

# Seed Deterioration: Physiological and Biological Changes

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Subhali Sukanya Patel and Soubhagya Behera

Department of Seed Science and Technology, College of Agriculture, OUAT, Bhubaneswar, Odisha, India –  
751003

Seeds are living entities that gradually lose viability and vigour due to an inherent ageing process known as deterioration. This paper describes the physiological, biochemical, and environmental factors responsible for the decline in seed quality from harvest through storage to germination. External factors such as field weathering, mechanical injury, and improper storage conditions (high temperature and humidity) accelerate deterioration. Internally, processes such as membrane degradation, enzyme inactivation, depletion of food reserves, accumulation of toxic metabolites, reactive oxygen species (ROS) damage, and genetic abnormalities impair seed performance. These changes result in reduced germination, weak seedlings, and lower crop productivity. Understanding these mechanisms helps in improving storage technologies and seed handling practices. Studies, including those from ICAR-Indian Agricultural Research Institute, indicate that maintaining low temperature and moisture conditions and minimizing physical damage can

significantly extend seed longevity. Therefore, preserving seed quality is essential for sustainable agriculture, stable crop production, and global food security.



High seed quality is essential for meeting the increasing demands of modern agriculture. Seed deterioration refers to a series of time-dependent physiological and biochemical changes that reduce seed viability and

vigour, ultimately affecting crop establishment and yield. These changes increase the susceptibility of seeds to environmental stresses and lead to a gradual loss of their survival potential (Kapoor et al., 2011).

Although some seeds exhibit extended longevity, all seeds eventually deteriorate. Understanding when and how deterioration occurs is crucial for improving agricultural productivity, conservation strategies, and seed storage practices. Major factors influencing seed deterioration include temperature, relative humidity, seed moisture content, and biotic factors such as fungi and insects.

Seed deterioration begins during seed development on the mother plant and continues through harvest, storage, and germination. It involves complex cellular, metabolic, and biochemical alterations, including lipid peroxidation, membrane damage, DNA degradation, and reduced synthesis of RNA and proteins.

### Types of Seed Deterioration

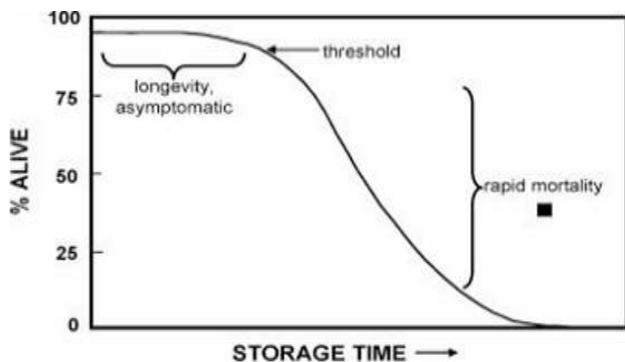
Seed deterioration can be broadly classified into:

1. Field weathering
2. Harvest and post-harvest deterioration
3. Storage deterioration

Field weathering occurs due to prolonged exposure of mature seeds to high temperature and humidity before harvest, leading to loss of quality. Khatun et al. (2009) reported that delayed harvesting may cause hardening and discoloration in pulse seeds.

Improper harvesting and handling practices cause mechanical damage, which facilitates pathogen entry and reduces seed storability.

Storage conditions play a critical role in determining seed longevity. High temperature and moisture accelerate deterioration, whereas cool and dry conditions help maintain seed viability.



### Physiological and Biochemical changes during deterioration

## Physiological and Biochemical Changes During Seed Deterioration

### 1. Membrane Degradation

Loss of membrane integrity is one of the earliest signs of seed deterioration. Increased membrane permeability leads to leakage of cellular constituents, reducing seed viability and vigour. Disruption of cellular membranes such as the plasmalemma, tonoplast, and endoplasmic reticulum impairs normal cellular functioning.

### 2. Enzyme Alterations

Seed ageing leads to a decline in the activity of important enzymes such as amylase, protease, lipase, catalase, peroxidase, and dehydrogenase. Reduced activity of antioxidant enzymes like catalase and peroxidase results in increased sensitivity to oxidative stress caused by reactive oxygen species.

### 3. Changes in Chemical Constituents

Deteriorated seeds exhibit a decrease in proteins, lipids, and total sugars, along with an increase in free fatty acids and reducing sugars. Structural carbohydrates and protective oligosaccharides decline, affecting membrane stability (Verma and Dubey, 2003).

### 4. Reduced Metabolic Activity

High moisture conditions accelerate the degradation of nucleic acids during storage, thereby limiting nucleotide synthesis and reducing metabolic efficiency.

### 5. Free Radical Damage

Reactive oxygen species (ROS) accumulate during seed ageing and cause oxidative damage to lipids,

proteins, and nucleic acids. This results in structural and functional impairment of cellular components.

## 6. Chromosomal Aberrations

Seed ageing induces genetic damage, including chromosomal breaks, fusions, bridges, and mutations, which negatively affect seed viability and seedling development.

## 7. Lipid Peroxidation

Lipid peroxidation is a major cause of seed deterioration, particularly in oilseeds. Accumulation of malondialdehyde (MDA), a by-product of lipid oxidation, is associated with reduced seed viability (Kibinza et al., 2006). Free fatty acids disrupt mitochondrial membranes and reduce energy production, while free radicals damage DNA, proteins, and enzymes (Ghassemi-Golezani et al., 2010).

## Other Changes Associated with Seed Deterioration

- Breakdown of cellular structure
- Decline in ATP levels

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- Reduction in sugar content
- Ribosome disintegration
- Enzyme inactivation (amylase, dehydrogenase, oxidases, phospholipase)
- Activation of hydrolytic enzymes
- Starvation of meristematic cells
- Increased leachate and free fatty acid content
- Reduced respiration rate

## Conclusion

Seed deterioration is a natural and inevitable process that begins at seed formation and continues until germination. Environmental conditions, storage practices, and internal biochemical changes collectively determine the rate of deterioration. Adoption of improved storage techniques and careful handling can significantly slow down this process and maintain seed quality. Ensuring high seed viability and vigour is essential for sustainable agricultural production and food security.