Faso	189		189
				Burundi	50		50
				Cambodia	2		2
				Canada	45		45
				Chad	3		3
				Chile	607		607
				China	18		18
				Colombia	2,214		2,214
				Costa Rica	134		134
				Cuba	104		104
				Czechoslovakia	12		12
				Dominican Republic	95		95
				Ecuador	108		108
				Egypt	9		9
				El Salvador	35		35
				Eritrea	5		5
				Ethiopia	156		156
				Finland	2		2
				Former Soviet Union	74		74
				France	13		13
				French Guiana	2		2
				Georgia	6		6
				Germany	5		5
				Greece	1		1
				Grenada	12		12
				Guadeloupe	7		7
				Guatemala	319		319
				Guinea	140		140
				Guyana	2		2
				Haiti	19		19
				Honduras	97		97
				Hungary	87		87
				India	36		36
				Indonesia	4		4
				Iran	6		6
				Iraq	2		2
				Israel	3		3
				Italy	82		82
				Jamaica	6		6
				Japan	57		57
				Jordan	1		1
				Kazakhstan	1		1
				Kenya	12		12
				Korea, South	5		5
				Lebanon	9		9
				Macedonia	99		99
				Madagascar	10		10
				Maldives	1		1
				Mali	19		19
				Martinique	3		3
				Mauritius	1		1
				Mexico	2,460		2,460
				Moldova	3		3
				Morocco	10		10
				Myanmar	1		1
				Nepal	47		47
				Netherlands	8		8
				Nicaragua	53		53
				Nigeria	3		3
				Oman	23		23
				Pakistan	37		37
				Panama	29		29
				Paraguay	68		68
				Peru	1,969		1,969
				Philippines	11		11
				Poland	15		15
				Portugal	201		201
				Puerto Rico	22		22
				Reunion	4		4
				Romania	43		43
				Russian Federation	19		19
				Saudi Arabia	8		8
				South Africa	48		48
				South America	6		6
				Spain	44		44
				Sri Lanka	1		1
				St Lucia	2		2
				St Vincent and Grenadines	5		5
				Sudan	3		3
				Suriname	5		5
				Swaziland	1		1
				Syria	9		9
				Tajikistan	1		1
				Thailand	7		7
				Togo	87		87
				Trinidad and Tobago	18		18
				Turkey	563		563
				US Outlying Islands	1		1
				Uganda	3		3
				Ukraine	11		11
				United Kingdom	2		2
				Uruguay	424		424
				Uzbekistan	3		3
				Venezuela	53		53
				Virgin Islands (British)	15		15
				Virgin Islands (U.S.)	9		9
				Yemen	17		17
				Yugoslavia	295		295
				Zaire	32		32
				Zambia	281		281
				Zimbabwe	27		27
				Total	**14,731**	**1,320**	**13,411**

Country	Institution	Collection Manager data	Accession category		No. of	No. of introductions [1]	
			Type accession	Country of origin	accessions	Own country	Other countries
USA	North Central Regional Plant Introduction Station, ARS, USDA	Mr. Mark J. Millard	**Improved populations and synthetics**	United States	804	804	
	(NC-7)	mjmillar@iastate.edu		Antigua and Barbuda	1		1
				Argentina	1		1
				Australia	1		1
				Barbados	2		2
				Brazil	19		19
				Bulgaria	7		7
				Cameroon	5		5
				Canada	38		38
				China	77		77
				Colombia	7		7
				Costa Rica	14		14
				Croatia	29		29
				Cuba	6		6
				Dominican Republic	4		4
				El Salvador	6		6
				Finland	1		1
				Former Soviet Union	35		35
				Germany	2		2
				Grenada	2		2
				Guadeloupe	4		4
				Guatemala	15		15
				Haiti	6		6
				Honduras	10		10
				Hungary	5		5
				India	1		1
				Indonesia	1		1
				Israel	9		9
				Jamaica	1		1
				Japan	1		1
				Kazakhstan	1		1
				Kenya	36		36
				Mauritius	1		1
				Mexico	123		123
				Moldova	4		4
				Netherlands	1		1
				New Zealand	4		4
				Nicaragua	9		9
				Nigeria	5		5
				Panama	11		11
				Paraguay	2		2
				Peru	1		1
				Philippines	1		1
				Poland	4		4
				Puerto Rico	21		21
				Reunion	1		1
				Romania	4		4
				Russian Federation	8		8
				South Africa	4		4
				St. Lucia	1		1
				St. Vincent and Grenadines	4		4
				Taiwan	6		6
				Tanzania	6		6
				Thailand	3		3
				Trinidad and Tobago	4		4
				Ukraine	7		7
				Venezuela	3		3
				Vietnam	1		1
				Virgin Islands (U.S.)	2		2
				Zambia	1		1
				Total	**1,393**	**804**	**589**
			Inbreds	United States	1,480	1,480	
				Argentina	29		29
				Australia	8		8
				Brazil	1		1
				Cameroon	45		45
				Canada	57		57
				China	48		48
				CIMMYT	80		80
				Former Soviet Union	11		11
				France	13		13
				Hungary	15		15
				India	6		6
				Israel	19		19
				Netherlands	4		4
				Nigeria	49		49
				Philippines	3		3
				Poland	34		34
				Portugal	3		3
				Reunion	1		1
				Romania	14		14
				South Africa	72		72
				Spain	17		17
				Taiwan	4		4
				Thailand	8		8
				Ukraine	2		2
				Uruguay	16		16
				Total	**2,039**	**1,480**	**559**
			Teosinte	Guatemala	22		22
				Honduras	2		2
				Mexico	169		169
				Nicaragua	1		1
				Unknown	45		45
				Total	**239**	**0**	**239**
				GRAND TOTAL	**18.402**	**3.604**	**14.798**
Venezuela	Inst . Nac . de Invest . Agrí .(INIA - CENIAP)	Víctor Segovia vsegovia@inia.gov.ve	**Landraces**	Venezuela	1,197	1,197	
				Total	**1,197**	**1,197**	**0**
			Improved populations and synthetics	Venezuela	289	289	
				México	183		183
				Total	**472**	**289**	**183**
			Open pollinated varieties	Venezuela	48	48	
				Total	**48**	**48**	**0**
			Inbreds	Venezuela	3,000	3,000	
				México	40		40
				Total	**3,040**	**3,000**	**40**
				GRAND TOTAL	**4.757**	**4.534**	**223**

Country	Institution	Collection Manager data	Accession category		No. of accessions	No. of introductions [1]	
			Type accession	Country of origin		Own country	Other countries
Yugoslavia	Maize Research Institute "Zemun Polje"	Drazen Jelovac djelovac@mrizp.co.yu	**Landraces**	Yugoslavia	1,238	1,238	
				Afghanistan	2		2
				Angola	16		16
				Austria	11		11
				Bolivia	1		1
				Bosnia and Herzegowina	323		323
				Brazil	3		3
				Bulgaria	74		74
				Canada	22		22
				China	19		19
				Croatia	285		285
				Czechoslovakia	241		241
				Democratic People's Republic of Ko	3		3
				Ethiopia	2		2
				France	23		23
				German Democratic Republic	48		48
				Germany	1		1
				Greece	68		68
				Hungary	18		18
				India	2		2
				Iran	88		88
				Israel	2		2
				Italy	76		76
				Jamaica	1		1
				Kenya	4		4
				Macedonia, Former Yugoslav Repu	221		221
				Mexico	24		24
				Morocco	6		6
				Netherlands	5		5
				Pakistan	186		186
				Poland	8		8
				Portugal	42		42
				Romania	49		49
				Slovenia	106		106
				South Africa	6		6
				Spain	2		2
				Sudan	4		4
				Tanzania	3		3
				Thailand	1		1
				Turkey	1,101		1,101
				URSS	230		230
				Uruguay	3		3
				USA	27		27
				Yugoslavia	1,238		1,238
				Total	**5,833**	**1,238**	**4,595**
			Improved populations and synthetics	Yugoslavia	6	6	
				Argentina	68		68
				Brazil	1		1
				Bulgaria	20		20
				Canada	5		5
				Czechoslovakia	7		7
				Ethiopia	2		2
				Germany	4		4
				Hungary	5		5
				Jordan	3		3
				Mexico	69		69
				Nepal	2		2
				Netherlands	5		5
				Poland	4		4
				Romania	5		5
				Spain	1		1
				URSS	17		17
				USA	93		93
				Zimbabwe	4		4
				Total	**321**	**6**	**315**
			Inbreds	Yugoslavia	134	134	
				Afghanistan	2		2
				Argentina	5		5
				Australia	2		2
				Austria	2		2
				Bulgaria	286		286
				Canada	60		60
				China	20		20
				Czechoslovakia	779		779
				Democratic People's Republic of Ko	26		26
				France	61		61
				German Democratic Republic	49		49
				Greece	122		122
				Hungary	67		67
				India	1		1
				Iran	64		64
				Italy	20		20
				Mexico	54		54
				Netherlands	10		10
				Pakistan	14		14
				Poland	110		110
				Portugal	4		4
				Romania	58		58
				Spain	5		5
				Switzerland	14		14
				Turkey	406		406
				URSS	684		684
				USA	288		288
				Total	**3,347**	**134**	**3,213**
			Unknown	Yugoslavia	8	8	
				Austria	1		1
				Bolivia	1		1
				Canada	6		6
				Czechoslovakia	1		1
				France	276		276
				Germany	17		17
				Greece	203		203
				Hungary	1		1
				Israel	1		1
				Italy	563		563
				Japan	2		2
				Mexico	25		25
				Netherlands	7		7
				Pakistan	9		9
				Peru	2		2
				Portugal	1		1
				Spain	950		950
				Turkey	2		2
				URSS	8		8
				USA	17		17
				Total	**2,101**	**8**	**2,093**
				GRAND TOTAL	**11,602**	**1,386**	**10,216**

APPENDIX 7: Summary of the questionnaire on maize collections by world regions

Region	Country	Institution	Accession category	No. of accessions	No. of introductions	
					Own country	Other countries
North America	Mexico	CIMMYT, INT	Landraces	50,895	21,939	28,956
		INIFAP-Mexico	Improved populations and synthetics	2,583	1,994	589
		INIFAP-Oaxaca	Open pollinated varieties	1,117	1,117	0
	USA	NC-7	Inbreds	2,397	1,838	559
			Teosinte	563	297	266
			Tripsacum	122	91	31
			GRAND TOTAL	**57,677**	**27,276**	**30,401**
Central America	Costa Rica	CATIE	Landraces	1,333	974	359
	Guatemala	Instituto de Ciencia y Tecnología Agrícolas (ICTA)				
			GRAND TOTAL	**1,333**	**974**	**359**
South America	Argentina	INTA				
	Bolivia	Centro de Invest. Fitoecogenéticas de Pairumani				
	Brazil	Embrapa Milho e Sorgo	Landraces	18,877	16,383	2,494
	Chile	Instituto de Investigaciones Agropecuarias	Improved populations and synthetics	691	691	0
	Colombia	CORPOICA	Open pollinated varieties	66	48	18
	Ecuador	INIAP-DENAREF	Inbreds	1,992	1,972	20
	Paraguay	CRIA	Teosinte	7	0	7
	Peru	Universidad Nacional Agraria La Molina	Tripsacum	1	0	1
	Uruguay	INIA				
	Venezuela	Inst. Nac. de Invest. Agrí. (INIA-CENIAP)				
			GRAND TOTAL	**21,634**	**19,094**	**2,540**
Europe	Austria	Austrian Agency for Health and Food Safety				
	Czech Republic	RICP Prague-Ruzyne				
		Research Institute of Crop Production of Prague				
	France	Inst. Nat. de la Recherche Agronomique				
	Georgia	Non specified				
	Netherland	Centre for Genetic Resources the Netherlands				
	Romania	Agricultural Research and Development Institute				
		Suceava Genebank				
		Agricultural Research and Station TURDA	Landraces	14,921	8,548	6,373
	Slovak Republic	Gene Bank, Research Inst. of Plant Production	Improved populations and synthetics	2,621	1,294	1,327
	Spain	Misión Biológica de Galicia (CSIC)	Open pollinated varieties	708	432	276
	Sweden	Nordic Gene Bank	Inbreds	13,698	5,329	8,369
	Turkey	Aegean Agricultural Research Institute	Population type unknown	172	10	162
	Ukraine	NCPGRU	Unknown	2,101	8	2,093
	Yugoslavia	Maize Research Institute "Zemun Polje"				
			GRAND TOTAL	**34,221**	**15,621**	**18,600**
Asia	China	Institute of Crop Science _ CAAS	Landraces	18,171	16,086	2,085
	India	National Bureau of Plant Genetic Resources	Improved populations and synthetics	855	321	534
	Indonesia	ICABIOGRAD	Open pollinated varieties	428	350	78
	Pakistan	Plant Genetic Resources Programme Nat. Agric. Res. Center	Inbreds	4,243	2,911	1,332
	Sri Lanka	Plant Genetic Resources Centre	Teosinte	3	0	3
	Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.				
			GRAND TOTAL	**23,700**	**19,668**	**4,032**
Africa	Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	Landraces	1,892	11	1881
	Nigeria	IITA	Improved populations and synthetics	38	4	34
			Inbreds	74	74	0
			GRAND TOTAL	**2,004**	**89**	**1,915**
Oceania	Australia	Australian Tropical Crops & Forages Germplasm Collection	Landraces	103	0	103
			Improved populations and synthetics	102	76	26
			Open pollinated varieties	95	20	75
			Inbreds	409	90	319
			GRAND TOTAL	**709**	**186**	**523**

APPENDIX 8: Summary of the questionnaire on seed storage conditions

Country	Institution	Seed storage category	Storage temp. (°C)	Storage humidity (% RH)	Type of container	Initial storage quantity	Seed viability (%)	Storage size (m^3)
Argentina	INTA	**Long-term collection (30 + years)**	-18	not controlled (6% seed moisture)	Aluminum foil	0,5 - 1 kg	> 85%	189
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	4 - 7	not controlled (6-8% seed moisture)	Aluminum foil	1,5 - 3 kg	> 85%	150
Australia	Australian Tropical Crops & Forages Germplasm Collection	**Long-term collection (30 + years)**	-20	15	Aluminum foil	2000 - 4000	90%	4
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*
Austria	Austrian Agency for Health and Food Safety	**Long-term collection (30 + years)**	-20	(20 - RH) 6% moisture	Sealed glass-jars	***	> 80	48
		Medium-term collection (until 30 years)	10 - 15	(25 - RH) 6% moisture	Glass jars	***	> 80	120
		Short-term collection (until 10 years)	***	***	***	***	***	***
Bolivia	Centro de Invest. Fitoecogenéticas de Pairumani	**Long-term collection (30 + years)**	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*
Brazil	Embrapa Milho e Sorgo	**Long-term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	8 - 10	0.3	Cotton bags	at least 2 Kg after the 1st multiplication	85 - 100%	135
		Short-term collection (until 10 years)	***	***	***	***	***	***
Chile	Instituto de Investigaciones Agropecuarias	**Long-term collection (30 + years)**	-18	0.15	Plastic container	2000 Seeds	OVER 75 %	
		Medium-term collection (until 30 years)	-5 - 0	0.45	Plastic container	2000 Seeds	OVER 75 %	59.85
		Short-term collection (until 10 years)	5 - 10	0.45	Plastic container	2000 Seeds	OVER 75 %	59.85
China	Institute of Crop Science – C A A S	**Long-term collection (30 + years)**	-18	≤ 50 % (6 -8 % seed moisture)	Aluminum foil	300g	85 - 100%	1440
		Medium-term collection (until 30 years)	-4	≤ 50 % (6 -8 % seed moisture)	Aluminum foil	1kg	85 - 100%	8160
		Short-term collection (until 10 years)	***	***	***	***	***	***
Colombia	CORPOICA	**Long-term collection (30 + years)**	-20	not controlled (10-13% seed moisture)	Plastic-aluminum foil	1500 seeds	85-100%	60
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	4	not controlled (10-13% seed moisture)	Plastic-aluminum foil	1500 seeds	85-100%	90
Costa rica	CATIE	**Long-term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	5	90	Aluminum foil	58.63	38%	40
		Short-term collection (until 10 years)	***	***	***	***	***	***
Czech Republic	RICP Prague-Ruzyne	**Long-term collection (30 + years)**	-18	4 - 5	Glass jars	NS*	NS*	300
		Medium-term collection (until 30 years)	-5	4 - 5	Glass jars	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	5	4 - 5	Glass jars	NS*	NS*	NS*
Czech Republic	Research Institute of Crop Production of Prague	**Long-term collection (30 + years)**	-18	7 - 8 %	Glass jars	50 - 250 g	≥ 80 %	0.5
		Medium-term collection (until 30 years)	-5	7 - 8 %	Glass jars	50 - 250 g	≥ 80 %	1.5
		Short-term collection (until 10 years)	***	***	***	***	***	***
Ecuador	INIAP-DENAREF	**Long-term collection (30 + years)**	-15	***	Aluminum foil bags	1000	over 85%	30
		Medium-term collection (until 30 years)	-15	***	Aluminum foil bags	1000	over 85%	20
		Short-term collection (until 10 years)	8	not controlled (78%)	Air-tight,plastic	3 Kg	over 90%	53
France	Inst. Nat. de la Recherche Agronomique	**Long-term collection (30 + years)**	- 18 ℃	not controlled	aluminum foil	2 bags in 2 different storage places	90%	10
		Medium-term collection (until 30 years)	6 ℃	0.3	aluminum foil	12 bags/600 kernels per population	90%	150
		Short-term collection (until 10 years)	6 ℃	0.3	tissue bags	» 3 kg	90%	150
Georgia	Non specified	**Long-term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
* Non specified		**Short-term collection (until 10 years)**	40	NS*	Glass jars	NS*	NS*	161 acces.

Country	Institution	Seed storage category	Storage temp. (°C)	Storage humidity (% RH)	Type of container	Initial storage quantity	Seed viability (%)	Storage size (m ³)
Guatemala	Instituto de Ciencia y Tecnología Agrícolas (ICTA)	**Long- term collection (30 + years)**	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*
India	National Bureau of Plant Genetic Resources	**Long- term collection (30 + years)**	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*
Indonesia	ICABIOGRAD	**Long- term collection (30 + years)**	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*
Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	**Long- term collection (30 + years)**	-20	18-20	Aluminium foil	At least 2,000 seeds	At lease 85%	75
		Medium-term collection (until 30 years)	5	18-20	Aluminium foil	At least 2,000 seeds	At lease 85%	75
		Short-term collection (until 10 years)	***	***	***	***	***	***
Mexico	CIMMYT, INT	**Long- term collection (30 + years)**	-18	not controlled (6-8% seed moisture)	Aluminum foil	1 - 2kg	85 - 100%	400
		Medium-term collection (until 30 years)	-3	25 - 30%	Air-tight, plastic	2 - 3kg	85 - 100%	400
		Short-term collection (until 10 years)	***	***	***	***	***	***
Mexico	INIFAP - Mexico	**Long- term collection (30 + years)**	-20	15 - 20	Aluminum foil	500	90%	45.3
		Medium-term collection (until 30 years)	0 - 5	45	Aluminum foil & glass	1000 seeds	80%	168
		Short-term collection (until 10 years)	enviroment	enviroment	papers	500	60 - 70	400
Mexico	INIFAP - Oaxaca	**Long- term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	4	40	Plastic boxes	300 - 3000 g.	>70	64
Netherland	Centre for Genetic Resources the Netherlands	**Long- term collection (30 + years)**	-20	not controlled	Aluminium foil	2000	> = 80%	3
		Medium-term collection (until 30 years)	4	not controlled	Aluminium foil	600	initial > = 80%	2
		Short-term collection (until 10 years)	***	***	***	***	***	***
Nigeria	IITA	**Long- term collection (30 + years)**	-20	not applicable	Aluminium foil	250 seeds	70-100%	483
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	5	25	Plastic Jar	variable	70-100%	755
Pakistan	Plant Genetic Resources Programme Nat. Agric. Res. Center	**Long- term collection (30 + years)**	-20	NS*	Aluminum foil	20 gram	Above 90%	NS*
		Medium-term collection (until 30 years)	5	NS*	Aluminum foil	200 g	Above 90%	NS*
* Non specified		**Short-term collection (until 10 years)**	10	NS*	Plastic bottle	500 g	Above 90%	NS*
Paraguay	CRIA	**Long- term collection (30 + years)**	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*
Peru	Universidad Nacional Agraria La Molina	**Long- term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	5 -10	40	Glass & cans	1 - 10 kg	60%	168
Romania	Agricultural Research and Development Institute	**Long- term collection (30 + years)**	-18	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	-3	≈75 – 80%	NS*	500 grams	>85%	NS*
* Non specified		**Short-term collection (until 10 years)**	4	0.75	NS*	NS*	NS*	NS*
Romania	Suceava Genebank	**Long- term collection (30 + years)**	-20	not controlled (5% seed moisture)	Aluminum foil	600 seeds	85 - 100%	85
		Medium-term collection (until 30 years)	4	not controlled (6-8% seed moisture)	Glass jars	700 -10000 seeds	85 - 100%	303
		Short-term collection (until 10 years)	***	***	***	***	***	***
Romania	Agricultural Research and Station TURDA	**Long- term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	10	30 - 40%	Plastic / metal boxes	1 - 3kg	80 - 100%	200
Slovak Republic	Gene Bank, Research Inst. of Plant Production	**Long- term collection (30 + years)**	-17	5 - 6%	Glass jars	NS*	80 - 100%	NS*
		Medium-term collection (until 30 years)	4	NS*	Glass jars	NS*	80 - 100%	NS*
* Non specified		**Short-term collection (until 10 years)**	***	***	***	***	***	***
Spain	Misión Biológica de Galicia (CSIC)	**Long- term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	2	65	Paper envelops	1000 Seed	70	80
Sri Lanka	Plant Genetic Resources Centre	**Long- term collection (30 + years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	1	0.25	Tin cans	150g	85%	NS*
* Non specified		**Short-term collection (until 10 years)**	5	0.25	Aluminium foil	600g	0.85	NS*
Sweden	Nordic Gene Bank	**Long- term collection (30 + years)**	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
		Medium-term collection (until 30 years)	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
* Non specified		**Short-term collection (until 10 years)**	***	***	***	***	***	***

Country	Institution	Seed storage category	Storage temp. (°C)	Storage humidity (% RH)	Type of container	Initial storage quantity	Seed viability (%)	Storage size (m^3)
Sweden	Nordic Gene Bank	**Long-term collection (30+ years)**	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
		Medium-term collection (until 30 years)	-18	NS*	Aluminum foil	NS*	85 - 100%	NS*
* Non specified		**Short-term collection (until 10 years)**	***	***	***	***	***	***
Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.	**Long-term collection (30+ years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	***	***	***	***	***	***
		Short-term collection (until 10 years)	5	60 - 70%	Plastic bottle	0.5 - 1kg	80 - 100%	35
Turkey	Aegean Agricultural Research Institute	**Long-term collection (30+ years)**	-18	not controlled	Aluminium foil	Variable	80 - 100%	191
		Medium-term collection (until 30 years)	0	not controlled	Aluminium foil	Variable	80 - 100%	268
		Short-term collection (until 10 years)	4	not controlled	Aluminium foil	Variable	90 - 100%	41
Ukraine	NCPGRU	**Long-term collection (30+ years)**	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*
Uruguay	INIA	**Long-term collection (30+ years)**	-20	NS*	Aluminum foil	NS*	NS*	NS*
		Medium-term collection (until 30 years)	-20	NS*	Aluminum foil	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	-20	NS*	NS*	NS*	NS*	NS*
USA	North Central Regional Plant Introduction Station, ARS, USDA	**Long-term collection (30+ years)**	***	***	***	***	***	***
		Medium-term collection (until 30 years)	4	0.25	Plastic jars (3.8 liters)	20,000 Seeds	85 - 100%	
		Short-term collection (until 10 years)	***	***	***	***	***	***
Venezuela	Inst . Nac . de Invest . Agrí .(INIA -CENIAP)	**Long-term collection (30+ years)**	-18	0.65	Aluminum foil	1200	0.85	400
		Medium-term collection (until 30 years)	5	45	Glass jars	1200	0.85	500
* Non specified		**Short-term collection (until 10 years)**	16	45	Metal cans	3000	85	100
Yugoslavia	Maize Research Institute "Zemun Polje"	**Long-term collection (30+ years)**	NS*	NS*	NS*	NS*	NS*	NS*
		Medium-term collection (until 30 years)	NS*	NS*	NS*	NS*	NS*	NS*
* Non specified		**Short-term collection (until 10 years)**	NS*	NS*	NS*	NS*	NS*	NS*

APPENDIX 9: Summary of the questionnaire on seed exchange policy and information databases

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Argentina	INTA	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager (x) Other*( ): MSc Marcelo Edmundo Ferrer	
		Are accessions duplicated elsewhere	Yes ³(x) No ( ) If yes, where: Base Bank Castelar Argentina, CIMMYT, NCGRP Fort Collins (EEUU)	
		Seed shipment **-No of landrace accessions for which seed are available upon request** **-Seed quantity available for a single routine request** **-Cost of seed** **-Cost of shipment**	Seed accessions available (x) Not available (x) certain materials are restricted in their portfolio No: 1300 Number or weight (g): 100-150 seeds Free (x) Charge (x) private institutions may be charged Free (x) Charge (x) Private institutions may be charged	
		MTA used/required	Used (x) Not used ( )	MLS (x) Bilateral (x) Other ( ) specify: Se utiliza MLS cuando Argentina Ratifique el Tratado
Australia	Australian Tropical Crops & Forages Germplasm Collection	**An accession database**	Used (√) Not used ( )	Updated (√) Not updated ( )
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager (√) Other *( ): Peter Lawrence	
		Are accessions duplicated elsewhere	Yes ³( ) No (√) If yes , where :	
		Seed shipment **-No of landrace accessions for which seed are available upon request** **-Seed quantity available for a single routine request** **-Cost of seed** **-Cost of shipment**	Seed accessions available (√) Not available ( ) No: all (103) Number or weight (g): Free (√) Charge ( ) Free (√) Charge ( )	
		MTA used/required	Used ( ) Not used (√)	MLS (√) Bilateral ( ) Other ( ) specify :
Austria	Austrian Agency for Health and Food Safety	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager (x) Other*( ): Paul Freudenthaler Dipling Head Wolfgang Kainz Ing Curator	
		Are accessions duplicated elsewhere	Yes ³( ) No (x) If yes where:	
		Seed shipment **-No of landrace accessions for which seed are available upon request** **-Seed quantity available for a single routine request** **-Cost of seed** **-Cost of shipment**	Seed accessions available (x) Not available ( ) No: 21 Number or weight (g): 10g Free (x) Charge ( ) Free ( ) Charge (x)	
		MTA used/required	Used (x) Not used ( )	MLS (x) Bilateral ( ) Other ( ) specify:
Bolivia	Centro de Investigación Fitoecogenética de Pairumani	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager ( ) Other*(x): The director of the center Gonzalo Avila Director	
		Are accessions duplicated elsewhere	Yes ³(x) No ( ) If yes where: CIMMYT and NSSL	
		Seed shipment	Seed accessions available ( ) Not available (x)	Bolivia only signed the International Treaty on Plant Genetic Resources for Food and Agriculture
Brazil	Embrapa Milho e Sorgo	**An accession database**	Used (X) Not used ( ) Passport data	Updated (X) Not updated ( )
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager ( ) Other*(X): Dr Ivan Cruz - General Manager of Embrapa Maize and Sorghum	
		Are accessions duplicated elsewhere	Yes ³(X) No ( ) If yes where: Embrapa Genetic Resources and Biotechnology and CIMMYT	
		Seed shipment **-No of landrace accessions for which seed are available upon request** **-Seed quantity available for a single routine request** **-Cost of seed** **-Cost of shipment**	Seed accessions available (X) Not available ( ) No: 3285 (Landraces except indigenous varieties, composites formed from landraces improved varieties) Number or weight (g): 100-200 seeds (60-100g) Free (X) Charge ( ) Free (X) Charge ( )	
		MTA used/required	Used (X) Not used ( )	MLS ( ) Bilateral ( ) Other (X) specify: AMTA is required and follow a template for all the requests
Chile	Instituto de Investigaciones Agropecuarias	**An accession database**	Used X Not used ( )	Updated X Not updated X
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager X Other*X: ERIKA SALAZAR HEAD GENETIC RESOURCES UNIT LA PLATINA IVETTE SEGUEL COORDINATOR NAS NATIONAL GENETIC RESOURCES PROGRAM	
		Are accessions duplicated elsewhere	Yes ³X No X If yes where: BASE BANK OF CHILE, CIMMYT AND NCGRP	
		Seed shipment **-No of landrace accessions for which seed are available upon request** **-Seed quantity available for a single routine request** **-Cost of seed** **-Cost of shipment**	Seed accessions available (X) Not available No: NOT DEFINED Number or weight (g): 50 SEEDS Free ( ) Charge ( ) NOT DEFINED Free ( ) Charge ( ) NOT DEFINED	
		MTA used/required	Used X Not used ( )	MLS ( ) Bilateral X Other ( ) specify:
China	Institute of Crop Science _ CAAS	**NON SPECIFIED DATAS**		
Colombia	CORPOICA	**An accession database**	Used ( ) Not used (X)	Updated ( ) Not updated (X)
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager ( ) Other*(X): MINISTERIO DEL MEDIO AMBIENTE - MINISTERIO DE AGRICULTURA INSTITUTO COLOMBIANO AGROPECUARIO - ICA	
		Are accessions duplicated elsewhere	Yes ³(x) No ( ) If yes where: NCGRP Fort Collins Co USA.	Safety duplicates at NCGRP is about 80%
		Seed shipment **-No of accessions for which seed are available upon request** **-Seed quantity available for a single routine request** **-Cost of seed** **-Cost of shipment**	Seed accessions available ( ) Not available (X) Free ( ) Charge ( ) Free ( ) Charge ( ):	
		MTA used/required	Used (x) Not used ( ):	
Costa rica	CATIE	**An accession database**	Used (X) Not used ( )	Updated (X) Not updated ( )
		Who authorizes the shipment? **Name 1 and title:** **Name 2 and title:**	Collection manager ( ) Other*(X) Head PGR group Andreas Ebert Head PGR group	
		Are accessions duplicated elsewhere	Yes ³( ) No (X) If yes where:	
		Seed shipment **-No of landrace accessions for which seed are available upon request** **-Seed quantity available for a single routine request** **-Cost of seed** **-Cost of shipment**	Seed accessions available ( ) Not available (X) No original samples have not been regenerated yet Number or weight (g): Free (X) Charge ( ) Free ( ) Charge (X)	
		MTA used/required	Used (X) Not used ( )	MLS (X) Bilateral ( ) Other ( ) specify:

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Czech Republic	RICP Prague-Ruzyne	**An accession database**	Used (x) Not used ( )	Updated ( ) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Vera Chytilova	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] ( ) No (x) If yes, where:	
		Seed shipment	Seed accessions available(x) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.:	
		- Seed quantity available for a single routine request	Number or weight (g):about 100 seeds	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x) Charge ( )	
		MTA used/required	Used (x) Not used ( )	MLS ( ) Bilateral( ) Other ( ) specify:
Czech Republic	Research Institute of Crop Production of Prague	**An accession database**	Used (X) Not used ( )	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager (X) Other* (X): Head of gene bank	
		Name 1 and title:	Zdenek Stehno	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] (partially) No ( ) If yes, where: RIPP Piestany, Slovakia	
		Seed shipment	Seed accessions available(X) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.:95	
		- Seed quantity available for a single routine request	Number or weight (g): 50 seeds maximum	
		- Cost of seed	Free (X) Charge ( )	
		- Cost of shipment	Free (X) Charge ( )	
		MTA used/required	Used (X) Not used ( )	MLS (X) Bilateral( ) Other ( ) specify:
Ecuador	INIAP-DENAREF	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* (x):	
		Name 1 and title:	Dr. Julio Cesar Delgado (Director INIAP)	
		Name 2 and title:	Ing. Abel Viteri Echanique (Director SESA)	
		Are accessions duplicated elsewhere	Yes[3] (x) No ( ) If yes, where: CIMMYT	
		Seed shipment	Seed accessions available(x) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.: 500	
		- Seed quantity available for a single routine request	Number or weight (g): 100	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free ( ) Charge (x)	
		MTA used/required	Used (x) Not used ( )	MLS (x) Bilateral( ) Other ( ) specify:
France	Inst. Nat. de la Recherche Agronomique	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		* There is 3 different databases	The database	
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Anne ZANETTO	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] (x) No ( ) If yes, where: INRA and commercial freezers	
		Seed shipment	Seed accessions available(x) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.: 558	
		- Seed quantity available for a single routine request	Number or weight (g): 600 kernels for populations 50 kernels for lines	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x) Charge ( )	
		MTA used/required	Used (x) Not used ( )	MLS ( ) Bilateral( ) Other (x) specify: French network and more or less on the MLS
Georgia	Non specified	**An accession database**	Used (X) Not used ( ) Passport data	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager (X) Other* ( ):	
		Name 1 and title:	Zurab Jinjikhadze - Charge of Maize collection at the Institute	
		Name 2 and title:	Tinatin Koshadze _Maize Curator in PGR Genebank	
		Are accessions duplicated elsewhere	Yes[3] ( ) No (X) If yes, where:	
		Seed shipment	Seed accessions available( ) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.:	
		- Seed quantity available for a single routine request	Number or weight (g):	
		- Cost of seed	Free ( ) Charge ( )	
		- Cost of shipment	Free ( ) Charge ( )	
		MTA used/required	Used ( ) Not used (X)	MLS ( ) Bilateral( ) Other ( ) specify:
Guatemala	Instituto de Ciencia y Tecnología Agrícolas (ICTA)	**NON SPECIFIED DATAS**		
India	National Bureau of Plant Genetic Resources	**An accession database**	Used (√) Not used ( )	Updated (√) Not updated ( )
		Who authorizes the shipment?	Collection manager ( ) Other *(√):	
		Name 1 and title:	Director, NBPGR	
		Name 2 and title:	Secretary, Department of Agriculture Research and Education	
		Are accessions duplicated elsewhere	Yes[3] ( ) No ( ) If yes, where:	
		Seed shipment	Seed accessions available(5855) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.: 1285	
		- Seed quantity available for a single routine request	Number or weight (g): 50acc., 5g	
		- Cost of seed	Free (√) Charge ( )	
		- Cost of shipment	Free (√) Charge ( )	
		MTA used/required	Used (√) Not used ( )	MLS (√) Bilateral ( ) Other ( ) specify :
Indonesia	ICABIOGRAD	**NON SPECIFIED DATAS**		
Kenya	Kenya Agricultural Research Inst. Nat. Genebank of Kenya	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Mr. Z.K. Muthamia	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] ( ) No (x) If yes, where:	
		Seed shipment	Seed accessions available( ) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.: 1,116	
		- Seed quantity available for a single routine request	Number or weight (g): 20-100 seeds	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free ( ) Charge (x)	
		MTA used/required	Used (x) Not used ( )	MLS ( ) Bilateral(x) Other ( ) specify:

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Mexico	CIMMYT, INT	**Are accessions on database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Dr Suketoshi Taba	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (x) No ( ) If yes, where NCGRP Fort Collins CO USA and the cooperator banks in Latin America	Safety duplicates at NCGRP is about 80%
		Seed shipment	Seed accessions available (x) Not available ( )	
			Seed requests are honored by seed availability and FAO's joint statement for the designated germplasm.	
		-No of accessions for which seed are available upon request	No 25487 landrace CIMMYT derived across several Teosinte across several Tripsacum acc)	
		-Seed quantity available for a single routine request	Number or weight (g): 100 seeds (30-50g)	10-50 seeds available for wild species and inbreds
		-Cost of seed	Free (x) Charge ( )	
		-Cost of shipment	Free (x) Charge (x) Private institutions usually charged	
		MTA used required	Used (x) Not used ( ) MTA for designated (in-trust collection landrace and wild species and others) and non-designated (CIMMYT deriv.	MLS (x) Bilateral ( ) Other ( ) specify:
Mexico	INIFAP-Mexico	**Are accessions on database**	used (X) not used ( )	updated (X) not updated ( )
		Who authorizes the shipment?	Collection manager ( ) other* (X):	
		Name 1 and title:	Dr Pedro Brajcich Gallegos Director de INIFAP	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (X) no ( ) If yes, where CIMMYT	
		Seed shipment	seed accessions available (X) not available ( ) by policy	
		-No of landrace accessions for which seed are available upon request:	N° (5000 accesiones de landrace)	
		-Seed quantity available for a single routine request	number or weight (g): 100 semillas	
		-Cost of seed	free (X) charged ( )	
		-Cost of shipment	free (X) charged ( )	
		MTA used required	used (X) not used ( )	MLS (X) bilateral ( ) Other ( ) specify:
Mexico	INIFAP-Oaxaca	**Are accessions on database**	Used (X) Not used ( )	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager ( ) Other* (X):	
		Name 1 and title:	Dr. Eduardo Garrido Ramírez . Director Regional del Centro de Investigación Regional del Pacífico Sur . INIFAP	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (X) No ( ) If yes, where CIMMYT e INIFAP	
		Seed shipment	Seed accessions available (X) Not available ( )	
		-No of landrace accessions for which seed are available upon request	No 1000	
		-Seed quantity available for a single routine request	Number or weight (g): 100 semillas para colecciones originales En materiales sobresalientes puede proporcionarse 500 gramos	
		-Cost of seed	Free (X) Charge ( )	
		-Cost of shipment	Free ( ) Charge (X)	
		MTA used required	Used (X) Not used ( )	MLS (X) Bilateral ( ) Other ( ) specify:
Netherland	Centre for Genetic Resources the Netherlands	**Are accessions on database**	Used (X) Not used ( )	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager (X) Other* ( ):	
		Name 1 and title:	Drs Noor Bas curator	
		Name 2 and title:	Dr Chris Kik Head curator	
		Are accessions duplicated elsewhere	Yes [3] (X) No ( ) If yes, where DEU271 Genebank Inst for Plant Gen & Crop Plant Res (IPK) Malchow Germany	
		Seed shipment	Seed accessions available (x) Not available ( )	
		-No of landrace accessions for which seed are available upon request	No of accessions 285	
		-Seed quantity available for a single routine request	Number or weight (g): 100 seeds	
		-Cost of seed	Free (X) Charge ( )	
		-Cost of shipment	Free (X) Charge ( )	
		MTA used required	Used (X) Not used ( )	MLS (X) Bilateral ( ) Other ( ) specify:
Nigeria	IITA	**Are accessions on database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (=Interim Curator) Other* ( ):	
		Name 1 and title:	Dumet Dominique Interim genebank curator	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (x) No ( ) If yes, where Some are in CIMMYT already	
		Seed shipment	Seed accessions available ( ) Not available ( )	
		-No of landrace accessions for which seed are available upon request	No inventory Rejuvenation is presently performed	
		-Seed quantity available for a single routine request	Number or weight (g): 30 to 100 seeds depending on availability Exact number of available accessions not yet known	
		-Cost of seed	Free (x) Charge ( )	
		-Cost of shipment	Free (x) Charge ( )	
		MTA used required	Used (x) Not used ( )	MLS (x) Bilateral ( ) Other ( ) specify:
Pakistan	Plant Genetic Resources Programme Nat Agric Res Center	**Are accessions on database**	Used ( ) Not used ( ) **Non specified**	Updated ( ) Not updated ( )
		Who authorizes the shipment?	Collection manager (=Interim Curator) Other* ( ):	
		Name 1 and title:	Dr Zahoor Ahmad Programme Leader PGRP, NARC.	
		Name 2 and title:	Muhammad Afzal Senior Scientific Officer PGRP, NARC.	
		Are accessions duplicated elsewhere	Yes [3] ( ) No ( ) If yes, where: **Non specified**	
		Seed shipment	Seed accessions available ( ) Not available ( )	
		-No of landrace accessions for which seed are available upon request	507 accessions	
		-Seed quantity available for a single routine request	20-50 seeds	
		-Cost of seed	Free (x) Charge ( )	
		-Cost of shipment	Free ( ) Charge (x)	
		MTA used required	Used (x) Not used ( )	MLS (x) Bilateral ( ) Other ( ) specify:
Paraguay	CRIA	**NON SPECIFIED DATAS**		
Peru	Universidad Nacional Agraria La Molina	**Are accessions on database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager ( ) Other *(x): INIEA (Instituto Nacional de Investigación y Extensión Agraria)	
		Name 1 and title:	Head of the INIEA	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (x) No ( ) If yes , where : NSSL (USA), CIMMYT (México)	
		Seed shipment	Seed accessions available (x) Not available ( )	
		-No of landrace accessions for which seed are available upon request	No 3000	
		-Seed quantity available for a single routine request	Number or weight (g): 200	
		-Cost of seed	Free (x) Charge ( )	
		-Cost of shipment	Free ( ) Charge (x)	
		MTA used required	Used (x) Not used ( )	MLS (x) Bilateral (x) Other ( ) specify:
Romania	Agricultural Research and Development Institute	**Are accessions on database**	Used ( ) Not used ( ) **Non specified**	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Dr. Verzea Marian	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (x) No ( ) If yes, where: Suceava Genebank	105 accessions
		Seed shipment	Seed accessions available ( ) Not available ( )	
		-No of landrace accessions for which seed are available upon request	234 accessions	
		-Seed quantity available for a single routine request	100 seeds	
		-Cost of seed	Free ( ) Charge (x) $1/seed	
		-Cost of shipment	Free ( ) Charge (x)	
		MTA used required	Used ( ) Not used (x)	MLS ( ) Bilateral ( ) Other ( ) specify:

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Romania	Suceava Genebank	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager ( ) Other* (x):	
		Name 1 and title:	Dr. Sila Strajeru, director of Suceava Genebank	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] ( ) No (x)	
		Seed shipment	Seed accessions available (x) Not available ( )	
		- No. of accessions for which seed are available upon request	No.:2224 (landraces, inbreds)	
		- Seed quantity available for a single routine request	Number or weight (g): 100 seeds (30-50g) 50 seeds available for landraces, 10-50 seeds available for inbreds lines which are confidentials	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x) Charge ( )	
		MTA used/required	Used (x) Not used ( ): MTA for designated inbred lines	MLS (x) Bilateral ( ) Other ( ) specify:
Romania	Agricultural Research and Station TURDA	**An accession database**	Not used (x)	Not update(x)
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Dr. ing. IOAN HAS; Director of the Agricultural Research Station Turda, Romania	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] ( ) No (X)	
		Seed shipment	Seed accessions available (x)	
		- No. of accessions for which seed are available upon request	No. 311	
		- Seed quantity available for a single routine request	Number or weight (g): 100 seeds (30-50g)	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x)	
		MTA used/required	Used (x) Not used ( ): MTA for designated (in-trust collection: landrace and wild sp	MLS (x) Bilateral ( ) Other ( ) specify:
Slovak Republic	Gene Bank, Research Inst. of Plant Production	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Daniela Benedikova, PhD.	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] (x) No (x) If yes, where:	safety duplication in Praque, Czech.rep.
		Seed shipment	Seed accessions available (x) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.: 746	
		- Seed quantity available for a single routine request	Number or weight (g): 50-100 seeds	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x) Charge ( )	
		MTA used/required	Used (x) Not used ( )	MLS ( ) Bilateral ( ) Other ( ) specify:
Spain	Misión Biológica de Galicia (CSIC)	**An accession database**	Used (X) Not used ( )	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager (X) Other* ( ):	
		Name 1 and title:	Dr. Amando Ordás	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] (X) No ( ) If yes, where: CRF (Madrid)	
		Seed shipment	Seed accessions available (X) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	165 (Sxpanish landraces)	
		- Seed quantity available for a single routine request	Number or weight (g): 500 kernels (landraces) or 50 kernels (inbreds)	
		- Cost of seed	Free (X) Charge ( )	
		- Cost of shipment	Free (X) Charge ( )	
		MTA used/required	Used (X) Not used ( )	MLS (X) Bilateral ( ) Other ( ) specify:
Sri Lanka	Plant Genetic Resources Centre	**NON SPECIFIED DATAS**		
Sweden	Nordic Gene Bank	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:	Katarina Wedelsbäck Bladh	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] (x) No ( ) Saftey depost Svalbard	
		Seed shipment	Seed accessions available (x) Not available ( )	
		- No. of accessions for which seed are available upon request		7
		- Seed quantity available for a single routine request	250 seeds	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x) Charge ( ):	
		MTA used/required	Used (x) Not used ( ):	MLS (x) Bilateral ( ) Other ( ) specify:
Thailand	National Corn and Sorghum Research Center, Kasetsart Univ.	**An accession database**	Used ( ) Not used (x)	Updated ( ) Not updated (x)
		Who authorizes the shipment?	Collection manager (x) Other* ( ):	
		Name 1 and title:		
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes[3] ( ) No (x) If yes, where:	No
		Seed shipment	Seed accessions available (x) Not available ( )	
		- No. of landrace accessions for which seed are available upon request	No.: improved populations	
		- Seed quantity available for a single routine request	Number or weight (g): 100-200 seeds	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x) Charge (x) private institutions usualy charged	
		MTA used/required	Used ( ) Not used (x) we will use MTA in the future.	MLS (x) Bilateral ( ) Other ( ) specify:
Turkey	Aegean Agricultural Research Institute	**An accession database**	Used (x) Not used ( )	Updated (x) Not updated ( )
		Who authorizes the shipment?	Collection manager (x) Other* (Genebank Manager):	
		Name 1 and title:	Dr. A. Ertug Firat	
		Name 2 and title:	Dr. Ayfer Tan	
		Are accessions duplicated elsewhere	Yes[3] (x) No ( ) If yes, where: Partly duplicated in Central Research Institute for Field Crops (CRIFC)-Ankara	
		Seed shipment	Seed accessions available (x) Not available ( ) Seed requests are sent depending on seed availability for distribution and the statements in Transfer Agreement Form.	
		- No. of accessions for which seed are available upon request	No.:1,587 (landrace, composite varieties and, parents of hybrid varieties improved in Turkey)	
		- Seed quantity available for a single routine request	Number of weight (g): 100 seeds (30-50 gr)	
		- Cost of seed	Free (x) Charge ( )	
		- Cost of shipment	Free (x) Charge ( )	
		MTA used/required	Used (x) Not used ( ):	
Ukraine	NCPGRU	**NON SPECIFIED DATAS**		

Country	Institution	Seed exchange function	Handling seed requests/shipments	Seed inventory/paperwork
Uruguay	INIA	**An accession database**	Used (X) Not used ( )	Updated ( ) Not updated (X)
		Who authorizes the shipment?	Collection manager (X) Other* ( ):	
		Name 1 and title:	Dr. Federico Condon	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (X) No ( ) If yes, where: INTA: many also at CIMMYT	
		Seed shipment	Seed accessions available( ) Not available (X)	
		-No. of landrace accessions for which seed are available upon request	852 landraces	
		-Seed quantity available for a single routine request	Number or weight (g):100 seeds standard; exceptions considered	
		-Cost of seed	Free ( ) Charge ( )	
		-Cost of shipment	Free ( ) Charge ( )	
		MTA used/required	Used ( ) Not used ( )	MLS ( ) Bilateral ( ) Other ( ) specify:
USA	North Central Regional Plant Introduction Station, ARS, USDA	**An accession database**	Used (X) Not used ( )	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager (X) Other* ( ):	
		Name 1 and title:	Mark Millard, Maize Geneticist, USDA, ARS	
		Name 2 and title:		
		Are accessions duplicated elsewhere	Yes [3] (X) No ( ) If yes, where: NCGRP, Ft. Collins, CO; many also at CIMMYT	
		Seed shipment	Seed accessions available(X) Not available ( )	
		-No. of landrace accessions for which seed are available upon request	No.:12,000 of all types	
		-Seed quantity available for a single routine request	Number or weight (g):100 seeds standard; exceptions considered	
		-Cost of seed	Free (X) Charge ( )	
		-Cost of shipment	Free (X) Charge ( )	
		MTA used/required	Used ( ) Not used (X)	MLS ( ) Bilateral ( ) Other ( ) specify:
USA	NCGRP	**An accession database**	Used (X) Not used ( ) - GRIN + inhouse	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager (X) Other* (X):	
		Name 1 and title:	Dave Ellis, NCGRP Curator and Program Coordinator	
		Name 2 and title:	*Marck Millard, NPGS Maize Curator, Ames Iowa	
		Are accessions duplicated elsewhere	Yes [3] - Ames primarily, but also CIMMYT and other genebanks in other countries	
		Seed shipment	# Maize accessions held at NCGRP	Available from
		National Plant Germplasm System	13, 621 - NPGS active collection	Ames, IA
			3710 - Genetic Stocks	Urbana Illinois
			176 - NCGRP-only	Fort Collins, CO
			4979 - restricted distribution (PVVP, Crop Science, Quarantine, collections)	Not currently publically available from NPGS
		Safety Back-up	6069 - held under MTA	Not currently publically available from NPGS
		Maize regeneration (in part from MOU & CIMMYT)	> 21,000	CIMMYT, NPGS, ?
		Total Maize accessions at NCGRP	49, 582	
Venezuela	Inst . Nac . de Invest . Agrí .(INIA - CENIAP)	**An accession database**	Used (X) Not used ( )	Updated (X) Not updated ( )
		Who authorizes the shipment?	Collection manager (X) Other* (X):	
		Name 1 and title:	Víctor Segovia (Curator)	
		Name 2 and title:	Prudencio Chacón (Presidente del INIA)	
		Are accessions duplicated elsewhere	Yes [3] (X) No ( ) If yes, where: CIMMYT	
		Seed shipment	Seed accessions available(X) Not available ( )	
		-No. of landrace accessions for which seed are available upon request	No.: 200	
		-Seed quantity available for a single routine request	Number or weight (g): 500	
		-Cost of seed	Free ( ) Charge ()	
		-Cost of shipment	Free ( ) Charge (X)	
		MTA1 used/required	Used (X) Not used ( )	MLS2 (X) Bilateral ( ) Other ( ) specify:
Yugoslavia	Maize Research Institute "Zemun Polje"	**NON SPECIFIED DATAS**		

APPENDIX 10: Standards for medium- and long-term storage

Medium-term storage for maize is generally considered to be +5°C and relative humidity of 25%. Long-term storage is usually -20° C in hermetically sealed bags, cans or bottles. Almost as important as storage conditions are seed-handling and drying procedures prior to storage. Drying temperatures in excess of 36^{o} C or conditions that promote fungal growth can both reduce subsequent germination significantly. The latter have a particularly severe effect on soft-kernelled floury maize. Perhaps even more important are functioning back-up generators to cover gaps in electrical service. The quantities of seed needed per accession varies from 1 kg per accession for most accessions to 3 to 5 kg for typical or core accessions.

For an example, at CIMMYT maize bank, the seeds are dried at 10^{0}C and 25%RH. Medium term storage is at -3^{0} C and 25%RH; long term conservation is at -18^{0} C. The seed moisture contents can be 6-8% in equilibrium with the drying conditions after 6-8 weeks. Seed is packed in laminated aluminum foil packets that can contain about 1 kg (1,000-2,500 seeds). The packages are hermetically sealed and two packets are prepared for regeneration using long-term conservation; one of these serves as a safety duplicate at another location. For active medium term conservation, one-gallon plastic airtight containers holding 2-3 kg (5,000-10,000 seeds) are used. No fungicides or insecticides are used for seed storage, except in cases where incoming seeds underwent seed treatment required by quarantine regulations. The first monitoring of seed viability is conducted after ten years of storage in the active collection, then after every five years as recommended by Genebank Standards (FAO/IPGRI, 1994) which is available at the website of Bioversity International (www.bioversityinternational.org). If the seed viability falls below 85% or the number of the seeds gets below 1500 in the active collection, the accession is regenerated or multiplied. The seed for regeneration is prepared from the base collection. As much as possible, 100 or more ears are used for the new set of seed.

APPENDIX 11: Acronyms used in this document

Acronym	Name
Bioversity	Bioveristy International, Rome, Italy, previously IPGRI
CGIAR	Consultative Group on International Agricultural Research, Washington, DC
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Texcoco, Mexico
CML	CIMMYT Maize Line
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Brasília, DF - Brasil
GEM	Germplasm Enhancement of Maize, Ames, IA and Raleigh, NC, USA
GMO	Genetically Modified Organism
GPWG	Grass Phylogeny Working Group
GRAMENE	Comparative Grass Genomics, Cold Spring Harbor, NY, USA
GRIN	Germplasm Resources Information Network, Beltsville, MD, USA
IBPGR	International Board for Plant Genetic Resources, Replaced by Bioversity International
ICTA	Instituto de Ciencia y Technologia Agricloas, Barcenas, Guatemala
IRRI	International Rice Research Institute, Manilla
IITA	International Institute for Tropical Agriculture, Ibadan, Nigeria
INIA	Instituto Nacional de Investigación Agraria, Lima, Peru
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico City
IPGRI	International Plant Genetic Resources Institute now Bioversity Internatnional
LAMP	Latin American Maize Project
MAIZEGDB	Maize Genetics and Genomics Database, Ames, IA, USA
MTA	Material Transfer Agreement
NAFTA	North American Free Trade Agreement
NARS	National Agricultural Research Centers
NCGRP	National Center for Genetic Resources Preservation, Ft. Collins, Colorado, USA
NCRPIS	North Central Regional Plant Introduction Station, Ames, Iowa, USA
NPGS	National Plant Germplasm System, Beltsville, MD, USA
SINGER	System-wide Information Network for Genetic Resources, Rome
SPS	Sanitary and Phytosanitary Standards
USDA-ARS	United States Department of Agriculture-Agricultural Research Service, Washington, DC
WTO	World Trade Organization, Geneva