# *Original Research Article*

## Effect ~~Influence~~ of p~~P~~lant growth regulators on growth and yield of tomato (*Lycopersicon esculentum* L.)


### Abstract

Thi~~se present~~ investigation was undertaken to study "~~"~~the effect ~~Influence~~ of p~~P~~lant growth regulators on growth and yield of tomato (*Lycopersicon esculentum* L.) during *Kharif* season of 2021 at the Crop Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P), India. The experiment was laid out in a r~~R~~andomized block design with 10 treatments and each replicated thrice. The treatments consisted of plant growth regulators $GA_3$ ~~@~~ at 10, 20, and 30 ppm, NAA ~~@~~ at 10, 20, and 30 ppm and 2,4-D ~~@~~at 2,3, and 4 ppm and a control plot. The results showed ~~revealed~~ that among all the treatments, foliar application of $GA_3$ (30 ppm) had ~~is significantly gave~~ positive impact on growth, yield and quality parameters i.e., plant height (81.68 cm), number of clusters per plant (36.66), days to 50% flowering (63.11 days), flowers per plant (72.22), fruits per plant (55.33), fruit yield per plant (3.90 kg), fruit yield per hectare (58.5 t), total soluble solids (4.2 °$Brix^0$), acidity (0.41%), gross returns (2,34,000 Rs/ha), net returns (1,87,792.5 Rs/ha) and b~~B~~enefit ~~–~~: Cost ratio (4.06) were obtained among all other treatments with foliar application of $GA_3$ ~~@~~ at 30 ppm, compared to other treatments.



***Keywords:*** *Economics, GA3, NAA, Tomato, Yield, 2,4-D.*


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**Comment [PM2]:** Name the treatments

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## 1. Introduction

Tomato (*Lycopersicon esculentum* L.) belongs to the genus Lycopersicon and ~~under~~ Solanaceae family (Reference needed). Tomato is an herbaceous sprawling plant with a weak woody stem. The flowers are yellow in colour and the fruits are red in colour due to lycopin pigment. Fruits of cultivated varieties vary in size like cherry tomatoes from 1-2 cm in diameter ~~size~~ and beefsteak tomatoes about 10 cm or more in diameter. Most varieties ~~cultivars~~ produce red fruits when ripe. Tomato is one of most important "protective foods" in India because of its nutritive value. It is one of the most ~~one of the~~ versatile vegetable with a ~~the~~ wide range of usage in Indian culinary tradition. Tomatoes are used for soups, salads, pickles, ketchup, puree, sauces and in many other ways it is also used as vegetable ~~salad vegetable~~. Tomato has ~~very~~ few competitors in the value addition chain of processing.

Tomato is the world's largest vegetable crop after potato and sweet potato, but it is number one in ~~tops the list of~~ canned vegetable (Reference needed). The total global area under tomato is 46.16l_akh/ha and the global production is ~~to the tune of~~ 1279.93 lakh tonnes (Reference needed). The major tomato producing countries are Brazil, China, Egypt, India, Iran, Italy, Mexico, Spain, T~~t~~urkey and USA (Reference needed) ~~and others~~. In Indian, the total cultivated area is 535_000 hectares with production of 9_362_000 tonnes and the productivity is 17.50 tonnes per hectare (Reference needed). It is cultivated as a cash crop as well as a vegetable crop on commercial scales in almost all parts of India. Andhra Pradesh is the leading state in India with an area of 76~~,~~_500 hectares cultivated tomato plants with a ~~,~~ production of 1~~,~~_453~~,~~_500 tonnes, ~~productivity~~ ~~–~~followed by ~~in~~ Bihar, Chhattisgarh, and Gujarat. states~~etc~~

Tomatoes are a commercially important crop throughout the world for both fresh fruits market and for processing food industries. ~~Believed to have its~~ it's the origin of tomato is believed to be from ~~in~~ tropical America (Thompson and Kelly, 1957). ~~it is one of the most popular vegetable around the world. It ranks third largest vegetable crop~~. ~~But it tops in the list of canned vegetable~~. ~~It is one of the most attractive crops~~. ~~It is cultivated as cash crop as well as a vegetable crop on commercial scales in almost all parts of India~~

Tomatoes are cultivated ~~The crop is grown from~~ at almost MSL to an altitude of 1500 m in tropical and subtropical region~~–~~, with an annual rainfall of 60-150 cm (Reference needed). Excessive ~~very high~~ rainfall during its growth period is harmful. In hot climates, ~~When growth under a hot weather,~~ tomatoes are ~~it is~~ cultivated as an irrigated crop. W~~The w~~inter

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crop is planted from Aaugust to September. OFor organic farming of tomatoes has been found to be ideal (Reference needed).

Well detained sandy loam soil with high content level of organic matter contents is most best suitable for tomato cultivation (Reference needed). Soils with high acidity are not suitable for tomato cultivation. 3 to 4 q of suitable lime can be applied in the field with in an interval of three years to reduce the level of acidity to tolerable limits. There is a need to go for sSoil testing is required at the beginning of the planting crop season.

Tomato is a "Poor man's orange". It is a good source of vitamins A, B and C (Reference needed)excellent source of vitamin C. According to Rai *et al.* (2002) tomato contains 94.5 % water, energy 23 calories, 1.0 g calcium, 7.0 g magnesium, 1000 iu vitamin, 22 mg ascorbic acid, 0.09 mg thiamin, 0.03 riboflavin and 0.8 mg niacin. It can be eaten as a fresh fruit and is one of the most popular salad vegetables. It is used for culinary purpose or is also used in preparation of soups, salads, pickles, ketchup's, sauces and many other products. Under normal conditions fruit setting in tomato does not have any serious problem. But when the crop isWhen tomatoes are planted in late in the spring and summer crop with a view to have harvest in spring and early summers, fruit production is often limited. High day-time temperatures during day time and comparatively cooler nights, can results in the to abscission of flowers (Singh and Choudhary, 1966). I, it is also affected by heavy rainfall and high humidity (Singh and Choudhary, 1966).

Tomatoes are usually staked, tied, or caged to keep the stems and fruits off the ground, and consistent watering is necessary to avoid blossom-end rot and cracking of the fruits. The plants are susceptible to a number of pests and diseases, including bacterial wilt, early blight, mosaic virus, Fusarium wilt, nematodes infestation, and tomato hornworms (reference needed). Many of these problems can be controlled with crop rotation, the use of fungicides and pesticides, and the planting of resistant tomato varieties. The tiny currant tomato (*S. pimpinellifolium*) is a closely related species and has been used by breeders to hybridize several pests- and disease resistant tomato varieties.

Plant growth regulators are synthetic substances; they stimulate and control the physiological processes in the plant (Reference needed). The most commonly used growth regulators are, $GA_3$, NAA, 2, 4-D. These growth regulators They are can be applied in small quantities concentration, which is profitable for farmer. However, Tthe improvement of yield and quality of crop can vary greatly depending on the type of growth regulators applied, its concentrations and the method and time of application. Their actions are quite different; however they have effect on growth, yield and quality of vegetable crops. Plant growth

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**Comment [PM10]:** What is "suitable lime"?

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**Comment [PM12]:** Is this per mg/g of fresh or dry weight tomato? Please clarify

**Comment [PM13]:** Already mentioned. Delete

**Comment [PM14]:** Already mentioned. Delete

**Comment [PM15]:** What is "under normal conditions"?

**Comment [PM16]:** What does "any serious problem"?

**Comment [PM17]:** This sentence does not make sense.

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regulators ~~They~~ have variable effects on the physiological processes of plants ~~e.g.~~e.g., a~~A~~uxins increases cell division in cambium tissue but inhibit lateral growth (Reference needed). Gibberellins also promote cell division and cell elongation in the shoot region~~s~~ (Pandey and Sinha, 1995).

Gibberellic acid (GA3) is a naturally occurring hormone or growth-regulating chemical that is found to varying degrees in all parts of plants (Reference needed). GA3 stimulates both cell division and elongation and has been used to manipulate flowering and fruit development in selected horticultural crops (Reference needed)~~for many years.~~

NAA is a synthetic plant hormone in the auxin family and is an ingredient in many commercial plant~~—~~rooting horticultural products; it is a rooting agent and used for the vegetative propagation of plants from stem and leaf cuttings (Reference needed). It is also used for plant tissue culture.

2,4-D is a widely used herbicide that affects plant cell growth and division. It affects primarily broad-leaf plants. ~~When the treatment occurs, the~~ During treatment, 2,4-D is absorbed by the ~~into the~~ plant and moved to the roots, stems, and leaves.

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**Comment [PM20]:** In what way does it "affect" broad leaf plants?

## 2. Materials and Methods

A field experiment entitled "Effect ~~Influence~~ of GA3, NAA and 2,4-D on plant growth and yield of tomato" was ~~is going out to be~~ carried out on the Experimental Field, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, India during the *Kharif* season of 2021. The climate of the region is semi-arid subtropical.

### 2.1 Experimental design and treatment combinations

The experiment was laid out in Randomized Block Design. The treatment consisted~~s~~ of three levels of GA3 (10 ppm, 20 ppm, 30 ppm), three levels of NAA (10 ppm, 20 ppm, 30 ppm) and 2,4-D (2 ppm, 3 ppm, 4 ppm) which were ~~was~~ applied in the form of foliar application and a control plot. The treatments are $T_0$ control, $T_1$ GA3 10 ppm, $T_2$ GA3 20 ppm, $T_3$ GA3 30 ppm, $T_4$ NAA 10 ppm, $T_5$ NAA 20 ppm, $T_6$ NAA 30 ppm, $T_7$ 2,4-D 2 ppm, $T_8$ 2,4-D 3 ppm, and $T_9$ 2,4-D 4 ppm. Benefits: ~~GA3 stimulates both cell division and elongation and has been used to manipulate flowering and fruit development in selected horticultural crops for many years. NAA is a rooting agent and used for the vegetative propagation of plants from stem and leaf cuttings. It is also used for plant tissue culture. 2,4-D is a herbicide that affects plant cell growth and division.~~ The ~~These~~ 9 nine treatments were replicated thrice.

### 2.2 Crop management

Tomato variety (TMTH288) was transplanted at the rate of 500 g~~m~~/ha. This is a new hybrid variety developed by Trimurti Plant Sciences P Limited Hyderabad, Telangana, India. This t~~T~~omato hybrid is suitable for cultivation during *Kharif* and *Rabi* seasons and has a ~~gives~~ high yield potential. Harvesting starts from 75-80 days after transplanting. It is a semi-determinate plant type. The average weight of fruit varies from 90-100 g~~m~~ and are firm. The recommended dose of fertilizer is 200:250:250 NPK kg/ha. The nutrient sources were Urea, SSP and MoP to fulfill the requirement of nitrogen, phosphorous and potassium. The tomato plants were irrigated 6-7 times. ~~irrigations were given to the crop~~. 3-4 W~~w~~eeding~~s~~ was done 3-4 times manually with hand hoe (khurpi).

## 3. Results and discussion

The ~~present~~ field experiment ~~entitled "Influence of Plant growth regulators on growth and yield of tomato (*Lycopersicon esculentum* L.)"~~ was aimed at identifying various levels of plant growth regulators. Nine ~~Ten~~ treatment combinations and a ~~including~~ control plot

~~were~~was evaluated during *Kharif* season of 2021 in the experimental field of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, India. ~~The results of the experiment are as following.~~

### 3.1 Effect ~~Influence~~ of plant growth regulators on growth attributes of tomato~~:~~

Observations regarding the growth attributes of tomato are given in the Table 1. The maximum survival ~~percentage~~ of ~~(~~96.67 %~~)~~ ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm)~~, plant height of ~~(~~81.68 cm~~)~~ ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm)~~, number of clusters per plant of ~~(~~36.66~~)~~ ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm)~~, d~~D~~Days to 50% flowering of ~~(~~63.85~~)~~ ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm),~~ and number of flowers per plant of ~~(~~72.22) was recorded in the treatment 3 with foliar application of ~~(~~GA3 30 ppm~~)~~.

### 3.2 Effect ~~Influence~~ of plant growth regulators on yield attributes of tomato~~:~~

Observations regarding yield attributes of tomato are given in the Table 2. The Maximum number of fruits per plant of ~~(~~55.33~~),~~ ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm)~~, fruit yield per plant of ~~(~~3.90 kg~~),~~ ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm)~~, fruit yield per plot of ~~(~~23.40 kg~~)~~ ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm)~~, fruit yield per hectare of ~~(~~58.5 t of ~~)~~ was recorded in the treatment 3 with foliar application of (GA3 30 ppm), ~~,~~ Total s~~S~~oluble s~~S~~olids of ~~(~~4.2~~)~~ $^{\circ 0}$Brix, ~~was recorded in the treatment 3 with foliar application of (GA3 30 ppm)~~, and a~~A~~cidity of ~~(~~0.41% ~~)~~ was recorded in the treatment 3 with foliar application of ~~(~~GA3 30 ppm~~)~~.

### 3.3 Effect ~~Influence~~ of plant growth regulators on economics of tomato~~:~~

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With the application of various plant growth regulators with different levels of gross returns, net returns and B:C ratio ~~was~~ increased with increasing level of GA3, NAA and 2,4-D. T~~t~~he maximum gross returns (2~~,~~ 34~~,~~ 000 Rs), net returns (1~~,~~ 87~~,~~ 792.5 Rs) and B:C ratio (4) was recorded in the treatment T3 of ~~(~~GA3 30 ppm?) and lowest was observed in the control plot with gross returns of ~~(~~1~~,~~ 62 ~~,~~000 Rs~~)~~, net returns of ~~(~~1~~,~~ 15~~,~~ 950 Rs~~)~~, and B:C ratio (4).

## 4. Conclusion:

Considering the result, ~~of the present experiment~~ it is ~~may be~~ concluded that treatment 3 with GA3 30 ppm/ha recorded the highest fruit yield (58.5 t/ha) and was found to be the best

treatment for improved better plant growth, yield of tomato and with benefit cost ratio of (4). TBherefore based on the above results, treatment 3 can be recommended for cultivation of tomatoes in province/state?, India.

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Table 1. Performance of growth attributes in tomato by growth regulators.

| Treatments | Survival percentage (%) | Plant height (cm) | No. of clusters/plant | Days to 50% flowering | No. of flowers/plant |
|---|---|---|---|---|---|
| Control | 91.33 | 65.76 | 23.66 | 78.22 | 50.22 |
| GA3 10 ppm | 93.67 | 77.06 | 33.44 | 67.33 | 64.67 |
| GA3 20 ppm | 94.67 | 80.36 | 35.44 | 64.00 | 70.11 |
| GA3 30 ppm | 96.67 | 81.68 | 36.66 | 63.85 | 72.22 |
| NAA 10 ppm | 93.33 | 72.68 | 29.55 | 73.11 | 59.44 |
| NAA 20 ppm | 94.33 | 73.58 | 31.11 | 71.44 | 60.77 |
| NAA 30 ppm | 94.67 | 74.92 | 32.00 | 69.33 | 63.44 |
| 2,4-D 2 ppm | 94.33 | 71.92 | 27.77 | 77.00 | 57.11 |
| 2,4-D 3 ppm | 92.67 | 70.42 | 25.89 | 76.44 | 55.44 |
| 2,4-D 4 ppm | 91.67 | 68.53 | 25.33 | 75.44 | 52.78 |

Table 2. Performance of yield attributes in tomato by growth regulators.

| Treatments | No. of fruits/plant | Fruit yield/plant (kg) | Fruit yield/plot (kg) | Fruit yield/hectare (t/ha) |
|---|---|---|---|---|
| Control | 35.33 | 2.70 | 16.20 | 40.5 |
| GA3 10 ppm | 50.77 | 3.50 | 21 | 52.5 |
| GA3 20 ppm | 54.22 | 3.79 | 22.40 | 56 |
| GA3 30 ppm | 55.33 | 3.90 | 23.40 | 58.5 |
| NAA 10 ppm | 43.55 | 3.17 | 19 | 47.5 |
| NAA 20 ppm | 45.00 | 3.40 | 20.40 | 51 |
| NAA 30 ppm | 48.44 | 3.53 | 21.20 | 53 |
| 2,4-D 2 ppm | 42.33 | 3.23 | 19.40 | 48.5 |
| 2,4-D 3 ppm | 40.77 | 3.10 | 18.60 | 46.5 |
| 2,4-D 4 ppm | 39.33 | 2.83 | 17 | 42.5 |

Table 3. Performance of quality parameters in tomato by plant growth regulators.

| Treatments | TSS ($^{0}$Brix) | Acidity (%) |
|---|---|---|
| Control | 3.27 | 0.31 |
| GA3 10 ppm | 3.9 | 0.38 |
| GA3 20 ppm | 4.1 | 0.39 |
| GA3 30 ppm | 4.2 | 0.41 |
| NAA 10 ppm | 3.6 | 0.37 |
| NAA 20 ppm | 3.9 | 0.38 |
| NAA 30 ppm | 4 | 0.4 |
| 2,4-D 2 ppm | 3.5 | 0.35 |
| 2,4-D 3 ppm | 3.4 | 0.34 |
| 2,4-D 4 ppm | 3.3 | 0.32 |

**Comment [PM22]:** Table 3 is not mentioned/discussed anywhere in the text.