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ORIGINAL RESEARCH ARTICLE

GA_3 and growing medium influence papaya seed germination and seedling growth

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ABSTRACT

The most crucial factor in producing papaya seedlings successfully is seed germination. The purpose of this study was to investigate the influence of seed priming with growing media on seed germination and seedling growth of papaya from October to December 2022. The experimental treatments included three seed priming treatments: T_0 = control (no seed priming treatments), T_1 = GA_3 (100 ppm), and T_2 = KNO_3 (1%), and four growing media, viz., M_1 = soil + vermicompost (1:1), M_2 = soil + cowdung (1:1), M_3 = soil + cocopeat + vermicompost (1:1:1), and M_4 = soil + cocopeat + cowdung (1:1:1). The treatments showed a significant effect on different parameters such as germination percentage, days to germination, survival percentage, chlorophyll content, seed vigor index, shoot, and root length. GA_3 treated seedlings performed better than non-GA_3-treated seedlings. Among the growing media, M_3 showed the best for seed germination and other growth attributes compared to other growing media. In terms of interaction effects, T_1M_3 showed the highest performance for germination percentage (84.33%), survival percentage (91.0%), and chlorophyll content (44.26%). T_1M_3 also showed the highest seed vigor index, shoot and root growth, and plant biomass. As a result, the combination of GA_3 and growing media containing soil + cocopeat + vermicompost was shown to be the most favorable for papaya seed germination and seedling growth.

Keywords: seed priming; germination, survival percentage; papaya

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1. Introduction

The papaya (*Carica papaya* L.) is an important fruit crop in Bangladesh and a member of the Caricaceae family. Papaya is mainly eaten fresh, and uncooked fruits are utilized as vegetables. Growers are expanding papaya planting due to high demand as a table fruit and vegetable when unripe. Papaya is typically propagated by seed[1].

Seed germination of papaya is very slow, incomplete, and time consuming. The seeds of papaya are encased in a gelatinous sarcotesta (aril, or outer seed coat derived from the outer integument) that might inhibit germination[2]. The farmers of Bangladesh faced difficulty during the rise of papaya due to low germination percentage. Production of vigorous seedlings is also a challenge for papaya growers. Papaya seeds germinate slowly because of the presence of certain inhibitors, such as phenolic compounds. Seed treatment is necessary to promote seed germination and shorten germination time using appropriate growing media[3].

Growing media is a substrate that gives growing plants the necessary ingredients and physical support[4]. In addition, the media should have appropriate water retention, drainage, and other physical and chemical qualities. As a result, it is preferable to supply soil media or a mixture that meets the requirements for maximal seed germination and improved seedling growth. Organic-based media promotes improved root development when compared to soil-based media, which contains a considerable quantity of field soil[5–7].

Osmopriming with chemical agents such as calcium nitrate and potassium nitrate stimulates seed germination by generating a water potential balance between the seeds and the solution via osmosis[8,9]. Pretreatment with potassium nitrate reduced dormancy and improved seed germination[10,11]. Gibberellic acid is a plant hormone that is essential for fruit plant growth and yield. It has an effect on plant cell development and cell elongation, particularly in horticultural crops[12]. Before sowing, seeds were soaked in water, or water soluble endogenous hormones have been observed to increase germination[13].

Limited work has been reported on papaya cultivation regarding the application of different priming treatments and growing media. As a result, the study was to determine the effect of various growing media and priming treatments on papaya seed germination and seedling growth.

2. Materials and methods

2.1. Plant materials and growing conditions

The experiment was conducted at Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experiment was conducted from October to December 2022. The papaya cv. Shahi papaya was planted under poly net house in plastic polybag (6 inch × 5 inch). The experiment was set up in a completely randomized design (CRD), with twelve treatments and four replications. Throughout the trial, all important cultural techniques and plant protection measures were applied identically to all plants. Three plants were chosen at random in each replication for morphological and physiological observations.

2.2. Treatments

The three priming treatments: T_0 = distilled water (control), T_1 = GA_3 100 ppm and T_2 = KNO_3 1% were employed. Seeds were rinsed in the solution for 12 h at room temperature in dark conditions. Following priming, seeds were planted in plastic polybags with various growing medium, including M_1 = soil + vermicompost (1:1), M_2 =soil + cowdung (1:1), M_3 = soil + cocopeat + vermicompost (1:1:1), and M_4 = soil + cocopeat + cowdung (1:1:1).

2.3. Germination percentage, days to germination, vigor index and survival percentage of papaya seedling

Days to germination were calculated from the day of starting germination to the end of germination. Germination percentage, seedling vigor and survival percentage was calculated by following formula:

Germination percentage = total number of seeds germination/total number of seeds sown × 100

Vigor index = germination percentage × total length of seedling[14]

Survival % = total survived seedlings/total germinated seeds × 100

2.4. Length of shoot and root (cm)

Shoot length was measured from the base of plant to the terminal growth point of main stem. The data was recorded between 30 and 50 days after germination (DAG). Root length was taken two times from collar level to the tip of the main root from each plant of each treatment at 30 and 50 DAG. The average length of shoot and root was computed and expressed in centimeter.

2.5. Stem diameter of plant (mm)

The stem diameter of the plant was manually measured by slide calipers at 30 and 50 days after germination. The average of three plants was measured and expressed in average stem diameter of the plant.

2.6. Fresh and dry weight of shoot and root (g)

After uprooting, the seedling was cleaned and cut into collar region. Then fresh shoot and root weight were measured by an electric digital balance at 30 and 50 DAG, and the mean value was calculated. Dry weight was measured after drying shoot and root in electric oven dryer at 65 °C for 72 h and mean value was calculated.

2.7. Leaf area (cm^2) and number of leaves per plants

Leaf area was calculated by multiplying the length and breadth of leaf. Total number of leaves and leaf area were recorded at 30 and 50 DAG. The average leaf area and leaf number were measured, and the mean value was calculated.

2.8. SPAD chlorophyll meter reading

SPAD-502 chlorophyll meter was used to measure the chlorophyll content of the first fully expanded leaves (Minolta, Tokyo, Japan). Measurements were taken from the middle of the leaf lamina of each treated and control plant.

2.9. Statistical analysis

Statistics 10 (IBM Corp, Armonk, NY, USA) was used for all statistical analyses. The mean value across treatments was considered statistically significant when $p < 0.05$. The replicated data was used to compute the mean ± SE for all outcomes. The graphs were created using the Microsoft Excel application.

3. Results and discussion

3.1. Seed germination (%) and days to germination

Different seed priming treatments and growing media significantly influenced on percentage of seed germination. Results revealed that the highest percentage of germination (83.33%) was recorded in T_1M_3 treatment and the lowest (60%) was recorded in T_0M_2 treatment (**Figure 1A**). GA_3 participates in two stages of germination: initial enzyme induction and activation of the reserve food mobilization mechanism, both of which improve papaya seedling germination[15]. Sahu et al.[16] found that cocopeat based growing media was the most beneficial for improving germination percentage of papaya.

The minimum days to germination (4.33 days) were obtained in GA_3 treated growing media (T_1M_3). The maximum days to germination (13.00 days) were obtained in growing media with no seed priming treatments (T_0M_2) which was statistically similar with T_0M_4 (12.00%) (**Figure 1B**). These findings were similar to those of Mandal et al.[17] who used cocopeat as a component of their growing media in papaya. More readily available moisture and certain acids might have aided in the seeds' better germination. The ability of GA_3 to promote better and quicker germination, since GA_3-treated lime seeds germinate more quickly than untreated seeds is stated by Dilip et al.[18]. The quicker and enhanced germination of papaya under GA_3 might be attributed to higher enzyme activities and a better supply of nutrients.

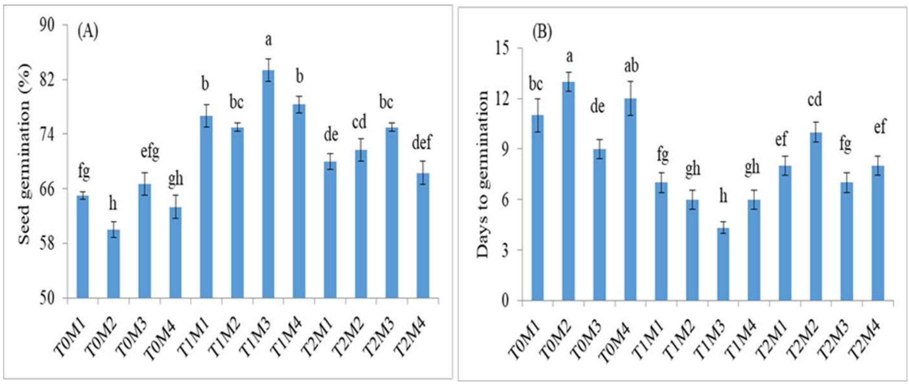

Figure 1. Effect of seed priming treatments and growing media on seed germination (%) and days to germination of papaya seedling. T_0M_1 = distilled water +soil + vermicompost; T_0M_2 = distilled water + soil + cowdung; T_0M_3 = distilled water + soil + cocopeat + vermicompost; T_0M_4 = distilled water + soil + cocopeat + cowdung; T_1M_1 = GA_3 + soil + vermicompost; T_1M_2 = GA_3 + soil + cowdung; T_1M_3 = GA_3 + soil + cocopeat + vermicompost; T_1M_4 = GA_3 + soil + cocopeat + cowdung; T_2M_1 = KNO_3 +soil + vermicompost; T_2M_2 = KNO_3 + soil + cow dung; T_2M_3 = KNO_3 + soil + cocopeat + vermicompost; T_2M_4 = KNO_3 + soil + cocopeat + cowdung.
Means followed by same letter(s) in a column do not differ significantly at 5% level of LSD.

3.2. Length of shoot and root (cm) of papaya seedling

Shoot length of papaya seedling at different growth stages varied significantly due to combined effect of GA_3 and growing media (**Table 1**; **Figure 2**). Length of shoot and root increase with the increase of time. At 50 DAG, the highest shoot length (21.03 cm) was recorded from T_1M_3 treatment, and the lowest root length (10.40 cm) was observed from the combination of T_0M_2 treatment. A similar trend was found for root length. The highest root length (19.50 cm) was recorded in T_1M_3 and the lowest root length (10.70 cm) was observed in T_0M_2 treatment (**Table 1**; **Figure 3**). This result was similar to that of Desai et al.[4] in papaya when they used GA_3 as ingredients of papaya seed priming. Endogenous levels of GA_3 generated by the papaya seedling may not be sufficient, and external application of GA_3 may have increased growth by enhancing cell multiplication and cell elongation, resulting in improved papaya plant development[2]. According to Khan et al.[19], coconut peat is an organic manure that is directly beneficial to plant growth of sweet potato by providing all necessary macro- and micronutrients in their easily accessible forms during mineralization and enhancing the physical and chemical properties of soils.

Table 1. Effect of seed priming treatments and different growing media on shoot and root length of papaya seedling.

Treatments	Shoot length (cm)		Root length (cm)	
	30 DAG	50 DAG	30 DAG	50 DAG
T_0M_1	7.90 g	12.03 d	10.46 e	12.46 d
T_0M_2	7.3 g	10.40 e	7.56 f	10.70 e
T_0M_3	8.20 fg	12.40 d	11.36 cde	11.63 d
T_0M_4	7.60 g	11.36 de	7.73 f	12.33 d
T_1M_1	13.16 b	17.567 b	15.50 b	12.33d
T_1M_2	11.16 c	15.73 c	14.33 b	17.73 ab
T_1M_3	16.56 a	21.03 a	17.20 a	19.50 a
T_1M_4	10.76 cd	18.10 b	12.26 cd	15.43 c
T_2M_1	8.96 ef	14.80 c	10.90 de	18.40 ab
T_2M_2	8.90 ef	12.26 d	8.20 f	14.26 c
T_2M_3	9.63 e	15.46 c	12.40 c	17.60 b
T_2M_4	9.83 de	14.70 c	12.40 c	17.56 b
$LSD_{0.05}$	0.97	1.04	1.37	1.77
CV%	5.77	4.20	6.93	6.97

T_0M_1 = distilled water +soil + vermicompost; T_0M_2 = distilled water + soil + cowdung; T_0M_3 = distilled water + soil + cocopeat + vermicompost; T_0M_4 = distilled water + soil + cocopeat + cowdung; T_1M_1 = GA_3 + soil + vermicompost; T_1M_2 = GA_3 + soil + cowdung; T_1M_3 = GA_3 + soil + cocopeat + vermicompost; T_1M_4 = GA_3 + soil + cocopeat + cowdung; T_2M_1 = KNO_3 +soil +

vermicompost; T_2M_2 = KNO_3 + soil + cowdung; T_2M_3 = KNO_3 + soil + cocopeat + vermicompost; T_2M_4 = KNO_3 + soil + cocopeat + cowdung (1:1:1)1.
Means followed by same letter(s) in a column do not differ significantly at 5% level of LSD.

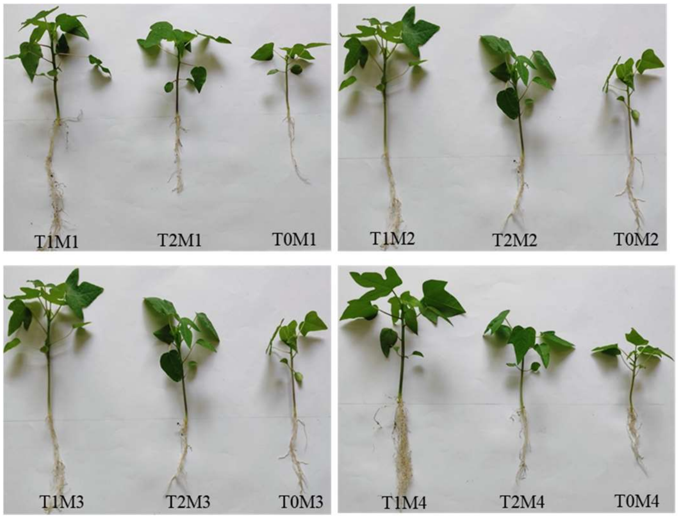

Figure 2. Effect of seed priming treatments and different growing media on length of shoot and root of papaya seedling.

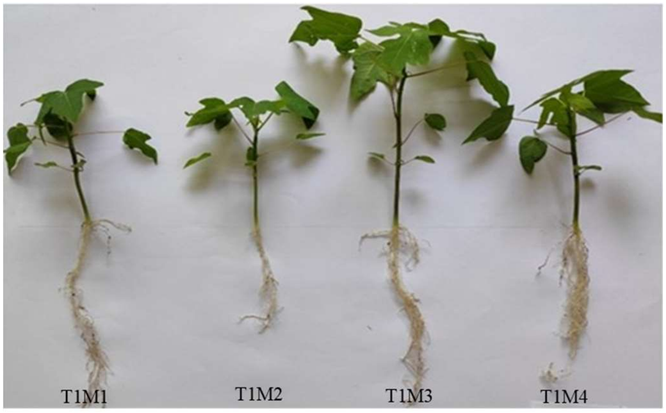

Figure 3. Effect of seed priming treatment (GA_3) and different growing media on length of shoot and root of papaya seedling.

3.3. Stem diameter (mm) and vigor index of papaya seedling

The T_1M_3 treatment combination recorded the maximum stem diameter of 6.96 mm at 50 DAG, which was statistically similar to the 6.76 mm of the T_1M_4 treatment combination. The minimum stem diameter (4.03 mm) was found in the treatment combination of T_1M_1 (**Table 2**). Vieira et al.[20] also reported that Gibberellins promote stem cell proliferation, a transverse arrangement of microtubules that governs the direction of cellulose microfibril deposition, and increased stem diameter in chrysanthemum plants. Vermicomposting with cocopeat may improve soil porosity, water content, drainage pore, soil permeability, water availability, air flow in the soil, and the availability of improved nutrition with water and air in the root zone of the papaya seedling, indicating an increased stem diameter of the seedling[21].

At 50 DAG, the highest seed vigor index (3357.3) of papaya seedling was observed from the treatment combination of T_1M_3 and the lowest seed vigor index (1262.8) of papaya seedling was recorded from the treatment combination of T_0M_2 (**Table 2**). Vithirak and Iwai[22] observed that vermicompost significantly increased the seed high vigor index in lettuce. GA_3 may aid in seed vigor index via seed priming because this treatment is ideal for the metabolic response, enhancing seed germination efficiency, and promoting seedling growth of okra[23].

Table 2. Effect of seed priming treatments and different growing media and on stem diameter and seed vigor index of papaya seedling.

Treatments	Stem diameter (mm)		Seed vigor index	
	30 DAG	50 DAG	30 DAG	50 DAG
T_0M_1	2.30 g	4.83 ef	1195.7 gh	1592.5 f
T_0M_2	2.26 g	4.46 fg	889.0 i	1262.8 g
T_0M_3	2.60efg	4.53 f	1305.8 fg	1602.2 e
T_0M_4	2.40 fg	6.16 b	972.5 hi	1500.7 fg
T_1M_1	3.36 ab	4.03 g	2199.8 b	2284.2 cd
T_1M_2	3.00 bcd	5.80 bc	1914.2 c	2506.7 bc
T_1M_3	3.56 a	6.96 a	2807.2 a	3357.3 a
T_1M_4	3.00 bcd	6.76 a	1802.8 cd	2628.3 b
T_2M_1	2.80 de	5.23 de	1387.8 fg	2327.2 cd
T_2M_2	2.93 cde	5.33 d	1224.3 g	1902.0 e
T_2M_3	2.76 def	5.13 de	1654.8 de	2484.2 bcd
T_2M_4	3.20 abc	5.40 cd	1516.7 ef	2203.7 d
$LSD_{0.05}$	0.39	0.44s	12.24	14.52
CV%	8.17	4.98	8.74	8.11

T_0M_1 = distilled water +soil + vermicompost; T_0M_2 = distilled water + soil + cowdung; T_0M_3 = distilled water + soil + cocopeat + vermicompost; T_0M_4 = distilled water + soil + cocopeat + cowdung; T_1M_1 = GA_3 + soil + vermicompost; T_1M_2 = GA_3 + soil + cowdung; T_1M_3 = GA_3 + soil + cocopeat + vermicompost; T_1M_4 = GA_3 + soil + cocopeat + cowdung; T_2M_1 = KNO_3 +soil + vermicompost; T_2M_2 = KNO_3 + soil + cowdung; T_2M_3 = KNO_3 + soil + cocopeat + vermicompost; T_2M_4 = KNO_3+ soil + cocopeat + cowdung.
Means followed by same letter(s) in a column do not differ significantly at 5% level of LSD.

3.4. Fresh weight of shoot and root (g)

Fresh weight of shoot and root (g) at papaya seedling varied significantly due to seed priming treatments and growing media (**Table 3**). At 50 DAG, the highest fresh weight of shoot (6.40 g) and root (4.30 g) of papaya were observed from the treatment combination of T_1M_3 and the lowest fresh weight of shoot (1.94 g) and root (0.88 g) of papaya were recorded from the treatment combination of T_0M_2 (**Table 3**). GA_3 increases the fresh weight of shoots and roots in *Syzygium cumini* seedlings, possibly due to its effect on increasing cell division, cellular and auxin metabolism, cell wall flexibility, and cell membrane permeability[24]. Nazari et al.[25] observed that the highest fresh weight of shoot and root was observed in hyacinth grown with cocopeat as potting media.

Table 3. Effect of seed priming treatments and different growing media and on fresh weight of shoot and root (g) of papaya seedling.

Treatments	Fresh wt. of shoot (g)		Fresh wt. of root (g)	
	30 DAG	50 DAG	30 DAG	50 DAG
T_0M_1	0.67 fg	2.15 f	0.15 bc	0.96 f
T_0M_2	0.60 g	1.94 g	0.11 c	0.88 f
T_0M_3	0.68 efg	2.25 f	0.14 bc	1.01 f
T_0M_4	0.75 defg	1.94 f	0.15 bc	0.88 f
T_1M_1	2.19 b	4.45 c	0.73 a	3.30 b
T_1M_2	2.26 b	3.27 e	0.82 a	2.06 de
T_1M_3	3.52 a	6.40 a	0.96 a	4.30 a
T_1M_4	1.61 c	5.80 b	0.38 b	3.38 b
T_2M_1	1.09 defg	3.546 e	0.28 bc	2.84 bc
T_2M_2	1.18 cde	2.21 f	0.26 bc	1.84 e
T_2M_3	1.25 cd	3.25 e	0.29 bc	2.27 de
T_2M_4	1.11 cdef	3.99 d	0.22 bc	2.44 cd
$LSD_{0.05}$	0.50	0.39	0.25	0.56
CV%	11.30	6.84	9.23	5.27

T_0M_1 = distilled water +soil + vermicompost; T_0M_2 = distilled water + soil + cowdung; T_0M_3 = distilled water + soil + cocopeat + vermicompost; T_0M_4 = distilled water + soil + cocopeat + cowdung; T_1M_1 = GA_3 + soil + vermicompost; T_1M_2 = GA_3 + soil + cowdung;

T_1M_3 = GA_3 + soil + cocopeat + vermicompost; T_1M_4 = GA_3 + soil + cocopeat + cowdung; T_2M_1 = KNO_3 + soil + vermicompost; T_2M_2 = KNO_3 + soil + cowdung; T_2M_3 = KNO_3 + soil + cocopeat + vermicompost; T_2M_4 = KNO_3 + soil + cocopeat + cowdung.
Means followed by same letter(s) in a column do not differ significantly at 5% level of LSD.

3.5. Dry weight of shoot and root (g)

At 50 DAG, the maximum fresh weight of shoot (0.75 g) and root (0.28 g) of papaya seedling was observed from T_1M_3 and the minimum dry weight of shoot (0.17 g) and root (0.06 g) of papaya was recorded from the treatment combination of T_0M_2 (**Table 4**). GA_3 may be involved in the mobilization, translocation, and accumulation of water and nutrients delivered at a faster rate, which may have stimulated more photosynthesis, resulting in a rise in the total dry weight of shoot and root of *Manilkara hexandra*[26]. The highest dry weight of shoot and root of pothos was recorded in medium containing cocopeat[27]. This might be due to increase water use efficiency in plants, thus increasing photosynthesis and plant biomass.

Table 4. Effect of seed priming treatments and different growing media on dry weight of shoot and root (g) of papaya seedling.

Treatments	Dry wt. of shoot (g)		Dry wt. of root (g)	
	30 DAG	50 DAG	30 DAG	50 DAG
T_0M_1	0.05 c	0.33 bc	0.01 cd	0.07 c
T_0M_2	0.05 c	0.17 e	0.01 cd	0.06 c
T_0M_3	0.05 c	0.21 de	0.01 cd	0.07 c
T_0M_4	0.05 c	0.18 e	0.01 cd	0.05 c
T_1M_1	0.21 bc	0.55 b	0.03 b	0.22 ab
T_1M_2	0.12 bc	0.41 c	0.02 bc	0.20 b
T_1M_3	0.64 a	0.74 a	0.05 a	0.28 a
T_1M_4	0.14 bc	0.75 a	0.02 b	0.27 a
T_2M_1	0.28 b	0.39 c	0.01 cd	0.27 a
T_2M_2	0.10 bc	0.25 cd	0.01 d	0.07 c
T_2M_3	0.13 bc	0.38 c	0.028 b	0.09 c
T_2M_4	0.09 bc	0.42 c	0.01 bcd	0.09 c
$LSD_{0.05}$	0.22	0.11	0.01	0.06
CV%	8.91	7.41	3.56	4.77

T_0M_1 = distilled water +soil + vermicompost; T_0M_2 = distilled water + soil + cowdung; T_0M_3 = distilled water + soil + cocopeat + vermicompost; T_0M_4 = distilled water + soil + cocopeat + cowdung; T_1M_1 = GA_3 + soil + vermicompost; T_1M_2 = GA_3 + soil + cowdung; T_1M_3 = GA_3 + soil + cocopeat + vermicompost; T_1M_4 = GA_3 + soil + cocopeat + cowdung; T_2M_1 = KNO_3 + soil + vermicompost; T_2M_2 = KNO_3 + soil + cowdung; T_2M_3 = KNO_3 + soil + cocopeat + vermicompost; T_2M_4 = KNO_3 + soil + cocopeat + cowdung.
Means followed by same letter(s) in a column do not differ significantly at 5% level of LSD.

3.6. Number of leaves/plant and leaf area (cm^2)

At 50 DAG, the highest number of leaves/plant (11.67) was obtained in T_1M_3 whereas the lowest (9.00) was obtained in T_0M_1 treatment (**Table 5**). According to Raju et al.[28], adequate nutrient supply from vermicompost and cocopeat intended rapid cell division and cell elongation, which resulted in greater number of leaves in cucumber. Exogenous GA_3 treatment increased the number of leaves in strawberries[29].

At 50 DAG, results revealed that the maximum leaf area (41.89 cm^2) was recorded from T_1M_3 treatment and minimum leaf area (20.91 cm^2) was observed from T_0M_4 treatment (**Table 5**). Bisht et al.[30] reported that the application of GA_3 significantly increases leaf area of fruit crops. This could be because gibberellins boosted cell division, elongation, and length as epidermal and parenchymal cell numbers grew. Vermicompost also contains phosphate-solubilizing bacteria, azotobacter, and azospirillum, which were all included in the microbial community. According to Hazarika et al.[31], beneficial microorganisms with the ability to provide controlled growth material, resulting in increased leaf area in cabbage.

Table 5. Effect of seed priming treatments and different growing media on number of leaves plant^{-1} and leaf area (cm^2) of papaya seedling.

Treatments	No. of leaf/plant		Leaf area (cm^2)	
	30 DAG	**50 DAG**	**30 DAG**	**50 DAG**
T_0M_1	7.33 de	9.00 d	7.06 e	21.00 e
T_0M_2	7.00 e	9.33 cd	6.78 e	21.17 e
T_0M_3	8.34 abc	10.00 bcd	6.78 e	20.93 e
T_0M_4	9.33 ab	10.00 bcd	6.48 e	20.91 e
T_1M_1	9.33 ab	10.33 bc	1.90 b	34.83 b
T_1M_2	8.66 abc	9.33 cd	19.79 b	35.63 b
T_1M_3	9.67 a	11.67 a	26.67 a	41.89 a
T_1M_4	8.66 abc	10.33 bc	14.78 c	29.95 c
T_2M_1	7.00 e	10.67 ab	12.37 cd	29.55 c
T_2M_2	8.00 cde	9.67 bcd	11.88 d	25.23 d
T_2M_3	7.33 de	9.33 cd	12.90 cd	25.88 d
T_2M_4	8.00 cde	9.00 d	10.91d	27.74 cd
$LSD_{0.05}$	1.19	1.23	2.53	2.92
CV%	8.58	7.35	11.33	6.20

T_0M_1 = distilled water +soil + vermicompost; T_0M_2 = distilled water + soil + cowdung; T_0M_3 = distilled water + soil + cocopeat + vermicompost; T_0M_4 = distilled water + soil + cocopeat + cowdung; T_1M_1 = GA_3 + soil + vermicompost; T_1M_2 = GA_3 + soil + cowdung; T_1M_3 = GA_3 + soil + cocopeat + vermicompost; T_1M_4 = GA_3 + soil + cocopeat + cowdung; T_2M_1 = KNO_3 +soil + vermicompost; T_2M_2 = KNO_3 + soil + cowdung; T_2M_3 = KNO_3 + soil + cocopeat + vermicompost; T_2M_4 = KNO_3 + soil + cocopeat + cowdung.
Means followed by same letter(s) in a column do not differ significantly at 5% level of LSD.

3.7. Survival percentage and Chlorophyll content (SPAD value) of papaya seedling

Survival percentage and chlorophyll content of papaya seedling varied significantly due to the combined effect of seed priming treatments and growing media (**Figure 2**). The highest survival percentage (91.00) was obtained from the T_1M_3 treatment, whereas the lowest survival percentage (67.00) was obtained in T_0M_4 treatment (**Figure 4A**). The result was similar to Ambica and Balakrishnan[32] in cluster beans. It could be because GA_3 maintained a high water content in the cell, accelerated cell division and cell elongation, which increased seedling germination and overall growth, which may have contributed to higher seed vigour. The retention of more water and air by vermicompost aided in speedy and early enzymatic action for the synthesis of metabolites for cell multiplication, as well as the breakdown of the seed coat, culminating in the embryo's metamorphosis into a seedling at an early enough stage[15].

The maximum chlorophyll content (44.26) was observed from the treatment combination of T_1M_3 and the minimum chlorophyll content (34.03) was recorded from the treatment combination of T_0M_2 (**Figure 4B**). The use of GA_3 enhanced the process of photosynthesis, which required more light absorption and water, resulting in higher chlorophyll concentration. GA_3 considerably boosted the photosynthetic pigments of marigold (*Calendula officinalis* L.)[33]. GA_3 acted by accumulating nutrition elements from plant parts to sites where GA_3 accumulated, and some of these nutrition elements became components of new chlorophyll molecules[34]. According to Dayeswari et al.[35], vermicopost enhanced nitrogen availability, which might have assisted in the production of chlorophyll and amino acids.

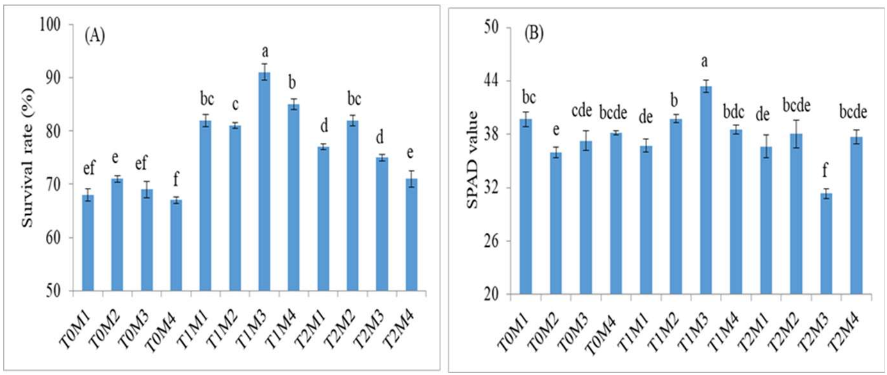

Figure 4. Effect of seed priming treatments and different growing media on survival rate (%) and SPAD value papaya seedling. Means followed by same letter(s) in a column do not differ significantly at 5% level of LSD.
T_0M_1 = distilled water +soil + vermicompost; T_0M_2 = distilled water + soil + cowdung; T_0M_3 = distilled water + soil + cocopeat + vermicompost; T_0M_4 = distilled water + soil + cocopeat + cowdung; T_1M_1 = GA_3 + soil + vermicompost; T_1M_2 = GA_3 + soil + cowdung; T_1M_3 = GA_3 + soil + cocopeat + vermicompost; T_1M_4 = GA_3 + soil + cocopeat + cowdung; T_2M_1 = KNO_3 +soil + vermicompost; T_2M_2 = KNO_3 + soil + cowdung; T_2M_3 = KNO_3 + soil + cocopeat + vermicompost; T_2M_4 = KNO_3 + soil + cocopeat + cowdung.

4. Conclusion

From the findings, it can be concluded that GA_3-treated seedlings performed better than non-GA_3 treated seedlings. Among the growing media, vermicompost with cocopeat performed the best for seed germination and other seedling growth attributes compared to other growing media. In terms of seed germination and other growth parameters of papaya seedlings, the combination of GA_3 and soil + cocopeat + vermicompost performed better.

Author contributions

This work was conducted in collaboration with all authors. Authors SC and NI conceived and designed the experiments; FH performed the experiments, analyzed the data, and contributed reagents/materials/analysis tools, prepared figures and/or tables. AK and SA performed the experiments, reviewed drafts of the paper. SC, NI, FH, AK and SA collected references, revised, and improved the manuscript. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

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