

Effect of Varying Storage Temperatures, Packaging Materials and Genotype differences on Kenaf Seed Viability and Longevity

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ABSTRACT

Storage of kenaf seeds at different temperatures significantly affects their viability and physicochemical properties. Partitioning the effects of varying storage temperatures on kenaf seeds is important for maintaining seed quality and ensuring successful cultivation. The study was conducted in the Seed Laboratory of the Forestry Research Institute of Ghana (FORIG) at the Council for Scientific and Industrial Research (CSIR), Fumesua, to evaluate germination of five kenaf genotypes (EB11, EN11, HN11, PN11, TN11) stored in hermetic glass containers, polybag and raw base over six months under varying temperatures (-10°C, 5°C and 25°C). The study demonstrated that temperature remains the primary determinant of kenaf seed preservation, with ambient condition (25°C) emerging as clearly optimal for maintaining viability for medium term raw storage. Although genotype differences were observed particularly in the superior heat tolerant genotypes EB11, EN11, PN11 and HN11, some factors remain secondary. Cold storage (-10°C) in combination with glass or polybag does not promote kenaf seed longevity (0-20% germination) across kenaf genotypes, specifically TN11 and EB11. Likewise low temperature of 5°C is slightly unfavourable for a medium term (6 months) glass and nonpackaged storage. However, nonpackaged storage at 25°C proved effective for medium term storage (6 months) evident in four kenaf genotypes (EB11, EN11, PN11 and HN11) with high germination rates of above 70% for all.

Keywords: varying temperatures, kenaf genotypes, package materials, storage duration

ISSN: 0855-6350

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INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) is a versatile plant grown for its fibre, which is utilised in various sectors such as textiles, paper and biocomposites (Ayadi *et al.*, 2017). Literature has demonstrated the economic significance of kenaf in textile, paper and composite industries, yet mass production faces persistent seed quality and storage challenges. Under typical storage conditions, the seed experiences rapid deterioration and sensitivity to environmental factors, which limits farmers' ability to maintain reliable planting stock. During storage, the temperature and relative humidity of the storage area fluctuate, which results in accelerated physiological and biochemical degradation (Adebisi *et al.*, 2014).

The storage of kenaf seeds at different temperatures significantly affects their viability and physicochemical properties. Understanding the effects of storage at 5°C, 25°C and -10°C on kenaf

seeds is important for maintaining seed quality and ensuring successful cultivation (Meints and Smith, 2003).

Studies have suggested that kenaf seeds in storage show a noticeable drop in germination over time. This decrease in viability is linked to increased metabolic activity and moisture levels at higher temperatures (Adebisi *et al.*, 2014). Providing good storage environment for kenaf seeds help retain their physicochemical properties better than those stored at higher temperatures (Adebisi *et al.*, 2014). The longevity and viability of kenaf seeds are vital for successful cultivation and achieving high yields (Meints and Smith, 2003). The choice of packaging materials plays an important role in preserving seed quality during storage. Polybags and glass jars are among the common materials studied for their effect on storing kenaf seeds (Islam *et al.*, 2023). The type of packaging used significantly affects the viability and longevity of kenaf seeds. Polybags, which are made of polyethylene, are commonly used due to their low cost and availability. They create a favourable microenvironment that helps maintain germination and the physicochemical state of kenaf seeds over time. Seeds stored in polybags at 4°C showed better germination and lower fungal infection than when stored using other packaging types (Islam *et al.*, 2023) (Victoria *et al.*, 2020).

In comparison, glass jars offer a more controlled environment that protects seeds from external influences such as humidity and temperature variations. Because glass jars are impermeable to gas and moisture, they also help preserve seed viability and longevity. Kenaf seeds stored in glass jars under ambient conditions were found to retain germination ability and physicochemical quality better than those in polybags. Kenaf seed stored under ambient temperature with glass jar retains longer germination ability might not necessarily apply to all kenaf varieties. The interplay of temperature fluctuations, packaging materials and varietal differences on kenaf seed viability and longevity remains poorly understood; a possibility for threat in seed conservation. (Adetumbi, 2019).

The kenaf seed contains high oil content that ranges from 21.4% to 26.4%, making the seed susceptible to oxidation and rancidity during storage (Webber and Bledsoe, 2002). This is because the interaction between storage conditions and these intrinsic biochemical characteristics often creates an unpredictable viability pattern (Esuruoso, 2010). As such, controlled storage temperature has been documented to preserve seed viability, maintain significantly higher germination percentages and lower physiological deterioration compared to ambient temperatures (Olasoji, *et al.*, 2012).

Studies have shown that the kenaf seed's germination potential declines significantly within a relatively short period of storage under ambient conditions (Adebisi *et al.*, 2014; Esuruoso, 2010). Research by Adebisi *et al.* (2014) recommended that kenaf seed should not exceed 180 days in storage when the temperature ranges from 27.5°C to 29.8°C and the relative humidity is between 59.10% and 64.68%, to maintain quality. This is concerning for farmers and kenaf seed producers as the seeds may lose quality from an initial value above 80% to below 60% within a single storage period (Islam *et al.*, 2023). There are economic losses to farmers when their stored seed germinates inadequately, resulting in reduced crop stands that compromise potential yield. There are, however, variations in the storage performance based on different kenaf varieties (Adebisi *et al.*, 2014; Esuruoso, 2010) and temperature.

As temperature and humidity are critical, the materials used to package these seeds are another variable to consider. Existing literature presents conflicting findings on optimal container types for seed storage across different environments. Islam *et al.* (2023) studied plastic pots, polythene bags,

cloth bags and earthen pots as storage containers over 120 days reporting the highest germination rate (81.6%) in plastic pots with a field emergence of 72.3% with earthen pots as the least performing container having germination potential and field emergence of 56.0% and 53.3%, respectively. In contrast, other researchers found jute bags to produce the lowest seed deterioration rates for two varieties (Cuba 108: 18.03%, Ifeken 400: 17.87%), under ambient conditions (Oluseyi *et al.*, 2024). These contradictory findings suggest a need for comprehensive understanding of interactions between container properties, storage environment and seed genotype to guide in selecting the right packaging material (Akinbode *et al.*, (2022).

Optimal use of different packaging materials depends on a comprehensive understanding of interactions between container properties, storage environment and seed genotype. Information on packaging materials and their interaction with varying temperatures among native varieties are yet to be seen in recent space of research publications, hence this current investigation. This study, therefore, investigate the effects of varying storage temperatures, packaging materials and genotype differences on kenaf seed viability and longevity.

The objective of this study was to evaluate varying temperatures, package materials, genotype differences and storage duration on longevity of kenaf seeds.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the Seed Lab of the Forestry Research Institute of Ghana (FORIG), Council for Scientific and Industrial Research (CSIR), Fumesua.

Experimental design for kenaf seed storage

The experiment was conducted using a completely randomised design (CRD) incorporating three factors in a 3 x 3 x 5 factorial arrangement. These factors included three storage temperatures, three types of packaging modes, storage duration and five kenaf genotypes. The storage temperatures used were 10°C, 5°C and 25°C. The packaging materials consisted of polybags, hermetic glass jars and nonpackaged samples (control) . Kenaf seeds were stored for a total duration of six months. Each treatment was replicated three times. For each genotype, 20 seeds were used in the standard germination test and the test was carried out in three replications.

Data collection and analysis

At the end of the storage period of six months, seeds placed in the incubator were observed daily for germination up to day six until no further germination occurred. Germination percentage data was recorded for each genotype under the different treatment conditions and documented in Microsoft Excel spreadsheets. Results were analysed using R data analysis tool version R4.3.2 released in 2023.

RESULTS

Effect of Varying Storage Temperatures and Packaging Materials on Seed Longevity and Viability

Raw storage (-10°C, 5°C and 25°C) and effect on germination

The results in Figure 1 and plates 1-3 show the trajectory of germination rates of different kenaf varieties (EB11, EN11, HN11, PN11, TN11) at 6-month nonpacked storage period under varying

temperatures (-10°C, 5°C and 25°C). At -10°C, germination remained relatively low for genotypes EB11, PN11 and TN11 (10-15%) while EN11 and HN11 showed higher (70%) germination percentage for the same storage temperature. At a temperature of 5°C, raw storage had germination percent range of 5-50% for all genotypes (EB11, PN11, TN11, HN11 and EN11) while at 25°C germination was progressively higher to 70% for four genotypes (EB11, EN11, PN11 and HN11) with the exception of TN11 which declined from 30-5% suggesting reduced viability in 25°C storage conditions with respect to the 6 months duration.

In contrast, -10°C storage temperature causes a sharp drop in germination, particularly after 6 months, demonstrating that at 100°C or below severely degrade seed viability. Genotype differences, which affect longevity of seed relative to viability are evident (EB11, PN11 and TN11) being low at cold storage. In all the above temperature regimes, germination rate is higher at day 0-3 and becomes constant from at least day 4 where the lines flatten up to day 6.

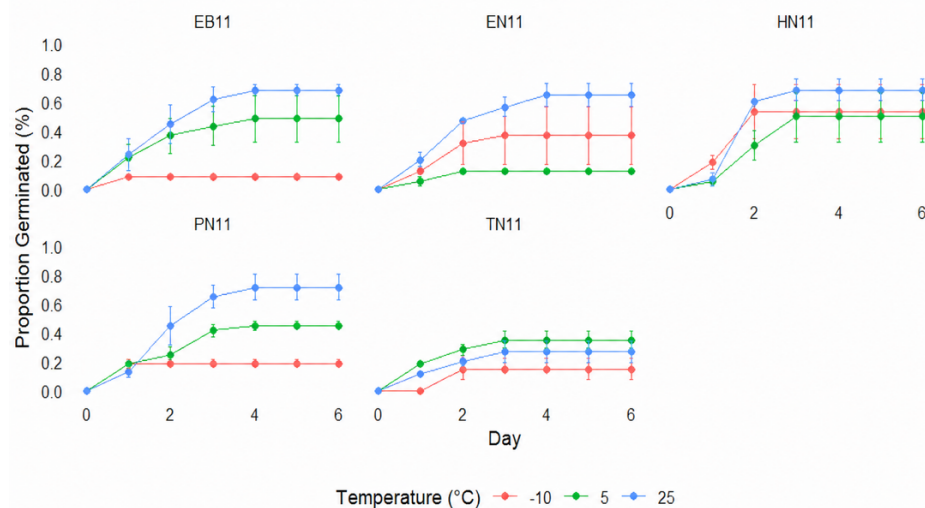


Figure 1: Effect of varying temperatures and 6-month storage duration nonpackaged storage of kenaf seed per genotype



Plate 1: Hermitic glass, Polybag, nonpackaged storage at 25°C up to the 6th month



Plate 2: Hermitic glass, Polybag, nonpackaged storage at -10°C up to the 6th month



Plate 3: Hermitic glass, Polybag, nonpackaged storage at 5°C up to the 6th month



Plate 4: Laboratory germination test in response to the storage treatments

Germination of kenaf seeds in glass storage at temperatures -10°C, 5°C and 25°C

Figure 2. shows the germination performance of five kenaf varieties (EB11, EN11, HN11, PN11, TN11) stored in glass containers over six months at three temperatures (-10°C, 5°C and 25°C).

At -10°C glass storage, all genotypes maintained minimal decline in germination rates (10-30%) with HN11 as the least and EN11, which was slightly high. Glass storage at 5°C resulted in slightly high germination percentage (20-50%) at the end of 6th month for genotypes EN11, EB11 and TN11 while 50% germination was constant for same genotypes from day 4-6. However, 25°C glass storage caused a steep increase in germination for HN11 (70%) and PN11 (50%) by month 6. Genotype difference show that glass storage of kenaf seeds at 25°C is favourable for HN11 especially for medium term duration.

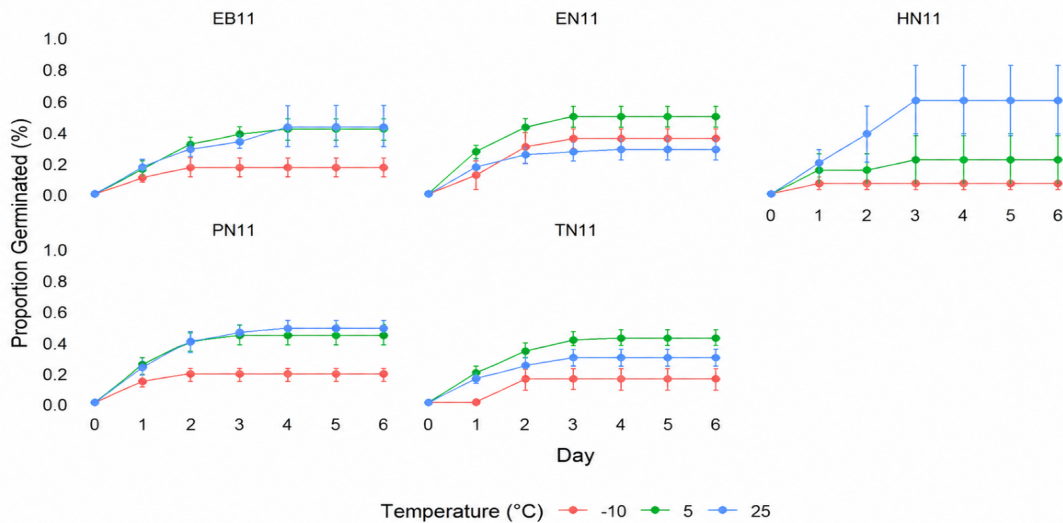


Figure 2: Impact of glass storage on kenaf seed germination at varying temperatures up to 6 months

Polybag storage and temperatures -10°C, 5°C and 25°C

The graph in Figure 3 illustrates the germination trends of five kenaf genotypes (EB11, EN11, HN11, PM11, TN11) stored in polybags over six months at three temperatures (-10°C, 5°C and 25°C).

At -10°C, germination percent remained consistently low (0-20%) across all varieties, specifically TN11 and EB11 (10%), respectively, leading to degradation of seed preservation in polybags under freezing conditions. Polybag storage at 5°C also led to a gradual decline in kenaf seed viability (5-40%) by month 6. Polybag seeds stored at 25°C exhibited a sharp drop in germination (0-30%) over the same period.

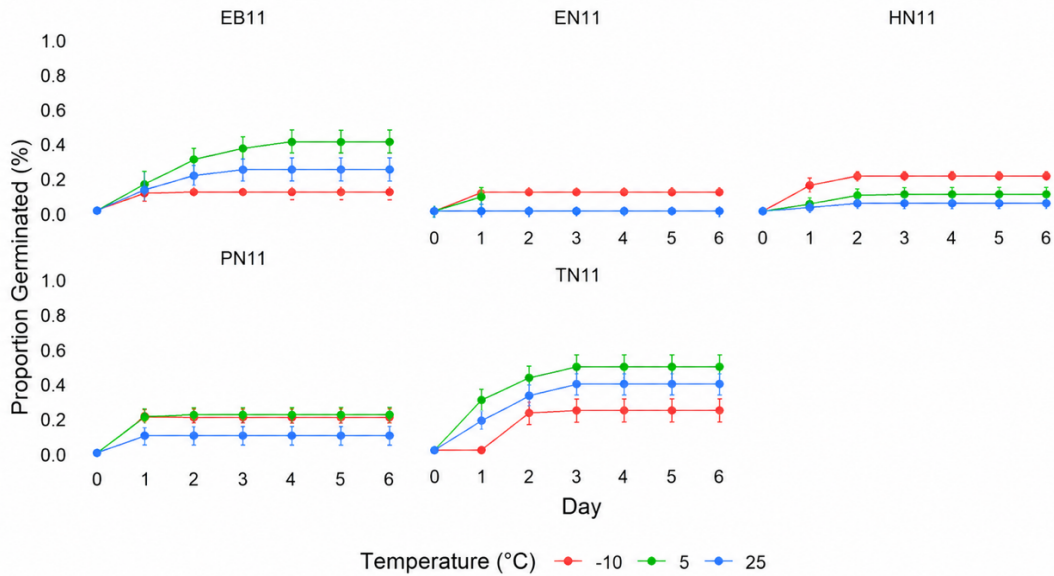


Figure 3.: Impact of polybag storage on kenaf seed germination at varying temperatures for 6 months

Summary bar plot on effect of packaging materials and varying temperatures on germination of kenaf seed stored for six months

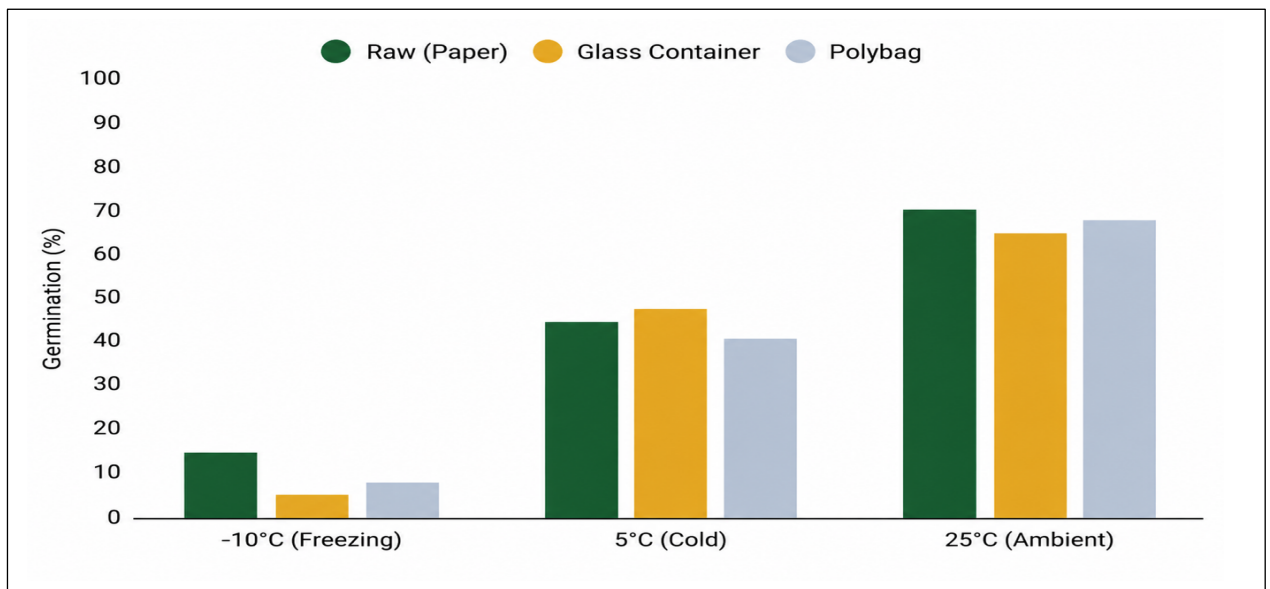


Figure 4 Summary bar plot on effect of packaging material and varying temperatures on germination of kenaf seed stored for six months

From Figure 4 summary analysis on the bar chart, it can be observed that all the seed stored under freezing (-10 °C) and cold temperatures (5°C) deteriorated with germination percent below 50% for 5°C and 15% for -10°C. Ambient temperature of 25°C was favourable for all packaging materials, duration of storage and genotype germination capacity. All genotypes maintained their viabilities ranging from 65-72% for the same storage duration. In ranking the high performing packaging material with respect to prolonged kenaf seed viability, raw storage appeared to be the best followed by polybag and then hermitic glass.

DISCUSSION

Seed viability, to a large extent, is dependent on the variety of the seed under study and the degree to which variety itself can withstand environmental stressors (Bewley and Black, 2014). In this study, temperature appears to be a critical determinant of germination success throughout the period of six months.

At -10°C, all varieties observed declining germination percentages, irrespective of storage material. This is in contravention of the studies that have reported that storing kenaf seeds at lower temperatures such as -10°C helps preserve their viability over longer periods (Meints and Smith, 2003). In contrast, storage at 5°C resulted in moderate germination declines. This indicated that while cooler temperatures were superior to ambient conditions, they were insufficient for long-term seed preservation, as metabolic processes, though slowed, persist and gradually degrade seed quality, a trend also observed in tropical seeds (Adebisi *et al.*, 2014). Storage at 25°C caused a slight viability drop, particularly after six months, highlighting impact of elevated temperatures on seed vigour. This aligned with research on heat-sensitive crops, where prolonged warmth accelerated oxidative damage, disrupted cellular membranes and depleted energy reserves, leading to irreversible loss of germination capacity (Bewley and Black, 2014; Tang *et al.*, 2019).

Temperature affects key physiological processes, including enzyme activation, water uptake, hormonal balance and other variety-specific requirements. As evidenced by electrical conductivity measurements of aged seeds, elevated temperature results in solute leakage due to increased membrane permeability (Gu *et al.*, 2024). Higher temperatures accelerate oxidative damage and lower temperature slows down the reaction, but do not eliminate it completely. Thus, when temperature is too low, there is slowed metabolism and germination is delayed (Bewley and Black, 2014).

The pronounced sensitivity of kenaf seeds to low temperatures demonstrated the need for controlled storage to maintain viability with 5°C in glass and 25°C nonpackaged storage, respectively, as a reliable method for medium term preservation of kenaf seeds. The differential response of the different kenaf genotypes to freezing stress suggested possible variations in lipid composition, which determines the membrane fluidity (Wolfe *et al.*, 2002). These temperature-dependent responses, not only reflect universal principles of seed physiology, but also emphasised the vulnerability of tropical species such as kenaf to thermal stress, necessitating tailored storage protocols to mitigate viability loss. This is similar to outcomes reported by Adebisi *et al.*, (2014) that under ambient tropical conditions, storage period cannot exceed 6 months to maintain higher physiological quality. This also confirms why EN11, EB11 and TN11 at lower temperatures of 5°C showed moderate germination irrespective of storage material.

For glass jars and polybags, performance at 5°C resulted in higher germination than 10°C. However, at 25°C, seeds stored in both glass and polybag showed significant difference in glass (maximum 70%) than polybag (maximum 30%). This aligns with earlier works suggesting that hermetic containers like glass jars could prolong seed longevity by mitigating moisture fluctuations (Bakhtavar and Afzal, 2021). The moisture barrier properties of glass prevent moisture uptake from ambient environment by maintaining stable moisture content throughout storage (Bakhtavar and Afzal, 2021). The maintenance of low and stable moisture content by the glass is paramount to seed longevity. Moreover, the superior performance of glass at 25°C aligns with the “dry chain” mechanism where seed is kept at low moisture content from harvest to storage, which is an important factor in preserving the viability of seeds under nonfreezing temperatures.

However, raw storage at 25°C proved effective for medium term storage (6 months) evident in four kenaf genotypes (EB11, EN11, PN11 and HN11) with high germination of 70%.

The study revealed distinct varietal responses to storage conditions, which highlighted the importance of genetic factors in seed preservation. Genotypes EB11, EN11, PN11 and HN11 demonstrated superior heat tolerance, particularly in raw storage, maintaining higher germination rates at elevated temperatures, compared to TN11. This enhanced resilience likely stems from genetic adaptations such as antioxidant systems or protective seed coat characteristics that mitigate oxidative stress. Several biochemical markers were reported, including elevated antioxidant levels, as key contributors to seed longevity in kenaf, like other tropical seeds. Another is the lipid composition, accumulation of late embryogenesis abundant (LEA) protein, heat shock proteins, or dehydrins that provide a stable cellular structure to prevent temperature stress. Moreover, the slow deterioration rate could be the effect of thicker and less permeable seed coats of these varieties that reduces effects of environmental fluctuations on the internal structure.

In contrast, TN11 exhibited pronounced sensitivity to 25°C storage, with rapid viability loss. This demonstrated structural or metabolic vulnerabilities, such as weaker membrane integrity or reduced stress-response mechanisms. These results aligned with broader research on heat-sensitive crops (Bewley and Black, 2014), where varietal differences in thermal tolerance were often linked to cellular defense capacities as observed in soybeans, where the effects were mapped to a specific genomic region (Okunlola *et al.*, 2020).

The findings are also consistent with those of other tropical and subtropical seeds, reinforcing the generality of temperature-dependent seed deterioration. For instance, Islam *et al.* (2021) observed analogous viability loss in jute seeds (*Corchorus* spp.), with optimal preservation achieved at -20°C, which is similar to the efficacy of sub-zero conditions for kenaf. Similarly, Tekrony *et al.* (1987) demonstrated that hermetic storage alone is not sufficient to preserve soybean seeds without concurrent low temperatures, supporting this study's finding that material effects were secondary to thermal effects (Groot *et al.*, 2015).

In the context of kenaf storage, a study by Olasoji *et al.* (2012) observed that harvesting timing affects storage performance with seeds harvested at 5 weeks showing higher germination and storability at 10°C as compared to earlier or later harvests were affected by temperature, packaging and genotype. While general principles of seed storage apply across species, crop-specific traits, particularly tolerance to environmental stressors must guide preservation strategies to ensure viability.

CONCLUSION AND RECOMMENDATION

The study demonstrates that temperature remains the primary determinant on kenaf seed preservation, with 25°C storage condition emerging as clearly optimal for maintaining kenaf seed viability for medium-term raw (ambient) storage. Although genotype differences were observed, genotypes EB11, EN11, PN11 and HN11 were not negatively influenced by ambient conditions (25°C).

Cold storage at -10°C in combination with glass or polybag does not extend kenaf seed preservation except for a shorter term. At the same temperature (-10°C), all varieties observed declining germination percentages, irrespective of storage material.

In contrast, storage at 5°C resulted in moderate germination declines. Low temperature of 5°C occur as slightly better for a medium term (6 months) raw and glass storages conditions suggesting that while cooler temperatures are superior to ambient conditions, they are insufficient for long-term kenaf seed preservation.

Future investigations should focus on elucidating the biochemical basis of genotype resilience, particularly the antioxidant pathways and seed coat properties that confer heat resistance, as well as examining potential interactions between moisture regulation and storage materials under different thermal regimes to optimise kenaf seed preservation strategies.

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