Seed Storage

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Storage may be defined as the preservation of viable seeds from the time of collection until they are required for sowing. When seed for crops can be sown immediately after collection, no storage is needed. More often it is necessary to store the seed for varying periods which may be

1. Up to one year when both seed production and crop cultivation are regular annual events, but it is necessary to await the best season for sowing.
2. 1 – 5 years or more when a species bears an abundant seed crop at intervals of several years and enough seed must be collected in a good year to cover annual crop needs in intermediate years of poor seed production.
3. Long-term storage for purposes of conserving genetic resources. The period of storage will vary according to the seed longevity of the species and the storage conditions, but will be measured in decades in species which are easy to store.

As the requirements become more exacting, the cost of storage facility per unit of seed stored increases rapidly.

Types of storage requirements. The types of storage needed can be related to the time of storage expected and can be classified into four types:

a) Storage of commercial seeds
b) Storage of carry-over seeds
c) Storage of foundation seed stocks
d) Storage for germplasm seeds

Seeds are generally categorized into the following types:

Orthodox: Seeds that can be dried, without damage, to low moisture contents, usually much lower than those they would normally achieve in nature. Their longevity increases with reductions in both moisture content and temperature over a wide range of storage environments.

Recalcitrant: Seeds that do not survive drying to any large degree, and are thus not amenable to long term storage.

Intermediate: Seeds that are more tolerant of desiccation than recalcitrants, though that tolerance is much more limited than is the case with orthodox seeds, and they generally lose viability more rapidly at low temperature.

Importance of seed storage

Seed storage is important to get adequate plant stands in addition to healthy and vigorous plants.

Purpose of Seed Storage

The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted.

Principles of seed storage

- **Drying:** Seeds should be dried before storage to remove excess water.

- **Temperature:** Seeds should be stored at cool temperatures, ideally between 32°F and 50°F (0°C to 10°C).
- **Moisture:** Seeds should be stored at low moisture levels to prevent mold, rot, and the growth of harmful microorganisms.
- **Oxygen:** Seeds should be stored in a way that restricts oxygen entry.
- **Pest control:** Seeds should be regularly monitored for insects and treated promptly to prevent contamination.
- **Mechanical damage:** Seeds should be handled carefully to avoid damage to the seed coat or embryo.
- **Quality:** Seeds should be high quality and suited to the storage period and system

Stages of seed storage

The seeds are considered to be in storage from the moment they reach physiological maturity until they germinate, or until they are thrown away because they are dead or otherwise worthless. The entire storage period can be conveniently divided into following stages.

1. Storage on plants (Physiologically maturity until harvest)
2. Harvest, until processed and stored in a warehouse.
3. In storages (Warehouses).
4. In transit (rail wagons , trucks, carts, railway sheds , etc)
5. In retail stores.
6. On the user's farm.

The seed quality, i.e germination and vigor, can be considerably affected at any of the stages mentioned above, unless sound principles involved in seed storage are practiced and the seeds properly handled.

Storage of seed on plants

Seeds are considered to be physiologically and morphologically mature when they reach maximum dry weight. At this stage dry down or dehydration of the seed is common. Dry down continues after physiological maturity until moisture content of the seed and fruit decreases to a level which permits effective and efficient harvest and threshing. This stage can be termed as harvest maturity.

The seed quality is greatly influence by prevailing environmental conditions; from the time seeds reach physiological maturity until harvest. Weathering damages are often a serious factor at this stage. As a result of weathering damages, seeds of many crops, e. g Soybean, lose their viability and vigor and are already low in germination even before they are harvested. Several factors such as soil conditions, mineral nutrient deficiencies, during plant growth, water stress, high or low temperatures, disease and insect damage, etc. may also deteriorate seed quality by reducing viability and vigor at physiological maturity.

It is, therefore, of the utmost importance, to maintain initial seed quality to the near maximum attainable, by keeping weathering and other types of damages to the minimum possible. This would mean raising a good health seed crop, early harvesting and adequate arrangements for seed drying.

Storage from harvest until processing

During the time of harvest seeds still have high moisture content. Seed deterioration can be rather rapid during this period. Transport from field to threshing floors, threshing floors to processing plants and at the processing plants, involves periods of storage during which deterioration can be rapid and serious, if the moisture content is above 13%. At moisture contents above this range, molds may grow on in the seed end heating may occur.

It is therefore, necessary to take the utmost care in handling of material after harvest. If harvesting has been done above 13% moisture content, necessary arrangements for drying / aeration, etc, of seeds

are necessary to preserve seed quality. In addition, adequate care is necessary in handling the seed materials at this stage so as to prevent mechanical mixtures and maintain lot identity.

Storage of seed in warehouse

It is customary for seed men and others interested in storage of seeds, to give primary attention to rooms or buildings labeled as seed storages. Seed ageing, and loss of germination during storage, cannot be stopped altogether, though it could be appreciably reduced by providing good storage conditions.

Factors affecting seed longevity in storage

1. Kind / variety of the seed

The seed storability is considerably influenced by the kind / variety of seeds. Some kinds are naturally short-lived, e.g. onion, soybeans, peanuts, etc. The genetic make-up of the lines/ varieties in the same kind also influences storability.

2. Initial seed quality

The seed lots having vigorous, undeteriorated seeds store longer than deteriorated lots. Depending upon the severity of damage, or degree of deterioration, e.g. extent of weathering damage, mechanical injury, flat, wrinkled or otherwise damaged seed, even seed lots of good germination, at the beginning of storage, can and do decline rapidly within a few months.

The important implication of this is that only high quality seed should be carried over. The mediocre quality seed may be retained only for the next plating seasons. The low quality seed should invariably be rejected.

3. Moisture Content

The amount of moisture in the seeds is probably the most important factor influencing seed viability during storage, over most of the moisture range, the rate of deterioration increases as the moisture content on seed storability.

Moisture content and storage life of cereal seeds at temperatures not exceeding 90° F for seeds of high germination and high vigor at start of storage.

Seed moisture content (%)	Storage life
11 to 13	½ year
10 to 12	1 year
9 to 11	2 years
8 to 10	4 years

It is important to note that very low moisture content (below 4%) may also damage seeds due to extreme desiccation. Since the life of seed and its span largely revolves around its moisture content, it is necessary to dry seeds to safe moisture contents. The safe moisture content, however, depends upon storage length, type of storage structure, kind/verity of seed, type of packaging material used.

Safe moisture content of selected seeds Crop Maximum moisture

Crop	Moisture content %
Rice	13
Millet	12
Maize	12
Sorghum	12
Pulses	9
Cowpea	9.5

4. Relative humidity and temperature during storage

Relative humidity and temperature by far are the most important factors determining the storage life of seeds. Seed attain a rather specific and characteristics moisture content when subjected to given levels of atmospheric humidity. This characteristics moisture content is referred to as equilibrium moisture content, for a particular kind of seed at a given relative humidity, tends to increase as temperature decreases and as deterioration progresses. Thus the maintenance of seed moisture content during storage is a function of relative humidity and to a lesser extent of temperature, at equilibrium moisture content, there is no net gain or loss in seed moisture content. Seed placed in an environment with a relative humidity higher or lower than that with which its moisture content is in equilibrium, will gain or lose moisture until an equilibrium is established with the new environment. In sealed storage, seed moisture content determines the relative humidity of the environment in the containers.

Establishment of moisture equilibrium in seeds is a time dependent process. It does not occur instantaneously. A period of time is required, the length of which varies with the seed kind, initial moisture content, the average relative humidity and the temperature. Under open storage conditions, seed moisture content, fluctuates with changes in relative humidity. However, normal diurnal fluctuation in relative humidity has little effect on moisture content. Table gives the equilibrium moisture content for important field and vegetable crops.

Temperature also plays an important role in life of seed, although if does not appear to be a controlling one. Within the normal range of biological activity of seeds, insect and moulds increases as temperature increases. The higher the moisture content of the seeds, the more they are adversely affected by temperature. Decreasing temperature and seed moisture, therefore, is an effective means of maintaining seed quality in storage.

Low temperatures are very effective in maintaining seed quality, even through relative humidity might be quite high. Good cold storage for seed should not exceed 60% in relative humidity.

The following simple rules put forth by Harrington are a useful guide as well as measure of the effect of moisture content, temperature and relative humidity on seed aging:

- A one percent decrease in moisture content nearly doubles storage potential of seed.
- A 10 °F decrease in temperature nearly doubles storage potential of seed
- Good seed storage is achieved when the percentage of relative humidity in storage environment and the storage temperature in degree Fahrenheit add up to one hundred but the contribution from temperature should not exceed 50 °F.

5. Effects of fluctuating environment conditions on viability

There have been a few reports to the effect that fluctuating conditions are harmful, however, at present there is not a priori reason to suppose that change in temperature, or moisture content , would in itself be deterious save, possibly , for very rapid changes in seed moisture content.

6. Oxygen pressure

Recent researches on the role of a gaseous environment on seed viability indicate that increases in pressure of oxygen tend to decreases the period of viability.

7. Other Factors

Factors besides those discussed above that affect storage life are the direct sunlight on the seed, number of times and kind of fumigation, effect of seed treatment, etc.

General Principles of Seed Storage

In view of the various factors affecting seed viability in storage, the following principles emerge as necessary for good storage.

a) Seed storage condition should be dry and cool.

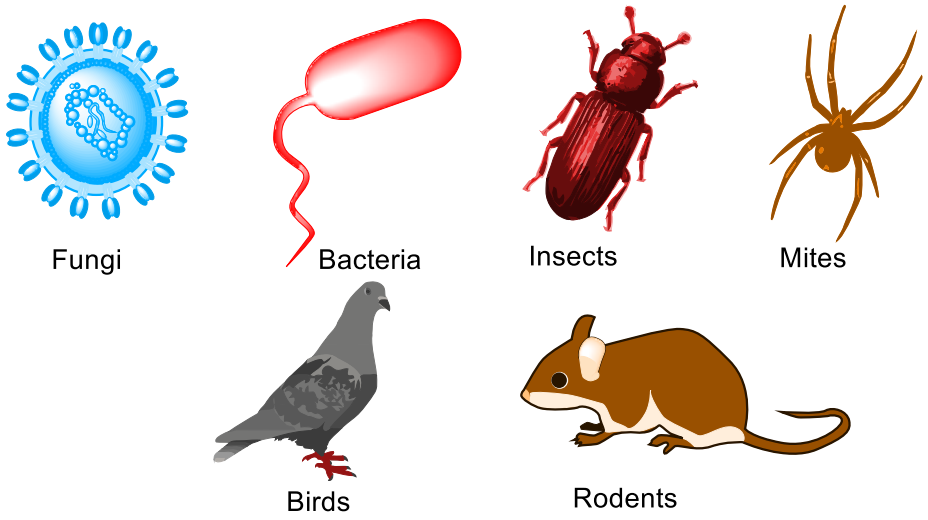
b) Effective storage pest control.
c) Proper sanitation in seed stores.
d) Before placing seeds into storage they should be dried to safe moisture limits, appropriate for the storage system.
e) Storing of high quality seed only, i.e well cleaned, treated as well as of high germination with vigor and good pre-storage history.
f) Determine seed storage needs in view of period or length of storage time, and prevailing climate of the area during storage period.

Construction features for good seed warehouse

a) Warehouse should have no windows and have only one door constructed of metal which can be sealed properly and locked.
b) The material used for construction may be stone, concrete, brick, metal or wood. Regardless of the material, the foundation should be made of stone or concrete and should extend 90 cm above the ground level.
c) The floor must be paved and any cracks that may develop must be repaired.
d) Construction of the floor, walls and ceiling of the storage should be such that no cracks exist which can harbor insects. All cracks around openings, e.g Electric conduits, ventilation openings, and doors should be thoroughly sealed.
e) Ventilation openings should be screened against birds and insects.

Effect of storage condition on the activity of organisms associated with seeds in storage

There are six main types of organism associated with seeds in storage, namely



Measures for pest and disease control

Sanitation

Good sanitation in the seed store is necessary for protection from insects and rodents. All spilled seeds or floor sweepings should be immediately removed. Discarded seed and cleanings should be carried away, not just dumped outside the door and left to harbor storage insects. In addition to cleanings, the floor and walls should be sprayed with a residual insecticide as often as required. In a well – maintained store, spraying once a year may be quite satisfactory. The recommended materials and rates are DDT 50 WP @ 1 to 2 g m^{-2} , Malathion 25 WP @ 1.25 g m^{-2}. Malathion should not be used on such surface as brick, cement and concrete.

Seed treatment

An insecticide combined with a fungicide may be applied as a protectant. The most commonly used insecticide is DDT. DDT also has the advantage of long duration.

Fumigation

Once the seed storage is completely free of insects, the most serious source of reinfestation is infested seed which is brought in seed may be brought from the field already infested, or it may be transferred from an infested storage. Such infestation is controlled by fumigation. Rather than fumigating the whole storage, it is better to have a fumigation room, or to fumigate the seed on a concrete floor under a tarpaulin before it enters the main storage room. The fumigation room should have its own door to the outside, and only after fumigation, should the seed be brought in to storage area.

Fumigation is effective only in gas-tight storage. Numerous effective fumigants are available. However, there is a small safety margin between the dose that is toxic to insects and a dose that will cause loss of germination or vigor of seed. Reasonably safe fumigants at temperatures below 30 °C and seed moisture below 12% are the following.

Dosage	Exposure period
Methyl Bromide @ 16 to 32 mg m^{-3}	24 hours
Hydrogen cyanide @ 32 to 64 mg $^{-3}$	24 hours
Hydrogen Phosphide 5-10 tablets per ton (Phostoxin, Phosphine)	3-7 days

Seed Moisture Content

To prevent damage from storage fungi, it is best to store seeds which have been well-dried to safe moisture content limits.

Temperature control in seed storage

As mentioned earlier, temperature is one of the most important environmental factors, which influence seed viability and vigor during storage, the lower the temperature, the longer the seeds maintain germination capacity, thus temperature control is an important consideration in building a seed storage.

Temperature control may be achieved in one of the following ways:

1. Ventilation
2. Insulation
3. Refrigeration

These methods are not mutually exclusive, and normally used to supplement each other.

Ventilation:

Ventilation could be used to reduce seed temperature and seed moisture content, if used judiciously. In addition, it also helps prevent hot spots from developing, the formation of convection air currents; and maintenance of uniform seed moisture content and temperature.

Time of ventilation

Whenever the outside temperature of air and relative humidity are low enough to benefit the seeds, either by reducing seed temperature or seed moisture content, the ventilating fans (exhaust fans) can be turned on.

Precautions to be taken during ventilation:

- The moisture content of the seed should not be allowed to increase to a value in equilibrium with air relative humidity above 65%
- The seed temperature should not increase above 33 °C for more than few hours.

Insulation

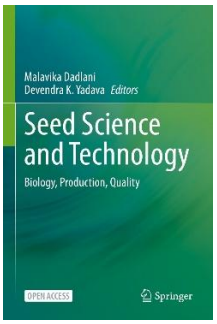
Insulation of seed storage is done to reduce the flow of heat from the warmer exterior , through the walls , roof, floor of the storage to the cooler air and seeds in storage. Heat flow depends upon:

1. Temperature difference between the two places in the material. Heat flow is twice as fast with a 20° temperature differences as with a 10° C difference.
2. Distance the heat must flow. Heat flows twice as fast through one inch of insulation as through two inches of the same material.

Refrigeration

The basic objective of refrigeration is to keep the storage temperature below the usual ambient temperatures. An alternative to refrigeration is storing the seeds dry, either by using dehumidification or by drying and storing in sealed containers. Refrigeration often becomes necessary for carry-over seeds, special kind of seeds, foundation seed and nucleus seed/ breeder seed.

Suggested reading:



Seed Science and Technology: Biology, Production, Quality
By Malavika Dadlani, Devendra K. Yadava (Eds)
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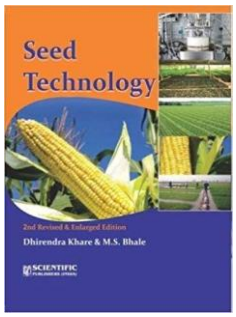
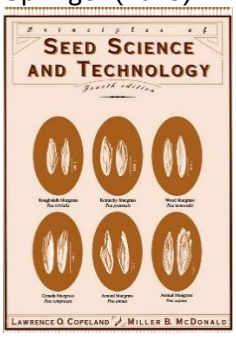


Seed Technology
By D Khare
Scientific Publishers India (2014)



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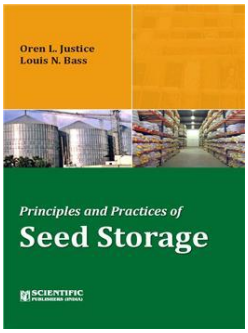
by Lawrence O. Copeland and Miller F. McDonald
Springer (2001)



Principles and Practices of Seed Storage
By O.L. Justice & L.N. Bass
Scientific Publishers (2021)