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RESEARCH ARTICLE

Growth, flowering, fruiting, yield and quality of tomato (*Lycopersicon esculentum* Mill.) as influenced plant bio regulators

■ **RANJEET, R.B. RAM, JAY PRAKASH AND M.L. MEENA**

SUMMARY

A field experiment was carried out to assess the growth, flowering, fruiting yield and quality traits of Tomato cv. KASHI VISHESH (H-86). The experiment was laid out in randomised block design with three replications for tomato crop consisted of 10 treatments namely, Control, GA_3 20 ppm, GA_3 40 ppm, GA_3 60 ppm, NAA 10 ppm, NAA 20 ppm, NAA 30 ppm, 2, 4-D 10 ppm, 2, 4-D 15 ppm and 2, 4-D 20 ppm to find out the effect of the growth, flowering, fruiting, yield and quality of tomato and various horticulture characters namely; plant height (cm), number of branches, number flowers per plant, number of clusters per plant, number of fruits per clusters, number of fruits per plant, average fruit length (cm), average fruit diameter (cm), average fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg), fruit yield per hectare (q), acidity (%) and total soluble solids TSS (^{0}Brix). However, application of the plant bio regulators had a significant influence on plant growth, flowering, fruiting, yield and quality traits of tomato and GA_3 gave the highest yield than other plant growth regulators. So, GA_3 was superior among all treatments under investigation for response tomato production.

Key Words : Tomato, Plant bio regulators, Growth, Flowering, Fruiting yield, Quality

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Tomato (*Lycopersicon esculentum* Mill.) which belongs to family solanaceae and cultivated tomato originated in Mexico. Tomato is one of the most highly praised vegetable consumed widely and it is major source of vitamins and minerals. It is one of the most popular salad vegetables and taken with great relish. It is widely employed in cannery and made into soups, conserves, pickles, ketchup, sauces, juice etc. Tomato juice has become an exceedingly popular appetizer and beverage .The well ripe tomato (per 100 g of edible portion) contains water (94.1%),energy (23 calories), calcium(1.0g) magnesium (7.0 mg),vitamin A (1000 IU),ascorbic acid (22 mg), thiamine (0.09 mg),riboflavin (0.03 mg),and niacin (0.8 mg), (Uddain *et al.*, 2009). Vegetables form the most important of a balanced diet and act as a protective food. India occupies a prime position in the word in vegetable next to China only. India produces about 146 MT. of vegetable from an area of 8.4 Mt. hectares. This is for below the desired requirement to full fill the need of growing population (N.H.B. Database, 2011).

There are many methods adopted to increase the yield of the crop which comprise mainly of cultural and chemical practices, both of these techniques have been successfully exploited by many to increase yield of tomato. The present study only concerns with chemicals especially growth regulators GA_3, NAA and 2, 4-D.

Growth regulator available are often inadequate in the

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
RANJEET, Department of Applied Plant Science (Horticulture), School for Biosciences and Biotechnology, Babasaheb Bhimrao Ambedkar University, LUCKNOW (U.P.) INDIA
Email: kumarireetesh94@gmail.com

Address of the Co-authors:
R.B. RAM, JAY PRAKASH AND M.L. MEENA, Department of Applied Plant Science (Horticulture), School for Biosciences and Biotechnology, Babasaheb Bhimrao Ambedkar University, LUCKNOW (U.P.) INDIA

plant the specific quantitites in the plant are directly responsible for the promotion inhibition or otherwise modification in the physiological processes. It is obvious that the growth directly related to yield. The growth regulators NAA and 2, 4-D belongs to the auxin group a GA_3 belongs to gibberellins.

Natural occurring auxin includes IAA, (Indol-acetic acid), IAN (Indil-acetonitril), IPyA (Indolepyruvic acid) and synthetic auxin analogs include NAA (naphthaleneacetic acid) , 2, 4-D (dichlorophenoxy acetic acid) and other the effect of NAA has been observed mainly cell elongation, improve phototropism, apical formation, respiration and flower bud initiation. NAA is commonly used in horticultural crops in higher concentration on NAA inhibit growth and exert toxic effect on the plant optimum concentration is required for beneficial NAA. That perhaps interfere with the variation in temperature which in turn affect the flowering adversely. It also effect the physiological process of the plant.

The name gibberellins ‘’was used by (Yabuta and Sumiki 1938) for a pure crystalline chemical which was isolated from ‘Bakanae or foolish seedling; disease rice plant. kurosawa of Japan in 1926 confirmed that the disease was caused by a fungus ‘Gibberella fujikoroi’ (*fusarium heterosporum*) due to this disease, rice plant grows abnormally thin and tall. The six gibberellins *viz.*, GA_1, GA_2, GA_3, GA_4, GA_7, GA_9, were isolated from the fungus Gibberella by Cross *et al*. (1961). Three gibberellins viz. GA_5, GA_6, GA_8 were isolated from bean seeds by (Mac Gillivary *et al*.,1961).

Gibberellins’ promotes shoot growth by accelerating the cell elongation and cell division in the sub apical meristem region which increases the length of internodes. Gibberellic regulates the mitotic activity of the sub apical meristem. Gibberellin induces the synthesis of hydrolytic enzymes, especially protease and á-amylase which triggers seed germination. Gibberellin is released by the seed embryo and is transported the aleuronic layer of endosperm where such enzymes are synthesized under its influence. This is the example of hormonal control of enzymes synthesis. Gibberellin has no effect on root growth and the activity of apical meristem of the apex. Physiological effects of the gibberellins are (i) Stem elongation: It increases the length of internodes (ii) Parthenocarpic fruit: GA induces parthenocarpic development in tomato (iii) It increases the size of leaves and fruits. (iv) It increases the cell division and cell size (Arun Katyan, 2009).

MATERIAL AND METHODS

The present investigation was carried out at the Horticultural Research Farm of the Department of Applied Plant Science (Horticulture), Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Rae Bareli Road, Lucknow (U. P.) in randomized block design with three replications in plot size of 1.80 x1.35 m with spacing of 60 x45 cm during *Rabi* season of 2012-13. All recommended package of practices was followed to raise good crop. Experimental field was laid out in Randomized Block Design with 10 treatments and replicated thrice. The treatments combinations comparised namely, T_1-Control, T_2-GA_3 20 ppm, T_3-GA_3 40 ppm, T_4-GA_3 60 ppm,T_5-NAA 10 ppm, T_6-NAA 20 ppm, T_7-NAA 30 ppm, T_8-2, 4-D 10 ppm, T_9-2, 4-D 15 ppm and T_{10}-2, 4-D 20 ppm. Other cultural practices like irrigation, hoeing, insect-pest and disease management were common for the each treatment. Observation were recorded on 14 characters including growth, flowering, fruiting yield and quality attributing characters *viz.*, plant height (cm), number of branches, number flowers per plant, number of clusters per plant, number of fruits per clusters, number of fruits per plant, average fruit length (cm), average fruit diameter (cm), average fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg), fruit yield per hectare (q), acidity (%), total soluble solids TSS (^{0}Brix). The data were subjected to statistical analysis to test the level of significance as per method (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

All parameters *viz.*, plant height (cm), number of branches, number flowers per plant, number of clusters per plant, number of fruits per clusters, number of fruits per plant, average fruit length (cm), average fruit diameter (cm), average fruit weight (g), fruit yield per plant (kg), fruit yield per plot (kg), fruit yield per hectare (q), acidity (%) and total soluble solids TSS (^{0}Brix).

Average plant height:

A maximum plant height at 30 DAT (23.7 cm), 60 DAT (31.28 cm) and 90 DAT (68.56 cm) was recorded from T_4 treatment (application of GA_3 @ 60 ppm) this increase in height may be due to the fact that GA_3 promotes vegetative growth by active cell division and elongation, and therefore the height must have increased. Another probable reason for the increase in plant height may be the osmotic uptake of water and nutrients under the influence of GA_3 which maintains a swelling force against the softening of cell walls or due to the stimulus caused by the GA_3 in the soil and therefore the plant height might have increased. These resulted were in close agreement with the findings of (Mehrotra *et al.*,1970).

Number of branches per plant:

Number of branch per plant tomato varied significantly at 30,60 and 90 DAT due to application on plant growth regulator (Table 1) the maximum number of branch at 30 DAT (3.77),60 DAT (11.07),90 DAT (21.83) was recorded from T_4 treatment application of GA_3 60 ppm. While the minimum number of branch per plant was recorded from control T_1 treatment application at 30 DAT (2.25), 60 DAT, (5.65), 90 DAT (11.25). It was revealed that number of branch per plant tomato increased which the of plant growth regulators in

tomato especially GA_3 at (20, 40and 60ppm). Similar trend of result was reported by author scientist like (Singh and Singh, 2005).

Number of flowers per plant:

Number of flower per plant of tomato showed statistically significant variation among different plant growth regulator the maximum number of flowers plant 104.55 was recorded from GA_3 at 60 ppm while the minimum number of flowers plant (72.68) was recorded from control (Table 1). Superior resulted in respect of number of flower plant was found in GA_3 application. This might be caused that GA_3 promoted flower primodia production in tomato plant. The result disagreed with the result of Onofeghara and (Saleh and Abdul, 1980).The might be due to the application of different concentration of GA_3.

Number of clusters per plant:

The data on number of cluster per plant have been presented in . A maximum number of 21.87 clusters per plant were recorded at 60 ppm GA_3 which was followed by 2,4-D at 20ppm, while the minimum number of cluster per plant (10.13) was recorded from control (Table 1). The above findings lead to supports with the finding of (Uddain and Hossain, 2009).

Number of fruits per cluster:

Probably the consequence increased flower count is reflected in the increase of number of fruit per cluster. As the data shown in the seems to be the reflection of the increased number of flower per plant. The same results were also reported by (Uddain and Hossain, 2009). On the GA_3 treatment of increasing concentrations (20, 40, 60 ppm) the number of fruit per cluster increased in a concentration dependent manner (9.43, 9.50, 12.13 fruit per cluster, respectevily). Beside this, NAA treatment shows the increased number of fruit per cluster (9.55, 9.68, 10.13 at 10, 20 and 30 ppm respectively) the reason behind this finding may be an attribute of the NAA which induces flower and fruit survival at plant. The 2-4-D at minute concentration *i.e.* 10 ppm has very moderate enhancing effect on number fruit per cluster (9.78 in compare to 5.13 of control) (Table 1). At higher concentrations it imposes a destabilizing effect of on the number of fruit per cluster (9.87 and 9.77 at15, 20 ppm, respectively).

Number of fruits per plant:

The data on number of fruit per plant have been presented in. As already reported in results that the effects of the growth regulators treatments have significantly increased the number of fruit per plant. A maximum 42.70 fruits per plant were recorded at 60 ppm of GA_3 as compared to 30.33 fruit per plant in control (Table 1). This may be due to the characteristic effect of GA_3. Fruiting in tomato is governed by optimum growth regulator concentration along with sufficient reserve carbohydrates. Since in general GA_3 at 60 ppm has significantly responded in promoting vegetative growth characters conductive to food manufacturing mechanism, hence the treated plants hade comparatively more food stokes. GA_3 level in treated plants was naturally more, which, itself has a property of increasing fruiting. GA_3 become more active in presence of extra plant food and hence the number of fruits seems to have increased. This finding lead support from the findings of (Uddain and Hossain, 2009).thus the availability of this growth regulator in the plants might have increased and hence the plants might have produced more fruit per plant.

Average fruit length (cm):

The result on fruit length has been presented in the. As reported earlier that the growth regulators treatments were found to be significant in increase fruit length. A maximum fruit length of 4.16 cm was reported as 60 ppm of GA_3 as compared to 3.20 cm in control (Table 1). This increase may be due to greater accumulation of carbohydrates owing to greater photosynthesis which caused the fruit to increase in length. These lend support from the findings of (Uddain and Hossain, 2009).

Average fruit diameter (cm):

The result on fruit diameter has been presented in the. As reported earlier that the growth regulators treatments were found to be significant in increase fruit diameter. A maximum fruit diameter of 6.07 cm was reported as 60 ppm of GA_3 as compared to 3.63 cm in control (Table 1). This increase may be due to greater accumulation of carbohydrates owing to greater photosynthesis which caused the fruit to increase in diameter. These lend support from the findings of (Uddain and Hossain, 2009).

Average fruit weight (g):

The results on average fruit weight have been presented in Table 1 indicated that the application of GA_3 at 60 ppm have produced maximum fruit weight of 43.93 gm concentration as compared to the 27.50 gm in control. This increase in fruit weight may be assigned to GA_3, since by its characteristics virtue (cell elongation) it has promoted the growth of all vegetative parts and consequently more food material for fruit development was produced by such plants and fruits with higher weight were obtained. Moreover the plant anabolic processes are be another causes of higher fruit weight. The increasing fruit weight as result of GA_3 application has also been obtained by (Uddain and Hossain, 2009).

Percentage acidity (%):

The data on percentage acidity have been presented in. A close review of the data reveals that all growth regulator treatments have significantly decreased the percentage acidity

of tomato fruits. A minimum of 0.40 percent acidity was obtained at 60 ppm concentration of GA_3 as compared to 0.56 per cent in control (Table 2). This might be due to greater conversion of acid into sugars as a result of GA_3 application had also be noticed by (Rappaport,1956).

Total soluble solids (^{0}Brix):

Total soluble solids (T.S.S.), the quality of solids dissolved in the liquid part of tomato, were observed to be increased after treatment with GA_3 and NAA. The best result was observed at 60 ppm concentration of GA_3 which leads to the 5.18 ^{0}Brix T.S.S. in compare to 3.37 ^{0}Brix of control (Table 2). In the same way, NAA show a content increase in TSS irrespective of concentration change (4.90 ^{0}Brix 10, 20 and 30 ppm concentration). 2, 4-D, in contrast to above two, has moment as, it does not target any protein/ enzyme involved in fruit formation or development (Rappaport, 1956).

Fruit yield per plant (kg):

The result on yield per plant has been presented in the A maximum yield of 1.87 kg. per plant was produced by GA_3 at 60 ppm concentration as compared to 0.83 kg (Table 2). In control this increase in yield may be due to GA_3 application by which the plant remained physiologically more active to build up sufficient food stocks for developing flowers, fruit and resulted in increased fruit set, which ultimately lead to higher yields. These finding were in accordance with the results obtained by (Uddain, and Hossain, 2009).

Fruit yield per plot (kg):

The results on average yield per plants are presented in the a close review of the data shows that all growth regulator treatments have significantly increased the yield per plant. The best treatments T_4 GA_3 at 60 ppm concentration where a maximum yield of (16.87 kg) per plat was noticed as compared to (7.51 kg) (Table 2) T_1 control .the other treatment have produced significantly higher yields than control, but their

Table 1 : Effect of plant bio regulators on growth, flowering, fruiting of tomato

Treatments	Plant height (cm)	Number of branches per plant	Number of flowers per plant	Number of clusters per plant	Number of fruits per cluster	Number of fruits per plant	Average fruit length (cm)	Average fruit diameter (cm)	Average fruit weight (g)
T_1 : Control	29.68	6.37	72.68	10.13	5.13	30.33	3.20	3.63	27.50
T_2 : GA_3 20 ppm	36.54	7.85	94.90	16.93	9.43	36.03	3.42	4.25	34.83
T_3 : GA_3 40 ppm	37.86	10.21	97.63	19.23	9.50	35.83	3.68	4.35	37.13
T_4 : GA_3 60 ppm	40.97	12.22	104.55	21.87	12.13	42.70	4.16	6.07	43.93
T_5 : NAA 10 ppm	35.72	9.90	101.07	19.19	9.55	38.87	3.33	4.82	38.02
T_6 : NAA 20 ppm	35.73	10.15	100.65	18.50	9.68	39.43	3.34	4.99	38.61
T_7: NAA 30 ppm	39.39	11.08	102.00	19.23	10.13	41.47	3.97	5.66	40.55
T_8: 2,4-D 10 ppm	37.70	10.70	101.07	18.17	9.78	38.60	3.20	4.65	36.26
T_9 : 2,4-D 15 ppm	36.19	10.50	99.95	18.32	9.87	38.17	3.32	4.45	32.80
T_{10}: 2,4-D 20 ppm	35.48	10.07	97.53	17.83	9.77	37.20	3.15	4.32	32.60
S.E.(±)	0.77	0.36	0.97	0.57	0.41	1.23	0.13	0.22	1.34
C.D. (P=0.05)	2.29	1.06	2.87	1.69	1.21	3.66	0.39	0.65	3.98

Table 2 : Effect of plant bio regulators yield and quality attributing traits of tomato

Treatments	Yield fruits per plant (kg)	Fruit yield per plot (kg)	Fruit yield per hectare (q)	Acidity (%)	Total soluble solids TSS (^{0}Brix)
T_1 : Control	0.83	7.51	309.25	0.56	3.37
T_2 : GA_3 20 ppm	1.25	11.29	464.81	0.46	4.27
T_3 : GA_3 40 ppm	1.33	11.97	492.59	0.46	4.50
T_4 : GA_3 60 ppm	1.87	16.87	694.44	0.40	5.18
T_5 : NAA 10 ppm	1.48	13.32	548.14	0.46	4.77
T_6 : NAA 20 ppm	1.52	13.68	562.96	0.46	4.23
T_7: NAA 30 ppm	1.68	15.12	622.22	0.41	4.90
T_8: 2,4-D 10 ppm	1.39	12.55	516.66	0.43	4.70
T_9 : 2,4-D 15 ppm	1.25	11.25	462.96	0.44	4.52
T_{10}: 2,4-D 20 ppm	1.21	10.93	450.00	0.43	4.16
S.E.(±)	0.10	0.86	3.55	0.02	0.13
C.D. (P=0.05)	0.28	2.56	10.54	0.06	0.39

values were lower than the maximum. These finding were in accordance with the results obtained by (Uddain and Akhter Hossain, 2009).

Fruit yield per hectare (q):

The result on yield per ha has been presented in the. A maximum yield of 694.44 q per hectare was produced by GA_3 at 60 ppm concentration as compared to 309.25quintal /ha (Table 2). In control this increase in yield may be due to GA_3 application by which the plant remained physiologically more active to build up sufficient food stocks for developing flowers, fruit and resulted in increased fruit set, which ultimately lead to higher yields. These finding were in accordance with the results obtained by (Bukovao *et al.*, 1957).

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