Bioversity International

Ex Situ Conservation of Plant Genetic Resources

Training Module

Sildana Jaramillo and Margarita Baena

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Foreword

Plant genetic resources form the basis on which humankind subsists. They provide basic needs and help solve problems such as hunger and poverty. However, they are being lost, mainly through inappropriate use and destruction of habitat. Given their vital importance, we must conserve them for the benefit of both present and future generations.

Plant genetic resources can be conserved within or outside their natural habitats, or by combining the two alternatives. Outside their natural habitats, plant genetic resources are conserved in germplasm collections and genebanks, going through different stages and procedures that require trained staff. To help train personnel in managing genebanks, Bioversity International has developed this teaching manual as part of a collaborative project with Spain to promote the training and research of plant genetic resources in Latin America.

The text trains users in the fundamental aspects of *ex situ* conservation of plant genetic resources, that is, from collecting to germplasm use. It explains principles and describes the procedures needed for effective *ex situ* conservation. It also includes bibliographic references and examples that illustrate how to move from theory to practice.

By developing and making this material available to users, Bioversity International hopes to significantly contribute to the training of technicians in plant genetic resources, thereby making them more efficient in *ex situ* conservation and germplasm use.

Ramón Lastra, Honorary Fellow
and former Regional Director, IPGRI Americas Group

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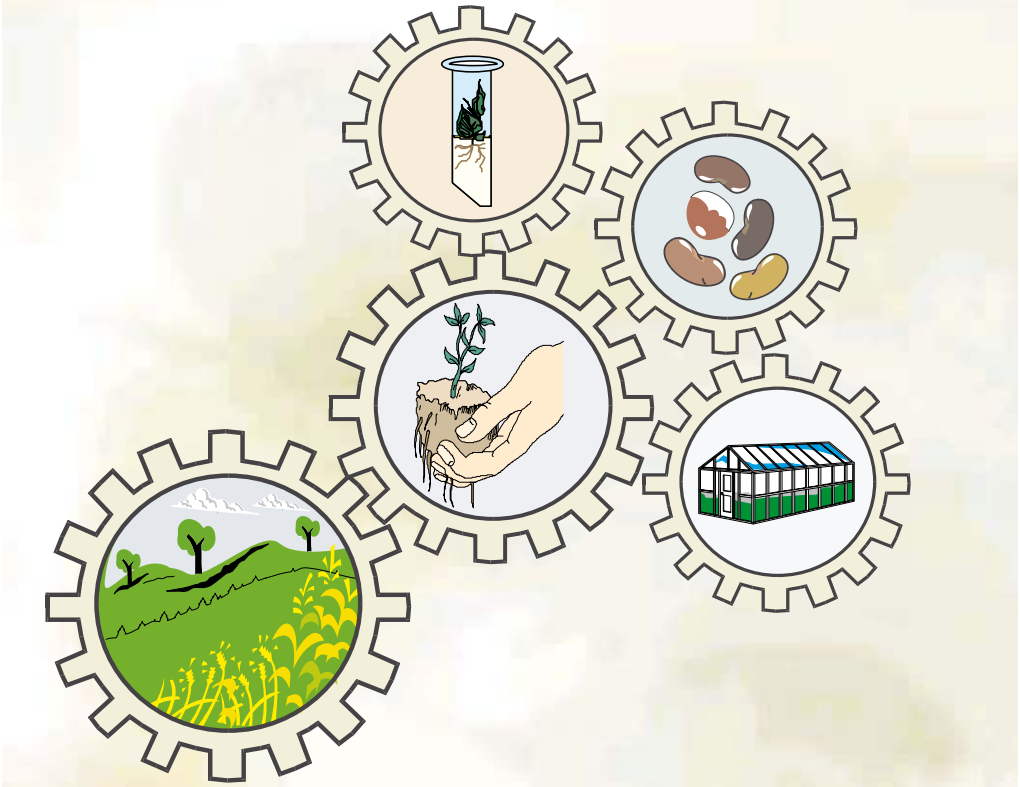
Ex Situ Conservation of Plant Genetic Resources



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I. Objectives

To study the alternatives and methods
for conserving plant genetic resources *ex situ*

On completing this module, the student will:

- be familiar with the purposes, methods and strategies used to conserve plant genetic resources *ex situ*
- know the various alternatives for conserving plant genetic resources *ex situ* (what to conserve, what type of samples and under what conditions)
- know the procedures for handling the conserved germplasm and the responsibilities inherent in managing a germplasm collection
- know the different types of collections and the purposes for which they are established

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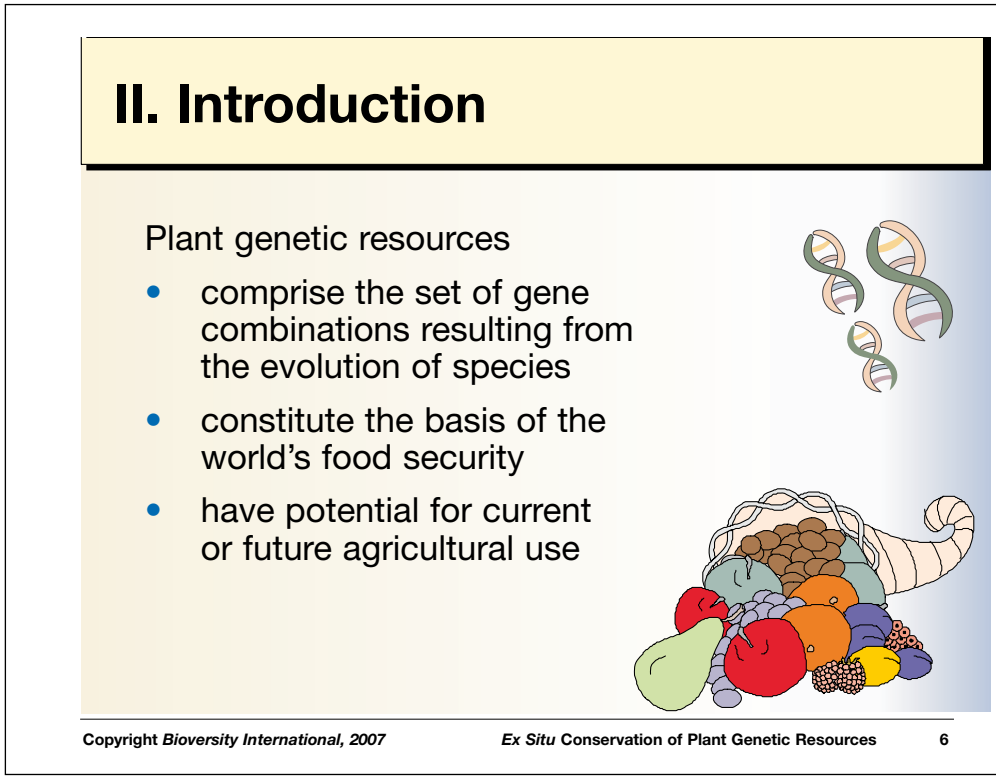


II. Introduction

A. Plant genetic resources

The human species depends on plants. These constitute the basis for food, supply most of our needs (including clothes and shelter) and are used in industry for manufacturing fuels, medicines, fibres, rubber and other products. However, the number of plants that humans use for food is minimal, compared with the number of species existing in nature. Only 30 crops, the most outstanding of which are rice, wheat and maize, provide 95% of the calories needed in the human diet (FAO 1998). Such dependency on so limited a number of crops threatens the food security[1] of humankind (Valois 1996).

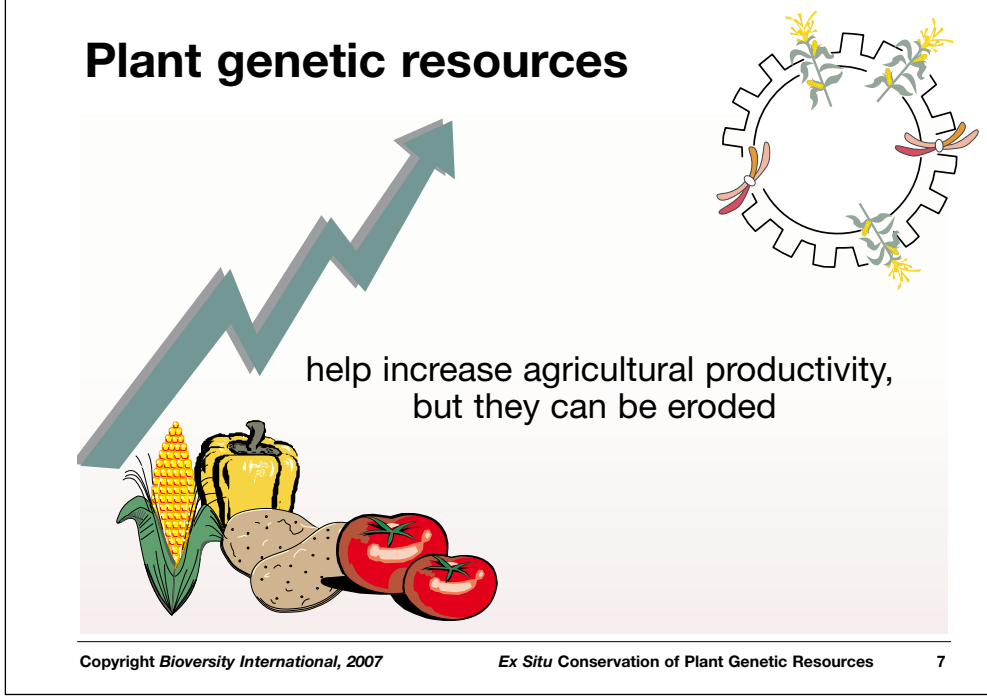
Plant genetic resources are currently of great interest inasmuch as they are related to the satisfaction of man's basic needs and to the solution of severe problems such as hunger and poverty. About 800 million people suffer from malnutrition, including 200 million children under the age of 5. The world's population is expected to increase from more than 6.1 billion in 2001 to 9.3 billion in 2050 (UNFPA 2001). To fulfill the demand for food by so many people, crop yields will need to be improved in an efficient and sustainable way (FAO 1996a, b, c).

Humans need to add to their diet those crops of high yield and quality that can adapt to environmental conditions and resist pests and diseases. Advantage must be taken of native and exotic species, with nutritional or industrial potential, or new varieties must be developed. Improving crops, however,

[1] For definitions of the underlined terms, see Appendix 10 (Glossary).

requires reserves of genetic materials whose conservation, management and use have barely begun to receive the attention that they deserve.

Plant genetic resources are the total of all the combinations of genes resulting from the evolution of a species. They include all those on the continuum from wild species with agricultural potential to cloned genes (Hidalgo 1991). The term genetic resources implies that the material (or germplasm) has or can have economic or utilitarian value, whether current or future, the most important being that which contributes to food security (IBPGR 1991). Humans take advantage of plant genetic resources inasmuch as they are useful to us, which means that we must understand them, and know how to manage, maintain and use them rationally.

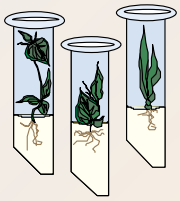


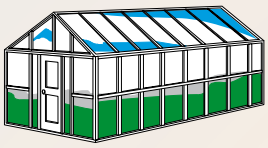
Plant genetic resources permit the development of resistant, productive and high-quality crops. They help nations increase their agricultural productivity and sustainability, and even the nations' economic development. However, despite contributing towards people's food supply as well as poverty relief, plant genetic resources are vulnerable; they can erode and disappear, endangering the continuity of our species. The loss of plant genetic resources is called genetic erosion.

Paradoxically, both the use and loss of plant genetic resources depend on human intervention. Population increase, industrialization and expansion of the agricultural frontier contribute to genetic erosion. To these are added the adoption of elite germplasm and the modification and/or destruction of centres of genetic diversity. This loss of plant genetic resources shows the urgent need for conserving them and using them sustainably.

Plant genetic resources are conserved

- for their current or future usefulness
- within or outside their natural habitats
- ideally, in a complementary manner



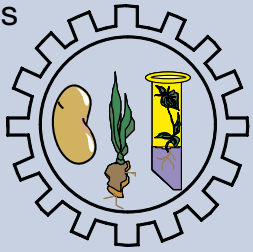


B. Conserving plant genetic resources

Plants are conserved according to their current or future usefulness to humans. Plant genetic resources can be conserved in their natural habitats (i.e. *in situ*), in conditions different from those of their natural habitats (i.e. *ex situ*) or in a combination of *in situ* and *ex situ* methods, that is, in complementarity. The selection of one or more methods depends on needs, possibilities and targeted species.

Conservation requires

- planning and continuity
- knowledge of targeted species and of how they are maintained
- sufficient and constant resources
- continuous institutional support



Conservation: a continuous and strategic process

Conservation of plant genetic resources is a continuous, long-term task that implies significant investments in time, personnel, installations and operation, which must be justifiable in terms of needs, not of desire or convenience of conserving a material. Reasons for conservation and species objectives should be defined in terms of logical, scientific and economic criteria, such as the need for, and the value and use of a given species, and the feasibility of conserving it (Maxted *et al.* 1997a, b).

Conservation leads to maximum benefit when the activities that comprise it are closely linked. The task's success will be measured in terms of producing the desired result at the lowest cost.

Requirements for conservation

As in any strategic process, the conservation of plant genetic resources implies planning and decision-making. For conservation, priorities need to be established with regard to (1) *the type of material* to be conserved ('at-risk' species or those of interest to food and agriculture), (2) *the activities* that are to be conducted afterwards, and (3) *the resources available* for carrying out these activities. Priorities may vary but those of conservation and germplasm use are the most important objectives.

The conservation strategy adopted should reduce, as much as possible, the effects of the new environment on the targeted species. Those responsible for conserving germplasm should know the species' taxonomy and the techniques for obtaining representative genetic variability and conserving the stability of the original genotype. Information such as passport data, characterization and evaluation should also be obtained (Cuevas 1988).

The facilities for conserving the material must guarantee isolation as much from environmental factors as from pests and diseases. Facilities can vary in design and dimensions, depending on the number and size of the samples being conserved, but they must have a constant supply of electric energy and equipment that permit the conditioning, conservation and regeneration of materials. They should also protect the germplasm from fires, floods, theft, pillage and public disorder.

The management of collections of plant genetic resources should be the responsibility of skilled personnel, who come, where possible, from various disciplines (physiologists, botanists, breeders and agronomists) and who know the technical aspects and safety procedures inherent in their tasks. Ideally, the collection is looked after by a group of people – not just the curator – whose stable employment history can give continuity to the conservation work, and who are not subject to political pressure or public disorder.

Merely creating a genebank does not guarantee the conservation of the genetic resources of interest to a country. Conservation requires institutional support, meaning, ongoing support in terms of the economic, human and technical resources needed for maintaining the collections and carrying out conservation activities.

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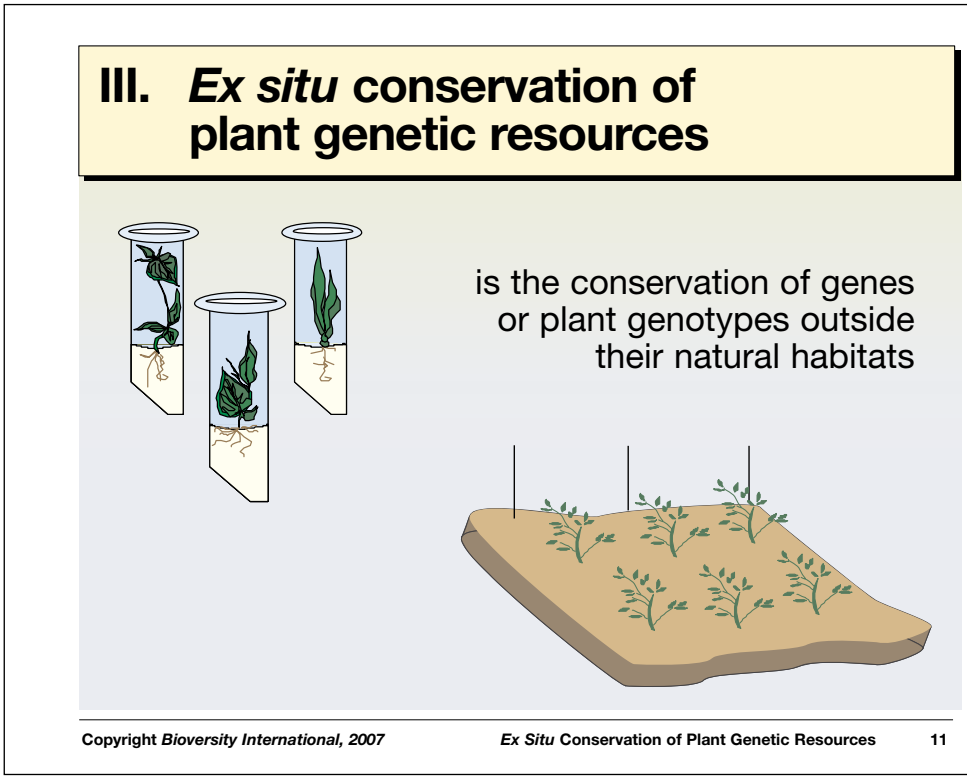

III. Defining *ex situ* conservation

Ex situ conservation is the conservation of genes or plant genotypes outside their environment of natural occurrence, for current or future use (Hoyt 1988, cited by Engle 1992). *Ex situ* conservation belongs to that important set of activities which comprise the management of the plant genetic resources. It complements *in situ* conservation inasmuch as *ex situ* conservation of all species is not possible.

Ex situ conservation encompasses a broad taxonomic spectrum. It can be used to protect species, ranging from wild and weedy species (or regressive forms) to cultivated species. When applied to domesticated species, *ex situ* conservation tries to conserve, outside their centre of origin or diversity, both the species and their variability produced during the evolutionary process of domestication. This type of conservation has been widely used in recent decades (Hidalgo 1991).

What can be conserved *ex situ*?

Any species that can multiply

These are mainly materials for agricultural use, including:

- wild and weedy species
- traditional and improved varieties
- products of biotechnology and genetic engineering

What can be conserved *ex situ*?

In theory, all species can be conserved *ex situ*, provided that we can multiply them. Outside nature, we can conserve individual genotypes but not the relationships between them and their ecological environment. Traditionally, important resources, useful to humans for food and agriculture, and whose conservation required security and immediate and future availability, were conserved *ex situ*.

Of those species that are of agricultural use and research interest, and form the basis of human sustenance, a broad range of materials exists that can be conserved *ex situ*, including:

- *Wild and weedy species* belonging to cultivated genera that constitute a broad and varied range of important materials for research and crop improvement (Harlan 1976; Stalker 1980; Prescott-Allen 1988, all cited in Frankel *et al.* 1995). The wild relatives and weedy species, commonly used as sources of genes for the improvement of traits of interest, can also provide resistance to diseases and pests. A good example among the many crops favoured by crossing with wild species is sugar cane. The modern sugar cane is a complex crop derived from artificial hybrids, whose pedigree includes wild *Saccharum spontaneum*, which had contributed to the crop's yield, vigour and disease resistance. Other examples are maize, rice and tomato.

- *Varieties from traditional agriculture:* landraces, primitive cultivars and species of cultural importance (e.g. those used in religious ceremonies).

- *Products of scientific improvement programmes:* for example, modern and obsolete cultivars, advanced lines, mutants and synthetic materials.

- *Products of biotechnology and genetic engineering* that include, among other products, transgenic plants, DNA fragments, cloned genes, marker genes, new genetic combinations, silent genes (introns) and chloroplastid genomes. These products are available because biotechnology and genetic engineering have made it possible to isolate and transfer plant genes carrying traits of agronomic interest, as well as genes of almost any plant, animal or bacterial species to which access was previously not available (Rao and Riley 1994; Frankel *et al.* 1995; FAO 1996a, b, c).

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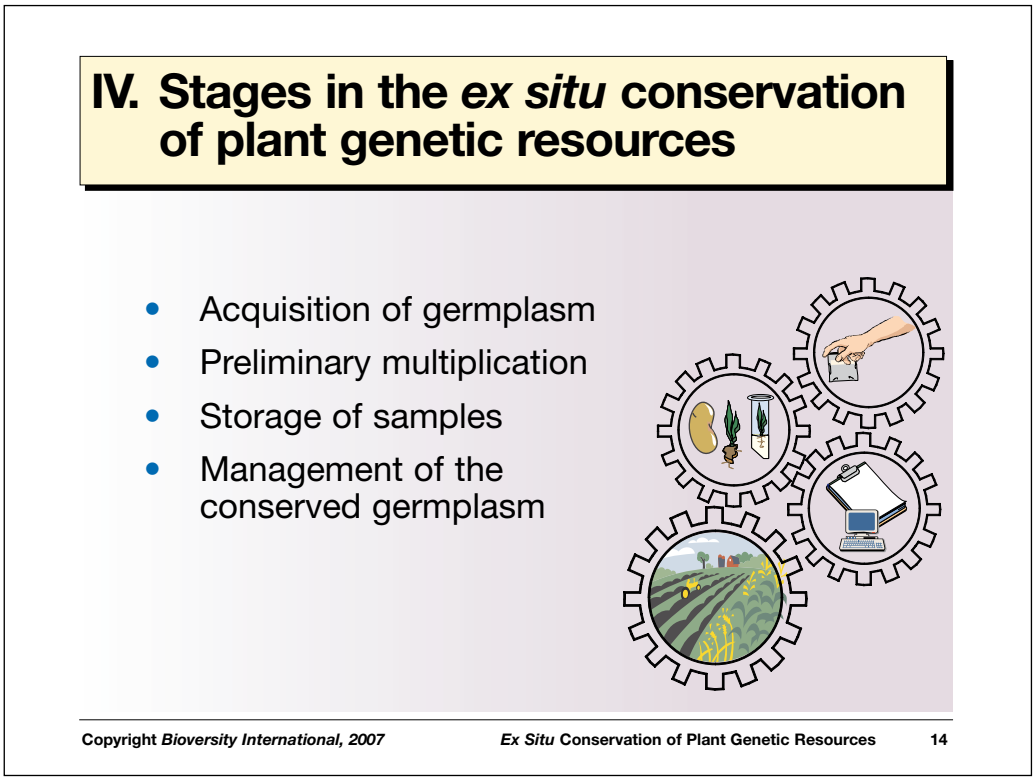


IV. Stages in the *ex situ* conservation of plant genetic resources

Ex situ conservation of germplasm includes a series of activities that begin with the acquisition of material and can even include the use of this material or its loan for use. The activities, or stages, include:

- Acquiring germplasm
- Multiplying before storage
- Storing
- Managing the conserved germplasm. This stage includes:
  - Characterization and evaluation
  - Multiplication and/or regeneration for distribution and use
  - Documentation
  - Use or loan for use

These stages will be described in detail later on in the module.

IV. Stages in the *ex situ* conservation of plant genetic resources

- ***Acquisition of germplasm***
- Preliminary multiplication
- Storage of samples
- Management of the conserved germplasm

Acquisition of germplasm

Germplasm is acquired

- by collecting, exchange or donation
- to protect it, use it or to complete collections

A. Acquiring germplasm

Germplasm can be acquired for many reasons such as for its protection, study, improvement and distribution, and/or to complete an existing collection (Engels *et al.* 1995).

Alternative means for acquiring germplasm

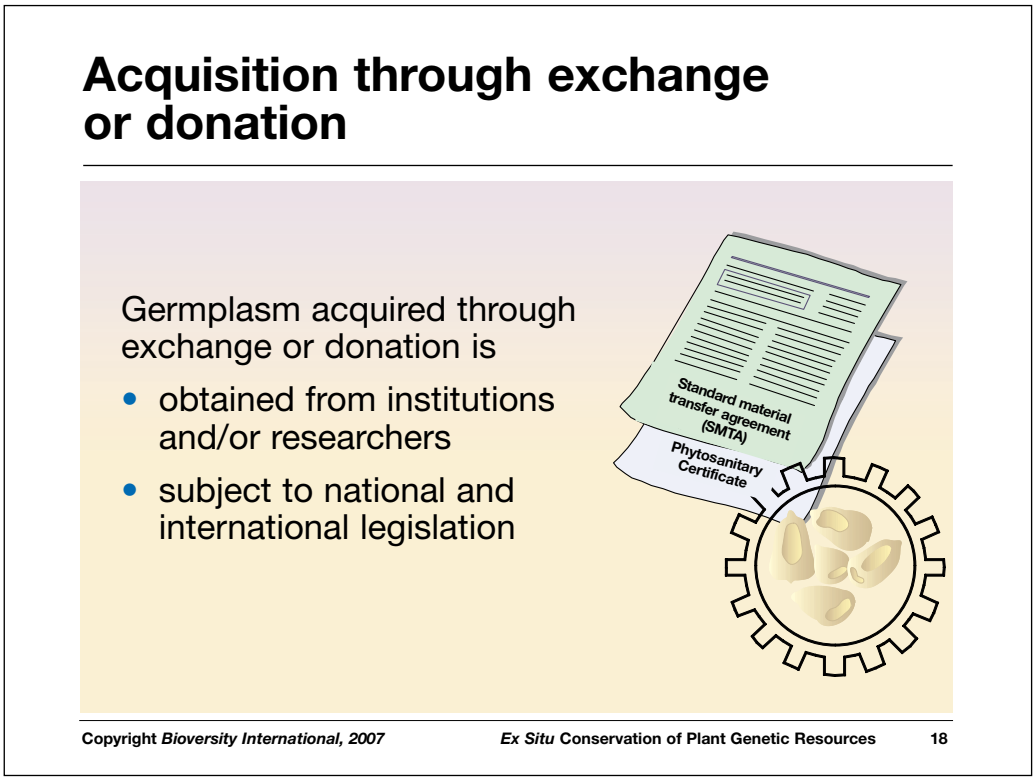
Germplasm of interest can be obtained through collecting, exchange or donation. For practical reasons, attempts should be made to obtain desired material without resorting to the sites of origin, that is, by making use of donations from or exchanges with institutions that have it. If this is not possible and collecting is necessary, material should be searched for in sites where populations of the required species grow.

Requirements of acquired materials

Samples should be representative, healthy and documented, and should meet pertinent legal requirements

Acquired samples should be healthy, representative of the targeted diversity and well documented so that they can enter the host country's system of conservation without problems and be used later on. The country of origin and, especially, the host country should be assured that the samples being moved are healthy. Accordingly, germplasm entering a country must be submitted to phytosanitary inspection and quarantine.

Movement of germplasm between countries is regulated by international agreements, discussed later in this section. Now, we discuss how to acquire germplasm through exchange, donation and collecting.

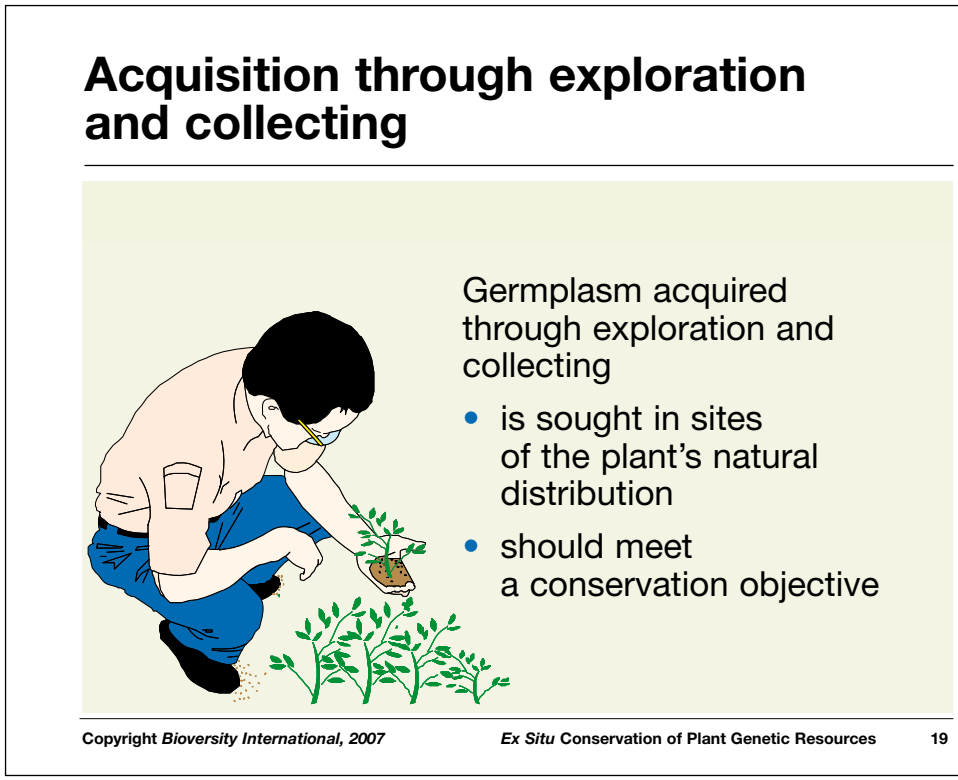


Acquisition through exchange or donation

Researchers have traditionally exchanged germplasm. Many accessions that today form part of large collections were obtained through exchange or donation. Similarly, other collections have recovered from losses incurred through war, natural disasters or negligence, by means of exchanges and donations.

To exchange or receive germplasm through donation, the interested party requests it from those who hold it. Germplasm transfer is effected through the signing of an agreement between the parties. The agreement stipulates the terms of both transfer and use of the material (e.g. conservation, research or production of commercial varieties). These agreements are known as 'material transfer agreements for the exchange of genetic resources' (MTA) (Barton and Siebeck 1994).

The agreements for germplasm transfer should respect the existing treaties on access to genetic resources of the countries involved. Because germplasm transfer implies plant health risks, the exchange or donation should be made through authorized institutions and within the stipulations of the International Convention on Plant Protection (FAO 1997).



Acquisition through exploration and collecting

Germplasm exploration and collecting consist of going to the field to search for and collect the genetic variability of cultivated and wild species that could not be obtained through genebanks, botanic gardens or other collections (Querol 1988). The reasons for collecting can be various but priorities are established according to the species of interest and/or in regions possessing a broad genetic diversity of the desired material. Collecting is justified, for example, when the targeted area contains endangered species of interest, when the material is essential to research or use, or when the variability of the targeted species in the *ex situ* collections has been lost or is insufficient. Sometimes the opportunity to collect the material justifies collecting it. Other times, non-targeted germplasm can be collected during a mission because of its potentially useful traits (Engels *et al.* 1995; Querol 1988; IPGRI 1996 c, d). However, the objective of conservation should not be forgotten.

Planning a collecting mission

- Determine the targeted species and their collecting sites
- Compile information on the species and sites
- Decide on a sampling strategy
- Meet legal requirements
- Prepare logistics

Acquiring germplasm through collecting missions

Exploration and field collecting are complex activities that put at stake many resources, whether biological, physical, economic or human, and therefore require planning. In this section, we explain the processes to be carried out before and during field collecting to guarantee that material of interest is acquired, that it will arrive at the place of conservation under the best conditions and that it fulfils the stipulations of the FAO International Code of Conduct on Plant Germplasm Collecting and Transfer (FAO 1994, Appendix 1).

Planning a collecting mission

Before the mission takes place, the targeted species should be determined and information compiled on them and the sites where they are likely to be found. That sufficient financial resources will be available for the expedition should also be confirmed. A strategy should be developed for taking samples, for their handling in the field so that they survive the journey to the place of conservation and for their documentation as they are collected. Likewise, permits must be requested from appropriate authorities and the regulations observed of the respective countries where collecting will be done. Once the permits are obtained, the logistics of the trip are prepared. Appendix 2 carries a checklist of logistical aspects, important at the time of planning and for the development of a successful mission.

Selecting the targeted species

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What should be collected: selecting the targeted or priority species

To determine if we should conserve a material, we must think about what we will do with it, that is, its usefulness, real or potential, for food, agriculture, industry, research or crop improvement. A species' usefulness determines the interest, commitment and priority in conserving it (Maxted *et al.* 1997a, b). A species with a recognized value will receive higher priority for conservation than others whose uses are not even known. Usefulness is determined by analyzing the following aspects of a species:

1. *State of conservation*. If the species is already present in collections, conservation activities are not undertaken so as not to duplicate existing material. For example, maize, rice and wheat have been collected for decades, unlike the Andean root and tuber crops: 'ulluco' (*Ullucus tuberosus*), sweetpotato (*Ipomoea batatas*), 'isaño' (*Tropaeolum tuberosum*) and 'arracacha' (*Arracacia xanthorrhiza*); or the promising Neotropical fruit trees: 'cherimoya' (*Annona cherimola*), papaya (*Carica papaya*), guava (*Psidium guajaba*), 'jaboticaba' (*Myrciaria cauliflora*), cashew (*Anacardium occidentale*) and 'borojó' (*Borojoa patinoi*).

2. *The urgency to conserve it*. A species' relevance for conservation also depends on how threatened it is: endangered species receive priority. The degree of threat can be ascertained through the *Red List Categories* of endangered species established by the World Conservation Union (IUCN) (Appendix 3); by locating it in a category of threatened species according to the country in which populations are found; or by consulting those countries' entities responsible for monitoring 'at-risk' species.

3. *The biological importance of the species with respect to other useful species*. Although some species have no apparent usefulness for humans, they interact with others that are useful, as in the case of the interdependent species forming part of a forest plant succession, where the disappearance of some would endanger the existence of others.

4. *The species' contribution in terms of genetic variability*. Selected species should be genetically different from others already conserved.

5. *The species' potential usefulness*. Species that contribute to the satisfaction of basic needs (food, medicines, housing) will receive higher priority for conservation than others, such as ornamentals or those considered as undesirable companion weeds.

6. *The relative costs of conserving the species*. Where two species have equal priority and the budget is limited, their relative costs of conservation will determine which is targeted. Cost as a criterion is also applied by comparing the potential costs of conserving the target species and other species. Another determinant is the possibility of conserving the targeted species alone or jointly with others of interest.

7. *The species' cultural importance to the human community*. The aesthetic, symbolic or cultural value of a species for a human community (e.g. the role that it fulfils in cultural or religious activities) can require its conservation. Examples are plants considered as national emblems, like the Quindío wax palm (*Ceroxylon quindiuense*), the national tree of Colombia. Other examples are forests conserved for their beauty.

Because the selection of targeted species can be based on interpretations that are, in fact, subjective assessments, those who select priority species need to justify their decisions and confirm that the species selected do indeed respond to the objectives of conservation.

Documentation before the collecting mission

Information on the targeted species and the sites they inhabit should be brought together and analyzed

Collecting and analyzing information on the species to be collected

Once the species to be collected have been determined, we need to locate the ecosystems where they are found, that is, their sites of origin or distribution, bringing together information on both aspects.

Information needed on habitats

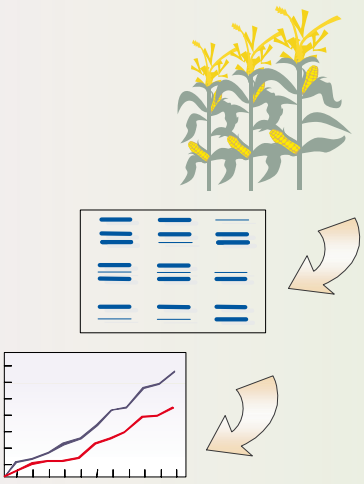
- Geographical location
- Topography
- Climate
- Type of vegetation
- Access routes
- Human settlements
- Social and political environment

Information on the targeted species' sites of origin and distribution

The geographical location of habitats can be found precisely by taking data from inventories and plant and ecogeographic studies. If no information is compiled in studies, it will need to be searched for in genebanks, herbaria, botanic gardens, agricultural databases and sources of ethnological information (Jenkins 1988, cited by Debouck 1995) or other researchers and collectors will need to be consulted. Information search and collection should result in a list of areas where representative populations of the targeted species can be found. Once these areas are geographically located, basic information will have to be compiled on their topography, climate, type of vegetation, access routes, human populations and social and political environment as all these determine the mission's organization.

Information needed on the targeted species

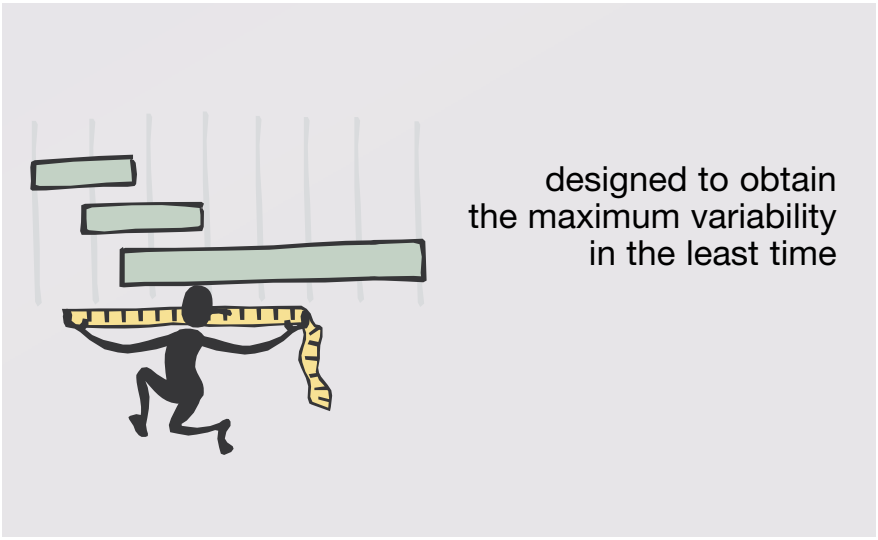
- Distribution
- Taxonomy
- Morphology
- Anatomy
- Physiology
- Genetic composition
- Reproductive strategy



Information on the targeted species

A successful mission requires an in-depth knowledge of the targeted species. As well as their distribution, we must know the taxonomy, morphological characteristics, especially those related to the species' genetic composition, and the reproductive strategy (genetics and population dynamics). A species' morphology will help us recognize it in the field, its population dynamics and genetics will show us how to take a representative sample, and physiology and anatomy will provide guidelines on handling samples. With these elements we can define the sampling strategy.

A sampling strategy is



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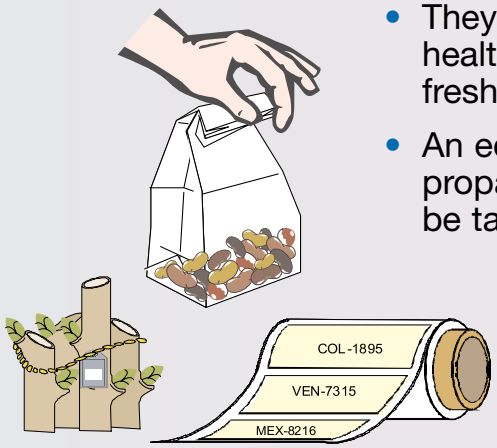
How to collect the targeted species? Defining the sampling strategy

Having selected the targeted species, collectors must define the sampling strategy, meaning that, they must plan how to obtain the maximum variability in the least possible time. Defining a sampling strategy means (1) locating the site or sites for collecting, (2) defining the frequency with which samples are taken (i.e. how often will stops be made to collect), (3) defining the methodology with which samples will be taken, and (4) defining the optimal sample size (i.e. the number of propagules that represent the genetic variability available). The sampling strategy is based on statistical procedures, which means that the collector should obtain advice from specialists on the matter. Annex 4 illustrates the steps for defining a sampling strategy.

When taking samples



- They should be healthy, viable and fresh
- An equal number of propagules should be taken per plant

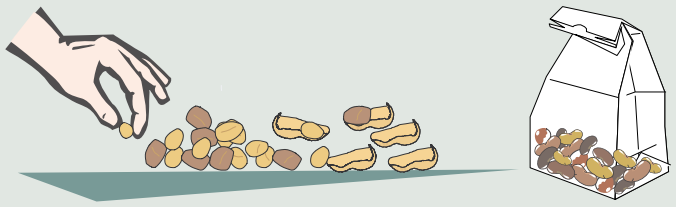
How to take samples in the field

Regardless of the type of propagule collected, the same number should be taken from every plant and in good physical and sanitary conditions. The moisture content and temperature at which the samples are to be maintained should also be controlled. The samples must be prevented from drying out or rotting, either of which affects their viability.

If the objective is to collect seeds, harvesting the fruits would be advisable because this prolong the seeds' viability. The seeds can be manually extracted later. The collected seeds should be mature so that they tolerate drying without losing viability. For vegetative material, however, fresh propagules and buds should be collected so that they will reproduce later. Samples may be entire plants, tubers, rhizomes or stakes. Plants can be collected in any container provided that it is safe and easy to transport. Plastic bags can be used for tubers, rhizomes and stakes. Collecting *in vitro* samples is another possibility. This will be explained later, further on in this module.

Sample conditioning during collecting

- Samples must be kept viable until their arrival at the place of conservation
- This includes cleaning, drying or humidifying and temporary storage



Conditioning and storing samples during the collecting mission

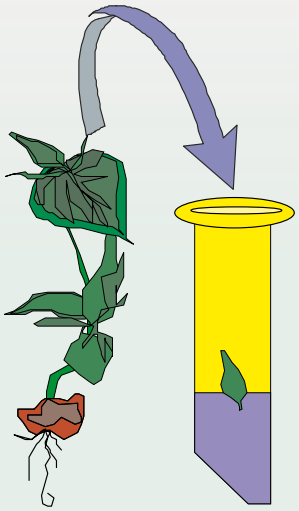
Collected samples should be kept viable until they arrive at the place of conservation. They must therefore be conditioned to prevent their being damaged or contaminated. Conditioning includes cleaning the samples, drying them if they are orthodox seeds or keeping them moist if they comprise vegetative material, or recalcitrant or intermediate seeds.

Cleaning consists of removing all impurities such as stones, soil, insects, damaged or infected seeds, seeds of other species and plant residues. Drying comprises the reduction of moisture levels in the seeds to be stored. This can be carried out with silica gel, dry-air circulation equipment or by spreading them out in thin layers, under shade, in cool airy sites.

Conditioned samples should be stored until they are taken to the place of conservation. Orthodox seeds are stored in cloth bags, away from light or in containers that permit the circulation of dry air. Recalcitrant and intermediate seeds and vegetative samples should be maintained in damp containers made of newspapers, paper towels, sawdust, sand or inflated plastic bags whose air is changed frequently. They can also be stored in polyethylene coolers.

To prevent germplasm material losing viability during the expedition, where possible, partial shipments of the samples should be made to the place of conservation. The shipped material should be clearly identified and be accompanied by handling instructions and the documentation stipulated by the FAO International Code of Conduct on Plant Germplasm Collecting and Transfer (FAO 1994).

Collecting *in vitro*



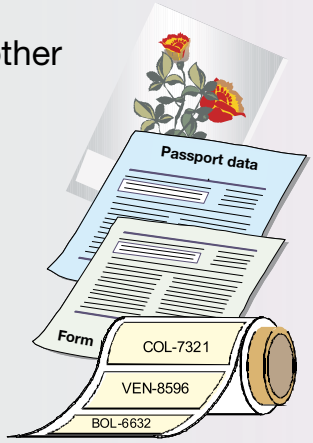
- is the extraction, culturing and *in vitro* transportation of plant tissues
- is needed for conserving difficult-to-handle species

Collecting *in vitro*

In vitro collecting consists of taking and transporting *in vitro* to the laboratory viable plant tissues known as explants (e.g. buds, meristems and embryos). An explant is extracted, sterilized and cultured onto a culture medium. *In vitro* collecting is practised with species whose samples are difficult to handle, such as those of vegetative reproduction or unorthodox seed. The *in vitro* method has been used to collect coconut (*Cocos nucifera*), cotton (*Gossypium* spp.), cacao (*Theobroma cacao*), *Prunus* spp., *Vitis* spp., grasses and forages (Withers 1995).

Documentation during collecting aims to

- record passport data and other relevant information from the collecting site
- label the material
- take herbarium specimens



 Ex Situ Conservation of Plant Genetic Resources 29

Documenting samples during collecting

Documenting the samples as they are being collected is fundamental to their later identification, characterization and use. Passport data and collection data are taken during collecting and recorded on collecting forms (Appendix 5). Passport data include (1) the order number of the collecting form; (2) genus; (3) species, subspecies and/or variety of the botanical material; (4) the place, province and country where the sample was collected; (5) collector(s) name(s), and (6) date the material was collected. These data should appear on all collecting forms. The forms, which could be in pre-established formats, should facilitate recording of data in an orderly and systematic fashion – avoiding the inconsistencies and omissions so characteristic of free annotations – while being adaptable to the collector's needs.

Identifying samples in the field is as important as documenting them. For later identification, each sample should carry an adhesive label that gives the sample's number, place of origin, collector's initials, and identification number of the respective collecting form. Other useful activities are obtaining herbarium specimens, photographs of the collected material, and data on ethnobotany, ecology and geography (e.g. altitude, latitude, height above sea level and slope). These data can be recorded in a field notebook (Querol 1988).

Care should be taken during collecting

- to protect the plant populations, their habitats, personnel and collecting equipment
- to respect the communities that populate the area

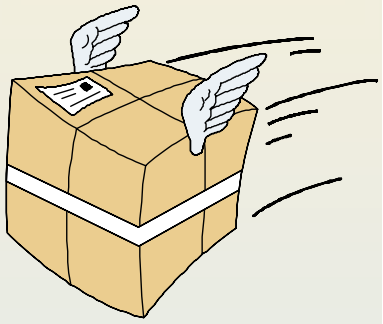
Taking care during collecting missions

Carelessness or negligence during collecting missions can damage plant populations and their habitats. This occurs, for example, when large samples are taken from small populations, contaminated germplasm is transported, or species are introduced that can displace native species by competition and/or hybridization.

Respecting the customs, knowledge, and beliefs of the communities that inhabit the area of the collecting site will guarantee their collaboration not only during the mission but also in the future. Safety measures should be established for the personnel who conduct the mission, especially with regard to medical care in case of emergency. Equipment should be handled with care and given appropriate maintenance.

Movement of germplasm is subject to

- legislation to prevent phytosanitary risks
- agreements among the interested parties

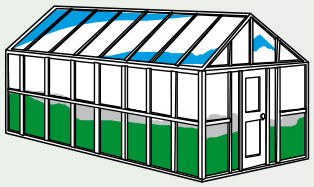


Requirements for moving germplasm

Moving germplasm from one country to another involves phytosanitary risks, which subjects this activity to legislation. The parties interested in moving germplasm must agree on the terms for transfer, ensuring that it is legal and that the transported germplasm is healthy. The agreements should also conform with current international regulations laid down in such legal instruments as the Agreement on Biodiversity (Glowka *et al.* 1994), the FAO International Code of Conduct on Plant Germplasm Collecting and Transfer (Appendix 1) and the International Convention on Plant Protection (Appendix 6). These agreements regulate the access, safe transfer and the rights and responsibilities of the parties with respect to the use of the transferred germplasm.

The principal risk in moving germplasm is the transfer of pests and pathogens, which should be detected during the sanitary inspection of the material when it enters a new country. Such inspection, through quarantine, is the most effective means of control for extensive application worldwide.

Quarantine



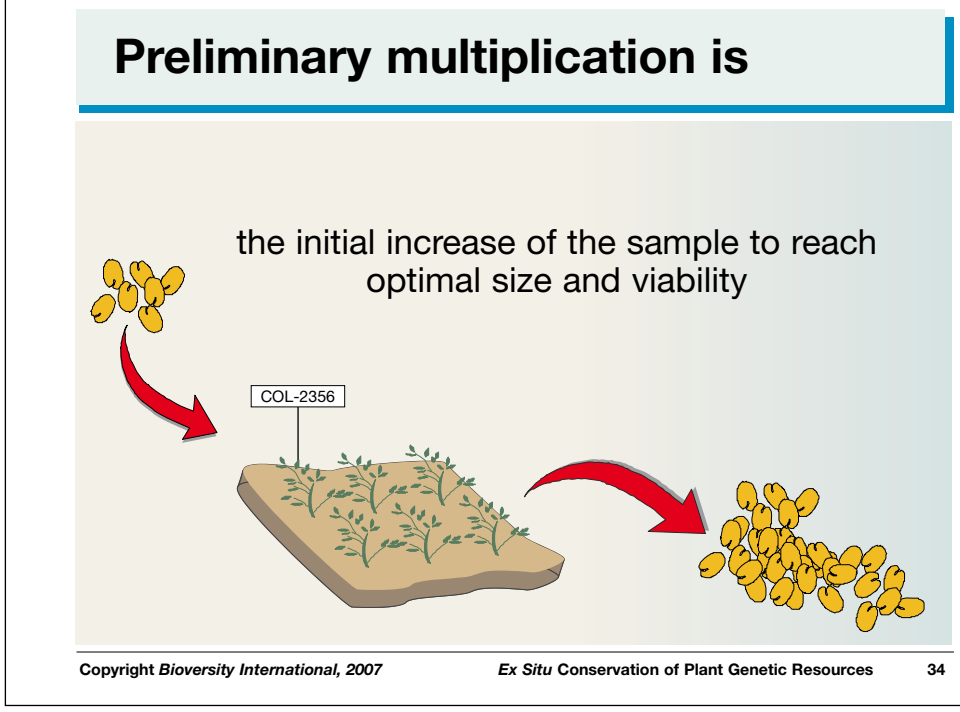
- is a governmental measure for plant health inspection
- includes inspection, treatment, certification and release or destruction of the material

Quarantine

Quarantine is a governmental measure to control the entry into a country of plants, plant material or other plant products, soil samples and live organisms to prevent pests, pathogens and weeds (Nath 1993) from being introduced or disseminated. Quarantine includes inspection to detect pests and pathogens, treatment or cleaning of samples, their certification and release if no danger is observed, or their destruction if highly contaminated or if no technology is available to clean them.

IV. Stages in the *ex situ* conservation of plant genetic resources

- Acquisition of germplasm
- ***Preliminary multiplication***
- Storage of samples
- Management of the conserved germplasm

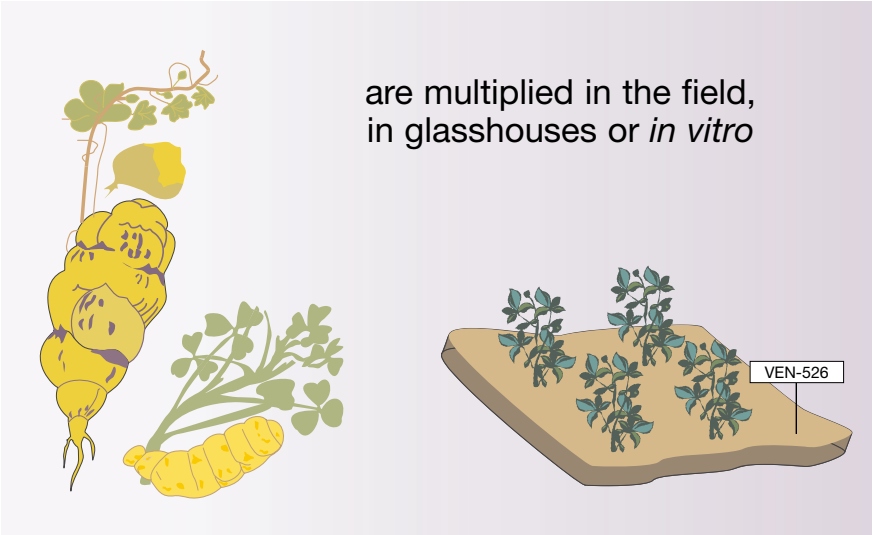


B. Preliminary multiplication

Once the phytosanitary transactions are fulfilled, the germplasm is taken to the place of conservation where the samples are checked for sufficient number and viability for conservation. If the samples are both viable and sufficient, they can be stored immediately. If, however, they are not, then they should be submitted for preliminary multiplication.

Preliminary multiplication is the initial increase of the germplasm under optimal cultivation conditions to guarantee sufficient and viable samples that will maintain the original genetic identity. The multiplied material will enable the storage, conservation and distribution of the targeted species. Representative populations can also be established for purposes of characterization and evaluation. Multiplication is almost always necessary because samples obtained through donation, exchange and/or collecting are usually small or have low viability.

Vegetative material and unorthodox seeds



Vegetative material is multiplied in the field or glasshouse (using propagules, such as stakes or bulbs, that had previously been sterilized) or *in vitro* through buds or meristems taken from the original samples. Recalcitrant and intermediate seeds are planted in the field or glasshouse to obtain whole plants from which buds or meristems are taken for multiplication *in vitro*. Another alternative is to wait for the new plants to produce seeds and multiply these in the field.

Orthodox seeds can be multiplied in the field, although multiplication in the glasshouse would prevent genetic recombination and the presence of pests and diseases. Before multiplication of the samples, their size and viability should first be confirmed. The initial viability of the sample will serve as a basis for later monitoring.

Initial viability

is determined through germination tests

Determining the initial viability of samples

Theoretically, orthodox seeds can be stored after having been conditioned. However, before conservation, the sample sizes and viability should be ascertained. Minimum standards for size and viability are 1000 seeds (preferably 2000) and 85% germination, respectively.

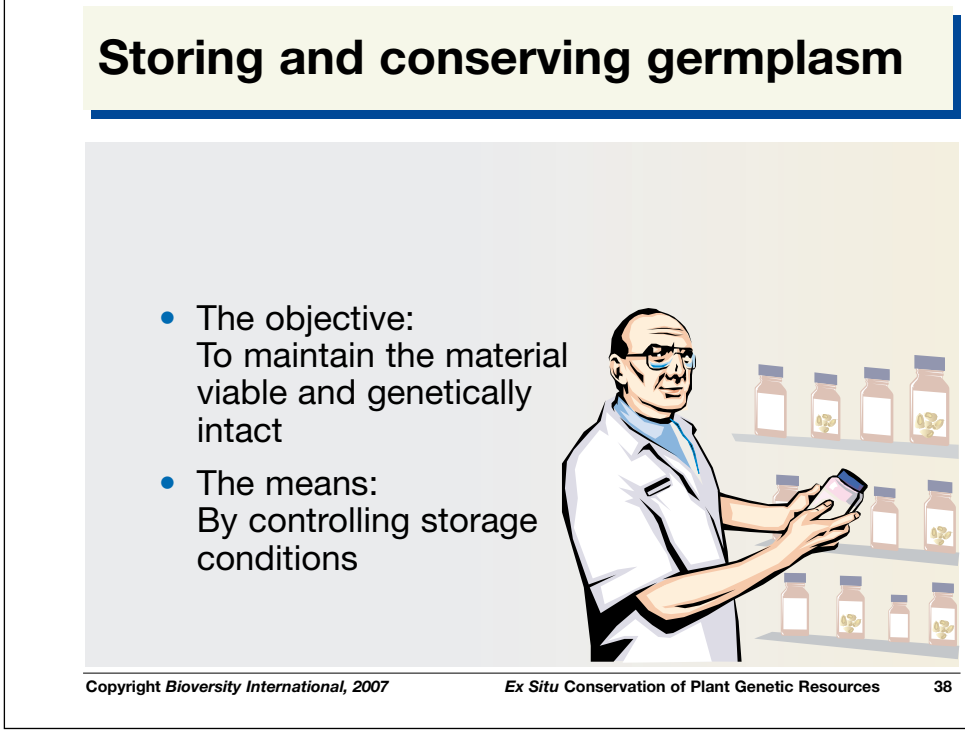
The initial viability of the samples is determined by submitting the seeds to germination tests, whose standards in terms of duration, seed number, levels of drying and incubation temperatures, have been established by the International Seed Testing Association (ISTA 1993a and b, cited by Hong and Ellis 1996). Occasionally, additional procedures may need to be carried out to determine the percentage of germination as when working with dormant seeds.

Detailed information on the various methods for determining seed viability can be found in the *International Rules for Seed Testing* (ISTA 1993), in the manual on seed technology for genebanks (Ellis *et al.* 1985) and in the protocol for determining the performance of seeds in storage (Hong and Ellis 1996).

Once preliminary multiplication is completed, the material is in optimal condition for storage and conservation.

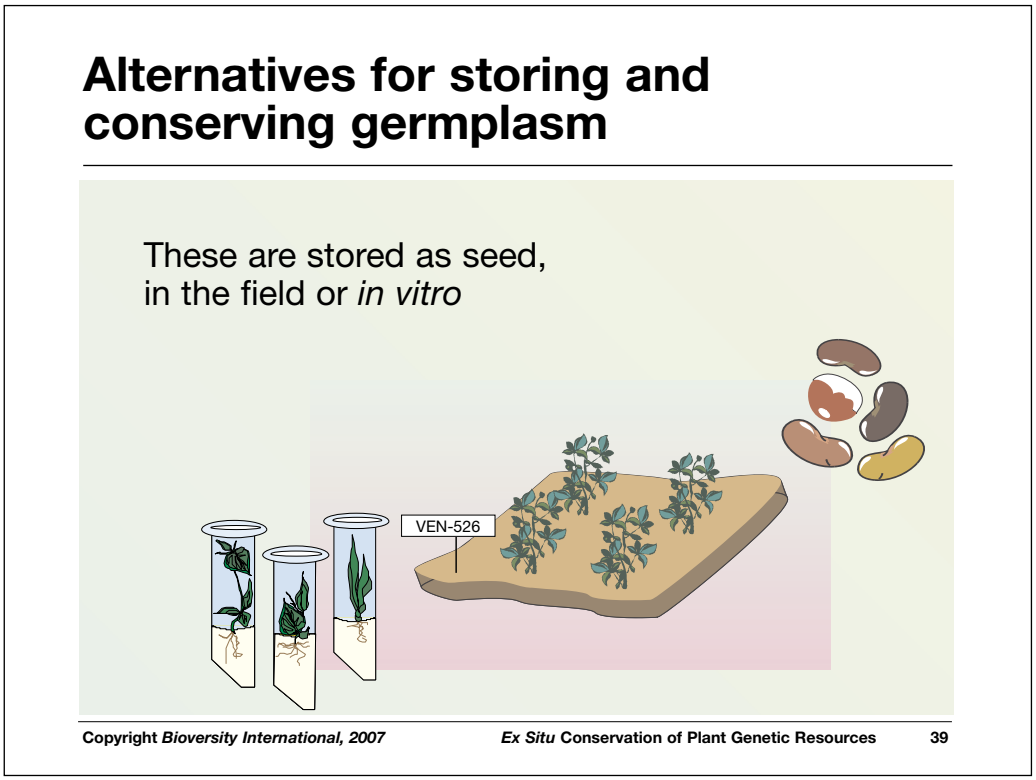
IV. Stages in the *ex situ* conservation of plant genetic resources

- Acquisition of germplasm
- Preliminary multiplication
- ***Storing and conserving germplasm***
- Management of the conserved germplasm



C. Storing and conserving germplasm

The conservation of plant genetic resources is not limited to the acquisition and physical possession of the materials (i.e. collecting and storage) but also the assurance that these will continue existing in a viable condition, with their original genetic characteristics intact. This is achieved, in the case of seeds or material conserved *in vitro*, by controlling storage conditions so that they inhibit or reduce the sample's metabolism. Vegetative material, in contrast, must be maintained under optimal cultivation conditions.



Alternatives for storing and conserving germplasm

Germplasm can be stored in the form of seed, in the field or *in vitro*, depending on how the species reproduces and reacts to storage. These characteristics determine the conditions under which a species will remain viable.

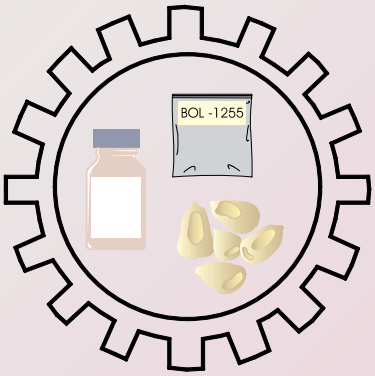
Vegetative material can be stored as entire plants in the field or as tissue cultured *in vitro*. If a species reproduces by seed, its reaction to storage must be determined to know if it is orthodox, recalcitrant or intermediate, because this characteristic will determine the manner, time and conditions under which samples should be stored. If the given species has orthodox seed, then the most convenient way to conserve it is in the form of seeds. If it has recalcitrant or intermediate seeds, then conserving it in the field or *in vitro* would be more appropriate because its seeds can be conserved only for very short periods and under special conditions.

The species' reaction to storage can be ascertained by reviewing literature such as the compendium on the performance of seeds in storage (Hong *et al.* 1996), which contains information on more than 2000 genera of about 250 families. If the information on the species of interest is not found, then tests will have to be carried out to classify its seeds. Information on the conditions suitable for storing seeds can be obtained in the protocol to determine the performance of seeds in storage (Hong and Ellis 1996). Both documents are available through Internet (*see* Bibliography).

Below, we discuss activities conducted before storing germplasm according to whether it is to be conserved as seed, in the field or *in vitro*.

Maintaining orthodox seed requires

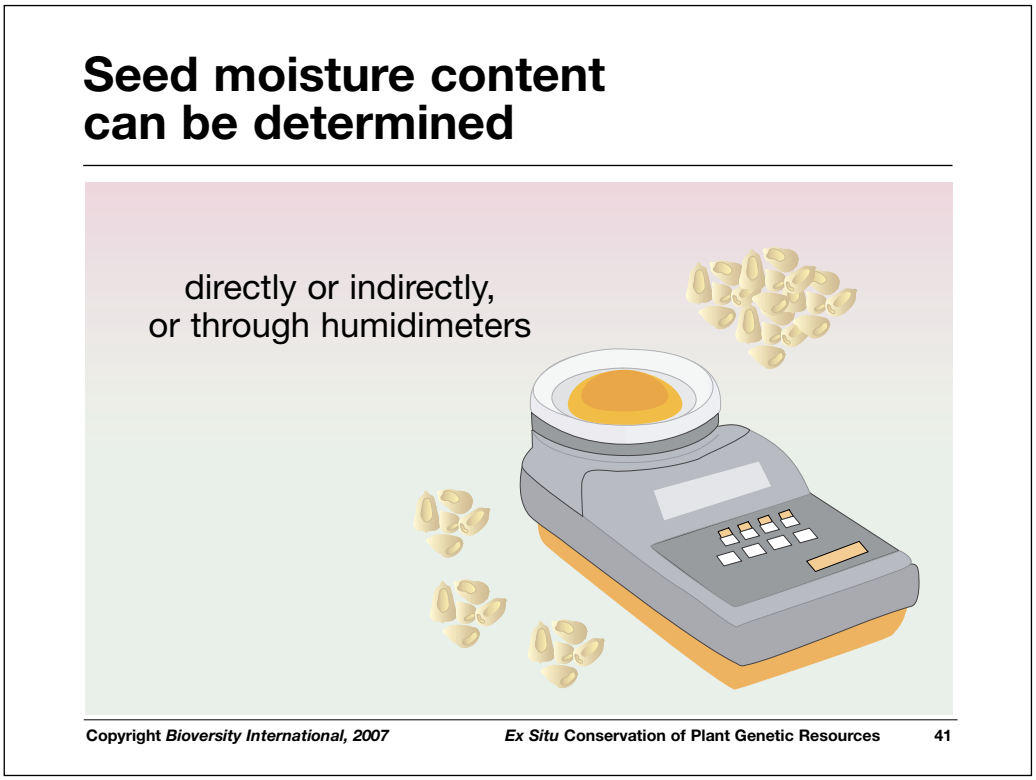
- conditioning
- packing
- storage



Storage in the form of seed

The storage of orthodox seeds is carried out in three stages: (1) conditioning, (2) packing and (3) storage of the samples in chambers with controlled environments. Conditioning, the objective of which is to produce a clean sample with a moisture content that guarantees its longevity in storage, consists of physical and sanitary cleaning, and drying.

The physical and sanitary cleaning is similar to that carried out during field collecting but is more rigorous. It consists of eliminating contaminants from the sample, such as inert impurities, infected seeds, alien seeds and insects. Drying involves reducing the moisture content in the seeds to a minimum level of metabolic activity, without their losing viability. Before drying, the initial moisture content of the sample must be determined. Appendix 7 provides a list of parameters for storing seed samples.

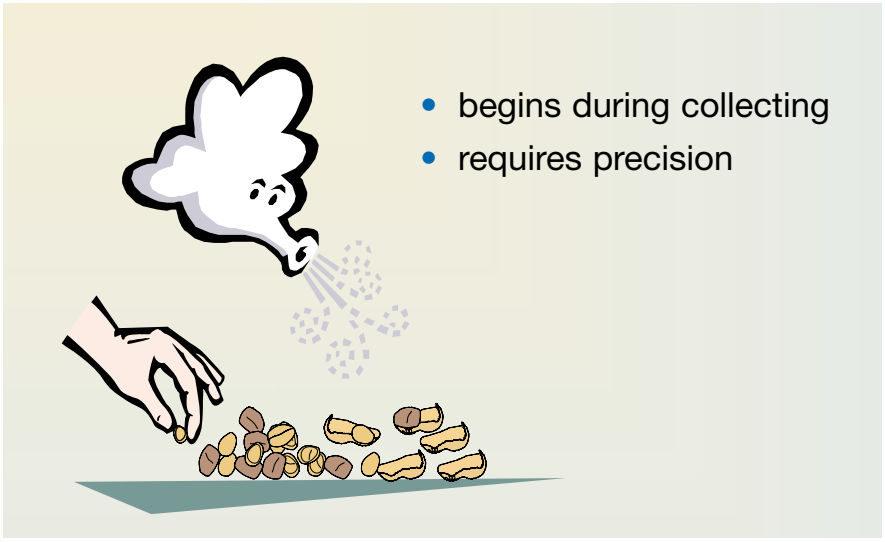


Determining seed moisture content before storage

Seed moisture content can be determined by quantifying directly or indirectly the water they contain. Direct determinations can be done through gravimetric methods, and through chromatography and spectrophotometry. Indirect methods include hygrometric methods, infrared spectroscopy, nuclear magnetic resonance and chemical reactions of the seeds (Grabe 1989).

Currently on the market are electronic analyzers (humidimeters) that can rapidly and accurately quantify a seed's moisture content. If this technology is not available, then the methods mentioned in the previous paragraph must be resorted to. They are also described in the manual on seed technology for genebanks (Ellis *et al.* 1985) and in the protocol for determining the performance of seeds in storage (Hong and Ellis 1996).

Seed drying

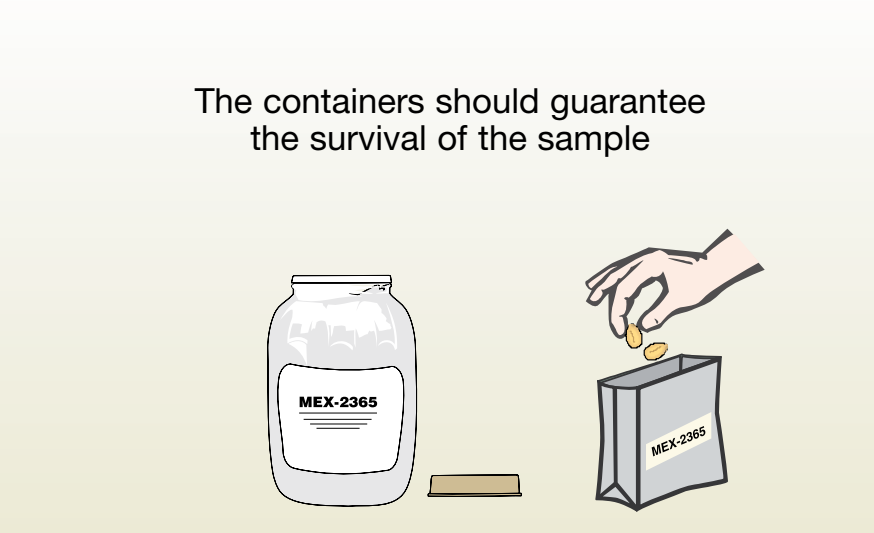


Drying the seeds

Drying should start in the field, immediately after collecting and/or when seeds are extracted. Seeds can be dried, using either equipment that circulates air at different temperatures or silica gel, an easy and effective method (Hong and Ellis 1996). Electronic driers exist that can programme drying cycles, temperatures, and air flows and speeds.

Once drying is finished, the seed's moisture content is again measured to confirm if the required level has been reached (8% – 12%) and to determine if the samples need to be submitted to a new cycle of drying or re-hydration. Temperatures and drying times must be established accurately so as not to endanger the samples' viability by repeating the procedures.

Packing



Packing

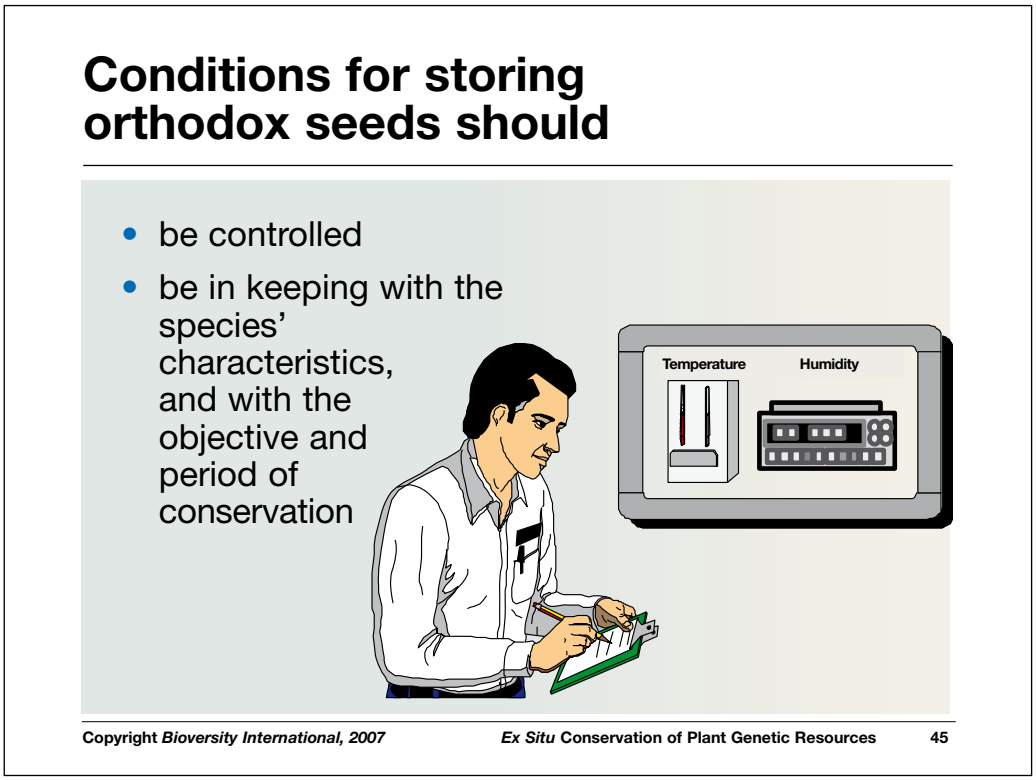
Once the material has been conditioned, it is ready to be packed and taken to storage. Both the container in which the sample is packed and the storage place should fulfil the needs of the targeted species, guaranteeing its survival.

Containers for orthodox seeds:

- Come in a variety of forms, materials and sizes
- Should be hermetic and be in keeping with the characteristics of the seeds being stored

Containers

A broad range of containers exists for packing seeds, varying in form and material, such as paper or aluminium bags, glass flasks and tins of different metals. More important than either form or material is the container's airtightness, that is, its ability to isolate the germplasm from moisture and/or contamination. The containers selected depend on the seeds' characteristics and the period over which they are to be conserved. In practice, the genebank's resources also determine container type because, as containers vary in form and materials, they also vary in cost. Hermetic containers, for example, are optimal but expensive. Investment will depend on the use the material is destined for. To illustrate, Appendix 8 describes a series of containers commonly used in genebanks.



Conditions for storing orthodox seeds

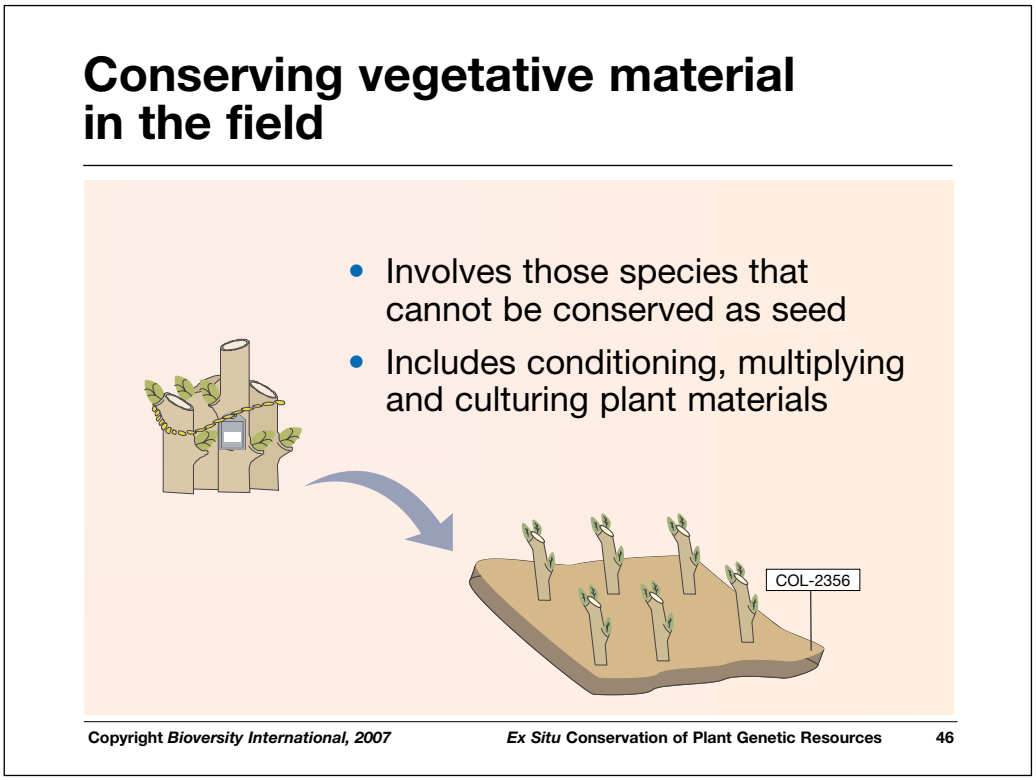
Seeds can be stored in chambers over the long, medium or short term. Storage conditions to keep samples viable are determined in accordance with the species, the objective of conserving it and the planned storage time. Storage conditions should be kept constant in terms of temperature, relative humidity and light intensity by means of equipment that provides refrigeration, dehydration and light control.

Most species with orthodox seed can be conserved indefinitely at temperatures between -10°C and -20°C, with a moisture content of 3% – 7% and a viability of no less than 85%. Seeds conserved under these conditions can be kept for 70 to 100 years.

If the seeds are to be conserved over the medium term (i.e. 10 – 20 years, with a maximum of 30), they can be kept at temperatures between 0°C and 15°C (usually 1°C to 4°C), with a moisture content between 3% and 7% and a viability of not less than 65%. If, however, the material is to be used in the short term, seeds can be stored in air-conditioned rooms (Cromarty *et al.* 1985; Towil and Roos 1989; Engle 1992).

The storage chamber should be hermetic and designed for the samples that it will store, the period for which they will remain and the climate of the area where the chamber is to be established. Usually, recommendations for building storage rooms include specifications for prefabricated galvanized-steel panels, lined with polyurethane foam and insulation that will protect germplasm from

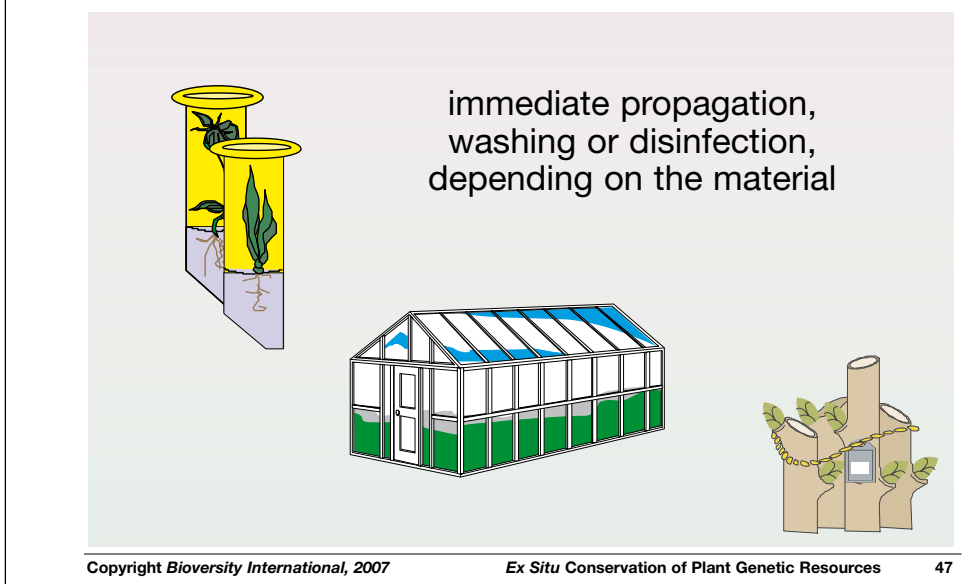
external conditions. Each chamber should have two independent refrigeration systems, a constant and stable energy supply and verification instruments such as mercury, and wet- and dry-bulb thermometers. Information on infrastructure and necessary equipment can be found in Cromarty et al.'s manual (1985) for designing seed storage installations.



Conserving vegetative material in the field

Not all species can be conserved as seed even if they reproduce this way, and even less so if they are propagated vegetatively. Recalcitrant and intermediate seeds are those that, even under optimal conditions, last only a few weeks, making their conservation in the field or *in vitro* easier.

Conservation in the field should be carried out for species that are perennial, arboreal, wild, semi-domesticated and heterozygous, or reproduce vegetatively, or have seeds that are short-lived or sensitive to drying. Field conservation implies conditioning the material (if necessary), multiplying it, selecting a site, preparing it for planting, planting the materials and recording the accessions' precise location.



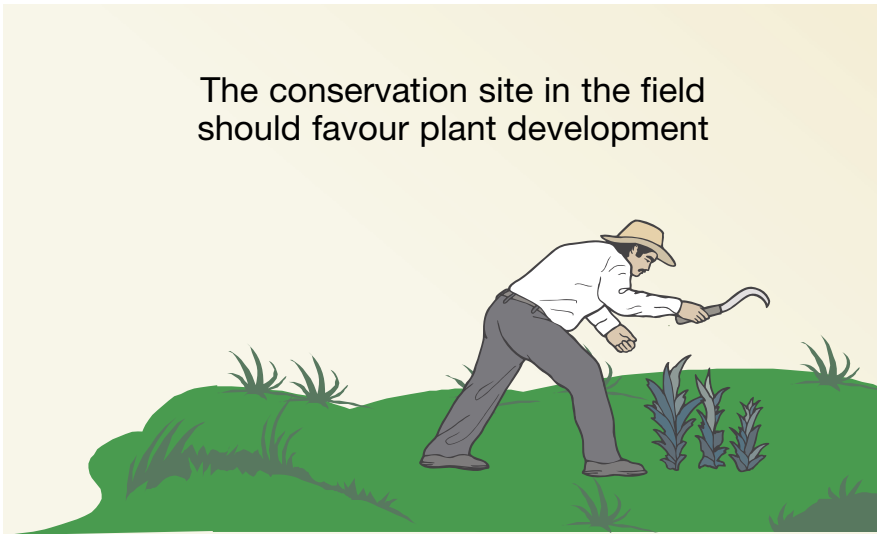
Conditioning and propagation of vegetative material

The collected plant material is washed and disinfected before propagation and transport to the place of conservation. Disinfection can be done with bactericides, fungicides (for bulbs and rhizomes) or thermotherapy (for stakes). Once disinfected, the vegetative material is propagated in the field, glasshouse or *in vitro*. In the field and in glasshouses, samples are planted in seedbeds or in pots and left to grow until mature enough to permit the taking of new samples. The procedure is repeated until the necessary number of plants is obtained for establishing the collection in the definitive site.

If propagation is to be *in vitro*, samples are planted in glasshouses, in soils of optimal nutritional quality. From the resulting plants – preferably the youngest – explants are extracted for micropropagation *in vitro* until complete plants are obtained which are then taken to the glasshouse, where they are planted in sterile soil. Two to three weeks later, they are transferred to the definitive site in the field. Micropropagation consists of (1) disinfecting explants in a solution of sodium hypochlorite or calcium, chloride of mercury or ethanol, (2) culturing the explants in an *in vitro* culture medium until they produce new shoots, and (3) rooting the shoots until entire plants are obtained (George and Sherrington 1984; Roca and Mroginski 1991; Frison 1994; IPGRI and CIAT 1994; George 1996).

Propagation in the field and in glasshouses is simple but requires time and space and does not guarantee that the plants obtained are healthy and genetically identical to the originals. *In vitro* propagation solves these problems and makes the propagation of many species possible, including those that reproduce by seed, as it is more convenient.

Selecting and preparing the site for conservation in the field

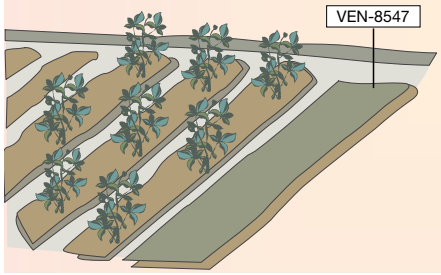


Selecting and preparing the site

The site selected to conserve the material in the field should be safe and should favour plant development. It should be isolated to prevent pest attacks and diseases but with easy access for management. The physical and chemical preparation of the planting site depends on the species' requirements and on the number of accessions expected to be kept in the field.

Planting the material in the field

- The conserved plants should be prevented from exchanging pollen
- All plants in the field should be recorded on maps and identified

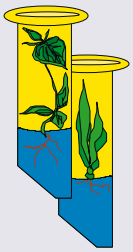


Planting the material in the field

Plants taken to the field should be vigorous and in sufficient numbers to represent the genetic variability of the accessions, thereby ensuring the continuity of the conserved materials. The plants should be arranged in such a way that they will not exchange pollen, thus preventing the populations from losing their original genotype. The exact site where each accession was planted should be recorded on a map; the accessions must be identified both in the field and as plants.

In vitro conservation involves

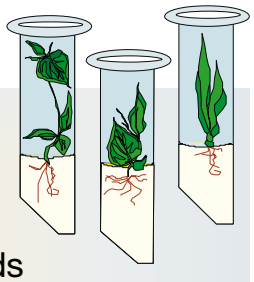
controlling the growth
of viable explants
by manipulating the environment
and/or storage conditions



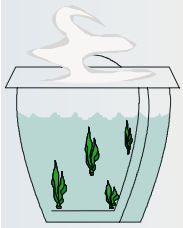
In vitro conservation and storage

Tissue culture makes *in vitro* conservation possible for a broad range of species, using various types of samples such as entire plants, seeds, sprouts, buds, cauline apices, meristems, ovules, embryos, cells in suspension, protoplasts, anthers, pollen and DNA. *In vitro* germplasm conservation focuses on controlling the normal growth of viable explants, and reducing or stopping it through manipulating either the constitution of the culture medium and/or the conditions of storage.

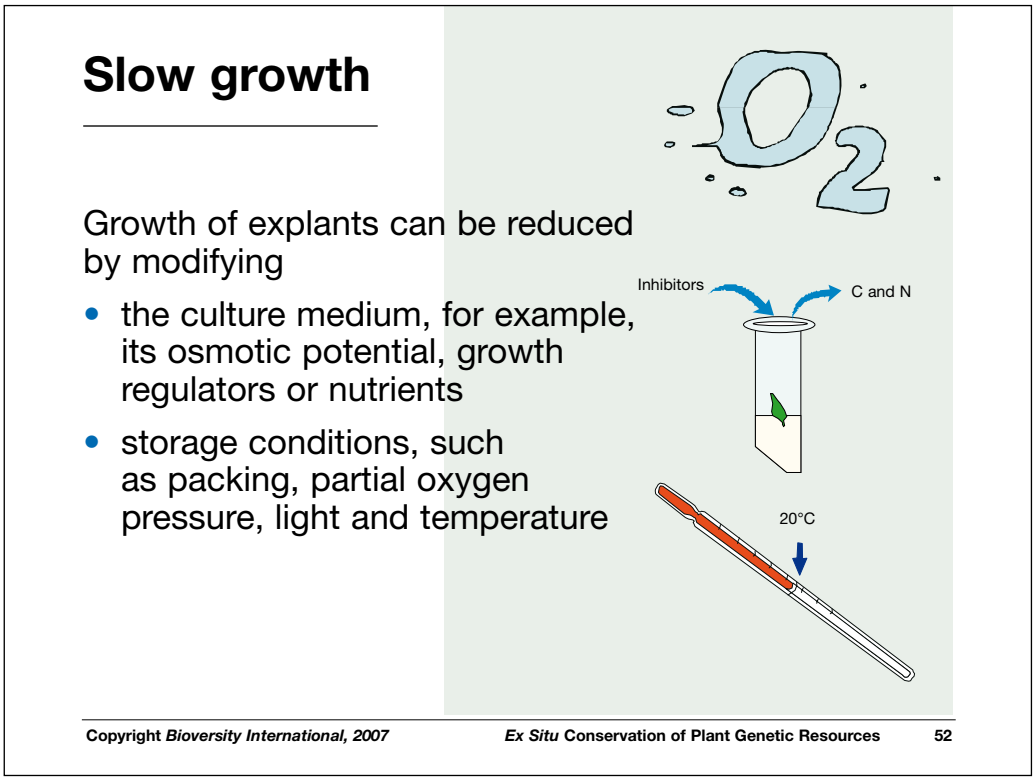
Storing germplasm *in vitro*



- Involves two methods – slow growth or cryopreservation
- Includes conditioning, *in vitro* culture and storage



As for conservation in the field, the material is conditioned, planted – but *in vitro* – and taken to the place of conservation. Conditioning comprises disinfecting samples, then washing them with distilled water to eliminate residues of the disinfectant. Disinfectants most used are solutions of sodium hypochlorite (NaOCl) at 1% to 3%, calcium hypochlorite [$Ca(OCl)_2$] at 6% to 12%, chloride of mercury ($HgCl_2$) at 0.1% to 1.5%, and ethanol at 70%. Explants (the smaller, the better) are extracted from the cleaned samples, planted on culture media and in glass recipients and submitted to one of two *in vitro* conservation methods: slow growth or cryopreservation. In both cases, the medium and conservation environment should be sterilized and the storage conditions controlled. Below, we describe the two ways of storing *in vitro* germplasm (Roca and Mroginski 1991; George 1996).



Slow growth

Slow growth consists of reducing the development of explants by modifying the culture medium and/or the conditions under which they are maintained. Through the culture medium, growth can be reduced by increasing osmotic potential (e.g. by adding mannitol, proline, glycerol or sucrose), adding growth regulators (abscisic acid), and reducing or suppressing the nutrients that the explants need to grow (e.g. carbon and nitrogen). Growth is also limited by controlling the conditions under which the samples are stored, such as using small containers or reducing temperature, illumination and partial oxygen pressure. Reducing the temperature is the most effective form of controlling explant growth in that it reduces metabolic activity. However, because the aim is to ensure and maintain a low growth rate that will enable the conservation of viable explants over the longest possible time, a combination of methods should be used.

Samples under slow growth are kept in chambers at low temperatures for periods that vary from some months to 2 or more years. Temperature will depend on the species and the variety, although most *in vitro* cultures are kept at temperatures between 20°C and 30°C. Lower temperatures can reduce even further the growth of some species but will negatively affect others. Certain species of the genus *Prunus*, for example, can be effectively conserved at -3°C, whereas temperatures lower than 15°C will quickly destroy explants of *Musa* spp. (Pérez-Ruíz 1997), and those below 18°C will lead to deteriorated explants in cassava varieties (Withers 1984, cited by Roca and Mroginski 1991).

Material conserved under slow growth needs to be renewed at intervals because it has continued to grow, even though slowly. The samples are micropropagated and transferred to a medium for recovery and strengthening. Once the new explants are established, they are propagated again, and taken again to the conservation medium. An example of the successful application of this methodology is the case of cassava at the Centro Internacional de Agricultura Tropical (CIAT, Colombia), where about 6017 accessions are conserved (Roca and Mroginski 1991; IPGRI and CIAT 1994).

Cryopreservation

- stops growth through immersion in liquid nitrogen
- depends on the species' reaction to freezing

Cryopreservation

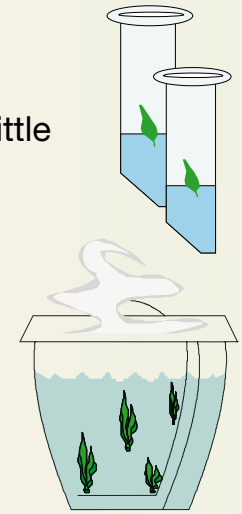
Cryopreservation consists of placing explants in liquid nitrogen at low temperatures (e.g. -196°C) to stop their growth while conserving their viability and genetic and physiological stability. Cryopreservation is a recent technique, with good prospects, because it makes possible the storing over indefinite periods of any species that tolerates and outlives freezing. For this reason, the technique is particularly useful for conserving species with unorthodox seed or vegetative reproduction that would otherwise be difficult to conserve in storerooms or in the field (Ashmore 1997; Benson 1999; Engelmann and Takagi 2000).

Cryopreservation consists of (1) culturing the explants *in vitro* (pregrowth), (2) drying them to the possible minimum according to the species, (3) treating them with cryoprotectors (e.g. glycerol, sucrose, mannitol, proline or polyethylene glycol) to prevent crystallization of intracellular liquids, (4) freezing in liquid nitrogen, (5) storing, (6) thawing, and (7) treating to recover viable plants (Wang *et al.* 1993; Rao and Riley 1994; Pérez-Ruíz 1997).

The success of cryopreservation depends on the species' reaction to freezing, which means that specific protocols are needed. Various techniques exist, such as dehydration-encapsulation, vitrification, encapsulation-vitrification, drying, pregrowth, pregrowth-drying and drip-freeze (Ashmore 1997). However, research in this field, like that carried out by the Centro Internacional de la Papa (CIP, Peru) with potatoes that tolerate freezing, and by CIAT with cassava, is still based on trial and error (Rao and Riley 1994). The methodology has its limitations, the principal ones being the difficulty and time required in regenerating entire plants from the conserved structures.

Applying *in vitro* conservation

- makes it possible to maintain many species in their diversity through samples, and requires little space
- facilitates germplasm exchange
- still depends on technological development
- requires considerable resources



Applying in vitro conservation

In vitro culture is becoming increasingly important as a tool for germplasm conservation and exchange because it enables the maintenance of a broad range of species in their diversity by means of healthy samples, and in relatively little space. It also facilitates exchange. However, it needs technology and knowledge that are still being developed, protocols for each species and considerable resources. Hence, to conserve germplasm, alternatives to *in vitro* conservation should be considered, applying this method only to those species that are difficult to conserve either as seed or in the field.

IV. Stages in the *ex situ* conservation of plant genetic resources

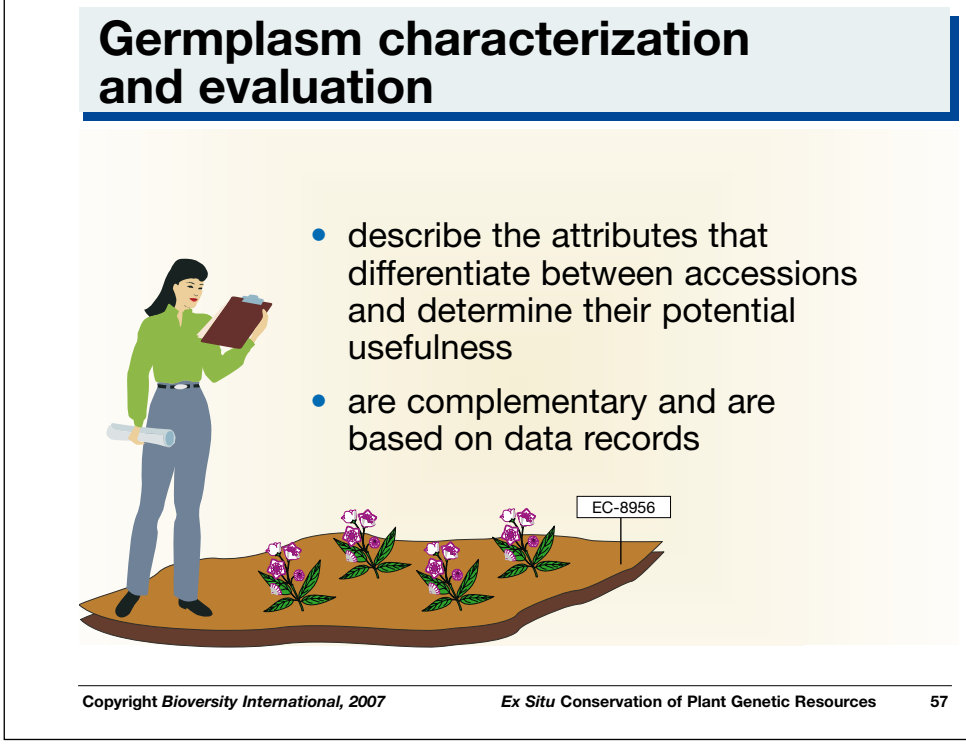
- Acquiring germplasm
- Preliminary multiplication
- Storing and conserving germplasm
- ***Management of the conserved germplasm***
  - Characterization and evaluation
  - Multiplication and regeneration
  - Information and documentation
  - Germplasm utilization

Managing the conserved germplasm

- ***Characterization and evaluation***
- Multiplication and regeneration
- Information and documentation
- Germplasm utilization

D. Managing the conserved germplasm

Once germplasm is conditioned and stored in the place of conservation under optimal conditions to ensure its survival, the germplasm has to be managed, starting with characterization and evaluation.

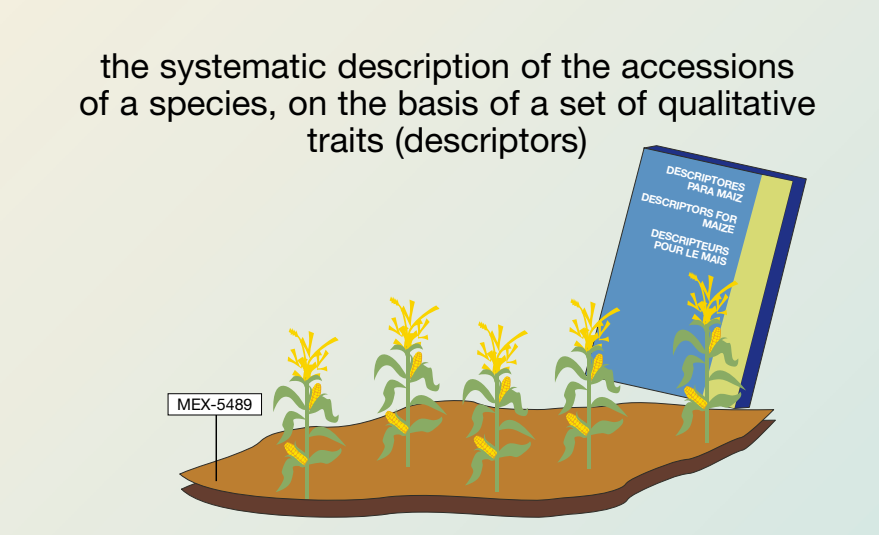


Characterizing and evaluating germplasm

Plant genetic resources are conserved in order to be used, but their use is only possible if their characteristics and possible applications are known. The information that enables us to identify the germplasm and determine its usefulness comes from taking and analyzing a set of data on the germplasm at various stages of conservation, but principally those of characterization and evaluation.

Characterization and evaluation complement each other in that they describe the qualitative and quantitative attributes of the accessions of a given species. The descriptions make their differentiation possible, determine their usefulness, assess their structure and genetic variability, show the genetic relationships among them and locate genes that express potentially useful traits in agricultural production or crop improvement. The two activities require accuracy, care and consistency, and include an important data-recording component.

Characterization is



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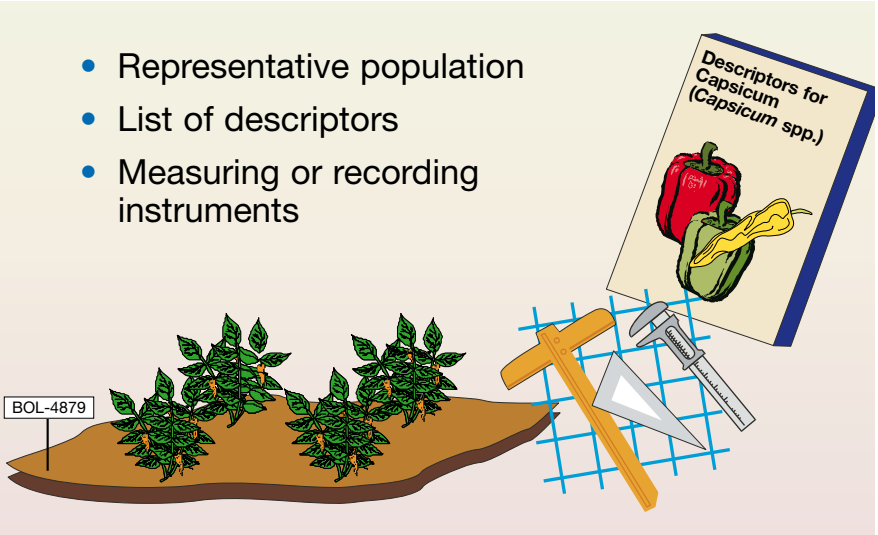
Characterizing germplasm

Characterizing germplasm consists of systematically describing the accessions of a species based on qualitative traits such as growth habit, plant height and flower colour. These traits are of high hereditability, not varying with the environment.

Characterization is carried out with a representative population of the accession, a list of descriptors (traits) and the instruments for recording them. The material to be characterized is planted in the field or glasshouse, in duly identified plots and under uniform conditions of management. Once established, the targeted populations are observed for species characteristics during the various developmental stages, and the observed expressions are recorded against a selected set of descriptors. The data are systematically collected and recorded to facilitate their later statistical analysis. The information obtained in different regions, based on the same descriptors, should therefore be comparable and compatible.

We will now study how to define and manage the components of characterization.

Characterization of components



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A plant population representative of the species

The population to be characterized should represent the total genetic variability of the accession involved to observe and record all the characteristics of that accession. In terms of variability, a representative population contains at least 95% of the accession's alleles. Population size will determine the species' type of reproduction because if it is allogamous (i.e. very variable), the population would be larger than if it were autogamous (i.e. not variable). Overall, large populations should be established so that the description will be reliable. Replicate division of the population will make it possible to record the datum of a single characteristic several times and, thus, use the average as the real value.

Descriptors

Descriptors are those characteristics by which we can know the germplasm and determine its potential usefulness. They should be specific to a given species, allow differentiation between the genotypes of that species and should express each attribute precisely and uniformly. Many attributes of a material can be described but the really useful characters are those that can be detected by the naked eye and easily recorded, have high hereditability and high taxonomic and agronomic value, can be applied to small samples and can differentiate one accession from another. Such a set of characteristics constitutes the species' list of descriptors.

During characterization, the expression of constant qualitative characters is recorded for each of the plant's (phenotype) physiological stages. Descriptors

would include, for the plantlet stage, colour and pubescence of the hypocotyl, length of the primary leaf and thickness of the petiole; for the adult plant, plant height, growth habit, leaf positioning, flower colour and days to flowering; and for the productive stage, number, size and form of fruits and yield. These descriptors are then added to the passport data, previously recorded during field collecting or material acquisition.

Not all of a plant's characteristics are expressed with the same intensity. Some, especially quantitative, can be expressed in different degrees, which are then recorded on a scale (from 1 to 9). These grades are known as states of the descriptor (IPGRI 1996a). An example is resistance or susceptibility to different types of biotic stress (pests and diseases) and abiotic stress (drought, salinity, acidity or low soil fertility).

Measuring instruments

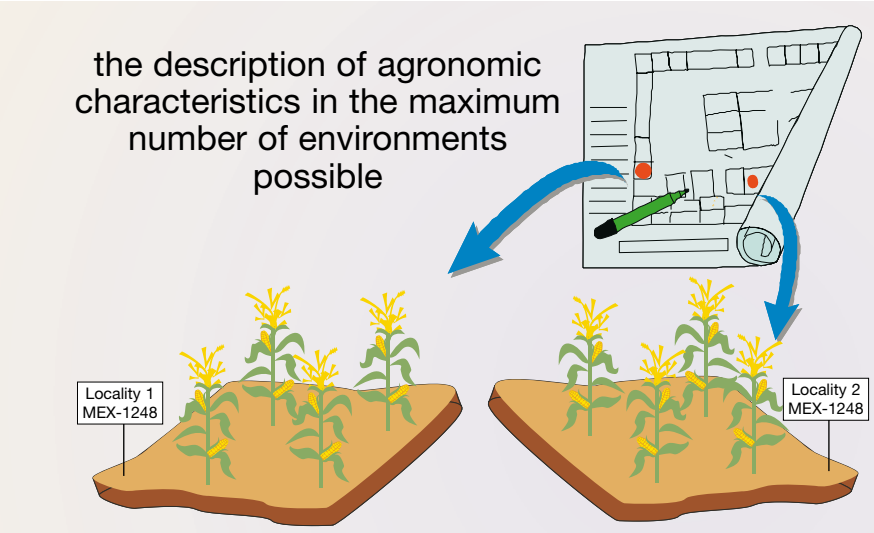
Characteristics are also expressed differently, requiring various instruments for recording them. While observing and recording the presence or absence of a characteristic (e.g. thorns or trichomes) will sometimes be enough, others (e.g. number of fruits or stamens and plant height) will need to be counted and/or measured with metric tapes and rulers of various sizes and gradations. Highly precise data recording may involve tools such as colour charts (like the Colour Charts of the Royal Horticultural Society, the Methuen Handbook of Colour or the Munsell Colour Charts for Plant Tissues), vernier calibrators, microscopes or stereoscopes, balances, pH meters, meters for measuring the resistance or hardness of peel and pulp, stoves (to calculate quantities of water and dry matter), and chemical reagents and laboratory instruments for characterization and for enzymatic and molecular evaluation.

Characterization is made easier by using lists of existing descriptors, prepared by experts and published by internationally-recognized agencies. Bioversity International (formerly IPGRI), for example, has so far published descriptor lists for more than 80 species and a multi-species list of available passport data (Appendix 9). These are also available on Internet (*see* Bibliography). Descriptor lists have also been published by the Informationzentrum für Genetische Ressourcen (IGR, Germany).

In addition, lists can be drawn up from previous works on the targeted species or related species and/or in consultation with experts. If, however, the targeted species has been little studied and/or a list of descriptors is not available, then the relevant characters, as described previously, must be identified. This task requires bringing together experts on the species in question.

From the characterization we should obtain a set of data that show the characteristics of the accessions we have. However, because we need to determine the benefit that those characteristics can offer us (i.e. possible uses), we evaluate the germplasm.

Evaluation is



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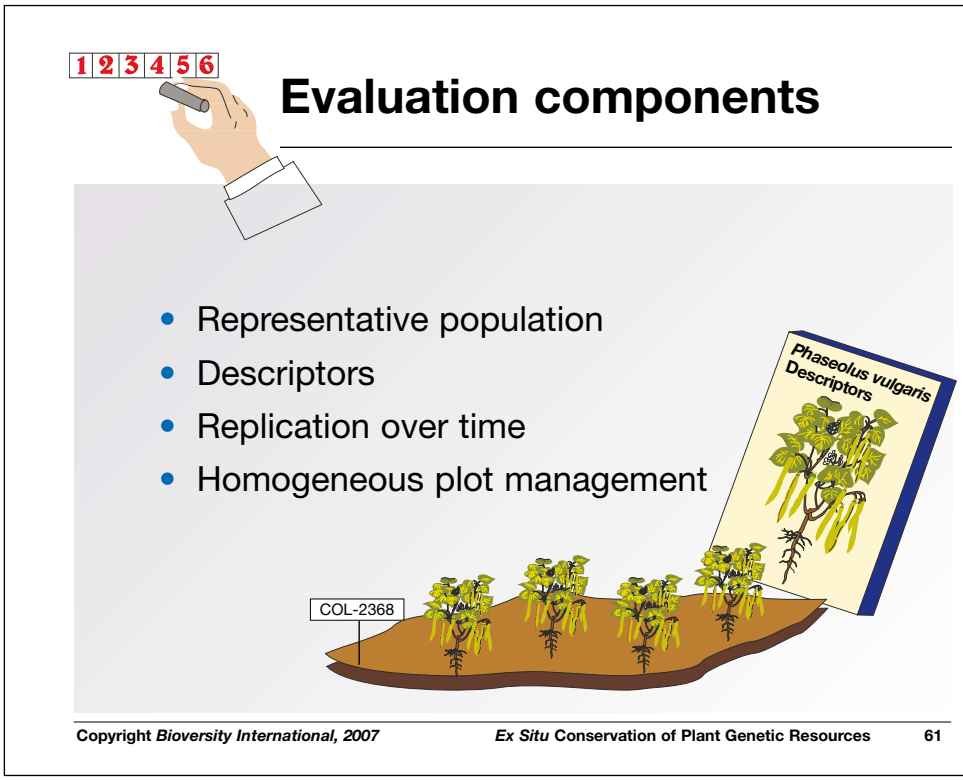
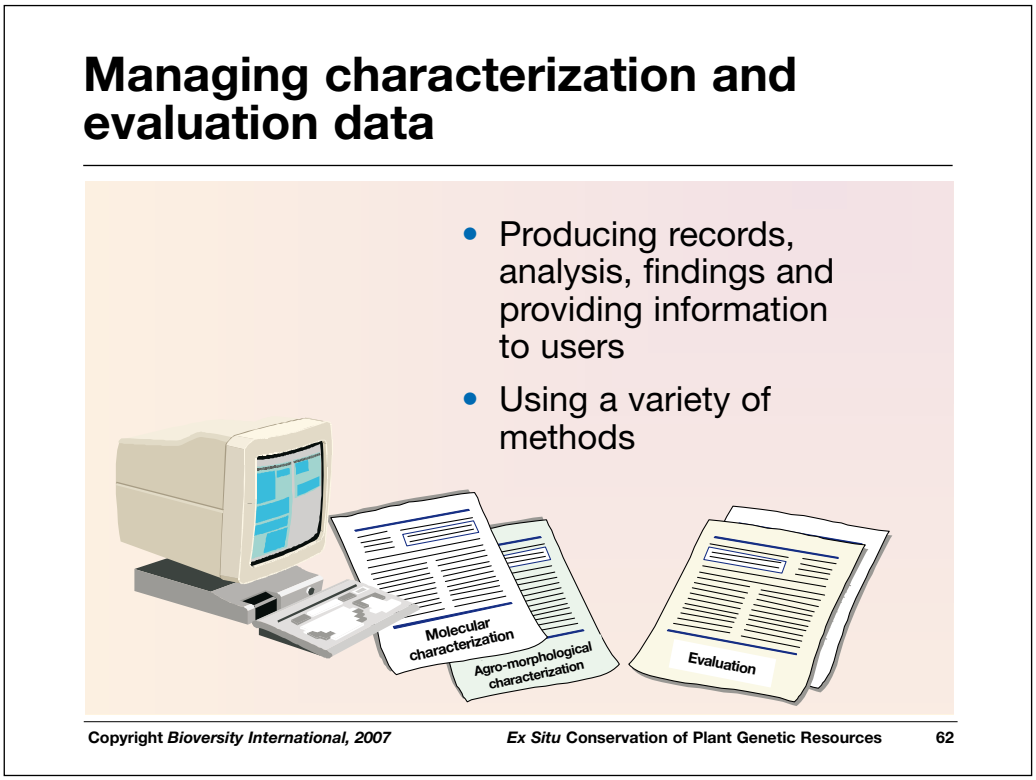
Evaluating germplasm

Once the morphological and anatomical characteristics of the germplasm are known through characterization, its potential for use is determined by evaluation. Evaluation consists of describing the accessions' agronomic characteristics (e.g. yield or resistance to biotic or abiotic stress) – usually quantitative (variable in accordance with the environment) and of low hereditability – in the maximum number of environments possible, to identify adaptable materials and those with useful genes for food production and/or crop improvement. Most evaluations are carried out by breeders.



Evaluation complements characterization and is also carried out on a representative population of the species and with descriptors. Evaluation can be conducted in the field, glasshouse or laboratory, depending on the characteristic being evaluated, and following the same procedure. Unlike characterization, where plants are planted once, evaluation requires planting the germplasm simultaneously in different environments and over several years. Hence, evaluating all the accessions is not economically feasible. A breeder must therefore opt for a preliminary evaluation to observe the adaptation of accessions to a new environment. Those that perform well against a check are then evaluated according to a specific objective. Evaluation trials should take into account the species, the objective of the evaluation and the sites. They should also follow an experimental design with several sites and replicates.

Germplasm evaluation also requires homogeneous management of the plots, and systematic data-collecting and recording to facilitate statistical analysis and thus reach conclusions on the material's usefulness.



Information analysis towards conclusions on the usefulness of the germplasm

In characterizing and evaluating germplasm, it is not enough to record, organize and store data – they must also be analyzed and made available to users. Without analysis, no conclusions can be made on the germplasm's potential usefulness. The obtained and analyzed data should faithfully represent the characteristics and behaviour of the accessions, so that they can be differentiated and those with potential for crop improvement can be selected – hence the importance of duly characterizing and evaluating the germplasm.

Data analysis can be simple or complex, ranging from graphs to such analytical methods as variance, comparison of means, multivariate, clustering, multiple correspondence and similarity.

Occasionally, the morpho-agronomic characterization and evaluation data are insufficient for establishing differences between species or between accessions. In these cases, studies of the genome are undertaken, such as those on the karyotype, number of chromosomes and level of ploidy. The genome can also be studied directly by using biochemical markers (isoenzymes), molecular markers [microsatellites, restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD) and quantitative trait loci (QTL)]. These methodologies make it possible to locate the genes of interest with greater accuracy but do not evaluate the effect of the environment on the expression of those genes. Accordingly, they do not replace – but complement – the characterization and evaluation of morpho-agronomic characters.

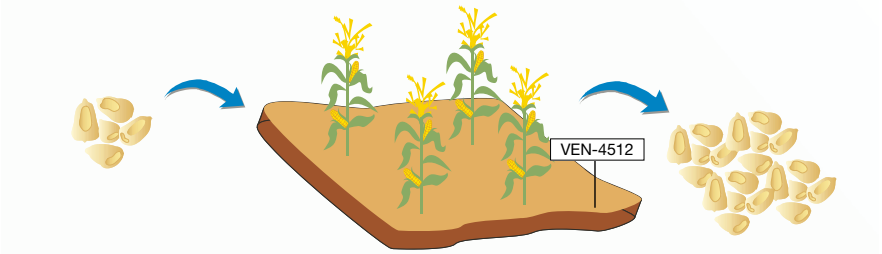
Management of the conserved germplasm

- Characterization and evaluation
- ***Multiplication and regeneration***
- Information and documentation
- Germplasm utilization

Multiplication and regeneration

Aim is to recover the quantity and viability of germplasm lost in storage by

- multiplying to recover size
- regenerating to optimize viability



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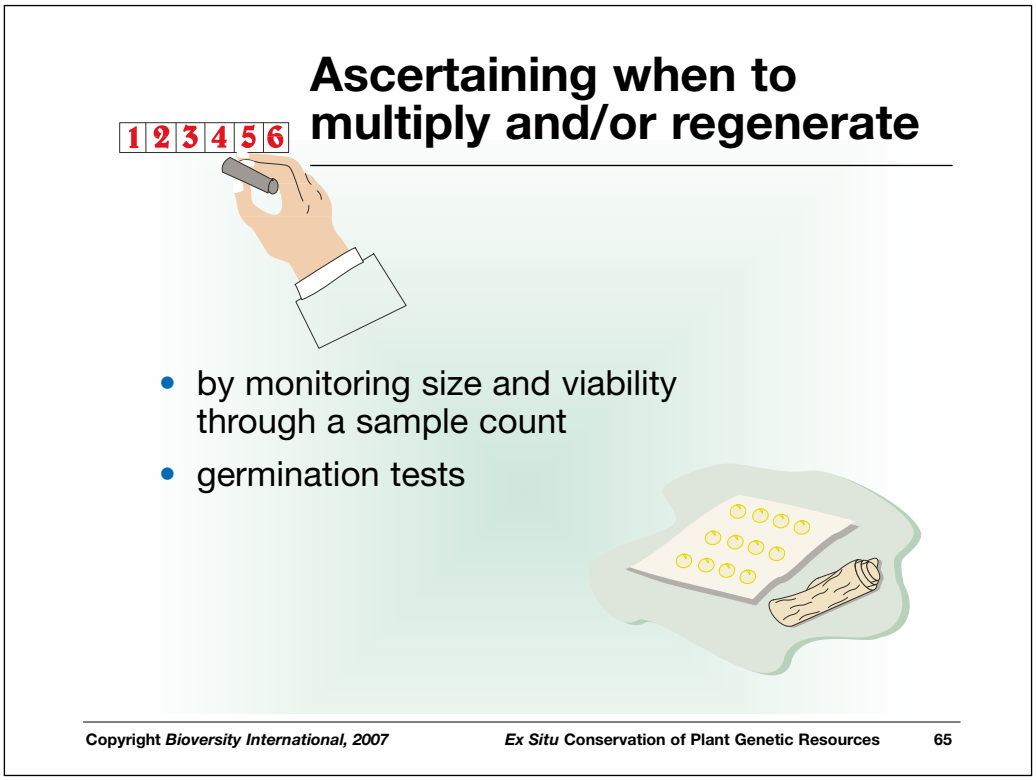
Multiplication and regeneration

During its period of conservation, germplasm can decline in quantity and quality (viability). Sample size diminishes with use and distribution while viability is reduced with time, even if the germplasm has been stored under optimal conditions (FAO 1996, cited by Sackville Hamilton and Chorlton 1997). When this happens, the germplasm must be multiplied and/or regenerated. If the objective is to recover viability, we speak of regeneration or rejuvenation, but if it is to bring the samples up to optimal size, we speak of multiplication. In either case, the samples obtained for multiplication and/or regeneration must be viable, healthy, of optimal size for storage and genetically identical to the original.

As with other conservation activities, multiplication and/or regeneration starts by monitoring the samples and is governed by standards and procedures that specify the quality and quantity of the required material, the number of plants, and the environment (Appendix 7) (Sackville Hamilton and Chorlton 1997). In the following pages we describe the procedures for multiplying and/or regenerating.



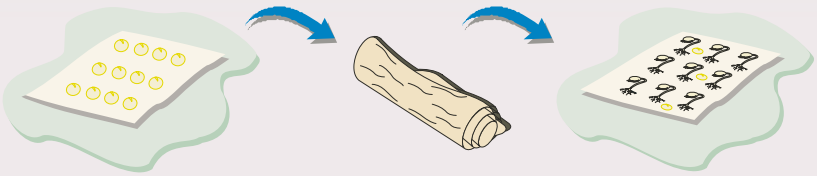
Monitoring to determine the need for multiplication and/or regeneration

A sample is under optimal conditions when it is viable and sufficient. If it is not, it should be multiplied and/or regenerated. The decision of whether to do so depends on monitoring both the size and viability of a sample's accessions. Size is monitored by counting the quantity of available propagules per accession. If the sample comprises seeds, the permissible minimum size, indicated in the 'Standards for Genebanks' (Appendix 7), is 1500 to 2000 seeds. Standards do not exist for sample size of vegetative propagules conserved in the field or *in vitro* but between 3 and 20 replicates are usually kept per accession. Viability is monitored through observation or tests, depending on the type of sample.

The viability of vegetative material (plants in the field or *in vitro* slow growth) is monitored by systematically observing the health, development and conditions under which it has been conserved. If some of these criteria are not met, then the sample should be regenerated. If the conserved material is seed, then viability is monitored by conducting germination tests that consist of sowing a sample of seeds to (1) ascertain what percentage germinate, and (2) if those that did not germinate are dead or dormant. The results are then compared with the initial data on viability, taken during preliminary multiplication. If viability has been reduced by 15% or more, then the sample needs to be regenerated.

Germination tests

- determine the percentage of viable seeds
- are subject to ISTA standards



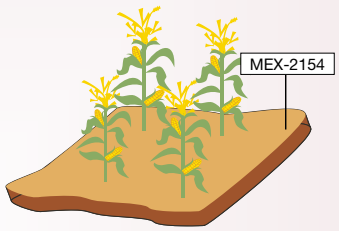
Germination tests

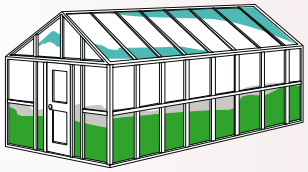
Germination tests are carried out on a minimum sample of 200 seeds taken at random (FAO and IPGRI 1994). Seeds are placed on paper towels and rolls or on substrates such as sand or soil. Depending on the species, they are then incubated at different temperatures until they germinate. The tests should follow the norms stipulated in the *International Rules for Seed Testing* (ISTA 1993). Should the germination tests not give satisfactory results, then complementary tests, such as those of tetrazole and X-rays, can be conducted to determine if the embryo is dead or dormant. These tests eliminate the possibility of using the material afterwards, which means that they should be applied only when sufficient seed is available.

The decision on multiplying and/or regenerating should not be left until the sample reaches minimal levels of size and viability, but neither should it be made frequently because the procedures are expensive and can endanger the germplasm's genetic integrity. Viability, however, should be given priority over size, that is, a large sample whose viability is declining is in more urgent need of regeneration/multiplication than a small sample whose viability is optimal.

To multiply and/or regenerate

- plants are established under optimal conditions for their respective species
- procedures can be conducted in the field, glasshouse, mesh house or *in vitro*





How to multiply and/or regenerate

Once the decision to multiply and/or regenerate the sample has been made, plants are established at the site of multiplication and/or regeneration and under optimal conditions of development so that the sample obtained is viable, healthy and sufficient to store, and is genetically equal to the original. The type of reproduction of the targeted species will determine those conditions.

Species that do not need control over pollination, such as those with asexual or autogamous reproduction, can be multiplied and/or regenerated in the field or mesh house. If they are multiplied and/or regenerated in the field, plants are planted in large populations on relatively small plots. Those of vegetative reproduction are multiplied from sterile samples of, for example, stakes, shoots and grafts. Species with sexual reproduction, which do need control over pollination (allogamous), are preferably multiplied and/or regenerated in the glasshouse or mesh house. They can be multiplied and/or regenerated in the field, but the land must be isolated and pollination strictly controlled. If the accessions comprise wild species, they can be multiplied and/or regenerated in furrows or plots in the field, or in the mesh house or glasshouse, depending on the quantity of available seed and on the species' requirements. A third group, comprising certain wild species (e.g. *Lycopersicon peruvianum*), needs special environmental conditions in order to reproduce.

The multiplication and/or regeneration of germplasm in the field or mesh house requires space, time and a great quantity of material and resources.

In vitro tissue culture requires little time and space, and makes it possible to work with various types of samples. It also offers the possibility of multiplying and/or regenerating a range of species, ensuring the establishment of healthy samples that are genetically identical to the original. It consists of micropropagating apices of axillary buds and meristems until entire plants are obtained. However, this method should be used preferably for germplasm conserved *in vitro* or in the field.

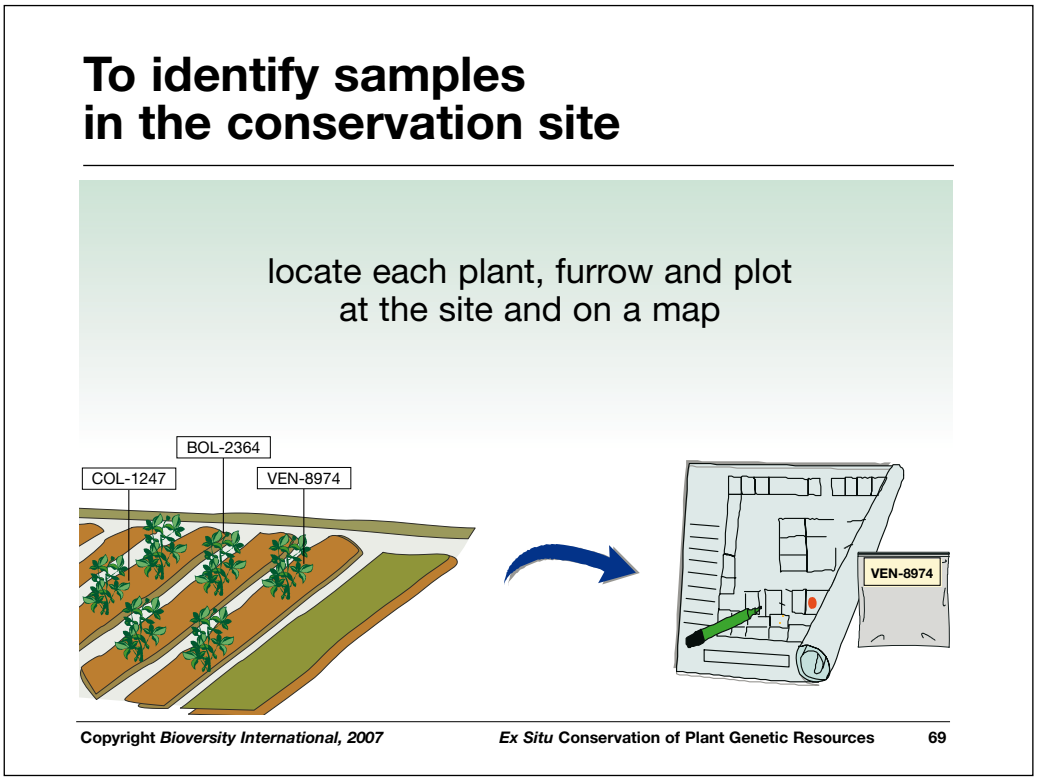
The environment of field collections is controlled to prevent

- pollen exchange
- mechanical mixtures
- pest and pathogen attacks

Controlling the environment of field collections

To obtain a sample of good physiological quality (i.e. viable, vigorous and healthy vegetative propagules or seeds) and identical to the original genotype requires strict control over the environment. Although the physiological quality of the germplasm depends on its genetic characteristics and on the environment in which it develops, it can be affected during the crop cycle by adverse environmental factors, which means avoiding biotic or abiotic stresses. The selected site should therefore have the required soil and water resources and, preferably, be isolated to prevent pathogen attacks or offer facilities for controlling them if they occur. Uniform distances will also need to be established between furrows, and between plants, and the agronomic tasks required by the species should be carried out. Seeds and propagules should be harvested when physiologically mature and healthy, taking care to avoid mechanical damage.

Environmental control to maintain the original genotype consists of preventing accessions from being contaminated by pollen exchange (allogamous) or mixed mechanically (autogamous and asexual). Populations can be isolated in the field or mesh house. If they are planted in the field, isolated plots should be used, separating the accessions by long distances. The plants should be submitted to thinning and pruning to prevent overlapping between plants and mixtures of fruits and seeds. Allogamous species also require strict control of pollination, which is achieved by bagging the reproductive structures and managing insect pollinator populations. Although the use of individual mesh houses for each accession eliminates the risk of contamination, it increases cost.

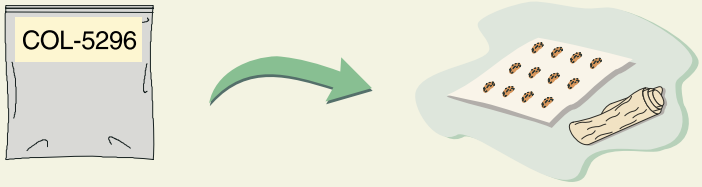


Identifying samples

As in all germplasm conservation activities, when multiplying and/or regenerating, samples must be precisely identified to prevent mixtures that would give rise to confusion and/or losses. The location of plots, furrows and plants being multiplied and/or regenerated should be marked on a map and at the site with their respective accession numbers. Labels should be weather resistant. Where a material's identification is in doubt, it can be confirmed by comparing the growing plants with herbarium specimens or with available passport data, and characterization and evaluation data.

Monitoring for viability and conditioning for storage

Multiplied and/or regenerated material is monitored for viability and then conditioned for storage

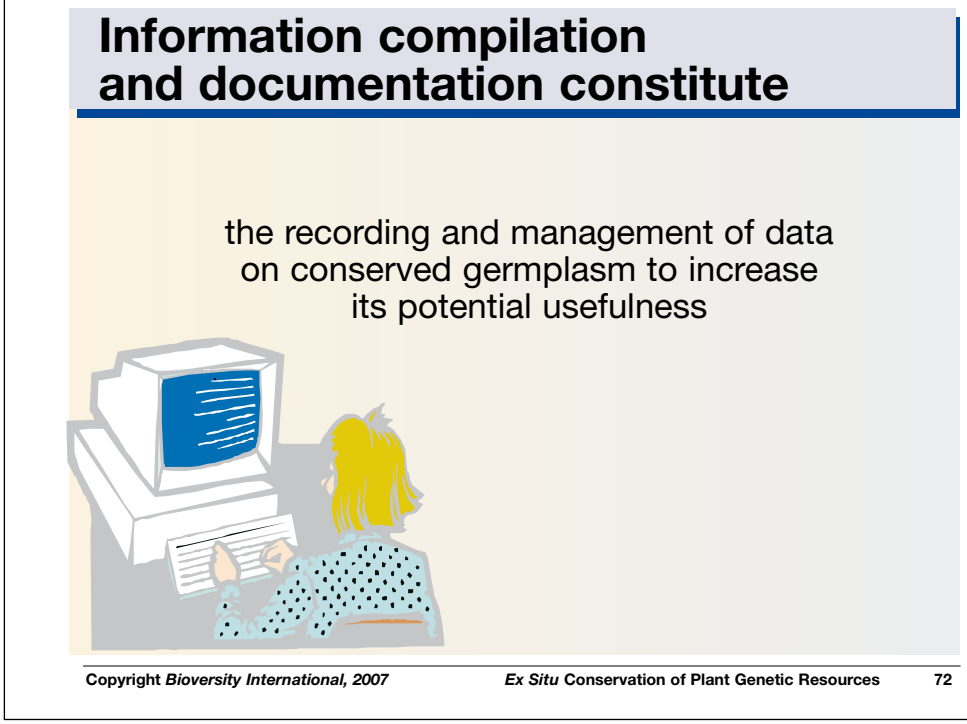


Monitoring for viability and conditioning for storage

Finally, once the material is multiplied and/or regenerated, it is submitted to viability tests and is conditioned for storing. The results of these tests serve as a reference for later monitoring.

Management of the conserved germplasm

- Characterization and evaluation
- Multiplication and regeneration
- ***Information and documentation***
- Germplasm utilization



Information and documentation

Germplasm conservation, in its various stages, encompasses a range of activities for which information is required or from which information is derived. Such information may refer to the species, their sites of origin and the activities or stages of conservation. The activities of recording, organizing and analyzing conservation data comprise documentation, and are fundamental to understanding the germplasm and making decisions on its management. The more that is known about a germplasm material, the more its value increases; hence, the importance of its being well documented.

Data recorded for documentation include

- passport data
- data from the collecting site
- data from characterization, evaluation and management activities

Categories of data on germplasm

Because of the large volume of information generated by conservation activities, categories of data should be established to facilitate their handling. These categories include passport data; data from field collecting, the site and environment; and from characterization, evaluation and management.

Passport and collection data

- identify the material and the collecting site
- can include traditional knowledge

Passport and collecting data

Passport data (which identify the material) and collecting data (which describe the characteristics and environment of the site where the sample was collected) are taken at the time of field collecting. They help determine how the sample should be handled and help interpret the characterization and evaluation data taken later.

Field collectors also record the local community's knowledge of the germplasm (i.e. indigenous or traditional knowledge, or ethnobotanic information), developed as a result of use over time. This information can include the species' characteristics, and how they are cultivated, conserved and used. Such information can be used later to characterize, evaluate, conserve and use the germplasm.

The importance currently being placed on ethnobotanic information is reflected in the establishment of centres that compile indigenous knowledge on a world level (Netherlands and USA), regional level (Nigeria and Philippines) and national level (Brazil, Burkina Faso, Germany, Ghana, Indonesia, Kenya, Mexico, Nigeria, Philippines, Republic of South Africa, Sri Lanka and Venezuela). These centres seek to study, understand and disseminate this knowledge to improve the conservation and use of plant genetic resources (Warren 1991; Warren and Rajasekaran 1993).

Characterization and evaluation data help

- determine the germplasm's physical and agronomic attributes
- make it possible to differentiate between accessions
- determine the germplasm's potential usefulness

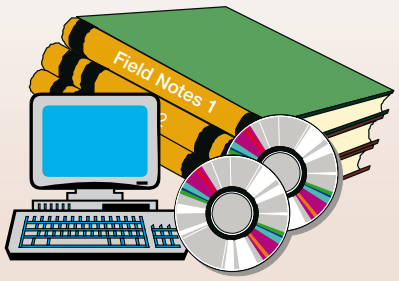
Characterization and evaluation data

Characterization data describe the germplasm's physical attributes. They vary according to species but, in general, describe the plant in all its developmental stages. They are needed for identifying and differentiating easily and quickly between accessions.

Evaluation data describe the plant in terms of its agronomic characteristics. They help determine the germplasm's potential usefulness and select those genotypes useful for agricultural production and crop improvement.

Management data

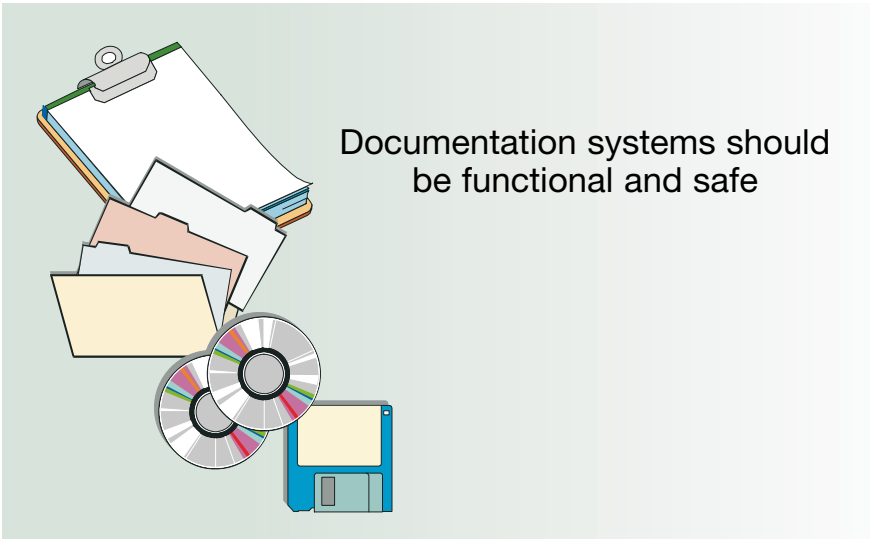
result from conservation activities and make it possible to evaluate their effectiveness



Germplasm management data

Data from management arise from different conservation activities, that is, those that are carried out with germplasm such as preliminary multiplication, the determination and monitoring of viability, multiplication and regeneration cycles, storage and distribution. This information serves as a basis on which to evaluate the efficiency and effectiveness of the conservation activities.

Recording and storing information



Storing information: using documentation systems

As we have already mentioned, the data being taken and recorded on conserved plant genetic resources are many, varied and voluminous. They, therefore, need to be organized, recorded, analyzed and stored in systems that facilitate conservation and management. Information can be stored by different means – paper, microfiche, databases, diskettes – but the one that is finally selected should be functional and safe. The means for handling the information on germplasm are called documentation systems.

Characteristics of effective documentation systems

- Accuracy
- Organization and functionality
- Flexibility
- Ease of management

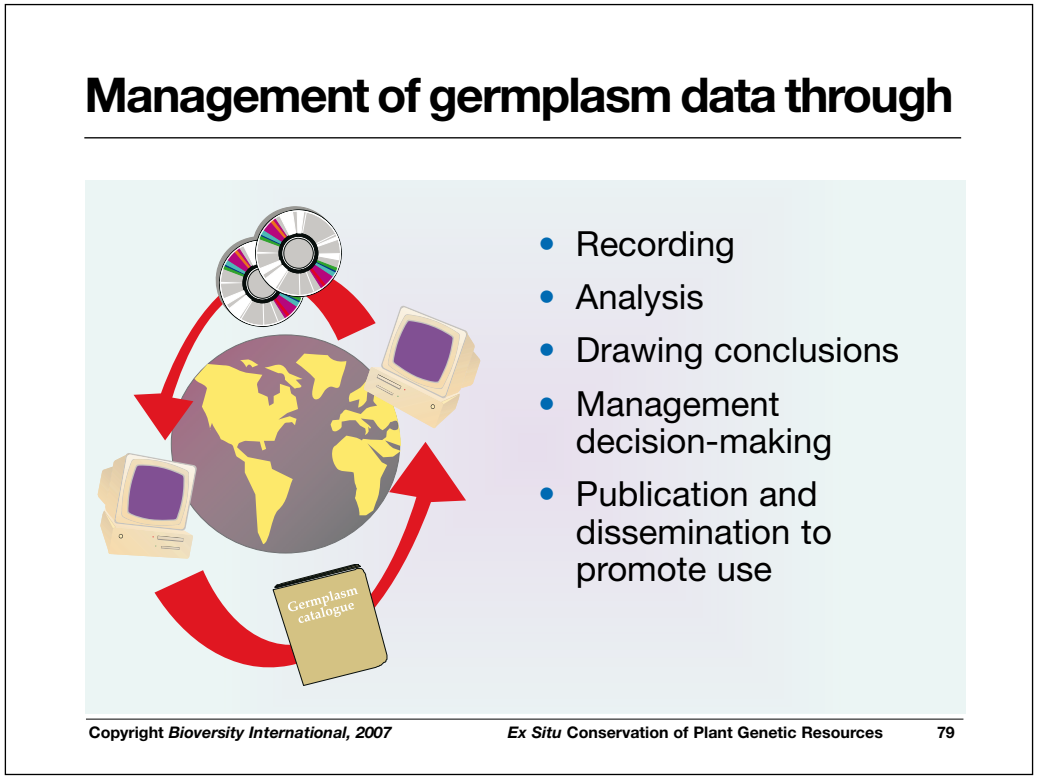
Characteristics of documentation systems

A documentation system should contain information that is as valuable for users as it is for those who conserve the material. Accordingly, the system should (1) include exact information, truthful, reliable and up to date; (2) enable users to readily access and recover information; (3) be easy to manage and require minimal training in using it; (4) be flexible so that it can adapt to future changes, and (5) be organized into categories of use that facilitate recording, storage, updating, processing and recovery (Painting *et al.* 1993).

Documentation systems can be manual or computerized. Manual systems store information in field books, printed formats or microfiches. They have been used for decades but are losing validity because, although the information is recorded, it is scattered and, thus, harder to locate, recover and handle as the number of accessions increases.

Computerized systems record information in databases, created on applications (software) that are either commercial or otherwise developed for germplasm documentation. These systems are increasingly being used because they permit a thorough and systematic allocation and organization of information, grouping and interrelating it and updating it regularly. They also permit the rapid location and recovery of information, and make storing considerable volumes of data possible. Furthermore, they occupy little space and are safer in that they can be duplicated.

Currently, most genebanks handle information in databases that they themselves developed or adapted from systems developed by others, such as the Genebank Management Information System (GMS), developed by IPGRI; the Germplasm Resources Information Network (pcGRIN), developed by the USDA and IPGRI; and the Caribbean Seed and Germplasm Resources Information Network (CSEGRIN), developed by FAO. These systems can be easily adopted by the genebank's requesting copies of the software from the institutions that developed them.



What to do with data stored in a documentation system

Once recorded and organized into categories, the data are analyzed to make management decisions on the germplasm holdings and to prepare publications for promoting use of the conserved germplasm. Comparing different groups of data across time makes it possible to plan activities to be carried out with the germplasm (e.g. to multiply and/or regenerate accessions); to detect problems such as deterioration and/or loss of accessions; and to evaluate the effectiveness of the conservation programme. Statistical analysis of characterization and evaluation data enables conclusions to be reached on the quantity and characteristics of the diversity being conserved and its possible uses; this information is directed at users to promote use of the germplasm.

Promoting the use of plant genetic resources also includes informing users of the services that the bank performs, the plant genetic resources that it conserves and how to access them. Germplasm catalogues (either on paper or in electronic form), and on-line databases and pamphlets are some examples of products and services through which germplasm information can be made known to users. Users are also being encouraged to use Internet to consult databases and virtual catalogues of holdings, which can even include pictures of accessions (Puzone and Hazekamp 1998). Examples of Internet publications on genetic resources include CGIAR 1997a, b; IPGRI 1998a, b; FAO 1999; the virtual germplasm catalogue for olive and fruit trees by the Istituto sulla Propagazione delle Specie Legnose of the Consiglio Nazionale delle Ricerche (CNR, Italy) (Roselli *et al.* 1998); the System-wide Information Network for Genetic Resources (SINGER) of the Consultative Group on

International Agricultural Research (CGIAR); Bioversity's germplasm database, and the World Information and Early Warning System (WIEWS) for plant genetic resources, administered by FAO.

SINGER is a network for exchanging information on germplasm holdings held in trust by CGIAR centres (which hold more than 500,000 samples of germplasm of crops, forages and trees important for food and agriculture. IPGRI's germplasm database contains information on the entity maintaining the holdings, the type of germplasm conserved, species names and type and number of accessions per species. It contains data for about 5 million accessions being held in germplasm holdings throughout the world, and is linked with WIEWS. WIEWS has several databases, including one on *ex situ* germplasm collections. This database indicates species names, the number of accessions for each species, type of material held (e.g. wild or mutant), geographical distribution and the place where duplicates are kept for safety.

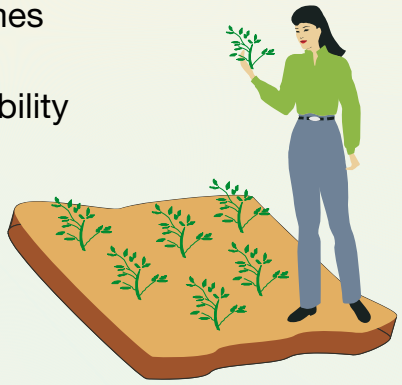
As we have seen, a solid documentation system constitutes a support for those who handle germplasm because it helps them establish priorities, plan management activities and optimize resources. It also promotes germplasm use by facilitating users' access to the information and enabling them to identify accessions of interest (Painting *et al.* 1993).

Management of the conserved germplasm

- Characterization and evaluation
- Multiplication and regeneration
- Information and documentation
- ***Germplasm utilization***

Using the germplasm

- Germplasm can be used in its original form or in breeding programmes
- Its use depends on knowledge and availability

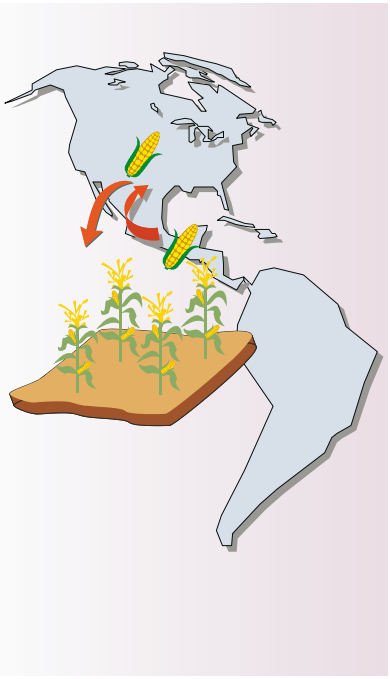


Using the germplasm

Germplasm is conserved to be used. Use depends on knowing where it is, understanding its characteristics and usefulness and maintaining it viable and available. Germplasm can be used directly for immediate use or indirectly for genetic improvement.

Direct uses of germplasm

- include introducing or re-introducing materials
- can offer immediate advantages but may reduce the genetic base



Direct use

Direct use consists of identifying materials with desirable traits – such germplasm usually comprises landraces – and introducing them in their original form to other regions. The germplasm is normally introduced to improve agricultural production but can be used for restoring a habitat or replenishing areas where the germplasm has been lost. This old form of use is appropriate because it takes advantage of materials with good traits but implies risks such as the introduction of pests, diseases and weeds, the replacement and/or elimination of native species and the genetic impoverishment of local varieties. Examples of direct use are the adaptation of maize and beans to several sites in the Americas and the introduction of the potato and tomato into Europe.

Indirect use

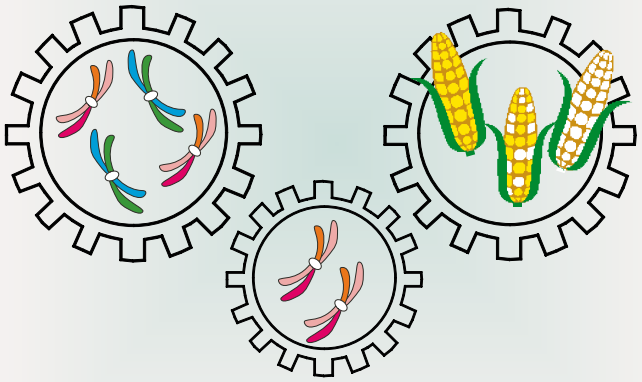
In plant breeding, to introduce genes of certain materials into others, to improve quality or productivity

Indirect use

Indirect use involves the search for genes in wild and weedy species and traditional varieties to introduce them into other cultivars, thereby obtaining materials that are attractive and easy to use. This form of use is known as breeding and aims to increase agricultural production and/or improve crop quality. Production is increased by improving yield, physiological efficiency, adaptation and agronomic traits, and by introducing pest and disease resistance. Quality is improved by elevating nutritional content and improving palatability, or by refining attributes such as form, colour and shelf life.

Germplasm is improved by

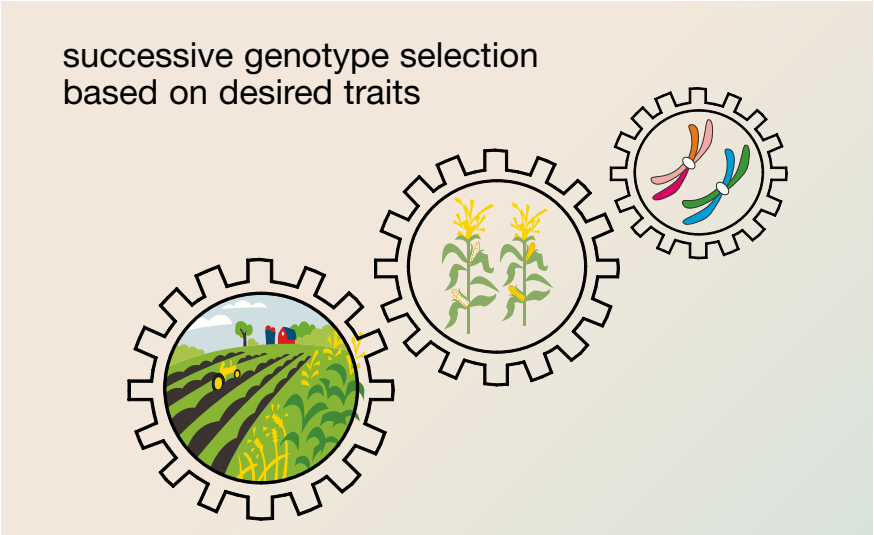
modifying allele frequency or the genotype



Improving germplasm

Improved materials are obtained by modifying the frequency of alleles or the combinations of genes (i.e. the genotype). Depending on the objective, the species' genetic variability and availability of resources, a plant breeder will use (1) selection to modify gene frequency, or (2) hybridization, backcrossing or gene transfer to modify the genotype.

Allele frequency is changed through



Changing allele frequency

Allele frequencies or genotypes are modified through selection, which is the identification – within a genetically variable population, cultivated in selected environments and under uniform conditions – of genotypes with one or more traits (genes) of interest and repeatedly selecting them until agronomically outstanding materials are obtained. The expression of the desired trait in the improved material is observed indirectly through the phenotype, but it should be a manifestation of the genotype and not an effect of the environment.

The most commonly used methods of selection are mass selection, that of pure lines, that of individual plants with a progeny test for autogamous species such as rice, recurrent selection and selection between and within families of half-siblings and full-siblings in allogamous species such as maize.

Changing the genotype involves

transferring genes from one material to another
by hybridization, backcrossing and pre-breeding

Use of gene transfer to modify the genotype

Genes can be transferred by crossing plants (hybridization, backcrossing and pre-breeding) or by inserting genes or DNA fragments directly into the genome through biotechnology and genetic engineering. Hybridization consists of crossing two genetically different cultivars to result in another generation (i.e. the hybrid) that combines the genes or traits of interest that the parents separately possess. This method is principally used for improving allogamous species such as maize. Hybridization increases the genetic variability of a given species while making possible new gene combinations (Poehlman and Sleper 1995).

Backcrossing consists of introducing – through hybridization – a trait of interest present in a donor progenitor into a cultivar with good agronomic traits. The hybrid, however, is crossed several times with the initial cultivar (recurrent progenitor) until traits lost in the hybridization are recovered. This method has been frequently used to improve tomato.

Pre-breeding involves either transferring genes or combining genes from wild species with those of improved or cultivated materials to increase crop quality and/or yield. This method expands the genetic base of cultivated species, and is carried out through introgression and enhancement (Duvick 1990; FAO 1998). The first operates on individual plants and the second on populations.

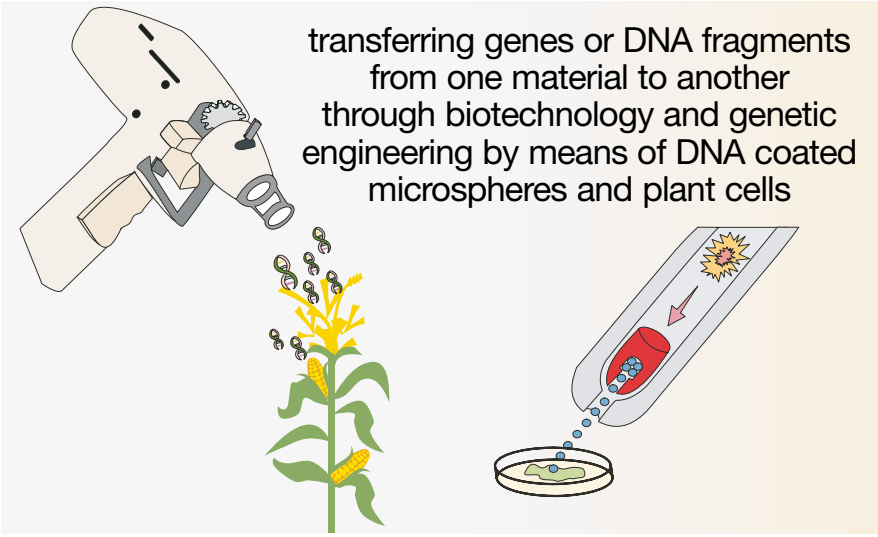
Introgression consists of crossing a donor material (which contains the gene of interest) with that which is being improved, and backcrossing the new material

until all traits of interest are recovered. This method has been successfully used to transfer resistance to biotic and abiotic stresses, and to introduce quality traits.

A classic example is that of tomato (*Lycopersicon esculentum*), whose wild relatives have contributed genes of resistance to fungi (*L. hirsutum* and *L. pimpinellifolium*), viruses (*L. chilense* and *L. peruvianum*), nematodes (*L. peruvianum*) and insects (*L. hirsutum*). *Lycopersicon chmielewskii* and *L. cheesmanii* have, respectively, been used to improve fruit quality and adaptation to different environments. Through introgression, other crops have also been improved, such as wheat, maize, alfalfa (*Medicago sativa*), rice, cassava and sorghum (FAO 1998).

Enhancement consists of improving locally-adapted populations with genes from wild species. Not only does this method work with populations, it also expands the species' genetic base. Examples of improvement by enhancement are the adaptation of tropical maize germplasm to the more temperate climate of southern USA, and the broadening of the genetic base of the European species *Solanum tuberosum* through germplasm of the South American *S. tuberosum* subsp. *andigena* (FAO 1998).

The genome can be directly modified by



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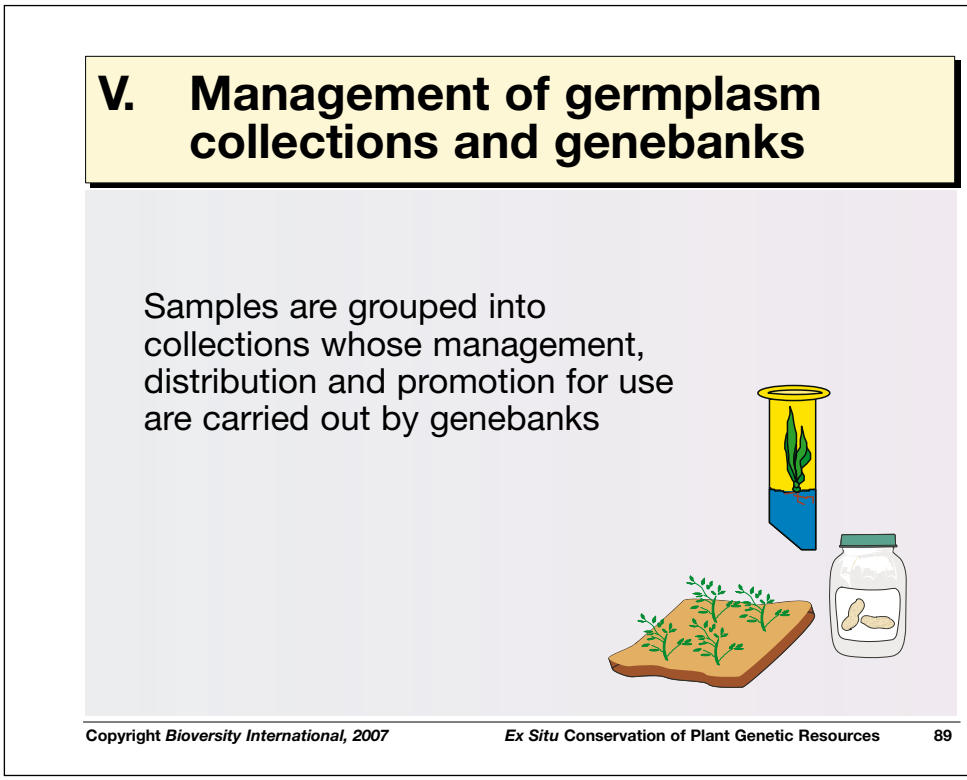
Transferring genes or DNA fragments to the genome

Biotechnology and genetic engineering enable a breeder to move from working with the entire plant (classic breeding) to working at the cellular or molecular level (genetic transformation), directly manipulating DNA. The procedure consists of (1) locating the desired gene or DNA fragment, (2) cutting it with restriction enzymes, (3) placing it inside a vector or plasmid, (4) inserting the vector carrying the DNA of interest into the genome of the targeted material, and (5) evaluating the expression of the inserted gene or fragment in the modified plant. These new methodologies, still being perfected, facilitate crop improvement by overcoming limitations of the classic methods, such as incompatibility, self-incompatibility and sterility.

Classic breeding and the new methodologies are not exclusive; on the contrary, they can be used in a complementary manner to produce better and more impressive results. Examples of such complementarity are improvement with the help of molecular markers, production of transgenic plants with resistance to pests and diseases, and the improvement of the nutritional quality of legumes and grains.

So far, we have seen how *ex situ* conservation is a process that ranges from determining the need to conserve a species, to understanding its traits and potential usefulness so as to promote its use. The diverse stages through which germplasm is maintained viable and available are interrelated and are made easier by grouping germplasm into collections and banks, as described in the next section.

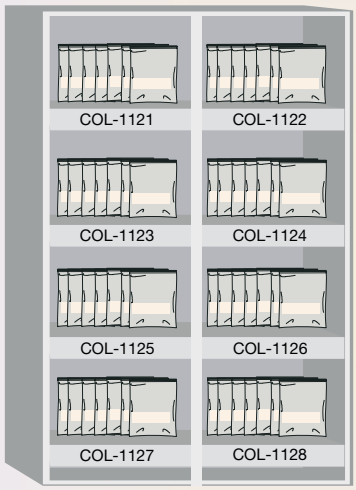
Contents



V. Management of germplasm collections and genebanks

Throughout the present module we have studied how to conserve *ex situ* samples of germplasm, that is, how to conserve them outside their natural habitats. Samples of a given species are grouped into a collection, which is then managed by an institution. The collections that the institution maintains as well as the activities it performs and the services it provides with the conserved germplasm lead us to speak of genebanks. Types of collections and genebanks and some examples are described below.

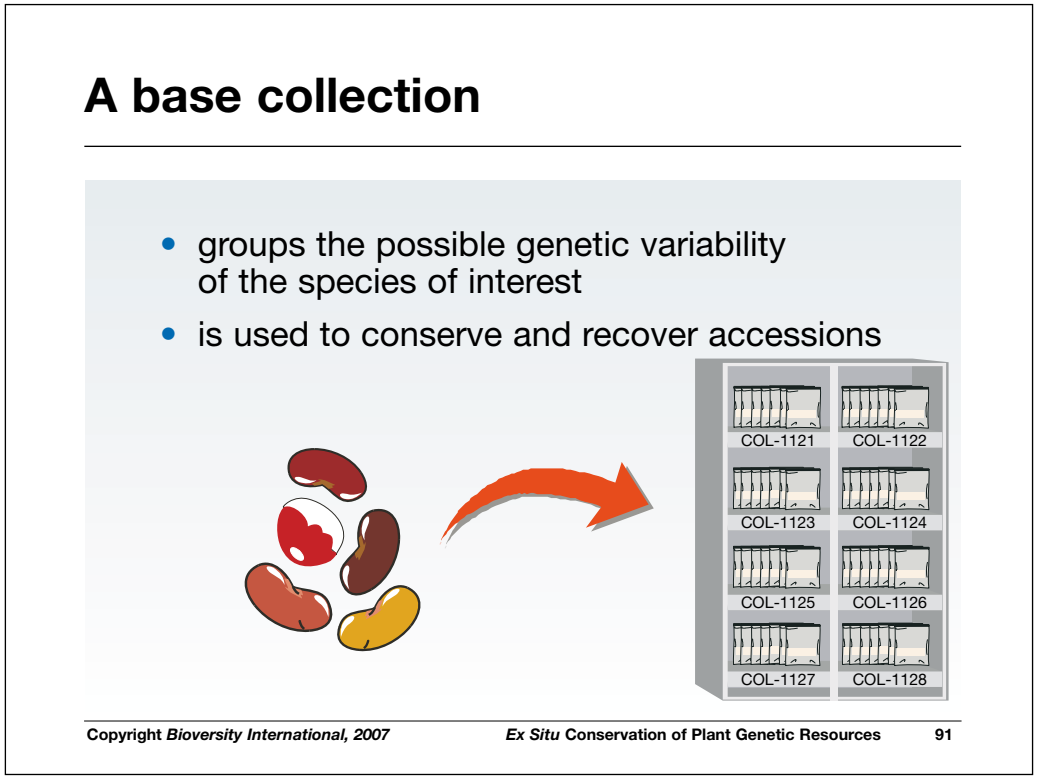
Germplasm collections are



collections of accessions that represent the genetic variability targeted for conservation and/or use

A. Germplasm collections

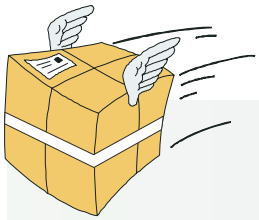
Germplasm collections are congregations of accessions that represent the genetic variability targeted for conservation and/or use. They can hold from tens of samples to thousands, all maintained under the appropriate environments and conditions. Germplasm collections are classified according to base, active, core and working collections. Each is composed of certain materials, conserved under particular conditions and kept for specific periods.



Base collection

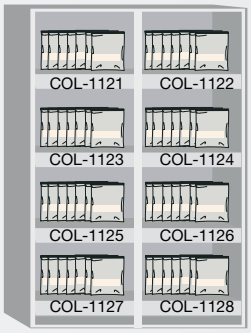
A base collection groups the possible genetic variability of the species of interest, including wild relatives, intermediate forms, cultivars, traditional varieties and elite germplasm (Vilela-Morales and Valois 1996a, b). The collection is established to conserve germplasm on a long-term basis and to recover missing accessions. It is not used for distribution or exchange (Hanson *et al.* 1984, cited by Plucknett *et al.* 1992; Towil and Roos 1989; NRC 1993; Vilela-Morales and Valois 1996a, b). It may contain samples of seed (orthodox only) or vegetative material. If it contains seeds, the moisture content of these is reduced to 3% – 7%. The seeds are then packed in sealed containers and stored in chambers at temperatures between -10°C and -20°C (Towil and Roos 1989; Paroda and Arora 1991; FAO and IPGRI 1994; Vilela-Morales and Valois 1996a, b). If vegetative material is conserved, it is maintained in the field or is cryopreserved.

Because of the variability it contains and its function, the base collection is of strategic importance to a country. It should therefore be duplicated and given into the charge of an institution that can respond for the germplasm's survival. Normally, such a collection is the responsibility of a national programme or of an international agricultural research centre (IARC). Some examples of base collections are those of *Arachis* spp. at the Centro Nacional de Pesquisa de Recursos Genéticos e Biotecnologia (CENARGEN, Brazil); *Phaseolus* spp. and *Manihot* spp. at CIAT (Colombia); *Zea* spp. and *Triticum* spp. at the Centro Internacional para Mejoramiento de Maiz y Trigo (CIMMYT, Mexico); and Andean roots and tubers at the Centro Internacional de la Papa (CIP, Peru).



An active collection

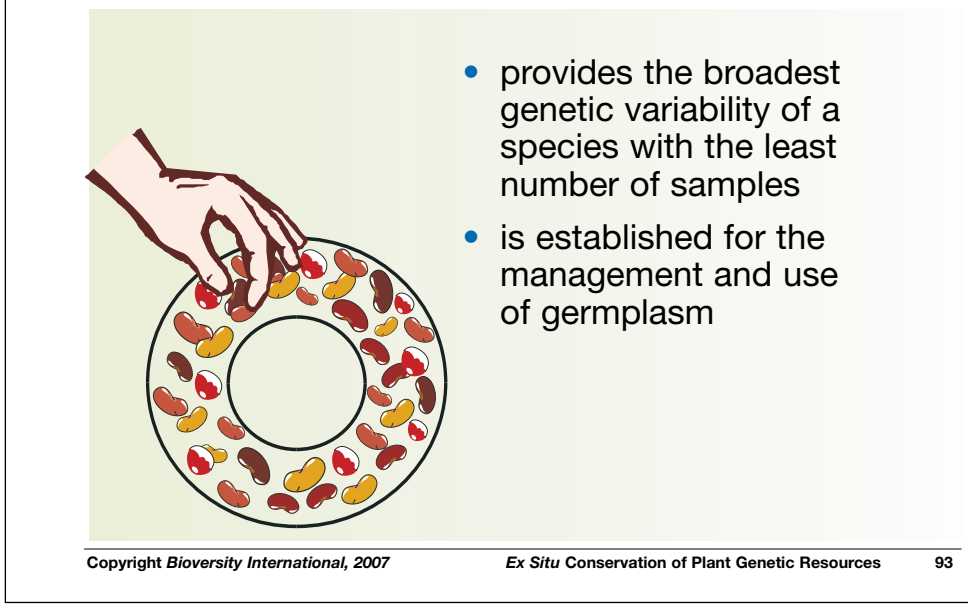
- duplicates the base collection
- is used to manage and distribute accessions



Active collection

An active collection is a duplicate of a base collection, established for the short and medium terms for management and distribution. It can conserve germplasm in the form of seed, in the field or *in vitro*. If it conserves seeds, these are stored at a moisture content between 3% and 7% and at temperatures between 0°C and 15°C (Engle 1992; NRC 1993). If the material is conserved *in vitro*, it is conserved under slow growth.

Active collections can be the responsibility of a variety of institutions, both public and private, and including IARCs; regional, national, provincial and municipal programmes; universities; and non-governmental organizations. Two examples are the collections of maize at CIMMYT (Mexico) and of cassava at CIAT (Colombia).



Core collection

The core collection brings together the greater genetic variability of a species with the least number of samples. It is formed by duplicating the base collection, separating those accessions that will constitute the core collection – that is, 70% to 80% of variability will be represented by 10% to 15% of the accessions – and taking the rest to a reserve collection. The core collection is established to facilitate germplasm management and promote its use. It permits the detection of duplicates in the base collection and helps establish priorities for characterizing and evaluating samples. It also offers easy access to conserved materials (Frankel *et al.* 1995; Hodgkin *et al.* 1995; Pérez-Ruíz 1997).

The core collection conserves seed or vegetative material under the same conditions as an active collection. As with the other two, the core collection is the responsibility of, among others, the IARCs, national programmes or collaborative programmes on specific crops. Some examples are the core collections of potato at the Instituto Nacional de Tecnología Agropecuaria (INTA, Argentina) and the Instituto Boliviano de Tecnología Agropecuaria (IBTA, Bolivia), those of cassava and potato at CENARGEN (Brazil), those of potato and sweetpotato at the Centro Nacional de Pesquisa de Hortalicas (CNPH, Brazil), and that of cassava at CIAT (Colombia).

Information technology makes creating a virtual core collection possible. If the germplasm is well documented and the documentation system permits specific searches, the virtual core collection is created by seeking and marking the accessions that have the traits of interest (J.F. Valls and J.M.M. Engels, 1999, pers. comm.).

A working collection

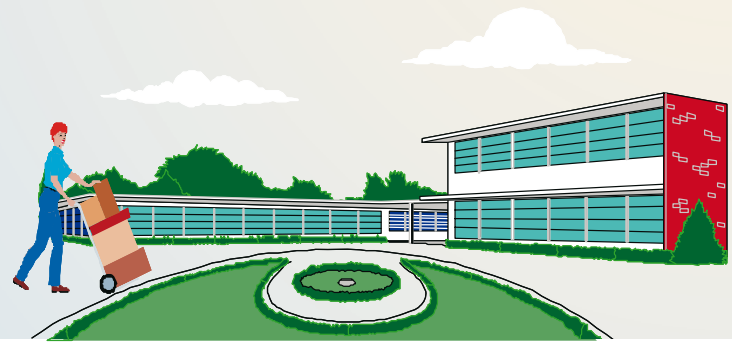
- holds accessions with traits of interest for breeding
- provides germplasm to breeders

Working collection

A working collection, or breeding collection, is established to provide germplasm to researchers, institutions or research and/or breeding programmes. It holds accessions with traits of interest for crop improvement, but is unrepresentative of a crop's genetic variability. It conserves seeds or plants over the short term. Seeds are kept at room temperature but if the climate is hot and moist they are put in rooms fitted with air conditioners and dehumidifiers. Plants are conserved in the field or in glasshouses. Working collections are normally the responsibility of crop breeding programmes.

Genebanks are

established to fulfil the conservation goals of institutions, countries or regions

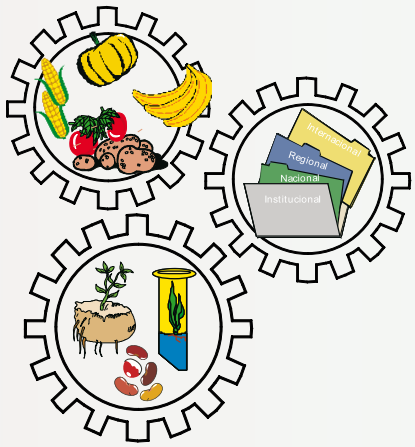


B. Genebanks

Genebanks are established to fulfil the conservation goals of a research institution, country or region. They conduct different activities that range from acquiring germplasm, studying their characteristics and potential usefulness, and ensuring their survival, to keeping it available for users and disseminating information that promotes its use. Usually, genebanks are attached to an institution or are in the charge of a group of people (curators) who have the capacity and resources to maintain the germplasm under optimal conditions for the required period.

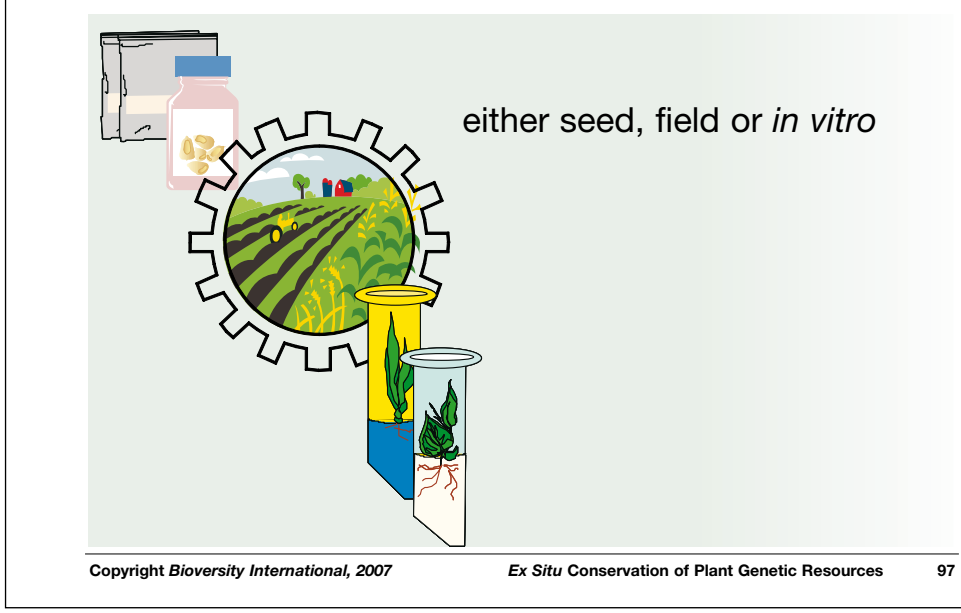
Genebanks are classified according to

- sample type
- number of species being conserved
- institutional mandate



Types of bank

Genebanks are classified according to sample type (seed; field, including botanic gardens and arboreta; or *in vitro*), number of species conserved (mono-, oligo- and polyspecific) and the mandate of the institutions to which they are attached (institutional, national, regional or international).



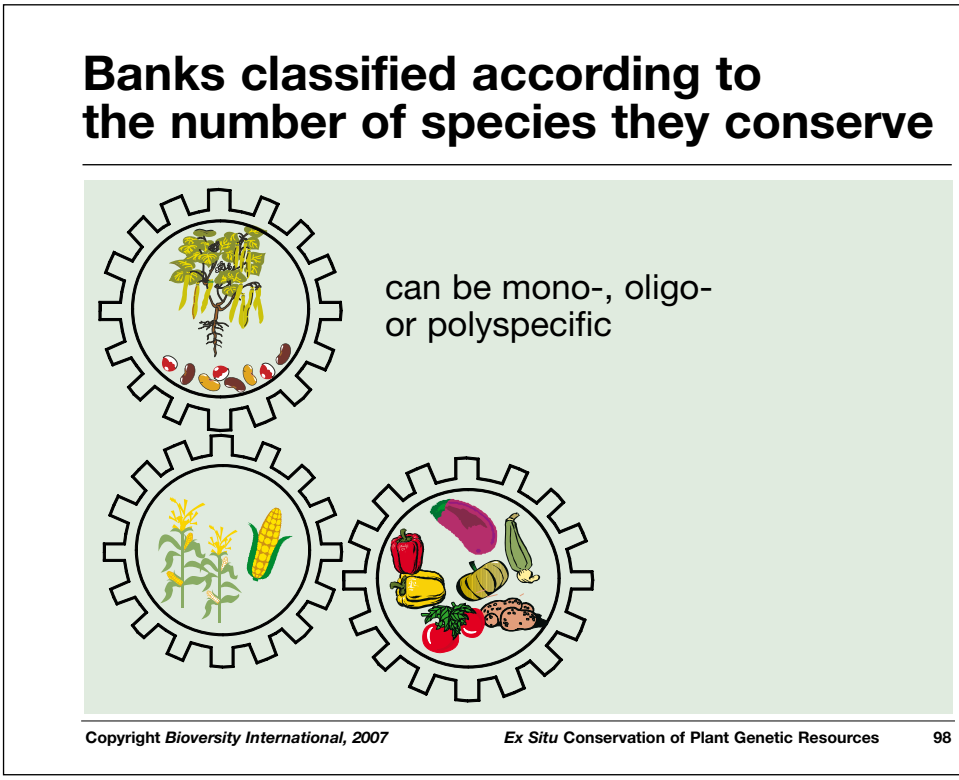
Banks classified according to sample type

Seed banks conserve orthodox seeds for the short, medium and long terms under controlled conditions of humidity and temperature (Ellis and Roberts 1991; Withers 1995; Maxted *et al.* 1997a, b). Examples of seed banks abound, including those of beans at CIAT (Colombia), maize and wheat at CIMMYT (Mexico), the genera *Capsicum*, *Cucurbita* and *Solanum* at the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE, Costa Rica), rice at the International Institute for Tropical Agriculture (IITA, Nigeria) and the International Rice Research Institute (IRRI, Philippines), and sorghum at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, India).

Field banks conserve species whose storage in the form of seed is problematic or not feasible. They include botanic gardens and arboreta, traditionally established for the study of plants (particularly medicinal species) and whose current goal is to conserve rare species, endangered species and/or species useful for restoring ecosystems (Querol 1988; Heywood 1991; Frankel *et al.* 1995).

Examples of field banks are of cassava at CIAT (Colombia), forages at INTA (Argentina), potato and Andean roots and tubers at CIP (Peru) and cassava and citrus fruits at CENARGEN (Brazil). Examples of botanic gardens are the José Celestino Mutis and the one at the Faculty of Agronomy of the University of Caldas (Colombia), the Arenal and Lankester (Costa Rica) and the Lancetilla (Honduras).

In vitro banks are germplasm collections maintained in the laboratory under conditions that reduce or suspend growth in samples. *In vitro* banks conserve species that cannot be conserved as seed, maintaining them as different sample types, such as entire plants, tissues (apices, meristems and calluses), and DNA fragments (Frankel *et al.* 1995). Two examples are the cassava bank at CIAT (Colombia) and the potato bank at CIP (Peru).



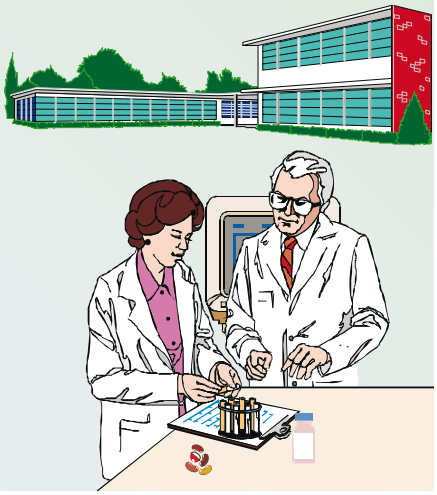
Banks classified according to the number of species they conserve

The mono- and oligospecific banks conserve, respectively, one or more species over the short and medium term. Examples are banks for research programmes in national and international agricultural research centres, the soybean genebank of the Oleaginous Plants Program of the Corporación Colombiana de Investigación Agropecuaria (CORPOICA, Colombia), and the maize genebank of CIMMYT's Breeding Program for Tropical Acid Soils (Colombian office).

Polyspecific banks are established in a manner similar to the national centres of plant genetic resources, and for the purposes of research and breeding. They conserve germplasm on a long-term basis and distribute a broad range of species of current or potential interest. An example of this type of bank is to be found at INTA (Argentina), which maintains, among others, collections of *Arachis* spp., *Linum usitatissimum*, *Triticum* spp., *Zea mays*, *Sorghum* spp., *Gossypium hirsutum*, *Glycine max*, *Solanum* spp. and *Helianthus* spp.

Banks established according to institutional mandate may be

institutional, regional or international



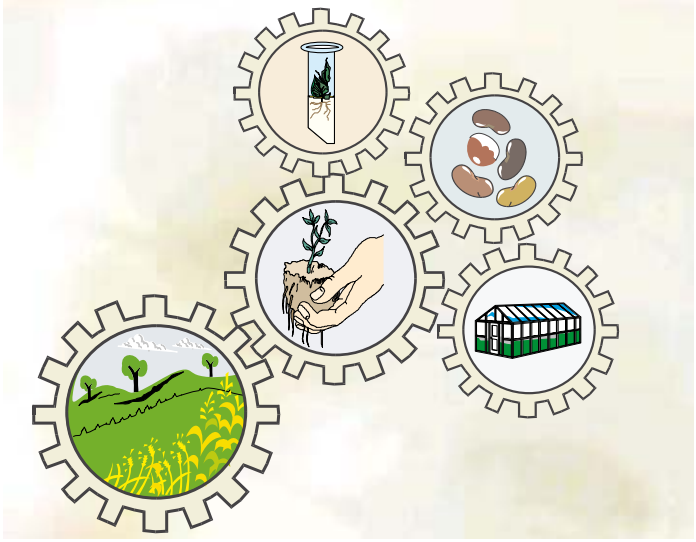
Banks classified according to institutional mandates

Genebanks are normally attached to an institution whose mandate, nature or geographical coverage is reflected in its goals. Hence, these banks can be called institutional, national, regional or international genebanks. Institutional banks conserve only germplasm used for research by the institute to which they are attached. An example is that of the Universidade Federal do Viçosa (Brazil), which conserves germplasm of the genera *Lycopersicon* and *Solanum*.

A regional bank is established as a collaborative entity between several countries to conserve the germplasm of a given region and support research on that germplasm. A Latin American example is the bank at CATIE (Costa Rica), which has collections of several genera such as *Capsicum*, *Cucurbita* and *Solanum*. The banks located in the IARCs were initially established to support breeding programmes and conserve germplasm of crops under their mandates, as well as of other crops. Two examples are the genebanks of the genera *Phaseolus* and *Manihot*, and tropical forages at CIAT (Colombia) as well as those of the genera *Zea*, *Triticum*, *Hordeum* and *Secale* at CIMMYT (Mexico).

Contents

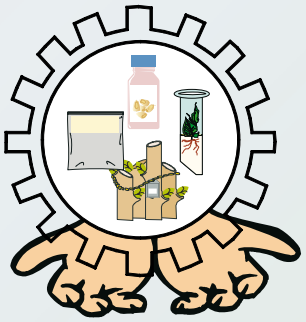
VI. Final considerations



VI. Final considerations on *ex situ* conservation

As this module developed, we saw that *ex situ* conservation is complex, requiring numerous resources and considerable effort and commitment on the part of those who carry it out and/or sponsor it. Although it offers many benefits, it constitutes but one alternative for conserving the existing diversity. To conserve diversity at all levels (genes, species and ecosystems), in continuous evolution and always available, means using or combining other conservation alternatives and tools.

Ex situ conservation



- assembles the genetic diversity of one or more species in one place
- keeps germplasm stable, safe and available
- interrupts the production of new diversity

Plant genetic resources can be conserved within (*in situ*) and/or outside (*ex situ*) their original environments, depending on what is to be done with them. Choosing between one or another alternative offers both advantages and disadvantages.

Ex situ conservation assembles at one site the genetic diversity of one or many species of interest that, without this conservation, would change or disappear, as they do in nature. It is a safe and reliable alternative in that it permits duplication of the same accessions at different periods and in diverse sample types, and facilitates access to the germplasm for study or distribution.

On the downside, however, only those genetic combinations existing at a given time are conserved. Evolution and co-evolution, which generate new diversity, are interrupted. Conservation can also affect the normal expression of characteristics in the conserved resources. Hence, it should be clearly indicated that the objective is to conserve the diversity of species or genotypes and not the interactions among them, nor their interactions with the environment.

Within the *ex situ* format, the use that will be given to the germplasm determines collection type and the period for which it will be kept. That is:

Goal	Collection type and period
Increased variability over time	Base collection, long term
Use in breeding	Working collection, short term
Facilitate management	Active collection, short or medium term
Promote use of germplasm	Core collection, short or medium term

The species' characteristics, in turn, will determine the most appropriate sample type for conservation. If a species has orthodox seed, it will be conserved as seed and in chambers, but if it has recalcitrant or intermediate seed, or vegetative reproduction, it will either remain in the field or be cultivated *in vitro*. In any case, the result should be a representative and viable collection with potential for use.

Complementary conservation

- combines *ex situ* and *in situ* methodologies
- compensates for the disadvantages of the one by the advantages of the other
- is more effective, safe, lasting, flexible and sustainable

Complementary conservation

If the goal is to conserve diversity in its broadest sense, then specific genetic combinations (*ex situ*) should be conserved, but permitting evolution to continue (*in situ*) and generating new diversity. Complementary conservation is therefore an approach that combines *in situ* and *ex situ* methodologies, permitting the conservation of plants, their natural habitats and the interactions among them. This approach makes the most of the advantages of one methodology to compensate for the disadvantages of the other. With this approach, the species of interest are maintained simultaneously at their site of origin (*in situ*, especially in traditional cropping systems) and in genebanks, where additional information is compiled and stored on the *in situ* management of the conserved species. This alternative is more effective, safer, more lasting and flexible, and is more economically and biologically sustainable than using either methodology independently (Maxted *et al.* 1997a).

Conserving and using diversity without damaging natural environments

For its existence, humankind depends on plant genetic resources, but the future use of these resources depends on the value given them and on the rationality with which they are handled. Conserving and using genetic resources should not damage the natural environment. Just as we should not forget that humans depend on plants, neither should we forget that humans also constitute the principal cause of erosion and loss of plant genetic resources. Informing the public and raising its awareness on these aspects will lead to the rational conservation and use of these resources.

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Acronyms and Abbreviations

AECI	Agencia Española de Cooperación Internacional, Spain
AVDRC	Asian Vegetable Research and Development Centre, Taiwan
CATIE	Centro Agronómico Tropical de Investigación y Enseñza, Costa Rica
CENARGEN	Centro Nacional de Pesquisa de Recursos Genéticos e Biotecnologia, Brazil
CFC	Common Fund for Commodities (of the European Union)
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical, Colombia
CIMMYT	Centro Internacional para Mejoramiento de Maiz y Trigo, Mexico
CIP	Centro Internacional de la Papa, Peru
CIRAD	Centre de cooperation internationale en recherché agronomique pour le développement, France
CNPH	Centro Nacional de Pesquisa de Hortalicas (of EMBRAPA)
CNR	Consiglio Nazionale delle Ricerche, Italy
CORPOICA	Corporación Colombiana de Investigación Agropecuaria, Colombia
CSEGRIN	Caribbean Seed and Germplasm Resources Information Network
CSSA	Crop Science Society of America
CTA	Centre Technique de Coopération Agricole et Rurale (of the European Union)
DNA	deoxyribonucleic acid
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Brazil
FAO	Food and Agriculture Organization of the United Nations
GMS	Genebank Management Information System
GPS	Global Positioning System
GRIN	Germplasm Resources Information Network (of the USDA)
IARCs	International agricultural research centres
IBP	International Biological Programme
IBPGR	International Board for Plant Genetic Resources (*now* Bioversity International)
IBTA	Instituto Boliviano de Tecnología Agropecuaria, Bolivia
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India

IDB	Inter-American Development Bank
IDRC	International Development Research Centre, Canada
IFAD	International Fund for Agricultural Development, Italy
IGR	Informationszentrum für Genetische Ressourcen, Germany
IICA	Instituto Interamericano de Cooperación para la Agricultura
IITA	International Institute of Tropical Agriculture, Nigeria
INIA	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Spain
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Ecuador
INIBAP	International Network for the Improvement of Banana & Plantain, France
INTA	Instituto Nacional de Tecnología Agropecuaria, Argentina
INTAS	"International Association of Scientists of Western and ex-Soviet Countries", Belgium (*apparently not an acronym*)
IPGRI	International Plant Genetic Resources Institute (*now* Bioversity International)
IRRI	International Rice Research Institute, Philippines
ISTA	International Seed Testing Association, USA
IUCN	The World Conservation Union, Switzerland
MSU	Michigan State University
MTA	Material Transfer Agreement (*agreement for moving germplasm*)
NGB	Nordic Gene Bank, Sweden
NRI	Natural Resources Institute, UK
pcGRIN	personal computer version of the Germplasm Resources Information Network (of the USDA)
PROINPA	Programa de Investigación de la Papa (of IBTA)
QTL	quantitative trait loci
RAPD	random amplified polymorphic DNA
RFLP	restriction fragment length polymorphism
RNA	ribonucleic acid
SINGER	System-Wide Information Network for Genetic Resources (of the CGIAR)
TBRI	Taiwan Banana Research Institute, Taiwan
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USDA	United States Department of Agriculture, USA
WIEWS	World Information and Early Warning System on plant genetic resources (of FAO)

ANNEXES

Annex 1

THE INTERNATIONAL CODE OF CONDUCT FOR PLANT GERMPLASM COLLECTING AND TRANSFER

The International Code of Conduct for Plant Germplasm Collecting and Transfer

Preamble

The International Code of Conduct for Plant Germplasm Collecting and Transfer aims to promote the rational collection and sustainable use of genetic resources, to prevent genetic erosion, and to protect the interests of both donors and collectors of germplasm. The Code, a voluntary one, has been developed by FAO and negotiated by its Member Nations through the Organization's Commission on Plant Genetic Resources.

The Code is based on the principle of national sovereignty over plant genetic resources and sets out standards and principles to be observed by those countries and institutions that adhere to it.

The Code proposes procedures to request and/or to issue licences for collecting missions, provides guidelines for collectors themselves, and extends responsibilities and obligations to the sponsors of missions, the curators of genebanks, and the users of genetic material. It calls for the participation of farmers and local institutions in collecting missions and proposes that users of germplasm share the benefits derived from the use of plant genetic resources with the host country and its farmers.

The primary function of the Code is to serve as a point of reference until such time as individual countries establish their own codes or regulations for germplasm exploration and collection, conservation, exchange and utilization.

The Code is fully compatible with both the Convention on Biological Diversity and the International Undertaking on Plant Genetic Resources.

The Code was adopted by the FAO Conference at its 27th session in November 1993.

Jacques Diouf
Director-General

The International Code of Conduct for Plant Germplasm Collecting and Transfer

CHAPTER I
Objectives and Definitions

Article 1:
Objectives

This Code has the following objectives:

1.1 to promote the conservation, collection and use of plant genetic resources from their natural habitats or surroundings, in ways that respect the environment and local traditions and cultures;

1.2 to foster the direct participation of farmers, scientists and organizations in countries where germplasm is collected, in programmes and actions aimed at the conservation and use of plant genetic resources;

1.3 to avoid genetic erosion and permanent loss of resources caused by excessive or uncontrolled collection of germplasm;

1.4 to promote the safe exchange of plant genetic resources, as well as the exchange of related information and technologies;

1.5 to help ensure that any collecting of germplasm is undertaken in full respect of national laws, local customs, rules and regulations;

1.6 to provide appropriate standards of conduct and to define obligations of collectors;

1.7 to promote the sharing of benefits derived from plant genetic resources between the donors and users of germplasm, related information and technologies by suggesting ways in which the users may pass on a share of the benefits to the donors, taking into account the costs of conserving and developing germplasm;

1.8 to bring recognition to the rights and needs of local communities and farmers, and those who manage wild and cultivated plant genetic resources and in particular to promote mechanisms:

(a) to facilitate compensation of local communities and farmers for their contribution to the conservation and development of plant genetic resources; and

(b) to avoid situations whereby benefits currently derived from plant genetic resources by these local communities and farmers are undermined by the transfer or use by others of the resources.

Article 2:
Definitions

2.1 **Collector** means a legal or natural person that collects plant genetic resources and related information;

2.2 **Curator** means a legal or natural person that conserves and manages plant genetic resources and related information.

2.3 **Donors** means a country or legal or natural person that makes available plant genetic resources for collection.

2.4 **Farmers' Rights** means the rights arising from the past, present and future contributions of farmers in conserving, improving, and making available plant genetic resources, particularly those in the centres of origin/diversity. These rights are vested in the International Community, as trustee for present and future generations of farmers, for the purpose of ensuring full benefits to farmers, and supporting the continuation of their contributions, as well as the attainment of the overall purposes of the International Undertaking.[1]

2.5 ***Ex situ* conservation** means the conservation of plant genetic resources outside their natural habitat.

2.6 **Genetic erosion** means loss of genetic diversity;

2.7 **In situ conservation** means the conservation of plant genetic resources in the areas where they have naturally evolved, and, in the case of cultivated species or varieties, in the surroundings where they have developed their distinctive properties;

2.8 **Plant genetic resources** - means germplasm or genetic material of actual or potential value.

2.9 **Plant germplasm** or "genetic material" means the reproductive or vegetative propagating material of plants.

2.10 **Sponsor** means a legal or natural person that sponsors, financially or otherwise, a plant collecting mission;

2.11 **User** means a legal or natural person that utilizes and benefits from plant genetic resources and related information.

CHAPTER II
Nature and Scope of the Code

Article 3:
Nature of the Code

3.1 The Code is voluntary.

3.2 The code recognizes that nations have sovereign rights over their plant genetic resources in their territories and it is based on the principle according to which the conservation and continued availability of plant genetic resources is a common concern of humankind. In executing these rights, access to plant genetic resources should not be unduly restricted.

3.3 The Code is addressed primarily to governments. All relevant legal and natural persons are also invited to observe its provisions, in particular those dealing with plant exploration and plant collection, agricultural and botanical activities and research on endangered species or habitat conservation, research institutes, botanical gardens, harvesting of wild plant resources, agro- industry including pharmaceutical plants and the seed trade.

3.4 The provisions of the Code should be implemented through collaborative action by governments, appropriate organizations and professional societies, field collectors and their sponsors, and curators and users of plant germplasm.

3.5 FAO and other competent organizations are invited to promote observance of the Code.

[1] This definition is extracted from the FAO Conference Resolution 5/89.

3.6 The Code provides a set of general principles which governments may wish to use in developing their national regulations, or formulating bilateral agreements on the collection of germplasm.

Article 4:
Scope

4.1 The Code describes the shared responsibilities of collectors, donors, sponsors, curators and users of germplasm so as to ensure that the collection, transfer and use of plant germplasm is carried out with the maximum benefit to the international community, and with minimal adverse effects on the evolution of crop plant diversity and the environment. While initial responsibility rests with field collectors and their sponsors, obligations should extend to parties who fund or authorize collecting activities, or donate, conserve or use germplasm. The Code emphasizes the need for cooperation and a sense of reciprocity among donors, curators and users of plant genetic resources. Governments should consider taking appropriate action to facilitate and promote observance of this Code by sponsors, collectors, curators and users of germplasm operating under their jurisdiction.

4.2 The Code should enable national authorities to permit collecting activities within its territories expeditiously. It recognizes that national authorities are entitled to set specific requirements and conditions for collectors and sponsors and that sponsors and collectors are obliged to respect all relevant national laws as well as adhering to the principles of this Code.

4.3 The Code is to be implemented within the context of the FAO Global System on Plant Genetic Resources, including the International Undertaking and its annexes. In order to promote the continued availability of germplasm for plant improvement programmes on an equitable basis governments and users of germplasm should endeavour to give practical expression to the principles of Farmers' Rights.

Article 5:
Relationship with the other legal instruments

5.1 The Code is to be implemented in harmony with:

(a) the Convention on Biological Diversity and other legal instruments protecting biological diversity or parts of it;

(b) the International Plant Protection Convention (IPPC) and other agreements restricting the spread of pests and diseases;

(c) the national laws of the host country; and

(d) any agreements between the collector, host country, sponsors, and the gene bank storing the germplasm.

CHAPTER III
Collectors' permits

Article 6:
Authority for Issuing Permits

6.1 States have the sovereign right, and accept the responsibility, to establish and implement national policies for the conservation and use of their plant genetic resources, and within this framework, should set up a system for the issuance of permits to collectors.

6.2 Governments should designate the authority competent for issuing permits. This authority should inform proposed collectors, sponsors, and the other agencies

of the government's rules and regulations in this matter, and of the approval process to be followed, and of follow- up action to be taken.

Article 7:
Requesting of permits

To enable the permit issuing authority to arrive at a decision to grant or to refuse a permit, prospective collectors and sponsors should address an application to the issuing authority to which they:

(a) undertake to respect the relevant national laws;

(b) demonstrate knowledge of, and familiarity with, the species to be collected, their distribution and methods of collection;

(c) provide indicative plans for the field mission - including provisional route, estimated timing of expedition, the types of material to be collected, species and quantities - and their plans for evaluation, storage and use of the material collected; where possible, the sort of benefits the host country may expect to derive from the collection of the germplasm should be indicated;

(d) notify the host country of the kind of assistance, that may be required to facilitate the success of the mission;

(e) indicate, if the host country so desires, plans for cooperation with national scholars, scientists, students, non- governmental organizations and others who may assist or benefit from participation in the field mission or its follow-up activities;

(f) list, so far as it is known, the national and foreign curators to whom the germplasm and information is intended to be distributed on the completion of the mission; and

(g) supply such personal information as the host country may require.

Article 8:
Granting of permits

The permit issuing authority of the country in which a field mission proposes collecting plant genetic resources should expeditiously:

(a) acknowledge the application, indicating the estimated time needed to examine it;

(b) communicate to the collectors and sponsors of the proposed collecting mission its decision. In case of a positive decision, conditions of collaboration be established as soon as possible before the mission arrives in the country, or begins field work. If the decision is to prohibit or restrict the mission, whenever possible, the reasons should be given, and where appropriate, an opportunity should be given to modify the application.

(c) indicate, when applicable, what categories and quantities of germplasm may or may not be collected or exported, and those which are required for deposit within the country; indicate areas and species which are governed by special regulation;

(d) inform the applicant of any restrictions on travel or any modification of plans desired by the host country;

(e) state any special arrangement or restriction placed on the distribution or use of the germplasm, or improved materials derived from it;

(f) if it so desired, designate a national counterpart for the field mission, and/or for subsequent collaboration;

(g) define any financial obligation to be met by the applicant including possible national participation in the collecting team, and other services to be provided; and

(h) provide the applicant with the relevant information regarding the country, its genetic resources policy, germplasm management system, quarantine procedures, and all relevant laws and regulations. Particular attention should be drawn to the culture and the society of the areas through which the collectors will be travelling.

CHAPTER IV
Responsibilities of Collectors

Article 9:
Pre-collection

9.1 Upon arrival in the host country, collectors should acquaint themselves with all research results, or work in progress in the country, that might have a bearing on the mission.

9.2 Before field work begins, collectors and their national collaborators should discuss, and to the extent possible, decide on practical arrangements including: (i) collecting priorities, methodologies and strategies, (ii) information to be gathered during collection, (iii) processing and conservation arrangements for germplasm samples, associated soil/symbiont samples, and voucher specimens, and (iv) financial arrangements for the mission.

Article 10:
During collection

10.1 Collectors should respect local customs, traditions, and values, and property rights and should demonstrate a sense of gratitude towards local communities, especially if use is made of local knowledge on the characteristics and value of germplasm. Collectors should respond to their requests for information, germplasm or assistance, to the extent feasible.

10.2 In order not to increase the risk of genetic erosion, the acquisition of germplasm should not deplete the populations of the farmers' planting stocks or wild species, or remove significant genetic variation from the local gene pool.

10.3 When collecting cultivated or wild genetic resources, it is desirable that the local communities and farmers concerned be informed about the purpose of the mission, and about how and where they could request and obtain samples of the collected germplasm. If requested, duplicate samples should be also left with them.

10.4 Whenever germplasm is collected, the collector should systematically record the passport data, and describe in detail the plant population, its diversity, habitat and ecology, so as to provide curators and users of germplasm with an understanding of its original context. For this purpose, as much as local knowledge about the resources (including observations on environmental adaptation and local methods and technologies of preparing and using the plant) should be also documented; photographs may be of special value.

Article 11:
Post-collection

11.1 Upon the completion of the field mission, collectors and their sponsors should:

(a) process, in a timely fashion, the plant samples, and any associated microbial symbionts, pests and pathogens that may have been collected for conservation;

the relevant passport data should be prepared at the same time;

(b) deposit duplicate sets of all collections and associated materials, and records of any pertinent information, with the host country and other agreed curators;

(c) make arrangements with quarantine officials, seed storage managers and curators to ensure that the samples are transferred as quickly as possible to conditions which optimize their viability;

(d) obtain, in accordance with the importing countries' requirements, the phytosanitary certificate(s) and other documentation needed for transferring the material collected;

(e) alert the host country and the FAO Commission on Plant Genetic Resources about any impending threat to plant populations, or evidence of accelerated genetic erosion, and make recommendations for remedial action; and

(f) prepare a consolidated report on the collecting mission, including the localities visited, the confirmed identifications and passport data of plant samples collected, and the intended site(s) of conservation. Copies of the report should be submitted to the host country's permit issuing authority, to national counterparts and curators, and to the FAO for the information of its Commission on Plant Genetic Resources and for inclusion in its World Information and Early Warning System on PGR.

11.2 Collectors should take steps to promote observance of the Code by the curators and users to whom they have passed the germplasm which they have collected. Where appropriate, this might be by means of agreements with curators and users consistent with Articles 13 and 14.

CHAPTER V
Responsibilities of Sponsors, Curators and Users

Article 12:
Responsibilities of Sponsors

12.1 Sponsors should take steps to ensure, as far as is possible and appropriate, that collectors of collecting missions which they sponsor abide by the Code, particularly Articles 9, 10 and 11.

12.2 Sponsors should, as far as is possible and appropriate, establish agreements with curators of the germplasm collected under missions that they sponsor to ensure that curators abide by the Code, particularly Article 13. Such agreements should, as far as is possible and appropriate ensure that subsequent curators and users of the collected germplasm also abide by the Code.

Article 13:
Responsibilities of CURATORS

13.1 In order to be able to identify in the future the origin of the samples, curators should ensure that the collectors' original identification numbers, or codes, continue to be associated with the samples to which they refer.

13.2 Curators of the collected germplasm, should take practical steps to ensure, as far as is possible and appropriate, that future enquiries from the local communities and farmers who have provided the original material, and the host country, are responded to, and the samples of the plant germplasm collected are supplied upon request.

13.3 Curators should take practical steps, inter alia by the use of material transfer agreements, to promote the objectives of this code including the sharing of benefits derived from collected germplasm by the users with the local

communities, farmers and host countries as indicated in Article 14.

Article 14:
Responsibilities of Users

Without prejudice to the concept of Farmers' Rights, and taking into account Articles 1.7 & 1.8, users of the germplasm, should, to benefit the local communities, farmers and the host countries, consider providing some form of compensation for the benefits derived from the use of germplasm such as:

(a) facilitating access to new, improved varieties and other products, on mutually agreed terms;

(b) support for research of relevance to conservation and utilization of plant genetic resources, including community- based, conventional and new technologies, as well as conservation strategies, for both ex situ and in situ conservation;

(c) training, at both the institutional and farmer levels, to enhance local skills in genetic resources conservation, evaluation, development, propagation and use;

(d) facilitate the transfer of appropriate technology for the conservation and use of plant genetic resources;

(e) support for programmes to evaluate and enhance local land races and other indigenous germplasm, so as to encourage the optimal use of plant genetic resources at national, sub- national, and farmers and community level and to encourage conservation;

(f) any other appropriate support for farmers and communities for conservation of indigenous germplasm of the type collected by the mission; and

(g) scientific and technical information obtained from the germplasm.

CHAPTER VI
Reporting, Monitoring and Evaluating the Observance of the Code

Article 15:
Reporting by Governments

15.1 Governments should periodically inform the FAO Commission on Plant Genetic Resources of actions taken with regard to the application of this Code. When appropriate, this may be effected in the context of the yearly reports provided under Article 11 of the International Undertaking on Plant Genetic Resources.

15.2 Governments should inform the FAO Commission on Plant Genetic Resources of any decision to prohibit or restrict proposed collecting missions.

15.3 In cases of non- observance by a collector or sponsor of the rules and regulations of a host country regarding the collecting and transfer of plant genetic resources, or the principles of this Code, the government may wish to inform the FAO Commission on Plant Genetic Resources. The collector and sponsor should receive copies of this communication, and have the right to reply to the host country with copy to the FAO Commission. At the request of collectors or their sponsors, FAO may provide a certificate stating that no unresolved complaints are outstanding about them under this Code.

Article 16
MONITORING AND EVALUATING

16.1 Appropriate national authorities and the FAO Commission on Plant Genetic Resources should periodically review the relevance and effectiveness of the Code. The Code should be considered a dynamic text that may be brought up to date as required, to take into account technical, economic, social, ethical and legal developments and constraints.

16.2 Relevant professional associations and other similar bodies accepting the principles embodied in this Code may wish to establish peer review ethics committees to consider their members' compliance with the Code.

16.3 At a suitable time, it may be desirable to develop procedures for monitoring and evaluating the observance of the principles embodied in this Code, under the auspices of the FAO Commission on Plant Genetic Resources which, where invited to do so by the parties concerned, may settle differences that may arise.

Annex 2

PREPARING FOR COLLECTING MISSIONS: CHECKLIST

Preparing for Collecting Missions: Checklist[1]

Some aspects that should be taken into account when organizing and carrying out collecting expeditions are given in the checklist below:

1. Knowledge of the targeted species

- Genetic variability, botany, ethnobotany, reproductive aspects, morphology, habitat and distribution, reaction to storage

2. Knowledge of the region where the mission will be carried out

- Ecogeographic conditions
- Social and cultural conditions

3. Sampling strategy based on:

- Knowledge of the species
- Knowledge of the area's climate and topography, and its ecological and edaphic conditions

4. Documentation that should be obtained in advance

- Permits and other authorizations required by the country where the mission will be carried out
- Visas
- Vaccines

5. Itinerary with the routes and collecting sites based on:

- Distribution of the targeted species, harvest times and/or fructification, access to the area
- Knowledge of the local expert associated with the mission
- Establishment of alternate routes

6. Sources for compiling information before the mission

- Previous publications of ecogeographic studies and plant studies to understand the area
- Consultations in herbaria and centres of genetic resources to understand the flora and species distribution and help determine specific sites for collection
- Consultations with experts and databases

7. Duration of the expedition

- Local: 1 to 4 weeks
- International: 2 to 3 months

8. Personnel who will do the collecting

- Experts capable of locating the targeted species
- Local experts
- Guides

[1] This checklist was developed with the collaboration of César Gómez of the Universidad Politécnica de Madrid, Spain.

9. Necessary items and equipment

Documents
- Personal documents such as passports and other identification
- Vehicle documents such as identification and insurance policies

Basic collection equipment
- Pocket altimeter
- Compass
- Camera and sufficient film
- Binoculars and magnifying glasses

Optional
- GPS (global positioning system)
- Tape recorder and tapes
- Hygrometer
- Soil thermometer
- Maximum and minimum thermometers
- Soil sampling equipment

For vegetative materials
- Collecting forms
- Field books
- Plastic bags of different sizes
- Paper bags of different sizes
- Cloth bags of different sizes
- Adhesive and hanging labels
- Markers with indelible ink or wax
- Envelopes
- Ropes and string
- Scissors
- Knife
- Wide-mouth flasks
- Adhesive tape
- Stapler and staples
- Pencils and erasers
- Spades
- Pruning scissors
- Penknife

For herbarium specimens
- Press
- Newspapers
- Cardboard for intercalation between specimens
- Formalin solution for succulents
- Insecticides
- Flasks for nodes
- Nets for insects
- Mesh cage for drying paper bags with seeds
- Boxes for threshing and cleaning seeds
- Portable refrigerator
- Drier (with alcohol burners or, preferably, with generator and light globes)
- Boxes for temporary storage of samples

Transport
- Vehicle with double traction and load capacity
- Spare parts
- Motorized winch with steel cable
- Internal lights
- Altimeter, hygrometer and thermometer installed in the vehicle's interior

Publications

• Maps of the collection area (geographical, climatological, geological and ecological); road maps, with data on fuel supplies, lodging, medical centres, telephones and other communications media
• Taxonomic keys of the targeted species
• Plant descriptions of the area
• Dialect dictionaries of the area

Equipment for use by personnel

• Tall waterproof boots
• Sufficient water and food
• Comfortable and sufficient clothing
• Personal hygiene pack
• Candles and matches
• Watch

First aid kit

• Water purification tablets
• Antihistamines, antibiotics and analgesics
• Syringes, gauzes, bandages, cotton wool
• Disinfectants for wounds
• Insect repellents and the like according to the area

Camping equipment

• Tent
• Hammocks and/or sleeping bags with mosquito nets
• Battery-powered torches
• Cooking equipment and fuel
• Matches
• Spare batteries
• Multiple-purpose penknife

Annex 3

CATEGORIES OF SPECIES AT RISK OF EXTINCTION

Categories of Species at Risk of Extinction

The *Red List Categories* of endangered species lists those species at risk of disappearing. The list classifies the species into seven categories according to the degree of threat to which they are subjected at a given time. Those species in those categories with the highest degree of threat receive the highest priority for conservation. The categories (taken from Glowka et al. 1994) are:

1. **Extinct:** A *taxon* is considered as extinct when it is known with certainty that the individuals composing it have died.

2. **Extinct in nature:** A taxon is considered as extinct in nature when it is known only under cultivation, and when studies of the habitats (exhaustive, at appropriate times and across the taxon's entire historical range) do not find an individual.

3. **Critically endangered:** When the risk of the species becoming extinct in nature, and in the immediate future, is extremely high.

4. **Endangered:** When the risk of the species becoming extinct in nature, and in the immediate future, is high.

5. **Vulnerable:** When the species is in danger but is neither 'critically endangered' nor 'endangered'. This category can be divided into three subcategories:
   - **Conservation dependent:** The targeted species is under continuous conservation, the suspension of which would bring it to the status of 'threatened' within a period of about 5 years.
   - **Near threatened:** The targeted species is not classified as being 'conservation dependent' but is sufficiently close to classify it as 'vulnerable' or 'at risk'.
   - **Least concern:** Targeted species that do not fall under the two previous subcategories.

6. **Deficiently documented species:** When the information available on the distribution and/or state of a species' populations does not reliably indicate the degree of danger of extinction in which it is. A species in this category can pass to one of either 'threatened' or 'at low risk'.

7. **Not evaluated:** When a species has not been evaluated as to whether it is at risk or not.

Annex 4

COMPONENTS OF A SAMPLING STRATEGY AND THE STEPS TO DEFINE IT

Components of a Sampling Strategy and the Steps to Define It

The sampling strategy is defined according to the characteristics of the targeted species and of the sites where they are found. It guides the collecting team in collecting samples that will represent the targeted genetic variability. The strategy is developed according to the following steps:

Locate the regions and sites where the targeted species are found. Regions can be located by checking maps from ecogeographic or plant studies, and the site coordinates can be specified by either using global positioning systems (GPS) or members of the local community (Guarino *et al*. 1995; Maxted *et al.* 1997a, b) or by consulting other collectors.

Compile information on the located regions and sites, and the species of interest. For the regions and sites, information should include topography, geographic accidents, climate, access routes and the social and political situation. For the species, as much information as possible should be compiled, especially on reproductive strategy, morphology, physiology and management.

Analyze the compiled information and develop the sampling strategy. The collector should now specify (a) how many populations will be sampled, (b) how many plants within each population, (c) how plants within each population will be selected and (d) what type and sized sample will be collected. These specifications constitute the components of the sampling strategy.

While the components of the sampling strategy depend on the characteristics of the targeted species and their sites, no standard parameters exist. In any case, the sampling strategy should be flexible, so that it can be modified and/or adjusted to field conditions and to the genetic variability found in the field. Some useful basic aspects for defining the sampling strategy's components are described below:

The number of populations to sample. To collect a representative sample, at least 50 populations of the targeted species should be sampled. Usually, sampling takes place in those sites where populations are most abundant and/or the genetic variability of the species is highest. If the area to be explored presents climatic variations, then populations in each environment will have to be sampled to collect different ecotypes.

The number of plants sampled per population. Within each population, a minimum of 50 plants is normally sampled. The number may be increased if the area shows ecogeographic or climatic variations. If samples of sufficient size are not obtained, sampling should be repeated.

Selecting plants within each population (sampling methodology). Sampling plants requires a methodology that permits the collection of a representative sample. Within the population, plants can be taken at random (random sampling), at small intervals (stratified sampling), according to specific characteristics (biased sampling), or according to special characteristics that determine how it is to be sampled (special sampling). The sampling option selected constitutes the sampling methodology.

The *random sampling method*, when samples are collected at random, is used when the sites present uniform characteristics in terms of biodiversity, climate, topography, altitude, soil type and cultural practices. If the sites present frequent changes in these characteristics, then the *stratified sampling method*, when samples are collected at small intervals, would be more appropriate.

Biased sampling, that is, collection according to specific traits of a species, is used to collect the variability of traits of interest (which are usually of low frequency) of that species. This type of sampling is unbalanced, that is, the collected samples do not faithfully represent the original population. *Special sampling* is used to collect species whose characteristics (e.g. distribution, fructification or long life cycles) make it necessary to sample in a specific way.

Once the sampling methodology is established, the collectors must then determine how to collect the propagules and how to handle them so that they may survive until they reach the place of conservation.

Determining sample type and size

A sample of optimal size includes all the available variability of the targeted species. To achieve an effective sample, the type of propagules to be taken and their quantity should be determined. For species with sexual reproduction, between 2000 and 5000 seeds should be collected for allogamous species and 1000 to 2000 seeds for autogamous species. For those species with vegetative reproduction, the same number of propagules per individual plant can be taken (with a minimum of two). Usually, samples of the largest size possible that would not endanger the population are recommended. If the populations are small, then sampling is preferably repeated in several areas so not to endanger each population's survival. The total quantity taken should account for possible losses and the needs for duplicates (e.g. *see* 'duplicate materials required' in Article 11 of the FAO International Code of Conduct on Plant Germplasm Collecting and Transfer).

Useful information for defining the sampling strategy and other relevant aspects for conducting collecting expeditions can be found in Querol (1988), Brown and Marshall (1995), Guarino *et al*. (1995), Engels *et al*. (1995) and IPGRI (1996c, d).

Annex 5

COLLECTING FORMS

Collecting form

General for wild and cultivated species

CN NUMBER (assigned by Bioversity International for internal use)

EXPEDITION

COUNTRY/AREA

1. COLLECTOR NAME(S)

2. COLLECTOR'S NUMBER

3. SITE NUMBER

4. DATE (DD/MM/YYYY)

5. GENIUS

6. SPECIES

7. SUBSPECIES/VARIETY

8. LOCAL SPECIES NAME LANGUAGE ETHNIC GROUP

9. CONFIRMATION REQUIRED OF LOCAL NAME / LANGUAGE / ETHNIC GROUP 1. Yes 0. No.

10. COUNTRY

11. PROVINCE

12. LOCATION Km from In a Direction

13. LAT (°min) N/S LONG (°min) E/W ELEVATION m

14. MAP NAME AND REFERENCE

15. STATUS OF SAMPLE

1. Wild 2. Weedy 3. Primitive cultivator/landrace
4. Breeders line 5. Advanced cultivar 6. Other (specify)

16. COLLECTION SOURCE

1. Wild habitat: forest/woodland	2. Farm: field	3. Market: town
shrubland	orchard	Village
grasslands	garden	Urban
desert/tundra	fallow	Other exchange system
	pasture	
	store	

4. Breeders line 5. Other (specify)

17. PARTS OF PLANT USED

1. Stalk/trunk 2. Branch/twig 3. Leaf 4. Bark 5. Rhizome
6. Flower/inflorescence 7. Fruit 8. Seed 9. Root 10. Tuber 11. Sap/resin

18. PLANT USES

1. Food 2. Medicine 3. Beverage 4. Fibre 5. Timber
6. Craft 7. Fodder, forage 8. Building 9. Ornamental/cultural 10. Other (specify)

19. TYPE OF SAMPLE 1. Seed 2. Vegetative (specify) 3. Other (specify)

20. NUMBER OF PLANTS FOUND Per site Site size/area(m^2)

21. NUMBER OF PLANTS SAMPLED

22. HOW WERE THE PLANTS SAMPLED?

23. OTHER SAMPLES FROM THE SAME SPECIES GROUP OF PLANTS 1.Yes 0. No

24. PHOTOGRAPH NUMBER 1. Yes 0. No Number

25. HERBARIUM SAMPLE 1. Yes 0. No Number

Cultivated Material

26. MICROENVIRONMENT

1. Boundaries 2. Forest margins 3. Water courses
4. Forest clearing 5. Houseyard 6. Wood lot 7. Other (specify)

27. CULTURAL METHODS

a) TYPE

1. Irrigated 2. Intercropped 3. Shifting cultivation
4. Fertilizer (org.) 5. Fertilizer (inorg). 6. Use of animal traction 7. Mechanized

b) DIVISION OF LABOUR (gender)	Male	Female
1. Field preparation	_____	_____
2. Planting	_____	_____
3. Weeding/fertilizer application	_____	_____
4. Plant protection	_____	_____
5. Harvest/seed handling	_____	_____

c) LAND TENURE

1. Public lands 2. Open communal lands 3. Freehold
4. Tenancy 5. Reserves/parks 6. Other (specify)

28. DATE (DD/MM/YYYY)

Sowing Transplanting Harvest

29. DISTRIBUTION OF CROP SAMPLED IN FARMING CYCLE – TEMPORAL NICHE

1. Main crop 2. Harvest prior to main crops 3. Harvest after main crops
4. Alongside main crops 5. Continuous harvest/gathering

30. POST HARVEST HANDLING (gender division of labor)

	Male	Female
1. Husking/milling	_____	_____
2. Fermentation	_____	_____
3. Drying	_____	_____
4. Seed selection	_____	_____

31. COMMERCIALIZATION

1. Mostly consumed locally 2. Mostly for sale – local markets
3. Mostly sold to buyers outside community 4. Partly sold

32. SITE PHYSIOGRAPHY

1. Plain 2. Basin 3. Valley 4. Plateau
5. Upland 6. Hill 7. Mountain 8. Other (specify)

33. SOIL DRAINAGE

3. Poor 5. Moderate 7. Well-drained

34. SLOPE (°)

35. SLOPE ASPECT (direction N,S,E,W)

36. SOIL TEXTURE

1. Clay 2. Loam 3. Sandy loam 4. Fine sand
5. Coarse sand 6. Organic 7. Other (specify)

37. STONINESS

0. None 3. Low 5. Medium 7. High

38. METHOD OF PROPAGATION

1. Seed 2. Vegetative 3. Both

39. RELATED WILD AND WEEDY FORMS GROWING NEARBY

40. DO YOU NOTE ANY RELEVANT SOCIOCULTURAL DIFFERENCES IN THE CULTIVATION

41. DESCRIBE CROP ROTATIONS IN COLLECTING SEASON: (and/or intercropping)

42. COMMENTS ON MORPHOLOGICAL VARIATION, DISEASES AND PESTS, GENETIC EROSION

1. Morphological variation

2. Diseases/pests

3. Genetic erosion (Major causes and extent at population and variety levels)

43. OTHER NOTES/COMMENTS

Wild and forage material

26. SITE PHYSIOGRAPHY

1. Plain	2. Basin	3. Valley	4. Plateau
5. Upland	6. Hill	7. Mountain	8. Other (specify)

27. HABITAT

1. Forest	2. Woodland	3. Bushland	4. Shrubland
5. Grassland	6. Wooden grassland	7. Desert	8. Alpine
9. Health	10. Arable	11. Wasteland	12. Swampland
13. Other (specify)			

28. MICROENVIRONMENT

1. Mountain/hilltop	2. Rockface/cliff	3. Hillside	4. Valley Bottom
5. Plains/steppe	6. Forest margins	7. Burnt forest area	8. Burnt grassland
9. Sand bank	10. Shore (river/sea)	11 Tidal areas	12. Urban/peri-urban
13. Roadsides			

29. SOIL DRAINAGE

3. Poor	5. Moderate	7. Well-drained

30. SLOPE (°)

31. SLOPE ASPECT (direction N,S,E,W)

32. SOIL TEXTURE

1. Clay	2. Loam	3. Silt	4. Sandy loam
5. Fine sand	6. Coarse sand	7. Organic	8. Combinations eg. Silty clay
9. Other (specify)			

33. STONINESS

0. None	3. Low	5. Medium	7. High

34. SOIL CHEMICAL PROPERTIES

a) pH

		Estimate	Field Measurement
1. Very acidic	(pH 2-5)	_____	_____
2. Acidic	(pH 5-6.5)	_____	_____
3. Neutral	(pH 6.5-7)	_____	_____
4. Alkaline	(pH≥7.5)	_____	_____

b) Sanity

7. High	5. Medium	3. Low

35. SOIL SAMPLE 1. Yes 2. No

36. OTHER NOTES ON SOIL (eg. Colour)

37. RHIZOBIUM SAMPLE 1. Yes 2. No

38. HUMAN MANAGEMENT OF HABITAT (land use)

1. Grazed areas	2. Managed forest	3. Fallows	4. Abandoned fields
5. Regenerating forest	6. No human management		7. Other (specify)

39. DISTURBANCE FACTORS

a) Describe if an area is regularly used or traversed by large mammals and humans

b) Key animal species using the habitat

c) Other factors, e.g. fire, flooding, mining, logging

40. MAJOR THREATS TO THE POPULATION – Genetic erosion

Overuse, habitat destruction e.g. desertification, soil erosion, deforestation, others (specify)

41. WHAT IS THE NATURAL MODE OF PROPAGATION?

a) 1. Seed 2. Vegetative 3. Seed and vegetative 4. Apomicitic

Give relative importance of mode of propagation

b) - Seed 1. Predominantly selfing

2. Obligate outbreeding

3. Facultative outbreeding

4. Others (specify)

- Vegetative Rhizomes, stolons, tibers, etc

- Apomicitic

42. IS THE POPULATION WELL ISOLATED FROM OTHERS? 1. Yes 0. No

43. WHAT ARE THE BARRIERS BETWEEN POPULATIONS IN THE AREA?

44. WHAT IS THE PLANT POPULATION DENSITY?

1. Few scattered individuals 2. Very scarce (<1% ground cover) 3. Scarce (1-5% cover)

4. Present (>5-25% cover) 5. High (>25%)

45. WHAT IS THE SPATIAL DISTRIBUTION OF INDIVIDUAL PLANTS IN THE POPULATION?

1. Patchy 2. Uniform/mixed stand 3. Pure stand

46. WHAT IS THE DOMINANT PLANT SPECIES?

47. WHAT ARE THE ASSOCIATES SPECIES?

48. CLOSEST METEROLOGICAL STATION

49. COMMENTS ON MORPHOLOGICAL VARIATION

50. COMMENTS ON DISEASES AND PESTS

51. ARE RELATED CULTIVATED FORMS GROWN NEARBY? 1. Yes 0. No

52. OTHER NOTES

Additional information for ecogeographical surveys

Soil descriptors

1. SOIL TYPE (UNESCO/FAO)
2. SOIL PARENTAL ROCK
3. SOIL DEPTH Analysis of soil sample
4. SOIL pH
5. SOIL PHYSICAL ANALYSIS (Distribution of particle size, etc.)
6. SOIL CHEMICAL ANALYSIS (P,K,Ca organic content, etc.)

Climatic descriptors

7. ANNUAL RAINFALL (mm)
8. RAINFALL SEASONALITY

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

9. MEAN ANNUAL TEMPERATURE
10. TEMPERATURE SEASONALLY

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

11. FROSTS (Occurrence and severity)

Site descriptors

12. SUCCESSIONAL STATUS OF VEGETATION

    1. Recently colonized 2. Pioneer 3. Intermediate 4. Climax

13. CURRENT PROTECTION OF SITE (Specify)
14. IS THE PROTECTION EFFECTIVELY ENFORCED?

    1. Yes 2. No 3. Do not know

15. PROTECTED SITE (In conjunction with local community stewardship or use rights)
16. SUGGESTIONS FOR FUTURE PROTECTION

Annex 6

INTERNATIONAL PLANT PROTECTION CONVENTION

INTERNATIONAL PLANT PROTECTION CONVENTION
TEXT PRESENTLY IN FORCE

PREAMBLE

The contracting parties,

- *recognizing* the necessity for international cooperation in controlling pests of plants and plant products and in preventing their international spread, and especially their introduction into endangered areas;
- *recognizing* that phytosanitary measures should be technically justified, transparent and should not be applied in such a way as to constitute either a means of arbitrary or unjustified discrimination or a disguised restriction, particularly on international trade;
- *desiring* to ensure close coordination of measures directed to these ends;
- *desiring* to provide a framework for the development and application of harmonized phytosanitary measures and the elaboration of international standards to that effect;
- *taking into account* internationally approved principles governing the protection of plant, human and animal health, and the environment; and
- *noting* the agreements concluded as a result of the Uruguay Round of Multilateral Trade Negotiations, including the Agreement on the Application of Sanitary and Phytosanitary Measures;

have agreed as follows:

Article I
Purpose and responsibility

1. With the purpose of securing common and effective action to prevent the spread and introduction of pests of plants and plant products and to promote appropriate measures for their control, the contracting parties undertake to adopt the legislative, technical and administrative measures specified in this Convention and in supplementary agreements pursuant to Article III.
2. Each contracting party shall assume responsibility without prejudice to obligations assumed under other international agreements, for the fulfillment within its territories of all requirements under this Convention.
3. The division of responsibilities for the fulfilment of the requirements of this Convention between member organizations of FAO and their member states that are contracting parties shall be in accordance with their respective competencies.
4. Where appropriate, the provisions of this Convention may be deemed by contracting parties to extend, in addition to plants and plant products, to storage places, packaging, conveyances, containers, soil and any other organism, object or material capable of harbouring or spreading plant pests, particularly where international transportation is involved.

Article II
Use of terms

1. For the purpose of this Convention, the following terms shall have the meanings hereunder assigned to them:

   "Area of low pest prevalence" - an area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specific pest occurs at low levels and which is subject to effective surveillance, control or eradication measures;

   "Commission" - the Commission on Phytosanitary Measures established under Article XI;

   "Endangered area" - an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss;

   "Establishment" - perpetuation, for the foreseeable future, of a pest within an area after entry;

   "Harmonized phytosanitary measures" - phytosanitary measures established by contracting parties based on international standards;

   "International standards" - international standards established in accordance with Article X, paragraphs 1 and 2;

   "Introduction" - the entry of a pest resulting in its establishment;

   "Pest" - any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products;

   "Pest risk analysis" - the process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it;

   "Phytosanitary measure" - any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of pests;

   "Plant products" - unmanufactured material of plant origin (including grain) and those manufactured products that, by their nature or that of their processing, may create a risk for the introduction and spread of pests;

   "Plants" - living plants and parts thereof, including seeds and germplasm;

   "Quarantine pest" - a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled;

   "Regional standards" - standards established by a regional plant protection organization for the guidance of the members of that organization;

   "Regulated article" - any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved;

   "Regulated non-quarantine pest" - a non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party;

   "Regulated pest" - a quarantine pest or a regulated non-quarantine pest;

   "Secretary" - Secretary of the Commission appointed pursuant to Article XII;

   "Technically justified" - justified on the basis of conclusions reached by using an appropriate pest risk analysis or, where applicable, another comparable examination and evaluation of available scientific information.

2. The definitions set forth in this Article, being limited to the application of this Convention, shall not be deemed to affect definitions established under domestic laws or regulations of contracting parties.

Article III
Relationship with other international agreements

Nothing in this Convention shall affect the rights and obligations of the contracting parties under relevant international agreements.

Article IV
General provisions relating to the organizational arrangements for national plant protection

1. Each contracting party shall make provision, to the best of its ability, for an official national plant protection organization with the main responsibilities set out in this Article.

2. The responsibilities of an official national plant protection organization shall include the following:

   (a) the issuance of certificates relating to the phytosanitary regulations of the importing contracting party for consignments of plants, plant products and other regulated articles;

   (b) the surveillance of growing plants, including both areas under cultivation (inter alia fields, plantations, nurseries, gardens, greenhouses and laboratories) and wild flora, and of plants and plant products in storage or in transportation, particularly with the object of reporting the occurrence, outbreak and spread of pests, and of controlling those pests, including the reporting referred to under Article VIII paragraph 1(a);

   (c) the inspection of consignments of plants and plant products moving in international traffic and, where appropriate, the inspection of other regulated articles, particularly with the object of preventing the introduction and/or spread of pests;

   (d) the disinfestation or disinfection of consignments of plants, plant products and other regulated articles moving in international traffic, to meet phytosanitary requirements;

   (e) the protection of endangered areas and the designation, maintenance and surveillance of pest free areas and areas of low pest prevalence;

   (f) the conduct of pest risk analyses;

   (g) to ensure through appropriate procedures that the phytosanitary security of consignments after certification regarding composition, substitution and reinfestation is maintained prior to export; and

   (h) training and development of staff.

3. Each contracting party shall make provision, to the best of its ability, for the following:

   (a) the distribution of information within the territory of the contracting party regarding regulated pests and the means of their prevention and control;

   (b) research and investigation in the field of plant protection;

   (c) the issuance of phytosanitary regulations; and

   (d) the performance of such other functions as may be required for the implementation of this Convention.

4. Each contracting party shall submit a description of its official national plant protection organization and of changes in such organization to the Secretary. A contracting party shall provide a description of its organizational arrangements for plant protection to another contracting party, upon request.

Article V
Phytosanitary certification

1. Each contracting party shall make arrangements for phytosanitary certification, with the objective of ensuring that exported plants, plant products and other regulated articles and consignments thereof are in conformity with the certifying statement to be made pursuant to paragraph 2(b) of this Article.

2. Each contracting party shall make arrangements for the issuance of phytosanitary certificates in conformity with the following provisions:

   (a) Inspection and other related activities leading to issuance of phytosanitary certificates shall be carried out only by or under the authority of the official national plant protection organization. The issuance of phytosanitary certificates shall be carried out by public officers who are technically qualified and duly authorized by the official national plant protection organization to act on its behalf and under its control with such knowledge and information available to those officers that the authorities of importing contracting parties may accept the phytosanitary certificates with confidence as dependable documents.

   (b) Phytosanitary certificates, or their electronic equivalent where accepted by the importing contracting party concerned, shall be as worded in the models set out in the Annex to this Convention. These certificates should be completed and issued taking into account relevant international standards.

   (c) Uncertified alterations or erasures shall invalidate the certificates.

3. Each contracting party undertakes not to require consignments of plants or plant products or other regulated articles imported into its territories to be accompanied by phytosanitary certificates inconsistent with the models set out in the Annex to this Convention. Any requirements for additional declarations shall be limited to those technically justified.

Article VI
Regulated pests

1. Contracting parties may require phytosanitary measures for quarantine pests and regulated non-quarantine pests, provided that such measures are:

   (a) no more stringent than measures applied to the same pests, if present within the territory of the importing contracting party; and

   (b) limited to what is necessary to protect plant health and/or safeguard the intended use and can be technically justified by the contracting party concerned.

2. Contracting parties shall not require phytosanitary measures for non-regulated pests.

Article VII
Requirements in relation to imports

1. With the aim of preventing the introduction and/or spread of regulated pests into their territories, contracting parties shall have sovereign authority to regulate, in accordance with applicable international agreements, the entry of plants and plant products and other regulated articles and, to this end, may:

   (a) prescribe and adopt phytosanitary measures concerning the importation of plants, plant products and other regulated articles, including, for example, inspection, prohibition on importation, and treatment;

   (b) refuse entry or detain, or require treatment, destruction or removal from the territory of the contracting party, of plants, plant products and other regulated

articles or consignments thereof that do not comply with the phytosanitary measures prescribed or adopted under subparagraph (a);

(c) prohibit or restrict the movement of regulated pests into their territories;

(d) prohibit or restrict the movement of biological control agents and other organisms of phytosanitary concern claimed to be beneficial into their territories.

2. In order to minimize interference with international trade, each contracting party, in exercising its authority under paragraph 1 of this Article, undertakes to act in conformity with the following:

(a) Contracting parties shall not, under their phytosanitary legislation, take any of the measures specified in paragraph 1 of this Article unless such measures are made necessary by phytosanitary considerations and are technically justified.

(b) Contracting parties shall, immediately upon their adoption, publish and transmit phytosanitary requirements, restrictions and prohibitions to any contracting party or parties that they believe may be directly affected by such measures.

(c) Contracting parties shall, on request, make available to any contracting party the rationale for phytosanitary requirements, restrictions and prohibitions.

(d) If a contracting party requires consignments of particular plants or plant products to be imported only through specified points of entry, such points shall be so selected as not to unnecessarily impede international trade. The contracting party shall publish a list of such points of entry and communicate it to the Secretary, any regional plant protection organization of which the contracting party is a member, all contracting parties which the contracting party believes to be directly affected, and other contracting parties upon request. Such restrictions on points of entry shall not be made unless the plants or plant products concerned are required to be accompanied by phytosanitary certificates or to be submitted to inspection or treatment.

(e) Any inspection or other phytosanitary procedure required by the plant protection organization of a contracting party for a consignment of plants, plant products, other regulated articles offered for importation shall take place as promptly as possible with due regard to the perishability.

(f) Importing contracting parties shall, as soon as possible, inform the exporting contracting party concerned or, where appropriate, the re-exporting contracting party concerned, of significant instances of non-compliance with phytosanitary certification. The exporting contracting party or, where appropriate, the re-exporting contracting party concerned, should investigate and, on request, report the result of its investigation to the importing contracting party concerned.

(g) Contracting parties shall institute only phytosanitary measures that are technically justified, consistent with the pest risk involved and represent the least restrictive measures available, and result in the minimum impediment to the international movement of people, commodities and conveyances.

(h) Contracting parties shall, as conditions change, and as new facts become available, ensure that phytosanitary measures are promptly modified or removed if found to be unnecessary.

(i) Contracting parties shall, to the best of their ability, establish and update lists of regulated pests, using scientific names, and make such lists available to the Secretary, to regional plant protection organizations of which they are members and, on request, to other contracting parties.

(j) Contracting parties shall, to the best of their ability, conduct surveillance for pests and develop and maintain adequate information on pest status

in order to support categorization of pests, and for the development of appropriate phytosanitary measures. This information shall be made available to contracting parties, on request.

3. A contracting party may apply measures specified in this Article to pests which may not be capable of establishment in its territories but, if they gained entry, cause economic damage. Measures taken against these pests must be technically justified.

4. Contracting parties may apply measures specified in this Article to consignments in transit through their territories only where such measures are technically justified and necessary to prevent the introduction and/or spread of pests.

5. Nothing in this Article shall prevent importing contracting parties from making special provision, subject to adequate safeguards, for the importation, for the purpose of scientific research, education, or other specific use, of plants and plant products and other regulated articles, and of plant pests.

6. Nothing in this Article shall prevent any contracting party from taking appropriate emergency action on the detection of a pest posing a potential threat to its territories or the report of such a detection. Any such action shall be evaluated as soon as possible to ensure that its continuance is justified. The action taken shall be immediately reported to contracting parties concerned, the Secretary, and any regional plant protection organization of which the contracting party is a member.

Article VIII
International Cooperation

The contracting parties shall cooperate with one another to the fullest practicable extent in achieving the aims of this Convention, and shall in particular:

(a) cooperate in the exchange of information on plant pests, particularly the reporting of the occurrence, outbreak or spread of pests that may be of immediate or potential danger, in accordance with such procedures as may be established by the Commission;

(b) participate, in so far as is practicable, in any special campaigns for combatting pests that may seriously threaten crop production and need international action to meet the emergencies; and

(c) cooperate, to the extent practicable, in providing technical and biological information necessary for pest risk analysis.

2. Each contracting party shall designate a contact point for the exchange of information connected with the implementation of this Convention.

Article IX
Regional Plant Protection Organizations

1. The contracting parties undertake to cooperate with one another in establishing regional plant protection organizations in appropriate areas.

2. The regional plant protection organizations shall function as the coordinating bodies in the areas covered, shall participate in various activities to achieve the objectives of this Convention and, where appropriate, shall gather and disseminate information.

3. The regional plant protection organizations shall cooperate with the Secretary in achieving the objectives of the Convention and, where appropriate, cooperate with the Secretary and the Commission in developing international standards.

4. The Secretary will convene regular Technical Consultations of representatives of regional plant protection organizations to:

(a) promote the development and use of relevant international standards for phytosanitary measures; and

(b) encourage inter-regional cooperation in promoting harmonized phytosanitary measures for controlling pests and in preventing their spread and/or introduction.

Article X
Standards

1. The contracting parties agree to cooperate in the development of international standards in accordance with the procedures adopted by the Commission.

2. International standards shall be adopted by the Commission.

3. Regional standards should be consistent with the principles of this Convention; such standards may be deposited with the Commission for consideration as candidates for international standards for phytosanitary measures if more broadly applicable.

4. Contracting parties should take into account, as appropriate, international standards when undertaking activities related to this Convention.

Article XI
Commission on Phytosanitary Measures

1. Contracting parties agree to establish the Commission on Phytosanitary Measures within the framework of the Food and Agriculture Organization of the United Nations (FAO).

2. The functions of the Commission shall be to promote the full implementation of the objectives of the Convention and, in particular, to:

   (a) review the state of plant protection in the world and the need for action to control the international spread of pests and their introduction into endangered areas;

   (b) establish and keep under review the necessary institutional arrangements and procedures for the development and adoption of international standards, and to adopt international standards;

   (c) establish rules and procedures for the resolution of disputes in accordance with Article XIII;

   (d) establish such subsidiary bodies of the Commission as may be necessary for the proper implementation of its functions;

   (e) adopt guidelines regarding the recognition of regional plant protection organizations;

   (f) establish cooperation with other relevant international organizations on matters covered by this Convention;

   (g) adopt such recommendations for the implementation of the Convention as necessary; and

   (h) perform such other functions as may be necessary to the fulfillment of the objectives of this Convention.

3. Membership in the Commission shall be open to all contracting parties.

4. Each contracting party may be represented at sessions of the Commission by a single delegate who may be accompanied by an alternate, and by experts and advisers. Alternates, experts and advisers may take part in the proceedings of the Commission but may not vote, except in the case of an alternate who is duly authorized to substitute for the delegate.

5. The contracting parties shall make every effort to reach agreement on all matters by consensus. If all efforts to reach consensus have been exhausted and no

agreement is reached, the decision shall, as a last resort, be taken by a two-thirds majority of the contracting parties present and voting.

6. A member organization of FAO that is a contracting party and the member states of that member organization that are contracting parties shall exercise their membership rights and fulfil their membership obligations in accordance, mutatis mutandis, with the Constitution and General Rules of FAO.

7. The Commission may adopt and amend, as required, its own Rules of Procedure, which shall not be inconsistent with this Convention or with the Constitution of FAO.

8. The Chairperson of the Commission shall convene an annual regular session of the Commission.

9. Special sessions of the Commission shall be convened by the Chairperson of the Commission at the request of at least one-third of its members.

10. The Commission shall elect its Chairperson and no more than two Vice-Chairpersons, each of whom shall serve for a term of two years.

Article XII
Secretariat

1. The Secretary of the Commission shall be appointed by the Director-General of FAO.

2. The Secretary shall be assisted by such secretariat staff as may be required.

3. The Secretary shall be responsible for implementing the policies and activities of the Commission and carrying out such other functions as may be assigned to the Secretary by this Convention and shall report thereon to the Commission.

4. The Secretary shall disseminate:

   (a) international standards to all contracting parties within sixty days of adoption;

   (b) to all contracting parties, lists of points of entry under Article VII paragraph 2(d) communicated by contracting parties;

   (c) lists of regulated pests whose entry is prohibited or referred to in Article VII paragraph 2(i) to all contracting parties and regional plant protection organizations;

   (d) information received from contracting parties on phytosanitary requirements, restrictions and prohibitions referred to in Article VII paragraph 2(b), and descriptions of official national plant protection organizations referred to in Article IV paragraph 4.

5. The Secretary shall provide translations in the official languages of FAO of documentation for meetings of the Commission and international standards.

6. The Secretary shall cooperate with regional plant protection organizations in achieving the aims of the Convention.

Article XIII
Settlement of disputes

1. If there is any dispute regarding the interpretation or application of this Convention, or if a contracting party considers that any action by another contracting party is in conflict with the obligations of the latter under Articles V and VII of this Convention, especially regarding the basis of prohibiting

or restricting the imports of plants, plant products or other regulated articles coming from its territories, the contracting parties concerned shall consult among themselves as soon as possible with a view to resolving the dispute.

2. If the dispute cannot be resolved by the means referred to in paragraph 1, the contracting party or parties concerned may request the Director-General of FAO to appoint a committee of experts to consider the question in dispute, in accordance with rules and procedures that may be established by the Commission.

3. This Committee shall include representatives designated by each contracting party concerned. The Committee shall consider the question in dispute, taking into account all documents and other forms of evidence submitted by the contracting parties concerned. The Committee shall prepare a report on the technical aspects of the dispute for the purpose of seeking its resolution. The preparation of the report and its approval shall be according to rules and procedures established by the Commission, and it shall be transmitted by the Director-General to the contracting parties concerned. The report may also be submitted, upon its request, to the competent body of the international organization responsible for resolving trade disputes.

4. The contracting parties agree that the recommendations of such a committee, while not binding in character, will become the basis for renewed consideration by the contracting parties concerned of the matter out of which the disagreement arose.

5. The contracting parties concerned shall share equally the expenses of the experts.

6. The provisions of this Article shall be complementary to and not in derogation of the dispute settlement procedures provided for in other international agreements dealing with trade matters.

Article XIV
Substitution of prior agreements

This Convention shall terminate and replace, between contracting parties, the International Convention respecting measures to be taken against the Phylloxera vastatrix of 3 November 1881, the additional Convention signed at Berne on 15 April 1889 and the International Convention for the Protection of Plants signed at Rome on 16 April 1929.

Article XV
Territorial application

1. Any contracting party may at the time of ratification or adherence or at any time thereafter communicate to the Director-General of FAO a declaration that this Convention shall extend to all or any of the territories for the international relations of which it is responsible and this Convention shall be applicable to all territories specified in the declaration as from the thirtieth day after the receipt of the declaration by the Director-General.

2. Any contracting party which has communicated to the Director-General of FAO a declaration in accordance with paragraph 1 of this Article may at any time communicate a further declaration modifying the scope of any former declaration or terminating the application of the provisions of the present Convention in respect of any territory. Such modification or termination shall take effect as from the thirtieth day after the receipt of the declaration by the Director-General.

3. The Director-General of FAO shall inform all contracting parties of any declaration received under this Article.

Article XVI
Supplementary agreements

1. The contracting parties may, for the purpose of meeting special problems of plant protection which need particular attention or action, enter into supplementary agreements. Such agreements may be applicable to specific regions, to specific pests, to specific plants and plant products, to specific methods of international transportation of plants and plant products, or otherwise supplement the provisions of this Convention.
2. Any such supplementary agreements shall come into force for each contracting party concerned after acceptance in accordance with the provisions of the supplementary agreements concerned.
3. Supplementary agreements shall promote the intent of this Convention and shall conform to the principles and provisions of this Convention, as well as to the principles of transparency, non-discrimination and the avoidance of disguised restrictions, particularly on international trade.

Article XVII
Ratification and adherence

1. This Convention shall be open for signature by all states until 1 May 1952 and shall be ratified at the earliest possible date. The instruments of ratification shall be deposited with the Director-General of FAO, who shall give notice of the date of deposit to each of the signatory states.
2. As soon as this Convention has come into force in accordance with Article XXII, it shall be open for adherence by non-signatory states and member organizations of FAO. Adherence shall be effected by the deposit of an instrument of adherence with the Director-General of FAO, who shall notify all contracting parties.
3. When a member organization of FAO becomes a contracting party to this Convention, the member organization shall, in accordance with the provisions of Article II paragraph 7 of the FAO Constitution, as appropriate, notify at the time of its adherence such modifications or clarifications to its declaration of competence submitted under Article II paragraph 5 of the FAO Constitution as may be necessary in light of its acceptance of this Convention. Any contracting party to this Convention may, at any time, request a member organization of FAO that is a contracting party to this Convention to provide information as to which, as between the member organization and its member states, is responsible for the implementation of any particular matter covered by this Convention. The member organization shall provide this information within a reasonable time.

Article XVIII
Non-contracting parties

The contracting parties shall encourage any state or member organization of FAO, not a party to this Convention, to accept this Convention, and shall encourage any non-contracting party to apply phytosanitary measures consistent with the provisions of this Convention and any international standards adopted hereunder.

Article XIX
Languages

1. The authentic languages of this Convention shall be all official languages of FAO.
2. Nothing in this Convention shall be construed as requiring contracting parties to provide and to publish documents or to provide copies of them other than

in the language(s) of the contracting party, except as stated in paragraph 3 below.

3. The following documents shall be in at least one of the official languages of FAO:

   (a) information provided according to Article IV paragraph 4;

   (b) cover notes giving bibliographical data on documents transmitted according to Article VII paragraph 2(b);

   (c) information provided according to Article VII paragraph 2(b), (d), (i) and (j);

   (d) notes giving bibliographical data and a short summary of relevant documents on information provided according to Article VIII paragraph 1(a);

   (e) requests for information from contact points as well as replies to such requests, but not including any attached documents;

   (f) any document made available by contracting parties for meetings of the Commission.

Article XX
Technical Assistance

The contracting parties agree to promote the provision of technical assistance to contracting parties, especially those that are developing contracting parties, either bilaterally or through the appropriate international organizations, with the objective of facilitating the implementation of this Convention.

Article XXI
Amendment

1. Any proposal by a contracting party for the amendment of this Convention shall be communicated to the Director-General of FAO.

2. Any proposed amendment of this Convention received by the Director-General of FAO from a contracting party shall be presented to a regular or special session of the Commission for approval and, if the amendment involves important technical changes or imposes additional obligations on the contracting parties, it shall be considered by an advisory committee of specialists convened by FAO prior to the Commission.

3. Notice of any proposed amendment of this Convention, other than amendments to the Annex, shall be transmitted to the contracting parties by the Director-General of FAO not later than the time when the agenda of the session of the Commission at which the matter is to be considered is dispatched.

4. Any such proposed amendment of this Convention shall require the approval of the Commission and shall come into force as from the thirtieth day after acceptance by two-thirds of the contracting parties. For the purpose of this Article, an instrument deposited by a member organization of FAO shall not be counted as additional to those deposited by member states of such an organization.

5. Amendments involving new obligations for contracting parties, however, shall come into force in respect of each contracting party only on acceptance by it and as from the thirtieth day after such acceptance. The instruments of acceptance of amendments involving new obligations shall be deposited with the Director-General of FAO, who shall inform all contracting parties of the receipt of acceptance and the entry into force of amendments.

6. Proposals for amendments to the model phytosanitary certificates set out in the Annex to this Convention shall be sent to the Secretary and shall be considered for approval by the Commission. Approved amendments to the

model phytosanitary certificates set out in the Annex to this Convention shall become effective ninety days after their notification to the contracting parties by the Secretary.

7. For a period of not more than twelve months from an amendment to the model phytosanitary certificates set out in the Annex to this Convention becoming effective, the previous version of the phytosanitary certificates shall also be legally valid for the purpose of this Convention.

Article XXII
Entry into force

As soon as this Convention has been ratified by three signatory states it shall come into force among them. It shall come into force for each state or member organization of FAO ratifying or adhering thereafter from the date of deposit of its instrument of ratification or adherence.

Article XXIII
Denunciation

1. Any contracting party may at any time give notice of denunciation of this Convention by notification addressed to the Director-General of FAO. The Director-General shall at once inform all contracting parties.

2. Denunciation shall take effect one year from the date of receipt of the notification by the Director-General of FAO.

ANNEX

Model Phytosanitary Certificate

No._____

Plant Protection Organization of _____

TO: Plant Protection Organization(s) of _____

I. Description of Consignment

Name and address of exporter: _____

Declared name and address of consignee: _____

Number and description of packages: _____

Distinguishing marks: _____

Place of origin: _____

Declared means of conveyance: _____

Declared point of entry: _____

Name of produce and quantity declared: _____

Botanical name of plants: _____

This is to certify that the plants or plant products or other regulated articles described herein have been inspected and/or tested according to appropriate official procedures and are considered to be free from the quarantine pests specified by the importing contracting party and to conform with the current phytosanitary requirements of the importing contracting party, including those for regulated non-quarantine pests.

They are deemed to be practically free from other pests*.

II. Additional Declaration

III. Disinfestation and/or Disinfection Treatment

Date _____Treatment _____Chemical (active ingredient)_____

Duration and temperature _____Concentration _____

Additional information _____

Place of issue _____

(Stamp of Organization) _____

Name of authorized officer_____

Date _____
(Signature)

No financial liability with respect to this certificate shall attach to
(name of Plant Protection Organization) or to any of its officers or representatives.*

* Optional clause

Model Phytosanitary Certificate for Re-Export

No. _____

Plant Protection Organization of _____
(contracting party of re-export)

TO: Plant Protection Organization(s) of _____
(contracting party(ies) of import)

I. Description of Consignment

Name and address of exporter: _____

Declared name and address of consignee: _____

Number and description of packages: _____

Distinguishing marks: _____

Place of origin: _____

Declared means of conveyance: _____

Declared point of entry: _____

Name of produce and quantity declared: _____

Botanical name of plants: _____

This is to certify that the plants, plant products or other regulated articles described above were imported into (contracting party of re-export) from (contracting party of origin)_____ _____ covered by Phytosanitary Certificate No. _____, *original o certified true copy o of which is attached to this certificate; that they are packed o repacked o in original o *new o containers, that based on the original phytosanitary certificate o and additional inspection o , they are considered to conform with the current phytosanitary requirements of the importing contracting party, and that during storage in _____ (contracting party of re-export), the consignment has not been subjected to the risk of infestation or infection.

* Insert tick in appropriate boxes.

II. Additional Declaration

III. Disinfestation and/or Disinfection Treatment

Date _____Treatment_____Chemical (active ingredient)_____

Duration and temperature _____Concentration _____

Additional information _____

Place of issue _____

(Stamp of Organization) Name of authorized officer _____

Date _____
(Signature)

No financial liability with respect to this certificate shall attach to _____ _____ (name of Plant Protection Organization) or to any of its officers or representatives.**

** Optional clause

Annex 7

GENEBANK STANDARDS

FAO/IPGRI Genebank Standards are published under the joint auspices of the Plant Production and Protection Division of the Food and Agriculture Organization of the United Nations (FAO) and the International Plant Genetic Resources Institute (IPGRI)[1].

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Genebank Standards. 1994. Food and Agriculture Organization of the United Nations, Rome, International Plant Genetic Resources Institute, Rome.

ISBN 92-9043-236-5

[1] IBPGR and IPGRI are forerunners of Bioversity International.

PREAMBLE

FAO and IBPGR have been cooperating since the early seventies to strengthen national capabilities in ex situ conservation of plant genetic resources, including the development of agreements and network activities with institutions that had accepted primary responsibility for long-term conservation of germplasm of particular species in their base collections.

The International Undertaking on Plant Genetic Resources, which was approved by FAO member countries in 1983, requests that: “there develops an internationally coordinated network of national, regional and international centres, including an international network of base collections in genebanks, under the auspices or the jurisdiction of FAO, that have assumed the responsibility to hold, for the benefit of the international community and on the principle of unrestricted exchange, base or active collections of the plant genetic resources of particular plant species”. FAO and IBPGR have agreed to merge the IBPGR register of base collections with the international network, within the context of the Global System for Conservation and Utilization of Plant Genetic Resources.

In 1991, the Commission on Plant Genetic Resources considered it “essential that appropriate standards be developed for genebanks operating within the international network”. The Commission requested “the convening of a panel of technical experts, to work in collaboration with FAO and IBPGR to assess and, if necessary, redefine genebank standards”. It also agreed that the standards should take into account the advances in seed storage technology and the requirements of seeds of wild species.

Subsequently, an FAO/IBPGR Expert Consultation was convened in 1992 to discuss and update the genebank standards that IBPGR published in 1985. The Genebank Standards recommended by the Expert Consultation were then endorsed by the 5th Session of the Commission on Plant Genetic Resources in April 1993.

FAO and IPGRI recommend that these standards be widely utilized as the international reference in national, regional and international genebanks.

I. INTRODUCTION

1. These Genebank Standards are based on the Report of the FAO/IBPGR Expert Consultation Group on Genebank Standards held in Rome, Italy, from 26 to 29 May 1992. The Group was convened in order to further refine International Standards for Genebanks to minimize the loss of genetic integrity in seed accessions during storage and regeneration using the Report of the Third Meeting of the IBPGR Advisory Committee on Seed Storage (AGPG/IBPGR/84/74, April 1985) as the basis of its discussions. Particular attention was paid to providing standards which would apply to wild species and to forest tree species as well as to crop species. A list of the members of the Expert Consultation is provided in Appendix I.

2. The Genebank Standards are concerned solely with the storage of seeds of orthodox species: that is those species whose seed can survive very considerable desiccation, and in which longevity is dramatically improved by reducing seed storage moisture content and/or temperature.

STANDARDS

3. Standards are essential in order to provide targets for institutes to aim at. However, the problems inherent in setting standards should be noted. On the one hand, there is the problem that the standards set now may limit future technological advances; in other words, the global genebank network may become fixed at one level. On the other hand, there is the problem that some institutes may be unable to meet the standards specified herein. In view of these problems, in some cases two standards are specified:

   (i) acceptable - in many cases minimal but considered adequate (at least in the short-term); and

   (ii) preferred - a higher and thus safer standard.

4. For most criteria there are good scientific reasons for meeting the “preferred standards”. Therefore, efforts should be made to achieve such standards. However, where resources are limited it would be possible for curators to reach pragmatic compromises such that even under operating conditions that were not ideal, the collection would not be placed in jeopardy. The aim should be to store as many accessions as possible in an acceptable manner rather than a few at the preferred standard. Long-term safe and sustainable conservation efforts are the ultimate objectives.

5. A particular problem has been associated with the wrong perception that if a genebank operated at a standard less than the ideal target its conserved germplasm was automatically considered to be in jeopardy. Recent research on seed storage and archaeological findings have indicated the potential of storing seeds of many crop species and retaining viability for more than a century at a seed moisture content of around 5% under a storage temperature of about +51°C. This storage standard is considered acceptable for conserving germplasm, although there are alternative standards, based on different combinations of storage temperature and seed moisture content, to realistically achieve the purpose of long-term germplasm preservation. An attempt has been made to propose standards that can preserve germplasm for a reasonable period. However, all genebanks are encouraged to try to achieve the preferred standard recommended.

TERMINOLOGY

6. The base collection is defined as a set of accessions, each of which should be distinct and, in terms of genetic integrity, as close as possible to the sample provided originally, which is preserved for the long-term future. The base collection for a crop genepool or any species may be dispersed among several institutions - a practice which is likely to increase with the development of crop networks. Normally, seeds will not be distributed from the base collection directly to users.

7. Active collections comprise accessions which are immediately available for multiplication and distribution for use. It is not, therefore, the role of base collections to provide seed samples to users: normally these would be provided via active collections. The terms “base collection” and “active collection” are not synonymous with the conditions under which the seeds are stored. However, in order to preserve base collections it is usual to maintain such collections under long-term seed storage conditions. There is no fundamental reason why active collections should not also be kept under long-term conditions but, because such collections are often accessed frequently, they are often maintained under medium-term storage conditions.

8. The Standards do not provide a detailed account of genebank construction and management. There are numerous publications available from FAO/IBPGR which provide detailed guidance on many aspects of genebank design and operation (see Appendix II).

II. STANDARDS FOR SEED STORAGE

Control of environmental conditions

9. There is a need to maintain seeds under the best possible conditions before storage, to maintain high levels of viability of germplasm entering active and base collections. The seeds should be held for the minimum amount of time under temporary conditions that do not meet acceptable standards for conservation.

10. There is no known benefit in chemically treating seeds during storage at the preferred conditions of storage for base collections to control pests and diseases. Such chemicals may even cause chromosomal damage or be against health and safety regulations for personnel. Chemicals may be necessary during regeneration to ensure that healthy seeds are produced, or for post-harvest treatment, especially in tropical countries.

11. Attention should be given to the environmental conditions of the seed processing area. In tropical areas with high ambient humidity, it may be necessary to have an ancillary room with controlled humidity and temperature to avoid condensation on the seeds during packing. Use of psychometric charts is recommended to decide which action is required to avoid condensation.

Seed Drying Procedures

12. The objective in drying seeds is to reduce the moisture content to a level which prolongs longevity during storage and therefore increase the regeneration interval. A variety of methods can be used for seed drying, the most common being the use of a desiccant or dehumidified drying chamber. The methods chosen will depend on the available equipment, number and size of the samples to be dried, local climatic conditions and cost considerations.

    (i) Drying at 10-25°C and 10-15% relative humidity (r.h.) using either a desiccant or drying chamber is preferred.

    (ii) Silica gel is suitable for seed drying and can be used to reach the very low moisture contents of ultra dry seed.

    (iii) Seeds need to be dried as soon as possible after reception to avoid substantial deterioration. The length of the drying period will depend on the size of the seed, the quantity being dried, the initial seed moisture content and the relative humidity in the drying room.

13. Genebank personnel should note that dry, and especially very dry, seeds are often brittle and thus prone to mechanical damage. Hence, seeds in genebanks should always be handled with care.

Seed Cleaning and Health

14. Seeds for storage in germplasm collections should be as clean and free from weed seeds, pests and diseases as possible. It has been reported that seed borne diseases affect longevity during storage. Curators should be aware of this potential problem, although no specific recommendations could be given at this time.

STORAGE CONTAINERS

15. A range of containers is now available which are moisture-proof and sealable. Choice of container will depend on availability and quality to withstand the storage conditions in the long term without leaks. When in doubt about the vapour exchange properties of containers, it is recommended that tests should be done to ensure that no moisture exchange occurs. It should be noted that many plastics are not moisture proof.

16. The use of any type of sealed moisture-proof containers, which are tested regularly to ensure quality of both material and seal, is acceptable. Storage of seeds of individual accessions in multiple containers for extra security is preferred. Some concern has been expressed that toxic gases may be produced in long-term storage which may affect the longevity of the seeds. However, at the low moisture contents and temperatures preferred for storage of base collections, metabolic and autocatalytic activity would be reduced to such low levels that the release of toxic gases would not reach a level at which there is any significant effect on seed longevity.

SEED STORAGE CONDITIONS FOR BASE COLLECTIONS

17. *Acceptable*: Sub-zero temperatures (<0ºC) with 3-7% seed moisture content (depending upon species).

    Preferred:- 18ºC or cooler with 3-7% seed moisture content (depending upon species).

    The above seed moisture content standard may need to be raised in exceptional cases where there is strong evidence that problems can arise at this moisture content (e.g. seed breakage during seed handling).

18. The preferred standards for storage of –18ºC or less with about 5% moisture content should not be relaxed. However, it should be emphasized that the choice of seed storage conditions by an individual genebank depends upon the species stored and the length of storage period envisaged before regeneration is likely to be required. Hence some flexibility is required with regard to what should be considered acceptable, particularly for those circumstances in which refrigeration to the extent required by the above preferred standard cannot be provided. Owing to the nature of the relation between seed longevity, storage temperature and seed moisture content, the same storage life can be achieved by different combinations of temperature and moisture.

19. The tendency to overemphasize the benefits of reduction in temperature compared to those in moisture content should be avoided. With. regard to the effect of temperature, the relative response of longevity to reduction in seed storage temperature is very similar among diverse orthodox species, but the relative benefit of a given reduction in temperature becomes less as temperature is reduced (at least, that is, within the ranges usually investigated down to –20ºC). Thus, longevity is increased by a factor of almost 3 if storage temperature is reduced from 20ºC to 10ºC; by 2.4 from 10ºC to 0ºC; by 1.9 from 0ºC to –10ºC; but by only 1.5 from –10ºC to –20ºC.

20. In contrast, the relative benefit to longevity of reduction in moisture content: (i) varies among species; and (ii) becomes greater for each successive reduction in moisture content. This variation among species appears to be largely a function

of difference in seed composition (which influences the equilibrium relation between seed moisture content and relative humidity).

21. A calculation which was made some years ago (but which, like many calculations involving extended periods of longevity, is to some extent based on extrapolation) to put the relative benefits of reduction in each of storage temperature and moisture content in context concerns the crop sesame (Sesamum indicum L.). The effect of a reduction from 5% to 2% seed moisture content provides about a forty-fold increase in longevity. This is about the same relative benefit as a reduction in temperature from +20ºC to –20ºC. However, in most crops the benefit of desiccation to longevity does not extend to such low moisture content values.

22. There is a low-moisture-limit to the increase in longevity observed to occur with reduction in seed storage moisture content. The value of this limit varies among species, but it is thought that this variation is also related to differences in seed composition such that equilibrium relative humidities at the critical moisture content are similar for different species. One estimate of this value is moisture contents in equilibrium with about 10 - 12% r.h. at 20ºC. It is reasonable to maximize the benefit of desiccation to subsequent longevity by drying seeds to 10 - 12% r.h. at 20ºC and then storing hermetically at ambient, but preferably cooler temperatures, if the storage temperature could not be controlled, or where the reduction in temperature provided by refrigeration is not adequate to meet the preferred standard for temperature. This approach has been previously described as “ultra-dry storage”. However, in some species this standard is actually slightly greater than the original 5% standard (e.g. 6-6.5% moisture content in pea).

23. Whether seeds are stored dry or ultra-dry, it is essential that all seeds be “conditioned” or “humidified” (by placing in a very moist atmosphere, usually overnight but occasionally slightly longer in the case of very large seeds) prior to testing for germination or growing out.

SEED STORAGE CONDITIONS FOR ACTIVE COLLECTIONS

24. Active collections should be kept in conditions which would ensure that accession viability remain above at least 65% for 10 to 20 years, being the only standard which should be provided. The precise storage regimes used to fulfil this objective will vary depending upon the species stored, the prevailing ambient environment and the relative local costs of (principally) electricity and labour. As indicated in the preceding section, different combinations of storage temperature and moisture can provide the same longevity. However, it could be emphasized that, in most locations, the reduction and control of seed storage moisture content will be a more cost-effective approach than controlling temperature.

ACCESSION SIZE IN BASE COLLECTIONS

25. It would be difficult to fulfill the function of a base collection unless accession size is sufficient to enable the accession to be regenerated, to provide an adequate sample to at least one active collection without regeneration, and to allow at least a few monitoring tests of viability.

    Acceptable: 1,000 viable seeds within the accession in store is considered an absolute minimum. It is accepted that any single number is, of course, arbitrary. In cases where fewer than 1,000 seeds are available, then the accession may nevertheless have to be accepted into good storage conditions until such time as it is possible to recollect or to regenerate.

    Preferred: 1,500 - 2,000 viable seeds.

    It is recognized that more seeds will be necessary in the case of genetically heterogeneous accessions.

VIABILITY MONITORING

26. Genebank managers have the responsibility to provide conditions which will maintain the viability of each accession held within the genebank above a minimum value. Hence accession viability must be monitored. The preferred standard is that this obligation extends not just to the genebank, which can be considered the originator of the accession, but also to those genebanks holding a duplicate of the accession.

27. Viability will usually be assessed by means of a germination test, although other test procedures (such as the topographical tetrazolium test) may be required in order to clarify whether the non-germinating seeds in these tests are non-viable or whether their dormancy has not been broken during the test. Empty seeds not already removed before storage should be removed before beginning the germination test. An IBPGR handbook (Appendix II, IBPGR, 1985) is available which provides both general and specific advice on the conduct of germination tests and appropriate dormancy-breaking procedures.

28. The minimum standard is that accession viability monitoring tests be carried out at, or soon after, receipt and subsequently at intervals during storage. The initial germination test should be carried out on a minimum of 200 seeds drawn at random from the accession.

29. The period between viability monitoring tests will vary among species and will also depend upon the seed storage conditions. Genebanks should regularly conduct monitoring tests. Under the preferred storage conditions for base collections, the first monitoring test should normally be conducted after 10 years for seeds with high initial germination percentage. Species known to have poor storage life or accessions of poor initial quality should be tested after 5 years. The interval between later tests should be based on experience, but in many cases may well be greater than 10 years. Note that where the preferred conditions of storage are not being met, then monitoring may need to be more frequent. Where a genebank has been operating for some years under the preferred conditions and has obtained sufficient information from their own monitoring tests on the range of material they work with to justify more extended monitoring intervals then this should be done.

30. The objective of the viability monitoring test is to decide whether regeneration is required. It is recommended that, in order to save seeds, 50 - 100 seeds be drawn at random from the accession for each monitoring test. The simplest method of determining whether substantial loss in viability is occurring, and distinguishing between this and the fluctuation in test results which is largely a consequence of sampling error, is to plot the results of successive monitoring tests against the period of storage and to see whether a progressive trend of loss in viability can be detected. Where such an indication is obtained, it is recommended that, provided sufficient seeds are available, a further sample of 100 seeds are drawn at random for a further viability monitoring test to reduce the probability that regeneration is initiated prematurely. Once it has been decided that an accession should be regenerated, further germination tests should be suspended to save valuable seeds.

31. It is essential that genebanks have, or have access to, sufficient laboratory equipment to enable viability monitoring tests to be carried out in a regulated, uniform and timely manner. In some cases the particular problems of the species maintained will require the provision of more specialized equipment, e.g. X-ray equipment to test for empty seeds and/or insect-damaged seeds.

32. Initial germination testing and viability monitoring during storage requires adequate facilities to carry out these tests according to the conditions described in paragraphs 27 to 31. It is acceptable that a base collection should have access to suitable seed testing facilities and it is preferred that these should be at the same site as the base collection.

33. In the case of active collections, it is suggested that monitoring every 5 years will normally be satisfactory. However, this should be adjusted up or down

depending upon the species stored, initial viability, and the storage environment. Where base and active collections are maintained side-by-side within the National Agricultural Research System under the preferred conditions for base collections then the advice for base collections should be followed for the active sample and in most cases it will not be necessary to sample from the base collection until the results for the active collection sample suggest this is necessary, or the latter becomes depleted. Note that this comment only applies in situations where the base and the active collections represent the same original seed sample which has simply been divided at random into the base and active samples.

34. There is no non-destructive viability monitoring test currently available. It is recommended that where the number of seeds within an accession is limited, and regeneration is feasible, the seedlings produced during accession viability monitoring tests should be grown out to provide a fresh stock of seeds (e.g. for distribution) providing, of course, that the number of seedlings available is sufficient for regeneration.

REGENERATION

35. Regeneration standards are needed to ensure that the seeds stored in base collections do not fall below acceptable levels of viability and yet minimize the number of regeneration cycles to ensure that the genetic integrity of accessions is maintained. The regeneration interval will depend on the longevity of the seed in storage and demand for the accession (if seeds are not available from an active collection).

36. Seeds which are produced for storage in base collections should, as far as possible, be of the highest possible viability and free of pests and diseases. Recognizing that the initial germination capacity will depend on the environment during production and processing, maturity and physiological state of the seeds at harvest and genetic differences between species, initial germination values should exceed 85% for most seeds, e.g. cereals, and 75% for some vegetables and even lower for some wild or forest species, which do not normally reach high levels of germination.

37. Regeneration should be undertaken when viability falls to 85% of the initial value. Regeneration methods should follow the standards for the crop, where available, and ensure that sufficient plants are used to maintain the genetic integrity of the accession. As far as possible all sources of selection pressure should be removed, the contribution of seeds from each plant should be equalized and all possible care taken to minimize genetic change.

38. It is desirable to use 100 plants or more for regeneration to avoid the probability of large losses of alleles. However, in wild species this may be limited by the total number of seeds available. Wild species may also vary in breeding system, storage behaviour and germination from the related crop species. This should be taken into consideration when deciding when, and how to regenerate an accession.

39. In order to ensure that the genetic integrity is maintained and accessions are distinct, it is recommended that seeds used to plant material for regeneration should be as close as possible genetically to the original germplasm. It is recommended that for active collections, regeneration should be done from original seeds whenever possible or from its offsprings within two or three cycles of regeneration to ensure that genetic integrity is maintained. This implies that, assuming a 15 year storage cycle for the active collection, seeds for regeneration will need to be taken either from the base collection or other original seed in long-term storage once in 45 to 60 years, providing sufficient seeds are regenerated to meet demands on the active collection for distribution. Genebanks carrying out regeneration should also consider what methods they could use to monitor variation during regeneration to measure any changes in genetic constitution in accessions.

INFORMATION ABOUT BASE COLLECTIONS

40. Information about the accessions in the base collection is an essential part of the base collection because good information will enhance the usefulness of the germplasm. Data on any accession should be as complete as possible in order to identify it as a distinct accession, although accessions without extensive data are also valuable and it may be justified to include them in base collections.

41. There are five major types of data relating to accessions held in base collections:
i. Passport
ii. Management
iii. Characterization
iv. Evaluation
v. Mode of reproduction

42. The standard descriptors for passport and management data are presented in Appendix III. As a minimum, each accession should be accompanied by available passport and management data and mode of reproduction (if known). In many cases individual accessions will vary with regard to mode of reproduction within a species. It is preferred that characterization and evaluation data on the accessions should also be held by base collections or be readily available from other sources.

III. STANDARDS FOR THE EXCHANGE AND DISTRIBUTION OF SEEDS FROM ACTIVE COLLECTIONS

43. Standards for seed exchange:

(i) Seeds should be sent out in the most suitable containers available in order to avoid deterioration in transit. Ideally these would be moisture-proof, but it is accepted that different decisions will be made on the basis of the packaging materials available, the likely delays to delivery and the several ambient environments the seeds will be exposed to during transit.

(ii) Adequate information, such as passport data and (if required) evaluation data should accompany the sample.

(iii) Special details of germination methods and mode of reproduction (where known) should be provided.

(iv) A sufficient number of viable seeds should be sent out in order to provide a genetically representative sample of the accession.

(v) Quarantine and other seed health requirements must be satisfied.

GENEBANK PERSONNEL AND TRAINING

44. Staff numbers: Considering the complexity of the different activities in both base and active collections, the range of species likely to be encountered, and the range of standards of staff training, it is misleading to quote numbers of staff. Similarly, among the specialist scientific staff required, it is not considered helpful to rank the different specializations in any particular order. Among the various disciplines (not ranked in any order), genebanks should have access to expertise in seed physiology, genetics, taxonomy, information management, plant pathology, engineering/maintenance and of course to various crop/species specialists as appropriate.

SAFETY AND SECURITY

45. Every effort must be made to ensure the safety and security of the germplasm in collections through adequate construction, maintenance and security controls of the installation. Equipment should undergo regular preventative maintenance

and trained maintenance personnel are essential for this. Genebank personnel should also be trained in safety procedures to minimize the risk to the germplasm in base collections.

46. The following points should be noted:

(i) Power Supply to the Seed Store: A stable and continuous power supply is acceptable. An alternative power supply is preferred; normally this would be a back-up generator with adequate fuel supply.

(ii) Fire Precautions: All reasonable fire precautions should be taken and equipment tested from time to time. Particular attention should be paid to maintaining appropriate fire fighting equipment and training personnel in its use. The installation of a lightning conductor rod, alarm system and high temperature cut out for the cooling system (mounted behind a wall) is recommended.

(iii) Security: The installation should be designed for high security and adequate security arrangements should be made for the protection of the facility.

(iv) Refrigeration Standards and Equipment: Refrigeration standards and equipment should conform to the Design of Seed Storage Facilities for Genetic Conservation ("DSSF") (IBPGR 1982) specifications. There should be trained personnel and spare parts available for repair and maintenance. Routine preventative maintenance should be carried out. A back-up refrigeration system is preferred.

(v) Construction and Insulation: The construction and insulation standards should follow the guidance given in "DSSF", taking into account the local conditions and, wherever possible, using locally available material. The size of the store should reflect the numbers and sizes of germplasm samples to be stored for efficiency. The use of modular units to increase flexibility and safety is appropriate.

(vi) Safety of Personnel: Protective clothing should be provided and used in the store. Personnel should be aware of and trained in safety procedures. Adequate precautions should be taken and safety equipment including alarms and devices to open doors from inside drying rooms and refrigerated rooms should be installed.

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Appendix II

RELATED FAO/IBPGR PUBLICATIONS

FAO, 1974. Proposed standards and procedures for seed storage installations used for long term conservation of base collections. FAO, Rome.

FAO, 1985. A Guide to Forest Seed Handling. FAO Forestry Paper 20/2. FAO, Rome. (Available in English, French and Spanish).

FAO, 1991. Report of the Fourth Session, Commission on Plant Genetic Resources. FAO, Rome.

IBPGR, 1982. Design of Seed Storage Facilities for Genetic Conservation. Revised 1985 and 1990. International Board for Plant Genetic Resources, Rome.

IBPGR, 1985. Handbook of Seed Technology for Genebanks. Volume I. Principles and Methodology. International Board for Plant Genetic Resources, Rome.

IBPGR, 1985. Handbook of Seed Technology for Genebanks. Volume II. Compendium of Specific Germination Information and Test Recommendations. International Board for Plant Genetic Resources, Rome.

IBPGR, 1985. Procedures for Handling Seeds in Genebanks. International Board for Plant Genetic Resources, Rome.

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DESCRIPTORS FOR PASSPORT AND MANAGEMENT PARAMETERS

Passport descriptors*

1. Accession data

Accession number; donor name; donor number; other number(s) associated with the accession; scientific name (genus, species, subspecies, botanical variety); pedigree; cultivar name; acquisition date; date of last regeneration or multiplication; accession size; number of times accession regenerated; number of plants in each regeneration.

2. Collection data

Collecting institute(s); collector's number; collection date of original sample; country of collection; province/state; department/county; collection site; conservation status.

Management descriptors*

M1. Management data

Accession number; population identification; location in storage; date place in storage; initial germination (%); date of last germination test; germination at the last test (%); date of next test; moisture content at harvest (%); moisture content at storage (initial) (%); amount of seed in storage(s) (number); duplication at other location(s).

M2. Multiplication/regeneration data

Accession number; population identification; field/plot/nursery/glasshouse number; location; collaborator; sowing date; sowing density; fertilizer application; germination in the field (%); number of plants established; agronomic evaluation; previous multiplication and/or regeneration (location, sowing date, plot number); others.

* For details see IBPGR Descriptors for White Clover (1993)

Annex 8

PRINCIPAL CHARACTERISTICS OF CONTAINERS COMMONLY USED IN GENEBANKS

Containers Characteristics Permitting storage for:

Containers		Characteristics		Permitting storage for:			Observations
		Material	Capacity [1]	Term [2]	Temperature (°C)	Relative humidity (%)	
Hermetic	Envelopes	Aluminum	Variable	L/M	4 to -20	10–20	Frequent use; several sizes; easy labelling and management; lose airtightness through perforations or deterioration over time.
	Tins	Various metals, especially aluminum	0.1–1	L/M		30–50	Frequent use; several sizes; vacuum seal; easy labelling and management; oxidation, except for those of aluminum.
	Glass phials	Pyrex	0.02–0.2	L	-10 to -3.7		Frequent use; several sizes; sealed to fire; good for storing small seeds in small quantities; do not require control of relative humidity; expensive; fragile.
Not hermetic	Bottles or flasks	Plastic, 0.4 to 2 mm thick	0.12–5	S/M	8 to –20	15–60	Several sizes; readily available; cheap; let moisture through under long-term storage
		Glass	0.12–1	S/L	0 to -23	<10	Several sizes; easy to use; readily available; must be made in glass resistant to low temperatures; must be fitted with safety lids; let moisture through.
	Tins	Several metals, preferably aluminum	0.11–4.5	M/L	4 to -20	20–50	Several sizes; must be constructed without openings; must be fitted with safety lids; oxidation, except those of aluminum; expensive; not readily available

Source: IPGRI (1996b)

[1] Capacity depends on container size
[2] S = short, M = medium, L = long term

Annex 9

LIST OF MULTICROP PASSPORT DESCRIPTORS

FAO/IPGRI MULTI-CROP PASSPORT DESCRIPTORS
December 2001

This list of multi-crop passport descriptors (MCPD) is developed jointly by IPGRI and FAO to provide international standards to facilitate germplasm passport information exchange. These descriptors aim to be compatible with IPGRI crop descriptor lists and with the descriptors used for the FAO World Information and Early Warning System (WIEWS) on plant genetic resources (PGR).

For each multi-crop passport descriptor, a brief explanation of content, coding scheme and suggested fieldname (in parentheses) is provided to assist in the computerized exchange of this type of data. It is recognized that networks or groups of users may want to further expand this MCPD List to meet their specific needs. As long as these additions allow for an easy conversion to the format proposed in the multi-crop passport descriptors, basic passport data can be exchanged worldwide in a consistent manner.

General comments:

- If a field allows multiple values, these values should be separated by a semicolon (;) without space(s), (i.e. Accession name:Rheinische Vorgebirgstrauben;Emma;Avlon).
- A field for which no value is available should be left empty (i.e. Elevation). If data are exchanged in ASCII format for a field with a missing numeric value, it should be left empty. If data are exchanged in a database format, missing numeric values should be represented by generic NULL values.
- Dates are recorded as YYYYMMDD. If the month and/or day are missing this should be indicated with hyphens. Leading zeros are required (i.e. 197506--, or 1975----).
- Latitude and longitude are recorded in an alphanumeric format. If the minutes or seconds are missing, this should be indicated with hyphens. Leading zeros are required.
- Country names: Three letter ISO codes are used for countries. The ISO 3166-1: Code List and the Country or the Country or area numerical codes added or changed are not available on-line, but can be obtained from IPGRI [ipgri-mcpd@cgiar.org]
- For institutes the codes from FAO should be used. These codes are available from http://apps3.fao.org/wiews/ for registered WIEWS users. From the Main Menu select: 'PGR' and 'Download'. If new Institute Codes are required, they can be generated online by national WIEWS administrators, or by the FAO WIEWS administrator [Stefano.Diulgheroff@fao.org].
- The preferred language for free text fields is English (i.e. Location of collecting site and Remarks).

MULTI-CROP PASSPORT DESCRIPTORS

1. Institute code **(INSTCODE)**
Code of the institute where the accession is maintained. The codes consist of the 3-letter ISO 3166 country code of the country where the institute is located plus a number. The current set of Institute Codes is available from the FAO website (http://apps3.fao.org/wiews/).

2. Accession number **(ACCENUMB)**
This number serves as a unique identifier for accessions within a genebank collection, and is assigned when a sample is entered into the genebank collection.

3. Collecting number **(COLLNUMB)**
Original number assigned by the collector(s) of the sample, normally composed of the name or initials of the collector(s) followed by a number. This number is essential for identifying duplicates held in different collections.

4. Collecting institute code **(COLLCODE)**
Code of the Institute collecting the sample. If the holding institute has collected the material, the collecting institute code (COLLCODE) should be the same as the holding institute code (INSTCODE). Follows INSTCODE standard.

5. Genus **(GENUS)**
Genus name for taxon. Initial uppercase letter required.

6. Species **(SPECIES)**
Specific epithet portion of the scientific name in lowercase letters. Following abbreviation is allowed: ‘sp.’

7. Species authority **(SPAUTHOR)**
Provide the authority for the species name.

8. Subtaxa **(SUBTAXA)**
Subtaxa can be used to store any additional taxonomic identifier. Following abbreviations are allowed: ‘subsp.’ (for subspecies); ‘convar.’ (for convariety); ‘var.’ (for variety); ‘f.’ (for form).

9. Subtaxa authority **(SUBTAUTHOR)**
Provide the subtaxa authority at the most detailed taxonomic level.

10. Common crop name **(CROPNAME)**
Name of the crop in colloquial language, preferably English (i.e. 'malting barley', 'cauliflower', or 'white cabbage')

11. Accession name **(ACCENAME)**
Either a registered or other formal designation given to the accession. First letter uppercase. Multiple names separated with semicolon without space. For example: Rheinische Vorgebirgstrauben;Emma;Avlon

12. Acquisition date [YYYYMMDD] **(ACQDATE)**
Date on which the accession entered the collection where YYYY is the year, MM is the month and DD is the day. Missing data (MM or DD) should be indicated with hyphens. Leading zeros are required.

13. Country of origin **(ORIGCTY)**
Code of the country in which the sample was originally collected. Use the 3-letter ISO 3166-1 extended country codes.

14. Location of collecting site **(COLLSITE)**
Location information below the country level that describes where the accession was collected. This might include the distance in kilometres and direction from the nearest town, village or map grid reference point, (e.g. 7 km south of Curitiba in the state of Parana).

15. Latitude of collecting site[1] **(LATITUDE)**
Degree (2 digits) minutes (2 digits), and seconds (2 digits) followed by N (North) or S (South) (e.g. 103020S). Every missing digit (minutes or seconds) should be indicated with a hyphen. Leading zeros are required (e.g. 10----S; 011530N; 4531--S).

16. Longitude of collecting site[1] **(LONGITUDE)**
Degree (3 digits), minutes (2 digits), and seconds (2 digits) followed by E (East) or W (West) (e.g. 0762510W). Every missing digit (minutes or seconds) should be indicated with a hyphen. Leading zeros are required (e.g. 076----W).

17. Elevation of collecting site [m asl] **(ELEVATION)**
Elevation of collecting site expressed in metres above sea level. Negative values are allowed.

18. Collecting date of sample [YYYYMMDD] **(COLLDATE)**
Collecting date of the sample where YYYY is the year, MM is the month and DD is the day. Missing data (MM or DD) should be indicated with hyphens. Leading zeros are required.

19. Breeding institute code **(BREDCODE)**
Institute code of the institute that has bred the material. If the holding institute has bred the material, the breeding institute code (BREDCODE) should be the same as the holding institute code (INSTCODE). Follows INSTCODE standard.

20. Biological status of accession **(SAMPSTAT)**
The coding scheme proposed can be used at 3 different levels of detail: either by using the general codes (in boldface) such as 100, 200, 300, 400 or by using the more specific codes such as 110, 120 etc.

100) Wild
- 110) Natural
- 120) Semi-natural/wild

200) Weedy
300) Traditional cultivar/landrace
400) Breeding/research material
- 410) Breeder's line
  - 411) Synthetic population
  - 412) Hybrid
  - 413) Founder stock/base population
  - 414) Inbred line (parent of hybrid cultivar)
  - 415) Segregating population
- 420) Mutant/genetic stock

500) Advanced/improved cultivar
999) Other (Elaborate in REMARKS field)

21. Ancestral data **(ANCEST)**
Information about either pedigree or other description of ancestral information (i.e. parent variety in case of mutant or selection). For example a pedigree 'Hanna/ 7*Atlas//Turk/8*Atlas' or a description 'mutation found in Hanna', 'selection from Irene' or 'cross involving amongst others Hanna and Irene'.

[1] To convert from longitude and latitude in degrees (º), minutes ('), seconds (''), and a hemisphere (North or South and East or West) to decimal degrees, the following formula should be used:

d° m' s''=h *(d+m/ 60+s/3600)

where h=1 for the Northern and Eastern hemispheres and –1 for the Southern and Western hemispheres i.e. 30º30'0'' S= –30.5 and 30º15'55'' N=30.265.

22. Collecting/acquisition source **(COLLSRC)**

The coding scheme proposed can be used at 2 different levels of detail: either by using the general codes (in boldface) such as 10, 20, 30, 40 or by using the more specific codes such as 11, 12 etc.

10) Wild habitat
- 11) Forest/woodland
- 12) Shrubland
- 13) Grassland
- 14) Desert/tundra
- 15) Aquatic habitat

20) Farm or cultivated habitat
- 21) Field
- 22) Orchard
- 23) Backyard, kitchen or home garden (urban, peri-urban or rural)
- 24) Fallow land
- 25) Pasture
- 26) Farm store
- 27) Threshing floor
- 28) Park

30) Market or shop

40) Institute, Experimental station, Research organization, Genebank

50) Seed company

60) Weedy, disturbed or ruderal habitat
- 61) Roadside
- 62) Field margin

99) Other (Elaborate in REMARKS field)

23. Donor insitute code **(DONORCODE)**

Code for the donor institute. Follows INSTCODE standard.

24. Donor accession number **(DONORNUMB)**

Number assigned to an accession by the donor. Follows ACCENUMB standard.

25. Other identification (numbers) associated with the accession **(OTHERNUMB)**

Any other identification (numbers) known to exist in other collections for this accession. Use the following system: INSTCODE:ACCENUMB;INSTCODE:ACCENUMB;… INSTCODE and ACCENUMB follow the standard described above and are separated by a colon. Pairs of INSTCODE and ACCENUMB are separated by a semicolon without space. When the institute is not known, the number should be preceded by a colon.

26. Location of safety duplicates **(DUPLSITE)**

Code of the institute where a safety duplicate of the accession is maintained. Follows INSTCODE standard.

27. Type of germplasm storage **(STORAGE)**

If germplasm is maintained under different types of storage, multiple choices are allowed, separated by a semicolon (e.g. 20;30). (Refer to FAO/IPGRI Genebank Standards 1994 for details on storage type.)

10) Seed collection
- 11) Short term
- 12) Medium term
- 13) Long term

20) Field collection

30) In vitro collection (Slow growth)

40) Cryopreserved collection

99) Other (Elaborate in REMARKS field)

28. Remarks **(REMARKS)**

The remarks field is used to add notes or to elaborate on descriptors with value 99 or 999 (=Other). Prefix remarks with the field name they refer to and a colon (e.g. COLLSRC:riverside). Separate remarks referring to different fields are separated by semicolons without space.

Annex 10

GLOSSARY

Glossary

English term	Spanish term	Definition
A		
Abiotic	Abiótico	Related to physical and chemical factors of the environment (e.g. water, temperature and soil)
Accession	Accesión, Entrada	Sample of a plant, line, or population maintained in a genebank or breeding program for conservation and use. A sample of germplasm that represents the genetic variation of a population
Active collection	Colección activa	Set of samples or germplasm accessions stored for the short or medium term and maintained for the purposes of study, distribution or use
Arboretum (pl. –reta)	*Arboretum* (pl. –reta)	Garden where trees and shrubs are cultivated for study and exhibition
B		
Base collection	Colección base	The broadest and most complete collection of germplasm accessions stored for the long term for the purpose of conservation. It is only used to fill in gaps in the active collection
Biochemical markers	Marcadores bioquímicos, Marcadores enzimáticos	Diverse molecular forms of an enzyme (i.e. isoenzymes) that catalyze the same substrate and which are used to evaluate the enzymatic heterogeneity of plants, that is, the genetic variability between individuals at the enzymatic and proteinic level. Markers indirectly evaluate the genome, based on their enzymatic products. They are susceptible to the environment
Biotic	Biótico	Related to living organisms and organic components of the biosphere. A biotic factor or agent is frequently associated with three important groups that affect crop yield: pests, diseases or nematodes
C		
Callus	Callo	Initial tissue formed by cellular division in explants, usually homogeneous, i.e. not differentiated into organized tissue
Characterization	Caracterización	Measure or evaluation of the presence, absence or degree of specificity of the traits whose expression is little modified by the environment

Clone	Clon (pl. –es)	Population of recombinant DNA molecules with the same sequence. Also population of cells or organisms with identical genotypes
Cloned gene	Gen clonado	Gene copied from an initial gene and which is inserted into a vector molecule, using in vitro recombination techniques
Co-evolution	Coevolución	Joint evolution of two or more organisms interrelated positively or negatively. Any situation in which two organisms act as selection agents on each other, e.g. Acacia of Mexico and the ants that inhabit it, and Opuntia acanthocarpa (cactus) and ants
Companion weeds	Arvenses compañeras	In agriculture: plants or species that grow where the man does not want them. In ecology: plants that are adapted to modified environments or open habitats
Conservation	Conservación	The maintenance of populations, selected for their genetic characteristics, in their natural habitat (in situ) or of samples of these populations in genebanks (ex situ). Conservation assumes that the materials are useful or potentially useful and aims to maintain and manage them for current and future benefit
Core collection	Colección nuclear	A collection that groups within a minimum number of accessions the broadest variability existing in a base collection
Cultivar	Cultivar	Synonymous with ‘variety’ (q.v.). Plant type within a cultivated species that is distinguished by one or more traits that are kept and transferred when the plant reproduces by seed or asexually
Curator	Curador, Encargado	Individual or legal entity that conserves and administers plant genetic resources
D		
Descriptors	Descriptores	Quantitative or qualitative characteristics that permit identification of a plant at different taxonomic levels, through morphological, agronomic and ecogeographic traits
DNA bank	Banco de DNA	Banks whose samples are genes or their fragments. Molecule collection of recombinant DNA that carry insertions that represent the entire genome of an organism
DNA library	Genoteca, Librería genómica, Librería de ADN	Collection of DNA fragments amplified in clonation vectors. The cloned fragments can come from genomic DNA or from complementary DNA

Dormancy	Dormición	Inability of a seed to initiate its own germination under appropriate conditions of light, temperature, aeration and humidity
Dormant	Durmiente	Seed in a state of dormancy (q.v.)
Duplicate	Duplicado	A germplasm sample introduced by mistake into a collection as a different accession, but which is genetically identical to others already in the collection
E		
Ecogeographic study	Estudio ecogeográfico	Collection and synthesis of ecological, geographic and taxonomic information, the results of which can be used to establish priorities and strategies of germplasm collection and conservation
Ecosystem	Ecosistema	Dynamic complex of communities of plants, animals and microorganisms, and their abiotic environment with which they interact to form a functional unit
Ethnobotany	Etnobotánica	Study of the folklore and history on the use of plants
Evaluation	Evaluación	Measurement, observation and analysis of a germplasm collection with a view to detecting potential use. Normally uses descriptors of quantitative traits affected by the environment
Explant	Explante	Segment of tissue or plant organ used to initiate an in vitro culture (e.g. leaves, roots, anthers, shoots, buds, embryos and meristems)
F		
Farmers' rights	Derechos de los agricultores	Rights attributed to farmers for their contribution (past, current or future) to the conservation, improvement and availability of plant genetic resources
Food security	Seguridad alimentaria	Capacity and ease of access of all people, across time, to a quantity of food that is sufficient to permit them lead active and healthy lives
G		
Genebank	Banco de germoplasma	Entity constituted to conserve genetic resources. It constitutes the most practical way of safeguarding genetic material. It stores samples of traditional varieties, products of breeding, varieties no longer used and wild species
Geneflow	Flujo de genes	Exchange of genetic material between populations through dispersion of gametes and zygotes.

Genetic drift	Deriva genética	Random fluctuation of genetic frequencies of a population from one generation to the next, due to factors such as natural selection. It is more evident in small isolated populations, and may lead to the permanence of one allele and to the extinction of another
Genetic erosion	Erosión genética	Loss of genetic diversity, that is, the loss of genetic material, including individual genes or combinations of genes (genetic complexes), genotypes and species
Genetic instability	Inestabilidad genética	Susceptibility to the genetic changes that accumulate with age in stored seeds and which results in the alteration of the initial genetic structure of the conserved sample
Genetic recombination	Recombinación genética	Combination of alleles from different progenitors to produce a recombinant individual. Such an organism or progeny can result from a crossing event or from an independent reorganization of the different chromosomes during meiosis. In genetics, the term refers to new combinations of sequences that result from the physical interaction of two DNA molecules
Genetic resources	Recursos genéticos	A set of sample populations of plants, animals, or microorganisms that was aquired to have available genetic characterization with current or potential usefulness. The environment in which genes are found. The genetic variability stored in chromosomes and other structures that contain DNA
Genetic stability	Estabilidad genética	Maintenance of certain degree of genetic balance in each individual of a population
Genetic uniformity	Uniformidad genética	The condition under which individuals of a population present an identical, or very similar, genetic structure, permitting the assumption that they will behave similarly and will have the same susceptibilities to biotic and abiotic stresses. This condition endangers the potential persistence of that population. Such a situation is known as genetic vulnerability. Both situations occur in greater degree when the population has been submitted to genetic improvement, and whose trend is to constitute genetically homogeneous populations, whether homo- or heterozygotic
Genetic variability	Variabilidad genética	The degree of genetic variation existing in a population or species. It is a consequence of the evolutionary processes to which the population or species has been submitted
Genetic variation	Variación genética	Inheritable variation. It occurs because of changes in genes, often caused by environmental factors
Genetic vulnerability	Vulnerabilidad genética	Susceptibility of plants to pathogens, pests, and environmental stress, resulting from, for example, genetic uniformity induced by breeding

Genotype	Genotipo (vegetal)	Total genetic constitution of an organism. It is a set of hereditary factors that regulate the organism's ways of reacting to external stimulants
Germplasm	Germoplasma	A structure that carries the total sum of hereditary characteristics of a species. The word germplasm supposes that the structure can give rise to a new generation, transmitting its genetic characteristics
H		
Habitat	Hábitat	Specific place occupied by organisms or communities that interact with the environment. The habitat is described as a function of those interactions
Heterozygous	Heterocigoto	Genetic condition in which the individual possesses two different alleles at one locus
Hybrid	Híbrido	Heterozygote resulting from the cross of two progenitors that differ in one or more traits
Hybridization	Hibridización	The crossing of genetically different individuals. The process that generates new genetic combinations and variability
I		
In situ conservation	Conservación *in situ*	Conservation of plant genetic resources in areas where they had developed naturally and, in the case of cultivated species or varieties, in the environs of the area where they acquired their distinctive properties
Incompatibility	Incompatibilidad	In plant reproduction, absence of fertilization and later formation of seeds. It is a condition in which viable gametes cannot join is because the stigma reduces or restricts the growth of the pollen tube, the formation of the reproductive organs is not synchronized, or structural and/or functional barriers are present, as in dichogamy, protandry and protogyny
Intron, Silent gene	Intron, Gen silencioso	DNA sequence within a eukaryotic gene that is not expressed in the proteinic product of that gene. Intron sequences are transcribed in the RNA but are eliminated before translation
Isozyme, Isoenzyme	Isoenzima	Multiple forms of an enzyme that occur in a given organism. While they have the same catalytic function (e.g. catalyzing a given substrate) they have different kinetic properties (e.g. speed of reaction)
L		
Landrace	Raza nativa	A population of usually heterozygotic plants, commonly developed in traditional agricultural systems through direct selection by farmers, and which are characteristically adapted to local conditions

Locus (pl. Loci)	Locus (pl. Loci)	Position within a chromosome at which the gene controlling a given trait is located
Longevity	Longevidad	Life span. In seeds, this is as long as they remain alive. Longevity depends on the species and on the storage conditions of the seeds
M		
Marker gene	Gen marcador	Gene whose function and location are known, which expresses certain traits or marked phenotypical differences that make it possible to analyze its heredity, establish its presence in the genome and detect recombination events
Meristem	Meristema(o)	Region of rapid cellular division (mitosis) and which comprises undifferentiated tissue from which cells tend to form differentiated and specialized tissues. Meristems are found in growth areas such as buds and apices
Molecular markers	Marcadores moleculares	Marker genes that directly evaluate the genome (DNA). They can evaluate each segment of the genome without being affected by the environment. They are, therefore, more accurate
Mutation	Mutación	Sudden variation or alteration in an organism, inheritable by following generations. It may involve changes in genes (gene mutation) or chromosomes (chromosomal mutation)
O		
Obsolete variety	Variedad obsoleta	Plant variety that is no longer cultivated commercially but may remain in collections for use in breeding programs
P		
Phenotype	Fenotipo	Final appearance of an individual that results from the interaction of its genotype with a given environment. The observable characteristics of an organism
Plant genetic resources	Recursos fitogenéticos, Recursos genéticos vegetales	Plant genetic resources comprise the total of all gene combinations produced during plant evolution. They encompass a range from wild species of potential agricultural use to cloned genes. The term genetic resources implies that the material has or can have economic or utilitarian value, whether current or future, and is highly significant in that it contributes to food security
Ploidy level	Nivel de ploidía	Complete number of complements or basic sets of chromosomes that a cell or organism possesses. The cell or organism can be haploid, diploid, triploid, tetraploid, pentaploid or hexaploid if they contain 1, 2, 3, 4, 5 or 6 basic sets of chromosomes, respectively. Those that possess more than two sets of chromosomes are called polyploids, whereas those that do not have an exact set (more or fewer chromosomes than a basic set) are called aneuploids

Propagule	Propágulo	Any structure that is used to propagate or multiply a plant vegetatively such as cuttings, tubers, differentiated tissues and cells
Protoplast	Protoplasto	A cell which is isolated and deprived of its wall
Pure line	Línea pura	Genetically pure individuals (homozygotes) originating from self-fertilization. Their descendants are equally homozygotic and homogeneous
Q		
Qualitative trait	Característica cualitativa	Characteristic whose observed variation is discontinuous, that presents several states, usually controlled by one or a few genes and is either not or little affected by the environment (e.g. yellow versus white flower)
Quantitative trait	Característica cuantitativa	Characteristic whose observed variation is continuous, usually controlled by many genes, and highly affected by the environment
Quarantine	Cuarentena	A legal procedure that consists of confining or isolating plants or other materials introduced from other countries to inspect them for the purpose of detecting potential plant health problems that may threaten the agriculture of the receiving country
R		
Regeneration	Regeneración	Cultivation of seeds (germplasm) from accessions to obtain a fresh, viable and sufficient sample (i.e. sufficient number of seeds, propagules, plants and cells)
Representative sample	Muestra representativa	A sample that contains at least 95% of alleles (genetic variability) of the sampled population
S		
Self incompatibility	Autoincompatibilidad	Physiological condition that impedes self-fertilization
Silent gene, Intron	Gen silencioso, Intron	DNA sequence within a eukaryotic gene that is not expressed in the proteinic product of that gene. Intron sequences are transcribed in the RNA but are eliminated before translation
Somaclonal variation	Variación somaclonal	Variation observed in somatic cells that divide mitotically in tissue culture. Depending on the species, this variation can be genetic, of form or of habitat. Many of these modifications are transferred to the progeny of regenerated plants

Somatic embryos	Embriones somáticos	Those embryos that originate by the fusion of somatic cells rather than of gametes
Static conservation	Conservación estática	A type of conservation that halts the natural processes of evolution and co-evolution of genetic resources, by conserving them in isolation, i.e. outside their natural habitats. The term is applied specifically to ex situ conservation
Subculture	Subcultivo	Aseptic transfer of a plant part from a collection to a fresh culture medium for renewal and strengthening
T		
Taxon (pl. Taxa)	Taxón (pl. Taxa)	A taxonomic group of any range of the classification system (e.g. species, genus or family)
Thermotherapy	Termoterapia	In plants, heat treatment for disinfecting plant material. It consists of taking stakes to the glasshouse and submitting them for 3 weeks to temperatures of 40ºC during the day and 35ºC during the night and to a photoperiod of 12 h. To increase its effectiveness, it is combined with in vitro tissue culture.
Trait	Carácter (pl. caracteres), Característica(s)	Structural or functional attribute of a plant that results from interaction between the plant's genes and the environment in which it develops
Transgenic plant	Planta transgénica	A plant in which a gene has been introduced from another species (transgene). The term transgenic is more broadly used for organisms (plants or animals) whose genome has been altered by in vitro manipulation. The term transgenesis is used to describe the artificial introduction of new genetic material into the genome of plants or animals, through genetic manipulation
V		
Variety	Variedad	Within a cultivated species, the plant that differs by one or more traits. When it reproduces by seed or asexually, these traits are conserved. Synonym for 'cultivar' (q.v.)
Vegetative propagation	Multiplicación vegetative, Multiplicación clonal	Synonymous with 'asexual reproduction'. Carries the constitution of homogeneous clones
Viability	Viabilidad	Capacity of an organism to stay alive after birth. In seeds, this comprises the ability to germinate when conditions are optimal for doing so. Being alive does not guarantee that the seed will germinate, even under optimal conditions, because of the occurrence of phenomena such as dormancy

W		
Weedy species	Formas regresivas	A species related to the cultivated species and which grows in the wild but is not used in agriculture. Usually shows characteristics of the cultivated species and its wild relatives
Wild species	Especie silvestre	Species or normal organism that has not mutated. This term was originally coined to denote organisms that were normally present in nature
Working collection	Colección de trabajo	Also called the 'breeding collection', it is used for crop research and improvement

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