



# Effect of Plant Growth Regulators on Growth, Yield and Quality of Papaya cv. Red Lady under Prayagraj Agro Climatic Conditions

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## Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

## Article Information

DOI: 10.9734/IJECC/2023/v13i92238

## Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/101980>

Original Research Article

Received: 18/04/2023

Accepted: 20/06/2023

Published: 01/07/2023

## ABSTRACT

The present investigation was conducted on 1-month-old seedlings from March 2022 to Jan 2023 to find out the suitable treatment for growth, yield and quality of Papaya cv. Red Lady. The statistical design adopted for the experiment was randomized block design (RBD) with three replications and ten treatment combinations. viz, T0 (Control), T1(NAA 100 ppm), T2 ( NAA 150 ppm), T3 (NAA 200 ppm), T4 (GA<sub>3</sub> 100 ppm), T5 (GA<sub>3</sub> 150 ppm), T6 (GA<sub>3</sub> 200 ppm), T7 (CCC 500 ppm), T8 (CCC 750 ppm), T9 (CCC 1000 ppm). The treatments were applied by soil drenching at the initiation of the experiment, vegetative phase, pre-flowering and fruit setting stage to assess the effect on growth, yield and quality of papaya. The results of the present investigation revealed that the treatment T6 (GA<sub>3</sub> 200 ppm) outstand in all the aspects like maximum plant height (142.13 cm), number of functional leaves per plant (17.14), stem diameter (54.37 mm) minimum days to first flowering (95.42), no. of flowers per plant (56.09), no. of fruit per plant (23.12), fruit weight (1263.38 gm), fruit yield/plant (29.22 kg), yield (129.85 t/ha<sup>-1</sup>), fruit length (20.49 cm), fruit diameter (18.21 cm) and quality parameters like maximum TSS (16.61 °Brix) and acidity (0.125 %), non-reducing sugar (2.16

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<sup>o</sup>Brix), reducing sugar (7.83 <sup>o</sup>Brix), total sugar (9.99 <sup>o</sup>Brix) followed by T5 (GA<sub>3</sub> 150 ppm). The lowest observation was recorded in T0 (Control). Treatment with GA<sub>3</sub>, NAA and CCC improved vegetative growth, yield and quality to a lesser extent as compared to the control. That's why a positive response has to be seen in particular treatment during the research trial.

**Keywords:** GA<sub>3</sub>; NAA; CCC; papaya; subtropical region; red lady.

## 1. INTRODUCTION

The papaya, also known as *Carica papaya* L. in botanical terms, is a member of the Caricaceae family and is both a genus and a species of *Carica*. chromosome no. (2n=18). One of the world's top crops is grown in tropical and subtropical areas [1]. Papaya is a fruit that originated in tropical America. It became popular due to its quick development, large yield, prolonged fruiting season, and high nutritional content. Papaya is a strong source of vitamin A (2020 i.u./100g), riboflavin (250 mg/100g), and a few minerals like calcium, phosphorus, and iron. It also comprises between 85- 90 percent water, 10-13 percent sugar, and 0. 6percent protein [2]. It is a cross-pollinated crop that can grow to a height of 2 to 10 meters, and is a big, quickly growing lactiferous, hollow-stemmed plant. The melon-like fruit hangs from short, thick peduncles at leaf axils and varies in size and shape. The seeds are tiny, spherical, black, and covered in gelatinous material. This species is trioecious because the plants have three fundamental sexual forms: female, male, and hermaphrodite. The fruit shape of a hermaphroditic plant is longer than the fruit shape of a female plant, which is typically shorter. According to Srinu, et al. [3], the seeds will grow in a mixture of female and hermaphrodite plants. 'Red Lady' produces a superior yield since it is an early-maturing, productive papaya. It is a self-pollinating dwarf papaya variety that has a high level of resistance to the virus that causes papaya ring spots. The duration of Red Lady Taiwan variety is of about 2 years. This plant will grow aggressively, high-yielding, and able to produce 50 tons per acre during a two-year productive life cycle. One tree may produce 50 to 120 fruits, each weighing an average of 1.5 to 2 kilos. About 50 to 80 cm in height, the semi-dwarf tree starts to produce fruit. The fruit has a sugar content of 13–14% and is of outstanding quality, being thick, firm, red in color, aromatic, and extremely sweet. A bisexual or hermaphrodite plant produces long, spherical fruits, whereas a female plant yields short, oblong fruits. Between 8 and 9 months after they are sowed, they are ready to be harvested.

## 2. MATERIALS AND METHODS

The experiment was carried out from March 2022 to January 2023 at the Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, India.

The location of experimental site is situated at an elevation of 98 meters above mean sea level (MSL) at 25.45<sup>o</sup> North latitude and 81.84<sup>o</sup> East longitudes.

This region falls under the sub-tropical zone. Prevailing in the South-Eastern part of the U.P. and has both extremities in temperatures, i.e., winter and summer. In winter, the temperature sometimes is as low as 32<sup>o</sup>F from December to January, and in summer the temperatures reach up to 115<sup>o</sup>F in May to June. During winter, frosts and during summer, hot scorching winds are pretty common. The average rainfall is around 1013.4 (mm) with maximum concentration during July to September months with occasional showers in winter.

The experiment was carried out using a randomized block design with three replications; One-month-old seedlings were bought from the Laxmi Paudshala, Prayagraj, and were transplanted to the field on 20th March 2022. Adopted the recommended farming methods for growing wholesome plants with ten treatments (T0: Control, T1: NAA 100 ppm, T2: NAA 150 ppm, T3: NAA 200 ppm, T4: GA<sub>3</sub> 100 ppm, T5: GA<sub>3</sub> 150 ppm, T6: GA<sub>3</sub> 200 ppm, T7: CCC 500 ppm, T8: CCC 750 ppm, and T9: CCC 1000 ppm) were applied and data were statistically analyzed. Application of manure and fertilizer was treated with 5 kg of well-rotten FYM. After the transplant, DAP was administered every 15 to 20 days. After the second month of transplanting, the first dose of urea and potash was applied by the specified doses. Preparation of GA<sub>3</sub> solution:- Weighed 1000 mg of GA<sub>3</sub> in an electronic digital scale and dissolved the powder in 10 ml of alcohol, mildly heated the mixture in a test tube for a while and then finally mixed the

solution in 1 liter of clean water. Preparation of NAA solution: - NAA can be dissolved in a small amount of 1 N NaOH or KOH, which also can be used to dissolve 2, 4-D and IAA. Preparation of CCC solution:-At a rate of 1gal.of spray per 200 sq. ft. of the growing area regardless of plant spacing.

### 3. RESULTS AND DISCUSSION

#### 3.1 Growth Parameters

The data about the impact of GA3, NAA, and CCC on fruit growth measures are shown in Table 1 and Graph 1. In terms of plant height, the maximum plant height was recorded to be (142.13) in the treatment T6 GA3 (200ppm) followed by T5 GA3 (100ppm) (138.99) and the minimum plant height (88.95) was observed under the treatment T0 (Control). "The increase in plant height of papaya along with trunk girth may be due to enhancement of physical properties of soil, advanced nutrient uptake and augmented activity of microorganisms which resulted in better carbohydrate production" [4].

The maximum number of functional leaves per plant (17.41) was recorded under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (16.99) and the minimum number of functional leaves per plant (10.91) was observed under the treatment T0 (Control). "Foliar application of GA3 has been reported to increase the plant height and the production of leaves and leaf area causing the increased plasticity of the cell wall followed by the hydrolysis of starch to sugars which lower the water potential of a cell resulting in the entry of water into the cell causing cell elongation. This might have been attributed to an increase in the photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products resulting in cell elongation and rapid cell division in the growing portion" [5]. Similar views were also expressed by Kadam et al. [6] in Kagzi lime, Surakshita et al., [7] in Jamun.

The maximum stem diameter (cm) (54.37) was recorded under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (51.73) and the minimum stem diameter (29.73) was observed under the treatment T0 (Control). "This increase in stem diameter is due to GA3 application which increases cell division and cell elongation, thereby increasing the vegetative growth by overcoming genetic dwarfism" [3,8].

#### 3.2 Flowering and Fruiting Attributes

Data on the impact of GA3, NAA, and CCC on the physical features of fruit are shown in Table 2 and Graph 2. Amongst the different treatments minimum days to first flowering (95.42) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (97.28) and the maximum Days to first flowering (116.27) was found in treatment T0 (Control). The minimum days taken for first flowering, were recorded in Red Lady (72.64 days) and the maximum days to flowering were recorded in Amrita (103.08 days). This might due to the genetical characters. These results were in close confirmation with results obtained by Chalak et al., [9], Srilatha et al., (2015) and Prakash et al., [10].

The maximum number of flowers per plant (52.34) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (52.34) and the minimum number of flowers per plant (27.22) was found in Control. "The increased number of flowers was observed in the case of papaya with application of GA3 which increased the flower bud initiation and also retards the effect of ABA" [8].

The maximum number of fruit per plant (23.12) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (21.99) and the minimum number of fruit per plant (9.23) was found in Control. "The increase in yield with gibberellic acid might be due to an increase in flower number, better fruit setting percentage and the production of a higher number of fruits with maximum fruit weight in addition to better vegetative growth. In addition, GA may have affected the auxin metabolism, which may have indirectly aided in fruit enlargement and thus the production of fruits in higher numbers, which ultimately increases yield/plant and yield/ha" [11,12].

The maximum fruit weight (gm) (1263.38) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (1220.13) and the minimum number of fruit per plant (9.23) was found in Control. GA improved the internal physiology of the developing fruits in terms of a better supply of nutrients and other compounds that are vital for their proper growth and development, which resulted in improved size and ultimately a greater yield [13].

The maximum fruit yield per plant (kg) (29.22) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (26.83)

and the minimum fruit yield per plant (kg) (8.46) was found in Control. "The increase in yield with gibberellic acid might be due to an increase in flower number, better fruit setting percentage and the production of a higher number of fruits with maximum fruit weight in addition to better vegetative growth. In addition, GA may have affected the auxin metabolism, which may have indirectly aided in fruit enlargement and thus the production of fruits in higher numbers, which ultimately increases yield/plant and yield/ha" [11,12].

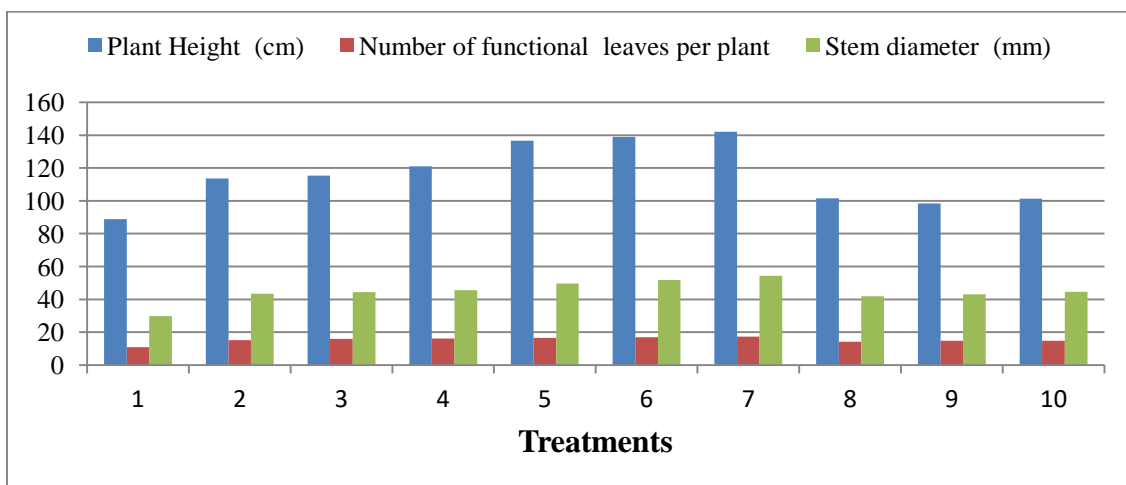
The maximum fruit yield (t ha<sup>-1</sup>) (129.85) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (119.22) and the minimum fruit yield (t ha<sup>-1</sup>) (37.59) was found in Control. "The increase in yield with gibberellic acid might be due to an increase in flower number, better fruit setting percentage and

the production of a higher number of fruits with maximum fruit weight in addition to better vegetative growth. In addition, GA may have affected the auxin metabolism, which may have indirectly aided in fruit enlargement and thus the production of fruits in higher number, which ultimately increases yield/plant and yield/ha" [11,12].

The maximum fruit length (cm) (20.49) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (20.07) and the minimum fruit length (cm) (14.25) was found in Control. "This increase in fruit size is due to the exogenous application of GA3 which increases the cell size of the fruit by the proliferation of the sink demand resulting in enhanced phloem unloading and carbon assimilate metabolism in the fruit and a greater supply of assimilates and photosynthates to the fruits" [14].

**Table 1. Effect of plant growth regulators on growth parameters of papaya cv. red lady**

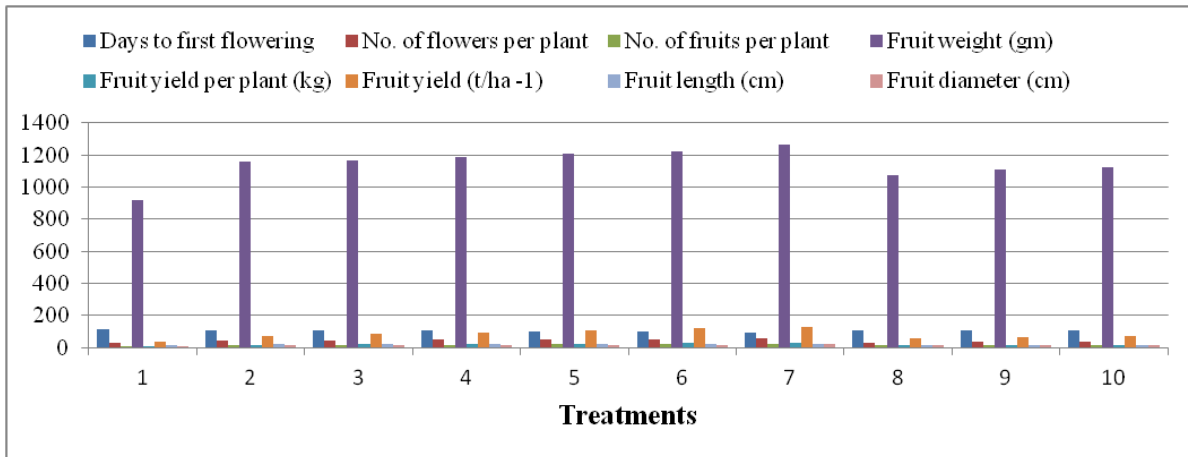
Treatment no.	Treatment Combinations	Plant Height (cm)	Number of functional leaves per plant	Stem diameter (mm)
T0	Control	88.95	10.91	29.73
T1	NAA (100ppm)	113.58	15.26	43.44
T2	NAA (150ppm)	115.45	15.94	44.34
T3	NAA (200ppm)	121.09	16.16	45.53
T4	GA3 (100ppm)	136.67	16.5	49.72
T5	GA3 (150ppm)	138.99	16.99	51.73
T6	GA3 (200ppm)	142.13	17.41	54.37
T7	CCC (500ppm)	101.58	14.19	41.89
T8	CCC (750ppm)	98.38	14.79	43.01
T9	CCC (1000ppm)	101.25	14.81	44.55
	F-Test	S	S	S
	C.D.at 0.5%	1.279	0.494	0.943
	S.Ed (+)	0.609	0.235	0.317



**Graph 1. Effect of plant growth regulators on growth parameters of papaya cv. red lady**

**Table 2. Effect of plant growth regulator on flowering and fruiting attributes of papaya cv. red lady**

Treatment no.	Treatment combinations	Days to first flowering	Number of flowers per plant	Number of fruits per plant	Fruit weight (gm)	Fruit yield per plant (kg)	Fruit yield (t ha-1)	Fruit length (cm)	Fruit diameter (cm)
T0	Control	116.27	27.22	9.23	916.28	8.46	37.59	14.25	10.29
T1	NAA (100ppm)	105.88	40.22	14.45	1156.25	16.71	74.26	18.33	15.15
T2	NAA (150ppm)	104.96	44.44	16.23	1163.35	18.88	83.91	18.39	15.26
T3	NAA (200ppm)	102.94	47.52	17.48	1185.08	20.71	92.05	19.29	15.7
T4	GA3 (100ppm)	98.55	50.38	19.94	1206.11	24.05	106.86	19.79	16.21
T5	GA3 (150ppm)	97.28	52.34	21.99	1220.13	26.83	119.22	20.07	17.54
T6	GA3 (200ppm)	95.42	56.09	23.12	1263.38	29.22	129.85	20.49	18.21
T7	CCC (500ppm)	109.29	31.53	11.93	1077.54	12.86	57.15	16.2	12.83
T8	CCC (750ppm)	108.68	34.85	12.91	1110.48	14.34	63.73	16.68	13.36
T9	CCC (1000ppm)	107.49	36.69	13.81	1125.78	15.55	69.1	17.28	14.16
	F-Test	S	S	S	S	S	S	S	S
	C.D.at 0.5%	0.953	1.855	1.327	33.415	1.772	7.876	0.428	0.555
	S.Ed (+)	0.454	0.883	0.632	15.905	0.844	3.749	0.204	0.264



**Graph 2. Effect of plant growth regulator on flowering and fruiting attributes of papaya cv. red lady**



**Picture 1. Flowers and fruits of papaya**

The maximum fruit diameter (cm) (18.21) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (17.54) and the minimum fruit diameter (cm) (10.29) was found in Control. "This increase in fruit size is due to the exogenous application of GA3 which increases the cell size of the fruit by the proliferation of the sink demand resulting in enhanced phloem unloading and carbon assimilate metabolism in the fruit and a greater supply of assimilates and photosynthates to the fruits" [14].

### 3.3 Quality Attributes

Data on the impact of GA3, NAA, and CCC on the Chemical Characteristics of fruit are shown in Table 3 and Graph 3. The maximum total soluble solids (<sup>o</sup>Brix) (16.61) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (16.22) and the minimum total soluble solids (<sup>o</sup>Brix) (13.06) was found in Control. The

increase in TSS with Ethrel may be the result of a higher accumulation of metabolites and a quick conversion of starch into soluble sugars during the fruit development in response to growth regulators [15]. Foliar sprays of PGRs (GA3 at 20-40 ppm or NAA at 25-50 ppm) are reported to enhance the yield and fruit quality traits of apples [16].

The maximum acidity (%) (0.125) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (0.138) and the minimum acidity (%) (0.194) was found in Control. The reduction in titratable acidity with ethrel may be due to its action on the fast conversion of organic acids and starch into reducing and non-reducing sugars and their derivatives through higher respiration and carbon assimilation activity during rapid ripening process. Yadav et al. [17] and Srinu et al. [3] recorded no significant effect on the acidity of papaya with various treatments.

The maximum non - reducing sugar (2.16) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (2.07) and the minimum non - reducing sugar (1.55) was found in Control. Sugar content might be increased because of metabolic activities which help in degrading polysaccharides to sugars and converting organic acid to simple sugars. The observations are similar to the research work done by Singh et al. (1986) in mango and Singh and Mirza [18].

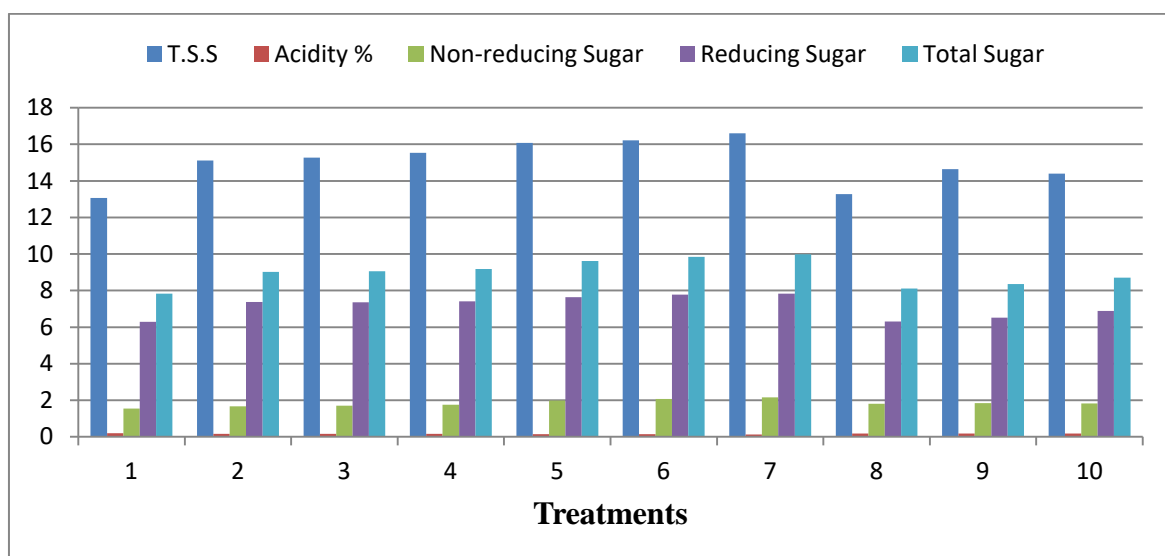
The maximum reducing sugar (7.83) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (7.78) and the minimum reducing sugar (6.29) was found in Control. The reducing sugar increases due to the reason

starch is converted into sugar and ultimately observed the more total soluble solids under the application of Plant growth regulators. Experimental results were related to Anawal et al. [19] in pomegranate.

The maximum total sugar (9.99) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (9.84) and the minimum total sugar (7.84) was found in Control. Sugar content might be increased because of metabolic activities which help in degrading polysaccharides to sugars and converting organic acid to simple sugars. The observations are similar to the research work done by Singh et al. (1986) on mango and Singh and Mirza [18] [20-25].

**Table 3. Effect of plant growth regulators on quality attributes of papaya cv. red lady**

Treatment no.	Treatment combinations	Total soluble solids	Acidity	Non – reducing sugar	Reducing sugar	Total sugar
T0	Control	13.06	0.194	1.55	6.29	7.84
T1	NAA (100ppm)	15.12	0.167	1.66	7.37	9.03
T2	NAA (150ppm)	15.27	0.162	1.71	7.35	9.06
T3	NAA (200ppm)	15.54	0.159	1.75	7.42	9.18
T4	GA3 (100ppm)	16.08	0.144	1.98	7.64	9.61
T5	GA3 (150ppm)	16.22	0.138	2.07	7.78	9.84
T6	GA3 (200ppm)	16.61	0.125	2.16	7.83	9.99
T7	CCC (500ppm)	13.27	0.185	1.8	6.31	8.11
T8	CCC (750ppm)	14.65	0.177	1.85	6.51	8.36
T9	CCC (1000ppm)	14.39	0.174	1.82	6.88	8.7
	F-Test	S	S	S	S	S
	C.D.at 0.5%	1.04	0.005	0.068	0.152	0.167
	S.Ed (+)	0.495	0.002	0.033	0.072	0.079



**Graph 3. Effect of plant growth regulators on quality attributes of papaya cv. red lady**

#### 4. CONCLUSION

Based on the results of the experiment, it is concluded that the papaya cv. Red Lady benefited from the different treatments used to improve its vegetative and reproductive growth. T6 (GA<sub>3</sub> 200 ppm) is found superior among others, followed by T5 (GA<sub>3</sub> 150 ppm) and the lowest was T0 (Control). Treatment T6 (GA<sub>3</sub> 200 ppm) and T5 (GA<sub>3</sub> 150 ppm) are best recommended for the overall growth and development of plants like plant height, number of functional leaves, stem diameter, number of flowers and fruit, fruit weight, length, etc., and best qualitative results like T.S.S., reducing, non-reducing sugar, etc., were produced by treatment T6 (GA<sub>3</sub> 200), which was followed by T5 (GA<sub>3</sub> 150ppm). Contrarily, CCC has slowed down all vegetative growth to promote early reproductive growth.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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