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# RESEARCH

## EFFECT OF PLANT GROWTH REGULATORS ON VEGETATIVE GROWTH, FLOWERING & YIELD PARAMETERS OF TOMATO (SOLANUM LYCOPERSICUM L.) CV. HEEMSHIKHAR UNDER POLYHOUSE CONDITIONS

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**Abstract:** In the Rabi season, we experimented on Tomato cv. Heemshikhar on 180 plants in a Poly-house at the School of Agricultural Sciences and Technology of RIMT University in Mandi Gobindgarh, Punjab, India, in 2022-2023. The experiment was layout in CRD (Completely Randomized Design) with three replications and ten treatments i.e. $T_1$ (control), $T_2$ ($GA_3$ @50ppm), $T_3$ ($GA_3$ @75ppm), $T_4$ ($GA_3$ @100ppm), $T_5$ (IAA @50ppm), $T_6$ (IAA @75ppm), $T_7$ (IAA @100ppm), $T_8$ (NAA @50ppm), $T_9$ (NAA @75ppm) and $T_{10}$ (NAA @100ppm) under Protected conditions. The results revealed that at 20 days interval, maximum plant height (39.86, 64.35, and 117.33cm) and Number of branches/Plant (7.86, 13.00 and 19.66) we have recorded in treatment $T_{10}$ (NAA@100ppm). However, the maximum number of flowers/Plant (26.50) and clusters/Plant (11.60), Days to first fruit set (51.66 days), days to first fruit picking (36.00 days), number of fruits/plant (25.00), fruits/cluster (4.66), Fruit weight (56.33g), Fruit length (12.66cm), Yield/plant (1.40kg), Yield/acre (16.90Tons), TSS ($3.96^0$Brix), Ascorbic acid (17.23%) and highest BC ratio (2.65) were recorded in $T_3$ $GA_3$ @75ppm whereas, lower value of most of the parameters were recorded in $T_1$ control under poly-house conditions.

**Keywords**: Growth regulators, Poly house, Tomato, Yield

### INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops grown in the world, and it belongs to the family Solanaceae with chromosome number (2n=24). It is a perennial, herbaceous, self-pollinated, and day-neutral plant that originated in the Peru-Equator region and is cultivated in tropical subtropical and temperate areas, in open fields or under poly-house in temperate climate in loam and sandy loam soil with a pH range of 6.0-6.8 which is suitable for its growth and production Basavarajeshwari *et al*. 2008. In India, tomatoes are produced next to potatoes, which cover an area of 852 thousand hectares along with a total output of 21003 thousand MT. In Punjab, the major tomato-growing districts are Amritsar, Ropar, Jalandhar, and Hoshiarpur, with a total area of 9.01 thousand ha with a total production of (224.26) thousand MT, NHB 2023.

Plant growth regulators are the general growth factors involved in many developmental processes throughout the plant, and they can be used extensively to enhance plant growth, fruit number, fruit set, fruit size, and yield of vegetable crops. So, an attempt was undertaken to assess the influence of plant hormones on the growth of flowering and yield of tomatoes. The natural occurrence of growth hormones in plants in minute quantities is known to control plant growth. Thus, the effect of the spray of $GA_3$, NAA, and IAA at deficient concentrations can be beneficially exploited. They are common phytohormones used commercially to improve the productivity and quality of several vegetable crops, especially tomato development Meena and Dhaka 2003. Appropriate concentration for the applications of these growth hormones in vegetable crops would be discussed so that such regulators are environmentally and toxicologically safe for both plants and consumers.

### MATERIALS AND METHODS

The experiment was conducted in an Agriculture Polyhouse, School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab. Mandi Gobindgarh is between 300 56' 11.90''N latitudes and 76018' 13.18''E longitudes and 268 meters above sea level. The experiment was conducted under a Completely Randomized Design (CRD) and replicated thrice from October–April (2022-2023). The variety Heemshikhar was used during the experiment. The crop was transplanted with a spacing of 30 ×40 cm inside the poly-house, and six plants were selected randomly from each row for observations. The data on plant height (cm),

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Number of branches/plant, Number of clusters/plant, Number of flowers/plant, Days to first fruit set, Days to first fruit picking, Fruits/cluster, Fruits/Plant, Fruit weight, Fruit length, Yield/Plant, Yield/acre, and TSS were done by placing a few drops of the sample in between the prism and allows the temperature to equilibrate and the note the Brix reading, which gives the percent of sucrose sugar or TSS and ascorbic acid is measured using isocratic ultra-high performance liquid chromatography with electrochemical detection at 450 mV serum, which is mixed with four parts of 6% metaphosphoric acid to acidify the serum and stabilize ascorbate.

## RESULTS AND DISCUSSION

**Plant height (cm):**

The Data on plant height is presented in Table 1. The result reveals that different growth regulators significantly influenced the plant height. The maximum plant height at 20,40 & 60 DAT was recorded in treatment ($T_{10}$) NAA @ 100 ppm (39.86, 64.35 & 117.33cm), and minimum plant height was recorded in treatment ($T_1$) control (25.16, 44.61 & 103.53cm) respectively. It might be due to the rapid increase in cell division and elongation in the meristematic region. Plant height was increased with the increasing level of NAA. These results are as per those reported by (Singh and Lal, 2001) on the cause of stem elongation. These results are in line with the findings of (Nibhavanti *et al*. 2006, Naeem *et al*. 2004, Rai *et al*. 2006).

**Number of branches/plants:**

The Data on the number of branches/plants is presented in Table 1, and the different growth regulators significantly influenced the branches number/plant. The maximum branches/plant at 20,40 & 60 DAT were recorded in treatment ($T_{10}$) NAA @ 100 ppm (7.86, 13.00 & 18.33), and minimum plant height was recorded in treatment ($T_1$) control (5.00, 9.00 & 14.33) respectively. The increase in branches is due to auxins attributed to the activation of cell division and cell elongation in the axillary buds, which had a promoting effect on the increased number of primary and secondary branches.

**Number of flowers/plants:**

The Data on the number of flowers/plants is presented in Table 2. Different plant growth regulators significantly affect the number of flowers/plant. The maximum numbers of flowers/plant were recorded in treatment ($T_3$) $GA_3$@75ppm (26.50), and the minimum numbers of flowers were recorded in ($T_1$) control (17.77), respectively. Application of $GA_3$ causes increased synthesis of cytokinin and auxins & transports them to auxiliary buds that help boost transformation from the vegetative phase to the reproductive phase. It might be due to the action of both auxin and gibberellins. The application of phytohormone increased the flower count in the plant. The increased number of flowers/plants might be because hormones might be involved in the transition of vegetative apices to floral apices, which would remain physiologically more active to build up sufficient food reserve for developing flowers.

**Number of clusters/Plant**:

The Data on the number of clusters/plants is presented in Table 2. Different plant growth regulators significantly affect the number of clusters per plant. The maximum number of clusters/plants were recorded in treatment ($T_3$) GA@75ppm (11.60), and the minimum number of clusters were recorded in ($T_1$) control (7.68), respectively. It might be due to increased respiration, photosynthesis, and better vegetative growth promoting flowering. Furthermore, Early flowering was promoted by $GA_3$, which resulted in a higher number of flowers/clusters and clusters/plant. It might have been exposed to a favorable environment, like accumulation of more photosynthates optimum light, the temperature which would increase in cluster number.

**Days to first fruit set and first fruit picking:**

The Data on days taken to the first fruit set and first fruit picking is presented in Table 2. Different plant growth regulators have a significant effect on days to first fruit set and days to first fruit picking in which minimum days to first fruit set were recorded ($T_3$) $GA_3$ @75ppm (46.33) and the maximum days taken to the first fruit set were recorded in ($T_1$) control (51.66) also in case of days to first fruit picking minimum days were recorded in ($T_3$) $GA_3$@75ppm (27.33). The maximum first days were recorded in ($T_1$) control (36.00). It is because $GA_3$ enhances the growth and development of plants, which speeds up flower development and early fruiting in tomatoes. It also checks the flower and fruit drop and ultimately increases the percentage of the fruit set. The application of plant growth regulators may have contributed to the faster enhancement of vegetative growth and the storage of sufficient reserved food materials to differentiate buds into flower buds.

Consequently, fruit growth and development ultimately resulted in early harvest. The above results conform with (Kumar *et al*. 2018) in tomatoes. Also, similar results were obtained by (Gurjar *et al*. 2018).

**Number of fruits/plant and fruits/cluster:**

The Data on the number of fruits/plant and fruits/cluster is presented in Table 2. Different plant growth regulators significantly affect the number of fruits/plant and fruits/cluster. The maximum number of fruits/plants was recorded in ($T_3$) $GA_3$ @75ppm (25.00), and the minimum number of fruits/plants was recorded in ($T_1$) control (14.00). Also, in the case of a number of fruits/clusters the maximum number of fruits/clusters were recorded in treatment ($T_3$) $GA_3$ @75ppm (4.66), and the minimum number of fruits/ clusters was recorded in ($T_1$) control (1.66). The maximum number of fruits/plants in a $GA_3$

might be due to rapid and better translocation of nutrients from root to apical parts of the Plant because $GA_3$ takes part in active photosynthesis, which ultimately helps towards an increase in number of fruits/plant. The application of $GA_3$ resulted in a significant increase in the number of fruits/plants. It was higher than the other growth regulators. The increased number of fruits/plants was due to $GA_3$ application is attributed to increased flowers and enhanced vegetative structure of plant, which was physiologically more active to produce a more significant number of fruits and also might be due to that $GA_3$ facilitated better reproductive development of the plant. It is supported by the similar findings of (Singh and Lal, 2001).

**Fruit weight (gm)**

The Data on the weight of fruit (gm) is presented in Table 3. The maximum fruit weight was recorded in treatment ($T_3$) $GA_3$ @ 75ppm (56.33gm), and the minimum fruit weight was recorded in treatment ($T_4$) $GA_3$@100ppm (55.00gm). It might be due to the increased supply of photosynthetic materials and their efficient mobilization in plants, resulting in a stimulation of fruit growth and high fruit weight and application increases membrane permeability that facilitate absorption and utilization of mineral nutrients) and transport of assimilates, which may result in a higher weight of fruits. It might be due to the increased supply of photosynthetic materials and their efficient mobilization in plants, resulting in a stimulation of fruit growth and high fruit weight and application increases membrane permeability that facilitates absorption and utilization of mineral nutrients) and transport of assimilates, which may result in a higher weight for fruits (Yadav and Pundir 2001, Naeem *et al*., 2006).

**Fruit length (cm):**

The Data on the fruit length (cm) is presented in Table 3. The maximum fruit length was recorded in treatment ($T_3$) $GA_3$75ppm (12.66 cm), and the minimum fruit length was recorded in treatment (T1) control (8.00cm). It may be due to a greater accumulation of carbohydrates owing to the more significant increase in fruit length. It may be due to the application of $GA_3$, which stimulates fruit growth and increases fruit length. This is because the application of $GA_3$ caused a significant increase in fruit length. Fruit length may increase due to the increased supply of photosynthetic materials and its efficient plant mobilization. It will increase fruit growth stimulation, increasing fruit length and diameter. These results conform with the study of (Choudhary *et al*. 2006).

**Yield/plant:**

The Data on the yield/plant (kg/plant) is presented in Table 4. Plant growth regulators significantly influence fruit yield (kg/plant). The maximum fruit yield (1.40 kg) was recorded in treatment ($T_3$) $GA_3$@75ppm. However, the minimum yield/plant was recorded in ($T_1$) control (0.80 kg). The increase in yield due to $GA_3$ application is attributed to the fact that the plant remained physiologically more active in building up sufficient food stocks for developing flower fruit, resulting in an increased fruit set and ultimately leading to higher yields.

**Yield/acre:**

The findings on fruit yield/acre (q) are presented in Table 4. Various doses of different plant growth regulators significantly affected fruit yield/acre (q). Maximum yield/acre (16.90q) was weighted with the application of ($T_3$) $GA_3$@75ppm while the minimum fruit yield/acre (7.22q) in ($T_1$) control. It was due to the increase in the number of flower clusters per plant and individual fruit weight in the combined PGR treatment. There was an increase in the yield per plant per plot and per hectare with an application of $GA_3$ at different concentrations as against the rest of the treatments, this might be due to the probable reason that $GA_3$ might be responsible for an increase in photosynthetic activities within the plant which might be resulted in more production of carbohydrates and related products accountable for increase in growth, fruit size, fruit weight of tomato, ultimately responsible for increased yield of tomato. These results are in agreement with the findings of (Chaudhary *et al*., 2006, Gitte *et al*., 2005, Zhang *et al*., 2009).

**TSS (Brix):**

The Data on the Total soluble solid TSS content is presented in Table 5. The result of the present investigation revealed that treatment ($T_3$) $GA_3$ @75ppm exhibited the highest TSS/Acidity content (3.96 $^0$Brix), and minimum TSS content was recorded in treatment ($T_1$) control (2.00 $^0$Brix). Total soluble solid content ($^0$Brix). There was no significant difference in TSS contents of tomato fruits due to applying various concentrations of $GA_3$. Similar results were found by (Chaudhary *et al*. 2006).

**Ascorbic acid (mg/100g):**

The Data on the Ascorbic acid is presented in Table 5. The result of the present investigation revealed that the maximum treatment was recorded in treatment ($T_3$) $GA_3$ @75ppm (17.23mg), and minimum Ascorbic acid content was recorded in treatment ($T_1$) control (11.10mg). The augment of ascorbic acid with $GA_3$ treatment might be either due to the encouragement of biosynthesis of ascorbic acid or protection of synthesized ascorbic acid from oxidation through the enzyme ascorbic acid oxidizes, and gibberellins may promote the activity of acid invertase which causing an increase in hexose level in plant tissue.

**Cost of cultivation:**

The Data on the Economics of Tomato (*Solanum lycopersicum* L.) cv. Heemshikhar, as presented in Table 6, revealed that gross net returns increased significantly under poly-house conditions. The results of the present investigation revealed that treatment ($T_3$) $GA_3$ @75ppm exhibited higher gross

return (338000 Rs/acre) and net return (210670 Rs/acre). These results agree with the findings of Jain and Tegar 2003.

## CONCLUSION

The present study concluded that foliar application of NAA @100ppm enhanced vegetative growth (plant height, branches/plant at 20, 40 & 60 DAT) and increased the number of primary & secondary branches. Whereas, in the case of flowering, yield and economic parameters $GA_3$ @75ppm sprayed at 20-, 40- & 60-days intervals causes early flowering, increased number of fruit/plants, fruits/cluster, fruit weight, fruit length, TSS, ascorbic acid, yield of Tomato first fruit set and first fruit picking cv. Heemshikhar also showed the highest cost-benefit ratio under poly-house conditions.

**Table 1.** Effect of plant growth regulators on Plant height and number of Branches/plant of Tomato cv. Himshikhar.

| Treatment No. | Plant height @20 DAT | Plant height @40 DAT | Plant height @60 DAT | No of branches /plant @20 DAT | No of branches /plant @40 DAT | No of branches /plant @60 DAT |
|---|---|---|---|---|---|---|
| $T_1$ | 25.16 | 44.61 | 103.53 | 5.00 | 9.00 | 14.33 |
| $T_2$ | 30.87 | 55.31 | 109.66 | 5.90 | 10.00 | 16.66 |
| $T_3$ | 35.92 | 60.06 | 112.00 | 6.86 | 11.33 | 18.00 |
| $T_4$ | 38.86 | 62.12 | 116.33 | 7.50 | 12.33 | 19.33 |
| $T_5$ | 27.12 | 50.24 | 105.66 | 5.20 | 9.33 | 15.00 |
| $T_6$ | 29.45 | 51.19 | 108.33 | 5.50 | 9.66 | 15.66 |
| $T_7$ | 34.37 | 58.86 | 111.33 | 6.26 | 11.00 | 17.00 |
| $T_8$ | 32.27 | 57.50 | 110.33 | 6.00 | 10.33 | 16.66 |
| $T_9$ | 37.94 | 60.33 | 113.00 | 7.00 | 12.00 | 18.33 |
| $T_{10}$ | 39.86 | 64.35 | 117.33 | 7.86 | 13.00 | 19.66 |
| C.D @5% | 0.96 | 3.37 | 3.21 | 0.83 | 1.23 | 1.32 |

**Table 2.** Effect of plant growth regulators on number of Flowers/plant, Cluster/plant, Days to first fruit set, Days to first fruit picking, Fruits/plant and Fruits/cluster of Tomato cv. Heemshikhar.

| Treatment No. | Treatments | Number of flowers/plant | Clusters/ Plant | Days to First Fruit set | Days to First Fruit Picking after flowering | Fruits /plant | Fruits/Cluster |
|---|---|---|---|---|---|---|---|
| $T_1$ | Control | 17.77 | 7.68 | 51.66 | 36.00 | 14.00 | 1.66 |
| $T_2$ | $GA_3$@50ppm | 21.14 | 9.67 | 49.00 | 33.00 | 18.00 | 3.03 |
| $T_3$ | $GA_3$@75ppm | 26.50 | 11.60 | 46.33 | 27.33 | 25.00 | 4.66 |
| $T_4$ | $GA_3$@100ppm | 25.44 | 11.03 | 46.66 | 28.66 | 24.00 | 4.00 |
| $T_5$ | IAA @50ppm | 20.56 | 8.15 | 50.66 | 35.00 | 15.00 | 2.00 |
| $T_6$ | IAA @75ppm | 18.23 | 8.73 | 50.00 | 34.66 | 16.00 | 2.33 |
| $T_7$ | IAA @100ppm | 22.29 | 10.05 | 49.00 | 32.00 | 19.00 | 3.00 |
| $T_8$ | NAA @50ppm | 19.25 | 9.16 | 49.33 | 33.66 | 17.00 | 2.66 |
| $T_9$ | NAA @75ppm | 23.19 | 10.47 | 48.00 | 31.00 | 20.00 | 3.33 |
| $T_{10}$ | NAA @100ppm | 24.13 | 10.72 | 47.66 | 30.00 | 21.00 | 3.66 |
| C.D @5% | | 2.71 | 0.74 | 1.40 | 1.70 | 1.53 | 0.71 |

**Table 3.** Effect of plant growth regulators on Fruit weight and fruit length of Tomato cv. Heemshikhar.

| S.No | Treatments | Fruit weight (gm) | Fruit length (cm) |
|---|---|---|---|
| $T_1$ | Control(distilled water} | 43.00 | 8.00 |
| $T_2$ | $GA_3$@50ppm | 48.00 | 10.00 |
| $T_3$ | $GA_3$@75ppm | 56.33 | 12.66 |
| $T_4$ | $GA_3$@100ppm | 55.00 | 11.33 |
| $T_5$ | IAA@50ppm | 44.66 | 8.66 |
| $T_6$ | IAA@75ppm | 45.00 | 9.33 |
| $T_7$ | IAA@100ppm | 49.00 | 10.33 |
| $T_8$ | NAA@50ppm | 47.00 | 9.66 |
| $T_9$ | NAA@75ppm | 51.00 | 10.66 |
| $T_{10}$ | NAA@100ppm | 52.00 | 11.00 |
| CD@5% | | 1.96 | 2.38 |

**Table 4.** Effect of plant growth regulators on yield/plant and yield/acre of Tomato cv. Heemshikhar.

| S.No | Treatments | Yield/Plant(Kg) | Yield/Acre(Tonnes) |
|---|---|---|---|
| $T_1$ | Control(distilled water} | 0.80 | 7.22 |
| $T_2$ | $GA_3$@50ppm | 0.86 | 10.38 |
| $T_3$ | $GA_3$@75ppm | 1.40 | 16.90 |
| $T_4$ | $GA_3$@100ppm | 1.32 | 15.84 |
| $T_5$ | IAA@50ppm | 0.60 | 8.04 |
| $T_6$ | IAA@75ppm | 0.67 | 8.63 |
| $T_7$ | IAA@100ppm | 0.93 | 11.18 |
| $T_8$ | NAA@50ppm | 0.70 | 9.58 |
| $T_9$ | NAA@75ppm | 1.01 | 12.22 |
| $T_{10}$ | NAA@100ppm | 1.09 | 13.09 |
| CD@5% | | 0.08 | 1.02 |

**Table 5.** Effect of plant growth regulators on TSS and Ascorbic acid of Tomato cv. Heemshikhar

| S.No | Treatments | TSS ($^0$Brix) | Ascorbic Acid (mg/100g) |
|---|---|---|---|
| $T_1$ | Control(distilled water} | 2.00 | 11.10 |
| $T_2$ | $GA_3$@50ppm | 2.80 | 14.00 |
| $T_3$ | $GA_3$@75ppm | 3.96 | 17.23 |
| $T_4$ | $GA_3$@100ppm | 3.83 | 16.67 |
| $T_5$ | IAA@50ppm | 2.33 | 12.00 |
| $T_6$ | IAA@75ppm | 2.43 | 13.00 |
| $T_7$ | IAA@100ppm | 3.30 | 14.83 |
| $T_8$ | NAA@50ppm | 2.50 | 13.26 |
| $T_9$ | NAA@75ppm | 3.37 | 15.93 |
| $T_{10}$ | NAA@100ppm | 3.66 | 16.00 |
| CD@5% | | 0.64 | 1.20 |

**Table 6.** Effect of plant growth regulators on the economics of Tomato cv. Heemshikhar

| Treatment No | Treatments | Cost of cultivation (Rs) | Gross return (Rs) | Net return (Rs) | BC Ratio |
|---|---|---|---|---|---|
| $T_1$ | Control | 100330 | 144480 | 44150 | 1.44 |
| $T_2$ | $GA_3$ @50ppm | 118330 | 160800 | 42470 | 1.35 |
| $T_3$ | $GA_3$ @75ppm | 127330 | 338000 | 210670 | 2.65 |
| $T_4$ | $GA_3$ @100ppm | 136330 | 316800 | 180470 | 2.32 |
| $T_5$ | NAA@50ppm | 109330 | 172800 | 63470 | 1.59 |
| $T_6$ | NAA@75ppm | 113830 | 207360 | 93530 | 1.82 |
| $T_7$ | NAA@100ppm | 118330 | 223440 | 105110 | 1.88 |
| $T_8$ | IAA@50ppm | 101830 | 191760 | 89930 | 1.88 |
| $T_9$ | IAA@75ppm | 102589 | 244800 | 142211 | 2.38 |
| $T_{10}$ | IAA@100ppm | 10330 | 262080 | 158750 | 2.35 |

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