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Effect of growing media on germination, growth and nutrients uptake of papaya seedlings (*Carica papaya* L.)

Aniket Kumar Sahu, BM Tandel and NK Patel

Abstract
An experiment was conducted at Navsari Agricultural University, Navsari, Gujarat, India in year 2022 to study the effect of growing media on germination, growth and nutrients uptake of papaya seedlings (*Carica papaya* L.). The experiment was laid out in a Completely Randomized Design (CRD) with three repetitions and eleven treatments combinations of Cocopeat, Vermicompost, Vermiculite, Perlite and Peatmoss. Nutrient solution applied once in a day for watering of papaya seedling. The results of an experiment on different growing media, Cocopeat + Peat moss (3:2 v/v) were found most beneficial for improving germination percent (95.23%), took minimum days for 50% germination (9.67), maximum vigour index-I (2301.61 cm) and vigour index-II (91.83 g). The maximum growth parameters such as height of seedling (8.05 and 24.16 cm), number of leaves (7.30 and 9.34), collar diameter (2.97 and 6.05 mm) at 30 and 45 DAS, leaf area (39.60 cm^2), length of tape root (17.92 cm), tape root diameter (5.14 mm), number of secondary roots (17.33), fresh weight of shoot (9.59 g), fresh weight of root (2.71g), dry weight of shoot (0.96 g), dry weight of root (0.29 g) and survival percentage (100%). The maximum nitrogen (24.62, 17.05 and 3.65 mg $plant^{-1}$), phosphorous (7.25, 4.91 and1.62 mg $plant^{-1}$) and potassium (23.08, 24.24 and 6.34 mg $plant^{-1}$) uptake of leaf, stem and root, respectively in papaya seedling at 45 DAS.

Keywords: Growing media, seed germination, growth, survival, nutrient uptake

Introduction
Papaya (*Carica papaya* L.) is India's important tropical commercial fruit crop that belongs to the family Caricaceae. A native to tropical America, papaya was introduced from Philippines through Malaysia to India in the 16th century. It includes 35 species and 6 genera. Biologically diverse forms of cultivated papaya are monoecious, dioecious and gynodioecious (Ray, 2002) [29]. It is the 7th important fruit crop of India after mango, citrus, banana, apple, guava and sapota. Area covered under papaya cultivation is 1.42 lakh hectares with 57.80 lakh MT production (Anon., 2020) [1]. Papaya is becoming more popular among farmers because of its high productivity with high net returns.

Seed germination is affected by many factors, which include type of growing media used, environmental factors such as oxygen, water, temperature, light and application of nutrients (Bhardwaj, 2014) [7]. Papaya is commercially propagated by seed only. Germination of seed is slow, erratic and incomplete (Chako and Singh, 1966) [9]. Among different papaya variety, Red Lady is an excellent variety of papaya because of its hermaphrodite nature and prolonged shelf life. But the cost of seed is extremely high. So, increasing germination percentage and producing healthier seedlings may be a challenge for papaya growers. For the growth of seedling, media is one of the most important aspects of horticultural production systems globally. The soil is generally used as a basic medium because of its low cost and easy to procure. All soils used for media are not always perfect for the germination of seeds and subsequent growth of seedling. A good growing medium provides adequate support to the plant. It is the reservoir for nutrients and water, allow oxygen to diffuse in roots and permits gaseous exchange between the roots (Abad *et al.*, 2002) [2].

A soilless media is the best starting mixture for seedling growth. Among the different growing media, sand, cocopeat, vermiculite, perlite and peatmoss *etc.* are found to be individual or in combination suitable for raising seedling of high value crops. The soilless medium reduces incidence of soil borne diseases and pests which leads to a reduction in use of soil fumigant, it improves water use efficiency and fertilizer use due to its high water-holding and cation exchange capacity (Cantliffe *et al.*, 2007) [8].

Soilless medium or substrate with good physical and chemical properties gives farmers a planting opportunity where soil conditions are certified to be detrimental to crop cultivation (Rodriguez *et al.,* 2006) [30]. The delay in germination and poor seedling growth is often a handicap to the nurserymen and seed growers. Therefore, it's very important to select proper growing media, containers and conditions that will shorten the time of germination, enable exchange of gas from the roots and assist in the development of uniform and improved seedling growth that will allow early transplanting possibilities. It is essential to standardize the nursery growing medium to produce quality seedlings for the growers thereby shortening the nursery time period.

Material and Methods

The present experiment was conducted during the year 2022 at Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India. Eleven treatment with different growing media combinations *viz.,*T_1- Cocopeat + Vermicompost (3:1 v/v), T_2- Cocopeat + Vermiculite (3:1 v/v), T_3- Cocopeat + Perlite (3:1 v/v), T_4- Cocopeat + Peat moss (3:1 v/v), T_5- Cocopeat + Vermiculite + Perlite (3:1:1 v/v), T_6- Cocopeat + Vermiculite + Peatmoss (3:1:1 v/v), T_7- Cocopeat + Perlite + Peatmoss (3:1:1 v/v), T_8- Cocopeat + Vermiculite + Perlite + Peatmoss (6:2:1:1 v/v), T_9- Cocopeat + Vermiculite (3:2 v/v), T_{10}- Cocopeat + Perlite (3:2 v/v) and T_{11}- Cocopeat + Peat moss (3:2 v/v) were tried in Completely Randomized Design (CRD) with three repetition. The potting mixture was prepared by mixing different growing media on volume basis as per treatment. Papaya seeds were sown in plug tray [size of plug tray is 42 holes/tray, hole diameter (5.5 cm) and hole depth (6.5 cm)] which was properly filled, labeled with tags, one seed in each hole at the depth of 2 cm on 2nd February 2022 and gentle irrigation with rose cane. All plug tray place overlaps each other and covered with black plastic for seven days. After seven days cover plastic is removed and plug tray arrange treatment wise in poly house for seeds to germinate and further growth. Nutrient solution 6 g 19:19:19, 6 g 0:0:50, 6 g 0:52:34 soluble fertilizer, 20 g Urea, 2 g micro-nutrient grade-4, 6 g $CaNO_3$ and 6 g $MgSO_4$ had to be dissolved in 100-liter water and this nutrient solution applied once in a day for watering of papaya seedling. Germination parameters *viz,* days taken for 50% germination (date of sowing to days taken for 50% germination), germination percentage (fifteen days after sowing), vigour index I and Vigour index II were recorded with below formula and growth observations were recorded at 30 and 45 DAS (end of experiment) and leaf area, tap root length, tap root diameter, number of secondary roots, fresh and dry weight of root and shoot and survival percentage were recorded at 45 DAS (end of experiment). Nutrient uptake by leaf, stem and root were analysis at end of the experiment with following formula:

$$\text{Nutrient uptake of leaf (mg plant}^{-1}) = \frac{\%\ \text{Nutrient content} \times \text{leaf dry weight (mg plant}^{-1})}{100}$$

$$\text{Nutrient uptake of stem (mg plant}^{-1}) = \frac{\%\ \text{Nutrient content} \times \text{stem dry weight (mg plant}^{-1})}{100}$$

$$\text{Nutrient uptake of root (mg plant}^{-1}) = \frac{\%\ \text{Nutrient content} \times \text{root dry weight (mg plant}^{-1})}{100}$$

Seedling vigour index I = Germination percentage × Seedling length

Seedling vigour index II = Dry weight of seedlings (g) × Germination percentage

Results and Discussion

Germination Parameters

A perusal of data given in Table 1 revealed the germination attributes *viz*., minimum days taken for 50% germination (9.67), maximum germination percentage (95.23%) and vigour index-I (2301.61 cm), vigour index-II (91.83 g) were found in papaya seedlings growing media Cocopeat + Peatmoss (3:2 v/v) *i.e.,* T_{11} while, the maximum days (13.67) for 50% germination, minimum germination percentage (75.82%), vigour index-I (731.66 cm) and vigour index- II (19.30 g) were recorded under treatment T_1 control *i.e.,* Cocopeat + Vermicompost (3:1 v/v). It might be due to the Cocopeat given warm condition, high water holding capacity and presence of organic matter and air retention capacity in the Peatmoss media, which helped in quick and early enzymatic action for the synthesis of metabolites for cell multiplication and enhanced the breakdown of the seed coat, resulting in the transformation of an embryo into a seedling early enough (Hasan *et al.,* 2010) [15]. Peatmoss have a high cation exchange capacity (CEC) and adsorb exchangeable cations which are available to the plant and will resist the leaching of nutrients during watering (Atif *et al.,* 2016) [6]. Media combinations Cocopeat + Peatmoss have high nutrient uptake capacity which increases the vegetative growth of the seedling. Similar results were obtained by Choudhary and Wilson (2020) [10] and Wagadre *et al.* (2019) [31] in papaya; Lepakshi and Reddy (2021) [17] in jamun and Patel *et al.* (2017) [23] in custard apple.

Growth Parameters

Among the growth characters, it is evident from the data in Table 1 reveal that the maximum seedling height (8.05 and 24.16 cm), collar diameter (2.97 and 6.05 mm) and number of leaves per plant (7.30 and 9.34) at 30 and 45 DAS were observed in papaya seedling grow in media combination T_{11} *i.e.,* Cocopeat + Peatmoss (3:2 v/v) and the minimum seedling height (5.26 and 10.25 cm), collar diameter (2.02 and 3.49 mm) and number of leaves per seedling (5.27 and 7.77) at 30 and 45 DAS was recorded under Cocopeat + Vermicompost (3:1 v/v). The maximum enhancement in plant height under Cocopeat + Peatmoss may be attributed to the fact that these media optimized pH and nutrient content which was given in the form of nutrient solution thereby improving plant growth. Besides, N stimulates the development of leaves, P promotes cell division and membrane development which increases plant height and K increases the sugar accumulation and

growth rate consequently enhancing the plant height (Madhavi *et al.*, 2021) [18]. The collar diameter and the number of leaves of papaya seedlings raised in this media might be due to dealing with the physical characteristics of the cocopeat + peatmoss growing medium increases the growth of the plant by providing suitable conditions, thereby increasing the growth and the number of leaves compared to other media (Aslanpour *et al.*, 2018) [5]. These results are in close conformity with the earlier report Nagar *et al.* (2016) [21], Desai *et al.* (2017) [12] and Mishra *et al.* (2017) [20] in papaya.

The data presented in Table 2 indicated that maximum leaf area (39.60 cm^2), tap root length (17.92 cm), tap root diameter (5.14 mm) and number of secondary roots (17.33) at 45 DAS were found in T_{11} *i.e.*, Cocopeat + Peatmoss (3:2 v/v). While the minimum leaf area (18.94 cm^2), tap root length (10.66 cm), tap root diameter (2.58 mm) and number of secondary roots (12.47) at 45 DAS were recorded in growing media Cocopeat + Vermicompost (3:1 v/v). Cocopeat and peatmoss which are rich in coconut waste and other biodegradable material enhance the soil fertility and nutrients available for overall seedling production (Raja *et al.*, 2018) [26]. It also provides desirable vegetative growth and increases the number of leaves and leaf area (Aslanpour *et al.*, 2018) [5]. It might be due to the successful use of lightweight growing media, cocopeat and peatmoss maintains sufficient aeration for the root zone it has air pockets or pores to supply oxygen to plant roots and allow for drainage. Oxygen plays a critical role in determining root orientation as well as root metabolic status. Similar results were obtained by Arvind *et al.* (2015) [4], Ramteke *et al.* (2015) [28], Rakibuzzaman *et al.* (2019) [27] and Nandini and Singh (2021) [22] in papaya.

It is obvious from the data presented in Table 2 growing media Cocopeat + Peatmoss (3:2 v/v) gave maximum fresh weight of shoot (9.59 g), fresh weight of root (2.71 g), dry weight of shoot (0.96 g) and dry weight of root (0.29 g) at 45 DAS. Although the minimum fresh weight of shoot (3.01 g), fresh weight of root (0.56 g), dry weight of shoot (0.33 g) and dry weight of root (0.10 g) were recorded in T_1 *i.e.*, Cocopeat + Vermicompost (3:1 v/v). The dry and organic matter content of a plant depends on the proportion of cell wall and content of the plant. If the cell wall is greater than its content, the dry matter content will be high. The addition of peatmoss, vermiculite and perlite in soilless media may positively affect vegetative growth and could reflect in shoot and root dry weight because these materials especially peatmoss increases air-filled and porosity in the container filled soilless media (Pill and Goldberger, 2009) [25]. These results are in close agreement with Anjanawe *et al.* (2013) [3], Dash *et al.* (2019) [11] and Nandini and Singh (2021) [22] in papaya.

Maximum survival percentage (100%) at 45 days after sowing was recorded under T_{11} *i.e.*, Cocopeat + Peatmoss (3:2 v/v) and lowest survival (95.05%) was noted in media Cocopeat + Vermicompost (3:1 v/v). This might be the reason why cocopeat and peatmoss have appropriate physical properties, such as low bulk density and high total porosity, nutrient exchange capacity and good drainage facilities which restrict the growth of some diseases such as damping off. These could have adversely affected seedling growth and survival. These results are closely related to Meena *et al.* (2017), Dash *et al.* (2019) [11], Mishra *et al.* (2017) [20], Nandini and Singh (2021) [22] in papaya; Patel *et al.* (2018) [24], in citrus and Khot *et al.* (2019) [16] in custard apple.

Chemical Analysis

In the chemical analysis of plant nutrient uptake by leaf, stem and root presented in Table 3 and revealed the maximum nitrogen uptake of leaf (24.62 mg $plant^{-1}$), stem (17.05 mg $plant^{-1}$) and root (3.65 mg $plant^{-1}$), phosphorous uptake of leaf (7.25 mg $plant^{-1}$), stem (4.91 mg $plant^{-1}$) and root (1.62 mg $plant^{-1}$) and potassium uptake of leaf (23.08 mg $plant^{-1}$), stem (24.24 mg $plant^{-1}$) and root (6.34 mg $plant^{-1}$) were recorded under treatment T_{11} *i.e.*, Cocopeat + Peatmoss (3:2 v/v). However, the minimum nitrogen uptake of leaf (6.37 mg $plant^{-1}$), stem (4.95 mg $plant^{-1}$) and root (1.09 mg $plant^{-1}$), phosphorus uptake of leaf (2.06 mg $plant^{-1}$), stem (1.66 mg $plant^{-1}$) and root (0.67 mg $plant^{-1}$) and potassium uptake of leaf (6.24 mg $plant^{-1}$), stem (7.65 mg $plant^{-1}$) and root (3.07 mg $plant^{-1}$) were estimated in treatment control T_1 *i.e.*, Cocopeat + Vermicompost (3:1 v/v). The maximum nutrient in papaya seedling might be due to peatmoss having a high% of organic matter normally less electrical conductivity < 0.2 ds m^{-1} (Grattana and Grieve, 1999) [14] and low bulk density so porosity in them was high, therefore root aeration is sufficient and residence of substrate to root penetration is low. As result, the root as well as penetrated into media and root expansion sufficiently was done led to an increase in water and nutrient elements uptake (Ghehsareh *et al.*, 2011) [13].

Table 1: Effect of different growing media on germination and growth parameters of papaya seedlings

Treatments	Days taken for 50% germination	Germination (%)	Vigour index - I (cm)	Vigour index - II (g)	Seedling height (cm)		Collar diameter (mm)		Number of leaves per seedling	
					30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
T_1	13.67	75.82	731.66	19.30	5.26	10.25	2.02	3.49	5.27	7.77
T_2	11.33	85.57	1576.34	69.16	6.47	18.46	2.77	4.73	6.77	8.53
T_3	12.33	86.27	1353.67	64.25	6.07	16.39	2.65	5.10	6.47	8.33
T_4	10.33	94.59	1976.10	87.13	7.80	20.85	2.78	5.74	6.95	9.07
T_5	12.67	90.17	1300.72	53.31	6.11	14.45	2.63	4.77	6.13	8.47
T_6	10.67	91.93	1688.03	79.87	7.14	18.36	2.54	5.47	7.03	9.00
T_7	12.67	89.49	1318.97	41.20	6.07	14.73	2.69	4.66	6.50	8.60
T_8	11.33	89.38	1339.83	47.79	6.21	14.99	2.68	4.91	6.41	8.53
T_9	11.67	90.73	1561.77	52.56	6.51	17.23	2.68	4.92	6.73	8.48
T_{10}	11.67	78.78	1192.92	38.17	5.59	15.13	2.47	4.87	6.80	8.53
T_{11}	9.67	95.23	2301.61	91.83	8.05	24.16	2.97	6.05	7.30	9.34
S.E.M ±	0.64	2.19	67.59	1.86	0.23	0.63	0.11	0.19	0.25	0.18
CD at 5 %	1.90	6.46	199.54	5.45	0.68	1.86	0.31	0.56	0.74	0.53
CV %	9.58	4.31	7.88	5.50	6.18	6.51	7.07	6.66	6.66	3.65

Table 2: Effect of different growing media on growth parameters and survival of papaya seedlings

Treatments	Leaf area (cm^2)	Tap root length (cm)	Tap root diameter (mm)	Number of secondary roots	Fresh weight of shoot (g)	Fresh weight of root (g)	Dry weight of shoot (g)	Dry weight of root (g)	Survival (%)
	At 45 DAS	At 45 DAS	At 45 DAS	At 45 DAS	At 45 DAS	At 45 DAS	At 45 DAS	At 45 DAS	At 45 DAS
T_1	18.94	10.66	2.58	12.47	3.01	0.56	0.33	0.10	95.05
T_2	27.37	14.52	4.86	15.30	5.59	1.98	0.81	0.20	96.89
T_3	22.45	17.51	4.81	14.53	6.25	2.53	0.78	0.25	97.09
T_4	32.87	16.95	4.59	16.53	6.82	1.78	0.92	0.23	99.13
T_5	21.44	16.56	4.67	15.10	4.34	2.15	0.59	0.15	97.17
T_6	25.23	14.13	5.09	16.63	5.28	1.63	0.87	0.15	98.33
T_7	22.87	16.34	4.44	14.67	4.17	1.27	0.46	0.12	96.87
T_8	24.16	11.44	4.57	15.73	4.77	1.99	0.53	0.14	96.23
T_9	23.84	17.08	4.77	14.80	4.88	2.14	0.58	0.15	96.30
T_{10}	22.72	16.91	4.46	14.40	4.48	1.86	0.49	0.13	95.61
T_{11}	39.60	17.92	5.14	17.33	9.59	2.71	0.96	0.29	100.00
S.E.M ±	1.01	0.78	0.22	0.73	0.20	0.08	0.02	0.001	0.76
CD at 5 %	3.00	2.32	0.65	2.14	0.59	0.25	0.07	0.03	2.22
CV %	6.89	8.82	8.46	8.33	6.55	8.03	6.04	9.09	1.36

Table 3: Effect of different growing media on nutrient uptake (mg $plant^{-1}$) of papaya seedlings

Treatments	Nitrogen uptake (mg $plant^{-1}$)			Phosphorus uptake (mg $plant^{-1}$)			Potassium uptake (mg $plant^{-1}$)		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
T_1	6.37	4.95	1.09	2.06	1.66	0.67	6.24	7.23	3.07
T_2	8.65	8.13	2.62	2.58	2.54	0.91	17.11	13.36	5.48
T_3	7.93	10.75	3.43	2.24	2.98	1.12	15.08	15.86	4.47
T_4	16.78	16.20	3.06	4.69	4.59	1.08	21.88	22.62	4.49
T_5	13.28	12.09	1.72	3.96	3.42	0.81	15.34	15.99	2.79
T_6	14.56	13.80	1.72	3.71	3.81	0.78	21.34	16.42	4.10
T_7	12.42	10.51	1.67	3.74	3.10	0.64	8.15	9.75	2.70
T_8	8.37	10.43	1.58	2.48	3.11	0.70	14.08	13.75	2.64
T_9	13.68	11.70	1.84	3.69	3.17	0.76	13.74	14.61	3.02
T_{10}	12.43	9.26	1.64	3.87	2.71	0.70	13.80	10.94	3.27
T_{11}	24.62	17.05	3.65	7.25	4.91	1.62	23.08	24.24	6.34
S.E.M ±	0.40	0.30	0.08	0.13	0.12	0.03	0.57	0.57	0.14
CD at 5 %	1.18	0.89	0.23	0.40	0.31	0.10	1.68	1.68	0.43
CV %	5.53	4.66	6.38	6.57	5.68	6.83	6.46	6.64	6.73

Conclusion

From the foregoing results, it can be concluded that papaya seedlings raised in a plug tray with growing media as a Cocopeat + Peatmoss (3:2 v/v) gave the best results in terms of seed germination, vegetative growth, biomass production, survival of plant and nutrient uptake at 45 days after sowing in papaya seedlings.

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