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Effect of different levels of GA_3 and NAA on vegetative growth and flowering parameters of tomato (*Solanum lycopersicum* L.)

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Abstract
GA_3 and NAA affect various aspects of plant physiology, mainly vegetative and flowering attributes including yield. A field experiment was carried out during 2015-16, at the Horticulture Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut to find out the response of foliar application of GA_3 and NAA on vegetative and flowering attributes of tomato cv. Pusa Rohini. The two bio-regulators i.e. GA_3 and NAA ware used in different concentration i.e. GA_3 (20, 30, 40 and 50 ppm) and NAA (15, 20, 25 and 30 ppm) and Control (distilled water spray). All variables parameters related to vegetative growth and flowering parameters were significantly influenced by different concentrations of the plant bio-regulators. Results revealed that between both the growth regulators, the foliar application of GA_3 (50 ppm) registered significantly higher vegetative growth viz., plant height (101.45cm) & internodes length (6.20 cm) and flowering parameters viz., minimum number of days to first flowering (24.60) & maximum number of flower per plant (50.13) as compared to other treatments.

Keywords: GA_3 and NAA on vegetative growth, flowering parameters, physiology

Introduction
Out of the total vegetable production, solanaceous group plays an important role. Among this group, tomato is one of the important crop. It is a native of tropical America (Peru) and belongs to the family Solanaceae. Tomato (*Solanum lycopersicum* L., 2n = 24) is commercially important throughout the world both for fresh fruit market and for the processed food industries. It ranks 2nd in importance after potato in many countries. It is grown under wide range of climates. India produces about 19402 thousand tonnes of tomato from an area of 1204 thousand hectares with the productivity of 16.1 tonnes per hectare. (Anonymous, 2014) [1].

The leaves are compound pinnatifid with small leaflet Inflorescence is extra-axillaries cymes with dichotomous or polychotomous branching. The number of flower per cluster varies from 3 to several. The flowers are bright yellow and are pentamerous, bisexual, regular, complete and hypogynous. According to Aykroyd (1963) [3] tomato fruit contains 93.1 g water, protein 1.9 g, fat 0.1 g, carbohydrate 3.6 g, mineral matter 0.6 g, calcium 20 mg, phosphorus 36 mg, iron .8 mg, vitamin A 320 IU, thiamine 2.27 mg, nicotinic acid 0.4 mg, riboflavin 0.01 mg and ascorbic acid 31 mg per 100 g of pulp of fruit. It also contains folic acid, pantothenic acid, vitamin K and inhibitors which are related to vitamin E. Fruits of tomato are eaten raw as salad or cooked as vegetable. A large quantity of tomato is used to produce soup, juice, ketchup, puree, paste and powder. Tomato is very popular because it supplies vitamin C and adds variety of colours and flavours to the food. Green tomatoes are used for pickles and preserves. It is rich in medicinal value.

The quantity of nutrients absorbed by the leaf during foliar application may be small; it is compensated by a higher efficiency of uptake than applying the same quantity of nutrients to the soil. The growth regulators have been known to be one of the quick means of increasing production. The dynamic role of plant growth regulators in various physiological and biochemical processes of plant is well known, which not only enables a rapid change in the phenotype of the plant by accelerating germination or growth but also helping in the augmentation of the produce. Gibberellic acid is an important growth regulator that may have many uses to modify the growth and flowering contributing characters of plant (Rafeekher *et al*., 2002) [10]. Plant growth regulators are used widely to improve plant performance. Gibberellic acid is one of those growth regulators that have positive effect on plant growth through the effect on cell division and elongation (Batlang *et al*., 2006) [4].

NAA has been shown to greatly increase cellulose fiber formation in plants when paired with another phytohormone. NAA is commonly used at relatively low concentration to elicit auxin type responses in cell growth, cell division, fruit setting and rooting (Sun and Hong, 2010) [12]. The adventitious root production was increased rapidly at lower NAA concentration, while the number of roots was decreased at higher concentration

Material and Methods

The experiment was carried out at Horticulture Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during 2015-16. The experimental field was laid out in a randomized complete block design with three replications. The seedlings of tomato cultivar Pusa Rohini were transplanted in the main field with the all recommended package of practices. Nine treatments comprising of two plant growth regulators viz., GA_3 (20, 30, 40 and 50 ppm), NAA (15, 20, 25 and 30 ppm) and Control (Water spray) were used as foliar spray. These treatments were applied as foliar sprays at 15 and 35 days after transplanting. The preventive measures for the control of insect were done by spraying with Diafenthiuron 50% WP @ 0.2%. The data on vegetative growth namely; plant height & internodes length and flowering parameters namely; days taken to first flowering & number of flowers per plant were recorded and subjected for statistical analysis.

Results and Discussion

The vegetative growth and flowering behavior of tomato were significantly influenced by the foliar application of GA_3 and NAA at different concentrations as compared to control treatment (table-1). From the statistical analyses of experimental data, it was concluded that maximum plant height at 30 days after transplanting (47.50 cm), plant height at 60 days after transplanting (76.94 cm) and plant height at final harvesting (101.45 cm) were recorded under the higher concentration of GA_3 @ 50 ppm followed by GA_3 @ 40 ppm, GA_3 @ 30 ppm and NAA @ 30 ppm. However, minimum plant height at 30 days after transplanting (29.19 cm), plant height at 60 days after transplanting (57.95 cm) and plant height at final harvesting (72.01cm) were recorded under control (distilled water spray). These results were in close agreement with the findings of Kaur *et al*. (1993) [8] and Gupta and Gupta (2000) [7] in case of tomato and Dev *et al.* (2017) in case of okra. It might be the results of their stimulatory effect of GA_3 on plant growth due to cell elongation and rapid cell division in growing portion, there are number of reports showing that gibberellins and naphthalene acetic acid promote growth of intact plants. These results are in conformity with the findings of Arora *et al*. (1999) [2] and Chovatia *et al.* (2010) [5].

Similarly, the maximum internodes length (6.20 cm) was measured with the higher concentration of GA_3 @ 50 ppm followed by GA_3 @ 40 ppm (6.14 cm) and GA_3 @ 30 ppm (5.86 cm), while minimum internodes length (2.84 cm) with controlled plants. As the concentration level of GA_3 decrease, it had less stimulate effect on the length of internodes. NAA also had positive effect on the internodes length of tomato with increasing concentration level. These findings are very close with the earlier findings of Uddain *et al.* (2009) [13]. This may be an attribute of GA_3 property of elongating the cell length in the intermodal stem cells. The NAA showed a variable, concentration independent internodes elongation pattern.

Days to first flowering determines the time of harvesting. Earliness of flowering is an expression of the increasing tendency of plants to become reproductive with age Leonard *et al*. (1983) [9]. Minimum number of days taken to first flowering is an important indication of start of early harvesting. Experimental results of the present study indicated that GA_3 (50, 40, 30 and 20 ppm) treated plants took minimum days to first flowering (24.60, 25.87, 26.93 and 28.27), respectively followed by NAA. Maximum days taken to first flowering (34.40) was estimated under control treatment. This earliness in anthesis may be because of GA_3 treatments which increased the number of leaves and promoted vegetative growth and thus there was translocated to other plants parts and might have facilitated early flowering. The results obtained by Rappaport (1956) [11] were in close conformity with the above finding.

Number of flower per plant is an important character become it is directly related to the number of fruit. it is apparent from given results that the 50 ppm concentration of GA_3 is best to increase the number of flower (50.13) which in turn will result in increased number of fruits consequently increasing the total yield. NAA also showed a positive effect on the increasing number of flowers, while minimum number of flowers (40.73) recorded with control.This finding confirmed with the findings of Uddain *et al*. (2009) [13], who reported that the increasing level of GA_3 had promotive effect on the number of flower per plant in case of tomato.This might be caused because GA_3 promoted flower primodia production in tomato plant.

Table 1: Effect of different levels of GA_3 and NAA on vegetative growth and flowering parameters of tomato (*Solanum lycopersicum* L.)

Treatments	Plant height (cm) at 30 days after transplanting	Plant height (cm) at 30 days after transplanting	Plant height (cm) at 30 days after transplanting	Internode length (cm)	Days taken to first flowering	Number of flowers per plant	Yield (q/ha)
GA_3 (20 ppm)	38.50	66.43	78.79	5.95	28.27	45.40	384.78
GA_3 (30ppm)	41.48	69.56	85.71	5.86	26.93	46.80	441.31
GA_3 (40ppm)	45.91	72.42	96.15	6.14	25.87	49.20	475.08
GA_3 (50ppm)	47.51	76.94	101.45	6.20	24.60	50.13	531.74
NAA (15 ppm)	33.29	60.65	80.99	4.93	32.27	46.40	373.25
NAA (20 ppm)	35.45	61.53	83.73	2.84	29.40	47.53	387.60
NAA (25 ppm)	36.45	68.45	85.04	3.84	27.87	49.20	397.41
NAA (30 ppm)	38.87	70.73	86.83	4.09	28.13	49.93	419.42
Control (water spray)	29.19	57.95	72.01	4.77	34.40	40.73	349.08
CD at 5%	0.86	0.99	1.14	0.31	1.07	1.38	1.84

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