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Productivity of Tomato (*Lycopersicon esculentum* Mill.) as influenced by Plant Growth Regulators under Protected conditions

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ABSTRACT: Protected cultivation offers several advantages to produce vegetables of high quality and yields, but tomato crop often faces problems of poor fruit setting due to poor or negligible release of pollens for pollination and fertilization thereby affecting fruit set and ultimately the yield. Plant growth regulators play an important role in increasing the growth, yield and quality of the produce if applied in suitable forms and at appropriate concentrations. The field experiment was conducted at Vegetable Research Farm, Kalyanpur of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India during two consecutive *rabi* seasons of 2019-20 and 2020-21, to find out the effect of PGRs and their spray schedules on tomato. The experiment was laid out in Factorial Randomized Block Design (FRBD) with 27 treatment combinations and replicated thrice under insect proof net house. The experiment comprised nine levels of plant growth regulators *viz.*, GA_3 @ 50 ppm, GA_3 @ 75 ppm, GA_3 @ 100 ppm, NAA @ 20 ppm, NAA @ 30 ppm, NAA @ 40 ppm, 4-CPA @ 20 ppm, 4-CPA @ 30 ppm and 4-CPA @ 40 ppm and three spray schedules *viz.*, at 30 and 45 DAT, at 30, 45 and 60 DAT and at 30, 45, 60 and 75 DAT. The tomato hybrid 'NS- 4266' was used in experiment. Results of the experiment revealed that the application of GA_3 @ 75 ppm recorded significantly highest no. of fruit clusters per plant (13.287 and 13.936), no. of fruits per cluster (13.300 and 14.211), no. of fruits per plant (76.744 and 77.480), average fruit weight (88.924 and 88.899 g), equatorial diameter of fruits (7.110 and 7.063 cm), polar diameter of fruits (6.234 and 6.192 cm), fruit yield per plant (12.223 and 13.208 kg), fruit yield per 1000m^2 (258.470 and 262.413 q) during both the years. In case of spray schedules, the plants were sprayed at 30, 45, 60 and 75 days after transplanting (DAT) produced significantly highest values of all the yield attributing traits. Based on mean values of two years study, the significantly highest fruit yield of 262.735 q/1000m^{2}was observed with the treatment combination of application of GA_3 @ 75 ppm and spray schedule of 30, 45, 60 and 75 days after transplanting (DAT). Hence, it may be recommended for higher productivity from tomato crop under protected conditions.

Keywords: Protected cultivation, PGRs, Productivity, Spray schedule and Tomato.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) was introduced in India during British period in the year 1828 by the Royal Agri-Horticultural Society, Calcutta. It has become a very popular vegetable and available in the market almost round the year. The yield of tomato can be increased and sustained by agronomic and nutritional management or by some exogenous supplementation with enzymes or growth hormones. Several important growth and development processes in plants are controlled and influenced by plant growth regulators (PGRs). Plant hormones are an organic substance which promotes growth of plant and used in low concentration. They play a significant role in physiological phenomena, which are essential for growth and development of tomato plant (Jasmin *et al.*, 2018). Presently, a large number of growth regulators are available in the market but basically, they are of two types i.e., growth promoters and growth inhibitors or retardants. Among growth promoters, gibberellic acid (GA_3), naphthalene acetic acid (NAA) and 4-chlorophenoxy acetic acid (4-CPA or PCPA) improves the growth and yield of various vegetable crops (Jha *et al.*, 2022). GA_3 promotes cell elongation and cell division, thus helps in the growth and development of many plants and plays an important role in controlling fruit setting, pre-harvest fruit dropping, fruit yield and shelf life (Kazemi *et al.*, 2014). Naphthalene acetic acid (NAA) affects the physiological processes, hastens maturity and improving the quality of fruits (Jha *et al.*, 2022). 4-chlorophenoxy acetic acid (4-CPA or PCPA) is absorbed by plant via root, stem, leaf, bloom, and fruit and used to prevent abscission of bloom and fruit and promotes fruit set, ripening and fruit thinning. It can also increase the percentage of the fruit bearing and promote the enlargement of fruit (Karim, 2015). In fact, the use of growth regulators had improved the production of tomato and quality which ultimately led to generate interest between the scientists and farmers for commercial application of growth regulators (Jasmin *et al.*, 2018). External supply of inputs has become important because of poor fertility status of the soil which is not able to meet the entire nutrient requirement of the crop (Rajiv and Tomar 2022).

In order to enhance the quality production and productivity per unit area of vegetable crops, protected cultivation technologies may be opted. Protected cultivation offers several advantages to produce vegetables of high quality and yields, thus using the land and other resources more efficiently (Rajiv and Kumari 2023). Protected cultivation is more sustainable as the effect of climate is minimized (Pachiyappan *et al.*, 2022). Protected cultivation of high-value crops offers higher productivity which in turn increases the profitability of the farm (Prakash *et al.*, 2022). Therefore, the current study included application of plant growth regulators and their spray schedules under protected conditions to study its influence on productivity of tomato in central plain zone of Uttar Pradesh.

MATERIALS AND METHOD

The field experiment was conducted for two consecutive *rabi* seasons in 2019-20 and 2020-21at Vegetable Research Station, Kalyanpur of C.S. Azad University of Agriculture & Technology, Kanpur under insect proof net house. This station is situated at 25.26° to 26.50° north latitude and 79.31° to 80.34° longitudes with an altitude of 125.9 m above the mean sea level. The climate is typically sub-humid and sub-tropical with extreme winter and summer. The average rainfall is 800-850mm while, the maximum and minimum temperature are 30.41 and 14.02°C, respectively. The soil was sandy loam in texture and soil pH was 7.8, which showed slightly alkaline reaction.The soil was low in organic carbon (0.40%), low in available N (162.0 kg/ha), medium in available phosphorus (15.2 kg/ha) and low in available potassium (192 kg/ha) at initiation of experiment. The experiment was laid out in Factorial Randomized Block Design (FRBD) with 27 treatment combinations and replicated thrice. The experiment comprised nine levels of plant growth regulators *viz.*, GA_3 @ 50 ppm, GA_3 @ 75 ppm, GA_3 @ 100 ppm, NAA @ 20 ppm, NAA @ 30 ppm, NAA @ 40 ppm, 4-CPA @ 20 ppm, 4-CPA @ 30 ppm and 4-CPA @ 40 ppm and three spray schedules *viz.*, at 30 and 45 DAT, at 30, 45 and 60 DAT and at 30, 45, 60 and 75 DAT. The tomato hybrid 'NS- 4266' was used in experiment.

The crop was planted on beds at 60×60 cm spacing on 28th October and 30th October during 2019-20 and 2020-21, respectively. The experiment was conducted in fixed layout during both years with the bed size of 0.90m (width) × 2.40m (length) and bed height of 15 cm was maintained. A total number of beds (plots) were 27 × 3= 81. Plant growth regulators were sprayed as per treatment. The spray was done in such a way that all the leaves of the individual plants were covered with a fine mist of solution. Package of practices recommended for the region was followed. The observations were recorded for yield attributes and analyzed by using statistical techniques.

RESULTS AND DISCUSSION

A. Effect of plant growth regulators on yield attributes and fruit yield

The entire yield attributes and fruit yield were influenced significantly by different plant growth regulators and their spray schedule during both the years of tomato experimentation (Table 1). Among the plant growth regulators, the application of GA_3 @ 75 ppm produced significantly highest number of 13.287 fruit clusters per plant followed by GA_3 @ 100 ppm with 12.018 and 4-CPA @ 40 ppm with 11.383. The lowest no. of 5.678 clusters per plant was found with the application of NAA @ 20 ppm during first year. Similar trend of no. of fruit clusters per plant was also observed during second year of the experimentation and application of GA_3 @ 75 ppm recorded significantly highest no. of 13.936 (Table 1).

In case of no. of fruits per cluster, the significantly highest values of no. of fruits per cluster (13.30 and 14.211) were also showed with the application of GA_3 @ 75 ppm. It was followed by application of GA_3 @ 100 ppm and 4-CPA @ 40 ppm in terms of no. of fruits per cluster. Similar trend was also observed in case of no. of fruits per plant and application of GA_3 @ 75 ppm produced the significantly highest values of no. of fruits per plant (76.744 and 77.480). The lowest values of these traits were found with NAA @ 20 ppm. The increase in number of fruits might be ascribed to the induction of higher photosynthetic efficiency and enhanced source to sink relationship of the plant (Jasmin *et al.*, 2018).

The average fruit weight (88.924 and 88.899 g), equatorial fruit diameter (7.110 and 7.063 cm), polar diameter (6.234 and 6.192 cm), fruit yield/plant (12.223 and 13.208 kg) and fruit yield/1000 m^2 (258.470 and 262.213 q) were also recorded significantly highest with the application of GA_3 @ 75 ppm (Table 1 and 2). Whereas, the lowest values of these traits were found with the application of NAA @ 20 ppm. The increase in fruit yield might be attributed to the positive influence of plant growth regulator on yield attributes. The results are in confirmation with the findings of Jha *et al.* (2022); Jakhar *et al.* (2018); Shankhwar *et al.* (2017); Verma *et al.* (2014).

Table 1: Effect of plant growth regulators and their spray schedule on yield attributes of tomato.

Treatments	No. of fruit clusters per plant		No. of fruits per cluster		No. of fruits per plant		Equatorial diameter of fruit (cm)		Polar diameter of fruit (cm)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Plant growth regulators										
GA_3 @ 50 ppm	9.990	9.136	10.969	11.078	65.295	65.897	6.540	6.537	5.713	5.667
GA_3 @ 75 ppm	13.287	13.936	13.300	14.211	76.744	77.480	7.110	7.063	6.234	6.192
GA_3 @ 100 ppm	12.018	12.662	12.326	13.050	72.753	73.263	6.970	6.920	6.083	6.092
NAA @ 20 ppm	5.678	4.871	5.940	7.454	45.103	45.656	5.444	5.400	4.587	4.540
NAA @ 30 ppm	7.967	7.141	9.566	9.681	58.217	58.551	6.093	5.820	5.272	5.287
NAA @ 40 ppm	7.262	6.232	8.604	8.969	54.119	54.686	5.943	5.957	5.131	5.136
4-CPA @ 20 ppm	6.688	5.942	7.699	8.130	50.569	51.590	5.773	5.723	4.928	4.922
4-CPA@ 30 ppm	9.368	7.470	10.130	10.326	62.118	62.861	6.360	6.377	5.503	5.508
4-CPA@ 40 ppm	11.383	10.585	11.681	11.978	67.451	67.713	6.783	6.787	5.952	5.979
SEm±	0.077	0.079	0.176	0.0.239	0.615	0.462	0.054	0.059	0.165	0.187
CD 5%	0.219	0.225	0.501	0.679	1.750	1.315	0.152	0.167	0.471	0.532
Spray schedule										
At 30 & 45 DAT	8.915	8.233	9.682	10.189	60.218	60.501	6.084	6.067	5.182	5.173
At 30, 45 & 60 DAT	9.385	8.693	10.111	10.690	61.323	62.307	6.439	6.297	5.611	5.599
At 30, 45, 60 & 75 DAT	9.580	9.065	10.278	10.747	62.583	63.090	6.482	6.498	5.676	5.669
SEm±	0.044	0.046	0.102	0.138	0.355	0.267	0.031	0.034	0.095	0.108
CD 5%	0.127	0.130	0.289	0.392	1.010	0.759	0.088	0.096	0.272	0.307

B. Effect of spray schedules on yield attributes and fruit yield

Yield attributing traits and fruit yield responded significantly to the spray schedules and a progressive increase in all these traits was observed as the number of sprays increased (Table 1 and 2). During both the years of tomato experimentation, spray schedule of 30, 45, 60 and 75 days after transplanting (four sprays) produced significantly highest no. of clusters per plant (9.580 and 9.065), no. fruits per cluster (10.278 and 10.690), no. of fruits per plant (62.583 and 63.090), equatorial diameter (6.482 and 6.498 cm), polar diameter (5.676 and 5.669 cm) and average fruit weight (74.962 and 74.978 g). However, in case of no. of fruits per cluster, equatorial diameter, polar diameter and average fruit weight, the significant improvement was noticed upto spray schedule of 30, 45 and 60 days after transplanting (three sprays). The lowest values of these traits were found with spray schedule of 30 and 45 days after transplanting.

The significant increase in fruit yield of tomato was recorded upto spray schedule of 30, 45 and 60 days after transplanting (three sprays) while, maximum fruit yield (9.793 and 10.656 kg/plant and 231.138 and 233.348 q/1000 m^2) was observed with the spray schedule of 30, 45, 60 and 75 days after transplanting (four sprays) (Table 1 and 2). The yield is largely governed by the yield attributes, hence their better development reflected in the higher fruit yield. These results are corroborates to findings documented by Rajput *et al.* (2011); Sangakkara *et al.* (2012); Jha *et al.* (2022). Dhotre and Mantur (2018) stated that the spray schedule of 30, 45, 60 and 75 days after planting of plant growth regulators was found beneficial in improving productivity in capsicum grown under polyhouse.

C. Interaction effect between plant growth regulators and their spray schedules

The interaction between different levels of plant growth regulator and spray schedule was found significant during both the year of experimentation in terms of fruit yield. The significantly highest values of fruit yield (260.620 and 264.850 q/1000 m^2) were recorded with the foliar application of GA_3 @ 75 ppm at 30, 45, 60 and 75 days after transplanting while, the lowest values were found with the application of NAA @ 20 ppm at 30 and 45 days after transplanting during both the years (Table 3). Based on mean values of two years study, the highest fruit yield of 262.735 q/1000m^2 was found with the treatment combination of application of GA_3 @ 75 ppm and spray schedule of 30, 45, 60 and 75 days after transplanting (DAT). The increased fruit yield might be due to the accumulation and translocation of metabolites towards the sink (fruit). This is in conformity with the reports by Rajput *et al.* (2011) who highlighted the importance of multiple applications of growth regulators.

Table 2: Effect of plant growth regulators and their spray schedule on average fruit weight and fruit yield of tomato.

Treatments	Average fruit weight (g)		Fruit yield per plant (kg)		Fruit yield per 1000 m^2 (q)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Plant growth regulators						
GA_3 @ 50 ppm	79.666	79.663	9.900	10.919	237.293	239.147
GA_3 @ 75 ppm	88.924	88.899	12.223	13.208	258.470	262.213
GA_3 @ 100 ppm	86.344	86.298	11.690	12.335	251.967	254.302
NAA @ 20 ppm	55.900	55.950	7.360	8.384	195.897	193.925
NAA @ 30 ppm	70.199	70.300	8.599	9.633	219.084	222.991
NAA @ 40 ppm	64.298	64.307	8.113	9.094	211.467	214.747
4-CPA @ 20 ppm	60.332	60.377	7.832	8.705	204.683	206.836
4-CPA@ 30 ppm	75.846	75.841	9.138	10.173	229.673	230.569
4-CPA@ 40 ppm	83.380	82.969	10.280	11.640	245.573	246.391
SEm±	1.591	1.666	0.209	0.097	2.037	1.833
CD 5%	4.528	4.742	0.595	0.275	5.798	5.217
Spray schedule						
At 30 & 45 DAT	71.890	71.702	8.987	10.095	225.636	233.348
At 30, 45 & 60 DAT	74.777	74.854	9.599	10.613	227.929	229.730
At 30, 45, 60 & 75 DAT	74.962	74.978	9.793	10.656	231.138	227.796
SEm±	0.919	0.962	0.121	0.056	1.176	1.058
CD 5%	2.614	2.738	0.344	0.159	3.348	3.012

Table 3: Interaction effect between different levels of plant growth regulator and spray schedule on fruit yield per 1000 m^2 (q).

Plant growth regulator levels	Spray schedule levels						
	2019-20				2020-21		
	30 & 45 DAT	30, 45 & 60 DAT	30, 45, 60 & 75 DAT		30 & 45 DAT	30, 45 & 60 DAT	30, 45, 60 & 75 DAT
GA3 @ 50 ppm	234.650	237.290	239.940		237.843	238.480	241.117
GA3 @ 75 ppm	256.320	256.470	260.620		259.576	260.213	264.850
GA3 @ 100 ppm	249.540	252.190	254.170		251.665	254.302	256.939
NAA @ 20 ppm	191.880	195.530	200.280		188.564	191.373	201.838
NAA @ 30 ppm	215.290	217.720	224.240		220.021	222.658	226.295
NAA @ 40 ppm	209.890	211.090	213.420		212.110	214.747	217.384
4-CPA @ 20 ppm	202.870	204.490	206.690		204.199	206.836	209.473
4-CPA@ 30 ppm	226.690	229.340	232.990		227.932	230.569	233.206
4-CPA@ 40 ppm	243.590	245.240	247.890		243.754	246.391	249.028
SEm±	1.450				1.602		
CD 5%	4.120				4.560		

CONCLUSIONS

From the present findings, it can be inferred that the of foliar application of GA_3 @ 75 ppm at 30, 45, 60 and 75 days after transplanting (DAT)was found suitable for realizing optimum fruit yield of tomato under insect proof net house. Hence, it may be recommended for higher productivity from tomato crop under protected conditions in central plain zone of Uttar Pradesh.

FUTURE SCOPE

Management of vegetative as well as reproductive growth and fruit development in tomato plant under protected cultivation can be achieved and manipulated through the use of plant growth regulators. Hence, the identified plant growth regulators and their appropriate concentrations can be exploited commercially to enhance the productivity of tomato under protected conditions.

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Conflict of interest: None.

REFERENCES

Dhotre, Mallikarjun and Mantur, S. M. (2018). Use of plant growth regulators to enhance productivity of hybrid capsicum grown under polyhouse. *J. Farm Sci., 31*(2), 172-177.

Jakhar, D., Thaneshwari, Nain. S. and Jakhar, N. (2018). Effect of plant growth regulator on growth, yield and quality of tomato (*Solanum lycopersicum* L.) cv. Shivaji under punjab condition. *International Journal of Current Microbiology and Applied Sciences, 7*(6), 2630-2636.

Jasmin, B. L., Kumar, Sanjeev and Modi, S. (2018). Influence of Plant Growth Regulators on Growth and Yield of Greenhouse Tomato (*Solanum lycopersicum* L.). *Int. J. Curr. Microbiol. App. Sci*., *7*(8), 1603-1609.

Jha, R. K., Thapa, R. and Shrestha, A. K. (2022). Effect of GA3 and NAA on tomato production under protected cultivation in Kaski, Nepal. *Journal of Agriculture and Food Research, 10*(5), 100450.

Karim, R. (2015). Improvement of summer tomato (*Lycopersicon esculentum* Mill.) production using 4-chlorophenoxy acetic acid. *J. Biosci. Agric. Res., 4* (2), 86-91.

Kazemi, M. (2014). Effect of gibberellic acid and potassium spray on vegetable growth and reproduction characteristics of tomato. *J. Biol. Environ. Sci., 8* (22), 1-9.

Pachiyappan, P., Kumar, P., Reddy, K.V., Kumar, K.N.R., Konduru, S., Paramesh, V., Rajanna, G. A., Shankarappa, S. K., Jaganathan, D., Immanuel, S., Kamble, A.L., Selvakumar, R., Immanuelraj, K. T., Manogaran, B.R., Perumal, A., Maruthanayagam, U. and Niranjan, S. (2022). Protected Cultivation of Horticultural Crops as a Livelihood Opportunity in Western India: An Economic Assessment. *Sustainability, 14*(12), 1-17.

Prakash, P., Kumar, P., Kar, A., Singh, A. K. and Ankukkani, P. (2022). Economic analysis of carnation (*Dianthus caryophyllus*) under protected cultivation in Maharashtra. *Indian Journal of Agricultural Sciences, 92*(4), 460–463.

Rajiv and Kumari, M. (2023). Protected cultivation of high value vegetable crops under changing climate. In: Advances in research on vegetable production under a changing climate Vol. 2, Advances in Olericulture, Springer Nature, Switzerland AG. pp 229-266.

Rajiv and Tomar, Saurabh (2022). Integrated use of organic and inorganic sources of nutrients in french bean (*Phaseolus vulgaris*). *Indian Journal of Agricultural Sciences*, *92*(4), 17-21.

Rajput, B. S., Ajeet, Singh, Patel, P. and Gautam, U. S. (2011). Study of different plant growth retardants on flowering, fruiting, yield and economics of okra (*Abelmoschus esculentus*). *Prog. Hort., 43*(1), 166-167.

Sangakkara, B. N. K., Weerakkody, W. A. P., Thrikawala, B. S. and Aramasekara, P. (2012). Effect of exogenous NAA and 1-MCP on reducing immature fruit drop and enhancing the quality of yield of bell pepper (*Capsicum annuum* L.). *Ann. Academic Ses.*, 33-35.

Shankhwar, B., Nigam, A. K., Vasure, N. and Vishvakarma, D. (2017). Effect ofdifferent plant growth regulators on growth of chilli (*Capsicum annum* L.) cv. Pusa Jwala. *Agric. Update*, 1187-1189.

Verma, P. P. S., Meena, M. and Meena, S. K. (2014). Influence of plant growth regulators on growth, flowering and quality of tomato (*Lycopersicon esculentum* Mill). *Indian Journal of Hill Farming, 27*(2), 19-22.

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