Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 02, Issue: 01 (JAN-FEB, 2022)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Seed Ageing and Their Mechanism

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Seed ageing is an irreversible process of the gradual decline of seed vigour. It is characterized by reduction of antioxidant systems, the disruption of cellular membranes, the damage of genetic integrity, the peroxidation of lipids, and the degradation of proteins in seeds. Ageing induces progressive seed deterioration ultimately leading to lethal damage and inability to germinate. Seeds are highly susceptible to damage and mechanical injury during post-harvest handling. However, the seed quality and viability during storage depend upon the initial quality of seed and the manner in which it is stored. Damage due to seed aging cannot be ignored but can be delayed and damage due to deterioration can be stopped by adopting different steps at different stages including from harvesting to pre-sowing. Seed ageing effect seed quality, germination and vigour which ultimately lead to economic loss.

Key words: Seed ageing**,** Germination, Vigour, Viability, Antioxidant, Seed deterioration, Lipoxidation, Peroxidation, ATP , ADP.

Introduction

Seed ageing is an irreversible process of the gradual decline of seed vigour. It is characterized as a reduction of antioxidant systems, the disruption of cellular membranes, the damage of genetic integrity, the peroxidation of lipids, and the degradation of proteins in seeds. Ageing induces progressive seed deterioration ultimately leading to lethal damage and inability to germinate. Seed ageing is a natural phenomenon, which is defined as sum total of all the changes that occur in a living entity with the passage of time and leads to a decreasing ability to survive stress, functional impairment and ultimately cause death. During storage, a number of physiological and physicochemical changes occur, termed seed ageing (Silva *et al*., 2005; Sisman, 2005).

Seed ageing adversely affect three important physiological drivers:

- Germination potential
- Vigour and
- Viability

Mechanism of Seed Ageing

The dissociation of polyribosomes must occur before attachment of preformed mRNA occurs leading to protein synthesis in germinating seedlings (App *et a1*., 1971). Nonviable seeds the ribosomes fail to dissociate (Bray and Chow, 1976) and protein synthesis is retarded. Such declines in protein synthesis are a measurable symptom of aging. Age-related chemical side reactions that can occur on proteins include: oxidation of amino acids, formation of adducts involving reactive nitrogen and chlorine species, chemical modification of proteins by products of lipid peroxidation reactions (lipoxidation) and Maillard reaction products.

Reactive oxygen species (ROS) and/or reactive nitrogen species (RNS) generated in vivo, play a role in aging, as already proposed in 1956. The carbonyl content of proteins has been observed to increase with age (Levine, 2002). Amadori and Millard reaction refers to a series of complex reaction that occur following and initial carboyl-amine reaction. These reactions generally follow four steps:

1. Non-emzymetic condensation of a reducing sugar, aldehyde or ketose with free amino group of protein. A group of protein or nucleic acids to form a glycosylamine (a reversible step)
2. The rearrangement of the glycosylamine to Amadori product, 1-amino-α-deoxyketose
3. The degradation and dehydration of Amadori products into amino or carbonyl intermediates.
4. The reaction of carbonyl intermediates with other amino group as well as the subsequent rearrangement to form advanced glycosylation end-products (AGE- product).

Formation and Activation of Hydrolytic Enzymes

As seed moisture content approaches levels necessary for germination, hydrolytic enzymes are activated. If the seed moisture content remains high or reaches higher levels, normal germination may occur; however, if moisture levels for germination are not attained, the seed deteriorates because of energy expenditure or accumulation of breakdown products. The increase in free fatty acids, a symptom of deterioration caused by activation of lipase enzymes in oil-containing seeds, has already been discussed. A related group of enzymes, the phospholipases, hydrolyzes the phospholipids and thus destroys the membrane structure of the seed. Activation of phosphatase enzymes converts ATP to ADP, resulting in an energy loss accompanied by increased phosphate acidity. Other hydrolytic enzymes activated by high moisture levels are amylases and proteolases. This kind of deterioration is rapid and is important only over short periods at moisture levels around 20% and above. Below 20% moisture, other kinds of deterioration predominate.

Genetic Degradation

A great deal of indirect evidence supports the view that seed deterioration is associated with random somatic mutations that impair the cellular functions of vital seed tissues. The increase in chromosomal aberrations in deteriorating seeds as a result of somatic mutation has been observed in many species. Fusion and fragmentation aberrations that were observed in both x-rayed and aged barley seeds occurred at higher rates than in fresh seeds (Gustafsson, 1937). One observer (Harrington, 1973) discounts genetic degradation as a primary cause of aging. Harrington cites evidence that although more chromosomal aberrations occur with increasing age, animal tissues rid themselves of the altered cells (Kohn 1963). This notion has been supported by Roos (1982). Further, radiation-induced injury in bacterial cells is reduced by quick repair of damaged DNA (Witkin 1966). If enough cells in the germinating seedlings are damaged, slower growth and seedling abnormality can occur; however, ordinarily radiation-killed cells are quickly crushed or replaced by normal tissue (Harrington, 1973). Two general observations have been made on work with barley seeds (James 1960): 1)

Depletion of Food Reserves

Depletion of food reserves is one of the oldest theories on deterioration; however, it has not survived critical scrutiny. In fact, most seeds contain enough food materials to last thousands of years (James 1960). Even 1000- to 2000-year-old wheat seeds that have been found in ancient tombs still retain most of their food reserves; thus, even nonviable seeds contain enough food reserves for seedling growth and development (Barton, 1961). We know that the biochemical degradation processes in dry seeds are almost imperceptibly small and could not account for depleting the food reserves within the life span of most seeds.

Starvation of Meristematic Cells

The theory of starvation of meristematic cells was introduced at the USDA-ARS Seed Quality Research Symposium in 1971 (Harrington, 1973); however, in principle, it had been implied earlier in an evaluation of the reserve food depletion theory (Harrington 1973). It was noted that respiration may deplete the tissues involved in the transfer of nutrition from reserve storage areas and thus prevent them from reaching the embryo. Another study elaborated on this, noting that meristematic cells, even though only a few cells away from abundant reserves of energy, may die from lack of food or from injury (Harrington, 1973). It was speculated that perhaps the meristematic cells exhausted their energy supply, with no way to convert ADP to ATP.

Accumulation of Toxic Compounds

Under low-moisture storage, the reduced respiration and enzyme activity may be responsible for accumulation of toxic substances that reduce seed viability (Harrington 1973). When aged wheat embryos were transplanted onto young endosperms and young embryos onto aged endosperms, a progressive decline in germination and vigor of both transplants has been observed (Floris 1970), strongly indicating a gradual accumulation of toxic metabolites. It has been suggested that the presence of abscisic acid, a germination inhibitor, in several seeds supports this theory as a probable cause of aging (Harrington 1973) as well as phenolic compounds (Sreeramulu 1983) and polyamines (Mukhopodhyay et al. 1983).

Symptoms of Seed Ageing

- Morphological Changes
- Ultra Structural Changes
- Cell Membrane Changes
- Loss of Enzyme Activity
- Reduced Respiration
- Increase in Seed Leachates

Conclusion

Seed ageing is an inexorable and irreversible process.Seed being a living entity and will always remain vulnerable to ageing.And Seed deterioration is not confined to any one cellular function but it is manifested in a variety of ways including to seed ageing. Seed ageing affect seed quality, germination and vigour which ultimately leads to economic loss. By maintaining optimum conditions deterioration can be stopped, seed ageing can be delayed. Knowledge about the mechanism of seed ageing helps us to reduce the damage and prolong the shelf life.

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