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Effect of Embryo and Seed Orientation on Germination and Early Growth of Jackfruit

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ABSTRACT

The present investigation was conducted during 2024 at the Department of Horticulture, Tilak Dhari Post Graduate College, Jaunpur, Uttar Pradesh. The study was undertaken to assess the combined influence of embryo direction and seed placement on germination behavior and subsequent seedling growth performance. The experiment comprised six treatment combinations based on embryo orientation (upward and downward) and seed positioning (horizontal, vertical and slanting), viz., T1 (Horizontal seed position with upward embryo), T2 (Vertical seed position with upward embryo), T3 (Slanting seed position with upward embryo), T4 (Horizontal seed position with downward embryo), T5 (Vertical seed position with downward embryo) and T6 (Slanting seed position with downward embryo). The experimental results exhibited statistically significant variation among different treatment combinations. Among all treatments, T1 (Horizontal seed position with upward embryo) was found superior over others with recording the highest germination percentage (94.39%), minimum days to germination (8.76 days), maximum survival percentage (94.13%). It also exhibited remarkable improvement in vegetative growth parameters such as maximum plant height (34.75 cm at 90 DAS), highest number of leaves (10.43 at 90 DAS), maximum stem diameter (7.86 mm) and root length (13.98 cm), root diameter (6.78 mm), higher number of primary (4.13) and secondary roots (21.07). Conversely, treatments with downward embryo orientation, particularly T4 (Horizontal seed position with downward embryo), recorded comparatively lower values for most germination and growth parameters.

Keywords: Embryo orientation, Seed position, Germination behavior, Germination percentage, Survival percentage, Number of leaves

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INTRODUCTION

Jackfruit (Artocarpus heterophyllus Lam.) is a fruit found in tropical regions, belonging to the Moraceae, a widespread family, often called the mulberry or fig family. Jackfruit is native to Western Ghats of India, Malaysia and also found in central and Eastern Africa and South- Eastern Asia. It is very popular in Bangladesh and considered as their national fruit. India is recognized as one of the leading producers of jackfruit in the world. The diverse agro-climatic conditions of India ranging from temperate to tropical along with fertile soils, adequate rainfall, and varied landscapes from hills to plains, provide highly favorable conditions for jackfruit cultivation. The crop thrives abundantly in the Western Ghats region, especially in Karnataka, Kerala, Tamil Nadu, Goa and Gujarat, and is also widely grown in states such as West Bengal, Maharashtra, Uttar Pradesh, Tripura, Assam, Odisha and Meghalaya.The jackfruit tree is recognized as a multipurpose species, valued for its nutritional, medicinal, and industrial importance. Its pulp is rich in carbohydrates, proteins, fiber, minerals, and vitamins, which contribute to antioxidant, anti-cancer, anti-aging, anti-hypertensive, anti-ulcer, and hypoglycemic properties (Ranasinghe et al., 2019; Arora and Parle, 2016).

Traditionally, jackfruit is propagated by seeds, which is considered one of the cheapest and most convenient methods. However, this technique results in a poor germination rate due to the recalcitrant nature of the seeds and seeds often show irregular germination and variable seedling growth due to differences in sowing methods and seed placement. Among these factors, embryo and seed orientation during sowing plays a crucial role in influencing water absorption, root emergence, shoot development, and overall seedling vigor.

Proper orientation of seeds may enhance germination percentage, reduce the time required for germination, and promote uniform seedling establishment. Incorrect positioning of the embryo can hinder the emergence of radicle

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and plumule, resulting in poor growth and weak seedlings. Despite the importance of seed orientation, limited scientific information is available regarding the most suitable embryo and seed position for successful germination and early growth of jackfruit seedlings.

Several studies in agricultural, horticultural, and forestry crops have demonstrated that seed orientation during sowing significantly influences germination, seedling emergence, and early growth. Seed placement affects the direction of radicle and plumule growth, energy expenditure during emergence, and subsequent seedling vigor. A recent review by Masilamani et al. (2023) reported that horizontal or appropriately oriented seeds generally exhibit superior germination and seedling establishment compared with unfavorable orientations across a wide range of crops.

Research on seed orientation has been conducted in crops such as mango, tamarind, sapota, neem, moringa, castor, and several forest tree species, where significant differences in germination percentage, emergence rate, seedling height, and vigor were observed among different seed orientations. These findings indicate that proper seed placement is an important nursery management practice for improving seedling production.

Therefore, the present study entitled "Effect of embryo and seed orientation on germination and early growth of Jackfruit (Artocarpus heterophyllus Lam.)" is needed to identify the optimum sowing orientation for improving germination behavior, seedling vigor, and nursery performance.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental Unit of the Department of Horticulture, Tilak Dhari Post Graduate College, Jaunpur, Uttar Pradesh, India during year 2024-25. Geographically, Jaunpur is located in the eastern zone of Uttar Pradesh and is characterized by its unique agro-climatic conditions. The district lies at approximately 25°44'0" North latitude and 82°41'0" East longitude, positioning it within the fertile middle Gangetic plains. The summer lasts from March to June, characterized by hot, dry winds and temperatures ranging from 23°C to 45°C. The rainy season occurs from July to September, with an average yearly rainfall of 850–1100 mm, where 80–85 percent of the rain falls from July to the end of September. The winter season starts in October and continues until March, with average temperatures between 10°C and 30°C. In the summer months of May and June, temperatures can reach up to 45°C, while in the winter months of December and January, they can drop to as low as 5°C. Winter may also bring occasional frost and rain. The treatments viz., T1 (Horizontal seed position with upward embryo), T2 (Vertical seed position with upward embryo), T3 (Slanting seed position with upward embryo), T4 (Horizontal seed position with downward embryo), T5 (Vertical seed position with downward embryo) and T6 (Slanting seed position with downward embryo) were evaluated in Randomized Block Design. Only healthy, uniform, and disease-free seeds were selected to ensure the reliability of the experimental results. In polybags, a suitable mixture prepared by combining soil (50%), FYM (20%) vermicompost (15%) and coco peat (15%), which together improves soil structure, microbial activity and water-holding capacity. Other cultural practices like weeding, irrigation, insect pest and disease management were done as and when required. The observations were recorded on five randomly selected plants from each treatment to evaluate the effect of different treatment.

The data recorded during the course of investigation were analyzed by analysis of variance (ANOVA) using the statistical program and the significance differences between the mean were tested against the critical difference at 5% probability level.

RESULTS AND DISCUSSION

Impact of embryo and seed position on germination percentage, number of days taken for germination and survival percentage

Germination percentage is the first critical indicator of seed vigor. The results showed that T1 (Horizontal seed position with upward embryo) had the highest germination rate 94.39%, followed by T3 (Slanting seed position with upward embryo) 92.42% and T2 (Vertical seed position with upward embryo) 90.90%. The lowest germination was observed in T4 (Horizontal seed position with downward embryo) 85.47%. Patil et al. (2020) also noted that embryo polarity determines radicle emergence success. Therefore, the current study confirms that proper embryo orientation enhances germination efficiency by optimizing water uptake, oxygen supply, and seed metabolism.

Seed orientation also influenced the number of days required for germination. Seeds in T1 (Horizontal seed position with upward embryo) germinated earliest, taking an average of 8.76 days, while T4 (Horizontal seed position with downward embryo) required maximum, 13.83 days. T5 (Vertical seed position with downward embryo) 9.07 days and T2 (Vertical seed position with upward embryo) 10.36 days showed intermediate performance. Similarly, Roy et al. (2020) found that correct seed orientation accelerates the hydrolysis of stored carbohydrates, leading to faster radicle protrusion.

The highest survival 94.13% was observed in T1 (Horizontal seed position with upward embryo) followed by T3 (Slanting seed position with upward embryo) 92.44% and T2 (Vertical seed position with upward embryo) 90.88%. Among downward orientations, T4 (Horizontal seed position with downward embryo) recorded the lowest survival 84.94%. Similarly, Kumar et al. (2017) in guava reported that vigorous seedlings with balanced root–shoot growth had improved

survival percentages. The better survival in T_1 can also be linked to thicker stems and larger leaf area, which support efficient photosynthesis and transpiration regulation.

Table 1. Impact of embryo and seed position on germination percentage (%), number of days taken for germination and survival percentage (%)

Treatments	Germination percentage (%)	Number of days taken for germination	Survival percentage (%)
T1 (Horizontal seed position with upward embryo)	94.39	8.76	94.13
T2 (Vertical seed position with upward embryo)	90.905	10.36	90.88
T3 (Slanting seed position with upward embryo)	92.42	9.06	92.44
T4 (Horizontal seed position with downward embryo)	85.47	13.83	84.94
T5 (Vertical seed position with downward embryo)	87.11	12.5	86.88
T6 (Slanting seed position with downward embryo)	89.19	11.10	85.91
CD at 5%	0.903	1.88	1.44
SEm±	0.293	0.61	0.47

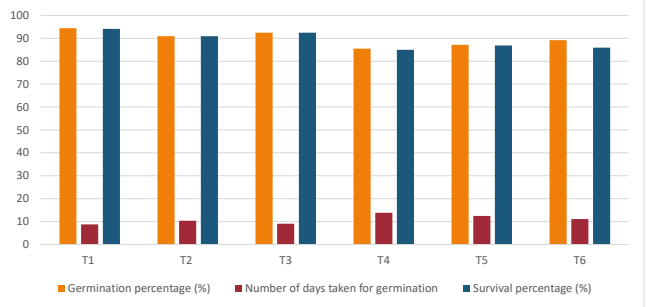


Fig. 1. Impact of embryo and seed position on germination percentage (%), number of days taken for germination and survival percentage (%)

Impact of embryo and seed position on plant height and number of leaves at 30, 60 and 90 DAS in jackfruit.

The data presented in table 2 shows significant differences among the treatments, the maximum mean plant height was recorded in T1 (Horizontal seed position with upward embryo) with values of 16.88 cm, 22.83 cm and 34.75 cm at 30, 60 and 90 days after sowing, respectively. The lowest height was observed in T4 (Horizontal seed position with downward embryo) with 10.04 cm, 19.26 cm, and 34.20 cm at the same intervals. These results support the findings of Rahman et al. (2020), who reported that embryo orientation significantly affects shoot elongation in jackfruit seedlings.

According to the data as depicted in table 2, number of leaves also followed a similar trend as plant height. At 30 DAS, T1 (Horizontal seed position with upward embryo) recorded 4.66 leaves, followed by T3 (Slanting seed position with upward embryo) 3.48 and minimum T4 (Horizontal seed position with downward embryo) 2.01. At 60 DAS, T1 (Horizontal seed position with upward embryo) 7.26 again led, and by 90 DAS, T1 (Horizontal seed position with upward embryo) had 10.43 leaves, significantly higher than T4 (Horizontal seed position with downward embryo) 6.51 and T5 (Vertical seed position with downward embryo) 6.49. These results are in agreement with Yadav and Singh (2018) and Nair et al. (2021) who reported that seed orientation affects vegetative parameters in guava by influencing apical meristem activity.

Table 2. Impact of embryo and seed position on plant height (cm) and number of leaves at 30, 60 and 90 DAS in jackfruit

Treatments	Plant height (cm)			Number of leaves		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T1 (Horizontal seed position with upward embryo)	16.88	22.83	34.75	4.66	7.26	10.43
T2 (Vertical seed position with upward embryo)	12.66	21.43	32.65	2.81	5.45	7.47
T3 (Slanting seed position with upward embryo)	14.51	21.95	33.76	3.48	5.84	8.36
T4 (Horizontal seed position with downward embryo)	10.04	19.26	34.20	2.01	4.79	6.51
T5 (Vertical seed position with downward embryo)	10.21	20.13	31.76	2.20	5.10	6.49
T6 (Slanting seed position with downward embryo)	11.38	20.86	32.16	2.6	5.32	7.21
CD at 5%	0.773	0.361	0.095	0.12	0.30	0.44
SEm±	0.254	0.119	0.031	0.04	0.1	0.14

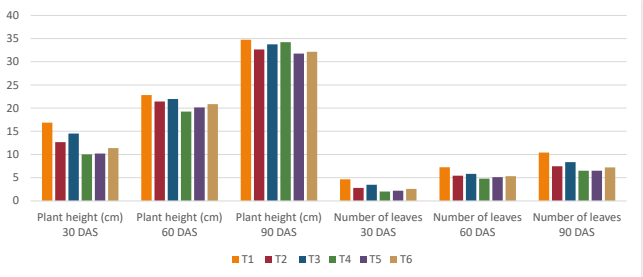


Fig. 2. Impact of embryo and seed position on plant height (cm) and number of leaves at 30, 60 and 90 DAS in jackfruit

Impact of embryo and seed position on stem diameter (mm), root length (cm), number of primary roots, number of secondary roots, root diameter (mm)

At 90 DAS, T1 (Horizontal seed position with upward embryo) exhibited the highest stem diameter 7.86 mm, followed by T3 (Slanting seed position with upward embryo) 7.45 mm and T2 (Vertical seed position with upward embryo) 7.37 mm. The lowest was recorded in T4 (Horizontal seed position with downward embryo) 4.75 mm. Stem diameter determines mechanical strength and nutrient transport capacity. Patel and Kumar (2021) and Kumar and Singh (2020) also observed that fruit seedlings with thicker stems exhibit superior vigor and survival due to higher xylem development.

The root length of jackfruit seedlings varied remarkably under different seed orientations. The maximum mean root length (13.98 cm), was recorded T1 (Horizontal seed position with upward embryo), followed by T3 (Slanting seed position with upward embryo) with 12.91 cm and T2 (Vertical seed position with upward embryo) with 12.55 cm. Whereas, T4 (Horizontal seed position with downward embryo) recording the minimum (8.62 cm). These findings clearly demonstrate that the horizontal seed placement with embryo facing downward resulted in maximum root elongation. These observations are supported by Hartmann and Kester (2011) and Rajasekhar et al. (2022).

The number of primary roots of jackfruit seedlings at 90 days after sowing (DAS) exhibited considerable variation among the different seed orientations. The maximum number of primary roots 4.13 was recorded in Treatment T1 (Horizontal seed position with upward embryo), followed by T3 (Slanting seed position with upward embryo) with 3.91 and T2 (Vertical seed position with upward embryo) with 3.48. While (Horizontal seed position with downward embryo) recorded comparatively lower values of 2.02.

Significant differences were also observed in the number of secondary roots among the treatments. The maximum number of secondary roots 21.07 was observed in Treatment T1 (Horizontal seed position with upward embryo), followed by T3 (Slanting seed position with upward embryo) 19.80 and T2 (Vertical seed position with upward embryo) 19.63. While T5 (Vertical seed position with downward embryo) 18.05 recorded comparatively lower values. These findings are supported by Taiz and Zeiger (2015).

The root diameter of jackfruit seedlings also showed noticeable differences among the various seed orientations. The highest mean root diameter (6.78 mm) was recorded in T1 (Horizontal seed position with upward embryo), followed by T3 (Slanting seed position with upward embryo) with 6.11 mm and T2 (Vertical seed position with upward embryo) with 5.64 mm. Whereas, T4 (Horizontal seed position with downward embryo) exhibited the lowest mean root diameter 4.10 mm. The present findings also agree with Pandey et al. (2020) and Khan et al. (2019) who found that horizontal placement of seeds enhanced the overall growth pattern of seedlings.

Table 3. Impact of embryo and seed position on stem diameter (mm), root length (cm), number of primary roots, number of secondary roots, root diameter (mm)

Treatments	Stem diameter (mm)	Root length (cm)	Number of primary roots	Number of secondary roots	Root diameter (mm)
T1 (Horizontal seed position with upward embryo)	7.86	13.98	4.13	21.07	6.78
T2 (Vertical seed position with upward embryo)	7.37	12.55	3.48	19.63	5.64
T3 (Slanting seed position with upward embryo)	7.45	12.91	3.91	19.80	6.11
T4 (Horizontal seed position with downward embryo)	4.75	8.62	2.02	18.32	4.10
T5 (Vertical seed position with downward embryo)	5.25	10.11	2.62	18.05	4.55
T6 (Slanting seed position with downward embryo)	6.44	11.54	3.07	18.96	5.11
CD at 5%	0.39	0.45	0.50	0.887	0.488
SEm±	0.13	0.14	0.16	0.292	0.161

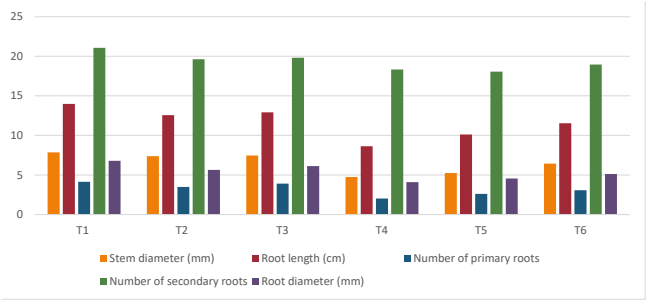


Fig. 3. Impact of embryo and seed position on stem diameter (mm), root length (cm), number of primary roots, number of secondary roots, root diameter (mm)

CONCLUSION

The orientation of the embryo and seed position significantly influenced germination and early seedling growth of jackfruit. Among all treatments, horizontal seed placement with an upward embryo (T1) proved to be the most effective, resulting in the highest germination percentage, faster germination, greater survival, and superior vegetative and

root growth. In contrast, treatments with downward embryo orientation, especially T4, showed comparatively poor performance. Therefore, for raising healthy and vigorous jackfruit seedlings, horizontal sowing with the embryo facing upward is recommended.

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