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Influence of nut size and storage duration on germination and survival of cashew seedling (*Anacardium occidentale* L.) var. V-4

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Abstract

To assess the "Influence of nut size and storage duration on germination and growth of cashew seedling (*Anacardium occidentale* L.) var. V-4," a study was carried out at the Horticultural Research Farm, Anand Agricultural University, Anand, Gujarat between May and October 2025. Three repetitions and twelve treatment combinations were used in the completely randomized design (factorial) study, which examined three nut sizes: N₁: Large (>8 g/nut), N₂: Medium (6-8 g/nut), and N₃: Small (<6 g/nut) across four storage durations: S₁: 30 days, S₂: 60 days, S₃: 90 days, and S₄: 120 days. Among the nut sizes, the large nut size yielded the highest values for germination (82.83%) and survival of seedlings (79.73%) as compared to the other nut sizes. Regarding the storage durations, the nuts stored for 60-days recorded the highest values for the germination (78.56%) and survival of seedlings (82.77%). The interaction effect revealed that the combination of large nut size and 60-day storage established the significant peak performance for the germination (95.6%). Therefore, the results of this study led to the conclusion that large nut size and a 60-day storage duration significantly enhance cashew germination and performance.

Keywords: *Anacardium occidentale*, cashew, nut size, storage duration, germination, survival, growth

Introduction

The cashew plant (*Anacardium occidentale* L.), which originated from north-eastern Brazil and was introduced to India in the 16th century by the Portuguese, primarily for soil conservation purposes. It is an evergreen perennial tree that belongs to the family Anacardiaceae, the same family as that of the mango, and is primarily grown for commercial sale and export, generating substantial revenue and employment. In the year 2024, India ranked 4th globally in the export of cashew nuts fresh/dried shelled and held a market share of 6.60% (Anonymous, 2024) [5]. In the year 2024-25, Gujarat had 14.423 thousand hectares under cashew cultivation with a total production of 7.304 thousand metric tons and an average productivity of 745 kilograms per hectare (Anonymous, 2026) [6].

Both sexual and asexual methods are used for propagating cashews. The softwood grafting technique is used for commercial propagation. Raising high-yielding rootstocks for successful graft production requires the use of seeds. Vengurla-4 (V-4) is frequently used as a rootstock and has a good grafting success rate. After harvesting, cashew seeds exhibit significant susceptibility to loss of viability and germination in tropical environments. As for the structure of seed quality management, two primary considerations determine the effectiveness of rootstock production. First, there are the seed nut's maternal traits, mainly its size; second, there are time-dependent elements of seed quality associated with the duration of storage.

The purpose of this study is to assess the effects of different nut sizes and storage periods at room temperature on cashew nut emergence and the resulting performance of Vengurla-4 (V-4) seedlings. Vengurla-4 is a high-yielding hybrid developed in the Regional Fruit Research Station in Vengurla, Maharashtra, specifically resulting from a cross between Midnapore Red and Vetore-56.

Materials and Methods

The experiment was conducted in the net house (50% shade) at the Horticultural Research Farm and Nursery, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, from May to October 2025. The experiment was laid out in factorial Completely Randomized Design (CRD) with three replications comprising three nut sizes-N₁: Large (>8 g/nut), N₂: Medium (6-8 g/nut), and N₃: Small (<6 g/nut) across four storage durations: S₁: 30 days, S₂: 60 days, S₃: 90 days, and S₄: 120 days. resulting in 12 treatment combinations. Each treatment consisted of 30 seeds per repetition.

Healthy seed nuts were stored in 11" × 8" (40-micron) polybags after being divided into three weight groups according to treatments. For internal aeration, it had eight tiny punctures. Depending on the treatment used, the storage period ranged from 30 to 120 days. It was carried out at ambient temperature (25 to 28 °C) with a relative humidity of roughly 60 to 70%. Two parts local soil, one part vermicompost, and one-part well-decomposed FYM (2:1:1 proportion v/v) were used to make the potting mixture for sowing the seeds. To enhance drainage, 5% of the polythene bags measuring 7" × 5" were pierced before being filled with this potting mixture. Sowing of seeds was done after soaking in tap water for 24 hrs and after sowing, regular watering was done along with the use of plastic mulch for early sprouting.

The following observations were taken for the research

- **Days taken to first sprout:** The number of days required for the first sprouting of the seeds was noted

when the seeds germinated. Data were collected from every repetition, and the average was calculated.

- **Number of Days required for 50% germination:** When 50% of the seeds germinated, the number of days needed for 50% germination was calculated. Data was collected from every repetition, and the average was calculated.
- **Germination (%):** The germination percentage was calculated after the final germination, i.e., after the stoppage of germination. It was calculated by counting the number of seeds germinated out of the total number of seeds sown in polythene bags for every repetition, and the average was calculated. The germination% was calculated based on the following formula:

$$\text{Germination\%} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

- **Survival percentage of seedlings:** Survival percentage of seedlings was calculated at 60 days after sowing. Data was collected from every repetition, and the average was calculated. It was calculated by the formula given below.

$$\text{Survival \% of seedlings} = \frac{\text{Number of seedlings survived}}{\text{Number of seeds germinated}} \times 100$$

Results and Discussion

Days taken to first sprout

The mean data on days to first sprouting as influenced by different nut sizes and storage durations are presented in Table 1.

Table 1: Effect of different nut sizes and storage durations on days taken to first sprout, number of days to 50% germination, germination% and survival% of the seedlings

Treatment	Days taken to first sprout	Number of days for 50% germination	Germination percentage	Survival% of the seedlings
Factor A: Nut size				
N ₁ : Large (>8 g/nut)	13.83	20.58	82.83	79.73
N ₂ : Medium (6-8 g/nut)	14.58	21.92	76.11	74.18
N ₃ : Small (<6 g/nut)	15.33	24.83	52.94	69.51
S.E.m.±	0.29	0.39	0.89	1.10
C.D. at 5%	0.84	1.15	2.60	3.22
Factor B: Storage duration				
S ₁ : 30 days	17.11	29.56	53.63	59.50
S ₂ : 60 days	12.33	18.00	78.56	82.77
S ₃ : 90 days	12.56	19.67	76.63	79.36
S ₄ : 120 days	16.33	22.56	73.70	76.28
S.E.m.±	0.33	0.45	1.03	1.27
CD at 5%	0.97	1.33	3.00	3.71
Interaction (N × S)	NS	Sig.	Sig.	NS
CV%	6.86	6.08	4.37	5.12

(NS: Non-significant, Sig.: Significant)

I. Influence of nut size

N₁ (>8 g/nut) recorded the significantly minimum days to first sprouting (13.83 days at par with N₂), whereas N₃ (<6 g/nut) recorded the maximum for first sprouting (15.33 days).

N₁ sprouted the fastest; this could be because its cotyledons contained more food reserves (proteins and carbs). To sustain the metabolic process required to fracture the shell and start the initial sprout, larger nuts often have greater resources available. Smaller nuts, on the other hand, most likely struggled with scarce resources, which caused a delayed emergence. These findings are consistent with those

of Aliyu and Akintaro (2007) ^[3], who found that larger nuts often have more vigor in cashews. In contrast, Oyewole and Koffa (2010) ^[14] and Adebisi *et al.* (2015) ^[1] found that small nuts appeared before large ones in cashews.

II. Influence of storage duration

For the storage duration, the data indicated that the seeds sown after 60 days of storage (S₂) recorded the significantly minimum days for first sprouting (12.33 days at par with S₃). Whereas the seeds sown after 30 days of storage (S₁) took the highest number of days for first sprouting (17.11).

After 30 days of storage, S₁ took the longest time to sprout. This could be because the seeds were subjected to heat stress (high temperature and low humidity in May), which can cause seed coat hardening that slows down water imbibition and embryo emergence. It can also cause secondary dormancy due to metabolic heat stress, which can slow down the enzymatic activities required for germination. The seeds that were sown 60 days after being stored were able to overcome the initial environmental stress and grow the earliest.

However, an additional delay in sprouting following 120 days of storage suggested that prolonged seed storage resulted in cellular aging and the depletion of food stores, which ultimately slowed down the sprouting process. According to Adebisi *et al.* (2015) ^[1], cashew seeds that were kept for a longer period of time required the most days to produce seedlings. The same was noted by Oyewole and Koffa (2010) ^[14] in cashew.

III. Interaction effect of nut size and storage duration

The interaction effect of nut size and storage duration (N×S) was found to be non-significant for the days taken to first sprout. But it was numerically lowest for N₁S₂ (large nuts with 60-day storage), indicating their better performance.

Number of days required for 50% germination

The average data on days to first sprouting, number of days to 50% germination and germination% as influenced by different nut sizes and storage durations are presented in Table 1.

Table 2: Interaction effect of different nut sizes and storage durations on germination% and number of days for 50% germination

Treatment	Germination%	Number of days for 50% germination
N ₁ S ₁	51.1	29.00
N ₂ S ₁	59.8	29.67
N ₃ S ₁	50.0	30.00
N ₁ S ₂	95.6	16.00
N ₂ S ₂	85.8	18.00
N ₃ S ₂	54.3	20.00
N ₁ S ₃	91.3	16.67
N ₂ S ₃	82.2	17.67
N ₃ S ₃	56.3	24.67
N ₁ S ₄	93.3	20.67
N ₂ S ₄	76.7	22.33
N ₃ S ₄	51.1	24.67
S.E.m.±	1.78	0.79
C.D. at 5%	5.20	2.30
CV%	4.37	6.08

III. Interaction effect of nut size and storage duration

The interaction effect of nut size and storage duration (N×S) was found to be significant for the number of days for 50% germination, and its values are given in Table 2. N₁S₂ registered the significantly least number of days for 50% germination (16.00 days at par with N₁S₃, N₂S₃ and N₂S₂). On the other hand, N₃S₁ yielded the highest days taken for 50% germination (30 days).

Due to the inadequate food supply of N₃ seeds and the combined effects of an unfavourable climate (high temperature and low humidity in May) following the sowing of seeds with S₁ storage (30 days), N₃S₁ achieved the highest number of days for 50% germination. The optimal physiology of the N₁S₂ seeds due to moderate storage and bigger food reserves led to the earliest 50% germination compared to the treatments with N₃ seeds. Oyewole and

I. Influence of nut size

N₁ (>8 g/nut) recorded the significantly minimum number of days to 50% germination (20.58 days), whereas N₃ (<6 g/nut) recorded the maximum days (24.83 days).

In comparison to the smaller nuts (N₃), which had a lesser food reserve, large nuts took the fewest days for 50% germination. This could be because N₁ had a larger reserve of nutrients and energy within the endosperm or cotyledons, giving it greater vigor and enabling it to emerge more quickly. Aliyu and Akintaro (2007) ^[3] and Mog *et al.* (2017) ^[12] found similar results in cashew, with the shortest germination time for large-sized nuts.

II. Influence of storage duration

For the storage duration, the data indicated that the seeds sown after 60 days of storage (S₂) recorded the significantly minimum days for 50% germination (18.00 days). Whereas the seeds sown after 30 days of storage (S₁) took the highest number of days for this (29.56 days).

S₂ took the fewest days to reach 50% germination. It might be because seeds kept for 60 days had the most optimal physiology for germination. Additionally, the scorching summer was the cause of the late 50% germination for 30-day-stored nuts, whereas cellular ageing and the depletion of food reserves may have contributed to the delay for 120-day-stored nuts. Similar findings were achieved by Gurung *et al.* (2014) ^[9] in passion fruit and Adebisi *et al.* (2015) ^[1] in cashew.

Koffa (2010) ^[14] found that bigger cashew nuts benefit more from storage than medium-or small-sized nuts, which is consistent with this relationship. Similar results were found by Gurung *et al.* (2014) ^[9] in passion fruit, Adebisi *et al.* (2015) ^[1] in cashew nut, and Prajapati *et al.* (2017a) ^[15] in acid lime.

Germination %

I. Influence of nut size

For the germination%, the data indicated that N₁ gave the significantly highest germination percentage (82.83%) and the lowest was recorded for N₃ with 52.94%.

This could be because the larger cashew seeds have more nutrient density and vigor, which gives them the necessary energy to overcome soil resistance and finish the germination process more efficiently than smaller, lighter

nuts. This supports research on cashew nuts by Adebisi *et al.* (2015)^[1] and Anjusha *et al.* (2015)^[4].

II. Influence of storage duration

For germination%, S₂ registered the significantly highest germination (78.56% at par with S₃). The lowest was by S₁ with 53.63%, followed by S₄ (120 days of storage), with 73.70%.

The lower germination values of 30-day stored nuts might be due to the adverse environmental conditions. While the better germination values were given after 60 days of seed storage, followed by the seeds stored for 90 and 120 days, because of the depletion of food reserves over time and the cellular ageing of the seeds. Khopkar *et al.* (2014)^[10] in pummelo, Adebisi *et al.* (2015)^[1] in cashew, and Purbey *et al.* (2018)^[16] in aonla gave similar results.

III. Interaction effect of nut size and storage duration

The interaction effect of nut size and storage duration (N×S) was found to be significant for the germination%, and its values are given in Table 2. N₁S₂ noted the significantly highest germination (95.6% at par with N₁S₄ and N₁S₃). On the other hand, N₃S₁ yielded the lowest germination (50%). Due to the limited food supply of N₃ seeds and the combined effects of an unfavourable climate (high temperature and low humidity in May) following the sowing of seeds with S₁ storage, N₃S₁ produced the lowest germination percentage. While the N₁S₂ seeds had larger food reserves than the N₃ seeds and optimum physiology due to moderate storage, this resulted in a better germination percentage. This interaction agrees with the conclusions of Oyewole and Koffa (2010)^[14] in cashew, who stated that large cashew nuts benefit more from storage as compared to medium or small-sized nuts.

Survival percentage of seedlings

The data related to the survival percentage of cashew seedlings collected at 60 DAS as influenced by different nut sizes and storage durations are presented in Table 2.

I. Influence of nut size

The percentage of cashew seedlings that survived was significantly impacted by nut size. At 79.73%, the N₁ seeds had the significantly greatest survival percentage, while the lowest (69.51%) was seen for N₃ seeds.

These findings were supported by Nnedu *et al.* (2019)^[13] & Konlan *et al.* (2014)^[11], who demonstrated that compared to lighter seed fractions, seedlings developed from larger cashew nuts exhibit greater physiological vigor, improved dry matter accumulation, and enhanced field survival capacities.

II. Influence of storage duration

Storage duration also significantly influenced the survival percentage of the cashew seedlings. The significantly maximum survival percentage was observed in S₂ (82.77% at par with S₃), and the lowest was recorded for S₁ (59.50%). Optimal storage for 60 days allows for physiological maturity, resulting in the most resilient seedlings. The decrease seen after 120 days of storage indicates that the seedlings' capacity to survive after germination is diminished by cellular ageing and the depletion of food reserves. These findings are consistent with those of

Chaudhary *et al.* (2019)^[8] in citrus and Chaudhari *et al.* (2022)^[7] in jackfruit.

III. Interaction effect of nut size and storage duration

The interaction effect of nut size and storage duration (N×S) was found to be non-significant for the survival percentage of seedlings, but it was numerically higher for N₁S₂, suggesting better stress resistance.

Conclusion

The results of this study led to the conclusion that large nut sizes (>8 g/nut) yielded the best outcomes in terms of germination and survival parameters. Similarly, a 60-to 90-day storage period improved seedling germination, establishment and survival. Thus, the interaction effect of the treatment combination of large nuts with 60-day storage showed better germination, early establishment, and survival of cashew seedlings.

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