EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, YIELD AND QUALITY OF PAPAYA CV. RED LADY UNDER PRAYAGRAJ AGRO CLIMATIC CONDITION.

Abstract

The present investigation was conducted at the Research farm of Department of Horticulture, SHUATS, Prayagraj, on 1 month old seedlings during March 2022 to Jan 2023 with the objective to find out the suitable treatment in relation to 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_3 100 ppm), T5 (GA_3 150 ppm), T6 (GA_3 200 ppm), T7 (CCC 500 ppm), T8 (CCC 750 ppm), T9 (CCC 1000 ppm). The treatments were applied by soil drenching at initiation of experiment, vegetative phase, pre-flowering and fruit setting stage to assess the effect on growth, yield and quality of papaya. The results of present investigation revealed that, the treatment T6 (GA3 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^{-1}), fruit length (20.49 cm), fruit diameter (18.21 cm) and quality parameters like maximum TSS (16.61 ºBrix) and acidity (0.125 %), non-reducing sugar (2.16 ºBrix), reducing sugar (7.83 ºBrix), total sugar (9.99 ºBrix) followed by T5 (GA_3 150 ppm). The lowest observation was recorded in T0 (Control). Treatment with GA_3, 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 trail.

Keywords- GA3, NAA, CCC, Papaya, subtropical region, Red Lady

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 **(Singh and Sexena, 2008).** 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 **(Syamal *et al.* (2010).** It is cross-pollinated crop which can grow to a height of 2 to 10 meters, 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 from a hermaphroditic plant is longer than the fruit shape from a female plant, which is typically shorter. According to **Srinu, *et al.* (2017),** 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 spot. Duration of Red Lady Taiwan variety is of about 2 years. This plant will grow aggressive, high-yielding, and able to produce 50 tons per acre during the course of 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.

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□ North latitude and 81.84□ East longitudes.

This region falls under the sub-tropical zone. Prevailing in the South-Eastern part of the U.P. and has both the extremities in temperatures, i.e., winter and summer. In winters, the temperature sometimes is as low as 32□F in December to January, and in summer the temperatures reach up to 115□F in the months of 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 winters.

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: GA3 100 ppm, T5: GA3 150 ppm, T6: GA3 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 in accordance with the specified doses. Preparation of GA3 solution:- Weighed 1000 mg of GA3 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 growing area regardless of plant spacing.

Result and Discussion

Growth Parameters

The data about the impact of GA3, NAA, and CCC on fruit growth measures is shown in Table 1 and Graph 1. In terms of plant height, 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 carbohydrates production **(Yadav *et al.* 2011a).**

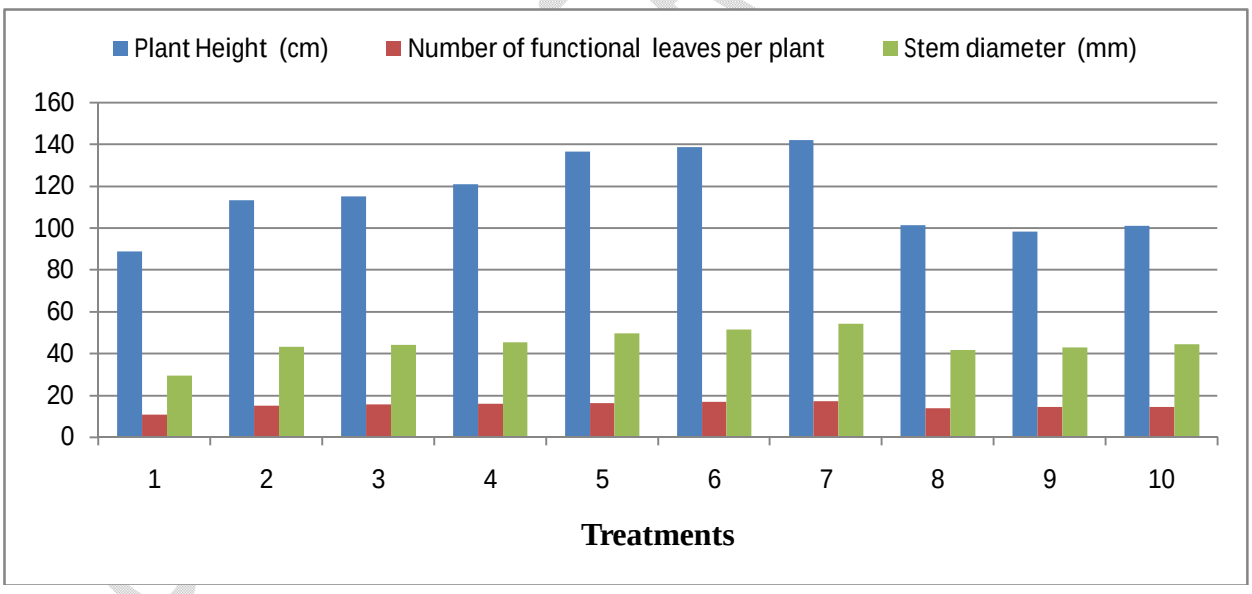
The maximum number of functional leaves per plant (17.41) was recorded under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) 16.99 and the minimum number of functional leaves per plant (10.91) was observed under the treatment T0 (Control). Foliar application of GA3 have been reported to increase the plant height and the production of more number of leaves and leaf area caused the increased plasticity of the cell wall followed by the hydrolysis of starch to sugars which lowers the water potential of cell resulting in the entry of water into the cell causing cell elongation. This might have attributed to increase the photosynthetic activity, accelerated translocation and efficiency of utilizing photosynthetic products resulting in cell elongation and rapid cell division in growing portion. **(Sargent, 1965).** Similar views were also expressed by **Kadam *et al.* (2010)** in Kagzi lime, **Surakshita *et al.*, (2014)** 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 **(Singh and Singh, 2009) and Srinu *et al.* (2017).**

Table No. 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 No. 1. Effect of plant growth regulators on growth parameters of Papaya cv. Red Lady



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, was recorded in Red Lady (72.64 days) and 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., (2016), Kumar et al., (2015) and Prakash et al., (2015)**.

The maximum number of flower per plant (52.34) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (52.34) and the minimum number of flower per plant (27.22) was found in Control. The increased number of flowers was observed in case of papaya with application of GA3 which increased the flower bud initiation and also retards the effect of ABA **(Singh and Singh, 2009).**

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 number, which ultimately increases yield/plant and yield/ha **(Kappel and MacDonald 2007, Singh and Singh 2006).**

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 **(Pandey1999).**

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 number, which ultimately increases yield/plant and yield/ha **(Kappel and MacDonald 2007, Singh and Singh 2006).**

The maximum fruit yield (t ha-1) (129.85) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (119.22) and the minimum fruit yield (t ha-1) (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 **(Kappel and MacDonald 2007, Singh and Singh 2006).**

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 exogenous application of GA3which increases the cell size of the fruit by the proliferation of the sink demand which resulting in enhanced phloem unloading and carbon assimilate metabolism in the fruit and a greater supply of assimilates and photosynthates to the fruits **(Zhang et al.2007).**

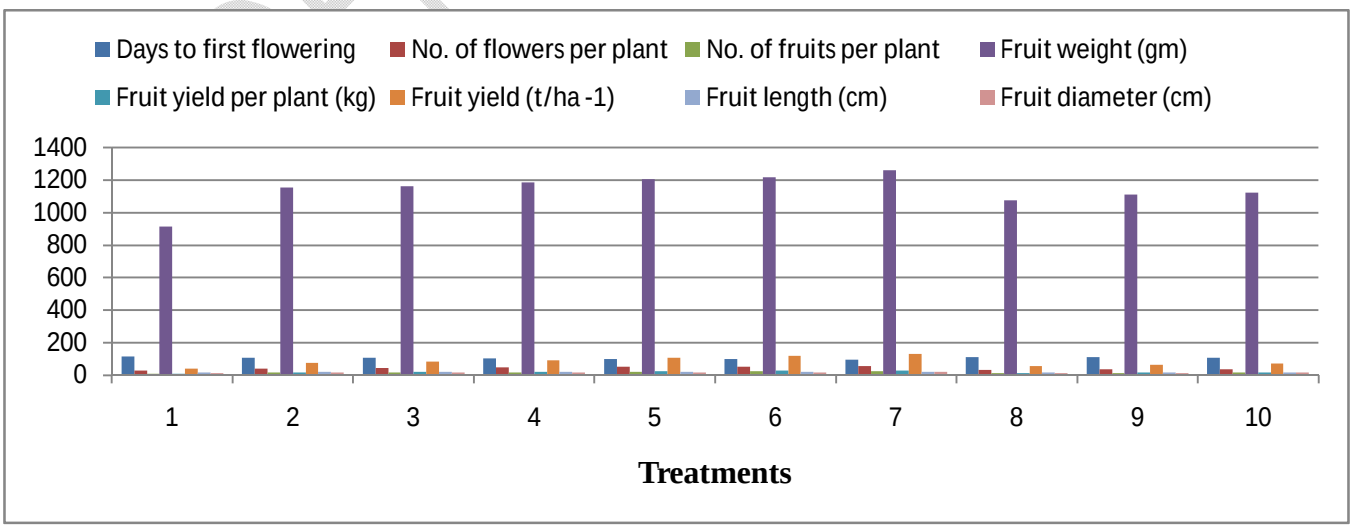
The maximum fruit diameter (cm) (18.21) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (17.54) and the minimum fruit diameter (cm) (10.29) was found in Control. This increase in fruit size is due to exogenous application of GA3which increases the cell size of the fruit by the proliferation of the sink demand which resulting in enhanced phloem unloading and carbon assimilate metabolism in the fruit and a greater supply of assimilates and photosynthates to the fruits **(Zhang *et al.* 2007).**

Picture 1. Flowers and Fruits of Papaya

Table No. 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 No. 2. Effect of plant growth regulator on flowering and fruiting attributes of Papaya cv. Red Lady



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 (^{0}Brix) (16.61) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (16.22) and the minimum total soluble solids (^{0}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 **(Agrawal and Dikshit, 2010).** Foliar sprays of PGRs (GA3 at 20-40 ppm or NAA at 25-50 ppm) are reported to enhance yield and fruit quality traits of apple **(Osama *et al.* 2015).**

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.* 2001) and Srinu *et al.* (2017)** recorded no significant effect on 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 helps in degrading polysaccharides to sugars and convert organic acid to simple sugars. The observations are similar with the research work done by **Singh et al. (1986)** in mango and **Singh and Mirza (2020)**

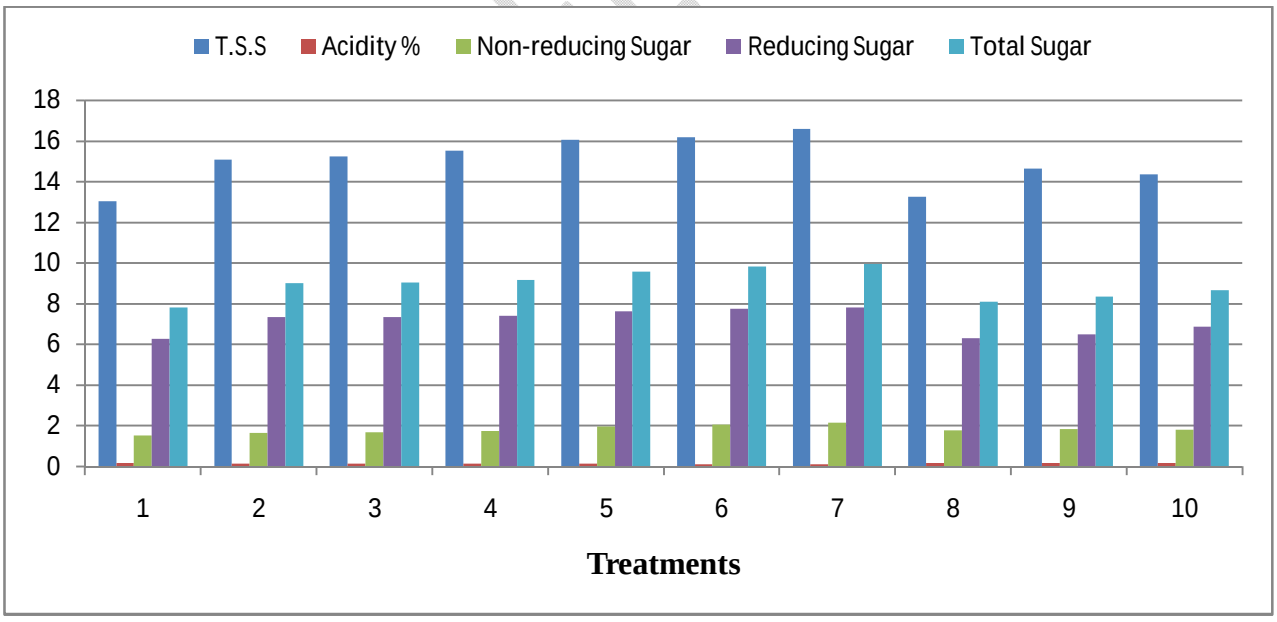
The maximum reducing sugar (7.83) was noticed under the treatment T6 GA3 (200ppm) followed by T5 GA3 (150ppm) (7.78) and the minimum reducing sugar (6.29) was found in Control. The reducing sugar increases due to reason starch is converted into sugar and ultimately observed the more total soluble solids under the application of Plant growth regulators. Experimental results were related to **Anawal et al. (2015)** 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 helps in degrading polysaccharides to sugars and convert organic acid to simple sugars. The observations are similar with the research work done by **Singh et al. (1986)** in mango and **Singh and Mirza (2020).**

Table No. 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 No. 3. Effect of plant growth regulators on Quality attributes of Papaya cv. Red Lady



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 (GA3 200 ppm) is found superior among others, followed by T5 (GA3 150 ppm) and the lowest was T0 (Control). Treatment T6 (GA_3 200 ppm) and T5 (GA3 150 ppm) is best recommended for 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 (GA3 200), which was followed by T5 (GA3 150ppm). Contrarily, CCC has slowed down all vegetative growth in an effort to promote early reproductive growth.

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