Further reading

FAO/IPGRI, 1994. Genebank standards. FAO and IPGRI, Rome.

6.2 Seed storage

What is seed storage?

Seed storage is the preservation of seeds under controlled environmental conditions that maintain seed viability for long periods.

The longevity of seeds depends on initial seed quality, moisture content and temperature during storage. In general, low moisture content and low temperature reduce the loss of seed viability. Different combinations of moisture content and temperature can be used to prolong seed viability during storage.

Types of storage

Two types of seed stores are used for conservation of genetic resources: those holding seed samples for long-term security—referred to as *base collections*—and those holding seed samples for immediate use—referred to as *active collections*. The temperature, RH, seed moisture content, containers and distribution arrangements of these stores vary.

Base collections

A base collection is a set of accessions in which each is distinct and as close as possible to the original sample in terms of genetic integrity. Normally, seeds are not distributed from base collections directly to users but are only used to regenerate active collections (FAO/IPGRI, 1994). Base collections are stored for long periods at below 0°C—usually at -18° to -20°C—to maintain seed viability.

Engels and Visser (2002) introduced the term 'most-original sample' (MOS) to qualify the samples in base collections. A MOS consists of seeds that have undergone the lowest number of regenerations since the material was acquired by the genebank; it may be a sub-sample of the original seed lot or a seed sample from the first regeneration cycle if the original seed lot required regeneration before storage.

Active collections

Active collections consist of accessions that are immediately available for distribution. These accessions are accessed frequently and maintained in conditions that ensure at least 65% viability for 10–20 years (FAO/IPGRI, 1994). Combinations of temperatures and moisture contents for storage of active collections that can assure viability above 65% for 10–20 years are given in Table 6.2. It is more practical to use a lower moisture content and store at a higher temperature to save on refrigeration costs. However, when drying

to the low moisture contents is not possible, storage with higher moisture but at a lower temperature can be considered.

Table 6.2. Suggested storage temperature and moisture content for active collections (source: Bioversity, unpublished).

Temperature (°C)	Storage characteristics	
	Poor (e.g. onion)	Good (e.g. barley)
	Moisture content (% wet basis)	
25	3	7
20	3.5	7.5
15	5.0	8.0
10	6.0	9.0
5	7.0	10.0
0	8.0	11.0

Organization of collections

The underlying principle of maintaining a base collection or MOS is that at least some seed of the original sample should be kept aside under the best possible conditions to ensure safe long-term survival. This may be achieved by keeping seeds for distribution physically separate (as active collections) from the original sample but there is no absolute requirement to do so. A genebank may opt to maintain one sample of each accession for both conservation (in a base collection) and utilization (in an active collection) as long as the maintenance cost is not too high. If the genebank maintains both base and active collections, it is more cost effective to store only those accessions in the active collection that are being used by breeders and other users. (For further information, see Engels and Visser, 2003.)

Type of storage facility

The two commonly available options for seed storage are *walk-in cold stores* and *freezers*. The choice depends on the number of accessions to be stored, seed size and storage temperatures selected. When collections are small and sub-zero temperatures are required, chest or upright freezers are a cheaper option for seed storage.

How is storage space organized?

The organization of storage space depends on the type of storage facility and the type of containers used in the genebank. In view of the cost of maintaining cold storage, the space should be optimized so that a maximum number of seed accessions can be stored.

Walk-in cold storage

If the genebank has a walk-in cold store, the best option is to use

moveable racks that maximize storage space. Each rack is divided into a number of shelves. The distance between each shelf will depend of the size of containers. Small containers or aluminium foil bags can be held in boxes or trays and placed on the shelves.

A coding system can help genebank staff to locate accessions readily for sample retrieval; coding can be computerized in a database or stock inventory system. For example, 'A010201' could be used to indicate the following location:

- Room number (if more than one storage room is being used): A
- Rack number: 01
- Shelf number: 02
- Tray/box number: 01

Chest or upright freezers

For genebanks using chest or upright freezers, containers that fit onto shelves or boxes holding individual small containers can be used to store accessions. As for cold storage, a coding system to help locating accession can be established, including freezer number, row number and box number.

Storing seed samples

Step 1: Check the number of seeds in the accession

1. Weigh the seeds of each accession. Convert the seed weights to numbers by using the 100-seed or 1000-seed weight as described in the previous section.
2. Verify if the sample contains more than the required number of seeds for a genetically homogenous sample (3000–4000 seeds) or a genetically heterogenous sample (4000–12 000 seeds).
3. If the sample contains less than the required amount, either proceed directly to regeneration or store temporarily in the genebank and regenerate at the earliest opportunity (see Chapter 8).

Step 2: Identify a location for storage

The next step is to determine the location inside the storage room or freezer in which the accession will be stored.

1. Check the inventory file to find the next available space for the accession.
2. Assign the space where the accession is to be placed. If the accession is stored in more than one container, keep them all together.

Step 3: Place seeds in store

1. Make a list of assigned spaces where each accession will be placed.
2. Place the containers in the storage room or freezer in their assigned locations.

Step 4: Enter data into the database

1. Enter the data regarding storage location, date and number of containers in the inventory file.

Safety duplication (security backup collection)

Safety duplication means a genetically identical sub-sample of the accession is stored at another location (preferably outside the country) to provide insurance against loss of material. Safety duplication includes both the duplication of material and its related information. Samples are prepared for safety duplication in the same way as the base collection:

- Seeds should be dried to a moisture content of 5±2% depending on species.
- Seeds should be clean and healthy.
- Percent germination should be greater than 85%.
- Seeds should be hermetically sealed in appropriate containers.

Sample size can be smaller, but it should be sufficient to conduct at least three regenerations (with the safety factor built in). To save time, samples for safety duplication may be prepared simultaneously when processing seeds for base collection.

Specific agreements should be made with the recipient institute for holding the duplicate of a collection. Ideally, duplicate collections should be held in the same conditions as base collections to ensure long-term survival, although several types of duplication are recognized:

- *Black box:* when the sole responsibility of the recipient genebank is to maintain the duplicates without handling them. Beyond providing the best possible storage conditions, the recipient institute has no further responsibility for the samples. It is the originator's responsibility to establish a viability monitoring scheme and regenerate the collection when necessary. If the storage conditions for the backup collection are the same as for base collection, loss of viability can be predicted from the results of base collection-monitoring. Following regeneration of the sample in the base collection, the originator also replaces the safety duplicate. For black-box duplication outside the country, special permission is required to export seeds without *phytosanitary certificates* from the originating country. Similarly, the phytosanitary authority in the destination country must permit the recipient to import seeds without the routine quarantine examination.
- *Base:* maintained under suitable condition for long-term storage and incorporated into the recipient collection.
- *Active:* when the duplicate collection is incorporated into the recipient's collection, and is therefore subject to regeneration, multiplication and distribution by the recipient.

Archive collection

Genebanks may choose to store germplasm samples that do not need to be represented in a base collection or distributed as an 'archive collection'. These samples are maintained under optimal conditions for long-term survival but with no further investment in monitoring and regeneration. Germplasm included to archive collection can be:

- experimental lines bound by intellectual property (IP) rights—samples can be held as black-box collections and returned upon request to the IP holder;
- germplasm that lies outside the genebank mandate—samples can be stored temporarily until another genebank with a relevant mandate is identified;
- accessions identified as duplicates following rationalization of an existing base collection; and
- accessions no longer needed in the collection following a reassessment of the genebank's mandate or material disbanded due to lack of funding.

Documentation

Proper documentation of seed packaging and storage procedures allows rapid accession of new samples; response to queries regarding conserved germplasm; and monitoring of the quality and quantity of stored material to carry out regeneration and distribution. Suggested descriptors include the following:

- Storage conditions/collection type
- Type of container, if this varies in the genebank
- Number of containers
- Total amount of seeds stored (by weight or number)
- Date of storage
- Location in genebank
- Minimum amount of seed allowed (base unit) for dissemination/regeneration
- Location of safety duplicate, if available

Further reading

Cromarty A.S, Ellis, R.H. and Roberts, E.H. 1982. The design of seed storage facilities for genetic conservation. IBPGR, Rome.

Engels, J.M. and Visser, L. (eds.). 2003. A guide to effective management of germplasm collections. IPGRI Handbook for Genebanks No. 6. IPGRI, Rome.

FAO/IPGRI, 1994. Genebank standards. FAO and IPGRI, Rome.

Linington, S. H. 2003. The design of seed banks. Pp. 591-636 in Seed conservation: Turning science into practice. (R.D. Smith, J.B. Dickie, S.H. Linington, H.W. Pritchard and R.J. Probert, eds.). Royal Botanic Gardens, Kew, UK.