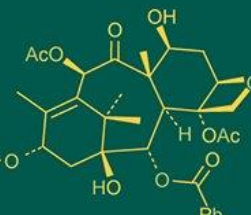
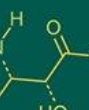
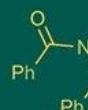


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Evaluating the effect of storage time and packaging materials on the quality of foxtail millet (*Setaria italica* (L.) P. Beauv.) seeds

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Abstract

This study aimed to assess the effect of storage duration and packaging materials on the seed quality of foxtail millet (*Setaria italica* (L.) P. Beauv.). The three seed lots were stored in jute and HDPE bags for up to 12 months under ambient conditions. Seed quality parameters, including germination, seedling length, seedling dry weight, vigor indices, seed moisture content, and seedling emergence, were recorded at monthly intervals. The results showed a progressive decline in all parameters with prolonged storage duration. HDPE bags constantly maintained superior seed quality compared with jute bags. Genotypes V₁ and V₂ demonstrated enhanced storability. The study mentions the use of HDPE packaging for short-to medium-term seed storage to lessen deterioration and maintain field efficacy.

Keywords: Foxtail millet, seed quality, storage period, packaging material, germination, seed vigour

Introduction

Foxtail millet (*Setaria italica* (L.) P. Beauv.) is a vital climate-resilient crop mainly cultivated in Asia, particularly in India and China. It is highly valued for its rich nutritional composition, which includes elevated levels of protein, dietary fiber, and micronutrients. Its importance is increasing under millet promotion initiatives because of its adaptability to marginal soils, minimal water requirements, and short growing seasons (FAO, 2021) [12]. Seed quality is essential to ensure a robust crop stand and yield. However, seeds tend to deteriorate during storage, leading to reduced germination, vigor, and field performance. Factors such as seed moisture, temperature, packaging material, and storage duration influence seed longevity (Ellis and Roberts 1980; Copeland and McDonald 2001) [1, 2]. Among these, storage period and packaging are manageable and critical for farmers. Jute bags are commonly used, but permit moisture fluctuations and pest entry. High-Density Polyethylene (HDPE) bags are less permeable and mitigate seed deterioration by limiting moisture ingress and microbial growth (Singh *et al.*, 2014; Rao & Sreevani, 2010) [5, 6, 8]. Previous studies on cereals, such as maize, pearl millet, and wheat, have demonstrated that extended storage results in declines in seed vigor, enzymatic activity, and seedling performance (Bewley *et al.*, 2013; Basra *et al.*, 2003) [3, 4]. However, limited research has been conducted on foxtail millets under ambient storage conditions. Therefore, this study aimed to evaluate the effect of storage period (0 to 12 months) and packaging materials (Jute and HDPE bags) on the seed quality parameters of three seed lots of foxtail millet up to IMSC level (75%). Observations included germination, seedling traits, vigor indices, seed moisture, and pot emergence to assess storage potential and recommend suitable practices.

Materials and Methods

This study assessed the effect of storage duration and packaging materials on the seed quality of foxtail millet (*Setaria italica* L.). Three seed lots, V₁ (DHFT109-3), V₂ (IIMR/2023/R/4), and V₃ (IIMR/2023/R/6), were packaged in jute and HDPE bags and stored under ambient conditions (25-30 °C, 50-70% RH) for 12 months at STR, RARI, Durgapura. The seed samples were evaluated at intervals of monthly up to 12 months. The recorded parameters included germination percentage, first count percentage, seedling length (cm), dry weight

(mg), seedling vigor indices I and II, moisture content percentage, and pot emergence. Germination was assessed using the top-of-paper method, with four replications of 100 seeds each. Seedling traits were recorded for ten normal seedlings. The dry weight was determined after oven-drying at 80 °C for 24 h. Vigor indices were calculated as germination multiplied by either seedling length or dry weight. The pot tests involved 50 seeds per pot, with emergence recorded at 30 d. Data were analysed using a Completely Randomized Design (CRD) with analysis of variance (ANOVA), and significance was determined at $p < 0.05$.

Results

This study demonstrated that both the storage duration and the type of packaging material significantly influenced the seed quality parameters of foxtail millet. The decline in seed performance became increasingly apparent with prolonged storage, with HDPE bags consistently outperforming the jute bags. The initial percentage count was highest at 0 months (mean: 93.42%) and gradually declined over time. The results indicated that storage periods led to a decline in most seed viability parameters under laboratory conditions. However, the effect of varieties on seedling length, fresh seedling weight, dry seedling weight, seedling vigor index I, and seedling vigor index II was found to be significant under laboratory conditions.

The results revealed that the germination percentage of 8-month-old seed lots declined below the IMSCS standard (75%) in Jute Bags for the variety V_1 (74.75%), whereas in HDPE Bags, the germination percentage dropped below IMSCS after 10 months (74.25%) in the same variety. The reduction in germination over the 9-month storage period was 23.58% in Jute Bags and 24.05% in HDPE Bags in 11 months (Fig. 1).

For V_2 , the germination percentage of 10-month-old seed lots declined below IMSCS (74.00%) in Jute Bags, while in HDPE Bags, the germination percentage fell below IMSCS at 12 months (68.12%). Over the same period, germination was reduced by 24.50% in Jute Bags (at 10 months) and 25.75% in HDPE Bags (at 12 months). Whereas in V_3 , germination fell below IMSCS level at 10 months in both Jute Bags (74.25%) and HDPE Bags (67.25%) at 12 months, with reductions of 22.83% in Jute Bags in 10 months and 30.21% in HDPE Bags in 12 months of the storage period.

Additionally, first count percentage, seedling growth (Fig.2), seedling vigor index I & II (Fig. 3), and seed moisture content (%) and in-pot observations declined with increasing storage duration.

Among the varieties

- V_3 performed best, maintaining $\geq 75\%$ (germination for 11 months in both jute & HDPE Bags.

- V_2 also maintained $\geq 75\%$ (IMSCS level) germination for 11 months in HDPE Bags, making it a viable alternative.
- V_1 should be used within 10 months in HDPE Bags and 8 months in Jute Bags for optimal germination.

HDPE Bags proved to be the best option for seed storage due to their better moisture control, reduced oxidation, pest protection, temperature stability, and prolonged germination viability. They are highly recommended for storing Foxtail millet and other seeds where maintaining seed quality over time is crucial.

Whereas after 12 months, it declined to 63.75% in jute bags and 67.25% in HDPE bags. The final plant stand exhibited similar trends, decreasing from 85.75-86.75% to 62.75-68.00%. HDPE bags maintained a better stand and emergence across all three genotypes. The reduction in emergence and stand can be attributed to physiological aging and diminished metabolic activity in the aged seeds.

Discussion

The present study demonstrated that both storage duration and packaging material significantly influenced seed quality in foxtail millet. Seed germination, first count, seedling growth, vigor, and field emergence declined progressively with increasing storage period due to physiological and biochemical deterioration associated with seed aging (Ellis & Roberts, 1980; Bewley *et al.*, 2013) [1, 3]. Seeds stored in HDPE bags consistently maintained higher germination, vigor, and seedling growth than those stored in jute bags because of reduced moisture and oxygen exchange, confirming the superiority of moisture-proof packaging (Singh *et al.*, 2014; Rao & Sreevani, 2010) [5, 6, 8]. Seedling Vigour Index-I and II also decreased steadily during storage, reflecting oxidative damage, reduced enzymatic activity, and impaired reserve mobilization (Basra *et al.*, 2003; Suma *et al.*, 2013) [4, 10]. Seed moisture content gradually declined throughout storage, with HDPE bags retaining moisture more effectively than jute bags, whereas excessive moisture loss in jute bags accelerated seed deterioration and reduced viability (Vertucci & Farrant, 1995; Sereme *et al.*, 2008) [11, 9].

Pot studies further confirmed that prolonged storage reduced seedling emergence and final plant stand, while HDPE-stored seeds exhibited superior establishment owing to better maintenance of physiological integrity (Kader *et al.*, 2005). Among the two genotypes, V_1 and V_3 showed comparatively better storability, indicating genotypic variation in seed longevity (Agrawal & Dadlani, 1987) [13]. Overall, the findings clearly indicate that HDPE bags are more effective than jute bags in preserving the viability, vigor, and overall seed quality of foxtail millet under ambient storage conditions.

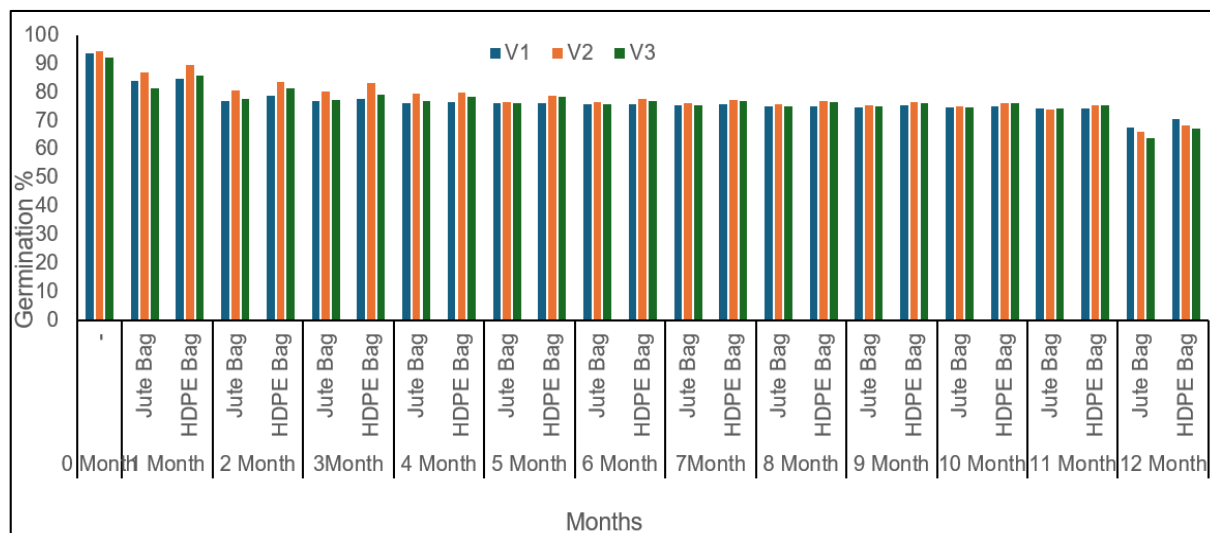


Fig 1: Effect of storage periods of seed lots of Foxtail millet on germination (%) at laboratory conditions

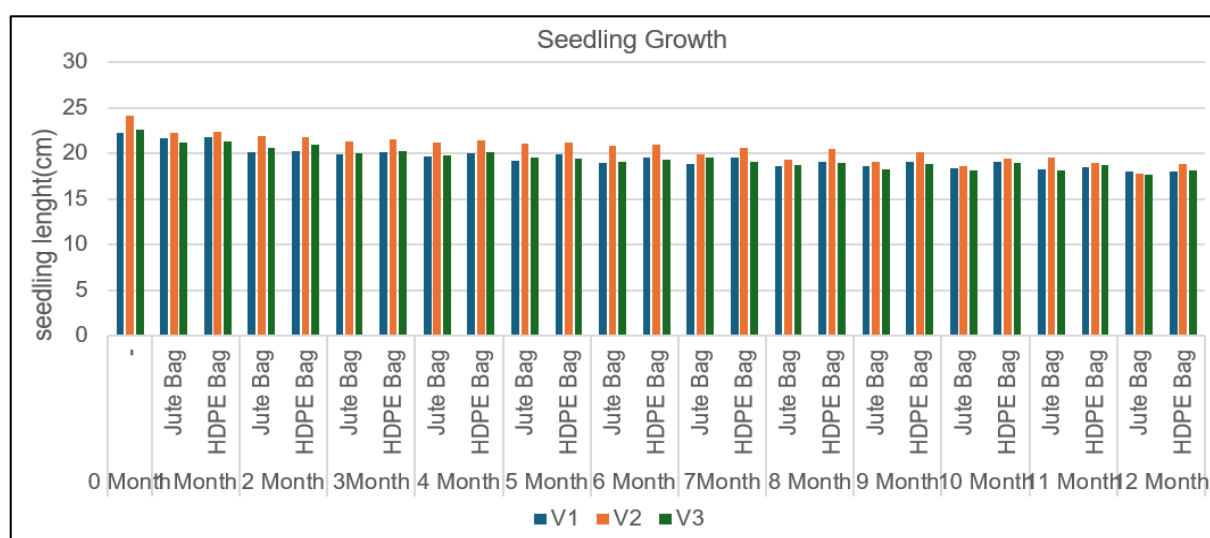


Fig 2: Effect of storage periods of seed lots of Foxtail millet on seedling growth (cm) under laboratory conditions

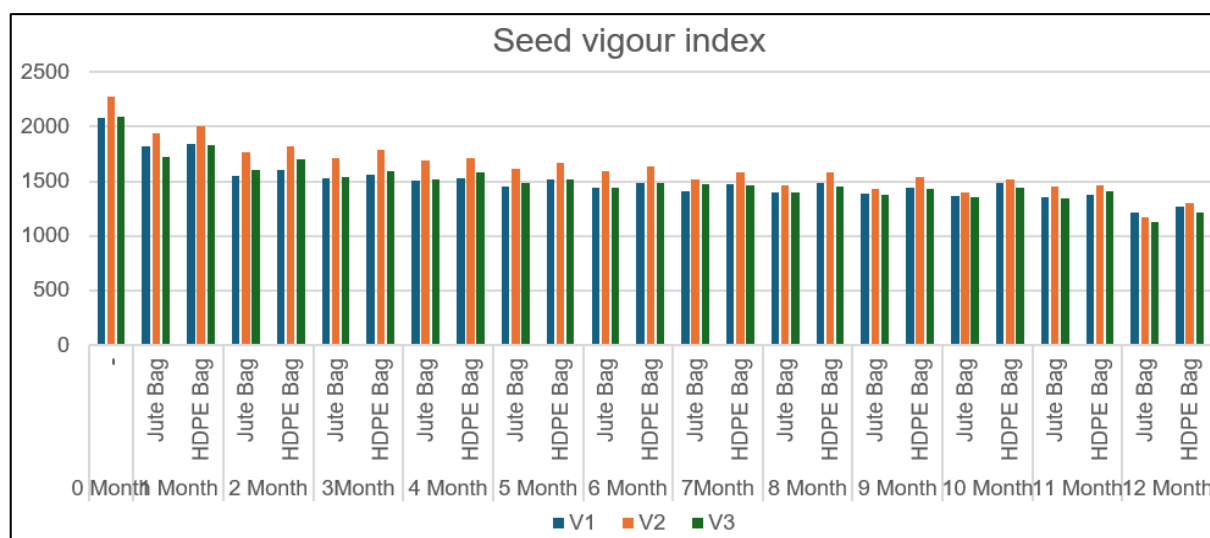


Fig 3: Effect of storage periods of seed lots of Foxtail millet on SVI under laboratory conditions

Conclusion

This study conclusively demonstrated that foxtail millet seeds are susceptible to a decline in viability and vigor during prolonged storage under ambient conditions. It is

recommended that foxtail millet seed storage, HDPE Bags provide superior protection and V₂ and V₃ are the best varieties for long-term storage, maintaining $\geq 75\%$ germination as IMSCS level up to 11 months of storage.

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