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Impact on biometric response of papaya as influenced by Phyto bio-regulator

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Abstract
The growing demand of papaya after the pandemic made the researchers think about its qualitative and quantitative production. In this regard, application of phyto-bio-regulators is a way forward approach to sustain the quality papaya production. The present investigation was conducted to determine the effect of various phyto bio stimulants on vegetative growth of papaya (*Carica papaya*) cv. Red Lady in a randomized block design using factorial arrangement during 2018-20. As many as 11 treatments and 3 replication includes five phyto bio stimulants with two different concentrations i.e. Naphthalene acetic acid (100 ppm and 150 ppm), Gibberellic acid (100 ppm and 150 ppm), Benzyl adenine (100 ppm and 150 ppm), Ethrel (100 ppm and 150 ppm) and 2,3,5-Triiodo benzoic acid (100 ppm and 150 ppm). The result revealed that gibberellic acid @150 ppm significantly increased the plant height, as compared to control in papaya cv. Red Lady. Among the various vegetative characters, the effect of phyto bio-regulator Gibberellic acid @150 ppm (T_4) imparts the significant effect over control with respect to plant height and number of leaves at 60, 90, 120, 150, 180 days after transplanting and at maturity. However, the maximum plant girth, petiole length and plant spread was observed under treatment T_{10} (2,3,5-Triiodo benzoic acid @150 ppm) as compared to control.

Keywords: Phyto-bio-regulators, papaya, biometric response, ga_3, red lady, TIBA

Introduction
Papaya (*Carica papaya*) is the third most cultivated tropical crop worldwide, and it has been hypothesized that Mesoamerica is the most likely centre of its origin and domestication. In different part of the world, it is called with different names *viz*. Papaw, melon zapote, frutamamboa, mamao, tree melon, etc. (Dubey *et al*., 2020a) [3]. Papaya possess a morphological structure and development according to Corner's model of architecture (Chávez-Pesqueiraand Núñez-Farfán, 2017) [1]: a monopodial, single, orthotropic and nonbranching trunk constructed by one vegetative meristem, with axillary inflorescences, hence with indeterminate growth. *Carica papaya* produces huge palmate-shaped leaves. Due to its nutritional, medicinal and high remunerative value, it is currently grown in most of the tropical and subtropical countries (Gaudence *et al*., 2019) [5]. Besides, these it's cultivation is easy and can be grown year round, with good income generation (Dubey *et al*., 2020b) [4]. This may be one of the reasons that this plant had established its utility in the form of commercial plantations instead of garden dwelling plant of home.
The growing demand for this fruit is a lagging supply of quality fruit for table purposes. The crop being highly perishable, need careful attention from the farm to feed. It's still a grievance for the researcher to extend the shelf life of the fresh fruit without deteriorating its quality attributes. In past few decades, various cultural practices being adopted across the globe to maintain its quality, out of which application of phyto bio-regulators seeks a special demand among the growers (De Pascale *et al*., 2017) [2], as a limited application in the field not only help the farmers in increasing yield but also helps in maintaining the quality parameters.
The plant hormones (or phyto bio-regulators) are the naturally producing organic substance in the plant that are produced in minute quantities and regulates the growth and other physiological functions of a plant. Hence, such chemical substances have proven to be an important component of modern fruit production technology both for improving the quantity as well as quality of fruit crops (Hota *et al*., 2019) [7]. It alters the parameters like vegetative growth (Hota *et al*., 2017a; Priyadarshi *et al*., 2017) [9, 18], fruit set, fruit drop (Hota *et al*., 2017b) [13], yield attributing parameter (Hota *et al*., 2017c, Priyadarshi *et al*., 2018a) [11, 17], physical parameters (Hota *et al*., 2017d) [12], chemical parameters (Hota *et al*., 2018, Priyadarshi *et al*., 2018b) [8, 16] and physico-chemical parameters (Hota *et al*., 2017e) [10].

Since, such chemical products have various diverse affects, hence, it is used at particular stage of production cycle to get maximum benefit out of them (Hota *et al*., 2019) [7]. Moreover, with the advancement of technology, these chemicals can be supplied exogenously, in both natural and synthetic form (as their chemical analogs, hormone releasing agents, hormone sensitivity altering agents and hormone synthesis inhibitors, in such a way that it can modify the plant production processes, thereby increasing the yield (Priyadarshi and Hota, 2021) [15]. Furthermore, biometric response (vegetative growth) of plants contributes a significance response towards the yield. So considering this an experiment was carried out to find out the response of phyto bio-regulators on biometric response of papaya cv. Red Lady.

Material and Methods

The Mahasamund district of Chhattisgarh is located at 20º47' to 21º31' N latitude and 82º00' to 83º15' longitude having sub humid climatic conditions with an average annual rainfall of 1200 mm. The present investigation was conducted at Farm of KrishiVigyan Kendra, Mahasamund for two consecutive years (2018-19 and 2019-20) in a moderately sloped land with appropriate drainage system.

The healthy, disease and pest free Red Lady seeds were raised in polybags (12 x 10 cm size) filled with a mixture of Soil, Sand and Vermicompost. The polybags were regularly irrigated and utmost care of nursery plants is taken until they are ready for transplanting in the field. The experimental plants were planted at a distance of 2mt.x 2mt.and were cultivated adopting recommended package of practices. The experiment was designed in Randomized Block Design with three replications and 11 treatment combinations which were as follows: T_0, Control (Water Spray); T_1, Naphthalene acetic acid (NAA) 100 ppm; T_2, Naphthalene acetic acid (NAA) 150 ppm; T_3, Gibberellic acid (GA_3) 100 ppm; T_4, Gibberellic acid (GA_3) 150 ppm; T_5, Benzyl adenine (BA) 100 ppm; T_6, Benzyl adenine (BA) 150 ppm; T_7, Ethrel 100 ppm; T_8, Ethrel 150 ppm; T_9, 2,3,5-Triiodo benzoic acid (TIBA) 100 ppm; T_{10}, 2,3,5-Triiodo benzoic acid (TIBA) 150 ppm.The foliar spray of growth regulators was done at different time slots i.e. 45, 75 and 125 days after transplanting (DAT). The solutions of different concentrations were sprayed to wet the whole plant with care to avoid its drooping on the soil surface.

The Plant height was measure with the help of a measuring tape and thread from ground level upto growing tip of main stem. The plant height stem girth was measured at 60 DAT, 90 DAT, 120 DAT, 150 DAT and also at 180 DAT. The spread of plant from North to South and East to West directions was measured with the help of a measuring tape along with measuring pole of five selected plants in each treatment and the average was worked out in centimeter. The petiole length was measured by measuring the length from base of petiole to the base of leaf lamina and the average was worked out.

Plant height (cm)

The data depicted in Table 1 clearly showed a significant difference in plant height after treated with phyto bio-regulator. An increasing trend in plant height was observed from 60 DAT to 180 DAT, suggesting the overall growth carried out by genotype and the effect of bio-regulators. The pooled data of 2018-20at 180 days after transplanting, clearly indicates that the minimum plant height of 195.95 cm was recorded in treatment T_{10} (2, 3, 5-Triiodobenzoic acid 150 ppm)whereas the maximum plant height of 224.11 cm was observed in treatment T_4 (Gibberellic acid 150 ppm).The treatment T_{10} was found to be at par with treatment T_9 (2, 3, 5-Triiodobenzoic acid 100 ppm) having a plant height of 198.64 cm whereas the treatment T_4 was at par with treatment T_3 (Gibberellic acid 100 ppm), having plant height of 221.80 cm. On the basis of the investigation carried out for two consecutive years' i.e. 2018-19 and 2019-20, the phyto bio regulators on the basis of their performance in respect to plant height they may be ranked as Gibberellic acid, Naphthalene acetic acid, Benzyl adenine, Ethrel, Control and 2, 3, 5-Triiodobenzoic acid i.e. Gibberellic acid gives maximum plant height whereas the 2, 3, 5-Triiodobenzoic acid gives minimum plant height.

The highest plant height had been investigated on treatment with gibberellic acid which might be due to the fact that this phyto bio-regulator promotes the active cell division and cell elongation process, thereby promoting the growth of vegetative parts of plant, which is reflected in the form of increased height of plant. Moreover, it causes the stimulus in the soil along with increasing nutrients and water through osmotic uptake, besides augmenting the soil microorganism's activity, resulting in better production of carbohydrates. These may be one of the reasons for increase in plant height of papaya plant. This finding was in agreement with those by Hazarika *et al.* (2016) [6] in papaya plant.

Stem Girth

The response of phyto-bio-regulators on stem girth presented through Table 1 clearly showed a significance difference among treatment. An increasing trend in plant height was observed from 60 DAT to 180 DAT, suggesting the overall growth carried out by genotype and the effect of bio-regulators. The pooled data of two years at 180 DAT clearly indicates that the minimum stem girth of 41.30 cm was recorded in treatment T_0 (Control/water spray) to 56.47 cm in treatment T_{10} (2, 3, 5-Triiodobenzoic acid 150 ppm). The treatment T_0 was found to be at par with treatment T_7 (Ethrel 100 ppm) and treatment T_8(Ethrel 150 ppm) having values of 44.13 cm and 44.48 cm respectively whereas the treatment T_{10} was found to be at par with treatment T_9 (2, 3, 5-Triiodobenzoic acid 100 ppm) having a value of 55.10 cm. On the two years study it can be concluded that the phyto bio regulators may be ranked as2, 3, 5-Triiodobenzoic acid, Benzyl adenine, Naphthalene acetic acid, Gibberellic acid, Ethrel and Control. On the basis of their performance in respect to stem girth i.e. 2, 3, 5-Triiodobenzoic acid gives maximum stem girth whereas in Control/water spray gives the minimum plant girth.

The maximum girth of papaya plant on treatment with 2, 3, 5-Triiodobenzoic acid ppm might be due to the fact that, in plants, it increases the auxin accumulation that causes the enhancement in the activity of cell division, thereby promoting the growth of plant girth. Similar findings were also reported by Singh *et al.* (2011) [19] in papaya plant.

Table 1: Response of phyto bio-regulators on plant height and stem girth of papaya cv. Red Lady

Treatments	Plant height						Stem girth				
	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	At Maturity	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
T_0 (Control/Water)	80.48	121.68	157.21	184.94	208.28	249.95	16.49	24.10	29.12	35.68	41.30
T_1 (NAA-100 ppm)	85.09	128.09	161.45	189.10	214.04	257.93	19.77	27.20	32.92	41.36	47.80
T_2 (NAA-150 ppm)	85.40	129.14	162.09	189.83	214.20	258.35	20.52	27.85	33.49	41.39	48.12
T_3 (GA_3- 100 ppm)	86.79	135.36	166.43	195.43	221.80	270.92	17.53	26.09	31.22	38.29	46.37
T_4 (GA_3- 150 ppm)	88.18	137.65	167.98	196.96	224.11	275.17	18.28	26.76	32.01	39.07	47.24
T_5 (BA- 100 ppm)	84.04	126.97	159.02	185.78	210.38	253.25	20.86	30.65	36.07	44.27	51.58
T_6 (BA- 150 ppm)	84.97	127.52	160.17	186.55	211.62	254.51	21.36	30.68	38.44	44.60	52.22
T_7 (Ethrel -100 ppm)	78.07	118.38	154.80	181.16	205.69	247.39	16.87	24.83	30.12	36.84	44.13
T_8 (Ethrel -150 ppm)	75.29	117.00	152.10	179.49	203.33	245.11	17.24	25.06	30.32	37.04	44.48
T_9 (TIBA- 100 ppm)	72.37	113.95	147.81	177.54	198.64	241.18	24.05	34.36	39.83	47.05	55.10
T_{10}(TIBA-150 ppm)	69.22	110.30	144.23	172.49	195.95	237.73	24.69	34.83	40.64	47.78	56.47
S.Em	1.35	1.66	1.48	1.65	1.27	1.23	0.65	1.01	0.98	1.01	1.41
CD	3.97	4.89	4.38	4.86	3.73	3.64	1.92	2.97	2.87	2.99	4.15

Number of leaves

The data depicted in Table 2 clearly showed a significant difference in plant height after treated with phyto bio-regulator. An increasing trend in plant height was observed from 60 DAT to 180 DAT, suggesting the overall growth carried out by genotype and the effect of bio-regulators. The pooled data of two consecutive years i.e. 2018-19 and 2019-20 at 180 DAT clearly indicates that minimum number of leaves i.e. 44.65 was recorded in treatment T_0 (Control/water spray) whereas the maximum number of leaves i.e. 57.06 was observed in treatment T_4 (Gibberellic acid 150 ppm).The treatment T_0 was observed at par with treatment T_8 (Ethrel 150 ppm) having a value of 46.02 leaves per plant while the treatment T_4 was found to be statistically different from rest of the treatments. Overall, the treatment with gibberellic acid was found to be best among all the tested treatments for increasing the number of leaves in each plant, which was followed by naphthalene acetic acid, benzyl adenine, Tri-iodobenzoic acid, ethrel and water spray.

The increase in the number of leaves due to the effect of gibberellic acid might be due to the fact that gibberellic acid at apical meristem leads to the formation of more nucleoprotein, which are necessary for increasing the process of leaf initiation as well as expansion. Similar findings were reported by Morales *et al.* (1999) [14] in papaya.

Petiole length

The response of phyto-bio-regulators on stem girth presented through Table 2 clearly showed a significance difference among treatment. An increasing trend in plant height was observed from 60 DAT to 180 DAT, suggesting the overall growth carried out by genotype and the effect of bio-regulators. The pooled data of 2018-20 at 180 DAT clearly indicates that the minimum petiole length of 70.25 cm was recorded in treatment T_0(Control/water spray) whereas the maximum petiole length of 89.44 cm was observed in treatment T_{10} (2, 3, 5-Triiodobenzoic acid 150 ppm) Although the treatment T_0 was found to be at par with treatment T_5 (Benzyl adenine 100 ppm), T_6 (Benzyl adenine 150 ppm), T_7 (Ethrel 100 ppm) and treatment T_8(Ethrel 150 ppm) having a petiole length of 72.37 cm,72.55 cm,71.04 cm and 72.17 cm respectively whereas the treatment T_{10} (2, 3, 5-Triiodobenzoic acid 150 ppm) was at par with treatment T_9(2, 3, 5-Triiodobenzoic acid 100 ppm) having values of 87.95 cm. On the basis of study conducted for two years, the phyto bio regulators may be ranked as 2, 3, 5-Triiodobenzoic acid, Gibberellic acid, Naphthalene acetic acid, Benzyl adenine, Ethrel and control which can be sum up as 2, 3, 5-Triiodobenzoic acid contributes maximum petiole length followed by the phyto bio regulators as mentioned in above order.

The maximum length of petiole had been observed due to the effect of phyto bio-regulator 2, 3, 5-Triiodobenzoic acid, which might be due to the fact that this phyto-chemical fastens the multiplication process by enhancing the rate of cell division and cell enlargement. This causes the improvement in the vegetative growth of plants. This finding was in confirmation with those observed by Hazarika *et al*. (2016)[6] in papaya plant.

Plant Spread

The data depicted in Table 3 clearly showed a significant difference in plant height after treated with phyto bio-regulator. An increasing trend in plant height was observed from 60 DAT to 180 DAT, suggesting the overall growth carried out by genotype and the effect of bio-regulators. The pooled data of 2018-20 at 180 DAT shows that the plant spread in East-West direction ranges from 185.53 cm to 224.33 cm. The minimum value of 185.53 cm was found in treatment T_0(Control/water spray) whereas maximum value of 224.33 cm was observed in treatment T_{10}(2, 3, 5-Triiodobenzoic acid 150 ppm). Both the treatments having minimum value i.e. treatment T_0(Control/water spray) and maximum value i.e. treatment T_{10}(2, 3, 5-Triiodobenzoic acid 150 ppm) show significant differences with rest of the treatments.

The plant spread in North-South direction at 180 DAT ranges from 187.23 cm to 225.60 cm. The minimum value of 187.23 cm was found in treatment T_0(Control/water spray) whereas maximum value of 225.60 cm was observed in T_{10}(2, 3, 5-Triiodobenzoic acid 150 ppm). Both the treatments having minimum value i.e. treatment T_0(Control/water spray) and maximum values i.e. treatment T_{10}(2, 3, 5-Triiodobenzoic acid 150 ppm) show significant differences with rest of the treatments.

From the entire study from 60 DAT to 180 DAT on plant spread it was found that application of 2, 3, 5-Triiodobenzoic acid was the best phyto bio regulator for increasing the stem girth also it was noted that the higher concentration of 2, 3, 5-Triiodobenzoic acid i.e. 150 ppm gives more plant spread as compare to 2, 3, 5-Triiodobenzoic acid i.e. 100 ppm. On the basis of two year study it can be concluded that the phyto bio regulator may be ranked as 2, 3, 5-Triiodobenzoic acid (TIBA), Gibberellic acid (GA_3), Naphthalene acetic acid

(NAA), Benzyl adenine (BA) and water spray in respect to their influence on plant spread.

The treatment with 2,3,5-Triiodobenzoic acid was found to increase the plant spread in both East-West and North-South direction as compared to the other treatments, which might be due to the fact that this phyto bio-regulator by stimulates the process of cell division as well as elongation of cell as it enhances the accumulation of auxin concentration. Similar findings were also noticed by Hazarika *et al.* (2016)[6] in papaya plant.

Table 2: Response of phyto bio-regulators on number of leaves and petiole length of papaya cv. Red Lady

Treatments	Number of leaves					Petiole length				
	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
T_0 (Control/Water)	18.73	28.34	32.42	38.24	44.65	40.76	54.27	58.90	63.65	70.25
T_1 (NAA-100 ppm)	22.17	34.02	41.46	46.57	50.10	54.89	67.75	70.36	73.62	76.29
T_2 (NAA- 150 ppm)	23.50	36.52	42.97	48.35	51.08	57.93	68.16	72.44	75.35	78.97
T_3 (GA_3- 100 ppm)	25.40	36.62	46.76	52.52	54.76	60.06	70.07	75.26	79.40	82.13
T_4 (GA_3- 150 ppm)	26.07	38.95	48.50	53.66	57.06	61.65	71.23	77.13	81.41	85.37
T_5 (BA- 100 ppm)	21.38	31.01	39.35	45.32	48.28	48.70	63.02	67.07	70.74	72.37
T_6 (BA- 150 ppm)	21.96	31.86	40.63	46.17	48.52	49.19	64.25	67.52	71.43	72.55
T_7 (Ethrel-100 ppm)	19.71	29.72	38.10	43.97	46.75	44.60	54.70	60.21	64.59	71.04
T_8 (Ethrel-150 ppm)	19.41	29.19	37.33	43.20	46.02	45.65	55.16	61.46	66.05	72.17
T_9 (TIBA- 100 ppm)	19.78	28.99	38.34	44.06	46.96	64.48	74.63	80.49	85.27	87.95
T_{10} (TIBA-150 ppm)	20.15	29.69	39.02	44.53	47.56	65.84	75.98	82.07	86.83	89.44
S.Em	0.32	0.43	0.47	0.47	0.60	1.05	1.08	1.26	1.30	1.42
CD	0.95	1.26	1.39	1.39	1.76	3.09	3.19	3.71	3.84	4.19

Table 3: Response of Phyto bio-regulators on east-west and north-south spread of papaya cv. Red Lady

Treatment	60 DAT		90 DAT		120 DAT		150 DAT		180 DAT	
	EW	NS	EW	NS	EW	NS	EW	NS	EW	NS
T_0 (Control/Water)	133.55	135.39	154.16	156.07	166.21	168.80	178.59	181.27	185.53	187.23
T_1 (NAA-100 ppm)	143.87	145.80	171.06	174.26	182.83	185.91	196.28	197.57	209.19	211.05
T_2 (NAA-150 ppm)	144.65	146.55	172.14	174.84	184.49	186.63	198.02	200.10	211.67	215.15
T_3 (GA_3- 100 ppm)	149.57	153.12	173.27	176.64	185.33	188.02	198.88	200.97	215.39	216.91
T_4 (GA_3- 150 ppm)	150.24	153.62	175.29	177.39	186.22	189.27	201.84	203.57	218.01	219.33
T_5 (BA- 100 ppm)	138.61	140.29	167.06	169.57	179.61	181.89	191.93	193.48	205.48	205.28
T_6 (BA- 150 ppm)	139.76	141.25	169.75	171.72	181.50	183.54	195.10	197.14	208.97	209.11
T_7 (Ethrel -100 ppm)	135.9	136.28	161.71	163.86	178.55	180.83	190.52	192.40	204.56	203.76
T_8 (Ethrel -150 ppm)	134.83	135.76	159.61	162.83	175.55	178.84	189.50	190.85	201.33	201.22
T_9 (TIBA- 100 ppm)	155.35	154.71	179.35	181.41	192.24	193.90	207.00	208.93	221.02	222.17
T_{10} (TIBA- 150 ppm)	156.90	157.81	181.84	183.45	195.66	197.55	208.87	211.46	224.33	225.60
S.Em	1.20	0.97	1.06	1.18	1.29	1.06	1.55	1.34	1.08	1.14
CD	3.53	2.87	3.11	3.48	3.81	3.14	4.57	3.94	3.18	3.36

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