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Effect of micronutrients and PGR on growth and yield of tomato (*Solanum lycopersicum* L.) Variety Azad-T$_6$

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Abstract
The present investigation entitled "Effect of micronutrients and PGR on growth and yield of tomato (*Solanum lycopersicum* L.) Variety Azad-T6" was carried out during the *rabi* season 2018-19 and 2019-20 both the year same time at Department of Vegetable Science Kalyanpur Chandra Shekhar Azad University of Agriculture & Technology Kanpur U.P (208024) India. Experiment was laid out in randomized block design (RBD) with eleven treatments in replicated three times consist of two levels of each micronutrients and growth regulators with control *i.e.* T_0: Control, T_1: GA_3 50ppm, T_2: GA_3 100ppm, T_3: NAA 50ppm, T_4: NAA 100ppm, T_5: $ZnSO_4$ 0.5%, T_6: $ZnSO_4$ 1%, T_7: Boric acid 50ppm, T_8: Boric acid 100ppm, T_9: $FeSO_4$ 100ppm and T_{10}: $FeSO_4$ 150ppm. Significantly differences were found for plant growth and yield parameters. The highest plant height (cm), number of branches plant^{-1}, number of flower cluster^{-1} and number of cluster plant^{-1} was recorded in T_2: GA_3 100ppm. The application of T_2: GA_3 100ppm was found early days to 50%flowering, days to first fruit set, no. of fruit per cluster, no. of fruit plant^{-1}, average fruit weight (g), fruit length (cm), fruit width (cm), fruit yield plant^{-1} (kg), fruit yield plot^{-1} (kg) and fruit yield (q ha^{-1}). Revealed that the use of GA_3 concentration of 100ppm, considerably increased the vegetative growth and yield parameters and significantly increased growth and yield parameters.

Keywords: Micronutrients, PGR, growth, yield, azad-T6 and tomato

Introduction
Tomato (*Solanum lycopersicum* L.) is an important vegetable of a solanaceous family having chromosome number 2n=2x=24. It has originated from wild form in the Peru-Equador-Bolivia region of the Andes, South America (Rick, 1969) [9] and grown in every country of the world (Roberston and Labate, 2007) [10]. For making the tomato pickles the unripe green fruit are used, preserve are consumed after cooking as vegetables (Kaur *et al*., 2004). The prime tomato producing countries of the earth are China, United States of America, India, Egypt, Turkey, Iran, Mexico, Brazil and Indonesia (FAO, 2019). In India, at present the total area under tomato cultivation is 778 thousand hectare and production is 19397 thousand MT (NHB, 2019). Considerable investigation work has been done on the different aspect of foliar spray of micronutrient in various crops and the research results specified not only an increase in yield up to 20 per cent but also helpful way to sustain crop production. Arora *et al.* (1979) reported that micronutrients like zinc, boron, and iron through foliage application can improve the plant growth parameters, fruit set and fruit yield of tomato (Salisbury and Rose, 1986) and (Halfare and Barden, 1979). Boron is necessary for cell division, germination of pollen, movement of sugars through protoplasmic membranes, development of phloem and transport of certain hormones (Edmond *et al.,* 1995). Zinc is a component of enzyme and necessary for chlorophyll formation and function in synthesis of auxins (Thompson and Kelly, 1972) and (Halfare and Barden, 1979). In some countries, tomatoes are commercially growing even at high temperature through application of plant growth regulators (PGRs). Gemici *et al.*, 2006 [3] reported that application of auxin and gibberellins are effective in increasing both fruit yield and quality of tomato. Application of certain PGRs like gibberellic acid (GA3) bring the possibility of tomato production under adverse environmental region. Those PGRs are used extensively in tomato to enhance yield by improving fruit set, size and number of fruits

(Batlang, 2008; Serrani *et al.*, 2007) [1, 11]. Fruit set in tomato was successfully improved by application of NAA. In fact the use of growth regulators had improved the production of not only but tomato other vegetables in respect of good plant growth and fruit quality which ultimately led to generate interest between the scientists and farmers for commercial application of growth regulators (Prawal *et al.*,2014) [8].

Materials and Methods

The present investigation entitled "Effect of micronutrients and PGR on growth and yield parameters of tomato (*Solanum lycopersicum* L.) Variety Azad-T6" was carried out during the rabi season 2018-19 and 2019-20 both the year same time at Department of Vegetable Science Kalyanpur C. S. Azad University of Agriculture & Technology Kanpur U.P (208002) India. The vegetable research farm is about 10 Km. away from the Kanpur central railway station in the north western part of the Kanpur city. It is situated in front of Indian Institute of Pulse Research. The experiment conduct at Departmental Farm of Vegetable Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur having an even topography with adequate irrigation and proper drainage facilities. The soil was sandy loam, good in fertility. The experiment was taken under in order to find out the Effect of micronutrients and PGR on growth and yield parameters of tomato (*Solanum lycopersicum* L.) seedling were obtained from vegetable research farm, Department of Vegetable Science, (CSAUT, Kanpur). Experiment was laid out in randomized block design (RBD) and replicated three times on tomato Variety Azad-T_6. Seedling were transplanted in first experiment at October 2018 and second experiment at October 2019 at a spacing 60 x 45 cm. A total of eleven treatments using two different concentration of each micronutrients *viz*., $ZnSO_4$, Boric acid & $FeSO_4$ and growth regulators *viz*., GA_3 and NAA. A total fourteen growth and yield parameters *viz*., days to 50%flowering, plant height (cm), number of branches plant^{-1}, number of flower cluster^{-1}, number of cluster plant^{-1}, days to first fruit set, no. of fruit per cluster, no. of fruit plant^{-1}, average fruit weight (g), fruit length (cm), fruit width (cm), fruit yield plant^{-1} (kg), fruit yield plot^{-1} (kg) and fruit yield (q ha^{-1}) of tomato were taken during the experiments in 2018-19 and 2019-20. Statistical analysis of the data was done by using analysis of variance (ANOVA) technique by (Fisher 1950).

Result and Discussion

The observation on various growth parameters was revealed significant differences among the treatment in both the years 2018-19 and 2019-20 same time. The application of micronutrients and plant growth regulators significantly increased the growth parameters *viz.*, days to 50% flowering, plant height (cm), number of branches plant^{-1}, number of flower cluster^{-1}, number of cluster plant^{-1}, days to first fruit set, days to first fruit picking of tomato Variety Azad-T6. The result of different levels of micronutrients and plant growth regulators in different treatments combination was shown in table 1.

It was observed that statistical analysis of data on days to 50%flowering, plant height (cm), number of branches plant^{-1}, number of flower cluster^{-1}, number of cluster plant^{-1}, days to first fruit set, days to first fruit picking of tomato Variety Azad-T6 shows significant. The minimum days to 50% flowering (28.36, 29.48 and 28.92) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the maximum days to 50% flowering (35.60, 30.42 and 29.87) was found in Control T_0.

The maximum plant height (cm) (118.43, 119.75 and 119.09) at 30, 60 and 90 DAT was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum plant height (cm) (95.87, 97.28 and 96.57) was found in Control T_0. The maximum number of branches plant^{-1} (13.76, 14.50 and 14.13) at 30, 60 and 90 DAT was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum number of branches plant^{-1} (8.70, 14.50 and 9.01) was found in Control T_0. The maximum number of flower cluster^{-1} (6.91, 7.79 and 7.35) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum number of flower cluster^{-1} (4.32, 5.05 and 4.70) was found in Control T_0.The maximum number of cluster plant^{-1} (5.56, 6.41 and 5.99) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum number of cluster plant^{-1} (3.32, 4.14 and 3.73) was found in Control T_0.

The minimum days to first fruit set (52.83, 51.53 and 52.18) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the maximum days to first fruit set (68.19, 67.43 and 67.81) was found in Control T_0.The minimum days to first fruit picking (61.40, 60.37 and 60.88) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the maximum days to first fruit picking (73.05, 71.26 and 72.15) was found in Control T_0. In experimental findings with the pooled data.

The Result of different levels of micronutrients ZnSO4 (0.5 & 1%), Boric acid (50 & 100ppm) and FeSO4 (100 and 150ppm) and growth regulators GA3 (50 & 100ppm) and NAA (50 & NAA 100ppm) with control in different treatments combination was shown in table-2. It was observed that statistical analysis of data on number of fruit per cluster, number of fruit plant^{-1},average fruit weight (g), fruit length (cm), fruit width (cm), fruit yield plant^{-1} (kg), fruit yield plot^{-1} (kg) and fruit yield (q ha^{-1})of tomato shows significant. The maximum no. of fruit per cluster (5.90, 6.19 and 6.05) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum no. of fruit per cluster (3.16, 4.28 and 3.72) was found in Control T_0. The maximum no. of fruit plant^{-1}(32.84, 39.69 and 36.27) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum no. of fruit plant^{-1} (10.49, 17.72 and 14.10) was found in Control T_0. The maximum Average fruit weight (g) (62.41, 62.77 and 62.59) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum Average fruit weight (g) (35.45, 36.36 and 35.91) was found in Control T_0. The maximum Fruit length (cm) (5.18, 5.30 and 5.24) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum Fruit length (cm) (3.61, 3.93 and 3.77) was found in Control T_0.

The maximum Fruit width cm (11.68, 11.85 and 11.77) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum fruit width (cm) (4.65, 4.74 and 4.70) was found in Control T_0. The maximum fruit yield plant^{-1} kg (2.049, 2.491 and 2.270) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum fruit yield plant^{-1} kg (0.373, 0.644 and 0.509) was found in Control T_0. The maximum Fruit yield plot^{-1} kg (20.49, 22.42 and 21.45) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum Fruit yield plot^{-1} kg (3.73, 5.80 and 4.77) was found in Control T_0. The maximum fruit yield q ha^{-1} (758.78, 922.72

and 840.75) was recorded in treatment T_2:GA3 100ppm followed by T_1:GA3 50ppm. Whereas the minimum fruit yield q ha^{-1} (138.24, 238.63 and 188.43) was found in Control T_0.

Table 1: Effect of micronutrients and PGR on growth parameters of tomato *(Solanum lycopersicum L.)*Variety Azad-T6

Treatment Combinations	Days to 50%flowering			Plant height (cm)			Number of branches $plant^{-1}$			Number of flower $cluster^{-1}$			Number of cluster $plant^{-1}$			Days to first fruit set		
	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled
T_0: Control	35.60	36.27	35.93	95.87	97.28	96.57	8.70	9.32	9.01	4.32	5.08	4.70	3.32	4.14	3.73	68.19	67.43	67.81
T_1: GA3 50ppm	29.31	30.42	29.87	116.45	117.74	117.10	13.50	14.23	13.86	6.52	7.28	6.90	4.43	6.24	5.34	53.54	52.44	52.99
T_2: GA3 100ppm	28.36	29.48	28.92	118.43	119.75	119.09	13.76	14.50	14.13	6.91	7.79	7.35	5.56	6.41	5.99	52.83	51.53	52.18
T_3: NAA 50ppm	31.25	32.44	31.85	113.78	114.50	114.14	12.31	14.34	13.33	5.65	6.38	6.02	4.79	5.48	5.14	55.72	54.72	55.22
T_4: NAA 100ppm	30.31	31.27	30.79	114.85	115.44	115.14	12.85	14.54	13.70	5.83	6.47	6.15	4.02	6.18	5.10	54.97	53.30	54.14
T_5: ZnSO4 0.5%	32.33	33.25	32.79	106.12	107.33	106.73	10.54	13.45	11.99	5.14	6.24	5.69	4.10	5.20	4.65	57.21	55.27	56.24
T_6: ZnSO4 1%	32.07	31.54	31.81	110.18	111.27	110.72	11.59	13.18	12.39	5.33	6.21	5.77	4.46	5.28	4.87	59.19	57.59	58.39
T_7: Boric acid 50ppm	32.07	33.35	32.71	112.21	113.43	112.82	10.57	12.47	11.52	5.36	6.27	5.82	4.40	5.37	4.89	58.73	54.51	56.62
T_8: Boric acid 100ppm	34.28	34.51	34.40	107.54	107.38	107.46	10.26	12.21	11.24	5.46	6.24	5.85	4.22	5.31	4.77	58.41	56.28	57.35
T_9: FeSO4 100ppm	33.15	34.49	33.82	108.53	108.41	108.47	11.65	13.33	12.49	5.33	6.19	5.76	4.22	5.26	4.74	60.92	56.49	58.70
T_{10}: FeSO4 150ppm	32.09	33.19	32.64	109.54	109.51	109.53	11.53	12.43	11.98	5.35	6.32	5.84	4.29	5.43	4.86	64.63	61.24	62.94
C.D. at 0.5	4.33	3.118	2.796	8.821	9.719	6.359	1.300	2.196	1.318	0.695	0.558	0.634	0.509	0.479	0.913	6.184	5.573	2.860
S.Em. (+)	1.47	1.057	0.948	2.990	3.295	2.155	0.441	0.744	0.447	0.236	0.189	0.215	0.172	0.162	0.310	2.096	1.889	0.969

Table 2: Effect of micronutrients and PGR on yield attributes of tomato *(Solanum lycopersicum L.)*Variety Azad-T6

Treatment Combinations	No. of fruit per cluster			No. of fruit $plant^{-1}$			Average fruit weight (g)			Fruit length (cm)			Fruit width (cm)		
	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled
T_0: Control	3.16	4.28	3.72	10.49	17.72	14.10	35.45	36.36	35.91	3.61	3.93	3.77	4.65	4.74	4.70
T_1: GA3 50ppm	5.34	6.49	5.91	23.65	40.51	32.08	58.51	59.85	59.18	4.50	4.61	4.55	10.18	10.25	10.22
T_2: GA3 100ppm	5.90	6.19	6.05	32.84	39.69	36.27	62.41	62.77	62.59	5.18	5.30	5.24	11.68	11.85	11.77
T_3: NAA 50ppm	4.40	5.58	4.99	21.12	30.58	25.85	57.30	60.05	58.67	4.29	4.41	4.35	9.20	9.36	9.28
T_4: NAA 100ppm	4.90	5.16	5.03	19.69	31.87	25.78	59.71	61.40	60.55	4.44	4.89	4.67	10.19	10.34	10.27
T_5: ZnSO4 0.5%	4.52	5.48	5.00	18.51	28.49	23.50	49.52	50.13	49.83	3.83	3.85	3.84	8.37	8.40	8.38
T_6: ZnSO4 1%	4.36	5.26	4.81	19.43	27.77	23.60	48.83	47.41	48.12	4.10	4.34	4.22	9.17	9.28	9.23
T_7: Boric acid 50ppm	4.34	5.49	4.92	19.12	29.49	24.30	43.01	43.33	43.17	4.11	4.42	4.26	7.97	8.03	8.00
T_8: Boric acid 100ppm	4.26	5.33	4.80	18.01	28.30	23.15	47.57	47.35	47.46	4.09	4.30	4.20	8.67	8.81	8.74
T_9: FeSO4 100ppm	4.30	5.20	4.75	18.15	27.35	22.75	42.22	42.40	42.31	3.97	4.31	4.14	8.22	8.37	8.30
T_{10}: FeSO4 150ppm	4.12	5.30	4.71	17.70	28.81	23.26	51.44	52.50	51.97	4.19	4.29	4.24	8.21	8.27	8.24
C.D. at 0.5	0.562	0.453	0.944	3.071	2.666	1.886	4.948	4.540	4.827	0.403	0.562	0.757	1.228	0.947	1.049
S.Em. (+)	0.190	0.153	0.320	1.041	0.904	0.639	1.677	1.539	1.636	0.137	0.190	0.257	0.416	0.321	0.356

Table 2: Conti…..

Treatment Combinations	Fruit yield $plant^{-1}$ (kg)			Fruit yield $plot^{-1}$ (kg)			Fruit yield (q ha^{-1})		
	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled	2018-2019	2019-2020	Pooled
T_0: Control	0.373	0.644	0.509	3.73	5.80	4.77	138.24	238.63	188.43
T_1: GA3 50ppm	1.384	2.425	1.905	13.84	21.83	17.83	512.74	898.17	705.46
T_2: GA3 100ppm	2.049	2.491	2.270	20.49	22.42	21.45	758.78	922.72	840.75
T_3: NAA 50ppm	1.211	1.836	1.523	12.11	16.53	14.32	448.45	680.04	564.25
T_4: NAA 100ppm	1.175	1.957	1.566	11.75	17.61	14.68	435.35	724.79	580.07
T_5: ZnSO4 0.5%	0.918	1.429	1.173	9.18	12.86	11.02	339.82	529.20	434.51
T_6: ZnSO4 1%	0.948	1.317	1.132	9.48	11.85	10.67	351.22	487.64	419.43
T_7: Boric acid 50ppm	0.822	1.278	1.050	8.22	11.50	9.86	304.30	473.27	388.79
T_8: Boric acid 100ppm	0.856	1.340	1.098	8.56	12.06	10.31	317.20	496.29	406.75
T_9: FeSO4 100ppm	0.766	1.160	0.963	7.66	10.44	9.05	283.63	429.49	356.56
T_{10}: FeSO4 150ppm	0.911	1.513	1.212	9.11	13.61	11.36	337.29	560.28	448.79
C.D. at 0.5	0.314	0.343	0.559	1.686	1.344	2.716	43.439	76.083	53.848
S.Em. (+)	0.107	0.116	0.189	0.571	0.455	0.921	14.723	25.791	18.253

Conclusion

The results concluded that, present investigation above fact the effect of various micronutrients $ZnSO_4$, Boric acid and $FeSO_4$ and plant growth regulators GA_3 and NAA at two different concentrations considerably increased the vegetative growth, flowering and significantly increased yield of tomato Variety Azad-T_6. Hence, from the present investigation it can be concluded that the T_2:GA_3 100ppm proved the best treatment combination influencing the vegetative growth and yield of tomato.

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