Lesson 41. Storage of Seeds

41.1 Introduction

Seed storage is a special form of crop storage in which the factors affecting viability must be carefully controlled. The post harvest treatments of seed, including harvesting, threshing, drying etc. have an important influence upon the maintenance of viability in storage. The viability and percentage germination of seeds may be affected by a number of separate but interacting factors during storage, including moisture content, relative humidity, temperature, breakage, gaseous atmosphere and chemical treatment. Seeds begin to age before harvest while still on the plant, from the point in time when physiological maturity is reached. From then onwards it is possible to slow down the aging process of seeds which accompanies or is followed by a fall in germination.

41.2 Breakage of Seeds:

Seeds can become damaged in several ways during harvesting, threshing and subsequent mechanical handling. The nature of the damage varies; the more intensive. Injuries may result in an immediate loss in viability, whereas those less serious may only become important during the subsequent storage period. Dry seeds are more liable to fracturing and moist seeds are likely to bruise. A common cause of breakage at harvesting (while combining) or during threshing is the use of too high a cylinder speed. Breakage increases as the moisture content decreases by field drying. Harvesting or threshing by machine can be more injurious to seeds than the use of manual methods, provided threshing by hand beating is not resorted to. Breakage can also be caused by traditional methods such as treading by bullocks, threshing by Olpad thresher, striking against bard surface etc.

Broken grains are more readily attacked by storage fungi. The higher the percentage of damage, the greater is the number of abnormal or diseased seedlings generally produced. Broken or cracked seeds are more readily attacked by certain types of insect pests such as the scavenging beetle which is usually unable to penetrate whole sound seeds. Seeds of high initial viability store better than those of lower initial viability.

41.3 Prerequisites for Safe Storage:

In general, the life of the seed during storage revolves around its moisture content, storage temperature and humidity. However, the processed seed has better storability. The rate of deterioration of crop seeds increases as respiration goes up with high moisture content. The effect of seed moisture content has been generalized as follows as presented below in table 41.1:

Table 41.1: Effect of moisture on the seeds

Moisture	**Effect on seed**
6-10%	Safe for sealed storage. No pest activity
12-14 %	Fungi, bacteria and insects grow
18-20 %	Heating occurs unless aerated
45-50 %	Germination occurs

Utmost care should be exercised in drying seeds to a safe limit and good storage should not allow further absorption of moisture.

The safe drying temperatures for seeds are as presented below in table 41.2.

Table 41.2: Safe drying temperatures for seeds

Seed moisture range	**Drying temperature**
Over 22 % 18--22 % 10-18 % Under 10 %	55°C 40 ^{0}C 40°C 40 °C

In open-storage conditions, moisture content fluctuates with changes in relative humidities. Once a state of equilibrium has been reached, further exchange of moisture will not take place as long as the storage atmosphere moisture is stable. For few selected seeds the equilibrium moisture content at 25 °C and at different relative humidity values are shown below in table 41.3.

Table 41.3: Equilibrium moisture content at 25 °C

Crop	**Relative humidity**	
	30%	**63%**
Pearl millet Maize Peas Soybean Sorghum Wheat	8·5 8·4 8·6 6·5 8·6 8·6	12·0 12·9 11·9 9·3 12·0 11·6

Hence, from the above figures, it is clear that under controlled storage conditions, seeds must be dried to proper level to coincide with the storage atmosphere. Seeds of most grains will store well for about a year at moisture contents of 11-13 % under reasonable storage temperatures. For two years storage, the moisture content should be decreased to 10 %. Oily seeds such as soybeans, ground-nut etc. require moisture contents below 8-10 % for storage upto 12 months. For storage periods over 1 year, both the temperature and moisture content have to be decreased.

41.4 Influence of Moisture Content, Relative Humidity, Temperature and Storage Fungi on Stored Seeds

Of all the factors which affect the viability of seeds during storage, moisture content is probably the most important. If seeds are adequately dried, the storage temperature assumes less importance. The principal reason that moisture content is so important is because it will establish

a relative humidity in the air surrounding the seeds which may support the growth of storage fungi. Storage fungi are likely to be one of the main causes of loss of viability of seeds in store. Seeds free of storage moulds do not loose their viability despite storage at moisture contents higher than that considered to be safe for long term storage. At very low moisture contents, the structure of the cell membrane may be destroyed; such damage is generally attributed to lipid intoxication. Being hygroscopic, seeds enter into equilibrium with the relative humidity of the surrounding air. The moisture content at which a particular type of seed is in equilibrium will depend upon the percentage of the hygroscopic material in the seed and upon the seed temperature. For each of the common fungi invading stored products there is minimum moisture content below which they are unable to grow. The most drought resistant of the storage fungi Aspergillus Restrictus, is unable to grow when the moisture content is below that in equilibrium with a Relative humidity of about 65%. Any seed below this moisture content should be safe from invasion by storage moulds. This moisture content is often referred to as the critical moisture content level. For cereals it is between 12·5 and 13·5 % and for oilseeds between 5 and 9 % at 20-25 °C temperature. Storage fungi affecting seeds grow most rapidly at 30--32 °C, but their growth rate decrease with decrease of temperature. The levels of temperature experience during storage in the tropics and subtropics are, therefore, favourable for the attack of seeds by fungi.

Reduction of storage temperature to an extent beneficial to the maintenance of viability of seeds under tropical conditions is costly. However, it may be desirable to provide a small cold room for the storage of breeders' valuable seed on experimental stations and large commercial farms. Where it is not possible to control the temperature of the stored seeds, greater attention must be given to the control of moisture content by reduction to a level at which the seeds are safe from attack by storage fungi. The level will be dependent upon the temperature and the length of the storage period. In areas of very high temperature, or where the storage period is long, the moisture contents for the maintenance of maximum viability will need to be lower than

in cooler areas or where the storage period is short. Most seeds will maintain the initial viability by storage or below a moisture content at which they are safe from invasion by storage fungi.

41.4.1 Temperature:

Temperature is important during the drying of seeds, particularly if the use of artificially heated air becomes necessary. Seeds are heat sensitive and heating to too high temperature may spoil the germinating properties. There is no definite agreement among the scientists to what is the maximum safe temperature for drying seeds. It has been reported that there are dangers in sun-drying in some parts of the world including India.

41.4.2 Atmospheric Gases:

There is conflicting evidence on the effect of gaseous environment on the viability of stored grains. At high moisture contents in sealed containers, seed viability is affected by the moisture contents and temperature. Viability of the seeds having moisture contents less than 14 % at 15°C temperature was not affected. In heavily infested wheat in a silo, the oxygen concentration fell to 2·2 % within 5 days (1). Germination of the grain fell also, presumably due to lack of oxygen. Sorghum at 10 % moisture content has been stored for 30 months in sealed metal drum with no appreciable fall in germination. Wheat stored at 7 % moisture content in a specially designed steel drum capable of holding 1'/2 tonnes of grain, showed only a 1--2 % decrease in viability after 8 months storage (l). Storage experiments with seeds using polyethylene bag (1/4 mm or 1/8 mm thickness) will remain at or near its initial germination level, for periods of several years. The experiments also indicated that at moisture contents above the critical level, loss of germination during storage was greater in polyethylene bags than in cotton or gunny bags. The hermetic storage of cereals and legumes in laminated plastic packs placed under water or underground has been examined in Japan in comparison with storage in air or in a CO_2 enriched atmosphere, using soybeans, wheat, barley and paddy at moisture contents of 11-14 %. Over one year storage period, the seeds stored under water and underground retained high viability whereas samples stored under normal open conditions declined steadily in viability during the corresponding period. In an experiment carried out under constant temperature, moisture content and gaseous constituents of storage environment, barley, peas and broad beans indicated the decrease in viability by the presence of oxygen. The effect of oxygen was most pronounced where the viability was lost most rapidly, irrespective of whether the rapid loss was caused primarily by high moisture content or high temperature. The most deleterious effect was when oxygen was increased from the level of 0 % to 21 % of the atmosphere. An increase beyond this upto 100 % had little or no further effect on viability. Seeds stored under identical conditions but in different gaseous atmospheres indicated that in oxygen the germination was 3 % that in air 36 % the seed stored in carbon dioxide, in nitrogen and in argon germinated 80, 75 and 79 %, respectively. These results also confirmed that the absence of oxygen is beneficial to the retention of viability of seeds during storage.

41.4.3 Chemicals:

The established contact insecticides DDT, Pyrethrins, Lindane and Malathion have been used on seeds throughout the world and they are generally regarded as having little effect upon seed viability. The harmful effects of Lindane are recorded, especially when the insecticide is applied in high degree rates. Wheat lost viability after four months storage when treated with Lindane at 467 ppm. Inert dusts are occasionally employed as insecticides, being directly admixed with grains. These dusts have no effect upon germination.

41.4.4 Fumigants:

Fumigants are widely used for the control of insect pests in stored products, including seeds. The most common fumigants used for protecting seeds are methyl bromide and phosphine. Increasing concentration and exposure time progressively lower seed viability, especially at high moisture content. At seed moisture of 11-12 %, germination of maize seed was affected and increasingly so by repeated fumigation. In addition the yield of the crop from treated seed was very much lowered by methyl bromide. Phosphine is widely reported to have little or no effect on seed viability.

Of the other fumigants which might be used to treat seeds, hydrogen cyanide is non-injurious, especially for cereal and small legume seeds that have been properly, dried. As reported by a few research workers, carbon disulphide did not affect the viability of dry seeds, but reduced the viability of moist seeds. No reduction in germination upon seeds of wheat, barley, maize, paddy, bean and peas were observed by the application of ethylene dibromide. Seeds of high oil content require rapid post-fumigation airing to prevent the residual ethylene dibromide from affecting the germination. However, the adverse effects of ethylene dibromide on the viability of high moisture cereal seeds at temperatures above 27°C have been reported by researchers.

41.4.5 Insects Pests:

It has been reported in literature that at temperature below 10°C and 40 % relative humidity (8 % moisture content in cereals) insects will not be active, However, in tropical area, temperatures are likely to be well above 10 °C and, therefore, unless the moisture content of untreated stored seeds is kept at a low level, insects pests can cause considerable damage. The insects affect the seeds in the following manner:

1. The storage environment may be altered by the presence of insects so as to increase the temperature and alter the moisture content of the seed.
2. Seed embryos may be damaged or killed by the feeding of adults or larvae;
3. Insects may introduce fungi which are harmful to seeds;
4. Webs may spun or cocoons constructed necessitating cleaning with some loss of seed;
5. Control measures taken against insects may cause lowering of seed viability.

Seeds that are damaged by insects are less likely to germinate and to produce sound healthy plants than undamaged ones. The evidence shows that even if the embryo remains undamaged, insects frequently destroy sufficient quantity of the endosperm or cotyledon so that the seeds which do germinate, fail to become established and die or become distorted. Insect pests, such as maize weevil (sitophilus zeamais*)*, can infest the growing crop in tropical countries and are brought into store at harvest where the insect persists. Seeds already damaged by such primary insect pests are liable to infestation by secondary feeders such as *Tribolium castaneum*, Timely control of primary pests at harvest time will reduce the likelihood of infestation by secondary feeders.

41.5 Seed Dressings:

Chemicals, usually referred to as dressings are applied to seeds for protection against fungal or insect pests in the soil after planting. Seed dressings are frequently applied just before planting, but in some circumstances, especially when the seed remains already dressed, the application may be necessary sometimes before planting and possibly early in the storage period. Manufacturers in some instances recommend that dressing be applied only to seeds that are below certain moisture content. It has been reported that some seeds may be killed by early application of seed dressing, due to the uneven distribution of the chemicals frequently encountered. Some of the workers have observed that the rapid deterioration in storage of mercury treated wheat was, however, linked with those seeds having seed coat damage. Treated seeds without damaged seed coat showed about 95 % germination.

41.6 Predicting Loss of Viability in Storage

On the basis of the data collected regarding the loss of viability in storage as a function of moisture content, temperature, and time, charts, nomographs, or equations can be developed. Harirngton developed the following two relationships:

(i) For seeds between 5 and 14 % moisture content, the length of time in storage before seed viability significantly declines is double for every 10 % reduction in seed moisture content.

(ii) For every 5°C reduction in storage temperature. The length of time before the seed viability declines significantly is doubled.

Hukill derived the following relationship between viability of seeds and the moisture content, temperature and storage period.

For soybean,

$$\text{Age Index} = P \times (100^{0.143}\,MC)\,(10^{0.645T}) \quad \text{..... (1)}$$

Where, P = Length of Storage period, months,

Me = Moisture content, per cent

T = Temperature, °C

The age index must attain a certain value before the germination of the seed begins to decline. Different equations can be developed for different kinds of seeds.

References:

1. K.M Sahay and K.K.Singh. Unit Operations of Agricultural Processing, Vikas Publishing House Pvt Ltd.

2. Michael, AM and Ojha, T.P. Principles of Agricultural Engineering (Vol-I), Ed. Jain Brothers, New Delhi.