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Studies on the influence of plant growth regulators and bio-inoculants on seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Red Lady under net tunnel

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Abstract
The present investigation entitled"Studies on the influence of plant growth regulators and bio-inoculants on seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Red Lady under net tunnel" was carried out during the year 2020-21 at Center of Excellence on Protected Cultivation and Precision Farming, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experiment was laid out in Completely Randomized Design and replicated thrice. Among the various treatments, application of GA_3 @ 300 ppm took shortest days to seed germination (13.80) and performed better seedling emergence (54.16%), germination percentage (85.17%), germination index (2.16), seedling vigour index I (2140.95) and seedling vigour index II (129.01) respectively. Sapling height (8.42, 12.94 and 24.96 cm at 30, 45, and 60 days, respectively), number of leaves (6.79, 8.96 and 11.71 cm at 30, 45 and 60 days, respectively), shoot length (3.52, 6.01 and 11.52 at 30, 45 and 60 days, respectively), fresh weight (14.77 g) and dry weight of sapling (1.49 g), number of roots per sapling (83.70), fresh weight (2.51 g) and dry weight of root (0.39 g), length of longest root (24.21cm), number of primary root (9.15) and secondary roots (74.98), and root diameter (1.25) was obtained best under GA_3 @ 300 ppm. Similarly, GA_3 @ 300 ppm delivered the most effective economical performance among the different treatments.

Keywords: Papaya, plant growth regulator, bio-inoculant, giberellic acid, NAA, Ethrel, PSB, azotobacter

Introduction
Papaya (*Carica papaya* L.) is an important fruit crop of tropical world and has long been known as wonder fruits of the tropics. It gives higher production of fruits per hectare and income next to banana. It belongs to the family Caricaceae and is native of Tropical America. It was introduced into India in the 16th century. It is grown in almost all tropical and subtropical countries of the world and occupies a unique place amongst the fruit crops grown in India. It can be cultivated in a temperature range of 25-35 ºC. "Papaya is an evergreen plant having hallow, softwood stem and generally unbranched. The leaves are palm like with very long petiole. Naturally growing plants are erect and fruits are various shapes like round or spherical to oblong produced from the axil of the leaves. Inside the fruit central cavity is having large number of seeds, remain attach with placenta."

Propagation of papaya is only through seeds as a viable option. Vigorous seedlings is very important for papaya growers. The germination of papaya seeds is slow, erratic and incomplete (Chacko and Singh, 1966) [8]. The seed is enclosed within a gelatinous Sarcotesta (aril or outer seed coat which is formed from the outer integument). This Sarcotesta is reported to prevent germination. Removal of seed covering structure by pre-soaking improves germination.

The papaya seeds when sown in various substrates along with biofertilizers enhanced seed germination and over all plant performance (Alarcon *et al*. 2002) [1]. However, biofertilizers are inputs containing microorganisms which are capable of mobilizing nutritive elements from non-usable form to usable form through biological processes (Athani, 2009) [4].

"The use of phytohormone is becoming increasingly important in agricultural and horticultural practices for many cultivated plants. Its use in pre-sowing seed treatment plays an important role in regulating germination and vigour. The hormones, GA_3, IAA and NAA used at various concentrations exert the same effect on the percentage germination and seedling vigour of various fruit crops.

Phytohormones like Gibberellins act in the mobilization of seed reserves during the germination process and auxins (NAA) applied on papaya seed stimulates root growth and development."'

"Bio-inoculants are carrier based preparation containing live micro-organisms in a viable from. They can be used as soil application or seed treatment and designed to improve the soil fertility and help the plant growth by increasing their number and biological activity in the rhizosphere (Subba Rao, 1998) [18]. Role of bio-inoculants in reducing the utilization of chemical fertilizers for amending the growth and development of many plants, information on the utilization of microbial-inoculants is nursery management of papaya is very limited."

Proper seed germination and seedling growth are most important considerations in successful production under nursery technique of papaya cultivation. The seed cost of many gynodioceious cultivars of papaya is very high. So increasing germination and producing vigorous seedling is very important for papaya nursery growers. The problem of uneven germination is also reported by farmers and papaya growers in India and Chhattisgarh.

Materials and Methods

The experiment "Studies on the influence of plant growth regulators and bio-inoculants on seed germination and seedling growth of papaya (*Carica papaya* L.) cv. Red Lady under net tunnel." was carried out at Research Farm of Centre of Excellence on Protected Cultivation and Precision Farming, located at College of Agriculture, IGKV, Raipur (C.G.) during the year 2020-21.The poly bags experiment was laid out in Completely Randomized Design with three replications. The experiment comprised of twelve treatments consisting of three plant growth regulators and two bio-inoculants. All PGRs were used in different concentrations. *viz.* T_0: Control (water), T_1: Gibberellic Acid @ 150 ppm, T_2: Gibberellic Acid @ 200 ppm, T_3: Gibberellic Acid @ 300 ppm, T_4: NAA @ 100 ppm, T_5: NAA @ 200 ppm, T_6: NAA @ 300 ppm, T_7: Ethrel @ 100 ppm, T_8: Ethrel @ 200 ppm, T_9 Ethrel @ 300 ppm, T_{10} PSB @ 0.5 g/10 g seed, T_{11} Azotobacter @ 0.5 g/10 g seed. The seeds were soaked for 24 hours under water before treating with the treatments. Growing media Soil: Sand: FYM was used in the ratio of (2:1:1) for all the treatments. The data for growth parameters like sapling height, number of leaves and shoot length was recorded 15, 45 and 60 days after sowing and rest of the growth parameters were recorded at the end of the experiment i.e. 60 days after sowing.

Significance of difference between means of data was tested through "F" test and critical difference (CD) was worked out wherever "F" value was found to be significant for the effect of treatment.

Results and Discussions

Days taken to seed germination

Among the various treatments, the early seed germination (13.80 days) was noticed under the treatment T_3: GA_3 @ 300ppm which was significantly superior as compared to other treatments whereas, the maximum (18.33) days taken to seed germination was registered under the treatment T_0-(Control). This might be due to the fact that, GA_3 plays an important role in two stages of germination one at initial enzyme induction and other in activation of reserve food mobilizing system which help in enhancement of germination (Jha *et al*. 1997) [12]. The above results are also in conformity with Barche *et al.* (2010) [7].

Rate of emergence (%)

The maximum 54.16% rate of emergence was recorded under the treatment T_3: GA_3 @ 300 ppm which was significantly followed by T_2: GA_3 @ 200 ppm and T_1: GA_3 @ 150 ppm having the respective mean rate of emergence 47.62% and 43.45%. Moreover, it was found that the minimum 28.97% rate of seedling emergence was observed under the treatment T_0 (Control) which was succeeded by T_{10}: PSB @ 0.5g/10g seed 30.15%. This might be due to the fact GA_3 having stimulatory effect in the formation of enzymes, which are important in early phase of germination. These results were in close agreement with the findings of Babu *et al.* (2010) [5] and Anjanawe *et al*. (2013) [3] in papaya.

Germination (%)

Maximum germination percentage was recorded when seeds were soaked in GA_3 @ 300 ppm. It might be due to the fact that GA_3 involved in the activation of cytological enzymes which stimulates α – amylase enzyme that converts insoluble starch into soluble sugars and it also initiates the radical growth by removing some metabolic blocks (Babu *et al*. 2010) [5]. The results are conformity with the findings reported by Deb *et al.* (2010) [10] and Barche *et al*. (2010) [7] in papaya.

Germination index (%)

The maximum percent seed germination index 2.16% was obtained under the treatment T_3-GA_3 @ 300 ppm which was found non-significant with T_1, T_2, T_4, T_5 and T_6 (1.75, 1.90, 1.56, 1.64 and 1.70%, respectively) under the present investigation. However, the minimum per cent germination index 1.06% was registered under the treatment T_0 (Control). This could bedue to its influence in early germination and increased percent germination. The results are in conformity with findings of Rajamanickam and Anbu (2001) [15] inaonla.

Seedling vigour index - I

The observations recorded and revealed that the highest 2140.95 of seedling vigour index – I was noted under GA_3 300 ppm which was followed by and significantly superior over T_2-GA_3 @ 200 ppm 2069.81 and T_1-GA_3 @ 150 ppm 1991.71. The lowest 1037.40 of seedling vigour index-I was recorded under the treatment T_0-Control. The vigour index of seedlings is directly dependent on germination percentage and seedling length. The hike in vigour index of GA_3 treated seeds might be due to the direct influence on the extensive growth of seedlings probably by increased mobilization of reserve foods to growing apices. Begum *et al.* (1983) [6] showed linear response of vigour index with the increase in the concentration of GA_3 in papaya.

Seedling vigour index - II

Significant variations were observed under different treatments with respect to seedling vigour index-II in papaya. As per the observations, the highest percentage of seeding vigour index–II 129.01was registered under GA_3 @ 300 ppm which was statistically superior over rest of the treatments and was followed by T_2: @ 200 ppm (117.13) and T_1: @ 150 ppm (108.59). The minimum (47.94) seedling vigour index-II was obtained under the control.The increase in seedling vigour index-II of papaya plant is might be due to more seedling dry weight due to effect gibberellic acid treatment. The present result is in close agreement with the result obtained by Sen *et al.* (2003) [17] in Kagzi lime.

Growth parameters

Height of sapling

The sapling height was significantly influenced by various treatments used during the experiment. According to observations recorded the sapling height increased with the increased observation period. At 30 days after sowing, the maximum (8.42 cm) height was noticed under the treatment T_3: GA_3 @ 300 ppm Whereas, the lowest (5.64 cm) height was observed under the treatment T_0 (Control), which was non-significantly different with T_9, T_8 and T_7 (6.95, 6.58 cm and 6.35 cm respectively). At 45 DAS the maximum (12.94 cm) height was observed under the treatment T_3 @ GA_3 300 ppm which was followed by T_2, T_1 and T_6 whose mean height was 12.60, 12. 45, and 12.28 respectively.). Whereas at 60 days after sowing, the length of the highest sapling was recorded as 24.96 cm under the treatment T_3: GA_3 @ 300 ppm which was at par with T_2, T1, T6, T5, and T4 with the mean sapling height of 24.81, 24.55, 24.09, 23.13 and 22.24 cm, respectively. While, the lowest (17.10 cm) sapling height was noted under control.

It might be due to the effect of gibberellic acid in increasing the osmotic uptake of nutrients and thereby causing cell elongation reflects in greater intermodal length, ultimately resulting in increase in plant height. These results are in conformity with Barche *et al.* (2010) [7], Babu *et al.* (2010) [5] inpapaya.

Number of leaves

Based on the data recorded it was observed that number of leaves of papaya seedling were significantly influenced by under different treatments used during current study. At 30 days after sowing, the maximum number of leaves 6.79 were observed under the treatment T_3: GA_3 @ 300 ppm, which was statistically at par with T_2: @ GA_3 200 ppm (6.37) but statistically superior over T_1: GA_3 @ 150 ppm (6.18).Significant differences were observed at 45 DAS, where the maximum number of leaves 8.96 were recorded under the treatment T_3: GA_3 @ 300 ppm and it was was followed by T_2, and T_1 (8.72 and 8.35, respectively). Similar increasing trend with respect of number to leaves was observed at 60 DAS. The treatment T_3 GA_3 @ 300 ppm performed the best (11.71) having maximum number of leaves and was followed by T_2 (11.50) and T_1 (11.14). It was statistically at par with most of the treatments except control, which performed poorest (9.75) among all. The poorest among them was observed under control during whole period of observation. It might be due to the cell division and cell elongation which had increased the number of leaves per seedlings and better nutrient availability leading higher production of photo synthetically functional leaves. Similar results were reported by Anjanawe *et al* (2013) [3].

Length of shoot (cm)

At 30 DAS, the maximum (3.52 cm) length of shoot was recorded under the treatment T_3: GA_3 @ 300 ppm which was followed by and at par with T_2: GA_3 @ 200 ppm and T_1: GA_3 @ 150 ppm having the respective mean shoot length 3.35 and 3.13 cm. Moreover, it was found that the minimum (2.71 cm) shoot length was observed under the treatment T_0 (Control) which was succeeded by T_7: Ethrel @ 100 ppm (2.87). At 45 days after sowing, the maximum (6.01 cm) length of shoot was recorded under the same treatment T_3: GA_3 @ 300 ppm which was at par with most of the treatments except T_8: Ethrel @ 200 ppm (4.69 cm) and T7: Ethrel @ 100 ppm (4.60 cm). With regards to shoot length at 60 days after sowing, the treatment T_3: GA_3 @ 300 ppm registered the highest (11.52 cm) shoot length and performed superiorly during whole observation period. Meanwhile, the lowest length of shoot (7.65 cm) was reported under control treatment. It was due to gibberellic acid, activated α- amylase which digested the available carbohydrate into simple sugar so that energy and nutrition were easily available to faster growing seedlings. Increase in shoot length. This finding is closely associated with the Desai *et al.* (2017) [11] in papaya.

Fresh weight of sapling (g)

Among the various treatments used during the study, the maximum (14.77 g) fresh weight was obtained under the treatment T_3: GA_3 @ 300 ppm which was found non-significant with T_2, T_1 and T_6 having the respective mean fresh weight 14.59, 14.21 and 13.97 g, under the present investigation. However, the minimum (8.42 g) mean fresh weight was registered under the treatment T_0-(Control).The maximum fresh weight with GA_3 @ 300 ppm seed treatment might be due to rapid growth of seedling with increase in plant height, number of leaves, leaf area and stem diameter which in turn resulted in maximum fresh weight of seedlings. The results are in conformity with the findings of Pandit *et al.* (2001) [14] in papaya.

Dry weight of sapling (g)

The maximum (1.49 g) shoot dry weight was registered under the treatment T_3 GA_3@300 ppm which was followed by and was statistically similar to T_2, T_1 and T_6 (1.40, 1.33 and 1.27 g, respectively). Whereas, the minimum (0.80 g) dry weight of plant was obtained under control treatment which was the least among all. It might be due to higher fresh weight of sapling and ultimately led into higher dry weight of sapling. It might be due to higher fresh weight of sapling and ultimately led into higher dry weight of sapling. This result is in conformity with the findings of Patel *et al.* (2012) [13] in papaya.

Number of roots /sapling

Among the various treatments, maximum number of roots (83.70) was noticed under the treatment T_3: GA_3 @ 300 ppm which was significantly superior over other treatments but was found statistically non-significant with T_2:GA_3 @ 200 ppm, T_1: GA_3 @ 150 ppm having the respective mean number of roots/sapling 81.66 and 79.81. However, the less number of roots (58.73) was recorded under the treatment T_0-(Control). The treatment with gibberellic acid might have resulted in more production of photosynthates and their translocation through phloem to the root zone, resulting in more number of roots. Results are closely associated with the results of earlier worker Anjanwe *et al*. (2013) [3] in papaya.

Fresh weight of root (g)

Sigificant variations were observed under different treatments with respect to root fresh weight of papaya. As per the observations recorded, the highest fresh weight of root (2.51g) was recorded under T_3-GA_3@300 ppm which was statistically superior over T_6 (2.06 g) and was at par with T_2 (2.42 g) and T_1 (2.34 g). However, the minimum (0.78 g) root fresh weight of sapling was obtained under the control T_0. This could be due to vigorous root growth which is caused by more production of photosynthetes and their movement from phloem to root zone which is ultimately responsible for more root growth. The similar results were also observed by Choudhary *et al.* (2018) [9].

Dry weight of root (g)

The observations recorded and presented in table revealed that the highest (0.39 g) dry weight of root was noted under T_3-GA_3 @ 300 which was statistically significant over and followed by T_2-GA_3 @ 200 ppm (0.35 g) and T_1-GA_3 @150 ppm (0.33 g), respectively. The lowest (0.18 g) dry weight of papaya root was recorded under the treatment T_0-Control

It might be due to higher fresh weight of roots which ultimately led into higher dry weight of roots. This result is in conformity with the findings of Patel *et al.* (2012) [13] in papaya.

Length of the longest root (cm)

Significant differences were observed among the different bio-regulators and bio-inoculants with respect to length of longest root. The longest (24.21 cm) length of root was recorded under the treatment T_3: GA_3 @ 300 ppm which was followed by T_2: GA_3 @ 200 ppm and T_1 GA_3 @150 ppm having the respective mean root length 23.40 and 23.18 cm and it was statistically similar to almost all the treatments. The minimum (16.15 cm) root length was observed under the treatment T_0 (Control) which was succeeded by T_{10}-PSB @0.5g/10g seed (21.10 cm) and T_{11}-Azotobacter @ 0.5g/10g seed (21.14 cm), respectively. It might be due to the production of photosynthates, which is translocated through phloem to the root zone might be responsible for increase in root length. Similar results were obtained in accordance with the results obtained by Anburani and Shakila (2010) [2] in papaya.

Primary roots/sapling

From the data, it is valid that there was significant difference among various treatments on number of primary roots/saplings. The treatment T_3-GA_3 @ 300 ppm triggered highest (9.15) average number of primary roots. This treatment is comparably similar to the saplings treated with T_2-GA_3 @ 200 ppm (8.99) and T_1-GA_3 @ 100 ppm (8.81) and T_6-NAA @ 300 ppm (8.66) but was statistically superior to treatment T_7 (7.24). The treatments T_8, T_9 and T_{10} with average number of primary roots 7.58, 7.82 and 7.98 per sapling were statistically similar to each other at 5% level of significance. However, the minimum (5.02) average number of primary roots per sapling was obtained under T_0-(Control). The increases in number of primary roots/sapling might be due to the elongation of cell in the sub-apical region of roots due to the action of gibberellin acid as reported by Salisbury and Ross (1991) [16] in different fruit crops.

Secondary roots /sampling

Among the various treatments, the maximum number of secondary root(74.98) was recorded under treatment T_3-GA_3 @ 300 ppm which was found statistically at par with T_2-GA_3 @200 ppm(72.81) but statistically superior over T1 GA3 @ 150 ppm having 70.74 numbers of secondary roots/sapling. The minimum average number of secondary roots (51.41)was recorded in T_0 (Control).It might be due to the effect of gibberellic acid, which elongates the cells in the sub-apical region of roots as reported by Salisbury and Ross (1991) [16] in different fruit crops.

Root diameter (cm)

The root diameter ranges from 0.69 T0 to 1.25 cm T3. The highest mean root diameter of 1.25 cm was obtained under the treatment T_3-GA_3 @ 300 ppm, which was followed by and was at par with T_2, $T_1$and T6 whose respective mean root thickness was 1.18 cm, 1.14 cm and 1.10 cm, respectively at 60 days after sowing. However, the lowest mean root diameter per sapling (0.69 cm) was obtained in T_0- (Control) at 60DAS. It might be due to the effect of gibberellic acid, which elongates the cells in the sub-apical region of roots as reported by Salisbury and Ross (1991) [16] in different fruit crops.

Table 1: Effect of plant growth regulators and bio-inoculation on seed germination of papaya seed cv. Red Lady under net tunnel

Treatments		Days taken to start germination	Rate of emergence %	Germination %	Germination index %	Seedling vigour index -I	Seedling vigour -II
T_0	Control (Water soaking)	18.33^{e}	28.97^{g}	59.53^{i}	1.06^{c}	1037.40^{j}	47.94^{i}
T_1	GA_3 @ 150 ppm	14.93^{c}	43.45^{c}	80.94^{bc}	1.75^{abc}	1991.71^{c}	108.59^{c}
T_2	GA_3 @ 200 ppm	14.66^{bc}	47.62^{b}	83.33^{ab}	1.90^{ab}	2069.81^{b}	117.13^{b}
T_3	GA_3 @ 300 ppm	13.80^{a}	54.16^{a}	85.17^{a}	2.16^{a}	2140.95^{a}	129.01^{a}
T_4	NAA @ 100 ppm	15.86^{d}	31.75^{fg}	73.80^{ef}	1.56^{abc}	1644.40^{f}	75.58^{f}
T_5	NAA @ 200 ppm	15.53^{cd}	37.89^{de}	76.23^{de}	1.64^{abc}	1766.38^{e}	83.42^{e}
T_6	NAA @ 300 ppm	15.06^{c}	39.28^{d}	78.56^{cd}	1.70^{abc}	1895.09^{d}	101.15^{d}
T_7	Ethrel @ 100 ppm	16.86^{e}	31.74^{fg}	69.04^{gh}	1.25^{bc}	1421.57^{i}	59.11^{h}
T_8	Ethrel @ 200 ppm	16.32^{de}	33.13^{f}	71.42^{fg}	1.48^{abc}	1483.36^{h}	65.92^{g}
T_9	Ethrel @ 300 ppm	15.93^{d}	36.11^{e}	76.18^{de}	1.65^{abc}	1607.46^{g}	76.32^{f}
T_{10}	PSB @ 0.5 g/10 g seed	15.86^{d}	30.15^{g}	66.66^{h}	1.29^{bc}	1490.15^{h}	67.77^{g}
T_{11}	Azotobacter @ 0.5 g/10 g seed	15.40^{c}	31.74^{fg}	69.04^{gh}	1.44^{abc}	1586.83^{g}	71.25^{fg}

Table 2: Effect of plant growth regulators and bio-inoculation on seedling growth of papaya seed cv. Red Lady under net tunnel

Treatments		Sapling height (cm)			Number of leaves			Length of shoot (cm)		
		30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_0	Control (Water soaking)	5.64^{d}	8.10^{f}	17.10^{e}	4.36^{f}	6.49^{e}	9.75^{b}	2.71^{d}	4.39^{b}	7.65^{e}
T_1	GA_3 @ 150 ppm	8.25^{ab}	12.45^{ab}	24.55^{ab}	6.18^{bc}	8.35^{abc}	11.14^{ab}	3.13^{bc}	5.18^{ab}	11.03^{abc}
T_2	GA_3 @ 200 ppm	8.30^{ab}	12.60^{ab}	24.81^{ab}	6.37^{ab}	8.72^{ab}	11.50^{ab}	3.35^{ab}	5.54^{ab}	11.26^{ab}
T_3	GA_3 @ 300 ppm	8.42^{a}	12.94^{a}	24.96^{a}	6.79^{a}	8.96^{a}	11.71^{a}	3.52^{a}	6.01^{a}	11.52^{a}
T_4	NAA @ 100 ppm	7.55^{abc}	11.02^{cde}	22.24^{abcd}	5.81^{cd}	7.38^{cde}	10.51^{ab}	2.95^{cd}	4.79^{ab}	10.48^{bcd}
T_5	NAA @ 200 ppm	8.05^{ab}	11.48^{cde}	23.13^{abcd}	5.90^{bcd}	7.77^{bcd}	10.56^{ab}	3.04^{bcd}	4.98^{ab}	10.70^{bcd}
T_6	NAA @ 300 ppm	8.12^{ab}	12.28^{abc}	24.09^{abc}	6.09^{bc}	7.98^{bcd}	10.78^{ab}	3.10^{bc}	5.11^{ab}	10.99^{abc}
T_7	Ethrel @ 100 ppm	6.35^{cd}	9.53^{ef}	20.51^{d}	5.04^{e}	6.95^{de}	9.81^{b}	2.87^{cd}	4.60^{b}	9.70^{d}
T_8	Ethrel @ 200 ppm	6.58^{cd}	9.78^{ef}	20.69^{d}	5.41^{de}	7.12^{de}	10.24^{ab}	2.91^{cd}	4.69^{b}	9.91^{d}
T_9	Ethrel @ 300 ppm	6.95^{bcd}	10.15^{de}	21.07^{cd}	5.69^{cd}	7.21^{cde}	10.43^{ab}	2.94^{cd}	4.77^{ab}	10.12^{cd}
T_{10}	PSB @0.5g/10g seed	7.16^{abc}	10.45^{de}	21.31^{cd}	5.72^{cd}	7.29^{cde}	10.47^{ab}	3.02^{bcd}	4.90^{ab}	10.25^{bcd}
T_{11}	Azotobacter @0.5g/10g seed	7.38^{abc}	10.77^{cde}	21.79^{bcd}	5.77^{cd}	7.34^{cde}	10.49^{ab}	3.07^{bc}	4.97^{ab}	10.30^{bcd}

Table 3: Effect of plant growth regulators and bio-inoculation on seedling growth of papaya seed cv. Red Lady under net tunnel

Treatments		Fresh weight of sapling at 60 DAS (g)	Dry weight of sapling at 60 DAS (g)	Number of roots/sapling	Fresh weight of roots at 60 DAS (g)	Dry weight of roots at 60 DAS (g)
T_0	Control (Water soaking)	8.42^{c}	0.80^{e}	58.73^{h}	0.78^{e}	0.18^{d}
T_1	GA_3 @ 150 ppm	14.21^{a}	1.33^{abc}	79.81^{ab}	2.34^{ab}	0.33^{b}
T_2	GA_3 @ 200 ppm	14.59^{a}	1.40^{ab}	81.66^{a}	2.42^{ab}	0.35^{b}
T_3	GA_3 @ 300 ppm	14.77^{a}	1.49^{a}	83.70^{a}	2.51^{a}	0.39^{a}
T_4	NAA @ 100 ppm	10.68^{b}	1.02^{bcd}	72.95^{cde}	1.82^{cd}	0.24^{c}
T_5	NAA @ 200 ppm	11.04^{b}	1.09^{bcd}	74.95^{cd}	1.93^{cd}	0.26^{c}
T_6	NAA @ 300 ppm	13.97^{a}	1.27^{abc}	76.44^{bc}	2.06^{bc}	0.30^{b}
T_7	Ethrel @ 100 ppm	9.56^{bc}	0.85^{de}	65.78^{g}	1.44^{d}	0.20^{c}
T_8	Ethrel @ 200 ppm	9.81^{bc}	0.91^{cde}	67.24^{fg}	1.57^{d}	0.21^{c}
T_9	Ethrel @ 300 ppm	10.03^{bc}	0.99^{cde}	68.93^{efg}	1.71^{cd}	0.22^{c}
T_{10}	PSB @0.5 g/10 g seed	10.14^{bc}	1.01^{bcd}	71.14^{def}	1.79^{cd}	0.23^{c}
T_{11}	Azotobacter @ 0.5 g/10 g seed	10.51^{b}	1.01^{bcd}	72.62^{cde}	1.81^{cd}	0.23^{c}

Table 4: Effect of plant growth regulators and bio-inoculation on seedling growth of papaya seed cv. Red Lady under net tunnel

Treatments		Length of the longest root (cm)	Number of primary roots/sapling	Number of secondary root/sapling	Root diameters (cm)	Benefit:Cost ratio
T_0	Control (Water soaking)	16.15^{b}	5.02^{c}	51.41^{i}	0.69^{f}	1.41
T_1	GA_3 @ 150 ppm	23.18^{a}	8.81^{ab}	70.74^{bc}	1.14^{abc}	2.04
T_2	GA_3 @ 200 ppm	23.40^{a}	8.99^{ab}	72.81^{ab}	1.18^{ab}	2.07
T_3	GA_3 @ 300 ppm	24.21^{a}	9.15^{a}	74.98^{a}	1.25^{a}	2.13
T_4	NAA @ 100 ppm	21.17^{a}	8.09^{ab}	64.95^{ef}	1.02^{bcde}	1.84
T_5	NAA @ 200 ppm	22.34^{a}	8.42^{ab}	66.14^{de}	1.05^{bcde}	1.89
T_6	NAA @ 300 ppm	22.90^{a}	8.66^{ab}	68.78^{cd}	1.10^{abcd}	1.94
T_7	Ethrel @ 100 ppm	20.14^{a}	7.24^{b}	58.24^{h}	0.86^{ef}	1.72
T_8	Ethrel @ 200 ppm	20.48^{a}	7.58^{ab}	61.23^{gh}	0.91^{de}	1.75
T_9	Ethrel @ 300 ppm	20.96^{a}	7.82^{ab}	62.44^{fg}	0.97^{cde}	1.79
T_{10}	PSB @ 0.5 g/10 g seed	21.10^{a}	7.98^{ab}	64.12^{efg}	1.00^{bcde}	1.71
T_{11}	Azotobacter @ 0.5g/10 g seed	21.14^{a}	8.04^{ab}	65.02^{ef}	1.01^{bcde}	1.73

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