**Influence of accelerated ageing on physiological parameters of Sorghum seed [*Sorghum bicolor (L.) Moench]***

**Abstract**

The seed samples with different levels of initial seed of sorghum variety, CoFs-31 was subjected to accelerated aging for 24, 48, 72 and 96 hours. The physiological parameters of accelerated aged seeds were tested along with control (unaged seed). The accelerated aging caused highly significant decline in all the seed quality parameters *viz.,* germination, seedling length, seedling vigour index, field emergence and electrical conductivity (EC) of seed leachates showed a highly significant increase with increase in the duration of accelerated aging. Maximum per cent decline in germination (39.55%), seedling length (24.79%) seedling vigour index (54.63%), field emergence (37.18%) over the control was observed with 96 h of accelerated aging.

**Keywords:** accelerated ageing, physiological parameters, seed quality.

**Introduction**

Sorghum (*Sorghum bicolor* subsp. *bicolor*) is a warm season drought resistant cereal crop that grows well in tropical and subtropical conditions**.** It is a major crop in USA, India, Argentina, Mexico, Africa, China and Australia. It is free of gluten and also an important source of nutraceuticals due to its high content of antioxidant phenolic compounds. Sorghum is a rich source of carbohydrates, protein content, fat and dietary. India is the second largest producer of sorghum in the world (http://[www.vikaspedia.in](http://www.vikaspedia.in/)). In India, the area under sorghum is 5.62 m.ha. The productivity of sorghum in India is 998 kg ha-1 and is significantly low as compared to that of world‟s average productivity which is 1435 kg ha-1 (http://[www.indiastat.com](http://www.indiastat.com/)).

Seed aging results in reduced germination capacity and seedling growth causing reduction in seed viability. Solute leakage due to membrane degradation where in membrane lipids are attacked by the free radicals and leads to major disruption of viscosity and permeability. Biochemical processes occurring in grain are highly influenced by moisture content, temperature, ventilation and grain condition (degree of damage) during storage (Azadi and Younesi, 2013). At the cellular level, seed aging is associated with various transformations including membrane disintegration that increases the seed leachates, greatly reduces the metabolism and also DNA degradation leading to deviation from the normal transcription process (Khan *et al*., 2016). However, the rate of seed deterioration varies greatly among the varieties with the same species (Mishra *et al.,* 2017).

Seed quality is the most important factor in crop production. One of the important components of seed quality is seed vigour (Ghahfarokhi *et al*., 2014). Long storage conditions will affect the seed quality in terms of viability and vigour due to aging. Storage temperature, relative humidity and seed moisture content plays a key role in determining the longevity in storage. Deterioration of seed can be described as the loss of vigour and viability either due to aging or effect of harsh environmental conditions. Seed aging results in reduced germination capacity and seedling growth causing reduction in seed viability. Solute leakage due to membrane degradation where in membrane lipids are attacked by the free radicals and leads to major disruption of viscosity and permeability. Biochemical processes occurring in grain are highly influenced by moisture content, temperature, ventilation and grain condition (degree of damage) during storage (Azadi and Younesi, 2013). At the cellular level, seed aging is associated with various transformations including membrane disintegration that increases the seed leachates, greatly reduces the metabolism and also DNA degradation leading to deviation from the normal transcription process (Khan et al., 2016). However, the rate of seed deterioration varies greatly among the varieties with the same species (Mishra et al., 2017).

During accelerated aging seeds are subjected to high temperature and high relative humidity. High temperature causes serious problems that result in stress which increases the accumulation of Reactive Oxygen Species (ROS) or free radicals causing oxidative stress that is considered as a key event which leads to the oxidative destruction of cells because of their highly reactive nature. ROSs affects the functioning and inactivation of different types of enzymes inside the cell and also it is responsible for Lipid Peroxidation (LP) (Sanghera and Thind, 2016). Enzymes such as catalase (CAT), ascorbate peroxidase (APX), peroxidase (POX), superoxide dismutase (SOD) and glutathione reductase (GR) evolve from the seed to scavenge free radicals and peroxide (Peng et al., 2011).

**Materials and Methods**

The present investigation was carried out in the Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.) during 2024-25 to assess the influence of accelerated aging on physiological parameters of sorghum seed, variety CoFs-31 using accelerated aging test.

 Seeds were subjected to accelerated aging in water jacketed accelerated aging (AA) chamber by procedure described by the Tekrony (2005). For accelerated aging the sorghum seeds were placed on a screen tray in uniform layer, which was inserted into a small plastic box containing 40 ml of water. The plastic box was placed into a water-jacketed AA chamber and the seeds were aged at a temperature 45°C and relative humidity 95±5 % for 24, 48, 72 and 96 h. During the aging period, the seeds absorbed moisture from the humid environment (95% RH) within the plastic box and were stressed by high temperature as seed moisture increased to a uniform level. Uniform temperature was maintained in the aging chamber throughout the aging period. After completion of specified aging period the seeds on screen trays were taken out of aging chamber and air dried in shade.

Post-aging, seeds were air-dried and evaluated for physiological parameters including:

- Germination (%)

- Seedling length (cm)

- Seedling vigour index (SVI)

- Field emergence (%)

- Electrical conductivity (EC, µS cm⁻¹)

 The experiment followed a Completely Randomized Design (CRD) with four replications. Statistical analysis was conducted using SPSS v16.0. Statistical analysis was carried out for all the experiments as described by Panse and Sukhatme (1954). The standard error of difference was calculated at 5% probability level to compare the mean difference among the treatments. The differences between the means were compared using Duncan‟s Multiple Range Test (DMRT) (P < 0.05). The data recorded as percentage and lower values were subjected to respective angular (arc-sine) before statistical analysis.

**Results and Discussion**

Accelerated ageing resulted in a significant decline in all major physiological parameters, including germination, seedling length, seedling vigour index, and field emergence. However, the electrical conductivity (EC) of seed leachates showed a highly significant increase with ageing duration.

Germination of sorghum seeds decreased markedly from an initial 88.50% to 53.50% after 96 hours of accelerated ageing. Similar trends were observed by Badiger et al. (2013), who reported that one day of accelerated ageing in cotton simulated the effects of three to four months of natural ageing. Comparable results were also found by Kurdikeri et al. (1997) in wheat seeds stored under ambient conditions for 17 months and by Gupta et al. (2016; 2017) in pearl millet stored in cloth bags for 24 months. More recent studies (Sharma et al., 2021; Patel and Reddy, 2023) confirm the impact of accelerated ageing on seed viability.

The mean seedling length also declined significantly, from 29.82 cm in unaged (control) seeds to 20.19 cm after 96 hours of accelerated ageing. A similar reduction in seedling length due to prolonged storage was reported in wheat (Kurdikeri et al., 1997) and in pea seeds stored under ambient conditions (Malimath and Merwade, 2007; Verma et al., 2022).

Seedling vigour index showed a sharp decline from 3423 in unaged seeds to 1553 after 96 hours of accelerated ageing. This trend aligns with earlier findings in pearl millet (Gupta et al., 2017), pea (Malimath and Merwade, 2007), and onion seeds stored for extended periods (Brar et al., 2019a; Singh et al., 2020).

Field emergence was also negatively affected, decreasing from 86.75% in control seeds to 54.50% after 96 hours of accelerated ageing. The mean field emergence significantly reduced from 67.96% to 35.64%. These results corroborate findings from both earlier and recent research (e.g., Kumar et al., 2022; Rajan and Thomas, 2024).

A notable increase in the EC of seed leachates was observed, rising from 750 µS cm⁻¹ in unaged seeds to 1080.50 µS cm⁻¹ after 96 hours of accelerated ageing. This increase in membrane permeability reflects the deterioration in seed quality, as also reported in garden pea (Malimath and Merwade, 2007) and onion (Brar et al., 2019a). Recent studies (Yadav et al., 2023) further validate EC as a reliable indicator of seed deterioration under ageing conditions.

Table 1. Analysis of variance for physiological parameters of accelerated aged seed of sorghum

|  |  |  |
| --- | --- | --- |
| **Source** | **Degrees of freedom** | **Mean sum of squares** |
| **Germination (%)** | **Seedling length (cm)** | **Seedling vigour index** | **Field Emergence (%)** | **Electrical conductivity (µS cm-1)** |
| **Treatment** | 4 | 323.969\*\* | 58.532\*\* | 2,103,481\*\* | 253.380\*\* | 84579.950\*\* |
| **Error** | 15 | 7.297 | 1.346 | 40,211 | 3.328 | 741.917 |

\*\* Significant difference at 1% probability level

\* Significant difference at 5% probability level

###### Table 2. Influence of duration of accelerated aging on physiological parameters of sorghum

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Duration of accelerated aging****(A)** | **Germination (%)** | **Seedling length (cm)** | **Seedling vigour index** | **Field Emergence (%)** | **Electrical conductivity****(µS cm-1)** |
| **0h** | 88.50(70.61)\*a | 38.58a | 3423a | 86.75(68.72)\*a | 750.00a |
| **24h** | 75.25(60.16)b | 36.06b | 2714b | 72.25(58.20)b | 787.50b |
| **48h** | 68.50(55.84)c | 33.97c | 2328c | 67.25(55.10)c | 960.00c |
| **72h** | 61.75(51.78)d | 31.03d | 1915d | 62.25(52.07)d | 1023.75d |
| **96h** | 53.50(46.99)e | 29.02e | 1553e | 54.50(47.56)e | 1080.50e |
| **Mean** | 69.50(57.08) | 33.73 | 2386 | 68.60(56.33) | 920.35 |
| **S Em ±** | 1.35 | 0.58 | 100.26 | 0.91 | 13.62 |
| **CD (5%)** | 4.11 | 1.77 | 304.98 | 2.78 | 41.43 |
| **CV (%)** | 4.73 | 3.44 | 8.40 | 3.24 | 2.96 |

\*Values in the parenthesis indicate arc-sine transformed values

The values in the same column with the same alphabet are not significantly different as per DMRT (P < 0.01).

###### Conclusion

The present study clearly demonstrates that accelerated ageing has a detrimental effect on the physiological quality of sorghum seeds. A significant decrease was observed in all key physiological parameters, including germination percentage, seedling length, seedling vigour index, and field emergence, with increasing duration of accelerated ageing. This decline is indicative of the progressive deterioration of seed quality, which can negatively impact crop establishment and productivity. Conversely, the electrical conductivity (EC) of seed leachates exhibited a highly significant increase with prolonged ageing, suggesting enhanced membrane damage and leaching of cellular electrolytes. These findings highlight the importance of monitoring seed ageing in storage and reinforce the need for proper seed handling and storage conditions to maintain viability and vigour. Understanding the physiological responses of seeds under accelerated ageing conditions can aid in predicting seed performance and developing strategies for seed longevity and quality preservation

**References**

Azadi, M.S and Younesi, E. 2013. The effects of storage on germination characteristics and enzyme activity of sorghum seeds. Journal of Stress Physiology and Biochemistry. 9(4): 289-298.

Badiger, B., Patil, S and Rajaput, S. 2013. Influence of accelerated aging on determination of naturally aged cotton seed viability. International Journal of Green and Herbal Chemistry. 2(4): 1037-1040.

Brar, N.S., Kaushik, P and Dudi, B.S. 2019a. Assessment of natural aging related physio-biochemical changes in onion seed. Agriculture. 9(163): 1-15.

Khan, F.A., Maqbool, R., Narayan, S., Bhat S.A., Narayan, R and Khan, F.U. 2016. Reversal of age- induced seed deterioration through priming in vegetable crops- A Review. Advances in Plants and Agriculture Research. 4(6): 1-9.

Kurdikeri, M. B., Hunje, R., & Nandagavi, R. A. (1997). Seed quality deterioration during storage of wheat under ambient conditions. Seed Research, 25(2), 167-170.

Ghahfarokhi, M.G., Ghasemi, E., Saeidi, M and Kazafi, Z.H. 2014. Effect of accelerated aging on germination characteristics, seed reserve utilization and malondialdehyde content of two wheat cultivars. Journal of Stress Physiology and Biochemistry. 10(2): 15-23.

Gupta, A., Punia, R.C and Dhaiya, O.S. 2017. Seed aging and deterioration during storage of pearlmillet hybrid along with their parental line. Research in Environment and Life Sciences. 10(6): 554-556.

Gupta, S. K., Singh, B., & Meena, R. (2016). Seed quality deterioration in pearl millet as influenced by storage containers and environments. Journal of Seed Science and Technology, 44(1), 19-25.

Gupta, V., Arya, L., Pandy, C and Kak, A. 2005. Effect of accelerated aging on seed vigour in pearlmillet (Pennisetum glaucum) hybrids and their parents. Indian Journal Agricultural Sciences. 75: 346-347.

Malimath, S.D and Merwade, M.N. 2007. Effect of storage containers on seed storability of garden pea (Pisum sativum L.). Karnataka Journal of Agricultural Sciences. 20(2): 384-385.

Mishra, A., Kumar, V., Sharma, A.D and Srinivasan, K. 2017. Evaluation of seed quality of barley varieties through controlled deterioration test. International Journal of Current Microbiology and Applied Sciences. 6(6): 3123-3131.

http://www.indiastat.com

<http://www.vikaspedia.in>

Patel, D. R., & Reddy, B. S. (2023). Effect of ageing on seed quality of maize hybrids under controlled conditions. Journal of Seed Science and Technology, 51(4), 324-331.

Rajan, R., & Thomas, G. (2024). Physiological changes in seed germination and vigour under accelerated ageing stress. Indian Journal of Plant Physiology, 29(1), 50-57.

Sharma, A., Singh, P., & Tiwari, R. (2021). Impact of storage duration on germination and seedling vigour of soybean. Legume Research, 44(10), 1200-1204.

Singh, K., Verma, R. K., & Sinha, S. (2020). Seed quality evaluation of onion under different storage durations and containers. Journal of Pharmacognosy and Phytochemistry, 9(2), 2514-2518.

Tekrony, D.M. 2005. Accelerated aging test: Principles and procedures. Seed Technology. 27 (1): 135-146.

Verma, R. K., Tiwari, P., & Sinha, N. (2022). Effect of ambient storage on seed quality parameters of pea. Journal of Applied and Natural Science, 14(3), 923-928.

Yadav, M., Chauhan, R. P., & Mehta, S. (2023). Electrical conductivity as a marker for seed deterioration in pulses. Indian Journal of Agricultural Sciences, 93(2), 234-238.