**EFFECT OF PLANT GROWTH REGULATORS ON GROWTH AND YIELD OF PAPAYA (*Carica papay*a L.) cv. PUSA NANHA**

**ABSTRACT**

This study was carried out on 2-month-old seedlings during the 2024-2025 period to determine the most effective treatment for the growth, yield, and quality of Papaya cv. Puaa Nanha. The experimental design utilized was a randomized block design (RBD) with three replications and ten treatment combinations, which included: T0: Control, T1: NAA 100 ppm, T2: NAA 200 ppm, T3: GA3 100 ppm, T4: GA3 200

ppm, T5: CCC 500 ppm, T6: CCC 1000 ppm, T7: Ethrel 200 ppm, T8: Ethrel 350 ppm, and T9: Ethrel 150 ppm. Treatments were administered through foliar application at the start of the experiment, during the vegetative phase, pre-flowering, and at the fruit setting stage to evaluate their impact on the growth, yield, and quality of papaya. The findings indicated that treatment T4 (GA3 200 ppm) excelled in all measured parameters, including maximum plant height (153.70 cm), stem girth (47.43 cm), number of leaves per plant (36.52), minimum days to first flowering (109.95), days to first fruiting (133.47), days to fruit maturity (238.58), number of fruits per plant (36.70), fruit length (18.00 cm), fruit diameter (15.40 cm), fruit weight (942.73 g), fruit yield per plant (34.60 kg), fruit yield per hectare (106.78 t), pulp weight (902.28 g), peel weight (40.45 g), total soluble solids (12.37 °Brix), minimum acidity (0.13%), and ascorbic acid content (66.88 mg/100 g). Consequently, a favorable response was observed for this specific treatment throughout the research trial.

**Key words:-** PGR, growth, flowering, fruit yield and papaya

**INTRODUCTION**

Papaya (*Carica papaya* L.) is the 4th most important fruit crop in India and is grown commercially in the tropical and subtropical regions of the world under different names, like papita, pawpaw and tree melon. Papaya belongs to the family Caricaceae and is a dicotyledonous, polygamous diploid species (2n=18) with a basic chromosome number of x=9. Originally, papaya is a tropical American fruit that was brought to India in the year 1576 by a Dutch traveler named Linschoten from Malacca, Malaysia **(Ram, 2009).** Papaya is a highly cross-pollinated perennial crop and for varietal improvement work, approximately 7-8 generations (15-16 years) are needed

to release a variety **(Ray, 2002).** The nutritive and medicinal properties of papaya are well known. 100gm edible portion of papaya contains moisture 89.6%, carbohydrate 9.5%, proteins

0.5%, fat 0.1%, calorific value 4.0%,

minerals 0.4%, calcium 0.01%,

phosphorus 0.01%, iron 0.4 mg, carotene (Vit A) 2020 IU, thiamine (Vit B) 40 IU, riboflavin (Vit B2) 250 IU, nicotinic acid 0.2 IU **(Ram, 2007).** In India, it is successfully grown all over the country and is available round the year. Papaya occupies 2.14 per cent total fruit crop area and 6.40 per cent of total fruit production in India. It occupies a cultivated area of 133 thousand hectares with 5699 thousand MT of production with average productivity of 42.3 t/ha**.** The

important papaya growing States are Andhra Pradesh, Gujarat, Maharashtra, Karnataka, Madhya Pradesh, Chhattisgarh, West Bengal, Telangana, Tamil Nadu, Assam, Karla, Uttar Pradesh and Rajasthan have ideal climate conditions for its growth and production. Chhattisgarh is one of the State in which papaya is being grown in an area of 13623 ha with annual production of 305523 metric tones with the productivity of

23.3 t/ha, accounting 11.6 and 6.85 per cent area and production, respectively**.** India is the largest producer of papaya, which shares 44.4% of the world's production. In India, it covers 2.13% of total fruit area (0.138 million ha) and shares 6.08% of total fruit production (5.98 million tonnes) with a productivity of 43.3 t/ha **(ICAR- Databook, 2019).** During the ripening process, major hormonal changes occur, which give a better scope for quality improvement by applying plant growth regulators (PGRs) exogenously. Most often, the fruit ripening period in northern India coincides with severe cold stress followed by warm sunny days as well as unseasonal rains, which affect the fruit's palatable quality. Previously, much research has been done on exogenous treatment of different PGRs such as auxins, gibberellins and cytokinins for the improvement of papaya fruit quality. But still a lot of research is needed to improve the fruit quality with respect to various aspects. Papaya is a climacteric fruit and synthesis of sugars and different acidic compounds are activated only a few days before full ripening. Therefore, it is very important to understand the role of different hormones at this particular stage. The use of plant growth regulators has assumed an integral part of modern fruit production to improve the quality and production of fruits, and it has resulted

in outstanding achievements in a number of fruit crops with regard to improvements in yield and quality **(Jain and Dashora 2011).**

**MATERIALS AND METHODS**

The present study, titled " **Effect of plant growth regulators on growth and yield of papaya (*Carica papay*a L.) cv. Pusa Nanha**” was conducted at the Horticulture Research Farm, Faculty of Agricultural Sciences and Allied Industries, Rama University, Kanpur (U.P.), Kanpur during the 2024-2025. Positioned approximately 25 km from the district headquarters of Uttar Pradesh 208024. The farm is situated at 20°16' North latitude and 80°08' East longitude in the southwestern plains of Uttar Pradesh. It sits at an altitude of

180 meters above sea level, falling within the subtropical zone. The field was effectively leveled, equipped with adequate irrigation and drainage facilities. The seedling of papaya cv. Pusa Nanha were purchased from reputed Bajrang nursery of Kanpur. Papaya seedlings two month old seedlings were transplanted during evening time in pre-determined location. One seedling in each pit was planted followed hy lighl irrigation. Papaya seedlings were transplanted respectively. The experimental field was ploughed with tractor draw moudl board plough to expose the seed of weed and root sutblles the month of may. Harrowing was done in the month of june to bread the clods followed by criss cross ploughing by the cultivator. The field was fulveried by rotovator before digging of pits. The experimnent was laoid out as per plan with the help of measuring tape, rope and mark pagegs, Demarked pit was dug in dimension of 60x60x60 cm at

1.8 x 1.8 m spacing. The top soil and sub soil of dug pit were kept separately in two heaps near the pit. Randomized block design was used in experiment with three replications and ten

treatments. The ten treatments were as followed: T0:Control, T1:NAA 100 ppm, T2:NAA 200 ppm, T3:GA3 100

ppm, T4:GA3 200 ppm, T5:CCC 500

ppm, T6:CCC 1000 ppm, T7:Ethrel

200 ppm, T8:Ethrel 350 ppm and T9:Ethrel 150 ppm. Plants were randomly selected and tagged for observing plant growth parameters. Observation of yield and fruit quality parameters was done by standard methods and in each treatment ten fruits were selected. The data on growth, yield and quality components were subjected to Fisher’s method of analysis of variance (ANOVA) as outlined by **Sundararaj *et al.* (1972)** where the ‘F’ test was significant for comparison of the treatment means, CD values were worked out at 5% probability level. **RESULTS AND DISCUSSION**

The application of plant growth regulators demonstrated significant variations in the vegetative growth, flowering, and fruiting of papaya cv. Pusa Nanha across various experimental treatments, as illustrated in Table 1. Notable differences in plant growth, flowering, and fruiting were observed following the application of different growth regulators. The results of analyzed data pertaining to increment in plant height (153.70 cm) was found to be statistically significant at harvest days after transplanting in treatment T4 (GA3 200 ppm). It was followed by GA3 100 ppm, Ethrel 350 ppm and Ethrel 200 ppm. Where as the minimum plant height at (71.14, 109.48 and 115.10 cm) was observed in treatment T0 (Control) at harvest DAT. The results of analyzed data pertaining to increment in stem girth (47.43) was found to be statistically significant at harvest days after transplanting in treatment T4 (GA3 200 ppm). It was followed by GA3 100 ppm, Ethrel 350 ppm and Ethrel 200 ppm. Where as the minimum stem girth at (30.67) was observed in treatment T0 (Control) at

harvest DAT. The possible reason for this could be the utilization of GA3, which stimulated cell division and elongation, resulting in enhanced vegetative growth by counteracting genetic dwarfism **(Singh and Singh, 2009).** Similar findings have been reported by **Syamal *et al.* (2010) and Hazarika *et al.* (2016),** who observed growth enhancement in papaya with the application of GA3 at different concentrations. The maximum number of leaves per plant was recorded in T4 GA3 200 ppm which was (36.52) at harvest DAT. The minimum number of leaves per plant was recorded in T0 Control which was (17.35) at harvest DAT. The increase in the leaves per plant of Strawberry cv. Chandler under black mulch could be attributed to the influence of gibberellins, which regulate plant growth by stimulating cell elongation within the strawberry system **(Kriti, 2016).** A similar result on leaves per plant was reported by **Mirza *et al.* (2019)** in Papaya. Among the different treatments, the results clearly showed that the days taken to first flowering was significantly minimum (109.95 days) was recorded in T4 GA3 200 ppm and it was followed by T3GA3 100 ppm, T2NAA 200 ppm and T1NAA 100

ppm. In T0 (Control) has registered significantly maximum days taken to first flowering (126.69 days). Among the different treatments, the results clearly showed that the days taken to first fruiting was significantly minimum (133.47 days) was recorded in T4 GA3

200 ppm and it was followed by T3GA3 100 ppm, T2NAA 200 ppm

and T1NAA 100 ppm. In T0 (Control) has registered significantly maximum days taken to first fruiting (160.80). Among the different treatments, the results clearly showed that the days taken to fruit maturity was significantly minimum (238.58 days) was recorded in T4 GA3 200

ppm and it was followed by T3GA3

100 ppm, T2NAA 200 ppm and T1NAA 100 ppm. In T0 (Control) has registered significantly maximum days taken to fruit maturity (292.80). It could be due to GA3 promotes cell elongation, particularly in stems and internodes. This elongation can accelerate the growth and development of the plant, leading to earlier flower initiation. These results were in close confirmation with results obtained by **Vyas & Mishra (2023), Chalak *et al.* (2016), Harinder and Anis (2020), and Prakash *et al.* (2015) in Papaya.** Table 2 the impact of plant growth regulators on yield parameters. The results obtained for number of fruit per plant was significantly maximum (36.70) with foliar application of T4 GA3 200 ppm, which was on par with the application of T3 GA3 100 ppm and it was followed by T8 Ethrel 350 ppm and T7 Ethrel 200 ppm. Where as in T0 Control was noticed minimum number of fruit per plant (18.28). The significant impact of GA3 on fruit quantity in strawberry can be attributed to its positive influence on pollen germination and fruit development. This led to a higher fruit set, resulting in an increased yield of fruits **(Sharma and Singh, 2009).** These similar results have been reported by **Borana *et al.* (2018)** in Pomegranate, **Hazarika *et al.* (2016), and Harinder and Anis (2020)** in Papaya. The results obtained for fruit length (cm) was significantly maximum (18.00) with foliar application of T4 GA3 200 ppm, which was on par with the application of T3 GA3 100 ppm and T8 Ethrel

350 ppm and it was followed by T9 Ethrel 150 ppm and T5 CCC 500 ppm. Where as in T0 Control was noticed minimum fruit length (cm) (12.15). The results obtained for fruit diameter (cm) was significantly maximum (15.40) with foliar application of T4 GA3 200 ppm, which was on par with

the application of T3 GA3 100 ppmand it was followed byT8 Ethrel 350 ppm, T7 Ethrel 200 ppm and T9 Ethrel 150 ppm. Where as in T0 Control was noticed minimum fruit diameter (cm) (10.85). The results obtained for fruit weight (g) was significantly maximum (942.73) with foliar application of T4 GA3 200 ppm, and it was followed by T3 GA3 100 ppm, T8 Ethrel 350 ppm, T7 Ethrel 200 ppm and T9 Ethrel 150 ppm. Where as in T0 Control was noticed minimum fruit weight (g) (719.11). **Zhang *et al.* (2007)** in Pear and **Ahmed *et al.* (2012)** in Mango reported that application of GA3 externally led to an enlargement of fruit cell size due to increased sink demand proliferation. This process also led to improved phloem unloading and carbon assimilate metabolism within the fruit, resulting in a greater supply of assimilates and enhanced photosynthesis, specifically benefiting the fruits. Similar findings were also observed by **Hazarika *et al.* (2016)** in Papaya. The results obtained for fruit yield per plant (kg) was significantly maximum (34.60) with foliar application of T4 GA3 200 ppm, and it was followed by T3 GA3 100 ppm, T8 Ethrel 350 ppm, T7 Ethrel 200 ppm and T9 Ethrel 150 ppm. Where as in T0 Control was noticed minimum fruit yield per plant (kg) (13.15). The results obtained for fruit yield per plant (t ha-1) was significantly maximum (106.78) with foliar application of T4 GA3 200 ppm, and it was followed by T3 GA3

100 ppm, T8 Ethrel 350 ppm, T7 Ethrel 200 ppm and T9 Ethrel 150 ppm. Where as in T0 Control was noticed minimum fruit yield per plant (t ha-1) (40.58). **Hazarika *et al.* (2016)** is reported that increase in papaya yield achieved with GA3 could be attributed to increase in number of flowers, improved fruit setting percentage, and a higher yield of fruits with maximum fruit weight and additionally, better

vegetative growth. The application of GA3 might also have had an impact on auxin metabolism, indirectly contributing to fruit enlargement and consequently leading to an increased production of fruits. This, in turn, can lead to higher yield per plant and yield per hectare **(Kappel and MacDonald, 2007; Singh and Singh, 2006).** The results obtained for pulp weight (g) was significantly maximum (902.28) with foliar application of T4 GA3 200 ppm, which was on par with the application T3 GA3 100 ppm and it was followed by T8 Ethrel 350 ppm, T7 Ethrel 200 ppm and T9 Ethrel 150 ppm. Where as in T0 Control was noticed minimum pulp weight (g) (667.54). The pulp weight increases due to reason that the size of fruit and weight of fruit was increased. Experimental results are similar to finding of **Bhogave *et al.* (2015)** in papaya. The results obtained for peel weight (g) was significantly minimum (40.45) with foliar application of T4 GA3 200 ppm and it was followed by T3 GA3 100 ppm, T8 Ethrel 350 ppm, T7 Ethrel 200 ppm and T9 Ethrel 150 ppm. Where as in T0 Control was noticed maximum peel weight (g) (51.57). These results are similar with **Bhogave *et al.* (2014)** and **Bhogave *et al.* (2014)** in papaya. The results obtained for total soluble solids (%) was significantly maximum (12.37) with foliar application of T4 GA3 200 ppm, which was on par with the application T3 GA3 100 ppm and it was followed by T2 NAA 200 ppm, T9 Ethrel 150 ppm and T7 Ethrel 200 ppm. Where as in T0 Control was noticed minimum total soluble solids (%) (9.16). The TSS content of fruit increases due to that reason the plant growth regulators enhance the hydrolysis of polysaccharides into soluble solids and carbohydrate mobilization was increased from source to sink (**Singh and Mirza (2020).** The

results obtained for acidity (%) was significantly minimum (0.13) with foliar application of T4 GA3 200 ppm, which was on par with the application T9 Ethrel 150 ppm, T7 Ethrel 200 ppm, T5 CCC 500 ppm and T2 NAA 200

ppm ppm and it was followed by T8 Ethrel 350 ppm and T3 GA3 100 ppm. Where as in T0 Control was noticed minimum acidity (%) (0.21). This might be attributed to GA3 catalytic impact on its biosynthesis from its precursor glucose-6- phosphate or to the blockage of its conversion into dehydroascorbic acid, which could be mediated by the presence of Ascorbic acid oxidase **(Hazarika *et al.* 2016).** The results obtained for ascorbic acid (mg/100g) was significantly maximum (66.80) with foliar application of T4 GA3 200 ppm, which was on par with the application T9 Ethrel 150 ppm, T7 Ethrel 200 ppm, T5 CCC 500 ppm and T2 NAA 200 ppm ppm and it was followed by T1 NAA 100 ppm and T2 NAA 200 ppm. Where as in T0 Control was noticed minimum ascorbic acid (mg/100g) (50.74). The ascorbic acid increases when glucose-6- phosphate is synthesised during the growth and development of fruit and the precursor of vitamin C is glucose-6- phosphate. The results were similar to results of **Mitra and Ghanta (2000)** in papaya.

**CONCLUSION**

Based on the findings, it can be concluded that the foliar application of T4 GA3 at 200 ppm is recommended for the Pusa Nanha papaya cultivar, as it exhibited a notably positive influence on growth, yield, and quality attributes in comparison to the other treatments.

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**Table 1. Effect of plant growth regulators on growth parameters of papaya cv. Pusa Nanha**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Treatment Number** | **Treatment Details** | **Growth parameters** | | | **Flowering and fruiting parameters** | | |
| **Plant height (cm)** | **Stem girth (cm)** | **Number of leaves per plant** | **Days taken to first flowering** | **Days taken to first**  **fruiting** | **Days taken to fruit maturity** |
| 1 | T0 | Control | 115.10 | 30.67 | 17.35 | 126.69 | 160.80 | 292.80 |
| 2 | T1 | NAA 100 ppm | 139.83 | 41.57 | 24.95 | 115.32 | 144.84 | 267.28 |
| 3 | T2 | NAA 200 ppm | 143.07 | 41.17 | 26.36 | 115.59 | 144.00 | 264.11 |
| 4 | T3 | GA3 100 ppm | 151.68 | 46.87 | 35.51 | 112.38 | 138.01 | 248.12 |
| 5 | T4 | GA3 200 ppm | 153.70 | 47.43 | 36.52 | 109.95 | 133.47 | 238.58 |
| 6 | T5 | CCC 500 ppm | 135.91 | 40.10 | 23.62 | 118.38 | 148.50 | 275.02 |
| 7 | T6 | CCC 1000 ppm | 128.57 | 37.80 | 22.12 | 122.26 | 154.81 | 283.21 |
| 8 | T7 | Ethrel 200 ppm | 145.39 | 42.53 | 30.11 | 118.26 | 145.67 | 261.30 |
| 9 | T8 | Ethrel 350 ppm | 149.93 | 44.53 | 34.29 | 121.25 | 147.77 | 260.40 |
| 10 | T9 | Ethrel 150 ppm | 117.85 | 31.30 | 28.85 | 118.25 | 146.03 | 264.69 |
|  |  | **F-Test** | **S** | **S** | **S** | **S** | **S** | **S** |
|  |  | **C.D.at 0.5%** | **3.037** | **1.197** | **0.943** | **2.566** | **2.456** | **2.427** |
|  |  | **S.Ed.** | **1.446** | **0.570** | **0.449** | **1.221** | **1.169** | **1.155** |

**Table 2. Effect of plant growth regulators on yield and quality parameters of papaya cv. Pusa Nanha**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.**  **No.** | **Treatment Number** | **Treatment Details** | **Yield parameters** | | | | | | **Quality parameters** | | | | |
| **Number of fruits per plant** | **Fruit length (cm)** | **Fruit diameter (cm)** | **Fruit weight (g)** | **Fruit yield per plant (kg)** | **Fruit yield per plant (t ha-**  **1)** | **Pulp weight (g)** | **Peel weight (g)** | **Total soluble solids (%)** | **Acidity (%)** | **Ascorbic acid (mg/100g)** |
| 1 | T0 | Control | 18.28 | 12.15 | 10.85 | 719.11 | 13.15 | 40.58 | 667.54 | 51.57 | 9.16 | 0.21 | 50.74 |
| 2 | T1 | NAA 100 ppm | 26.72 | 14.26 | 12.45 | 869.97 | 23.24 | 71.72 | 820.74 | 49.23 | 10.51 | 0.14 | 60.62 |
| 3 | T2 | NAA 200 ppm | 28.60 | 14.87 | 12.57 | 878.86 | 25.14 | 77.58 | 830.27 | 48.59 | 11.48 | 0.15 | 60.22 |
| 4 | T3 | GA3 100 ppm | 34.48 | 17.81 | 15.10 | 932.93 | 32.17 | 99.27 | 888.64 | 44.28 | 12.19 | 0.17 | 64.00 |
| 5 | T4 | GA3 200 ppm | 36.70 | 18.00 | 15.40 | 942.73 | 34.60 | 106.78 | 902.28 | 40.45 | 12.37 | 0.13 | 66.88 |
| 6 | T5 | CCC 500 ppm | 24.92 | 15.02 | 12.34 | 836.77 | 20.86 | 64.36 | 786.66 | 50.11 | 10.44 | 0.15 | 57.47 |
| 7 | T6 | CCC 1000 ppm | 22.64 | 14.17 | 12.28 | 821.51 | 18.60 | 57.40 | 771.10 | 50.41 | 11.17 | 0.18 | 54.60 |
| 8 | T7 | Ethrel 200 ppm | 31.46 | 15.91 | 14.18 | 911.89 | 28.68 | 88.33 | 865.46 | 46.43 | 11.34 | 0.15 | 52.89 |
| 9 | T8 | Ethrel 350 ppm | 33.04 | 17.46 | 14.26 | 920.18 | 30.40 | 93.81 | 874.22 | 45.96 | 10.69 | 0.16 | 54.40 |
| 10 | T9 | Ethrel 150 ppm | 30.19 | 15.48 | 14.12 | 905.19 | 27.33 | 84.33 | 858.13 | 47.06 | 11.34 | 0.15 | 56.27 |
|  |  | **F-Test** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** |
|  |  | **C.D.at 0.5%** | **0.746** | **0.571** | **0.128** | **10.632** | **0.614** | **1.449** | **10.859** | **0.820** | **0.330** | **0.023** | **2.427** |
|  |  | **S.Ed.** | **0.355** | **0.272** | **0.061** | **5.061** | **0.292** | **0.690** | **5.169** | **0.390** | **0.157** | **0.011** | **1.155** |