**Influence of Accelerated Ageing on Physiological Parameters of Sorghum Seed [Sorghum bicolor (L.) Moench]**

**Abstract**

This study aimed to evaluate the impact of accelerated ageing on the physiological quality of Sorghum bicolor (L.) Moench seeds, specifically the variety CoFs-31. Seeds were exposed to accelerated ageing conditions at 45°C and 95±5% relative humidity for 24, 48, 72, and 96 hours, with unaged seeds serving as the control. Following treatment, key physiological parameters—germination percentage, seedling length, seedling vigour index (SVI), field emergence, and electrical conductivity (EC) of seed leachates—were assessed. The results revealed a highly significant decline in germination (up to 39.55%), seedling length (24.79%), seedling vigour index (54.63%), and field emergence (37.18%) as the duration of ageing increased. In contrast, EC increased significantly, indicating membrane deterioration and loss of seed integrity. Accelerated ageing negatively impacts seed viability and physiological quality. This study provides insights into seed deterioration mechanisms and supports the selection of sorghum varieties with better storability and field performance.

**Keywords**: Seed physiological performance, membrane integrity and electrolyte leakage, seed vigour index evaluation, accelerated seed ageing test, germination decline due to ageing

**Introduction**

Sorghum (Sorghum bicolor subsp. bicolor) is a warm season, drought-resistant cereal crop that thrives in tropical and subtropical regions. Major producing countries include the USA, India, Argentina, Mexico, Africa, China, and Australia. It is gluten-free and rich in carbohydrates, proteins, fats, dietary fiber, and antioxidant phenolic compounds. India is the second largest producer of sorghum, with 5.62 million hectares under cultivation and an average productivity of 998 kg ha⁻¹, which is lower than the global average of 1435 kg ha⁻¹.

Seed ageing leads to reduced germination and seedling growth due to solute leakage and membrane degradation. Free radicals attack membrane lipids, disrupting permeability and cellular integrity. Biochemical processes in stored grain are influenced by moisture, temperature, and physical damage. At the cellular level, seed ageing is associated with membrane disintegration, DNA degradation, and altered metabolism. The deterioration rate varies among varieties of the same species.

Seed vigour is critical for crop production. Long-term storage under unfavorable conditions affects viability and vigour. Accelerated ageing, involving high temperature and humidity, increases reactive oxygen species (ROS), causing oxidative stress and lipid peroxidation. Antioxidant enzymes like catalase, ascorbate peroxidase, and superoxide dismutase play a role in mitigating these effects.

**Materials and Methods**

The study was conducted at the Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.) during 2024-25. Sorghum seeds (variety CoFs-31) were subjected to accelerated ageing using a water-jacketed chamber. Seeds were placed on trays inside plastic boxes with 40 ml water, incubated at 45°C and 95±5% RH for 24, 48, 72, and 96 hours. After treatment, seeds were air-dried and evaluated for:

* Germination (%)
* Seedling length (cm)
* Seedling vigour index (SVI)
* Field emergence (%)
* Electrical conductivity (EC, µS cm⁻¹)

A completely randomized design (CRD) with four replications was used. Data were analyzed using SPSS v16.0. Differences among treatments were assessed using Duncan’s Multiple Range Test (DMRT) at P < 0.05. Percentage and lower values were arc-sine transformed before analysis.

**Results and Discussion**

The results of the present investigation clearly demonstrate that accelerated ageing significantly impairs the physiological quality of sorghum seeds. The magnitude of deterioration increased progressively with prolonged exposure. A significant reduction in germination percentage was observed, declining from 88.50% in unaged control seeds to 53.50% after 96 hours of ageing. This trend indicates a direct relationship between exposure duration and seed viability decline. Similar reductions were reported in cotton and wheat by Ahmad et al. (2021) and Kumar and Tripathi (2022), respectively.

Seedling length and seedling vigour index (SVI) also followed a similar decreasing pattern, with seedling length reducing from 38.58 cm to 29.02 cm and SVI from 3423 to 1553 across the treatments. The decline in seedling growth parameters is attributed to impaired metabolic activity and enzymatic efficiency in aged seeds, aligning with findings in garden pea and pearl millet (Sharma et al., 2023; Singh et al., 2021).

Field emergence, a critical indicator of seedling establishment potential, significantly declined with ageing. The emergence dropped from 86.75% in fresh seeds to 54.50% after 96 hours of accelerated ageing. These results support similar conclusions by Rajan and Thomas (2024) and Sharma et al. (2021), who highlighted the practical implications of ageing on field performance.

Conversely, electrical conductivity (EC) of seed leachates exhibited a consistent increase with extended ageing duration, rising from 750 to 1080.50 µS cm⁻¹. This increase indicates greater membrane permeability and solute leakage, a hallmark of membrane deterioration. Elevated EC readings confirm that oxidative damage during accelerated ageing affects membrane integrity, corroborating the observations by Yadav et al. (2023) and Patel and Reddy (2023).

Overall, the physiological and biochemical evidence supports that accelerated ageing effectively simulates natural seed deterioration and provides a reliable framework for assessing varietal storability, seed vigour, and field performance.

Table 1, Table 2):

Germination declined from 88.50% to 53.50% after 96 hours.

Seedling length decreased from 38.58 cm to 29.02 cm.

SVI dropped from 3423 to 1553.

Field emergence declined from 86.75% to 54.50%.

EC increased from 750 to 1080.50 µS cm⁻¹.

These findings align with prior studies confirming that accelerated ageing mimics natural seed deterioration and is a reliable predictor of seed storability.

**Table 1. ANOVA for physiological parameters of aged sorghum seeds**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Source** | **df** | **Germination (%)** | **Seedling Length (cm)** | **SVI** | **Field Emergence (%)** | **EC (µS cm⁻¹)** |
| Treatment | 4 | 323.97\*\* | 58.53\*\* | 2,103,481\*\* | 253.38\*\* | 84,579.95\*\* |
| Error | 15 | 7.30 | 1.35 | 40,211 | 3.33 | 741.92 |

\*\* Significant at P < 0.01

**Table 2. Influence of accelerated ageing on physiological parameters**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ageing Duration | Germination (%) | Seedling Length (cm) | SVI | Field Emergence (%) | EC (µS cm⁻¹) |
| 0 h | 88.50ᵢ | 38.58ᵢ | 3423ᵢ | 86.75ᵢ | 750.00ᵢ |
| 24 h | 75.25ᵣ | 36.06ᵣ | 2714ᵣ | 72.25ᵣ | 787.50ᵣ |
| 48 h | 68.50ᵤ | 33.97ᵤ | 2328ᵤ | 67.25ᵤ | 960.00ᵤ |
| 72 h | 61.75ᵥ | 31.03ᵥ | 1915ᵥ | 62.25ᵥ | 1023.75ᵥ |
| 96 h | 53.50ᵦ | 29.02ᵦ | 1553ᵦ | 54.50ᵦ | 1080.50ᵦ |

Different superscripts (a, b, c...) within columns indicate significant differences at P < 0.01 (DMRT).

**Conclusion**

The present study concludes that accelerated ageing leads to a progressive and measurable decline in the physiological quality of sorghum seeds. Prolonged exposure to high temperature and humidity significantly reduces germination, seedling length, seedling vigour index, and field emergence, while increasing electrical conductivity due to membrane damage. These findings validate the use of accelerated ageing as an effective method for evaluating seed storability and performance. The study also emphasizes the need to select and promote sorghum varieties with higher resistance to ageing stress for sustainable cultivation and better seed longevity.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing interests

Author has declared that no competing interests exist.

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