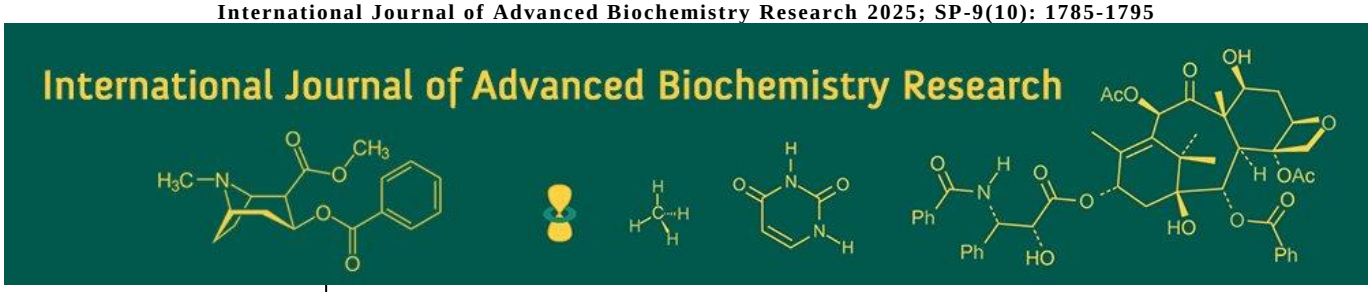

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Effect of plant growth regulators on growth and yield of tomato crop (*solanum lycopersicum* L.) cv. best of all

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Abstract
The present investigation entitled "Effect of Plant Growth Regulators on Growth and Yield of Tomato Crop (*Solanum lycopersicum* L.) cv. Best of All" was carried out during March, 2018 at the Vegetable Demonstration and Research Block, Department of Vegetable Science, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar. The experiment was laid out in Randomized Complete Block Design with three replications consisted of ten treatments had different concentrations of Gibberellic acid, Naphthalene Acetic Acid and Ethrel. All plant growth regulators were sprayed at 50, 100 and 150 ppm concentrations, one month after transplanting and then repeated twice at 10 days interval. The plant growth regulators were applied on 4 true leaf stage. The data obtained for different characters were statistically analysed to find out the significance of the plant growth regulators. The application of plant growth regulators had shown significant results on all characters *viz.*, vegetative as well as yield attributes of the crop. The results revealed that the exogenous application of (T_4) Gibberellic Acid @ 150 ppm recorded maximum height of the plant (133.200 cm), number of branches per plant (9.333), number of flower per plant (9.773), fruit set per cent (74.307), number of fruits per plant (50.667), Average fruit weight per plant (35.733 g), yield per plant (1.583 kg), yield per plot (19.007 kg), total soluble solids (5.733 °Brix), shelf life (9.667) and vitamin C (19.067mg/100g). Whereas, minimum days to first flowering (36.133), days to first fruit set (47.333) and days to maturity (70.333) were also found in (T_4) Gibberellic Acid @ 150 ppm. On the other hand, application of (T_7) Naphthalene Acetic Acid @ 150 ppm found maximum Cost Benefit ratio (1:3.28) followed by (T_{10}) $_{Ethrel}$ @ 150 ppm (1:3.14) and (T_4) Gibberellic Acid @ 150 ppm (1:3.07). Therefore, on the basis of results obtained in present studies, it is suggested that the spray of Naphthalene Acetic Acid @ 150 ppm is found more favourable for the farmers because it has low cost of cultivation as compare to the other plant growth regulators.

Keywords: PGRS, ga_3, NAA, ethrel, FYM, TSS, ascorbic acid

Introduction
Tomato (*Solanum lycopersicum* L.) (2n = 2x = 24) is one of the most important crop which belongs to the family Solanaceae and the genus *Solanum.* Peru-Ecuador region is the origin of cultivated tomato which is in wild form (Rick and Holle, 1990) [64]. On the basis of its morphological and molecular studies, the tomato was renamed as *Solanum lycopersicum* from *Lycopersicon esculentum* (Peralta and Spooner, 2000) [55].
Native region of tomato is South America. In different parts of the world, it is widely grown, particularly in USA, China, Turkey, Italy, Egypt, Spain and Brazil. It is also grown in India and the leading tomato growing states are Karnataka, Assam, Himachal Pradesh, Uttar Pradesh and Uttarakhand. Tomato was introduced into India by Portuguese. The production of vegetables has increased from 58.5 million tonnes to 175 million tonnes since 1991-92 to 2016-17. During 2016-17, the area under vegetables is estimated at 10.3 million hectares with a production of 175 million tonnes in India and the area under tomato cultivation in Uttarakhand is 8.57 thousand hectares with an annual production of 93.25 thousand metric tonnes (Anonymous, 2017) [6].
In many countries, tomato is also known as "Poor Man's Orange, Wolf Apple and Valayti Baingan" (Dhall and Singh, 2013) [22]. It is a day neutral plant of warm season but it can be grown in a variety of climatic conditions. It is susceptible to frost as well as high temperature as it adversely affects the growth and development. It can also be grown in the hills of India

as an off-season vegetable crop. It is mainly a self-pollinated crop, but cross-pollination also takes place at a certain percentage.

Throughout the country, the fresh tomatoes are in great demand around the year. For small and marginal farmers, it contributes to the nutrition of the consumer and fetches very good income after sending their produce (Singh *et al*., 2010) [72].

Day by day, the tomato crop is becoming popular among hill farmers due to its short duration, high market value and constant demand throughout the year on account of its popularity. It is widely grown all over the world next to potato and sweet potato (Choudhury, 1979) [17].

Tomato consists of annual to perennial herbaceous, prostrate, sexually propagated and thick solid stems coarsely hairy with a strong characteristic odour. It has strong taproot with dense fibrous and adventitious roots. Varieties of the tomato are grouped as determinate, indeterminate and semi-indeterminate based on their growth habit. Determinate types of tomato are dwarf having inflorescence in almost every internode, terminal bud ends in a floral bud called self-topping and elongation ceases. While in Indeterminate plants, growth is continued, inflorescence cluster occurs at every third internode and has terminal bud ends in leafy bud but there is less initiation of flowers and fruits on the stem. Semi-determinate type is between determinate and indeterminate.

Tomato flowers are borne in a small forked raceme cyme. They are pendent, perfect and hypogynous. In each compound inflorescence, there are four to eight flowers. The stigma leading to self-pollination due to the presence of light protective anther core. In tomato, pollen fertility is maximum on the day of anthesis which occurs at 7.00-8.00 and stigma is fully receptive at 16 hours before anthesis to the day of anthesis (Sidhu *et al*., 1980) [71].

Ancestor of tomato is *Lycopersicon esculentum* var. *cerasiforme*. *Lycopersicon chilense* and *Lycopersicon peruvianum* is the wild tomatoes have a large genetic diversity, especially within the self-incompatible species (Rick, 1988) [65]. Poor adaptability to sub-optimal low-temperature condition at high altitudes and lack of promising high yielding cultivars are major constraints of tomato cultivation in Uttarakhand state.

Tomato is universally treated as "Protective Food". It reduces the risk of several types of cancers and heart attacks due to the presence of lycopene because lycopene has important dietetic properties (Dorgan *et al.*, 1998; Clinton, 2005) [23, 19]. Tomato has plenty of good compounds like the pulp and juice are assimilabile, act as a blood purifier, mild aperients and it has antiseptic properties against intestinal infections. It is also reported that it has anti-cancer properties which give protection from or reduces the risk of contracting chronic degenerative diseases (Gupta and Gupta, 2004) [30].

Tomato is an outstanding source of vitamins such as vitamin C (31.0 mg), vitamin A (321 IU), protein (1.98 g), moisture (93.1g), fibre (0.7g), sulphur (24 mg), chlorine (38 mg) and calcium (20 mg) and organic acids on per 100 g fresh weight basis. It also act as an antioxidant as it is rich in carotenoids, particularly lycopene, ascorbic acid, vitamin E and phenol compounds, like flavonoids (Rai *et al.*, 2012) [60].

The red colour of tomato is due to the presence of lycopene pigment. Carotene and pro-lycopene gives yellow and orange colour, respectively.

The ripe fruits are taken as raw and large quantities of tomatoes are used to prepare salads, soups, juice, preserve, pickles, ketchup, puree, paste and many other products (Chadha, 2001) [13]. Plant growth regulators (PGRs) are used extensively in horticulture crops to raise plant growth and increase yield by increasing fruit number, fruit set and size. Plant growth regulators are the organic compounds other than nutrient which is required in small quantity to promote or modify the physiological processes of the plant. It improves the yield and quality to a great extent by genetic manipulations (Philosoph-Hadas *et al.*, 2005; Kucera *et al.*, 2005) [56, 42].

Gibberellic acid (GA), is a tetracyclic di-terpenoid compound which stimulates plant growth and development. Gibberellic acid stimulate seed germination, trigger transitions from meristem to shoot growth, juvenile to adult leaf stage, vegetative to flowering, determines sex expression and grain development along with an interaction of different environmental factors *viz.*, light, temperature and water. The major site of bioactive Gibberellic acid is stamens that influence male flower production and pedicel growth. The appropriate elucidation of Gibberellic acid transport mechanism is essential for the survival of plant species and successful crop production (Gupta and Chakrabarty, 2013) [31].

Naphthalene Acetic Acid is commonly used in horticultural crops because it is a synthetic plant hormone. It accelerates the maturity, produces better quality fruits, affects the physiological process and some other aspects such as to increase the number of branches, increased fresh weight, and yield (Revanappa, 1998) [63]. It boost up the plant growth by enhancing the cell division, cell elongation and cell differentiation which may beginning the development of plant organs. It is in the auxin family so that it prevents premature dropping and thinning of fruits from stems and is applied after blossom fertilization. It is essentially required for the formation of root cambium. Naphthalene Acetic Acid also enhanced the flowering, heavy fruit setting and check abortion of young embryo and fruit drop.

Ethrel, a plant growth regulator is versatile which enhance colouration and trigger uniform ripening of fruits, raise abscission and senescence of leaf. It can be arranged in specific uses like defoliation and help in breaking alternate bearing. It penetrates into the plant tissues, translocated and progressively decomposed to ethylene, which positively affects the growth process because of its systemic properties.

The experiment "Effect of Plant Growth Regulators on Growth and Yield of Tomato Crop (*Solanum lycopersicum* L.) cv. Best of All" has been planned to be conducted Vegetable Demonstration and Research Block, Department of Vegetable Science, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar with the following objectives

- To study the effect of different concentrations of plant growth regulators on growth and yield of tomato under mid-hill conditions.
- To work out the economics of different treatments in tomat.

Materials and Methods

The investigation on titled "Effect of Plant Growth Regulators on Growth and Yield of Tomato Crop (*Solanum lycopersicum* L.) cv. Best of All", was carried out at

Vegetable Demonstration and Research Block, Department of Vegetable Science, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand 246 123 during 2018. Pauri Garhwal is one of the thirteen districts of Uttarakhand and is located between 29° 20'- 29° 75' N latitude and 78° 10'-78° 80' E longitude. Bharsar is situated at about 57 km from the district headquarter of Pauri Garhwal, situated at an altitude of 1900 meters above mean sea level. The climate of the Bharsar has mild summer, higher precipitation and colder or severe prolonged cold winter. The experimental site has clay loam soil with pH of 6.5. Cultivar 'Best of All' of Tomato was chosen for the study. This is introduced from Indian Agriculture Research Institute, New Delhi. Seeds of tomato cv. Best of All (IC-7466) indeterminate in habit. The seeds were sown in polyhouse on 24th March, 2018. Ten treatments of different concentrations of Naphthalene Acetic Acid (NAA), Gibberellic acid (GA3) and Ethrel were applied as foliar application at 30, 45 and 60 days after transplanting.

Table 1: The details of the experiment conducted during 2018 was as under

Name of crop	**Tomato (*Solanum lycopersicum* L.)**
Cultivar	Best of All
Experimental Design	Randomized complete block design (RCBD)
Number of replications	03
Number of treatments	10
Plot size	3.24 m^2 (1.8 x 1.8)
Spacing	60 cm x 45 cm
Number of plants per plot	12

Table 2: Detail of treatments

T_1	**Control**	**Untreated**
T_2	Naphthalene Acetic Acid	50 ppm
T_3	Naphthalene Acetic Acid	100 ppm
T_4	Naphthalene Acetic Acid	150 ppm
T_5	Gibberellic Acid	50 ppm
T_6	Gibberellic Acid	100 ppm
T_7	Gibberellic Acid	150 ppm
T_8	Ethrel	50 ppm
T_9	Ethrel	100 ppm
T_{10}	Ethrel	150 ppm

Nursery bed of 1 m x 1 m x 0.15 m prepared on well-ploughed and levelled field with 30 cm distance between two beds. The seeds had sown in lines 10 cm apart. Gibberellic acid, Naphthalene Acetic Acid and Ethrel @ 50, 100 and 150 ppm was weighed separetly in digital electric balance. After dissolving them in 95% ethyl alcohol, the solution was replaced in 1000 c.c. volumetric flask then distilled water added to it to make up the volume 1000 c.c. of solution and then used for foliar spray. Application of Gibberellic acid, Naphthalene Acetic Acid and Ethrel at 15 days interval was done at 25, 40, and 55 days after transplanting.

Nearly 30- 35 days old healthy seedlings of tomato were transplanted in the experimental field on 2nd May, 2018 at the spacing of 60 cm between rows and 40 cm between plants within a row. A plot size of 1.80 m x 1.80 m was taken for each treatment. The seedbed was watered before uprooting the seedlings from the nursery seedbed so as to minimize damage of the roots and after transplanting in the main field. The healthy seedlings were planted in a Randomized Complete Block Design with three replications (Table 3). Five competitive plants were randomly selected from each plot and tagged for observations. The observations on the following characters were studied in the successive stages of crop growth to make a critical analysis of the performance of the crop as affected by different treatments. Growth Parameters was Height of plant (cm), Number of branches, Days to first flowering, Number of flowers per cluster, Days to first fruit set, Fruit set per cent, Days to maturity; Yield parameter was Number of fruits per plant, Average fruit weight per plant (g), Yield per plant (kg), Yield per plot (kg) ;Quality parameter was Total soluble solids (°Brix), Shelf life, Vitamin C (mg/100g); Economics of the treatments was Cost of cultivation, Cost benefit ratio.

Statistical Analysis

The statistical analysis was carried out for each observed character under the study using MS-Excel, OPSTAT and SPAR 2.0 packages. The mean values of data were subjected to analysis of variance for Randomized Block Design (RBD) given in the standard book "Statistical Procedures for Agricultural Research" 2nd ed. by Kwanchai A. Gomez and Arturo A. Gomez (1984) [28]. For estimation of different statistical parameters, following procedure and formulae were adopted:

Analysis of Variance

Table 3: The table for analysis of variance (ANOVA) will set as explained by Kwanchai A. Gomez and Arturo A. Gomez (1984) [28].

Source of variance	**Degree of freedom**	**Sum of squares**	**Mean sum of squares**	**Variance ratio (V.R.)**
Replication (r)	(r-1)	Sr	Sr /(r-1) = Mr	Mr/Me
Treatment (t)	(t-1)	St	St /(t-1) =Mt	Mt/ Me
Error (e)	(r-1) (t-1)	Se	Se/(r-1) (t-1) = Me	Error (e)

Where,
r =Number of replications
t = Number of treatments
Sr = Sum of squares due to replications
St = Sum of squares due to treatments
Se = Sum of squares due to error
Mr = Mean sum of squares due to replications
Mt = Mean sum of squares due to treatments
Me = Mean sum of squares due to error

The calculated F-value was compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one entry over the others.
The standard error and critical differences were calculated as follows:

$\pm$S.E. (m) = $\sqrt{Me/r}$

$\pm$S.E. (d) = $\sqrt{2Me/r}$

C.D. $_{(0.05)}$ = S.E.(d) × t $_{(0.05)}$ error df

Where,
S.E. (m) = Standard error of mean
S.E. (d) = Standard error of difference
C.D. $_{(0.05)}$ = Critical difference at 5 per cent level of significance

Overview of tomato nursery **Overview of experimental field of tomato**

Plate 1: View of experimental site

Result and Discussions

The experimental findings of the present investigation entitled "Effect of Plant Growth Regulators on Growth and Yield of Tomato Crop (*Solanum lycopersicum* L.) cv. Best of All" were carried out and described in this chapter. Data related to the various growth and yield parameters of tomato were subjected to statistical analysis for interpretation of result and the analysis of variance for these data has been presented in the appendices (II) at the end. The data recorded for important characters have also been presented graphically for explanation for the important trends, wherever, necessary.

Growth Parameters

Vegetative phase is a crucial feature for plant height. It indirectly influences the yield components. In the study, the height of the selected plants was recorded at final harvest after transplanting. All the treatments were found significant as compared with control. At final harvest, the significantly tallest plant (133.200 cm) was obtained in T_4 (Gibberellic Acid @ 150 ppm) treatment followed by (132.067 cm) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (129.133 cm) in T_{10} (Ethrel @ 150 ppm) treatment. While, the shortest plant height (112.400 cm) was recorded in T_1 (Control). Significant variation was recorded in tomato for different plant growth regulators in terms of number of branches per plant at final harvest. It was revealed from the data that the maximum number of branches (9.333) was obtained in treatment T_4 (Gibberellic Acid @ 150 ppm), which was found statistically at par with treatment T_7 (Naphthalene Acetic Acid @ 150 ppm) *i.e.,* (9.200). While, the minimum number of branches was observed (4.667) in T_1 (Control). Plant growth regulators showed statistically significant variation on days to first flowering from the date of transplanting of tomato**.** The data indicated that the minimum days (36.133) required to first flowering were found in treatment T_4 (Gibberellic Acid @ 150 ppm) followed by (37.133) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (37.667) in T_3 (Gibberellic Acid @ 100 ppm), respectively. While, the maximum days (45.400) required to first flowering were observed in treatment T_1 (Control). Remarkable variation in number of flowers per cluster in tomato due to application of different plant growth regulators. The maximum number of flowers per cluster (9.773) was recorded in treatment T_4 (Gibberellic Acid @ 150 ppm) which was found statistically at par with T_7 (Naphthalene Acetic Acid @ 150) *i.e.,* (9.400).
While, the minimum number of flowers per cluster (5.480) was recorded from treatment T_1 (Control). The result revealed that gibberellic acid increased the number of flowers per cluster. Plant growth regulators showed statistically significant variation on days to first fruit set from the date of transplanting of tomato. The data indicated that the minimum days (47.333) required to first fruit set in treatment T_4 (Gibberellic Acid @ 150 ppm) followed by (48.133) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (48.467) in T_3 (Gibberellic Acid @ 100 ppm), respectively. While, maximum days (55.867) required to first fruit set in treatment T_1 (Control). The maximum fruit set percent (74.307) was recorded in the treatment T_4 (Gibberellic Acid @ 150 ppm) followed by (69.447) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (68.057) in T_3 (Gibberellic Acid @ 100 ppm), respectively. While, minimum fruit set per cent (50.693) was recorded in the treatment T_1 (Control). The data indicated that the minimum days (70.333) required to maturity were found in treatment T_4 (Gibberellic Acid @ 150 ppm) followed by (72.333) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (72.693) in T_3 (Gibberellic Acid @ 100 ppm), respectively. While, the maximum days (79.947) required to maturity was recorded in treatment T_1 (Control). All the treatments were found significant as compared with control.

Table 4: Effect of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flower per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Treatment code	Height of the plant	Number of branches per plant	Number of flower per cluster	Fruit set per cent
T_1	112.4	4.667	5.48	50.693
T_2	123.267	8.133	8.793	63.887
T_3	126.133	8.733	9.187	66.667
T_4	133.2	9.333	9.773	74.307
T_5	120.733	7.467	8.353	60.417
T_6	124.4	8.467	8.893	63.193
T_7	132.067	9.2	9.4	69.447
T_8	113.4	7.4	8.04	59.72
T_9	122.533	8.067	8.347	61.113
T_{10}	129.133	8.667	8.94	68.057
S.E. (d)	0.36	0.146	0.522	1.659
C.D. (0.05)	0.762	0.31	1.104	3.513

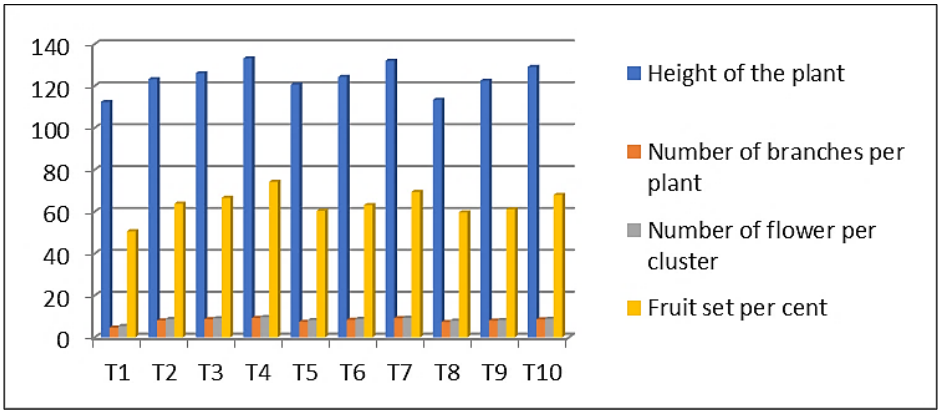

Fig 1: Graphical representation of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flower per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Table 5: Effect of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flower per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Treatment code	Days to first flowering	Days to first fruit set	Days to maturity
T_1	45.4	55.867	79.947
T_2	39.133	49.2	73.44
T_3	37.667	48.467	72.693
T_4	36.133	47.333	70.333
T_5	39.133	49.467	74.14
T_6	38.133	48.867	73.213
T_7	37.133	48.133	72.333
T_8	40	49.933	75.067
T_9	39.4	49.4	74.347
T_{10}	38.733	48.867	73.2
S.E. (d)	0.251	0.236	0.119
C.D. (0.05)	0.531	0.5	0.252

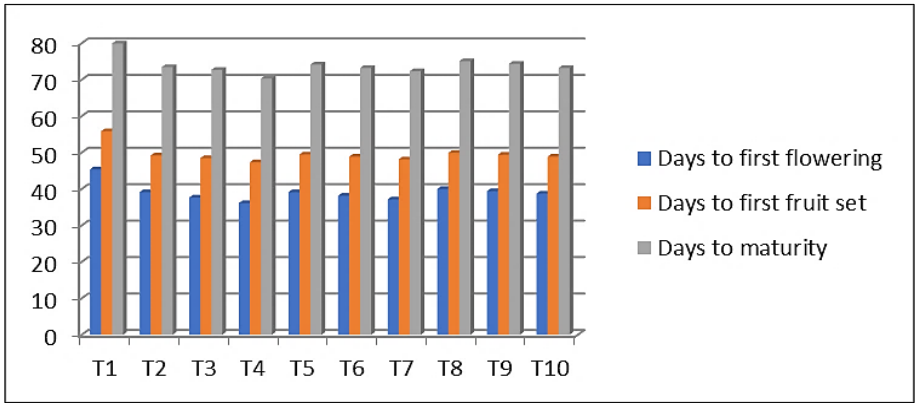

Fig 2: Graphical representation of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flowers per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Yield Parameters

The data for various treatments with respect to the number of fruits per plant. All the treatments were found significant as compared with control. The significantly maximum number fruits per plant (50.667) was recorded in the treatment T_4 (Gibberellic Acid @150 ppm) followed by (48.333) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (47.333) in T_{10} (Ethrel @ 150 ppm), respectively. While, the minimum number fruit per plant (22.000) was recorded in the treatment T_1 (Control). Average weight of individual fruit (g) was recorded and ranged between 25.400 -35.733 g. All the treatments were found significant as compared with control. The maximum average fruit weight per plant (35.733) was recorded in the treatment T_4 (Gibberellic Acid @ 150 ppm) followed by (34.733) treatment T_7 (Naphthalene Acetic Acid @ 150 ppm) and (34.467) in T_{10} (Ethrel @ 150 ppm), respectively. While, minimum average fruit weight per plant (25.400) was recorded in the treatment T_1 (Control). Yield per plant (kg) was recorded and ranged between 0.547 - 1.583 kg. All the treatments were found significant as compared with control. The maximum yield per plant (1.583) was recorded in the treatment T_4 (Gibberellic Acid @ 150 ppm) which was found statistically at par with (1.470) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (1.437) in T_{10} (Ethrel @ 150 ppm), respectively. While, minimum yield per plant (0.547) was recorded in the treatment T_1 (Control). Yield per plot (kg) was recorded and ranged between 6.603 - 19.007 kg. All the treatments were found significant as compared with control. The maximum yield per plot (19.007) was recorded in the treatment T_4 (Gibberellic Acid @ 150 ppm) followed by the treatment T_7 (Naphthalene Acetic Acid @ 150 ppm) and T_{10} (Ethrel @ 150 ppm) valued (17.643) and (17.240), respectively. Minimum yield per plot (6.603) was recorded in the treatment T_1 (Control).

Table 6: Effect of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flowers per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Treatment code	Number of fruits per plant	Average fruit weight per plant (g)	Yield per plant (kg))	Yield per plot (kg)
T_1	22	25.4	0.547	6.603
T_2	46	29.267	0.977	11.73
T_3	46.667	31.133	1.18	14.187
T_4	50.667	35.733	1.583	19.007
T_5	44.667	28.333	0.857	10.293
T_6	45.667	32.4	1.2	14.393
T_7	48.333	34.733	1.47	17.643
T_8	43	28.133	0.81	9.677
T_9	43.667	30.667	1.113	13.363
T_{10}	47.333	34.467	1.437	17.24
S.E. (d)	1.076	0.676	0.081	0.969
C.D. (0.05)	2.278	1.43	0.172	2.051

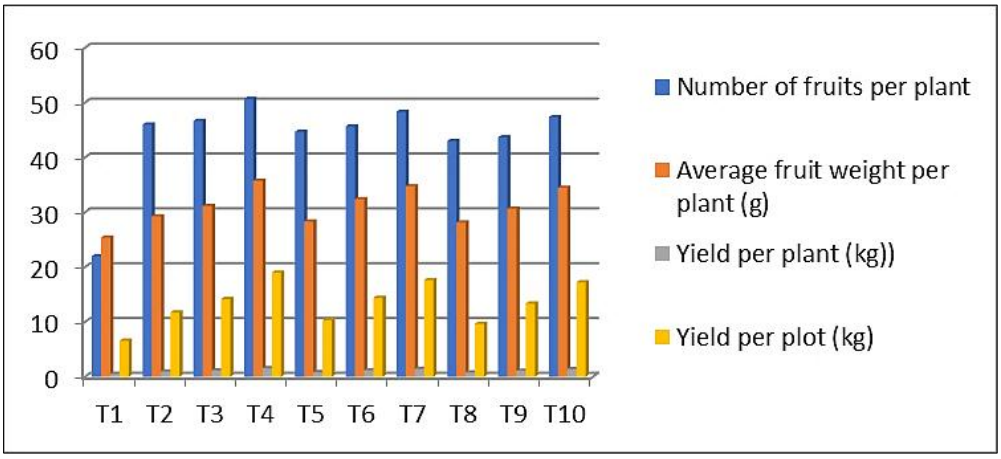

Fig 3: Graphical representation of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flower per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Quality Parameters

All the treatments were found significant as compared with control. The maximum TSS (5.733) was recorded in the treatment T_4 (Gibberellic Acid @ 150 ppm) followed by T_6 (Naphthalene Acetic Acid @ 100 ppm), T_3 (Gibberellic Acid @ 50 ppm) and T_7 (Gibberellic Acid @ 150 ppm) valued (5.333), (5.067) and (5.033), respectively. While, the minimum TSS (3.400) was recorded in the treatment T_1 (Control). Data revealed that maximum shelf life (9.667) was determined under T_4 (Gibberellic Acid @ 150 ppm) that was statistically at par with T_7 (Naphthalene Acetic Acid @ 150 ppm) and valued (9.267). While, the minimum shelf life (5.033) was found under T_1 (Control). The significantly maximum vitamin C (19.067) was recorded in the treatment T_4 (Gibberellic Acid @ 150 ppm) that was statistically at par with T_7 (Naphthalene Acetic Acid @ 150 ppm) and T_{10} (Ethrel @ 150 ppm) valued (18.133) and (17.933), respectively. While, the minimum vitamin C (10.400) was recorded in the treatment T_1 (Control).

Table 7: Effect of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flower per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Treatment code	Total Soluble Solid (°brix)	Shelf life	Vitamin C (mg / 100 g)
T_1	3.4	5.033	10.4
T_2	4.767	6.667	15.533
T_3	5.067	8.7	17.2
T_4	5.733	9.667	19.067
T_5	4.733	6.533	14.733
T_6	5.333	6.6	16.6
T_7	5.033	9.267	18.133
T_8	4.3	6.467	12.933
T_9	4.467	6.8	16.267
T_{10}	4.933	9	17.933
S.E. (d)	0.378	0.248	0.718
C.D. (0.05)	0.801	0.6	1.519

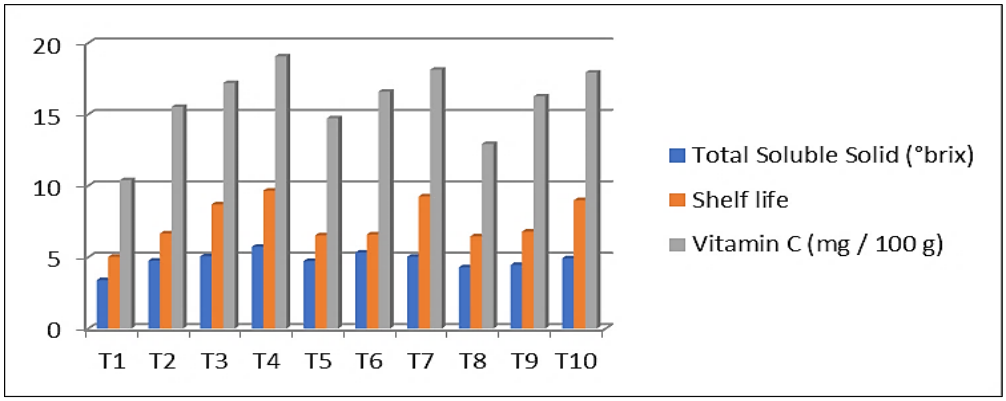

Fig 4: Graphical representation of plant growth regulators on height of the plant (cm), Number of branches per plant, Days to first flowering, Number of flower per cluster, Days to first fruit set, Fruit set per cent and Days to maturity

Economics of The Treatments

Benefit: Cost ratio

The data on cost of cultivation for different treatmentas have been presented in Table 8 and in appendix I. Maximum yield per hectare (52802.97) and net benefits Rs (1195032.12) was obtained with the spray of T_4 (Gibberellic Acid @ 150 ppm) followed by (49009.74) and Rs (1127483.93) in T_7 (Naphthalene Acetic Acid @ 150 ppm) and (47887.55) and Rs (1089905.84) in T_{10} (Ethrel @ 150 ppm) as compared to control but spray of (Naphthalene Acetic Acid @ 150 ppm) in T_7 was found to be most economical which gave the maximum cost benefit ratio (1:3.34) over the control.

Table 8: Effect of plant growth regulators on yield and economics"

Treatment code	Yield Kg/ha	Total cost of Cultivation (Rs/ha)	Gross Return (Rs/ha)	Net return (Rs/ha)	C:B Ratio
T_1	18,343.93	3,40,725.00	5,50,317.90	2,09,592.90	01:00.6
T_2	32,576.87	3,56,835.66	9,77,306.10	6,20,470.44	01:01.7
T_3	39,403.34	3,72,946.32	11,82,100.20	8,09,153.88	01:02.2
T_4	52,802.97	3,89,056.98	15,84,089.10	11,95,032.12	01:03.1
T_5	28,592.53	3,41,419.42	8,57,775.90	5,16,356.48	01:01.5
T_6	39,978.88	3,42,113.85	11,99,366.40	8,57,252.55	01:02.5
T_7	49,009.74	3,42,808.27	14,70,292.20	11,27,483.93	01:03.3
T_8	26,883.69	3,42,697.16	8,06,510.70	4,63,813.54	01:01.4
T_9	37,123.40	3,44,722.11	11,13,702.00	7,68,979.89	01:02.2
T_{10}	47,887.55	3,46,720.66	14,36,626.50	10,89,905.84	01:03.1

Plate 2: Effect of plant growth regulators on yield and fruit size of tomat

Conclusion

Results obtained from the present investigation revealed that among all the different treatments applied; best growth, yield and quality parameters were found from the plants grown in the plots applied with Gibberellic acid @ 150 ppm, *viz.*, height of the plant, number of branches per plant, days to first flower initiation, number of flower per cluster, days to first fruit set, fruit set per cent, number of fruits per plant, average fruit weight per plant (g), yield per plant (kg), yield per plot (kg), total soluble solids (°Brix), shelf life (days) and vitamin C (mg/100g). So, overall results showed Gibberellic acid @ 150 ppm was that most effective treatment.

On the other hand, application of (T_7) Naphthalene Acetic Acid @ 150 ppm produced maximum Cost Benefit ratio (1:3.28) followed by (T_{10}) Ethrel @ 150 ppm (1:3.14) and (T_4) Gibberellic Acid @ 150 ppm (1:3.07). Therefore, on the basis of results obtained in present studies, it is suggested that the spray of Naphthalene Acetic Acid @ 150 ppm is found more favourable for the farmers because it has low cost of cultivation as compare to the other plant growth regulators

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