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Effect of ga_3 and growing media on seedling growth of papaya (*Carica papaya* L.) cv. pusa Nanha

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Abstract
The present study was carried out to investigate "Effect of GA_3 and growing media on seedling growth of papaya (*Carica papaya* L.) cv. Pusa Nanha". The study revealed that the treatments comprised combinations of soil, FYM and vermicompost with varying levels of GA_3. The result indicated that GA_3 200 ppm is found to be the most effective for better root growth parameters (number of primary and secondary roots, length of primary and secondary roots, fresh and dry weight of roots), shoot growth parameters (height of the seedling, number of leaves, girth of seedling, average leaf area, fresh and dry weight of shoot) and survival percentage whereas root/shoot ratio was maximum reduced in GA_3 150 ppm. Among different growing media soil + FYM + vermicompost (1:1:1) recorded higher values for root growth parameters, shoot growth parameters and survival percentage of papaya seedlings. The treatment combination of GA_3 200 ppm and growing media soil: FYM: vermicompost (1:1:1) showed better root growth parameters and shoot growth parameters and survival percentage. Therefore, the combination of GA_3 200 ppm and growing media soil: FYM: vermicompost (1:1:1) was found most suitable for better growth of papaya seedling.

Keywords: FYM, Vermicompost, Soil and GA_3

Introduction
Papaya is botanically known as *Carica papaya* L. and belongs to the family Caricaceae, is originated from tropical America (Hafmer, 1990) [10] and introduced in India during 16th century from Malacca (Kumar and Abraham, 1983) [11]. Papaya occupies 2.0 percent total fruit crop area and 5.3 percent of total fruit production in India. It occupies a cultivated area of 126.0 thousand ha with an annual production of 5508.0 thousand MT with average productivity of 43.7 MT/ha (Anonymous, 2016). Papaya is generally propagated by seed (Cheema and Dhani, 1990) [6] and it is interested by the researchers due to the presence of gelatinous sarcotesta preventing germination and dormancy. Gibberellins act in the mobilization of seed reserves during the germination process. Therefore, GA_3 considered as a important germination promoters which increased the seed germination of papaya (Zanotti and Barros, 2014) [18]. Growing media plays an important role in seed germination and subsequent vegetative growth of seedlings (Srivastava *et al.,* 1998) [16]. Media not only acts as a growing place but also as a source of nutrient for plant growth. The soil is usually used as a basic medium because it is cheapest and easy to procure (Bhardwaj, 2013) [3]. Vermicompost provides sufficient levels of oxygen to roots, adequate storage of water and nutrient for the plants. FYM is having good water holding capacity as well as sufficient porosity.

Material and methods
The present investigation was carried out at Shade net house, Department of Fruit Science, K.N.K. College of Horticulture, Mandsaur (M.P.), RVSKVV, Gwalior (M.P.) during the year 2016-2017. The experiment was laid out in Factorial Complete Randomized Block Design. The experiment comprised of sixteen treatment with combination of GA_3 and growing media. Gibberellic acid (GA_3) presoaking for 12 hours with three concentrations i.e. GA_3 100 ppm, 150 ppm, 200 ppm and Control as water soaking of seeds and different growing media used in different ratio i.e. Soil as control, Soil: FYM (1:1), Soil: Vermicompost (1:1) and Soil: FYM: Vermicompost (1:1:1).

Results and discussion

Effect of GA_3

According to table 1a & 1b, the various root growth parameters such as number of primary and secondary roots, length of primary and secondary roots, fresh and dry weight of roots and root/shoot ratio were found significant among different treatments. At 60 days after sowing (DAS) the seeds pre-treated with G_3 (GA_3 200 ppm) observed the maximum number of primary roots (6.42), maximum number of secondary roots (25.00), longest primary roots (9.65 cm), longest secondary roots (3.56 cm), highest fresh weight of roots (2.49 g) and highest dry weight of roots (0.24 g) were observed with treatment G_3 (GA_3 200 ppm). The minimum root/shoot ratio (0.51) were observed in treatment G_2 (GA_3 150 ppm) and Maximum root/shoot ratio (0.56) was found in G_3 (GA_3 200 ppm). This might be due to the fact that, vigorous root growth due to GA_3 might have resulted in more production of photosynthetic product and their translocation through phloem to the root zone, which might be responsible for improving the root growth. The findings are supported by Dhankhar *et al.*, (1997) [8].

Table 1 (a): Effect of GA_3 and growing media on Root parameters of papaya seedlings (*Carica papaya* L.) cv. Pusa Nanha

Treatment	Treatment details	Number of primary roots	Number of secondary roots	Length of primary roots (cm)	Length of secondary roots (cm)
G0	Untreated seed	5.17	20.83	7.96	2.86
G1	GA_3- 100ppm	5.33	21.58	8.60	3.18
G2	GA_3- 150ppm	6.08	24.00	9.28	3.42
G3	GA_3- 200ppm	6.42	25.00	9.65	3.56
SE(m)		0.14	0.37	0.18	0.06
C.D. at 5%		0.41	1.08	0.52	0.18
M0	Soil	5.25	21.08	8.13	2.87
M1	Soil + FYM (1:1)	5.42	21.25	8.41	3.06
M2	Soil + Vermicompost (1:1)	5.83	24.00	9.26	3.52
M3	Soil + Vermicompost + FYM (1:1:1)	6.50	25.08	9.69	3.57
SE(m)		0.14	0.37	0.18	0.06
C.D. at 5%		0.41	1.08	0.52	0.18
G0M0	Untreated seeds + Soil	5.00	18.00	6.48	2.23
G0M1	Untreated seeds + Soil + FYM (1:1)	5.00	18.33	7.87	2.51
G0M2	Untreated seeds + Soil + Vermicompost (1:1)	5.33	23.33	8.59	3.28
G0M3	Untreated seeds + Soil + Vermicompost +FYM (1:1:1)	5.33	23.67	8.90	3.42
G1M0	GA_3-100 ppm + Soil	5.00	19.33	8.18	2.69
G1M1	GA_3-100 ppm + Soil + FYM (1:1)	5.33	21.00	8.17	3.19
G1M2	GA_3-100 ppm + Soil + Vermicompost (1:1)	5.33	23.33	8.90	3.46
G1M3	GA_3-100 ppm + Soil + Vermicompost +FYM (1:1:1)	5.67	22.67	9.14	3.40
G2M0	GA_3-150 ppm + Soil	5.33	23.33	8.81	3.26
G2M1	GA_3-150 ppm + Soil + FYM (1:1)	5.67	22.67	8.48	3.26
G2M2	GA_3-150 ppm + Soil + Vermicompost (1:1)	6.00	23.67	9.56	3.54
G2M3	GA_3-150 ppm + Soil + Vermicompost +FYM (1:1:1)	7.33	26.33	10.26	3.62
G3M0	GA_3-200 ppm + Soil	5.67	23.67	9.06	3.29
G3M1	GA_3-200 ppm + Soil + FYM (1:1)	5.67	23.00	9.11	3.28
G3M2	GA_3-200 ppm + Soil + Vermicompost (1:1)	6.67	25.67	9.99	3.80
G3M3	GA_3-200 ppm + Soil + Vermicompost +FYM (1:1:1)	7.67	27.67	10.45	3.86
SE(m)		0.28	0.75	0.36	0.12
C.D. at 5%		0.83	2.17	NS	0.36

Table 1 (b): Effect of GA_3 and growing media on Root parameters of papaya seedlings (*Carica papaya* L.) cv. Pusa Nanha

Treatment	Treatment details	Fresh weight of roots (g)	Dry weight of roots (g)	Root/Shoot ratio
G0	Untreated seed	1.79	0.14	0.55
G1	GA_3- 100ppm	2.06	0.18	0.55
G2	GA_3- 150ppm	2.14	0.21	0.51
G3	GA_3- 200ppm	2.49	0.24	0.56
SE(m)		0.04	0.004	0.01
C.D. at 5%		0.12	0.012	0.03
M0	Soil	1.93	0.17	0.54
M1	Soil + FYM (1:1)	2.00	0.18	0.54
M2	Soil + Vermicompost (1:1)	2.23	0.20	0.56
M3	Soil + Vermicompost + FYM (1:1:1)	2.31	0.22	0.54
SE(m)		0.04	0.004	0.01
C.D. at 5%		0.12	0.012	NS
G0M0	Untreated seeds + Soil	1.45	0.12	0.53
G0M1	Untreated seeds + Soil + FYM (1:1)	1.64	0.14	0.53
G0M2	Untreated seeds + Soil + Vermicompost (1:1)	2.02	0.15	0.58
G0M3	Untreated seeds + Soil + Vermicompost +FYM (1:1:1)	2.03	0.16	0.56
G1M0	GA_3-100 ppm + Soil	1.97	0.17	0.55
G1M1	GA_3-100 ppm + Soil + FYM (1:1)	2.02	0.18	0.56
G1M2	GA_3-100 ppm + Soil + Vermicompost (1:1)	2.11	0.19	0.53
G1M3	GA_3-100 ppm + Soil + Vermicompost +FYM (1:1:1)	2.13	0.19	0.53
G2M0	GA_3-150 ppm + Soil	2.09	0.19	0.54

G2M1	GA_3-150 ppm + Soil + FYM (1:1)	2.11	0.19	0.51
G2M2	GA_3-150 ppm + Soil + Vermicompost (1:1)	2.17	0.21	0.51
G2M3	GA_3-150 ppm + Soil + Vermicompost +FYM (1:1:1)	2.20	0.23	0.48
G3M0	GA_3-200 ppm + Soil	2.22	0.20	0.52
G3M1	GA_3-200 ppm + Soil + FYM (1:1)	2.23	0.21	0.54
G3M2	GA_3-200 ppm + Soil + Vermicompost (1:1)	2.61	0.27	0.60
G3M3	GA_3-200 ppm + Soil + Vermicompost +FYM (1:1:1)	2.89	0.29	0.57
SE(m)		0.08	0.008	0.02
C.D. at 5%		0.25	0.024	NS

The various shoot growth parameters such as height of the plant, number of leaves per plant, girth of seedling, average leaf area, fresh weight of shoot and dry weight of shoot of seedling were found to be significant enhanced by GA_3 applications. But chlorophyll content (SPAD Value) of seedling was recorded non-significant (Table 2a & 2b). The maximum plant height (11.08 cm), maximum number of leaves per plant (9.78), maximum girth of seedling (3.58 mm) and largest average leaf area (37.50 cm^2) were found in treatment G_3 (GA_3 200 ppm). This may be attributed due to the reason that the endogenous levels of GA_3 synthesized by the papaya seedling might not be sufficient and external application of GA_3 might have boosted growth by increasing cell multiplication and cell elongation resulting in better plant growth (Shanmugavellu, 2007) [15].

Table 2 (a): Effect of GA_3 and growing media on Shoot parameters of papaya seedlings (*Carica papaya* L.) cv. Pusa Nanha

Treatment	Treatment details	Plant height (cm)	Number of leaves	Girth of seedling (mm)	Average leaf area (cm^2)
G0	Untreated seed	8.85	7.82	3.26	31.33
G1	GA_3- 100ppm	9.58	8.47	3.33	32.54
G2	GA_3- 150ppm	10.61	9.41	3.54	36.57
G3	GA_3- 200ppm	11.08	9.78	3.58	37.50
SE(m)		0.11	0.10	0.01	0.33
C.D. at 5%		0.33	0.29	0.03	0.96
M0	Soil	9.50	7.91	3.26	31.60
M1	Soil + FYM (1:1)	9.62	8.37	3.34	33.83
M2	Soil + Vermicompost (1:1)	10.11	9.40	3.50	35.88
M3	Soil + Vermicompost + FYM (1:1:1)	10.90	9.80	3.61	36.63
SE(m)		0.11	0.10	0.01	0.33
C.D. at 5%		0.33	0.29	0.03	0.96
G0M0	Untreated seeds + Soil	8.67	6.63	3.10	25.53
G0M1	Untreated seeds + Soil + FYM (1:1)	8.88	7.33	3.16	30.36
G0M2	Untreated seeds + Soil + Vermicompost (1:1)	8.93	8.27	3.30	34.33
G0M3	Untreated seeds + Soil + Vermicompost +FYM (1:1:1)	8.93	9.03	3.48	35.08
G1M0	GA_3-100 ppm + Soil	9.07	7.63	3.21	30.32
G1M1	GA_3-100 ppm + Soil + FYM (1:1)	9.37	8.03	3.24	31.33
G1M2	GA_3-100 ppm + Soil + Vermicompost (1:1)	9.93	8.73	3.39	33.67
G1M3	GA_3-100 ppm + Soil + Vermicompost +FYM (1:1:1)	9.97	9.47	3.49	34.85
G2M0	GA_3-150 ppm + Soil	10.00	8.33	3.35	34.23
G2M1	GA_3-150 ppm + Soil + FYM (1:1)	10.03	8.80	3.52	36.26
G2M2	GA_3-150 ppm + Soil + Vermicompost (1:1)	10.43	10.23	3.64	37.59
G2M3	GA_3-150 ppm + Soil + Vermicompost +FYM (1:1:1)	11.97	10.27	3.65	38.19
G3M0	GA_3-200 ppm + Soil	10.27	9.03	3.39	36.33
G3M1	GA_3-200 ppm + Soil + FYM (1:1)	10.20	9.30	3.44	37.36
G3M2	GA_3-200 ppm + Soil + Vermicompost (1:1)	11.13	10.37	3.65	37.93
G3M3	GA_3-200 ppm + Soil + Vermicompost +FYM (1:1:1)	12.73	10.43	3.83	38.38
SE(m)		0.23	0.20	0.02	0.66
C.D. at 5%		0.67	NS	0.07	1.92

Table 2 (b): Effect of GA_3 and growing media on Shoot parameters of papaya seedlings (*Carica papaya* L.) cv. Pusa Nanha

Treatment	Treatment details	Fresh weight of shoot (g)	Dry weight of shoot (g)	Chlorophyll content (SPAD Value)	Survival percentage (%)
G0	Untreated seed	3.24	0.39	49.76	77.33 (61.79)
G1	GA_3- 100ppm	3.78	0.57	50.60	78.11 (62.56)
G2	GA_3- 150ppm	4.21	0.77	49.73	82.61 (65.43)
G3	GA_3- 200ppm	4.44	0.97	47.70	86.42 (68.49)
SE(m)		0.05	0.026	0.74	0.91
C.D. at 5%		0.14	0.075	NS	2.64
M0	Soil	3.60	0.54	45.50	74.36 (59.77)
M1	Soil + FYM (1:1)	3.73	0.60	49.99	78.61 (62.61)
M2	Soil + Vermicompost (1:1)	4.02	0.70	50.89	83.93 (66.47)
M3	Soil + Vermicompost + FYM (1:1:1)	4.32	0.85	51.41	87.58 (69.43)
SE(m)		0.05	0.026	0.74	0.91
C.D. at 5%		0.14	0.075	2.14	2.64

G0M0	Untreated seeds + Soil	2.77	0.30	42.03	70.00 (56.67)
G0M1	Untreated seeds + Soil + FYM (1:1)	3.08	0.37	50.57	76.67 (61.20)
G0M2	Untreated seeds + Soil + Vermicompost (1:1)	3.48	0.43	52.34	78.00 (62.01)
G0M3	Untreated seeds + Soil + Vermicompost +FYM (1:1:1)	3.61	0.46	54.11	84.67 (66.99)
G1M0	GA_3-100 ppm + Soil	3.55	0.53	45.60	67.33 (55.13)
G1M1	GA_3-100 ppm + Soil + FYM (1:1)	3.57	0.55	52.17	71.43 (57.67)
G1M2	GA_3-100 ppm + Soil + Vermicompost (1:1)	3.97	0.59	52.82	85.71 (67.77)
G1M3	GA_3-100 ppm + Soil + Vermicompost +FYM (1:1:1)	4.02	0.61	51.80	87.97 (69.68)
G2M0	GA_3-150 ppm + Soil	3.84	0.64	49.22	77.78 (61.85)
G2M1	GA_3-150 ppm + Soil + FYM (1:1)	4.11	0.62	49.44	81.33 (64.38)
G2M2	GA_3-150 ppm + Soil + Vermicompost (1:1)	4.30	0.73	49.75	84.33 (66.66)
G2M3	GA_3-150 ppm + Soil + Vermicompost +FYM (1:1:1)	4.59	1.08	50.52	87.00 (68.85)
G3M0	GA_3-200 ppm + Soil	4.25	0.70	45.15	82.33 (65.14)
G3M1	GA_3-200 ppm + Soil + FYM (1:1)	4.15	0.87	47.78	85.00 (67.19)
G3M2	GA_3-200 ppm + Soil + Vermicompost (1:1)	4.32	1.04	48.65	87.67 (69.44)
G3M3	GA_3-200 ppm + Soil + Vermicompost +FYM (1:1:1)	5.04	1.25	49.23	90.67 (72.20)
SE(m)		0.10	0.052	1.49	1.83
C.D. at 5%		0.29	0.150	NS	5.29

The highest fresh weight of shoot (4.44 g) and highest dry weight of shoot (0.97 g) were observed with G_3 (GA_3 200 ppm) while, lowest were recorded in G_0 (control). This seems to be the effect of mobilization of water and nutrients transported at higher rate which might have promoted more production of photosynthetic product and translocated them to various plant parts which might have resulted in better growth of the seedlings and hence more fresh and dry weight. These findings are in agreement with the results obtained by Lay *et al*., (2015) [12] in papaya. The different levels of GA_3 did not affect significantly to increase chlorophyll content.

The highest survival percentage of seedling (86.42%) was observed with G_3 (GA_3 200 ppm). Lowest (77.33%) was found in G_0. This may be due to GA_3 are used for weakening of the seed coat so that the emergence of radical and plumule is positively influenced for root and shoot initiation. Beside this, GA_3 also helps in cell expansion and its elongation resulting better root and shoot growth, which supports and encourage better survival of the seedlings (Rahangdale, 2015) [14].

Growing media

The maximum number of primary roots (6.50), maximum number of secondary roots (25.08), longest primary roots (9.69 cm) and longest secondary roots (3.57 cm), highest fresh weight of roots (2.31 g) and highest dry weight of roots (0.22 g) were observed in treatment M_3 (Soil + Vermicompost + FYM (1:1:1)) and minimum in M_0 (control) (Table 1a & 1b). This may be due to synergetic effect of different media composition. The role of FYM in improving the physical characteristics of the soil, increasing soil ventilation by increasing the porosity and this animal fertilizers being an organic matter in soil is considered as a big source of nutrient elements especially nitrogen and phosphorus by Vishwakarma, (2013) [17]. Vermicompost represented hormone-like activity and increased the number of roots, thereby, enhancing nutrient uptake as well as plant growth and development. The effect of growing media on root/shoot ratio was observed non-significant.

According the table 2a & 2b, the various shoot parameters have significant results. The treatment M_3 (Soil + Vermicompost + FYM (1:1:1)) gained maximum height of plant (10.90 cm), maximum number of leaves per plant (9.80), maximum seedling girth (3.61 mm) This could be attributed to the conducive effect of this media mixture on water holding capacity, porosity, soil aeration and supplying substantial amount of nutrient specially nitrogen and micro nutrients for good root and shoot growth over soil alone (Chopde *et al*., 1999) [7].

The application of growing media combinations had significant effect on average leaf area (36.63 cm^2), highest fresh weight of shoot (4.32 g) and highest dry weight of shoot (0.85 g) of papaya seedling. The maximum fresh weight and dry weight of shoot and largest average leaf area in treatment M_3 might be due to the fact that, organic manure initially form conducive environment with regard to physical parameters of soil which promote better shoot growth and other vegetative growth the presence of beneficial microorganisms or biologically active plant growth influencing substances such as phytohormone are released by beneficial microorganisms present in the vermicompost rich soil that increase the average leaf area, fresh weight and dry weight of shoot (Edwards, 1998) [9].

Among the different growing media, M_3 (Soil + Vermicompost + FYM (1:1:1)) media had maximum chlorophyll content (51.41 mg) and highest survival percentage (87.58%).This could be due to the higher uptake of nutrients, particularly nitrogen. This fact is supported by the works of Pafli (1965) [15] that the uptake of N, the chief constituent of chlorophyll, protein and amino acids is accelerated through its increased supply at appropriate time to the plants.

Interaction effect

The results given in table 1a & 1b have significant with various root parameters. The maximum number of primary roots (7.67), maximum number of secondary roots (27.67) and longest secondary roots (3.86 cm) were given by G_3M_3 (Soil + Vermicompost + FYM (1:1:1) + GA_3 200 ppm). Interaction of GA_3 and growing media were also significantly enhanced fresh and dry weight of roots. Highest fresh weight of roots (2.89 g) and highest dry weight of roots (0.29 g) were also recorded with the treatment G_3M_3 (Soil + Vermicompost + FYM (1:1:1) + GA_3 200 ppm). While, length of primary and root/shoot ratio were observed non-significant. In root growth parameters the overall growth may be improved due to synergistic effect of media and GA_3, media helps to provide better water holding capacity, porosity, soil aeration and supplying substantial amount of nutrient specially nitrogen and micro nutrients for the proper growth of root (Chopde *et al*. 1999 ; Edwards, 1998) [7, 9] and GA_3 might have increased the physiological activities of seedlings, essential for cell division or cell enlargement or both, because growth of the plant occurs by two processes i.e. cell division

by mitosis which adds new cells and elongation of already existing cells by enlargement of the vacuoles (Vishwakarma, 2013) [17].

The various shoot parameters have significant results in table 2a & 2b. The maximum plant height (12.73 cm), girth of seedling (3.83 mm), maximum average leaf area (38.38 cm^2), fresh weight of shoot (5.04 g) and dry weight of shoot (1.25 g) were given by media combination G_3M_3 (Soil + Vermicompost + FYM (1:1:1) + GA_3 200 ppm). Because, GA_3 stimulate the cambium and its immediate cell progeny by the process of enhancing the rate of cell multiplication. The rate increase in the dimension of the cell both in pith and cortex region is faster than number of cells per unit area resulting better shoot growth (Agha *et al*., 1990) [1] and a appropriate media mixture provides better root environment to the plant leading to better nutrient availability to the photo synthetically functional leaves that ultimately utilized for shoot growth promotion (Borah *et al*., 2007) [4]. However, the number of leaves and chlorophyll content had result non-significant.

The maximum survival percentage (90.67%) was recorded under the treatment G_3M_3 (Soil + Vermicompost + FYM (1:1:1) + GA_3 200 ppm). This may be due to GA_3 helps in cell expansion and its elongation resulting better root and shoot growth, which supports and encourage better survival of the seedlings (Rahangdale, 2015) [14] and media containing FYM and vermicompost as most of the constituents provided a start for establishment of seedlings which further got supplemented by PGPR's. This encourage beneficial effect on plant health and growth and accelerate the availability of nutrients and assimilates as well as the production of substances promoting plant growth (Chawla and Mehta, 2015) [15].

Conclusion

It may be concluded from the findings of the present study that papaya seeds after treating among the different GA_3 treatments, G_3 (GA_3 200 ppm), recorded better root growth parameter, shoot growth parameter and survival percentage. In different media combinations, growing media M_3 (Soil + Vermicompost + FYM (1:1:1)) recorded better root growth parameter, shoot growth parameter and survival percentage. Among the interaction, application of G_3M_3 (Soil + Vermicompost + FYM (1:1:1) + GA_3 200 ppm) recorded better root growth parameter, shoot growth parameter and survival percentage as compared to other treatment of GA_3 and other media combinations, but maximum reduced root/shoot ratio was recorded in treatment G_2 (GA_3 150 ppm).

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