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Factors Affecting Seed Longevity in Storage

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Seed longevity refers to the duration for which a seed remains viable and capable of germination under storage conditions. It is a complex trait influenced by genetic, physiological, and environmental factors. Different species and even seed lots within the same species show considerable variation in storage life. Proper understanding of factors affecting seed longevity is essential for maintaining seed quality during storage and ensuring successful crop establishment.

Factors Affecting Seed Longevity in Storage

Kind or Variety of Seed

The storability of seeds varies significantly depending on the species and variety. Some seeds such as onion, soybean, and groundnut are short-lived, whereas cereals and other starchy seeds can be stored for longer durations. This variation is mainly due to seed composition. Seeds rich in oils and proteins are more susceptible to deterioration compared to starchy seeds because lipids are prone to oxidation, leading to faster ageing. Additionally, genetic makeup determines the seed's resistance to environmental stresses during storage (Kumar et al., 2023).

Initial Seed Quality

Initial seed quality is one of the most critical factors determining storage life. Seeds that are well-developed, mature, and free from mechanical damage or pest infestation exhibit higher longevity. High-quality seeds possess better physiological and biochemical stability, enabling them to withstand storage conditions. It is important to note that storage conditions can only maintain seed quality but cannot improve it. Therefore, poor-quality seeds should be rejected before storage (Singh & Yadav, 2022).

Moisture Content

Moisture content is considered the most important factor influencing seed longevity. Seeds are hygroscopic in nature and continuously exchange moisture with the surrounding environment. Higher seed moisture content accelerates metabolic activity, leading to rapid deterioration, fungal growth, and insect infestation. Lower moisture levels significantly enhance storage life. According to Harrington's thumb rule, for every 1% decrease in seed moisture content (within the range of 5–14%), the storage life of seeds doubles. Safe moisture content varies depending on seed type, storage duration, and packaging materials. The use of desiccants such as silica gel helps maintain low moisture levels and prolong seed viability (Corbineau, 2024).

Relative Humidity and Temperature During Storage

Temperature and relative humidity (RH) are key environmental factors affecting seed longevity. Seeds reach an equilibrium moisture content depending on the surrounding RH and temperature. High humidity increases seed moisture, which accelerates deterioration processes. Similarly, high temperatures increase metabolic and enzymatic activities, leading to faster ageing. Harrington's rule also states that for every 5°C reduction in storage temperature, seed life doubles. Low temperature and moderate RH conditions are ideal for

maintaining seed viability. Studies have shown that seeds stored at low temperature (around 5°C) and low RH exhibit higher germination rates and vigour compared to those stored under high temperature and humidity (Zhang et al., 2022).

Provenance

Provenance refers to the geographical origin of the seed. It significantly influences seed longevity due to variations in climatic and environmental conditions during seed development. Seeds produced under favorable conditions, such as optimal temperature and low rainfall during maturation, generally have better storability. In contrast, seeds exposed to adverse conditions such as high humidity or temperature fluctuations during development tend to deteriorate faster during storage. Provenance also affects genetic adaptability and physiological characteristics of seeds (Rao et al., 2021).

Activity of Organisms Associated with Seeds in Storage

Various biological agents such as fungi, bacteria, insects, mites, rodents, and birds can cause severe damage to stored seeds. Fungal growth is particularly common under high moisture and temperature conditions, leading to loss of viability and contamination with toxins. Insects and rodents not only consume seeds but also create conditions favorable for microbial growth. Maintaining proper sanitation and using pest control measures such as fumigation and insecticides are essential for minimizing damage. Storage facilities should be clean, well-ventilated, and protected from pest entry to ensure seed longevity (Patel et al., 2023).

Temperature Control in Seed Storage

Temperature control plays a crucial role in preserving seed viability and vigour. Lower temperatures reduce metabolic activities and slow down deterioration processes. Effective temperature control can be achieved through ventilation, insulation, and refrigeration. In many storage systems, these methods are used together to maintain optimal conditions. Cold storage, especially at sub-zero temperatures, is highly effective for long-term preservation of orthodox seeds. However, temperature fluctuations should be avoided as they can lead to moisture condensation and damage to seeds (Corbineau, 2024).

Humidity Control in Seed Storage

Maintaining appropriate relative humidity is essential for successful seed storage. This can be achieved by selecting storage locations with low ambient humidity, using moisture-proof packaging materials, or employing dehumidification systems. The ideal RH level depends on seed type, storage duration, and temperature. Proper humidity control prevents moisture absorption, thereby reducing microbial activity and physiological deterioration. Moisture-proof containers are especially useful in maintaining stable seed moisture levels during long-term storage (Singh & Yadav, 2022).

Sanitation in Storage

Sanitation is a fundamental practice in seed storage management. Clean storage facilities help minimize pest infestations and microbial contamination. Infested seed lots should never be stored with healthy seeds unless properly treated. Seeds should be stored on wooden pallets instead of directly on concrete floors to prevent moisture absorption. Adequate ventilation and regular monitoring further help maintain a hygienic storage environment. Proper sanitation combined with pest management ensures longer seed viability and better quality (Patel et al., 2023).

Seed Ageing and Deterioration

Seed ageing is an inevitable process characterized by a gradual decline in seed viability and vigour. The primary cause of ageing is oxidative damage due to the accumulation of reactive oxygen species (ROS). These molecules damage cellular components such as membranes, proteins, and nucleic acids. Ageing leads to reduced germination, delayed seedling emergence, and poor crop establishment. High temperature and humidity accelerate oxidative damage, making proper storage conditions essential for slowing down the ageing process (Corbineau, 2024).

Maintenance of Seed viability and vigour during storage

Maintaining seed viability involves controlling environmental factors such as moisture, temperature, and humidity. Pre-storage treatments such as seed drying and cleaning improve storability. Advanced techniques such as seed priming and antioxidant treatments can partially restore the performance of aged seeds by enhancing enzymatic activity and reducing oxidative stress. However, these methods are effective only when seeds have not completely lost viability (Kumar et al., 2023).

Conclusion

Seed longevity is influenced by a combination of genetic, environmental, and management factors. Among these, moisture content and temperature play the most critical roles. Proper storage practices such as maintaining low moisture, controlling temperature and humidity, ensuring sanitation, and protecting seeds from pests can significantly extend seed life. Understanding these factors is essential for effective seed storage and ensuring high-quality planting material for sustainable agriculture.

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