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Review on Seed Process and Storage Condition in Relation to Seed Moisture and Ecological Factor

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Abstract
Seed processing is to achieve clean, pure seeds of high physiological quality (germinability) which can be stored and easily handled during succeeding processes, such as pretreatment, transport and sowing. Seed storage serve as a buffer between demand and production and has a regular turn over stores for conservation of genetic resources in addition to maintain the viability of the seed at the highest level possible after storage period. The two most important factors affecting seed longevity are seed moisture content and seed temperature. As a general rule, each 1% reduction in seed moisture doubles the life of the seeds. To protect from premature germination and seed pests, seeds should be dried as quickly as possible to less than 14% seed moisture and should be stored below this moisture content at all times.
Keywords: seed, seed processing, storage, treatment

1. Introduction
Botanically, seed is a fertile and ripened ovule which contains an embryonic plant usually supplied with food storage tissue, and surrounded by a protective coat (Ellis et al, 1985). However, physiologically, seed is the organ for propagating plant species. Seed being a living organism, respires by absorbing oxygen and giving off carbon dioxide and water vapour and producing heat at the same time. These phenomena play a major role in the preservation of seeds, (Jean, 1987).The seed is a very important element in the quality of seedlings produced in the nursery since the quality of the seedling is determined by the genotype of the seed from which it originates. Hence, to produce high quality crop one has to sow high quality seeds and have to maintain the quality of that seed from harvest till it is germinate (Feistritzer, 1975).

Seed processing is the normal sequence of operations included in the processing of seed after its harvest include threshing, drying to optimum moisture level for storage, cleaning and grading, testing for purity and germination, treating for storage pests and seed borne diseases, bagging , labeling and distributing. This because of Seed is almost never pure as it comes from the field and is mixed with weed seeds, trash, chaffs, leaves, other crop seeds, insects and small seeds etc. Seeds are also often harvested at higher moisture content than that recommended for storage. Therefore, the seed must be free from inert matter, weed seeds, seeds of other variety of the same crop, have safe moisture content, high germination and vigor and be relatively free of damage and diseases. The seed must also be treated, bagged and labeled (Schmidt, 2000).

People may think that seed storage is equivalent to placing seeds in storage, but what is more important is how the seed and its internal biological-physiological-biochemical process function and interact with its surrounding environment. In reality, if we pay attention to the way the seeds function, seed storage actually starts in the field (Hartmann etal.1997). It starts when the seeds have reached physiological maturity, because after that moment, the seed does not receive the full protection of the mother plant any more. Rather, starting in that physiological point, the seed depends on the external environment in terms of moisture, temperature, even biotic pressures. So the environmental conditions during seed maturation and threshing have high impact in the seed viability and the storage potential of the seed (McCormark, 2004). This is why, the location where the seeds are produced have a high impact not only in yield, but also in seed moisture management and overall quality in terms of viability, germinability, seed health, vigor and even plant performance according to(Elias *et al*., 2016).

The purpose of seed storage is to preserve planting stocks from one season to the next. In some cases (e.g. seed companies) the objective of seed storage is to maintain seed quality for the longest duration possible. In addition, seed storage enables the maintenance of germplasm over time for improved plant breeding program. The seed should be harvested when it reaches harvest maturity, dried to safe moisture content, cleaned and stored under favorable conditions, and protected from damage and pests until planted. The most important factors affecting storability are the type of seed crop, moisture content, storage conditions (temperature, relative humidity) and storage pests(Babiker, 2015).

Generally seed processing includes a number of handling procedures that important to achieve clean, pure seeds of high physiological quality (germinability) which can be stored and easily handled during succeeding processes, such as pre -treatment, transport and sowing, where applicability differs depending on seed type, condition of the seeds at collection and potential storage period. Storage conditions are critical in order to maintain seed viability over an extended period of time. The objective of this study is to review the seed process and storage condition with in relation to seed moisture as well as ecological factors (**Desai, 2004)**.

2. Literature Review

2.1. Seed Processing

Seeds often require cleaning and dewinging, removing dirt, leaves, stems and chaff from the seeds to reduce the bulk for handling and storage, remove moist, material that may cause heating and mold formation in storage, and facilitate flow through seeding equipment (Schmidt, 2000). Seed processing mainly consists of seed drying, cleaning, pesticide treatment, packaging and storage under closely integrated control. All these operations like cleaning, grading, and treatment are must be carried out without mixing or damaging the seed. The sequence of operations depend on the kind of seed, its initial quality, type of the contaminants present and seed moisture content(**Desai, 2004)**.

2.1.1. Seed Drying.

Seed-drying is the reduction of seed moisture content to recommended levels for storage using techniques that are not detrimental to seed viability. Freshly harvested seeds can have high moisture contents, which promote respiration and growth of seed embryos, insects and fungi. Seeds must therefore be dried to a safe moisture content to prevent damage, heating and infestation during storage (Rao *et al*. 2006).

The moisture content in seeds varies according to their grain type, chemical composition, moisture at harvest, harvesting methods, relative humidity of the atmosphere, and seasonal fluctuations. Seed drying should reduce the moisture content to safe limits to maintain its viability and vigor during storage, which may otherwise deteriorate quickly due to mold growth, heating and enhanced microbial activity. Seed drying also permits early harvesting, and long term storage of seeds (McCormack, 2004).

The rate at which a seed dries is a function of how fast the moisture evaporates from its surface. This in turn depends on the temperature and relative humidity of the drying air, and the rate at which moisture moves from inside the seed to the seed surface. Drying air temperatures of up to 45 ^{o}C are generally safe. There is a relationship between safe drying temperature and initial seed moisture content. The general recommendation for field crops is to dry the seed at temperature of no more than 40, 37 and 32^{0}C for moisture contents of not more than 18%, 10-18% and less than 10% moisture, respectively. Although drying seed may be necessary to preserve its viability in storage, there are potential dangers associated with the drying process. Seed viability is decreased by drying at temperature above 40^{0}C. If drying is too rapid, there is a tendency for the seed coat to split or harden which may prevent the interior of the seed from drying. Any loss of additional weight by prolonged drying is also associated with extra cost to the farmers. It is very important that after drying the seed is cooled by forced ventilation before it is stored. Maximum moisture content for safe storage of seeds of some crops is 10-14% (Rao *et al.*2006).

There are two types of drying according to (McCormark, 2004).

1. Natural sun drying: In natural drying, the atmospheric air moves naturally around damp seed on floors or on the fields. Farmers traditionally dry small quantities of seed, utilizing the sun and natural wind, by spreading the threshed seed in a thin layer on a smooth floor or on straw matting. Sun drying requires no additional expenditure or special requirements. The major limitations of sun drying are delayed harvest, risk of weather damage, and the possibility of mechanical admixtures. Direct sun light also can adversely affect seed germinability owing high temperatures and ultraviolet radiation, especially if the moisture content of the seed is high. Prolonged exposure of seed to direct sun must be avoided.

2. Artificial drying (Forced air drying): also known as dehydration uses heated or unheated air that is forced mechanically through a drier. In forced air drying, natural air or air supplemented with heat is blown through a layer of seed until drying is completed. Two types of driers are used: batch driers and continuous flow driers.

a. Batch driers: in a batch drier, relatively dry air is blown through a layer of seed until the seed is dried completely, after which it is removed and replaced by another batch of seed. The method is simple and well suited to small quantities of seed.

b. Continuous flow driers: in this type of drier, the seed moves horizontally or vertically through a stream of hot air and then in to a cooling chamber. It is a continuous drying process on a factory scale suitable to handle large quantities of seed. It can use air temperatures higher than those of batch driers, because the seed is heated for a much shorter time.

2.1.2. Seed Cleaning

Seed as it comes from the field is often mixed with impurities (seeds of weeds, and other plants, plant debris, soil and stones), which must be separated to obtain pure live crop seeds for replanting. Cleaning includes the removal of inert matter, seed of weeds, other crops, other varieties and seeds of the same variety which are shriveled, damaged, deteriorated or diseased, to improve and upgrade seed quality (Rao etal,2006).Traditionally, winnowing follows threshing, to remove chaff, straw and other light materials from the seed. Hand cleaning using sieves to remove seeds of different sizes and heavier materials (stones, soils) then follows according to (Schmidt, 2000).

Cleaning thus reduces the bulk to be handled and stored and removes moist and green plant material that may cause heating in storage. Each crop requires a different set of machines and sequences where a combination of machines is used. Cleaning usually requires a succession of operations, which can be regarded as proceeding in three stages: conditioning or pre-cleaning, basic cleaning and grading.

a. Pre-cleaning or scalping: is partial cleaning and the main cleaning operation occurs later when the seed has been dried and stored for some time. It is the removal of material coarse enough to be easily separated by screens. The twig fragments are very difficult to separate from the seed during the subsequent cleaning operation (Marcar *et al*., 1995). During processing, seeds first go through a pre-cleaning operation. Pre-cleaning process consisting essentially of an air blast and large meshed screens or cylinders to remove the most bulky material and the rubbish most liable to choke up conveyers and sieves. Thus, the purpose of scalping is to facilitate movement of the seed through the machine in subsequent cleaning operations. Vibrating screens or revolving cylinders allow the seed size particles to pass through, retaining chaff, pods, stem, leaves and any other large sized particles, which are shaken off to the side.

b. Basic or secondary cleaning: basic cleaning is a second stage of cleaning carried out with air blasts and vibrating screens and is applicable to all kind of seeds. It is essentially the same as scalping but more refined, carrying the cleaning processes a stage further. Basic cleaning is performed mostly by a machine known as air/screen cleaner. The air blast removes lighter material and a series of screens separate particles larger and smaller than the crop seed, which may be seeds of weeds or other crops or broken seeds. After the basic cleaning operation removes most of the impurities that can be removed by a simple combination of air blast and screens, some seed lots require further cleaning treatment to remove adulterants that have remained too close to the pure seed in size and shape to be separated by air/screen cleaner. Grading can be introduced at this stage by including screens that can separate seeds on the basis of their size.

c. Seed Grading: Grading consists of removal of cracked, damaged, or defective seeds, which may have reduced germinability and vigor(Harty,1980). Sizing is the operation of removing seeds larger or smaller than the required size using special machines. The objective of seed grading is to produce even-sized and uniformly shaped seed for ease of mechanical planting. It also improves the appearance of processed seed which increase sales appeal. Most seed cleaning machines simultaneously grade the seed into first grade, second grade, etc, based on uniform size and shape. Mechanized planting requires seed of a uniform size, which can be obtained by more precise sizing and grading techniques according to (Creemer etal., 1990).

Cleaning methods divided into two depending on the types of crops according to (McCormack, 2004).

i. **Wet cleaning** - Plants which carry seeds in their moist flesh can be cleaned by this method. Seeds scooped from the flesh of a ripened fruit should be collected in a vessel and rubbed vigorously with coarse sand to remove flesh around the seeds. Then seeds are taken in a sieve and washed repeatedly under running water to remove the bits and pieces of flesh and mucilage. After such cleaning seeds should be dried for 10 days before storage. E.g. Coffee, Fruit trees, Cucumber, Tomato etc.

ii. **Dry cleaning** - This method is used for the matured seeds in a dry capsule / pod. Either the dry pods can be harvested individually or the whole plant with the pod is pulled out and shade dried, threshed for the collection of seeds. After threshing seeds are gently crushed or rolled and winnowed before storing. E.g. most cereals, Paddy, Millets, Oilseeds etc.

2.1.3. Seed Treatment

It is commonly refers to the application of pesticides (fungicides, insecticides, or a combination of both) to seeds to disinfect and disinfest them from various seed born and soil born pathogenic organisms and storage insect pests. It is the process of applying chemical substances to seeds in order to reduce, control or repel seed borne, soil born, or air born organisms. After cleaning, seed must be treated for several different purposes such as:

1. Seed disinfection, disinfestations to combat seed born diseases and insect pests.
2. Protection of seeds against diseases and insect pests that may be present in soil or be air born when seedlings emerge.
3. Specialized seed treatments such as seed coating, pelleting, scarification, to protect seeds against pests or aid in germination. Seed treatment increases germination, seedling growth, dry matter production, and vigor index (Babiker, 2015).

Disinfection: refers to the eradication of fungal spores established within the seed coat or the inner tissues.

Disinfestation: refers to destruction of surface organisms (fungi, bacteria, and insects) that have contaminated but not infected the seed surface. Simple chemical dips, soaks and fungicides applied as dust, slurry, or liquid have been found to be quite satisfactory for this purpose.

Seed treatments are used to prevent or reduce losses from diseases caused by organisms associated with seed or present in the soil. The pathogens may be present in or on seeds. There are three seed treatment methods: mechanical, physical and chemical methods (Schmidt, 2000).

a. Mechanical methods: are designed to remove infectious materials mixed with seeds. Seeds can be mechanically cleaned before seedling to remove most pathogenic organisms from the seed surface.

Mechanically treated seed is not completely free from pathogens and requires further treatment.

b. Physical methods: are used primarily to kill pathogens rooted deep in to the seeds. Physical methods include hot water and soak water treatments and ultraviolet, infrared, x-ray and other types of irradiation. However, only the hot water and water soak treatments are more practical. Physical methods, however, do not protect seeds against soil born organisms; they are effective only against pathogens present on or in the seeds.

The hot water treatment requires adequate supplies of steam or hot water, accurate thermometer, water tanks, and drying facilities. The use of this method has been restricted mostly on disinfecting small seed lots and batches of small seed crops that require low seeding rates. Water soak methods are safer than the traditional hot water treatments. These are effective to control loose smuts of wheat and barley and other pathogens.

c. Chemical methods: Chemical methods of seed treatment are the most commonly used means of treating seeds because of their effectiveness and ease of handing. Several excellent chemicals are available for seed treatment. The recommended dosages vary with the chemical, the crop, the length of storage period after treatment, and the method of application

Chemical seed treatment is applied to protect stored seed through the distribution chain and during the early stages of crop growth. Seed dressing is a more general used term and includes insecticide/fungicide treatment, pelleting, priming and rhizobium inoculation. Pests and diseases can also attack the seed in the storage and in the field. A seed dressing of pesticide, bird repellent and fungicides, therefore, may be useful. Insecticidal and fungicidal seed dressings should act against seed-borne diseases, storage pests and fungi, and soil-borne pests and diseases that attack the seedling and the plant in the later growth stages.

2.1.4. Seed Packaging

After seeds are dried, cleaned, and treated with suitable chemicals, they must be packaged in containers specifying their net weight. Packaging is the last operation of the seed-processing line, in which seed are packed into bags of uniform size. Proper packaging is important for safe handling, storage, marketing and distribution. Packing consists of the following operations:

- ✓ Filling of seed bags to the specified weight and placing leaflets in the seed bags regarding improved cultural practices pertaining to the cultivar.
- ✓ Attaching labels and seed-certification tags to the seed bags and sewing of the bags
- ✓ Transportation or storage of the bags.

Packaging can minimize the seed damage depending on the material used. Use of proper packaging material contributes to minimizing quantitative and qualitative losses. In recent years, polypropylene bags are becoming standard packaging materials for seed. Availability of different bag sizes enables the packaging of seed in quantities desired by farmers. Attractive packaging plays a crucial role in product promotion and marketing. Packaging materials commonly made from jute, hemp, sisal, cotton and paper and sometimes from polythene, aluminum foil and laminated fibers (**Desai, 2004)**.

Packaging materials designed to protect most physical qualities of seeds, such as weight, size, color, moisture content, and purity (freedom from weeds, inert matter, and disease organisms and damage), as well as their physiological aspects, like viability, vigor, and dormancy, are made up of materials that have sufficient tensile strength, bursting strength, and tearing resistance to withstand normal pressures and handling procedures. Such materials do not normally protect seeds against insects, rodents, or changes in moisture unless special protective qualities are built into them.

2.1.5. Seed Labeling

The seed is often properly packaged in attractive containers, labeled with necessary information regarding quality, and sealed before marketing to the users. Filled seed packages must be labeled appropriately to show the species, variety, grade and lot number, percentage of live seed, purity, content of noxious weeds, and seed treatment if any. All this information may be printed on a tag attached to the bag or on a label that is glued to the container. It may also be printed or stamped directly on the container. A packaging bag of any suitable material should also be regarded as a means of promoting sales, and the minimum amount of information, as required by law, should be supplemented by a bold distinctive design and, for high-technology cultivars, some advice on cultural methods **(Desai, 2004).**

2.2. Seed storage condition.

Seeds can be divided into two groups with regard to storage (Hartmann etal.1997).one group are those which can be dried to low moisture contents and stored at low temperature without damage and their longevity in storage is increased by so doing, seeds of this group are called orthodox seeds (e.g. all arable crops and many small-seeded tree species produced orthodox seeds). The other group includes those seeds which cannot be dried without damage, because they cannot be dried, and therefore cannot be stored at sub-zero temperature with freezing, seeds of this group are called recalcitrant seeds (many tropical examples also show chilling injury). Consequently recalcitrant species cannot be stored under the conditions recommended by International Plant Genetic Resource Institute (IPGRI) for long-term storage. No methods are presently available for the medium or long-term storage of recalcitrant seeds. E.g. Seeds of coca, rubber and many of the woody species which produce large seeds (Ellis *et al*, 1985)).

2.2.1. Seed moisture relationship.

Seed moisture content (SMC) is the amount of water in a seed. Water is present both in free form and bound to chemical compounds in cells such as carbohydrates and protein. It is expressed in terms of the weight of water contained in a seed as a percentage of the total weight of the seed before drying, known as the wet-weight (wb) or fresh-weight basis (International Seed-Testing Association [ISTA], 2005). SMC (% wb) = wet weight – dry weight over wet weight x 100 Moisture content can also be expressed on a dry weight basis (db)—that is, the loss in weight as a percentage of the dry weight of the seeds. SMC (% db) = wet weight – dry weight over dry weight x 100 (Rao et al., 2006)

On the study of the relationship between moisture and seed, Copeland (1976) revealed that the state of water in the seed is recognized as: -

Bound water: This is tightly held to ionic groups like amino or carboxyl group. It is in a monolayer around the large molecules.

Adsorbed water: sometimes known as bulk water, which is held loosely by bonding to hydroxyl and amino group in multilayer above the monolayer of the bound water.

Free water: - It is the capillary or solution water held only by capillary force. As the plant seeds are hygroscopic, their moisture content comes to equilibrium with the environment relative humidity

2.2.2. Types of Seed Storage

There are four principal types of seed storage: conditioned storage, cryogenic storage, hermetic storage, and containerized storage according to (Copeland and McDonald, 1995).

1. Conditioned Storage

Seeds of most species can be safely stored for several years by careful control of temperature and relative humidity. Although such conditions are too costly for most agricultural seed lots, they may be extremely valuable for preserving germplasm and certain high value seed stocks. Conditioned storage involves placing seeds in a dry and cool environment for extended periods. Under long term storage seed viability is harmed by a high oxygen atmosphere and benefited by a high carbon-dioxide atmosphere. Seeds of most grain crops (maize, wheat, barley, sorghum) will maintain satisfactory germination and vigor for about one year at moisture content of 12-13% under normal warehouse temperatures.

When longer storage is needed, seed moisture content should be less than 11% and the temperature should not exceed 20^{o}C. Similarly, seeds of most temperate zone legume crops can be stored safely for one year at a moisture content of 10-11% under normal warehouse temperature. When longer storage is needed, 10% seed moisture content and temperature of 20^{o}C or less are recommended. Seeds of some spp.(soybean and groundnut) may lose viability even over one year if kept at 11-12% moisture content at temperatures of 20^{o}C or less. These seeds may be kept safely for 18-20 months in conditioned storage facilities of 20^{o}C and 50% RH. Conditioned storage rooms typically contain refrigeration and dehumidification equipment. The refrigeration is necessary to lower temperature of the seed storage room and dehumidification is necessary because lower storage air temperatures hold less water causing the relative humidity of the air to increase (Harty, 1980).

In general in conditioned storages the temperature and RH conditions of the storage environment are determined to meet satisfactory storage conditions. Conditioned storage aims at storing seeds by carefully controlling the temperature and relative humidity. This method may be too costly to store most seed lots of agricultural crops, but it is extremely valuable to preserve germplasm and other high value seed stocks. Conditioned storage is necessary to maintain seed viability.

2. Cryogenic Storage

In cryogenic storage, seeds are placed into liquid nitrogen at -196^{0}C (seeds are actually placed into the gaseous phase of the liquid nitrogen at about -150^{0}C for easy handling and safety). At these temperatures, there is little detrimental physiological activity, prolonging the storage life of seeds. This method is safe and cheaper than conditioned storage, but it is limited in capacity to the amount of storage space available in the cryogenic tanks. Hence, it is not practicable for most commercial seeds, but is useful to maintain a valuable germplasm over a prolonged period of time. The cost of liquid N is minimal compared to the cost of maintaining conditioned store rooms (Pritchard and Nadarajan, 2008).

3. Hermetic Storage

Hermetic storage refers to packaging seeds in moisture-resistant or hermetically sealed containers for storage and marketing. The purpose of such containers is to maintain seeds at safe storage moisture levels. Such completely moisture proof containers hermetically seal the seed and are effective for long term seed storage up to 10 years or more. One of the central benefits of hermetic storage is the ability to remove ambient air from the seeds and replace it with specific gases known to prolong seed storage life. eg. Decrease in oxygen concentration and increase in carbon dioxide level. The effectiveness of the materials is directly associated with their ability to resist moisture. Ordinary paper and cloth containers are least effective, whereas various laminate and polyethylene materials are moderately effective. Metal cans are completely effective in maintaining seed moisture.

4. Containerized Storage

Absolute humidity control in seed storage areas require considerable investment in specially constructed rooms and dehumidifying equipment. Where elaborate facilities are not available, humidity can be regulated in a closed container by the use of chemical desiccants. In containerized seed storage, humidity is regulated in a closed container by the use of chemical desiccants like sulfuric acid, saturated salt solutions, or silica gel treated with cobalt chloride, which serves as an indicator dye, turning from blue to pink when relative humidity exceeding 45%. The desiccant storage system is cheaper and insect, rodent, and moisture proof. The seeds remain undamaged by storage fungi, since they are maintained at 45% RH.

Generally the following general rules have to be observed in the management of stored seed;

- ✓ The seed stocks should be kept under continuous observation, especially for hot spots.
- ✓ Seeds should be fumigated between outgoing and incoming stocks.
- ✓ Floors should be swept thoroughly and rubbish burned.
- ✓ Ventilation should be encouraged within and between stocks.
- ✓ The storage building should be repaired and kept in good condition.

2.2.3. Ecological Factors affecting seed storage

According to Justice and Bass (1978) many factors affect seed storage of these are : Pre-harvest field conditions (e.g. high temperature, high humidity, and high moisture), maturity at harvest, mechanical injury, high temperature, high moisture, fungi, insects, pests like rats, mice and birds and seed treatment (fumigation). Mechanically injured seeds have reduced storability. They do not only deteriorate faster, but are also more susceptible to storage fungi and treatment damage.

Storage life of seeds decreases as storage temperature and moisture content increase. Harrington and Douglas (1970) stated that from 0 to 50°C each 5°C increase in storage temperature halves the seed’s life span and that for seed of 5-14% moisture content, each 1% reduction in moisture content approximately doubles seed storage life.

Storage fungi, primarily Aspergillus and Penicilium species, occur almost universally and may attack seed stored at relative humidity of 65-100% (Justice and Bass, 1978). When seed moisture content and/or atmospheric relative humidity is high, storage fungi can grow rapidly. Insects cause serious damage to seed stored at 9% or higher moisture content by attacking endosperm and/or embryo (Justice and Bass, 1978). Pest, rats, mice, and birds eat seeds, damage bags, and scatter, mix and contaminate seeds.

Seeds of high moisture, with mechanical damage, or stored for long periods are sometimes adversely affected by certain seed treatment chemicals. Treatments which are safe for some crop seeds may damage other; excessive treatment rate also affects storability. Some fumigants adversely affect seed viability under certain conditions, increase in seed moisture, temperature, fumigant dosage, and time of exposure increased the risk of damage.(Justice and Bass, 1978).

3. Conclusion

Seed is living matter and can deteriorate if not handled and stored properly. Seed Processing is the drying, cleaning, grading, treating, bagging and storage of the seed, obtained after harvesting and threshing. In the seed processing, the seed is protected from all sources of contamination and identity of the seed lot is maintained during seed processing. It is an important segment of seed industry. It has great role for quality improvement, to store health seed and better higher yield at low cost of seed production.

The purpose of seed storage is to preserve planting stocks from one season to the next. In some cases (e.g. seed companies) the objective of seed storage is to maintain seed quality for the longest duration possible. In other way, seed storage enables the maintenance of germplasm over time for improved plant breeding program. The seed should be harvested when it reaches harvest maturity, dried to safe moisture content, cleaned and stored under favorable conditions, and protected from damage and pests until planted. The most important factors affecting storability are the type of seed crop, moisture content, storage conditions (temperature, relative humidity) and storage pests. Cereals store better than legumes, and legumes store better than oilseed crops. Keeping the store clean, cool and dry is the best management practice because this reduces physiological processes, fungal and insect activities. The storage facilities should be cleaned and sprayed with suitable pesticides to protect the seed from insect pests.

A number of factors influence the viability and maintenance of seed quality in the storage. The two most important factors that influence the life span of seeds are relative humidity and temperature. The effect of relative humidity (and its subsequent effect on seed moisture) and temperature of the storage environment are highly interdependent. Most crop seeds lose their viability at relative humidity’s approaching 80% and temperature of 25-30^{o}C, but can be kept 10 years or longer at relative humidity’s of 50% or less and a temperature of 5^{o}C or lower.

Generally care needs to be given to seed storage conditions and the resulting effect on shelf life and performance. Proper seed storage conditions and facilities can be developed based on the desired length of storage, the type of crop, the packaging materials, and environmental conditions.

4. References.

Babiker, A.Z., 2015. Evaluation of alternative drying methods and storage techniques on the storability of sorghum (sorghum bicolor) seeds in genebanks (doctoral dissertation, UOFK).

Copeland, L.o. 1976. Principles of seed science and technology. Burgress publishing Company, Minneapolis, Minnesota, USA.

Copeland, L., and M. McDonald. 1995. Principles of Seed Science and Technology. 3rd ed. Chapman & Hall.

Cremer, K.W., Boland, D.J., von Carlowitz, P.G., Ogden, C.L., Koppell, C.R.S., Anderson, G.W., Rummery, R.A., Wiersum, K.F., Hof, J., Rideout, D. and Binkley, D., 1990. Trees for rural Australia (No.GTZ 54). CSIRO, Canberra (Australia).

Desai.B.B, 2004. Seeds Hand Book: Biology, production, Processing and Storage, 2nd ed. Marcel Dekker.Inc. NewYork, U.S.A. Pp787.

Elias, S., Garay, A., Young, B. & Chastain, T. 2016.Maintaining Grass Seed Viability in Storage. Oregon state university

Ellis, R.H., Hong, T.D. and Roberts, E.H. 1985. Handbook of Seed Technology for Gene banks Volume 1. Principles and methodology. IBPGR Rome, Italy.

Harrington, J.F., and Douglas, J.E, 1970.Seed storage and packaging. National Seeds Cropland Rockefeller Foundation. New Delhi, India. 222pp.

Hartmann, H.T., Kester, D.E., Davies, F.T. and Geneve, R.L., 1997. Plant propagation: principles and practices (No. Ed. 6). Prentice-Hall Inc.

Harty R.L, 1980. Seed Processing, Storage and Quality Control. Tropical Grasslands, 14(3), p.169.

ISTA. 2005. International Rules for Seed Testing. International Seed Testing Association, Bassersdorf, Switzerland.

Jean, A, 1987. The storage of Food Grains and Seeds. CTA, Macmillan, (eds. Rene Coste), pp. 146.

Justice, O.L. and Bass, L.N, 1978. Principles and Practices of seed Storage. Agriculture Handbook, No. 506. Washington, D.C., US Government Printing Office, 289 pp.

Marcar, N., Crawford, D., Leppert, P., Jovanovic, T., Floyd, R. and Farrow, R., 1995. Trees for saltland: a guide to selecting native species for Australia. Csiro Publishing.

McCormack, J.H., 2004. Principles and practices of seed harvesting, processing, and storage: an organic seed production manual for seed growers, Creative Commons. Stanford, California, 94305, p.28.

Pritchard, H.W. and Nadarajan, J., 2008. Cryopreservation of orthodox (desiccation tolerant) seeds. In Plant Cryopreservation: A Practical Guide (pp. 485-501). Springer New York.

Rao NK, Hanson J, Dulloo ME, Ghosh K, Nowell D and Larinde M, 2006. Manual of seed handling in genebanks. Handbooks for genebanks No. 8.Biodiversity International, Rome, Italy.

Schmidt, L., 2000. Planning and preparation of seed collections. Guide to handling of tropical and subtropical forest seed (Kirsten Olesan, ed.). Danida Forest Seed Centre, Humlebaek, Denmark, pp.292-293.