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EFFECT OF GA_3 AND PROPAGATION MEDIA ON GERMINATION, GROWTH AND VIGOUR OF PAPAYA CV. COORG HONEY DEW

VIKAS RAMTEKE[1]*, D. H. PAITHANKAR[2], EKTA P. NINGOT[2] AND VIVEK KUMAR KURREY[3]
[1]Department of Fruit Science,
ASPEE College of Horticulture and Forestry, N.A.U., Navsari - 396 445, Gujarat, INDIA
[2]Department of Horticulture, Dr. PDKV, Akola - 444 104, Maharashtra, INDIA
[3]Department of Horticulture, I.G.A.U., Raipur - 492 012, Chhattisgarh, INDIA
e-mail: ramtekeviks@gmail.com

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***Corresponding author**

ABSTRACT
An experiment was conducted during 2013-14 to study the influence of GA_3 and growing media on seed germination and seedling growth of papaya. The treatments comprised combinations of soil, sand, FYM, cocopeat and vermicompost with varing levels of GA_3. Altogether, 21 treatments were applied in a Factorial completely randomized block design with three replications. The result indicated that GA_3 200 ppm is found to be the most effective for better germination of papaya seeds as well as growth of papaya seedlings (height of the seedling, average leaf area, stem diamter, length of tap root, fresh and dry weight of seedlings as well as survival per cent of seedlings). Among different growing media soil + FYM (1:1) recorded higher values for germination percentage, seed vigour index, height of the seedling, number of leaves, average leaf area, stem girth and length of tap root, whereas maximum shoot and root weight and survival percentage was noticed in soil: sand : cocopeat: vermicompost (1:1:1:1) media. The treatment combination of GA_3 200 ppm and growing media soil: sand: cocopeat: vermicompost (1:1:1:1) showed higher germination per cent, seed vigour index, average leaf area, length of tap root and survival percentage. Therefore, the combination of GA_3 200 ppm and growing media soil + sand + cocopeat + vermicompost (1:1:1:1) was found most suitable for growing of papaya nursery.

INTRODUCTION

The papaya (*Carica papaya* L.) is an important fruit crop of India, is grown throughout the tropical and subtropical region of the country. The growers are increasing area under papaya cultivation due to great demand as table fruits as well as vegetable when unripe. It is also used in soft drinks, jams, ice-cream flavouring etc. Papaya occupies 2.0 per cent total fruit crop area and 5.3 per cent of total fruit production in India (5381.73 thousand MT of production from 132.18 thousand hectares with average productivity of 40.71 t ha^{-1} (Anon., 2014). The important papaya growing states are Andhra Pradesh, Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Bihar, West Bengal, Tamil Nadu, Kerela, Uttar Pradesh and Rajasthan have ideal climate conditions for its growth and production. Papaya is normally propagated by seed (Cheema and Dhani, 1930). Proper seed grmination and seedling growth are most important considerations in successful seedling prodution under nursery technique of papaya cultivation. The germination of seeds of *Carica papaya* is frequently reported to be slow, erratic and incomplete (Chako and Singh, 1966; Lange, 1961). The seed is enclosed within a gelatinous sarcotesta (aril or outer seed coat which is formed from the outer integument). Removal of seed covering structures, arils then presoak arils improves germination (Lange, 1961). Gibberellins act in the mobilization of seed reserves during the germination process. Therefore, they are considered important germination promoters and contribute to increased and uniform seed germination, thus improving the performance of papaya seeds (Zanotti and Barros, 2014).

Propagation media also plays an important role in seed germination. Media not only acts as a growing place but also as a soure of nutrient for plant growth. Vermicompost provides sufficent levels of oxygen to roots, adequate storage of water and nutrient for the plants; humic substances significantly increase nutrients availability and consequently affect growth, yield and quality of plant. FYM is having good water holding capacity as well as sufficient porousity, thus permitting adequate moisture and exchange of gases between the germination growth media and the embryo (Anjanawe *et al.*, 2013). Cocopeat is considered as a good growing media component with acceptable pH, electrical conductivity and other chemical attributes (Abad *et al.*, 2002). Hence the study was carried out to increase the germination potential and subsequent seedling growth of papaya seeds with various pre soaking treatments of GA_3 and propagation media.

MATERIALS AND METHODS

The experiment was conducted at the Commercial Fruit Nursery, Department of Horticulture, Akola (M.H.). The poly bags experiment was laid out in factorial completely randomized design with three replications. The experiment comprised of twenty one treatment combinations, Gibberellic

acid (GA_3) presoaking for 12 hours with two concentrations *i.e.* GA_3 at 100ppm (G_1) , 200ppm (G_2) and Control as water soaking of seeds (G_0) and different growing media used in different ratio i.e. Soil as control (M_0), Soil:FYM (1:1) (M_1), Soil: Cocopeat (1:1) (M_2), Soil: Sand: FYM (1:1:1) (M_3), Soil: Sand: Cocopeat (1:1:1) (M_4), Soil: Sand: Vermicompost(1:1:1) (M_5) and Soil: Sand: Cocopeat : Vermicompost (1:1:1:1) (M_6). The germination percentage was worked out after complete germination, i.e., after stoppage of germination. It was calculated by dividing the total number of seeds sown by the number of seeds germinated and was multiplied by 100. Observations were recorded with respect to seedling height, number of leaves and stem girth at 25 and 50 days after sowing (DAS). Seedling height was measured from base of seedling to highest tip of plant. Stem daimeter was measured 1 cm above from the base of the stem using vernier caliper. Average leaf area was calculated by taking a random leaf tranced on a graph paper. Number of secondary roots and length of tap root was measured by destructive method of uprooting the plant and taking measurement by standard method. Fresh weight and dry weight of seedlings were also recorded. Seedling vigour was calculated based on the following formula (Bewley and Black, 1982).

Vigour index I = Per cent germination × Length of seedling

Vigour index II = Per cent germination × Total dry weight of seedling

Survival per cent was recorded by using following formula;

$$\text{Survival \%} = \frac{\text{Total survived seedlings}}{\text{Total germinated seeds}} \times 100$$

Per cent values are transformed into arc sign values. All data was subjected to analysis of variance (ANOVA) to determine significant differences and comparison of mean at a significant level of 5 %.

RESULTS AND DISCUSSION

GA_3

The results (Table1) revealed that the maximum (73.01%) seed germination of papaya was obtained under G_2 (200 ppm GA_3) followed by G_1 (68.57%) and G_0 (62.85%). The promising effect of GA_3 as pre-sowing treatment to the seeds replaced the dormancy mechanism of the seeds resulting in early germination (Khan, 1981). Gibberellic acid acts on the embryo and causes synthesis of hydrolyzing enzymes particularly amylase and protease and this hydrolyzed food is utilized for growth of embryo and thereby enhanced the germination (Paleg, 1965). Similar results were reported by Dhankhar and Singh (1996) in aonla; Bharche *et al.* (2010) and Dhinesh Babu *et al.* (2010) in papaya.

The various vegetative growth parameters such as height of the seedling, number of leaves per seedling, average leaf area, stem girth and length of tap root were found to be significant among different treatments (Table 1). At 25 and 50 days after sowing (DAS) the seeds pre-treated with GA_3 200 ppm recorded maximum height of the seedling (6.01 and 14.92 cm) followed by GA_3 100 ppm (5.52 and 14.44 cm). Significantly least plant height was recorded in control (5.41 and 13.36 cm). The increased height in GA_3 200 ppm seeds may be attributed 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. The results obtained in the present investigation are in close conformity with the results obtained by Pawshe *et al.*, (1997).

The number of leaves per seedling (Table-1) was maximum with GA_3 100 ppm (4.22 and 8.20) followed by GA_3 200 ppm (4.14 and 7.80) whereas, control recorded the minimum (3.68 and 7.65) at 25 and 50 days of sowing respectively.Increase in number of leaves might be due to the reason that GA_3 helps in invigoration of physiological process of plant and stimulatory effect of chemicals to form new leaves at a faster rate. The results are in confirmity of Sen *et al.* (1990) in papaya seeds.

The stem girth recorded at 25 days after sowing was significantly maximum in seed pre soaking in GA_3 200 ppm(2.31 mm) while maximum stem girth at 50 days after sowing were also associated in GA_3 200 ppm (4.28 mm) which was statistically at par with GA_3 100 ppm (4.16 mm). The increase in diameter as a result of GA_3 application might be due to the fact that GA_3 increase somatic uptake of nutrients causing cell elongation and thus increasing height of the plant (Faucht and Watson, 1958). Similar, results were also recorded by Dhankar and Singh (1996) in aonla and Bharche *et al.* (2010) in papaya.

The fresh weight and dry weight of plant were found significantly maximum under treatment GA_3 200 ppm followed by seed treatment with GA_3 100 ppm (Table 2). 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. The results are in confirmity with the findings of Dhankhar and Singh (1996) in Aonla.

Similarly average leaf area was also higher in seed pre soaking with GA_3 200 ppm (38.52 cm^2) which was statistically at par with GA_3 100 ppm (36.16 cm^2). This might be due to maximum height of seedling under this treatment. This also helps in invigoration of physiological process of plant and stimulatory effect of chemicals to form new leaves at faster rate (Sharma *et al.,* 1991).

Significantly the maximum length of tap root (7.90 cm) and number of secondary roots per seedling (11.55) was recorded with seed saoking in GA_3 200 ppm (Table 2). This might be due to the fact that, GA_3 increases somatic uptake of nutrients, causing cell elongation and thus increasing the length of tap root and number of secondary roots. The results obatined in the present studies are in agreement with that reported by Wagh *et al.* (1998) in aonla.

Similarly the significantly maximum Vigour index I and Vigour index II *i.e.*, 1646.0 and 47.00 respectively were recorded in GA_3 200 ppm followed by seed treatment with GA_3 100 ppm. This might be due to the increased germination and seedling height which have contributed to higher vigour index-I. Increased dry matter production might be attributed to higher

Table 1: Effect of GA_3 and media on germination and seedling growth of papaya

Treatments	Germination percentage	Height of the seedling (cm)		Number of leaves		Stem girth (mm)	
		25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS
G_0	62.85 (52.80)	5.41	13.36	3.68	7.65	1.83	3.90
G_1	68.57 (56.23)	5.52	14.44	4.22	8.20	1.98	4.16
G_2	73.01 (59.01)	6.01	14.92	4.14	7.80	2.31	4.28
SE(m)	1.37	0.13	0.31	0.13	0.13	0.08	0.10
C.D. at 5 %	3.90	0.37	0.89	0.37	0.08	0.23	0.29
M_0	57.03 (49.16)	5.54	12.77	3.74	7.59	1.72	4.02
M_1	75.55 (60.60)	5.56	17.37	4.70	8.70	2.44	4.76
M_2	65.18 (54.08)	5.91	12.26	3.22	6.89	1.70	3.46
M_3	61.48 (51.82)	5.27	13.97	4.26	8.14	2.04	4.02
M_4	74.07 (59.62)	5.45	12.21	3.44	7.44	1.65	3.64
M_5	70.37 (57.28)	5.64	15.18	4.29	8.14	2.33	4.70
M_6	73.33 (59.55)	6.18	15.91	4.44	8.29	2.37	4.18
SE(m)	2.09	0.20	0.48	0.20	0.20	0.13	0.15
C.D. at 5 %	5.96	0.57	1.36	0.57	0.50	0.36	0.44
$G_0 M_0$	51.11(45.63)	5.67	12.52	3.66	7.66	1.78	4.11
$G_0 M_1$	77.78(61.92)	5.58	16.69	4.33	8.33	2.11	4.66
$G_0 M_2$	55.55(48.24)	5.60	11.76	3.00	7.00	1.44	3.11
$G_0 M_3$	53.33(46.92)	5.28	13.31	3.77	7.77	1.89	4.11
$G_0 M_4$	73.33(59.02)	4.87	12.41	3.33	7.33	1.55	3.77
$G_0 M_5$	71.11(58.03)	5.17	12.78	3.55	7.55	1.89	3.77
$G_0 M_6$	57.78(49.86)	5.68	14.03	4.11	7.89	2.11	3.77
$G_1 M_0$	62.22(52.20)	4.99	13.36	4.00	8.11	1.67	3.88
$G_1 M_1$	73.33(59.36)	5.50	16.23	4.77	8.77	2.22	4.55
$G_1 M_2$	64.44(53.48)	6.23	14.20	3.22	7.66	1.78	4.11
$G_1 M_3$	62.22(52.24)	5.28	14.27	4.89	8.89	2.00	3.94
$G_1 M_4$	71.11(57.92)	5.23	12.37	3.66	7.66	1.61	3.94
$G_1 M_5$	66.66(54.80)	5.72	14.98	4.44	7.66	2.22	4.55
$G_1 M_6$	80.00(63.64)	5.70	15.70	4.55	8.66	2.33	4.11
$G_2 M_0$	57.78(49.64)	5.95	12.41	3.55	7.00	1.73	4.06
$G_2 M_1$	75.55(60.53)	5.58	19.20	5.00	9.00	3.00	5.06
$G_2 M_2$	75.55(60.53)	5.88	10.82	3.44	6.00	1.89	3.17
$G_2 M_3$	68.89(56.31)	5.23	14.32	4.11	7.77	2.22	4.00
$G_2 M_4$	77.78(61.92)	6.25	11.86	3.33	7.33	1.78	3.22
$G_2 M_5$	73.33(59.02)	6.03	17.79	4.88	9.22	2.89	5.78
$G_2 M_6$	82.22(65.15)	7.17	18.01	4.66	8.33	2.67	4.66
SE(m)	3.61	0.35	0.83	0.35	0.35	0.22	0.26
C.D. at 5 %	NS	NS	2.36	NS	1.01	NS	0.75

vigour index II (Gurung *et al.,* 2014). Maximum survival (75.02 %) was noticed in seed treatment with GA_3 200 ppm.

Propagation media

Among different media significantly maximum germination percentage of papaya seeds (77.33 %) were recorded in M_1 media *i.e.* Soil + Farm Yard Manure (1: 1) followed by M_4 (Soil: sand: cocopeat: 1:1:1) and M_6 (Soil: sand: cocopeat: vermicompost 1:1:1:1) media. Treatments M_1, M_4 and M_6 show at par value. It might due to the reason that media containing organic manures possess organic acid within them. Therefore, more available moisture and some acids may have helped in minimum days to germination and better germination percentage. Similar results were reported by Parasana *et al.* (2014) in mango.

The maximum height of seedling (6.18 cm) at 25 DAS was recorded in soil + sand + cocopeat + vermicompost (1:1:1) media. Whereas, maximum height of seedling (17.37 cm) at 50 DAS was recorded in soil + FYM (1:1) media. This may be attributed to general improvement in the physical and chemical properties of the rooting medium. Similar results were obtained by Shamet *et al.* (1994) in Chilgoza pine, and Nelson *et al.* (2008) in arnotta plant (*Bixa orellana*).

Similarly at 25 and 50 days also M_1 i.e. Soil + Farm Yard Manure (1 : 1) media produced maximum number of leaves per plant i.e. 4.70 and 8.70 closely followed by M_6 i.e. soil + sand + cocopeat + vermicompost (1:1:1:1) having 4.44 and 8.29 number of leaves respectively. It may be due to better nutrient availability leading to higher production of photo synthetically functional leaves due to growing media (Borah *et al.,* 2008). Similar results were reported by Anjanawe *et al.* (2013) in papaya and Parasana *et al.* (2014) in mango.

In respect of stem girth, Soil + Farmyard Manure (1:1) media produced maximum stem girth 2.44 mm and 4.76 mm respectively at 25 and 50 DAS which was found at par with soil + sand + cocopeat + vermicompost (1:1:1:1) media 2.37 mm and 4.18 mm respectively . It may be due to better nutrient availability leading to higher production of photo-synthetically functional leaves in these treatments finally resulting in better girth of seedling (Borah *et al.,* 2008). Similar results were also obtained by Parasana *et al.* (2014) in mango.

The application of different media combinations had significant effect on leaf area (cm^2) of papaya seedling. The medium consisting of soil + Farmyard Manure (1:1) showed maximum average leaf area (41.92 cm^2) closely followed by

Table 2: Effect of GA_3 and media on leaf area, root parameters, biomass, vigour and survival of papaya

Treatments	Average leaf area (cm^2)	Length of tap root (cm)	Number of secondary roots	Fresh weight of plant (g)	Dry weight of plant (g)	Vigour index I	Vigour index II	Survival percentage
G_0	30.12	7.11	7.11	3.74	0.44	1278.0	27.87	70.30 (57.39)
G_1	36.16	6.77	10.11	4.39	0.59	1392.0	41.11	72.43 (58.79)
G_2	38.58	7.90	11.55	4.54	0.66	1646.0	47.00	75.06 (60.51)
SE(m)	0.73	0.22	0.37	0.13	0.02	47.6	1.77	1.50
S.D.	2.10	0.62	1.06	0.08	0.06	136.0	5.05	NS
M_0	29.95	4.18	7.81	3.36	0.39	980.3	22.70	72.90 (59.14)
M_1	41.92	9.42	8.26	5.68	0.73	1900.0	48.84	76.53 (61.64)
M_2	29.00	7.00	6.48	2.54	0.42	1248.0	27.74	63.48 (52.19)
M_3	38.49	7.71	14.60	4.83	0.62	1295.0	42.01	72.59 (58.97)
M_4	30.12	6.39	7.29	3.60	0.44	1375.0	33.17	69.57 (56.55)
M_5	35.26	7.09	7.78	3.84	0.56	1456.0	38.85	75.83 (60.95)
M_6	39.95	9.03	14.90	5.70	0.77	1816.0	57.28	77.28 (62.11)
SE(m)	1.12	0.33	0.57	0.20	0.03	126.0	4.68	2.30
CD	3.20	0.94	1.63	0.56	0.09	359.9	13.35	NS
$G_0 M_0$	27.24	3.67	3.66	3.72	0.35	824.1	20.32	69.20(56.29)
$G_0 M_1$	40.48	9.97	5.67	5.04	0.78	2068.0	60.00	76.37(61.56)
$G_0 M_2$	20.55	8.47	7.33	2.19	0.23	1130.0	6.21	54.60(47.65)
$G_0 M_3$	38.97	7.87	13.40	5.75	0.68	986.9.0	34.52	75.47(60.98)
$G_0 M_4$	19.00	6.83	6.00	2.41	0.26	1413.0	14.89	68.92(56.13)
$G_0 M_5$	30.58	5.37	6.78	3.35	0.43	1290.0	27.66	72.48(58.37)
$G_0 M_6$	34.04	7.60	6.89	3.68	0.36	1233.0	20.40	75.07(60.73)
$G_1 M_0$	29.81	3.27	8.33	2.59	0.37	1056.0	29.34	73.51(59.82)
$G_1 M_1$	43.16	10.40	8.78	6.33	0.76	1589.0	42.60	76.61(61.68)
$G_1 M_2$	32.86	5.57	4.22	2.88	0.46	1274.0	29.88	65.31(53.93)
$G_1 M_3$	34.57	4.90	13.20	3.55	0.49	1193.0	35.86	66.75(54.86)
$G_1 M_4$	35.81	5.37	8.44	4.06	0.48	1247.0	40.80	69.50(56.51)
$G_1 M_5$	36.03	9.93	7.89	3.57	0.54	1605.0	29.40	77.36(62.15)
$G_1 M_6$	40.91	7.93	19.90	7.72	1.01	1783.0	68.22	78.00(62.56)
$G_2 M_0$	32.8	5.60	11.40	3.75	0.46	1061.0	29.63	75.99(61.32)
$G_2 M_1$	42.12	7.90	10.30	5.67	0.64	2044.0	39.40	76.61(61.68)
$G_2 M_2$	33.58	6.97	7.89	2.55	0.58	1340.0	36.59	70.52(57.14)
$G_2 M_3$	41.93	10.40	17.20	5.18	0.68	1704.0	57.84	75.55(61.06)
$G_2 M_4$	35.55	6.97	7.44	4.34	0.59	1466.0	43.76	70.30(62.06)
$G_2 M_5$	39.16	5.97	8.67	4.62	0.70	1473.0	35.58	77.65(62.34)
$G_2 M_6$	44.89	11.60	17.90	5.70	0.94	2430.0	63.44	78.78(63.06)
SE(m)	1.94	0.57	0.98	0.34	0.05	126.0	4.68	3.98
CD	5.55	1.63	2.82	0.97	0.15	359.9	13.35	NS

Figures in parenthesis shows arc sign transformation

soil + sand + cocopeat + vermicompost (1:1:1:1:1) media having value 39.95 cm^2 and minimum average leaf area was observed in medium soil + cocopeat -1:1, that is, 29.00 cm^2.

The length of tap root was significantly maximum (9.42 cm) in media treatment soil + Farmyard manure (1:1). Whereas, the minimum length of tap root (4.18 cm) were reported in control.This could be due to availability of sufficient nutrient content in Farmyard Manure. Famryard Manure initially forms conductive environment with regard to physical parameters of soil which promotes better root growth. The maximum number of secondary roots (14.90) was noticed in media M_6: soil + sand + cocopeat + vermicompost (1:1:1:1) followed by M_3: soil + sand + FYM (1:1:1) *i.e.*, 14.60. Treatments M_6 and M_3 are at par with each other but significantly superior to all other treatments.Vermicompost represented hormone-like activity and increased the number of roots, thereby, enhancing nutrient uptake as well as plant growth and development (Alvarez and Grigera, 2005). Similar results were obatined by Yadav *et al.* (2012) in acid lime using soil: sand: vermicompost: vermiculite: cocopeat (1:1:1:1:1) media.

The maximum fresh and dry weight of seedling i.e. 5.70 g and 0.77 g was recorded with Soil + Sand + cocopeat + vermicompost (1:1:1:1) which were at par with Soil + Farm yard Manure (1:1) media 5.68 and 0.73 g respectively. These findings indicated that the effect of vermicompost on plant growth and development were not only nutritional but also hormonal and biochemical. The vermicompost increased leaf area and biomass in various plants have been reported by some researchers (Bachman and Metzger, 2008) which are in agreement with findings of current study. Results are obtained in accordance with the results of earlier worker Yadav *et al.* (2012) in acid lime.

Vigour index-I was found to be highest (1900.0) in media Soil + Farmyard manure (1:1) which was found to be at par with Soil + Sand + Cocopeat + Vermicompost (1:1:1:1) media *i.e.* 1816.0. This might be due to increased germination and seedling height which have contributed to higher vigour index-I. Vigour index-II was found to be maximum (57.28) in Soil + Sand + Cocopeat + Vermicompost (1:1:1:1) followed by media Soil + Farmyard Manure (1:1) *i.e.* 48.84, where as minimum under treatment Soil: Cocopeat (1:1). This might be due to the fact that this media has suitable physical properties

and good water holding capacity that supports the vigrous growth of seedlings.

The maximum survival *i.e.* 77.28 % was recorded in Soil + Sand + Cocopeat + Vermicompost (1:1:1:1) media, while minimum survival (63.48 %) was observed in the media Soil + Cocopeat (1:1). This may be due to favorable media for better growth of the seedling, particularly for good development of a root system. These results are in close agreement with Shamet *et al.* (1994).

Intraction effect

Interaction of G_2M_6 {GA_3 200 ppm and (Soil + Sand + Cocopeat + Vermicompost (1:1:1:1)} recorded maximum germination percentage of papaya seeds (82.22 %). Maximum height of seedling (19.20 cm) was reported in G_2M_1 {GA_3 200 ppm and (Soil + Farmyard Manure (1:1)} whereas, maximum number of leaves (9.22) and stem girth (5.78 mm) was observed in the treatment combination G_2M_5 {GA_3 200 ppm and (Soil + Sand + Vermicompost (1:1:1:1)} at 50 DAS.

At 50 DAS, maximum average leaf area (44.89 cm^2), length of tap root (11.60 cm) and number of secondary roots (17.90) were noted in combination of G_2M_6 {GA_3 200 ppm and (Soil + sand + Cocopeat + Vermicompost (1:1:1:1)} depicted in Table 2. Maximum fresh weight of plant (7.72 g) as well as dry weight of plant (1.01 g) was recorded in G_1M_6 {GA_3 100 ppm and (Soil + Farmyard Manure (1:1)}. Vigour index I was noticed maximum (2430.0) in G_2M_6 {GA_3 200 ppm and (Soil + sand + Cocopeat + Vermicompost (1:1:1:1)}. The vigour index II was found highest in G_1M_6 {GA_3 100 ppm and (Soil + sand + Cocopeat + Vermicompost (1:1:1:1)}. The promising effect of GA_3 on seed germination might be due to its participation in the activity of alpha amylase, which catalyzes the starch conversion into simple carbohydrates and chemical energy is liberated which is used in the activation of embryo (Anjanawe *et al.*, 2013). Growth media has appropriate cation exchange capacity for retention of nutrients and having properties like good water holding capacity as well as sufficient porosity, thus permitting adequate moisture and exchange of gasses between the germination growth media and the embryo. It is essential for rapid and uniform germination of seeds (Anjanawe *et al.*, 2013).

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