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Seed Deterioration: Physiological and Biological Changes

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Introduction

The need for increased seed quality has become a priority necessary to face the current demand for high standards in the agricultural market. The various factors which contribute to the loss in seed quality, viability, and vigor can be either physical or physiological. Seed deterioration can be defined as "deteriorative alterations occurring with the time that increase the seed's exposure to external challenges and decrease the ability of the seed to survive". It is associated with loss of seed quality, viability, and vigor due to the effect of adverse environmental factors (Kapoor *et al*., 2010). Some seeds have exceptional life spans, but eventually, all seeds succumb with time. This inevitability of seed mortality leads to scientific questions about *when* and *how* deterioration occurs, rather than *if*. The questions are critically important to agricultural productivity, conservation, and the evolution of natural populations.

The basic causes for deterioration are temperature, relative humidity, seed moisture content, and invasion by microorganisms and insects. Deterioration of seed starts with its formation on the mother plant till the development of seedling by the seed in the next generation. Seed deterioration is associated with various cellular, metabolic and chemical alterations including lipid peroxidation, membrane disruption, DNA damage, impairment of RNA, and protein synthesis and causes several detrimental effects on the seed.

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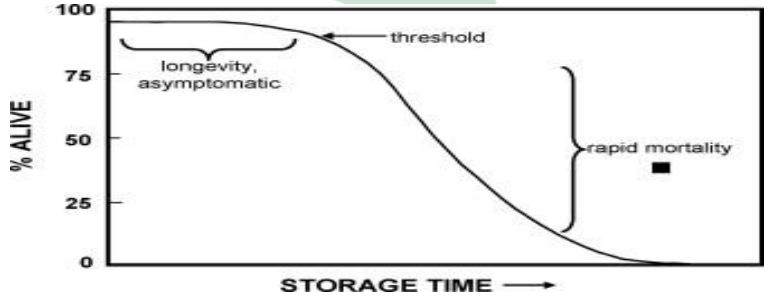
Types of seed deterioration:

1. Field weathering
2. Harvest and Post-harvest Deterioration
3. Storage

Field weathering occurs due to high relative humidity and high temperature during the post-maturation and pre-harvest periods. It results in the loss of seed quality. According to Khatun *etal*., 2009 if the seeds are retained on the mother plant even after physiological maturity they will deteriorate and physiological changes in the seed may lead to the formation of rigid seeds or off-color seeds in pulse crops.

Seed quality is highly affected by improper harvesting and handling methods. Mechanical damage is one of the major causes of seed deterioration after harvest and storage. It permits early entry and easy access for microflora and makes the seed vulnerable to fungal attack and reduces storage potential.

The seed storage environment highly influences the period of seed survival. If seeds get deteriorated because of unfavourable conditions of storage, seed and seedling vigor may be poor. Therefore lower temperature and humidity have to be maintained during storage which delays the seed deteriorative process.



Physiological and Biochemical changes during deterioration

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According to Kibinza *et al*., (2006) Seed deterioration is associated with various cellular, metabolic and chemical alterations including chromosome aberrations,damage to the DNA, impairment of RNA and protein synthesis, changes in the enzymes and food reserves, and loss of membrane integrity. Some of the major physiological and biochemical events of deterioration are as follows.

Membrane Degradation:

Damage in membrane permeability leads to increased leaching of seed constituents and hence loss in viability. During seed deterioration, membrane degradation increases electrolyte leakage. Which results in a decline in seed germination, field emergence, and seedling vigor. Alterations of membrane systems, such as the tonoplast, plasmalemma, and endoplasmic reticulum, result in the diminishing of normal cell function and energy production. Membrane deterioration and loss of permeability occur at an early stage during the seed deterioration.

Enzymes Alterations:

Reduced activity of lipase, ribonuclease, acid phosphatase, protease, diastase, catalase, peroxidase, α and β amylase, DNase, and dehydrogenase enzymes were observed during deterioration. Catalase and peroxides help in destroying ROS and hydrogen peroxides that are produced from several metabolic reactions. But aging leads to a substantial decrease in Peroxides activity. Due to these seeds become more sensitive to the effects of oxygen and free radicals.

Changes in Cell Chemical Constituents:

A significant decrease in protein, oil content, and total sugars and an increase in free fatty acids and reducing sugars have been observed in the deteriorated seed. Verma *et al*., (2003) showed that carbohydrates increased with a decrease in protein content in deteriorated seeds. Some studies indicated that oligosaccharide which has been associated with stabilizing membranes decreased during storage.

Reduced Metabolic Activity:

It is due to high relative humidity which hastens deterioration. This results in a reduction of nucleic acids with an increased storage period. Long-term storage decreases the ability to form nucleic acids and nucleotides. In turn metabolism of all biomolecules is reduced.

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Free Radical Damage:

Deterioration is partially associated with the accumulation of freeradicals produced by the metabolic process. Seed storage subjects lipids to slow and consistent attack by oxygen, forming hydrogen peroxides, other oxygenated fatty acids, and free radicals. These free radicals are unstable and may react and damage nearby molecules. Lipid peroxidation and free radical formation are the major causes of the deterioration of oil seeds in storage.

Chromosome Aberrations:

One of the changes linked with seed aging is an aberration of chromosomes, sometimes pertained to as mutagenic effects. Some of the chromosome alterations in seeds comprise fragmentation, bridges, fusion, ring formation of chromosomes, and variations in nuclear size.

Lipid peroxidation and seed deterioration:

- In oil plants, auto-oxidation of lipids and an increase in the content of free fatty acids throughout the storage period are the main reasons for the rapid deterioration of the seed of oil plants (Balesevic-Tubic *et al*., 2005).
- In sunflower seeds, loss of viability is associated with an accumulation of malondialdehyde (MDA), suggesting that seed deterioration is accompaniedby lipid peroxidation related to a decline in the efficiency of the antioxidant defense system (Kibinza *et al.*, 2006).
- Lipid peroxidation can result in not only the destruction of the lipid itself but also damage to cell membranes and other cellular components.
- The free fatty acid can damage the lipid bilayer, particularly mitochondria leading to reduced energy production and free radicals have the potential to damage membranes, DNA, enzymes, protein, and ultimately cellular repair mechanism (Ghassemi-Golezani *et al*., 2010).

Some other changes during deterioration are:

- Degradation of functional structures
- Biochemical changes resulting in lower levels of ATP
- The decline in sugar content
- The inability of ribosomes to dissociate
- Enzyme degradation and inactivation (amylase, dehydrogenase, oxidases, phospholipase)

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- Formation and activation of hydrolytic enzymes
- Starvation of meristematic cells
- Increases in seed leachates and free fatty acid content
- Reduced respiration

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