



RESEARCH COMMUNICATION

Influence of seed priming and growing media on germination and seedling vigour of papaya (*Carica papaya* L.) var. CO8

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Abstract

Papaya (*Carica papaya* Linn.) is globally recognised for its nutritional and dietary benefits. Papaya is extensively cultivated for its high nutritional and medicinal value. A nursery experiment was conducted at Karunya Institute of Technology and Science, Coimbatore, during 2024-2025 to evaluate the influence of seed priming agents on papaya germination and seedling vigour. Eleven priming treatments including water soaking, coconut water (50 % and 100 %), kinetin (25 and 50 ppm), GA₃ (100 and 200 ppm), salicylic acid (1 mM), vermi wash (50 %) and humic acid (1 %) and an untreated control were evaluated in a factorial completely randomised design with three replications. Kinetin at 25 ppm (P₅) significantly improved seed germination, viability and seedling survival, recording the highest germination (96.16–98.83 %), while the lowest values were observed in the untreated control. The combination of kinetin (25 ppm) with the growing medium consisting of soil, cocopeat and FYM supplemented with Trichoderma and vermicompost produced the highest seedling vigour and germination.

Keywords: germination; growth parameters; papaya; seedling growth; seedling vigour; seed priming

Introduction

Papaya (*Carica papaya* L.) is a well-known tropical climacteric fruit belonging to the family Caricaceae. It is believed to have originated in Tropical America and it is extensively grown on around 1.49 lac ha in India (1). India is the world's leading producer of papaya, with an annual production of approximately 5.2–5.3 million ton. The crop is widely distributed across several agro-climatic regions of India.

Papaya is a nutritious and refreshing fruit, highly valued for its digestive properties. The fruit contains carbohydrates, vitamins and minerals that contribute to its nutritional importance (2). In addition to fresh consumption, papaya is used in processed products and for extraction of papain, an important industrial enzyme.

According to the latest report, India is the world's largest producer of papaya, producing approximately 5.3 million tonnes annually and contributing nearly 38–40 % of the global production (1, 3).

Seed propagation is the most common method for papaya multiplication. Although this approach does not guarantee progeny purity, it remains essential due to the absence of commercially viable vegetative propagation techniques. The commercialisation of papaya cultivation has increased the demand for high-quality seeds from established cultivars.

Seed germination is influenced by various parameters, including substrate type, ambient conditions (e.g., oxygen, water, temperature) and light requirements (4). Papaya seed germination can be sluggish, inconsistent and partial (5). Papaya seeds are protected by a gelatinous sarcotesta, an exterior seed coat made

from the integument, which prevents germination and dormancy. Dormancy can also occur in seeds without the sarcotesta (6). Papaya seeds contain chemical development inhibitors, which might lead to sluggish germination when producing seedlings (7). Proper seed germination and growth are crucial for optimal papaya seedling production using the nursery technique. Pre-sowing papaya seeds with growing media and micronutrients affects their germination rate and seedling growth.

An effective growth medium provides adequate support for the plant, stores nutrients and water and facilitates oxygen diffusion to the roots and gas exchange with the atmosphere. Fruit crop seedlings require a substrate composed of soil, organic matter, pond soil and sand. Pond soil is frequently used as a basic medium due to its affordability and availability, while sand is added to increase porosity. In addition to organic matter such as farmyard manure and vermicompost, copolymer serves as a high-quality growing medium with appropriate pH, electrical conductivity and other chemical properties (8). Cocopeat is valued for its favourable physical properties, including high total pore space, water retention and minimal shrinkage.

Despite the importance of papaya cultivation, poor and uneven seed germination often limits successful nursery establishment. Seed priming and suitable growing media may improve germination performance and seedling vigour. The present study was conducted to evaluate the influence of different seed priming agents and growing media combinations on germination, seed viability and seedling survival of papaya (*Carica papaya* L.) var. CO8 under nursery conditions.

Materials and Methods

An investigation into the effect of seed priming on the growth and vigour of papaya was conducted at North Farm, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India, during 2024-2025. Fully ripe papaya fruits CO8 were collected from Tamil Nadu Agricultural University (TNAU) for seed extraction. Seeds were separated from the fruits by washing and rubbing with sand to remove the sarcotesta. The seeds were then shade-dried for 2-3 days under controlled conditions to reduce moisture content without compromising viability. There were three replications of the experiment and each treatment included ten seeds. At around 2 mm of radicle emergence, germination was noted. Observations were made at regular intervals during the 120 day duration of the trial. Standard measurement techniques were used to measure growth characteristics, such as weighing balances for fresh and dry weight and scales and rulers for seedling length.

After drying, a minimum of 10 seeds per replication were selected for priming. Seed priming involves pre-soaking seeds in a solution or under controlled conditions to enhance germination rates. In this study, priming was conducted for 24 hr. Seeds were soaked for 24 hr in plastic containers containing different priming solutions at the specified concentrations. Standard cultural practices such as irrigation and weeding were performed as required.

Soaking of seeds

The extracted seeds were soaked in plastic bottles for 24 hr in different priming agents viz., solution of coconut water, kinetin, GA₃, salicylic acid, vermi wash, humic acid in different concentration. Preparation of growing media, pot filling and sowing of treated seeds involved selecting 4 × 5-inch pots and filling them with various growing media. The standard medium for all pots consisted of soil, cocopeat and farmyard manure (FYM) in a 2:1:1 ratio. Additionally, *Trichoderma*, *Trichoderma* with *Azospirillum* and *Trichoderma* with vermicompost were added to the pots according to the replication. Treated seeds were sown in the pots, ensuring they were not placed too deep, with a sowing depth maintained at 2 cm. Seeds were covered with a thin layer of topsoil. Germination was monitored daily and other observations were recorded at specified intervals for various parameters.

The experimental data were analysed using factorial completely randomised design (FCRD). Statistical analysis was performed using the GRAPES software package and treatment means were compared using the critical difference (CD) test at 5 % significance.

Results

Seed viability

Seed priming treatments and growing media significantly affected papaya seed viability when seeds were sown immediately after extraction and after 15 days of seed extraction. P₅ (Kinetin at 25 mg L⁻¹) had the highest seed viability among the priming treatments, with 97.16 % under immediate sowing and 91.66 % after 15 days of seed extraction; P₁ (control) had the lowest seed viability, with 23.00 % and 25.66 % respectively. The growth media also showed notable variations. The medium M₃ (soil + cocopeat + FYM + *Trichoderma* + vermicompost) had the highest seed viability (71.90 % in immediate sowing and 74.72 % after 15 days), followed by M₂ (soil + cocopeat + FYM + *Trichoderma* + *Azospirillum*) with 68.90 % and 68.12 % respectively, while M₁ (soil + cocopeat + FYM + *Trichoderma*) had the lowest seed viability (63.40 % and 60.25 %). The treatment combination P₅M₃ (Kinetin at 25 mg L⁻¹ with soil + cocopeat + FYM + *Trichoderma* + vermicompost) had the highest seed viability of 99.00 % under immediate sowing and 99.50 % after 15 days of seed extraction, according to the interaction effect, while P₁M₃ had the lowest seed viability of 20.50 % and 23.00 % respectively. Results are presented in Tables 1–4.

Germination percentage

Under both immediate sowing and seeding after 15 days of seed extraction, the germination percentage varied significantly between different priming agents and growth conditions. P₅ (kinetin at 25 mg L⁻¹) had the maximum germination (96.16 %) in immediate sowing, while P₁ (control) had the lowest germination (35.66 %). M₃ (soil + cocopeat + FYM in 2:1:1 ratio along with *Trichoderma* and vermicompost) produced the highest germination (74.77 %), followed by M₂ (70.31 %) and M₁ (soil + cocopeat + FYM with *Trichoderma*) had the lowest germination (65.81 %). Priming agents and growing media showed a significant interaction effect; P₅M₃ (kinetin at 25 mg L⁻¹ + soil + cocopeat + FYM with *Trichoderma* and vermicompost) had the highest germination (99.00 %), while P₁M₃ (control + soil + cocopeat + FYM with *Trichoderma* and vermicompost) had the lowest (32.00 %). Similarly, germination under seeding after 15 days of seed extraction varied from 42.66 % to 98.83 %, with P₅ (kinetin at 25 mg L⁻¹) showing the highest germination (98.83 %) and P₁ (control) showing the lowest (42.66 %). Germination in the growing media varied from 65.50 % to 77.09 %; M₃ (soil + cocopeat + FYM in a 2:1:1 ratio with *Trichoderma* and vermicompost) had the highest germination (77.09 %), followed by M₂ (70.45 %) and M₁ (soil + cocopeat + FYM with *Trichoderma*) had the lowest germination (65.50 %). In delayed sowing, the interaction effect was equally significant; P₅M₃ had the highest germination rate (100.00 %), whereas P₁M₃ had the lowest (40.00 %). Results are presented in Tables 5–7 and Fig. 2.

Table 1. Seed priming treatments and their description

Treatment	Description
P ₁ – Control	Seeds in the control treatment were not primed, directly sown without immersing in distil water
P ₂ – Water soaking	Seeds are soaked in 100 mL diluted water
P ₃ – Coconut water at 50 %	Seeds are soaked in 50 % coconut water + 50 % diluted water
P ₄ – Coconut water at 100 %	Seeds are soaked in pure coconut water
P ₅ – Kinetin at 25 ppm	Seeds are soaked in a 25 ppm kinetin solution
P ₆ – Kinetin at 50 ppm	Seeds are soaked in a 50 ppm kinetin solution
P ₇ – GA ₃ at 100 ppm	Seeds are soaked in a 100 ppm GA ₃ solution
P ₈ – GA ₃ at 200 ppm	Seeds are soaked in a 200 ppm GA ₃ solution
P ₉ – Salicylic acid at 1 mM	Seeds are soaked in a 1 mM salicylic acid solution
P ₁₀ – Vermi wash at 50 %	Seeds are soaked in 50 % vermi wash + 50 % diluted water
P ₁₁ – Humic acid at 1 %	Seeds are soaked in 1 % humic acid solution + 99 % diluted water

Table 2. Effect of seed priming agents on seed viability (%) of papaya (*Carica papaya* L.) var. CO8

Priming	Seed viability (%) (Immediate sowing)	Seed viability (%) (After 15 days of seed extraction)
P ₁ : Control (without priming)	23.00	25.66
P ₂ : Water soaking	44.00	49.33
P ₃ : Coconut water at 50 %	41.50	66.66
P ₄ : Coconut water at 100 %	60.33	53.66
P ₅ : Kinetin at 25 ppm	97.16	91.66
P ₆ : Kinetin at 50 ppm	73.66	90.83
P ₇ : GA ₃ at 100 ppm	83.50	82.16
P ₈ : GA ₃ at 200 ppm	83.33	83.33
P ₉ : Salicylic acid at 1 mM	85.33	84.16
P ₁₀ : Vermiwash at 50 %	87.50	57.00
P ₁₁ : Humic acid at 1 %	87.83	83.00
S.Em. ±	1.350	0.827
C.D. at 5 %	3.890	2.380
C.V	4.750	2.904

Table 3. Effect of different growing media on seed viability % of papaya var. CO8

Media	Seed viability (%) (Immediate sowing)	Seed viability (%) (After 15 days of seed extraction)
M ₁ (Soil + Cocopeat + FYM) + <i>Trichoderma</i>	63.40	60.25
M ₂ (Soil + Cocopeat FYM) + <i>Trichoderma</i> + <i>Azospirillum</i>	68.90	68.12
M ₃ (Soil + Cocopeat + FYM) + <i>Trichoderma</i> + Vermicompost	71.90	74.72
S.Em. ±	0.707	0.827
C.D. at 5 %	2.033	2.380
C.V	4.752	2.904

FYM: Farmyard manure.

Table 4. Interaction effect of different priming agent and growing media on seed viability of papaya var. CO8

Priming Treatment	M ₁ (Immediate)	M ₂ (Immediate)	M ₃ (Immediate)	M ₁ (After 15 days)	M ₂ (After 15 days)	M ₃ (After 15 days)
P ₁	27.50	21.00	20.50	29.00	25.00	23.00
P ₂	42.50	43.00	46.50	43.50	50.00	54.50
P ₃	32.50	43.00	49.00	65.50	61.00	73.50
P ₄	53.00	62.50	65.50	77.50	83.50	–
P ₅	95.00	96.00	99.00	83.00	95.50	99.50
P ₆	72.50	67.50	81.00	96.50	84.50	88.50
P ₇	86.50	77.00	87.00	92.50	73.50	80.50
P ₈	93.50	84.00	72.50	74.00	87.00	89.00
P ₉	85.50	83.00	87.50	85.50	91.50	75.50
P ₁₀	93.00	83.00	86.50	83.00	88.00	–
P ₁₁	83.50	91.00	89.00	77.00	82.50	89.50
Parameter	Immediate sowing			After 15 days		
S.Em. ±	2.344			1.433		
C.D. at 5 %	6.743			4.123		
C.V (%)	4.752			2.904		

Table 5. Interaction effect of different priming agents on germination percentage of papaya var. CO8

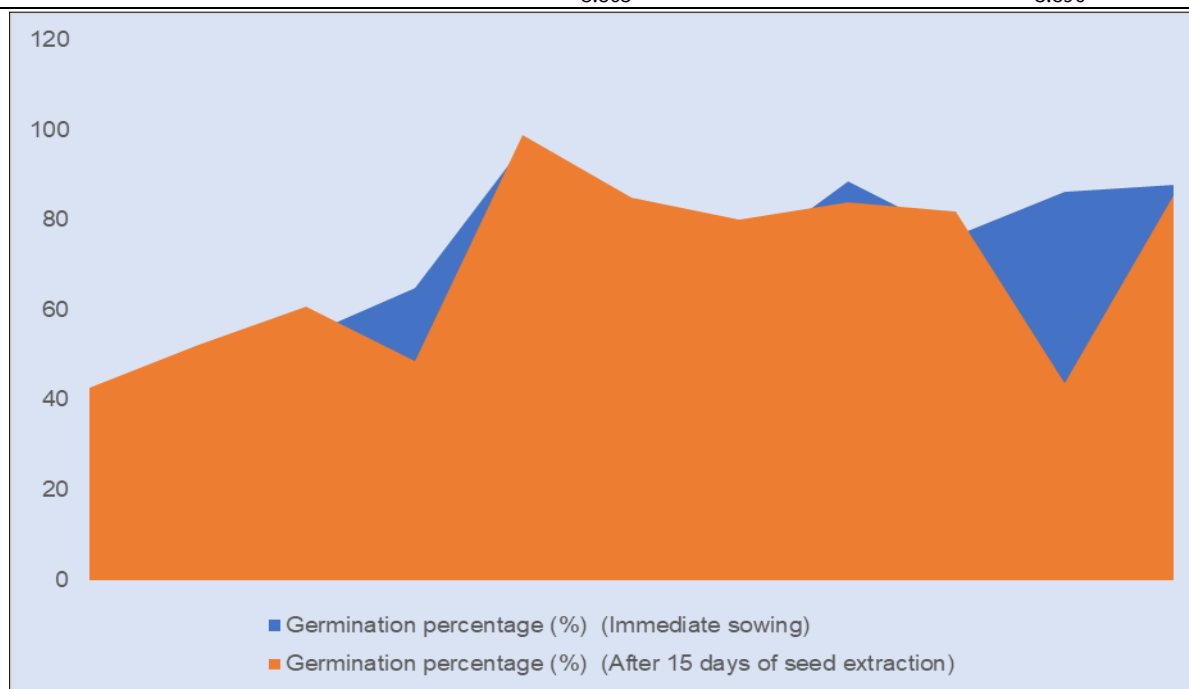
Priming	Germination percentage (%) (Immediate sowing)	Germination percentage (%) (After 15 days of seed extraction)
P ₁ : Control (without priming)	35.66	42.66
P ₂ : Water soaking	44.83	52.16
P ₃ : Coconut water at 50 %	54.33	60.83
P ₄ : Coconut water at 100 %	64.83	48.66
P ₅ : Kinetin at 25 ppm	96.16	98.83
P ₆ : Kinetin at 50 ppm	82.16	85.00
P ₇ : GA ₃ at 100 ppm	70.83	80.00
P ₈ : GA ₃ at 200 ppm	88.66	83.83
P ₉ : Salicylic acid at 1 mM	76.50	81.83
P ₁₀ : Vermiwash at 50 %	86.16	43.66
P ₁₁ : Humic acid at 1 %	87.83	85.50
S.Em. ±	1.130	0.576
C.D. at 5 %	3.252	1.658
C.V	3.865	3.896

Table 6. Interaction effect of different growing media on germination percentage of papaya var. CO8

Media	Germination percentage (%) (Immediate sowing)	Germination percentage (%) (After 15 days of seed extraction)
M ₁ (Soil + Cocopeat + FYM) + <i>Trichoderma</i>	65.81	65.50
M ₂ (Soil + Cocopeat FYM) + <i>Trichoderma</i> + <i>Azospirillum</i>	70.31	70.45
M ₃ (Soil + Cocopeat + FYM) + <i>Trichoderma</i> + Vermicompost	74.77	77.09
S.Em. ±	0.590	0.576
C.D. at 5 %	1.699	1.658
C.V	3.865	3.896

Table 7. Interaction effect of different priming agent and growing media on germination percentage of papaya var. CO8

Priming treatment	M ₁ (Immediate)	M ₂ (Immediate)	M ₃ (Immediate)	M ₁ (After 15 days)	M ₂ (After 15 days)	M ₃ (After 15 days)
P ₁	39.00	36.00	32.00	41.00	47.00	40.00
P ₂	47.50	42.00	45.00	49.00	53.50	54.00
P ₃	52.00	47.50	63.50	56.00	61.50	65.00
P ₄	66.50	54.50	73.50	71.00	75.00	–
P ₅	93.50	96.00	99.00	98.00	96.00	100.00
P ₆	82.00	83.50	81.00	83.00	84.50	87.50
P ₇	62.50	71.00	79.00	84.00	77.50	78.50
P ₈	87.50	90.50	88.00	74.50	86.00	91.00
P ₉	78.00	76.00	75.50	90.00	88.00	67.50
P ₁₀	81.50	84.50	92.50	40.00	91.00	–
P ₁₁	90.50	86.50	86.50	87.00	87.00	82.50
Parameter	Immediate sowing			After 15 days		
S.E.m. ±	1.958			1.911		
C.D. at 5 %	5.633			5.498		
C.V (%)	3.865			3.896		

**Fig. 2.** Interaction effect of seed priming treatments and growing media on germination percentage of papaya var. CO8 seedlings.

Survival percentage

Significant differences in survival percentage were observed among priming treatments during immediate sowing. The variation range was observed from 38.33 % to 97.33 %. Out of eleven priming agents evaluated, the highest survival percentage of (97.33 %) was recorded for P₅(kinetin at 25 mg L⁻¹) whereas the lowest survival percentage of (38.3 %) was observed in the control treatment (P₁). The variation range for survival percentage in growing media was observed from 70.06 % to 76.72 %. M₃ (soil: cocopeat: FYM in a 2:1:1 ratio) supplemented with *Trichoderma* and vermicompost demonstrated the highest survival percentage of (76.72 %) followed by M₂(74.54 %) and lowest survival percentage of (70.06 %) was observed in soil + cocopeat + FYM, *Trichoderma*. The interaction between priming agents and growing medias indicated that the combination P₅M₃ (kinetin 25 mg L⁻¹) soil: cocopeat: FYM, *Trichoderma* and vermicompost significantly outperformed other treatments, producing the highest survival percentage of (98.00 %) and lowest survival percentage among the combination was observed in P₁M₃(37.5 %) control soil + cocopeat + FYM, *Trichoderma* and vermicompost.

There is a significant difference after 15 days of seed extraction. The variation range for survival percentage was observed from 43.00 % to 95.16 %. The priming agent P₅(kinetin at 25 mg L⁻¹) (95.16 %) was found to be significantly superior

compared to other treatment whereas, the lowest (43.00 %) survival percentage was recorded in P₁ control. The variation range for survival percentage in growing media was observed from 60.45 % to 74.22 %. Among the growing medias used soil + cocopeat + FYM, *Trichoderma* and vermicompost are found to be better for getting maximum survival percentage (74.22 %) followed by M₂ (65.84 %) and it was lowest in M₁ soil + cocopeat + FYM, *Trichoderma* (60.45 %). In interaction effect combination of kinetin and media P₅M₃ (kinetin 25 mg L⁻¹) soil + cocopeat + FYM, *Trichoderma* and vermicompost showed the significantly highest survival percentage of (99.00 %) and the lowest survival percentage (37.50 %) was obtained in the combination P₁M₃ control soil + cocopeat + FYM, *Trichoderma* and vermicompost. Results are presented in Tables 8–10 and Fig. 1.

Discussion

Seed priming treatments and growing media significantly influenced seed viability, germination percentage and survival of papaya seedlings under nursery conditions. These findings underscore the importance of both factors in promoting successful seed germination and healthy seedling production in papaya nurseries Fig. 3. The best results were obtained with treatment P₅, which recorded the highest seed viability (97.16 %

Table 8. Interaction effect of different priming agents on survival percentage of papaya var. CO8

Priming	Survival percentage (%) (Immediate sowing)	Survival percentage (%) (After 15 days of seed extraction)
P ₁ : Control (without priming)	38.33	43.00
P ₂ : Water soaking	54.33	53.50
P ₃ : Coconut water at 50 %	60.66	71.50
P ₄ : Coconut water at 100 %	75.00	55.66
P ₅ : Kinetin at 25 ppm	97.33	95.16
P ₆ : Kinetin at 50 ppm	82.66	83.33
P ₇ : GA ₃ at 100 ppm	78.66	77.00
P ₈ : GA ₃ at 200 ppm	87.16	84.33
P ₉ : Salicylic acid at 1 mM	86.16	76.50
P ₁₀ : Vermiwash at 50 %	80.00	53.50
P ₁₁ : Humic acid at 1 %	87.33	72.00
S.Em. ±	1.179	1.569
C.D. at 5 %	3.391	4.515
C.V	3.837	5.523

Table 9. Interaction effect of different growing media on survival percentage of papaya var. CO8

Media	Survival percentage (%) (Immediate sowing)	Survival percentage (%) (After 15 days of seed extraction)
M ₁ (Soil + Cocopeat + FYM) + <i>Trichoderma</i>	70.06	60.45
M ₂ (Soil + Cocopeat FYM) + <i>Trichoderma</i> + <i>Azospirillum</i>	74.54	65.84
M ₃ (Soil + Cocopeat + FYM) + <i>Trichoderma</i> + Vermicompost	76.72	74.22
S.Em. ±	0.615	0.819
C.D. at 5 %	1.771	2.358
C.V	3.837	5.523

Table 10. Interaction effect of different priming agent and growing media on survival percentage of papaya var. CO8

Priming treatment	M ₁ (Immediate)	M ₂ (Immediate)	M ₃ (Immediate)	M ₁ (After 15 days)	M ₂ (After 15 days)	M ₃ (After 15 days)
P ₁	38.00	41.00	36.00	48.50	43.00	37.50
P ₂	52.50	54.00	56.50	52.00	56.00	52.50
P ₃	62.00	55.00	65.00	64.00	74.00	76.50
P ₄	71.00	76.50	77.50	87.00	80.00	–
P ₅	96.00	97.00	98.00	97.00	95.50	99.00
P ₆	81.00	85.00	82.00	90.00	84.00	76.00
P ₇	78.00	75.00	83.00	81.00	69.00	81.00
P ₈	90.00	86.50	85.00	80.50	87.50	85.00
P ₉	88.50	85.00	85.00	72.00	76.50	81.00
P ₁₀	76.50	78.50	85.00	87.00	73.50	–
P ₁₁	89.00	85.00	89.00	68.50	72.50	75.00
Parameter	Immediate sowing			After 15 days		
S.Em. ±	2.041			2.718		
C.D. at 5 %	5.873			7.820		
C.V (%)	3.837			5.523		

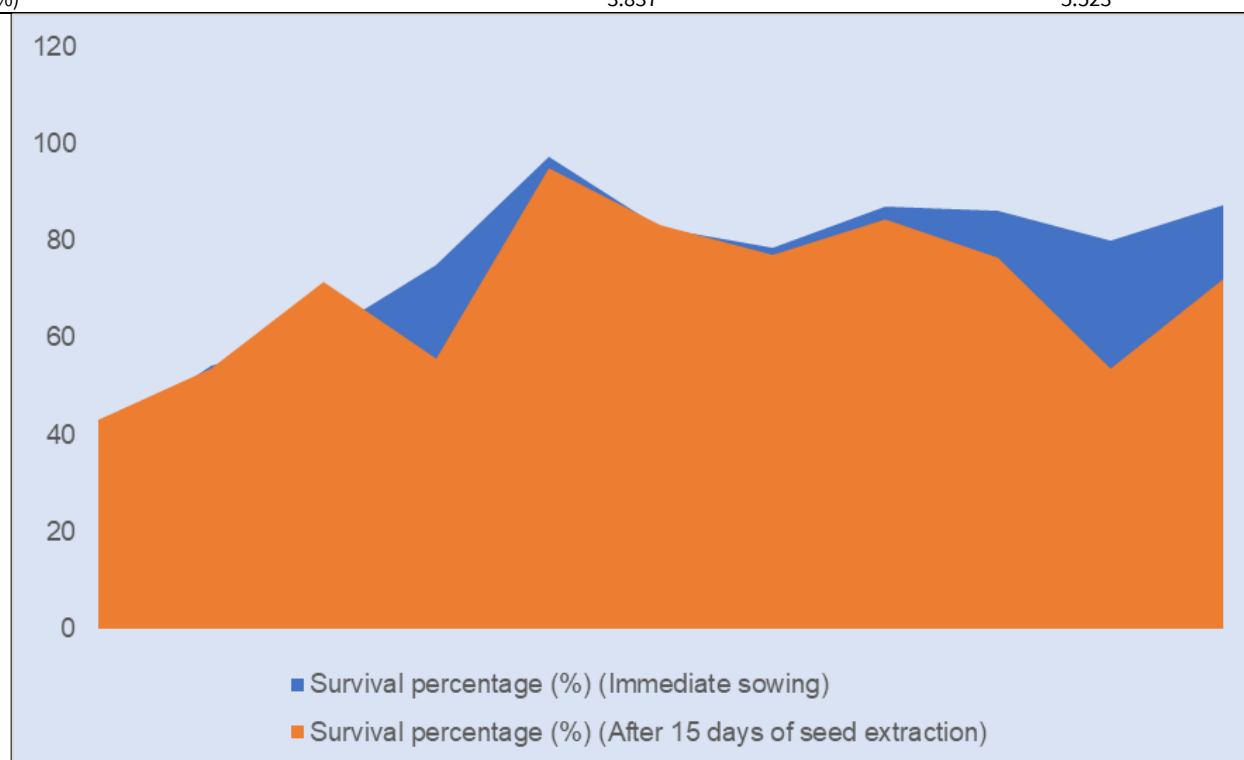
**Fig. 1.** Interaction effect of seed priming treatments and growing media on survival percentage of papaya (*Carica papaya* L.) var. CO8 seedlings.



Fig. 3. Seedling performance of papaya var. CO8 under the best treatment combination (kinetin 25 ppm + M₃ growing medium).

and 91.66 %), while the lowest values were observed in P₁ (23.00 % and 25.66 %). Kinetin likely enhances papaya seed viability by increasing enzyme activity and nutrient availability, consistent with previous findings (9–11). Kinetin may also neutralize inhibitors in seeds or increase cytokinin activity to overcome seed coat inhibition (12). Additionally, kinetin promotes seed germination by enhancing cytokinin action and counteracting germination inhibitors (13) and may stimulate the production of hydrolysing enzymes such as amylase and protease, which facilitate embryo expansion and germination (14). Similar trends were observed for germination percentage, with P₅ achieving the highest values (96.16 % and 98.83 %) and P₁ the lowest (35.66 % and 42.66 %). This improvement may be attributed to kinetin's activation of alpha-amylase, which converts starch into simple carbohydrates, providing energy for embryo activation (14). Chemical priming may also deteriorate the seed coat and remove germination inhibitors (15). Kinetin further promotes germination by converting insoluble starch into soluble carbohydrates and reducing metabolic barriers (13). Enhanced amino acid synthesis, activation of cytological enzymes, increased cell wall plasticity and improved water absorption may also contribute to increased germination percentage with kinetin at 25 mg L⁻¹ (12). For survival percentage, P₅ registered the highest values (97.33 % and 95.16

%), while P₁ had the lowest (38.33 % and 43.00 %). Kinetin may contribute to higher seed vigour by maintaining high water content within cells, accelerating cell division and elongation and promoting faster seedling germination and growth. Vermicompost's water and air retention properties may facilitate rapid enzymatic action and metabolite synthesis, supporting early seedling development. Enhanced root and shoot development, resistance to root diseases and improved post-transplant growth contribute to higher survival rates in papaya seedlings. Kinetin's efficiency may be linked to increased membrane permeability and cytokinin migration due to phytochrome activity, further promoting survival (16, 17). Overall, kinetin may increase survivorship by promoting robust root and shoot development, enhancing resistance to transplant shock and root infections. Papaya seedling germination is enhanced by GA₃'s involvement in two stages of germination: initial enzyme induction and reserve food mobilisation mechanism activation (18). GA₃ can encourage better and faster germination since treated lime seeds germinate faster than untreated seeds (19). Higher enzyme activity and a stronger food supply may be responsible for the papaya's faster and improved germination under GA₃ (20). The papaya seedling's endogenous GA₃ levels might not be adequate and exogenous GA₃ administration might

have boosted growth by improving cell elongation and multiplication, improving papaya plant development. *Syzygium cumini* seedlings' fresh weight of shoots and roots is increased by GA₃, potentially as a result of its effects on cell division, cellular and auxin metabolism, cell wall flexibility and cell membrane permeability (18). The mobilisation, transport and storage of water and nutrients given at a faster rate may have been facilitated by GA₃, which may have increased photosynthesis and raised the total dry weight of *Manilkara hexandra* shoots and roots. Higher seed vigour may have resulted from GA₃ ability to maintain a high-water content in the cell, speed up cell division and elongation and boost seedling germination and overall growth (21). The enzymes and growth-promoting chemicals found in coconut water, particularly cytokinin, are widely known. The average dry weight of the plant may have increased because of growth hormones in coconut water, which may have caused accelerated cell division inside the apical meristem of roots of seeds (22). The longest roots were formed by seed priming with fresh coconut water. This was probably caused by increased cell division in the apical meristem of the seedling roots, which was triggered by the plant growth hormones in the coconut water. Plants produced from seeds primed with coconut water have deeper roots (23).

Conclusion

The present investigation concludes that P₅ (kinetin 25 ppm) was the most effective priming agent, while M₃ (soil, cocopeat and FYM in a 2:1:1 ratio, supplemented with *Trichoderma* and vermicompost) was the optimal growing medium. The combination of P₅ and M₃ was most effective in enhancing the growth and germination of papaya var. CO8 in nursery conditions, particularly when considering their interaction effects. The findings demonstrate that appropriate seed priming combined with biologically enriched growing media can improve papaya seedling establishment and may support efficient nursery management practices.

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Authors' contributions

DNR conducted the experiments, performed seed treatments, collected data, and drafted the manuscript. JD planned and supervised the study and revised the manuscript. UBC and MBS collected papaya varieties and supported the research. VTV designed the experiments, analysed the data, and interpreted the results. HS helped in observations recording. GRS and BA assisted with field maintenance, procurement of media and chemicals, and data recording. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

References

- Ram M. Papaya. New Delhi: Indian Council of Agricultural Research. 2005; 142-43.
- National Horticulture Board. Area and production statistics of horticultural crops. Ministry of Agriculture and Farmers Welfare, Government of India; 2024.
- Hartmann HT, Kester DE, Davies FT, Geneve RL. Plant propagation: principles and practices. 7th ed. New Jersey: Prentice Hall. 2011;243-58.
- Chacko EK, Singh RN. The effect of gibberellic acid on papaya seed germination. Acta Hortic. 2015;1078:45-50.
- Lange W. Seed dormancy in tropical fruit species. Seed Sci Res. 2019;29:85-94.
- Nishina MS, Nagao AM, Furutani SC. Chemical inhibitors affecting papaya seed germination. J Plant Growth Regul. 2018;37:1212-21.
- Anburani A, Shakila A. Influence of seed treatment on the enhancement of germination and seedling vigour of papaya. Acta Hortic. 2010;851:231-38. <https://doi.org/10.17660/ActaHortic.2010.851.45>
- Gurung N, Swamy GSK, Sarkar SK, Ubale NB. Effect of kinetin on seed viability of papaya. J Hortic Sci. 2014;9(1):45-50.
- Ambica S, Balakrishnan K, Sujatha K. Enhancing papaya seed germination and vigour. J Agroecol Nat Resour Manag. 2015;2(2):40-43.
- Yadav RS, Sharma TR, Pandey SK, Maske G. Influence of cytokinin on tropical fruit seeds. Seed Sci Res. 2018;28:77-85.
- Hore DK, Sen P. Overcoming seed coat inhibition in ber with kinetin. Sci Hortic. 2017;218:120-26.
- Tuan P, Kumar AR, Rehal PK, Toora PK, Ayele BT. Molecular mechanisms underlying abscisic acid/kinetin balance in the control of seed dormancy and germination in cereals. Front Plant Sci. 2018;9:668. <https://doi.org/10.3389/fpls.2018.00668>
- Paleg LG. Hydrolyzing enzymes in seed germination. Plant Growth Regul. 2011;35:55-65.
- Shepley KE. Alpha-amylase activity in kinetin-treated seeds. Plant Growth Regul. 2018;85:103-12.
- Sahib MM, Hamzah NA, Hussein HJ. Effects of chemical priming on seed coat permeability. Seed Sci Technol. 2014;42:15-22.
- Thirupathi A, Mullaimaran P. Kinetin and seedling survivorship in papaya. Int J Plant Sci. 2020;15:67-74.
- FAOSTAT. FAOSTAT statistical database. Rome: Food and Agriculture Organization of the United Nations; 2023
- Dilip WS, Singh D, Moharana D. Effect of gibberellic acid (GA) at different concentrations and time intervals on seed germination and seedling growth of Rangpur lime. J Agroecol Nat Resour Manag. 2017;4(2):157-65.
- Sahu AK, Tandel BM, Patel NK. Effect of growing media on germination, growth and nutrients uptake of papaya seedlings (*Carica papaya* L.). Pharma Innov J. 2022;11(12):682-86.
- Hota SN, Karna AK, Jain PK, Dakhad B. Effect of gibberellic acid on germination, growth and survival of jamun (*Syzygium cumini* L. Skeels). J Pharm Innov. 2018;7(8):323-26.
- Sejal B, Kanzaria DR, Parasana JS. Impact of GA₃ and growing media on seed germination and seedling parameters of khirmi (*Manilkara hexandra* Roxb.). Pharma Innov J. 2022;11(2):1907-11.
- Lakmali KND, Seran TH. Impact of seed priming with king coconut water on growth and yield of okra (*Abelmoschus esculentus* L.). J Sci Food Agric. 2022;15. <https://doi.org/10.4038/jfa.v15i2.5271>
- Marne GO, Renato LL. Effect of coconut water as a presowing treatment additive on seed germination and initial seedling growth performance of kamagong (*Diospyros discolor*). Asian J Res Agric For. 2020;6(4):58-71. <https://doi.org/10.9734/ajraf/2020/v6i430116>

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