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Effect of Gibberellic Acid Spray on Performance of Tomato

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Abstract: A pot experiment was performed according to a factorial randomized design at Aligarh to study the effect of 4 levels of gibberellic acid spray (0, 10^{-8}, 10^{-6} and 10^{-4} M GA_3) on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars (*Lycopersicon esculentum* Mill.), namely Hyb-SC-3 and Hyb-Himalata. Irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of Hyb-SC-3.

Key Words: Tomato cultivars, GA_3 spray, growth, leaf-NPK, yield and quality characteristics

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is a rich source of lycopene and vitamins. Lycopene may help counteract the harmful effects of substances called "free radicals", which are thought to contribute to age-related processes and a number of types of cancer, including, but not limited to, those of prostate, lung, stomach, pancreas, breast, cervex, colorectum, mouth and oesophagus (1-6). It is, therefore, highly desirable to explore possible ways and means to enhance the productivity of this important crop employing cost-effective and easy to use techniques. In this regard, the effect of spray of gibberellic acid (GA_3) at very low concentrations could be exploited beneficially as its natural occurrence in plants in minute quantities is known to control their development. It is an established phytohormone used commercially for improving the productivity and quality of a number of crop plants (7-10). Moreover, experience at Aligarh with crop plants other than tomato has been highly encouraging (11). It was, therefore, decided to study the efficacy of foliar application of graded low levels of GA_3 on the performance of 2 cultivars of tomato.

Materials and Methods

A pot experiment was conducted on tomato (*Lycopersicon esculentum* Mill.) during the 'rabi' (winter) season in a net house of the Department of Botany, Aligarh Muslim University, Aligarh (27°52' N latitude, 78°51' E longitude and 187.45 m altitude, India). The aim of the experiment was to study the effect of 4 concentrations of gibberellic acid spray, i.e. 0, 10^{-8}, 10^{-6} and 10^{-4} M, on the performance of 2 high yielding cultivars of tomato, namely Hyb-SC-3 and Hyb-Himalata. The cultivars were selected on the basis of a screening test conducted earlier at Aligarh (12). The seeds, obtained from the Sun-grow Seed Company, New Delhi, were surface sterilized with ethyl alcohol for half an hour and washed thoroughly in double distilled water (DDW). A nursery-raised healthy vigorously growing 4-week-old seedling was transplanted in each of 5 earthen pots (25 cm height × 25 cm diameter) containing 4 kg of a homogeneous (3:1) mixture of soil and cow dung manure [texture - sandy loam, pH (1:2)-7.9, EC(1:2)-0.58dS/m, available nitrogen (N) 106.3 mg/kg soil (238.2 kg N/ha), phosphorus (P)-5.4mg/kg soil (12 kg P/ha) and potassium (K)-123.7 mg/kg soil (277 kg K/ha)] for each treatment, including the control to be sprayed with DDW. Each pot was supplied with NPK at the rate of 50 kg N + 30 kg P + 30 kg K/ha at the time of transplanting. A second split of 50 kg N/ha was top-dressed after another 4 weeks (13). Four levels of GA_3 (0, 10^{-8}, 10^{-6} and 10^{-4} M GA_3) were sprayed on the foliage of the plants with the help of an atomizer at 6 weeks after transplanting. A 10^{-2} M stock solution of GA_3 was prepared by dissolving 0.346 g GA_3 (SIGMA, USA) in 10 ml of ethyl alcohol and the final volume was made up to 1000 ml with DDW.

By diluting this stock solution with DDW, 10^{-8}, 10^{-6} and 10^{-4} M solutions of GA_3 were prepared. The pots were gently irrigated as and when required. The design of the experiment was factorial randomized. The performance of the crop was assessed with regard to plant height, number of branches, number of leaves, leaf area, fresh weight (without fruits), dry weight (without fruits), leaf-NPK content, number of matured fruits and fruit lycopene content 8 weeks after transplanting. The remaining fruits were collected at maturity.

The total area of each leaf was measured with the help of a transparent graph-sheet. Leaf N and P content was determined by adopting the methods of Lindner (14) and Fiske and Subba Row (15), respectively. Leaf K was measured with the help of a flame photometer. Lycopene in fruits was estimated as described by Sadasivam and Manikam (16). The data were analyzed statistically according to Panse and Sukhatme (17). When the 'F' value was found to be significant at the 5% level of probability, critical difference (CD) was calculated for comparison.

Results

The data (Tables 1-4) reveal that, except for branch and leaf number per plant, the effect of (i) treatments, (ii) treatment x cultivar interactions and (iii) that due to cultivar differences was significant for all parameters studied. Moreover, fresh and dry weight per plant and leaf P content did not differ from one cultivar to the other.

Growth Characteristics: Compared with the water-sprayed control, treatment 10^{-8} M GA_3, being at par with 10^{-6} and 10^{-4} M GA_3 in its effect, gave higher value for plant height and leaf area. However, for fresh and dry weight, 10^{-8} M GA_3 proved superior in its effectiveness to the other 2 treatments that were at par (Tables 1 and 2).

Of the 2 cultivars, Hyb-SC-3 proved superior to Hyb-Himalata for plant height and leaf area (Tables 1 and 2).

Interaction 10^{-8} M GA_3 x Hyb-SC-3 (being at par with 10^{-4} M GA_3 x Hyb-SC-3 and 10^{-4} M GA_3 x Hyb-Himalata in its effect) gave the maximum value for plant height.

Table 1. Effect of GA_3 spray on growth parameters of 2 cultivars of tomato.

Treatments (T) (M GA_3)	Cultivars (C)		Mean
	Hyb-SC-3	Hyb-Himalata	
	Plant height (cm)		
0	73.0	66.0	69.5
10^{-8}	85.6	73.8	79.7
10^{-6}	76.6	77.2	76.9
10^{-4}	83.0	79.2	81.1
Mean	79.6	74.1	
CD at 5%	T = 4.5	C = 3.2	TxC = 6.4
	Branches per plant		
0	39.6	34.6	37.1
10^{-8}	46.4	43.6	45.0
10^{-6}	36.6	44.0	40.3
10^{-4}	40.6	28.4	34.5
Mean	40.8	37.7	
CD at 5%	T = NS	C = NS	TxC = NS
	Leaves per plant		
0	277.6	242.6	260.1
10^{-8}	304.2	320.4	312.3
10^{-6}	263.2	308.0	285.5
10^{-4}	302.0	256.6	279.3
Mean	286.8	281.9	
CD at 5%	T = NS	C = NS	TxC = NS

NS = Non-significant

Table 2. Effect of GA_3 spray on growth parameters of 2 cultivars of tomato.

Treatments (T) (M GA_3)	Cultivars (C)		Mean
	Hyb-SC-3	Hyb-Himalata	
	Area per leaf (cm^2)		
0	24.0	23.0	23.5
10^{-8}	34.0	20.4	27.2
10^{-6}	37.0	22.2	29.6
10^{-4}	39.2	25.4	32.3
Mean	33.6	22.8	
CD at 5%	T = 5.5	C = 3.9	TxC = 7.8
	Fresh weight per plant (g)		
0	26.4	21.0	23.7
10^{-8}	70.4	53.0	61.7
10^{-6}	42.0	39.2	40.6
10^{-4}	37.4	35.0	36.2
Mean	44.1	37.1	
CD at 5%	T = 19.7	C = NS	TxC = 27.9
	Dry weight per plant (g)		
0	9.6	7.0	8.3
10^{-8}	24.2	17.8	21.0
10^{-6}	12.6	13.4	13.0
10^{-4}	11.8	11.0	11.4
Mean	14.6	12.3	
CD at 5%	T = 4.9	C = NS	TxC = 7.0

NS = Non-significant

Regarding area per leaf, treatments 10^{-8}, 10^{-6} and 10^{-4} M GA_3 (interacting equally effectively with Hyb-SC-3) proved superior to the others. For fresh and dry weight per plant, effect of 10^{-8} M GA_3 x Hyb-SC-3, equaled by that of 10^{-8} M GA_3 x Hyb-Himalata, proved best (Tables 1 and 2).

Leaf NPK content: N content was maximum in treatment 10^{-6} M GA_3, with 10^{-8} M GA_3 following it closely. However, treatment 10^{-8} M GA_3 proved superior for P content. Treatments 10^{-8} and 10^{-4} M GA_3 being at par, gave higher value than the remaining treatments for leaf K content (Table 3).

Cultivar Hyb-SC-3 contained more N than Hyb-Himalata. However, the latter possessed a higher percentage of K.

Interaction 10^{-6} M GA_3 x Hyb-SC-3, followed by 10^{-8} M GA_3 x Hyb-SC-3, gave maximum leaf N content. For P content, 10^{-8} M GA_3 x Hyb-SC-3, being at par with 10^{-8} M GA_3 x Hyb-Himalata in its effect, gave the maximum value. Leaf K content was maximum in 10^{-8} M GA_3 x Hyb-SC-3. However, its effect was at par with 10^{-8} M GA_3 x Hyb-Himalata in its effect, 10^{-4} M GA_3 x Hyb-Himalata and 10^{-4} M GA_3 x Hyb-SC-3 (Table 3).

Yield Characteristics: Treatments 10^{-8}, 10^{-6} and 10^{-4} M GA_3, being at par in their effect, proved superior to the water-sprayed control for fruit number and yield per plant (Table 4).

Cultivar Hyb-SC-3 produced more fruits and gave higher fruit yield per plant than Hyb-Himalata (Table 4).

Interaction 10^{-8} M GA_3 x Hyb-SC-3, being at par with 10^{-6} M GA_3 x Hyb-SC-3 and 10^{-4} M GA_3 x Hyb-SC-3, gave higher values for both fruit number and fruit yield per plant (Table 4).

Quality Characteristics: Treatment 10^{-8} M GA_3 gave the maximum lycopene content of fruits. The water-sprayed control gave the minimum value (Table 4).

Table 3. Effect of GA_3 spray on leaf-nitrogen, phosphorus and potassium content of 2 cultivars of tomato.

Treatments (T) (M GA_3)	Cultivars (C)		Mean
	Hyb-SC-3	Hyb-Himalata	
	Nitrogen content (%)		
0	2.88	2.62	2.75
10^{-8}	2.80	2.76	2.78
10^{-6}	3.00	2.84	2.92
10^{-4}	2.28	2.34	2.31
Mean	2.74	2.64	
CD at 5%	T = 0.08	C = 0.06	TxC = 0.12
	Phosphorus content (%)		
0	0.20	0.20	0.20
10^{-8}	0.50	0.47	0.49
10^{-6}	0.39	0.43	0.41
10^{-4}	0.45	0.44	0.45
Mean	0.39	0.39	
CD at 5%	T = 0.03	C = NS	TxC = 0.04
	Potassium content (%)		
0	1.72	1.72	1.72
10^{-8}	1.80	1.86	1.83
10^{-6}	1.26	1.70	1.48
10^{-4}	1.92	1.84	1.88
Mean	1.68	1.78	
CD at 5%	T = 0.10	C = 0.08	TxC = 0.14

NS = Non-significant

Cultivar Hyb-SC-3 had more lycopene than Hyb-Himalata (Table 4).

The interaction 10^{-8} M GA_3 x Hyb-SC-3 gave the maximum lycopene content. However, its effect was at par with that of 10^{-6} M GA_3 x Hyb-SC-3 and 10^{-8} M GA_3 x Hyb-Himalata. The lowest value was noted with water x Hyb-Himalata (Table 4).

Discussion

Compared with the water-sprayed control, the observed increase in plant height, leaf area, leaf P content, fruit number, fruit yield and fruit lycopene content of GA_3-treated plants (Tables 1-4) could be ascribed to the well-known roles of GA_3. For example, GA_3 treatment promotes cell enlargement (18) and cell division (19-21), 2 important processes that enhance plant height and leaf area. The promoting effect of GA_3 on DNA, RNA and protein synthesis (22-26) and ribose and polyribosome multiplication (27) would contribute towards biomass production of vegetative parts as well as fruits and their contents. Enhancement of enzyme activity (28-30) would also result in biomass accumulation in plants as they advance in age. An increase in membrane permeability (31-33) would facilitate absorption and utilization of mineral nutrients (11,31,34,35) and transport of assimilates (36-39). This would also contribute towards enhancing the capacity of the treated plants for biomass production as is reflected in the observed increase in the fresh and dry weight of plants (Table 2) and the observed leaf P content (Table 3).

This sustained increase in the above-mentioned parameters of the GA_3-treated plants (Tables 1-3), which is expected to culminate in maximization of number and yield of fruits, would have a positive effect on the

Table 4. Effect of GA_3 spray on yield and quality characteristics of 2 cultivars of tomato.

Treatments (T) (M GA_3)	Cultivars (C)		Mean
	Hyb-SC-3	Hyb-Himalata	
	Fruits per plant		
0	6.4	5.6	6.0
10^{-8}	9.4	8.6	9.0
10^{-6}	9.4	8.4	8.9
10^{-4}	9.6	8.0	8.8
Mean	8.7	7.7	
CD at 5%	T = 0.4	C = 0.3	TxC = 0.8
	Fruit yield per plant (g)		
0	210.2	190.4	200.3
10^{-8}	330.0	295.2	312.6
10^{-6}	322.0	280.4	301.2
10^{-4}	339.2	275.6	307.4
Mean	300.4	260.4	
CD at 5%	T = 15.2	C = 10.8	TxC = 21.5
	Fruit lycopene content (mg/100 g)		
0	1.37	0.54	0.96
10^{-8}	1.88	1.79	1.84
10^{-6}	1.79	1.45	1.62
10^{-4}	1.60	1.11	1.36
Mean	1.66	1.22	
CD at 5%	T = 0.10	C = 0.07	TxC = 0.14

lycopene content of the fruit (Table 4). Moreover, as P facilitates the availability of metabolic energy required for the synthesis of various important biomolecules through ATP production, the higher value of leaf P is consistent with this observation.

It may, therefore, be concluded that the sustained increase in the observed parameters expectedly culminated in maximization of the process of biomass accumulation leading to higher productivity and lycopene content of tomato fruits, particularly in cultivar Hyb-SC-3. Lastly, it may be suggested that spray of 10^{-8} M GA_3 on Hyb-SC-3 cultivar of tomato would be highly cost effective for the mass production of tomato with high lycopene content for human consumption.

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