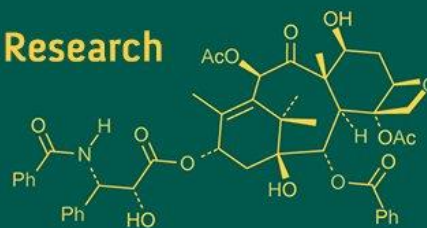
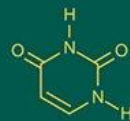


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Effect of seed priming on seed germination and seedling growth of papaya (*Carica papaya* L.)

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Abstract

A field investigation entitled “Effect of seed priming on seed germination and seedling growth of papaya (*Carica papaya* L.)” was conducted during 2023-24 at the Horticulture Farm, Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), to identify an effective seed priming agent for improving germination and seedling vigour of papaya cv. Red Lady under open-field conditions. The experiment was laid out in a Completely Randomized Design (CRD) with eleven treatments and three replications, comprising T₀ (control, water soaking), T₁ (cow urine 100%), T₂ (cow dung 100%), T₃ (GA₃ @ 150 ppm), T₄ (GA₃ @ 200 ppm), T₅ (NAA @ 150 ppm), T₆ (NAA @ 200 ppm), T₇ (*Azotobacter* @ 10%), T₈ (PSB @ 10%), T₉ (KNO₃ @ 1000 ppm) and T₁₀ (KNO₃ @ 2000 ppm), with seeds soaked for 12 hours before sowing. Among the treatments, T₄ (GA₃ @ 200 ppm) recorded the best performance, with the fewest days to germination (14.31), the highest rate of emergence (47.48%) and germination percentage (86.67%). The same treatment produced the maximum seedling height (25.01 cm), number of leaves (12.01), stem girth (3.70 mm) and shoot length (13.65 cm) at 60 DAS, along with the highest fresh weight of sapling (16.67 g), dry weight of sapling (1.63 g), Seedling Vigour Index-I (1183.00), Seedling Vigour Index-II (140.98), root length (25.83 cm), number of roots (85.59), primary roots (9.08), secondary roots (72.86), fresh weight of root (2.49 g) and dry weight of root (0.46 g). The highest Root:Shoot ratio (0.31) was recorded under T₁ (cow urine 100%), followed by T₃ (0.30) and T₄ (0.28). The minimum values for most parameters were recorded under the control (T₀). The study concludes that seed priming with GA₃ @ 200 ppm is the most effective treatment for enhancing seed germination and seedling growth of papaya.

Keywords: Papaya, Seed priming, Gibberellic acid (GA₃), Germination percentage, Seedling vigour, Red Lady

Introduction

Papaya (*Carica papaya* L.), a member of the family Caricaceae (2n = 18), is an important tropical and subtropical fruit crop grown throughout India. Native to Central America and southern Mexico, it is valued for its delectable flavour, quick returns and rich nutritional and medicinal properties. In India it is cultivated on a large scale in Andhra Pradesh, Gujarat, Maharashtra, West Bengal, Karnataka, Madhya Pradesh and Chhattisgarh. Papaya is nutritionally rich, supplying carbohydrates, vitamin A, vitamin C and minerals in the edible portion (Ram, 2005) ^[20].

Papaya is commercially propagated through seeds as no economically viable vegetative method is available (Lay *et al.*, 2013) ^[15]. However germination in papaya is slow, incomplete and erratic largely because the seeds are enclosed in a gelatinous sarcotesta that acts as a physical and biochemical barrier to germination (Hossain *et al.*, 2023) ^[12]. Germination is further influenced by temperature, moisture, oxygen and the growing substrate by naturally occurring germination inhibitors (Olivas, 2021) ^[16].

Seed priming is a simple low-cost pre-sowing technique that improves the rate and uniformity of germination and enhances seedling vigour. Plant growth regulators such as gibberellic acid (GA₃) promote uniform germination by activating hydrolytic enzymes that mobilize food reserves, while auxins such as naphthalene acetic acid (NAA) and salts such as potassium nitrate (KNO₃) are also used to break dormancy. Biofertilizers such as *Azotobacter* and Phosphate-Solubilising Bacteria (PSB) produce growth-promoting hormones that stimulate root and shoot development (Sukhade *et al.*, 1995) ^[25]. In view of the high cost of chemical growth regulators, farmers are also turning to affordable organic alternatives such

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as cow urine and cow dung, which contain nutrients and bio-active substances that support seedling growth (Subramaniam, 2005) ^[24]. The growing medium comprising soil, sand and farmyard manure (FYM) also plays a key role in providing anchorage, aeration and nutrients for germinating seeds (Abad *et al.*, 2002; Srivastava *et al.*, 1998) ^[1, 23]. The high cost of hybrid cv. Red Lady seed coupled with irregular germination makes efficient nursery raising critical for papaya cultivation. Keeping these facts in view the present investigation was undertaken to evaluate the comparative efficacy of different seed priming agents plant growth regulators, salts, organic inputs and biofertilizers on the germination and seedling growth of papaya cv. Red Lady.

Materials and Methods

The experiment was carried out during 2023-24 at the Horticulture Farm, Department of Fruit Science, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh), which is situated at 21.25° N latitude and 81.62° E longitude at an altitude of 298.15 m above mean sea level (Chhattisgarh Plains) in the seventh agro-climatic zone of India. The crop was raised under open-field conditions from November 2023 to February 2024.

The investigation was laid out in a Completely Randomized Design (CRD) with eleven treatments replicated three times. Seeds of papaya cv. Red Lady were soaked separately for 12 hours in the respective priming solutions before sowing: T₀ (control, water soaking), T₁ (cow urine 100%), T₂ (cow dung 100%), T₃ (GA₃ @ 150 ppm), T₄ (GA₃ @ 200 ppm), T₅ (NAA @ 150 ppm), T₆ (NAA @ 200 ppm), T₇ (*Azotobacter* @ 10%, 0.5 g per 10 g seed), T₈ (PSB @ 10%, 0.5 g per 10 g seed), T₉ (KNO₃ @ 1000 ppm) and T₁₀ (KNO₃ @ 2000 ppm). Thirty seeds were used per treatment (330 seeds in total). GA₃ and NAA (150 mg each) were dissolved in 5 ml ethyl alcohol and 2-3 ml of 1N NaOH respectively and made up to one litre with distilled water the required quantities of cow urine, cow dung, *Azotobacter* and PSB were prepared as fresh solutions.

The growing medium for all treatments consisted of soil, sand and FYM in a 1:1:1 ratio filled into 6" × 4" (200 gauge) black polybags. Treated seeds were sown one per bag at a depth of 2-2.5 cm followed by light irrigation. The bags were irrigated regularly kept weed-free and protected with imidacloprid (0.5 ml L⁻¹) at 15-day intervals and with mancozeb and copper oxychloride against fungal diseases. Observations on germination parameters (days taken to germination, rate of emergence and germination percentage) were recorded during the germination period, while growth

parameters (seedling height, number of leaves, stem girth and shoot length) were recorded at 30, 45 and 60 days after sowing (DAS). Fresh and dry weights of sapling and root, Root: Shoot ratio, Seedling Vigour Index and root parameters were recorded at 60 DAS on five randomly selected seedlings per replication. The parameters were computed as follows:

Rate of emergence (%) = (No. of seedlings emerged 5 DAS / No. of seedlings emerged 15 DAS) × 100

Germination percentage (%) = (Total no. of seeds germinated / Total no. of seeds sown) × 100

Root: Shoot ratio = Dry weight of root / Dry weight of shoot
Seedling Vigour Index-I = Germination (%) × Total seedling length at 60 DAS

Seedling Vigour Index-II = Germination (%) × Dry weight of seedling at 60 DAS

The data were subjected to analysis of variance (ANOVA) for a Completely Randomized Design following Fisher and Yates (1963) ^[11]. The significance of treatment effects was tested by the F-test, and treatment means were compared using the critical difference (CD) at the 5% level of significance.

Results and Discussion

Germination parameters

The pre-sowing priming treatments significantly influenced all germination parameters (Table 1). The earliest germination (14.31 days) was recorded under T₄ (GA₃ @ 200 ppm), which was statistically at par with T₃ (14.44 days), whereas the control (T₀) took the longest (19.84 days). GA₃ accelerates germination by activating α-amylase and other hydrolytic enzymes that convert stored starch into simple sugars, supplying energy for early embryo growth. Similar results were reported by Barche *et al.* (2010) ^[5] and Babu *et al.* (2010) ^[4] in papaya and Yadav *et al.* (2018) ^[30] in custard apple.

The maximum rate of emergence (47.48%) was also recorded under T₄ followed by T₃ (42.97%), while the minimum (28.63%) was under the control. The germination percentage ranged from 50.00% (T₀) to 86.67% (T₄); T₄ was followed by T₃ (83.33%), T₆ (80.00%) and T₅ (78.33%), which were statistically at par. The improvement in germination under GA₃ may be attributed to its role in overcoming physiological dormancy imposed by the seed coat, thereby enhancing water uptake and metabolic activity. These findings corroborate those of Chacko and Singh (1966) ^[6], Deb *et al.* (2010) ^[8] and Kumawat *et al.* (2014) ^[13] in papaya.

Table 1: Effect of seed priming on germination parameters of papaya seedlings

Notation	Treatment	Days to germination	Rate of Emergence (%)	Germination (%)
T ₀	Control (water soaking)	19.84	28.63	50.00
T ₁	Cow urine 100%	15.23	32.72	70.00
T ₂	Cow dung 100%	18.38	29.81	53.33
T ₃	GA ₃ @ 150 ppm	14.44	42.97	83.33
T ₄	GA ₃ @ 200 ppm	14.31	47.48	86.67
T ₅	NAA @ 150 ppm	15.72	32.84	78.33
T ₆	NAA @ 200 ppm	15.39	38.18	80.00
T ₇	<i>Azotobacter</i> @ 10%	15.73	30.50	73.33
T ₈	PSB @ 10%	15.91	29.86	68.33
T ₉	KNO ₃ @ 1000 ppm	16.61	31.36	63.33
T ₁₀	KNO ₃ @ 2000 ppm	16.29	31.54	66.67
SE(m)±		0.27	0.91	2.84
CD at 5%		0.78	2.67	8.34

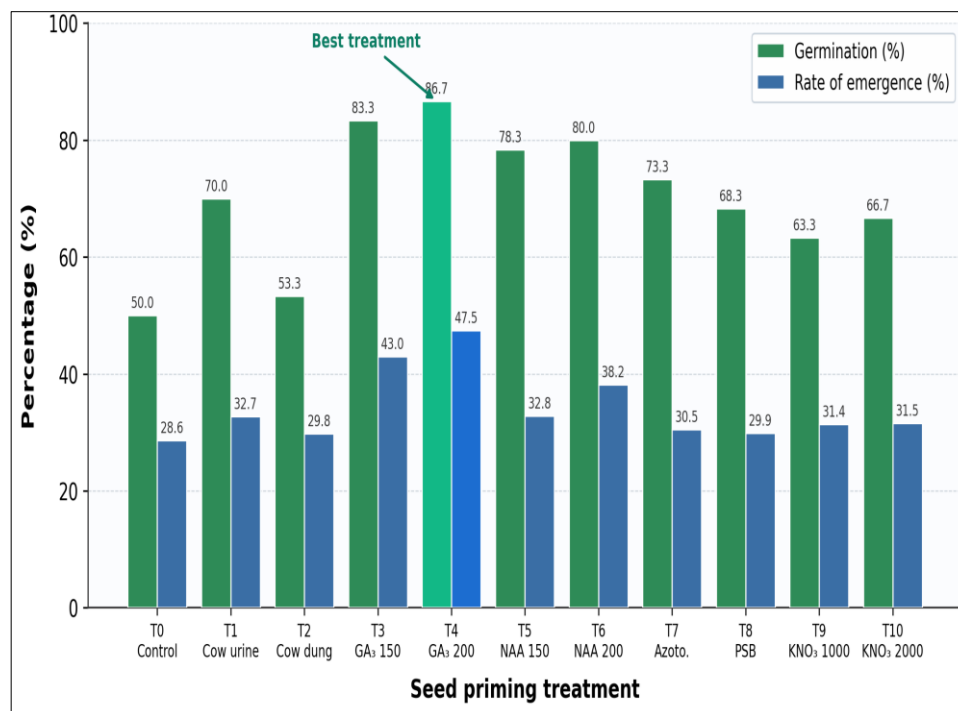


Fig 1: Effect of seed priming on germination percentage and rate of emergence of papaya seedlings

Growth parameters

Seedling height, number of leaves, stem girth and shoot length were significantly influenced by the priming treatments at all growth stages (Table 2). At 60 DAS, the tallest seedlings (25.01 cm) were recorded under T₄ (GA₃ @ 200 ppm) followed by T₃ (24.59 cm) while the control (T₀) produced the shortest seedlings (17.36 cm). The increase in seedling height under GA₃ may be due to enhanced nutrient uptake and cell elongation resulting in greater internodal length. Comparable results were reported by Wagh *et al.* (1998) ^[29] in aonla, Pampanna and Sulikeri (2001) ^[17] in sapota and Rajput *et al.* (2020) ^[19] in custard apple. The maximum number of leaves per seedling (6.76, 8.79

and 12.01 at 30, 45 and 60 DAS) was recorded under T₄, whereas the control recorded the minimum (4.40, 6.62 and 9.39). Stem girth was also highest under T₄ (1.67, 3.28 and 3.70 mm) the minimum under T₀ (0.43, 1.72 and 2.07 mm); the increase in girth is associated with GA₃ induced cambial activity and cell division (Dhankar and Singh, 1996) ^[10]. Similarly, shoot length was maximum under T₄ (5.89, 8.87 and 13.65 cm) and minimum under T₀ (2.80, 5.05 and 7.83 cm). The enhanced shoot growth under GA₃ reflects rapid mobilization of carbohydrates by α -amylase, providing energy for cell expansion, in agreement with Vincent and Thandapani (2003) ^[28], Desai *et al.* (2017) ^[9] and Zainudin and Adini (2019) ^[31] in papaya.

Table 2: Effect of seed priming on seedling height, number of leaves, stem girth and shoot length of papaya at 30, 45 and 60 DAS

Notation	Height of seedling (cm)			No. of leaves/seedling			Stem girth (mm)			Length of shoot (cm)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T ₀	5.40	8.33	17.36	4.40	6.62	9.39	0.43	1.72	2.07	2.80	5.05	7.83
T ₁	6.25	11.39	20.57	5.47	8.56	11.68	1.49	3.22	3.64	4.81	8.29	13.34
T ₂	5.91	9.08	18.35	4.83	7.23	9.97	1.07	2.17	2.76	3.65	6.59	10.36
T ₃	8.12	12.55	24.59	6.57	8.47	11.65	1.50	3.21	3.66	5.55	8.45	13.45
T ₄	8.48	13.48	25.01	6.76	8.79	12.01	1.67	3.28	3.70	5.89	8.87	13.65
T ₅	7.87	12.06	23.31	5.97	7.96	10.70	1.40	2.66	3.43	4.98	7.67	12.23
T ₆	7.95	12.20	23.57	6.08	8.12	11.14	1.44	2.76	3.51	5.14	7.98	12.99
T ₇	7.28	9.89	21.49	5.76	7.87	10.52	1.35	2.23	3.33	4.78	7.17	11.65
T ₈	7.12	10.60	21.33	5.72	7.54	10.22	1.56	2.04	3.03	4.27	6.43	10.92
T ₉	6.40	9.53	20.34	5.12	6.82	9.93	1.10	1.86	2.76	3.76	5.76	9.79
T ₁₀	6.29	9.95	20.63	5.29	7.07	10.29	1.13	1.97	2.86	3.84	5.86	10.22
SE(m)±	0.13	0.25	0.22	0.14	0.06	0.10	0.02	0.04	0.07	0.12	0.09	0.12
CD at 5%	0.38	0.73	0.65	0.40	0.16	0.30	0.07	0.12	0.21	0.35	0.27	0.34

T₀-T₁₀ as defined in Table 1

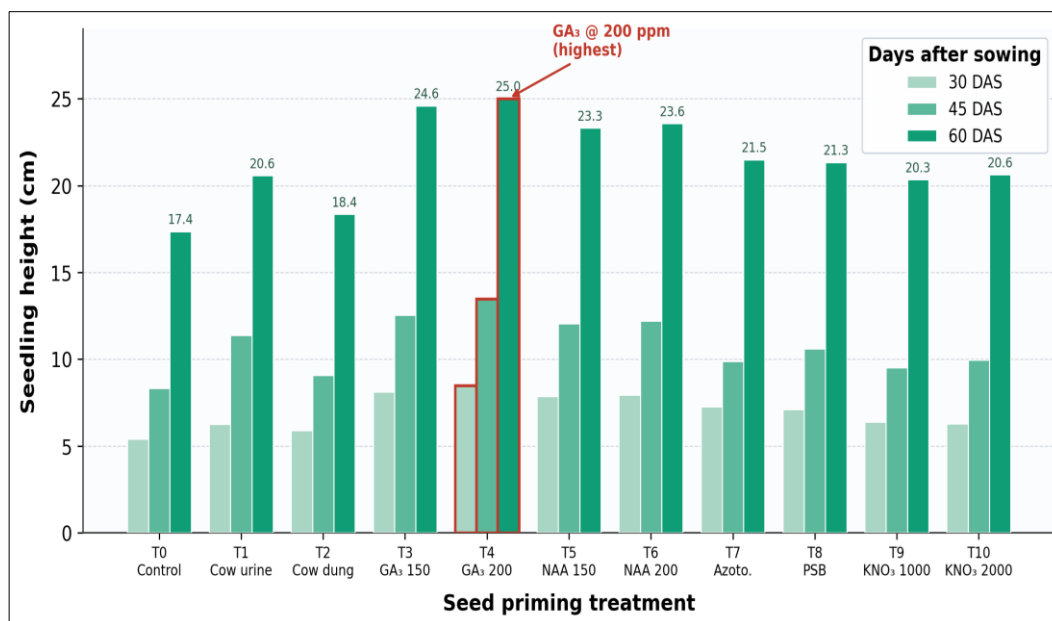


Fig 2: Effect of seed priming on seedling height of papaya at 30, 45 and 60 days after sowing (DAS)

Fresh and dry weight, Root: Shoot ratio and seedling vigour

The fresh and dry weights of sapling, Root: Shoot ratio and Seedling Vigour Indices differed significantly among treatments (Table 3). The maximum fresh weight (16.67 g) and dry weight (1.63 g) of sapling were recorded under T₄ (GA₃ @ 200 ppm), and the minimum (9.02 g and 0.82 g) under the control. Greater biomass under GA₃ is attributed to more efficient mobilization of water and nutrients, promoting the production and translocation of photosynthates as reported by Lay *et al.* (2013) [15] and Anjanawe *et al.* (2013) [3] in papaya.

The highest Root: Shoot ratio (0.31) was recorded under T₁ (cow urine 100%) followed by T₃ (0.30) and T₄ (0.28) while T₀, T₂ and T₉ recorded the lowest (0.22). The higher ratio under cow urine may be due to sustained cell turgidity that favours cell division and elongation (Sutheesh *et al.* (2016) [26]. Seedling Vigour Index-I and Index-II were maximum under T₄ (1183.00 and 140.98) and minimum under T₀ (391.50 and 41.17) reflecting the combined improvement in germination, seedling length and dry weight under GA₃ priming in agreement with Pandit *et al.* (2001) [18], Deb *et al.* (2010) [8] and Shukla *et al.* (2012) [22].

Table 3: Effect of seed priming on fresh weight, dry weight, Root:Shoot ratio and Seedling Vigour Indices of papaya seedlings (at 60 DAS)

Notation	Fresh wt. of sapling (g)	Dry wt. of sapling (g)	Root:Shoot ratio	Seedling Vigour Index-I	Seedling Vigour Index-II
T ₀	9.02	0.82	0.22	391.50	41.17
T ₁	15.73	1.41	0.31	863.10	98.93
T ₂	11.19	1.02	0.22	552.71	54.58
T ₃	16.28	1.40	0.30	1120.56	116.67
T ₄	16.67	1.63	0.28	1183.00	140.98
T ₅	14.06	1.19	0.26	957.76	92.17
T ₆	14.39	1.37	0.29	1022.67	109.87
T ₇	12.39	1.22	0.23	854.58	89.71
T ₈	11.93	1.11	0.24	746.17	76.08
T ₉	9.92	1.14	0.22	619.82	71.99
T ₁₀	10.22	1.18	0.23	681.11	78.44
SE(m)±	0.12	0.04	0.01	71.29	2.59
CD at 5%	0.34	0.11	0.03	209.10	7.58

T₀-T₁₀ as defined in Table 1

Root parameters

All root parameters were significantly influenced by the priming treatments (Table 4). At 60 DAS, T₄ (GA₃ @ 200 ppm) recorded the maximum root length (25.83 cm), number of roots per seedling (85.59), number of primary roots (9.08), number of secondary roots (72.86), fresh weight of root (2.49 g) and dry weight of root (0.46 g), whereas the minimum values were recorded under the

control (T₀). The enhanced root development under GA₃ is attributed to increased synthesis of photosynthates and their translocation through the phloem to the root zone together with cell elongation in the sub-apical region of the roots. These results are in agreement with Anburani and Shakila (2010) [2], Deb *et al.* (2010) [8], Lanjhiyana *et al.* (2020) [14] and Choudhary *et al.* (2022) [7] in papaya, and Verma *et al.* (2008) [27] in aonla.

Table 4: Effect of seed priming on root parameters of papaya seedlings (at 60 DAS)

Notation	Length of root (cm)	No. of roots/seedling	No. of primary roots	No. of secondary roots	Fresh wt. of root (g)	Dry wt. of root (g)
T ₀	15.36	59.20	5.01	51.71	0.83	0.18
T ₁	24.36	81.27	8.56	69.20	2.32	0.44
T ₂	19.20	71.63	7.83	56.36	1.55	0.23
T ₃	25.07	82.45	8.84	70.11	2.33	0.41
T ₄	25.83	85.59	9.08	72.86	2.49	0.46
T ₅	24.10	78.12	8.19	65.24	2.03	0.30
T ₆	24.69	79.29	8.52	66.56	2.29	0.39
T ₇	22.88	76.12	8.06	64.87	2.07	0.31
T ₈	22.17	74.18	7.91	64.07	1.96	0.29
T ₉	21.42	68.26	7.33	58.05	1.45	0.25
T ₁₀	21.97	69.66	7.56	61.50	1.59	0.26
SE(m)±	0.11	0.17	0.09	1.59	0.04	0.01
CD at 5%	0.32	0.49	0.26	4.65	0.12	0.03

T₀-T₁₀ as defined in Table 1

Conclusion

The present investigation clearly demonstrated that seed priming markedly improves the germination and seedling growth of papaya cv. Red Lady. Among all the treatments evaluated, seed priming with GA₃ @ 200 ppm (T₄) proved the most effective, giving the earliest germination, the highest germination percentage and rate of emergence and superior seedling growth, biomass and root development. Whereas the untreated control consistently recorded the poorest performance. GA₃ @ 200 ppm can therefore be recommended as an effective and practical seed priming treatment for raising vigorous papaya seedlings in the nursery. As these findings are based on a single season, further multi season and multi-location trials are suggested for confirmation.

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