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Effect of growth media and plant growth regulators on growth parameters of papaya (*Carica papaya* L.)

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Abstract
The papaya (*Carica papaya* L.) is one of the 22 accepted species in the genus carica of the family *caricaceae*. It is also grown extensively as a filler plant in orchards. The applications of different growth media and organic as well as inorganic fertilizers at nursery stage are the key factors to enhance the production. Growth media and plant growth regulators both are an integral part of most of the horticultural production system Soil, vermicompost, cocopeat, vermiculite *etc*. as different growing media and NAA (Auxin) and Gibberellic acid of different concentrations are included as growth regulators were used. Use of growth media and plant growth regulators also brought out perceptible variation in growth parameters like seedling height (30 and 45 DAS), number of leaves per plant (45 DAS), leaf area, seedling girth (45 DAS), number of roots (45 DAS) and root length (45 DAS). The perusal data was observed that in having Soil + Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm (T_3) recorded significantly higher seedling height at 30 and 45 DAS (11.30 and 15.73 cm, respectively). The maximum number of leaves per plant as 7.89 and 9.29, respectively, were recorded in same above treatment T_3 at 30 and 45 DAS. Treatment T_3 recorded the maximum leaf area of papaya seedlings (32.28 cm2) and the maximum stem girth of papaya seedlings at 30 and 45 DAS was recorded as 3.98 mm and 5.48 mm, respectively also in T_3 treatment. Higher number of roots per plant were recorded (18.67) under treatment T3 (Soil+ Vermicompost (2:1) along with 50 ppm NAA. And maximum root length (10.81cm) was observed in treatment T_3 at 45 DAS of papaya seedling. The maximum and significantly higher survival percentage (10 days after transplanting) was also observed in the treatment with the application of Soil + Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm over most of the treatments.

Keywords: Growth media, vermicompost, cocopeat, leaf area

Introduction

The papaya, papaw or pawpaw (*Carica papaya* L.) is one of the 22 accepted species in the genus carica of the family caricaceae. The cultivated papaya might have originated as a cross between two species of the genus *Carica*. Papaya is one of the most important fruit crops of Hawaii, Malaysia, Burma, Sri Lanka, India, Queens land, South Africa and other tropical and sub-tropical. It covers a cultivated area of 462 thousand hectares with 13735 thousands MT of production with average productivity of 30 t/ha. (Anonymous, 2019a) [2].

In India, it is successfully grown all over the country and. papaya occupies 2.0 percent of the total fruit crop area and 5.3 percent of total fruit production in India. It occupies a cultivated area of 149 thousand hectares with 6050 thousand MT of production with average productivity of 41 t/ ha. (Anonymous, 2019b) [3]. The important papaya growing states are Andhra Pradesh, Gujarat, Karnataka, Madhya pradesh, West Bengal, Assam, Bihar, Uttar Pradesh *etc*. Whereas it is grown 0.51 thousand hectares with annual production of 4.37 thousand tonnes in Rajasthan and it has 8.6 t/ha productivity (Anonymus, 2017-18) [2].

Papaya has become a popular fruit plant due to its fast growth, high yield, long fruiting period and nutritional value as well. The nutritive and medicinal properties of papaya are well known. Papaya fruit is very low in calories (43 calories/100g) and contains no cholesterol. 100g edible portion of papaya contains 89.6 per cent moisture, 9.5 per cent carbohydrate, 0.5 per cent proteins, 0.1 per cent fat, 4.0 per cent calorific value. Papaya is commercially propagated by seed and the best time of raising seedling is June to September but in North India frost is a common problem, therefore seedlings can be raised from February to May (Singh and Dahiya, 1982).

The major production constraint encountered in papaya is difficulty in maximizing yield with in unit time. Balanced nutrition plays a vital role on plant growth, yield and fruit quality. Therefore the applications of different growth media and inorganic fertilizers at nursery stage along with organic manures at later stage are the key factors to enhance the production. During seedling stage it requires a fertile soil or suitable growth media for better growth and development of the plants. The development of root system is suppressed and plants are more susceptible to soil borne diseases in heavy soils without drainage (Beattie and White, 1992) [6]. Therefore, the use of suitable growing media for sowing of seed plays an important role in seed germination and subsequent vegetative growth of seedlings (Srivastava *et al*., 1998).

Similarly, the plant growth regulators are also profoundly influence the growth and differentiation of plant cells, tissues and organs. Auxins are synthesized in stem or root apices and transported through the plant axis. The principal auxin present in the plants is indole-3 acetic acid (IAA). Furthermore, the other PGR's like gibberellins are also responsible to cause stem elongation and flowering of the plants (Shanmugavelu, 1985) [12].

Growth media and plant growth regulators both are an integral part of most of the horticultural production system Soil, vermicompost, cocopeat, vermiculite etc. as different growing media and NAA (Auxin) and Gibberellic acid of different concentrations were used in this present investigation.

Materials and Methods

The experiment was arranged in a Completely Randomized Design (CRD) with three replications. Each of ten treatments (Table 1) consisted of 150 polybags and each polybag containing one seedling variety of "Red Lady".

In order to evaluate the effect of growth media and plant growth regulators on growth parameters of papaya (*Carica papaya* L.) cv. "Red Lady", necessary periodical observations were also recorded. A methodology of individual aspect is briefly described in the following parameters.

Table 1: Treatments with their symbols

Treatments	Symbols
Soil + Vermicompost (2:1)	T_1
Soil + Vermicompost (2:1) +Seed soaking with GA_3 @ 150ppm	T_2
Soil + Vermicompost (2:1) +Seed soaking with NAA @ 50ppm	T_3
Soil +Cocopeat (2:1)	T_4
Soil+ Cocopeat (2:1) + Seed soaking with GA_3 @ 150ppm	T_5
Soil+ Cocopeat (2:1) + Seed soaking with NAA @ 50ppm	T_6
Soil + Vermiculite (2:1)	T_7
Soil + Vermiculite (2:1) + Seed soaking with GA_3 @ 150ppm	T_8
Soil + Vermiculite (2:1) + Seed soaking with NAA @ 50ppm	T_9
Control (Soil)	T10

A. Seedling height

Ten seedlings were randomly selected from each treatment and tagged permanently. Height of tagged seedlings was measured from the base to the tip of the shoot at 30 and 45 days after sowing by meter scale and average height of selected ten seedlings was computed as mean plant height.

B. Number of leaves

Ten seedlings selected for measurement of seedling height were also used to record number of leaves per seedlings at 30 and 45 days after sowing and their average was drawn by counting them.

C. Stem girth

The stem girth of randomly selected ten papaya seedlings was measured from the base of the stem with the help of vernier calipers at 30 and 45 days after sowing in millimeters.

D. Number of roots

Counting the number of roots per seedling was done at the time of transplanting in selected ten seedlings in each treatment.

E. Root length

The root length of randomly selected ten papaya seedlings was measured after uprooting the plant from the point of initiation of roots to the tip of the root in centimeter at 45 days after sowing with the help of meter scale and average length was calculated.

F. Fresh weight of shoot

Shoots of selected ten seedlings in each replication were separated and weighed at 45 days after sowing with the help of electronic balance to record their fresh weight. The average fresh weight of shoot in gram was drawn.

G. Fresh weight of root

Similarly, the selected ten seedlings in each replication were separated and weighed to record their fresh weight and average root weight in gm" was calculated

Plate A: Showing germination of seed of papaya

Plate B: Effect of growth media and plant growth regulators on root length (T_1 - T_{10})

Plate C: Effect of growth media and plant growth regulators on seedling growth (C-1 & C-2)

H. Leaf area

Leaf area of selected ten seedlings at the time of transplanting (45 DAS) was measured with the leaf area meter and the average leaf area per sq. cm was observed.

I. Shoot: Root Ratio

The weight of root and shoot of selected ten seedlings in each replication were recorded separately and their ratio was calculated.

J. Survival percentage

Survival percentage of papaya seedlings was observed by transplanting the seedlings in the field. Five plants of each treatment were transplanted in field and survivality up to 10 days after transplanting was calculated using the formulae as

$$\text{Survival \%} = \frac{\text{Total number of surviving seedlings}}{\text{total number of transplanted seedlings}} \times 100$$

Results

Seedling height (cm): The data presented in Table 2 & Plate C revealed that seedling height was significantly influenced by different growth media and plant growth regulators at 30 and 45 days after sowing of papaya seedling. Growth media and plant growth regulators having Soil + Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm recorded significantly higher seedling height at 30 and 45 DAS (11.30 and 15.73 cm, respectively) as compared to rest of the treatments except treatment T_6, which was remained at par at both the stages. The increase in plant height of papaya seedling under T_3 was registered 88.01 and 74.77 per cent higher over T_{10} at 30 and 45 DAS, respectively.

Table 2: Effect of growth media and plant growth regulators on seedling height, number of leaves and stem girth of papaya

Treatments		Seedling height (cm)		Number of leaves		Stem girth (mm)	
		30DAS	45 DAS	30DAS	45 DAS	30DAS	45 DAS
T_1	Soil + Vermicompost (2:1)	8.82	11.63	6.00	7.09	3.48	4.03
T_2	Soil + Vermicompost (2:1) +Seed soakingwith GA_3 @ 150 ppm	10.27	13.97	7.29	7.93	6.67	4.63
T_3	Soil + Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm	11.30	15.73	7.89	9.29	3.968	5.48
T_4	Soil + Cocopeat (2:1)	8.76	11.52	6.09	6.65	3.63	4.52
T_5	Soil + Cocopeat (2:1) + Seed soaking with GA_3 @ 150	9.85	13.93	6.28	7.19	3.70	4.78
T_6	Soil + Cocopeat (2:1) + Seed soaking with NAA @ 50	11.18	14.77	7.33	3.69	3.81	5.42
T_7	Soil + Vermiculite (2:1)	7.64	10.13	5.23	6.14	3.37	3.97
T_8	Soil + Vermiculite (2:1) + Seed soaking with GA_3 @	7.97	11.89	5.70	6.42	3.66	4.14
T_9	Soil + Vermiculite (2:1) + Seed soaking with NAA @	8.91	13.37	6.10	6.67	3.73	4.29
T_{10}	Control (Soil)	6.01	9.00	4.69	5.62	3.10	3.97
	S.Em±	0.22	0.37	0.21	0.25	0.15	0.15
	CD (P =0.05)	0.66	1.10	0.61	0.73	0.44	0.47

Number of roots

Data presented in Table 3 indicated that significantly higher number of roots per plant were recorded (18.67) under treatment T_3 than rest of the treatments, except treatment T_6*i.e.* Soil + Cocopeat (2:1) + seed soaking with NAA @ 50 ppmwhich was remained at par. However, the minimum number of roots (12.43) were recorded under the treatment T_{10}*i.e.* soil. The increase in number of roots per plant was registered 50.20 per cent higher in this treatment T_3 (Soil+ Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm over treatment.

Root length (cm)

The data pertaining to root length in Table 3 & Plate B clearly indicated that maximum root length (10.81cm) was observed in treatment T_3 at 45 DAS of papaya seedling. While, minimum (6.20cm) was recorded under treatment T_{10}. Treatment T_3 proved significantly superior over rest of the treatments except treatment T_6, which was statistically at par to treatment T_3. Treatment T_3 registered 74.35 per cent higher root length of papaya seedlings than treatment T_{10}*i.e.* soil.

Fresh weight of shoot (g)

It is amply clear from data (Table 4) that use of different growth media with plant growth regulators significantly influenced the fresh weight of papaya shoots. The maximum fresh weight of shoot (3.76 g) was recorded under treatment T_3. This treatment also found significantly superior than treatment T_1, T_4, T_7, T_8 and T_{10} but statistically at par with T_2, T_5, T_6, and T_9. However, the minimum fresh weight of shoot (2.03 g) was recorded under the treatment T_{10}. The use of treatment T_3 *i.e.* Soil+ Vermicompost (2:1) with NAA @ 50 ppm registered 85.22 per cent higher fresh weight of shoot over treatment T_{10} (soil).

Fresh weight of roots (g)

It is evident from data (Table 4) that use of different growth media and plant growth regulators had significant effect on fresh weight of roots of papaya seedlings at 45 days after sowing. The maximum fresh weight of root (1.02 g) was recorded with treatment T_3 (Soil+ Vermicompost (2:1) along with NAA @ 50 ppm, while minimum was found under T_{10} (0.62 g). The treatment T_3 was significantly superior over most of the treatments, but found to be statistically at par with T_2 andT_6. The increase in fresh weight of roots of papaya seedling under T_3 was noted 64.51 per cent higher over treatment T_{10} *i.e.* soil.

Table 3: Effect of growth media and plant growth regulators on number of roots and root length per plant of papaya seedling

Treatments	Number of roots	Root length (cm)
T_1 Soil + Vermicompost (2:1)	15.10	8.11
T_2 Soil + Vermicompost (2:1) + Seed soaking with GA_3 @ 150 ppm	16.87	9.52
T_3 Soil + Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm	18.67	10.81
T_4 Soil + Cocopeat (2:1)	15.56	8.24
T_5 Soil + Cocopeat (2:1) + Seed soaking with GA_3 @ 150 ppm	16.65	9.56
T_6 Soil + Cocopeat (2:1) + Seed soaking with NAA @ 50 ppm	18.00	10.47
T_7 Soil + Vermiculite (2:1)	13.39	7.93
T_8 Soil + Vermiculite (2:1) + Seed soaking with GA_3 @ 150 ppm	14.82	8.43
T_9 Soil + Vermiculite (2:1) + Seed soaking with NAA @ 50 ppm	16.00	9.50
T_{10} Control (Soil)	12.43	6.20
S.Em ±	0.30	0.27
CD (P = 0.05)	0.87	0.81

Table 4: Effect of growth media and plant growth regulators on fresh weight of shoot, root and shoot/root ratio of papaya

Treatments	Fresh weight of shoot (g)	Fresh weight of roots (g)	Shoot: Root Ratio
T_1 Soil + Vermicompost (2:1)	2.52	0.69	3.65
T_2 Soil + Vermicompost (2:1) + Seed soaking with GA_3 @ 150 ppm	3.48	0.98	4.35
T_3 Soil + Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm	3.76	1.02	4.53
T_4 Soil + Cocopeat (2:1)	2.79	0.71	3.93
T_5 Soil + Cocopeat (2:1) + Seed soaking with GA_3 @ 150 ppm	3.54	0.83	4.26
T_6 Soil + Cocopeat (2:1) + Seed soaking with NAA @ 50 ppm	3.67	0.99	4.44
T_7 Soil + Vermiculite (2:1)	2.38	0.63	3.78
T_8 Soil + Vermiculite (2:1) + Seed soaking with GA_3 @ 150 ppm	3.20	0.78	4.10
T_9 Soil + Vermiculite (2:1) + Seed soaking with NAA @ 50 ppm	3.59	0.86	4.27
T_{10} Control (Soil)	2.03	0.62	3.25
S.Em ±	0.13	0.03	0.11
CD (P = 0.05)	0.40	0.08	0.32

Shoot: ratio

A perusal of data given in Table 4 revealed that use of different growth media with plant growth regulators brought out perceptible variation in shoot: root ratio of papaya seedlings at 45 days after sowing. Maximum and significantly higher shoot: root ratio (4.53) was observed in treatment $T_3$and it was statistically at par with treatment T_2, T_5, T_6 and T_9 during the course of experimentation. However, minimum shoot: root ratio (3.25) was found in treatment T_{10} *i.e.* soil. Treatment T_3 and T_6 registered 38.53 and 35.77 per cent, respectively, higher shoot: root ratio as compared to treatment T_{10}.

Survival percentage

It is apparent from data (Table 5) that use of growth media and plant growth regulators significantly enhanced the survival percentage of papaya seedlings at 10 days after transplanting in field. The maximum survival percentage (92.38) was recorded in treatment T_3 (Soil+ Vermicompost + Seed soaking with NAA @ 50 ppm), while minimum was observed under T_{10} (73.66). The treatment T_3 was significantly superior over T_{10}, but found to be statistically at par with treatments (T_2, T_4, T_5, and T_6). It registered 25.41 per cent higher survival percentage over treatment T_{10} *i.e.* soil.

Table 5: Effect of growth media and plant growth regulators on survival of papaya (10 days after transplanting)

Treatments	Survival (%)
T_1 Soil + Vermicompost (2:1)	86.94
T_2 Soil + Vermicompost (2:1) + Seed soaking with GA_3 @ 150 ppm	89.26
T_3 Soil + Vermicompost (2:1) + Seed soaking with NAA @ 50 ppm	92.38
T_4 Soil + Cocopeat (2:1)	87.90
T_5 Soil + Cocopeat (2:1) + Seed soaking with GA_3 @ 150 ppm	90.05
T_6 Soil + Cocopeat (2:1) + Seed soaking with NAA @ 50 ppm	91.65
T_7 Soil + Vermiculite (2:1)	81.39
T_8 Soil + Vermiculite (2:1) + Seed soaking with GA_3 @ 150 ppm	83.38
T_9 Soil + Vermiculite (2:1) + Seed soaking with NAA @ 50 ppm	86.87
T_{10} Control (Soil)	73.66
S.Em ±	1.58
CD (P = 0.05)	4.65

Results of present studies are in confirmity with Rajamanickam and Anbu (2010) [11], Parasana *et al.* (2012) [10] and Bhardwaj (2013) [7] suggested Soil+ Vermicompost + Seed soaking with NAA @ 50 ppm as a better growth medium for papaya plant establishment. Edwards (1998) [8] and Kalalbandi *et al.* (2003) [9] reported that vermicompost showed positive effects on root and shoot development and leaf area in vegetative propagation. Abirami *et al.* (2010) [1] reported that good physical and biological conditions in vermicompost and cocopeat had positive effect on root development, which is helpful in increased survival percentage of seedling in main field after transplanting. Beneficial effect of Vermicompost and cocopeat on root system was also observed on nutmeg seedling.

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