Eco. Env. & Cons. 29 (2) : 2023; pp. (940-945)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i02.066

Effect of plant growth regulators and their spray schedule on growth parameters and fruit yield of tomato (*Lycopersicon esculentum* Mill.) under protected cultivation

Virendra Kumar*, Rajiv, Durgesh Kumar, Braj Kishor and Buddhesh Pratap Singh

Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur 208 002, India

(Received 28 February, 2023; Accepted 7 April, 2023)

ABSTRACT

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 plant height (327.277 and 315.377 cm), stem girth (3.233 and 3.207 cm), internodal length (17.164 and 18.153 cm) and fruit yield per plant (12.223 and 13.208 kg) during both the years. The significantly earliest flowering (31.094 and 31.536 days), fruiting (40.352 and 40.307 days) and first harvest/picking (105.204 and 104.517) were also observed with this treatment. In case of spray schedules, the plants were sprayed at 30, 45, 60 and 75 days after transplanting (four sprays) recorded significantly highest values of all the growth parameters and fruit yield. The earliest flowering, fruiting and harvesting were also observed with four sprays schedule. Based on two years study, the significantly highest growth parameters, fruit yield and earliness in flowering, fruiting and harvesting were found with the treatment of application of GA_3@75 ppm and spray schedule of 30, 45, 60 and 75 days after transplanting. Hence, it may be recommended for higher productivity from tomato crop under protected conditions.

Key words: *Growth parameters, Insect proof net-house, PGRs, Spray schedule, Tomato and Yield*

Introduction

Fresh vegetables are rich source of essential vitamins, minerals, dietary fibers and contain fair amount of carbohydrates and proteins therefore, plays an important role in balanced nutrition. The constituents of vegetables have both the nutritional and therapeutic values due to their antcarcinogenic and antioxidant properties. Among all the vegetables, tomato (*Lycopersicon esculentum* Mill.) is one of the most popular and widely grown vegetables in the world, ranking second after potato and it is

grown under wide range of climatic conditions (Tomar *et al.,* 2020a). Tomatoes are used as raw vegetable in sandwiches, salad etc. and used in preserved products like ketch-up, sauce, chutney, soup, paste, puree etc. Tomato is very good appetizer and is recommended for persons suffering from indigestion. It is universally treated as protective food because, it is rich source of vitamins, minerals, organic acids, sugars, ascorbic acids, acidity and lycopene. Tomato is also rich in medicinal values. The pulp and juice are digestible, mild aperients, a promoter of gastric secretion and act as blood purifier. It is reported to have antiseptic properties against intestinal infestations. Due to antioxidant property of ascorbic acid and lycopene content of tomato fruits, it is gaining more medicinal importance now-a-days (Tomar *et al.,* 2019). Tomato is grown for fresh market and tops the list of canned vegetables. It is day neutral, self pollinated and annual fruit vegetable crop which is extensively grown in Asian and European countries (Tomar *et al.,* 2020b). Globally, the production share of tomato of India is 10.4% with second rank next to China. In India, area under tomato crop is 789 thousand ha with the production of 19759 thousand MT. Tomato can be planted from November to February. Due to day neutral behaviour of tomato plant, many varieties are planted round the year (Tomar *et al.,* 2021).

Tomato has sympodial shoot development. The primary vegetative shoot terminates in a flower after the development of 8 to 12 leaves. Subsequently, new vegetative shoots arise from the axillary bud just below the terminating inflorescence. This new shoot, in turn, terminates again after making three leaves, and the next shoot arises from the newly formed axillary bud. This cycle is repeated continuously to form sympodial shoots. By definition, tomato shoots are considered to be determinate because each shoot terminates in a flower. However, the wild-type growth habit of tomatoes is classified as indeterminate because they continuously produce sympodial units. Gibberellic acid (GA_3) promotes cell elongation and cell division, thus helps in the growth and development of many plants. Naphthalene acetic acid (NAA) affects the physiological processes, hastens maturity and improving the quality of fruits. 4-chlorophenoxy acetic acid (4-CPA or PCPA) promotes fruit bearing and enlargement of fruit. In fact, the use of growth regulators had improved the production of tomato and quality. 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).

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 growth parameters and fruit yield of tomato in central plain zone of Uttar Pradesh.

Materials and Methods

The field experiment was conducted for two consecutive *rabi* seasons in 2019-20 and 2020-21 at Vegetable Research Station, Kalyanpur of C.S. Azad University of Agriculture and Technology, Kanpur under insect proof net house. This station is situated at 25.26^0 to 26.50^0 north latitude and 79.31^0 to 80.34^0 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 800-850 mm 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 in zigzag manner 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 growth parameters and yield and analyzed by using statistical techniques.

Results and Discussion

Effect of plant growth regulators on growth parameters and fruit yield

All the growth parameters were influenced significantly by plant growth regulators during both the years of tomato experimentation (Table 1). Among plant growth regulators, application of GA_3 @ 75 ppm recorded significantly tallest plant (327.277 cm) followed by GA_3 @ 100 ppm with 314.980 cm and 4-CPA @ 40 ppm with 305.240 cm during first year. The lowest plant height of 235.56 cm was expressed with application of NAA @ 20 ppm. Similar trend of plant height was also observed during second year of the experimentation and application of GA_3 @ 75 ppm recorded significantly tallest plant with 315.377 cm height. The promoting effect of gibberellic acid (GA_3) on cell elongation and rapid multiplication of cell might have resulted in higher plant height. These findings are in accordance with the reports of Naeem *et al.* (2001) and Nibhavanti *et al.* (2006).

Similar to plant height, the significantly highest values of stem girth (3.233 and 3.207 cm) and internodal length (17.164 and 18.153 cm) were also recorded with the application of GA_3 @ 75 ppm. It was followed by the application of GA_3 @ 100 ppm and 4-CPA @ 40 ppm. The lowest values of these traits were found with the application of NAA @ 20 ppm (Table 1). The gibberellic acid (GA_3) is the most important growth promoting and stimulating substance which helps in the growth and development of plants. The results are corroborates the findings of Mukati *et al.* (2019), Meena *et al.* (2017) and Gochar *et al.* (2017).

The significantly earliest flowering (31.094 and 31.536 days) was observed with the application of GA_3 @ 75 ppm followed by GA_3 @ 100 ppm (32.814 and 32.357 days) and 4-CPA @ 40 ppm (33.443 and 33.358 days) while, the latest flowering (39.837 and 40.037 days) was found with the application of NAA @ 20 ppm during both years. In case of fruiting and harvesting, the similar trend was also noticed and the significantly earliest fruiting (40.352

Table 1. Effect of plant growth regulators and their spray schedule on growth parameters of tomato grown under insect proof net house

Treatments	Plant height at 120 DAT (cm)		Stem girth (cm)		Internodal length (cm)		Days to first flowering	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Plant growth regulators								
GA3 @ 50 ppm	292.787	284.800	2.898	2.892	13.674	13.850	34.748	34.874
GA3 @ 75 ppm	327.277	315.377	3.233	3.207	17.164	18.153	31.094	31.536
GA3 @ 100 ppm	314.980	305.480	3.117	3.114	16.177	16.108	32.814	32.357
NAA @ 20 ppm	235.560	251.367	1.656	1.946	8.264	8.307	39.837	40.037
NAA @ 30 ppm	268.380	270.173	2.582	2.578	11.954	12.052	36.287	36.488
NAA @ 40 ppm	256.227	263.167	2.346	2.342	10.087	10.166	37.557	37.710
4-CPA @ 20 ppm	247.460	256.907	2.048	2.136	9.051	9.046	38.811	38.363
4-CPA@ 30 ppm	279.360	276.887	2.762	2.737	12.771	12.758	35.450	35.571
4-CPA@ 40 ppm	305.240	293.990	2.987	3.018	15.059	15.073	33.443	33.358
SEm±	4.595	1.967	0.069	0.045	0.277	0.311	0.299	0.280
CD 5%	13.076	5.599	0.194	0.127	0.788	0.885	0.850	0.798
Spray schedule								
At 30 & 45 DAT	274.199	277.148	2.524	2.588	12.298	12.228	36.138	35.974
At 30, 45 & 60 DAT	282.951	279.373	2.653	2.696	12.699	12.987	35.499	35.633
At 30, 45, 60 & 75 DAT	285.273	282.861	2.700	2.706	13.070	13.289	35.044	35.159
SEm±	2.653	1.136	0.040	0.026	0.16	0.180	0.172	0.162
CD 5%	7.549	3.232	0.114	0.073	0.455	0.511	0.491	0.461

and 40.307 days) and harvesting (105.204 and 104.517 days) were found with the application of GA_3 @ 75 ppm while, the latest with the application of NAA @ 20 ppm (Table 2). The earliest flowering, fruiting and harvesting might be attributed to suppression of vegetative phase which leads to accelerate the reproductive phase of the plant. Reza *et al.* (2015), Meena *et al.* (2017) and Imran *et al.* (2018) also reported similar findings.

The fruit yield/plant (12.223 and 13.208 kg) was also recorded significantly highest with the application of GA_3 @ 75 ppm (Table 2). Whereas, the lowest values of fruit yield 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 and the yield is largely governed by the yield attributes, hence their better development reflected in the higher fruit yield. The results are in confirmation with the findings of Shankhwar *et al.* (2017) and Jakhar *et al.* (2018). Baby *et al.* (2018) reported maximum fruit yield per plant (6.94 kg) with the treatment of GA_3 @ 75 ppm in cherry tomato.

Effect of spray schedule on growth parameters and fruit yield

Growth parameters 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 values of plant height (285.273 and 282.861 cm), stem girth (2.700 and 2.706 cm) and internodal length (13.070 and 13.289 cm). However, the significant improvement in these parameters was noticed upto spray schedule of 30, 45 and 60 days after transplanting (three sprays). The lowest values of these parameters were found with spray schedule of 30 and 45 days after transplanting (two sprays). Results revealed that the application of four sprays increased growth parameters but significant improvement in these parameters was noticed upto three sprays. It might be due to better utilization of the resources. The results are corroborates the findings of Rajput *et al.* (2011) and Dhotre and Mantur (2018).

In case of earliness in flowering, fruiting and harvesting, the spray schedule of 30, 45, 60 and 75 days after transplanting (four sprays) recorded earliest flowering (35.044 and 35.159 days), fruiting (47.261 and 46.770 days) and harvesting (114.031 and 112.154) (Table 1 and 2). The earliness in flowering, fruiting and harvesting might be attributed to accelerate the reproductive phase of the plant. These results are in agreement with Rajput *et al.* (2011).

The significant increase in fruit yield of tomato was recorded upto spray schedule of 30, 45 and 60

Table 2. Effect of plant growth regulators and their spray schedule on earliness in fruiting and fruit yield of tomato grown under insect proof net house

Treatments	Days to first fruiting		Days to first harvest		Yield per plant (kg/ha)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Plant growth regulators						
GA_3 @ 50 ppm	45.632	45.214	112.416	110.049	9.900	10.919
GA_3 @ 75 ppm	40.352	40.307	105.204	104.517	12.223	13.208
GA_3 @ 100 ppm	43.545	42.018	107.653	107.634	11.690	12.335
NAA @ 20 ppm	55.561	55.590	125.211	123.349	7.360	8.384
NAA @ 30 ppm	49.290	49.020	116.495	114.230	8.599	9.633
NAA @ 40 ppm	51.227	50.178	119.197	116.692	8.113	9.094
4-CPA @ 20 ppm	53.171	52.907	122.299	119.049	7.832	8.705
4-CPA@ 30 ppm	47.221	47.437	114.679	112.114	9.138	10.173
4-CPA@ 40 ppm	45.118	44.151	109.494	108.643	10.280	11.640
SEm±	0.402	0.404	0.917	0.901	0.209	0.097
CD 5%	1.145	1.149	2.609	2.564	0.595	0.275
Spray schedule						
At 30 & 45 DAT	48.520	48.135	116.001	114.157	8.987	10.095
At 30, 45 & 60 DAT	47.924	47.369	114.183	112.448	9.599	10.613
At 30, 45, 60 & 75 DAT	47.261	46.770	114.031	112.154	9.793	10.656
SEm±	0.232	0.233	0.529	0.520	0.121	0.056
CD 5%	0.697	0.663	1.506	1.480	0.344	0.159

Table 3. Interaction effect between plant growth regulator levels and spray schedule levels on fruit yield per plant (kg)

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
GA_3 @ 50 ppm	9.417	10.120	10.163	10.350	11.183	11.223
GA_3 @ 75 ppm	11.733	12.260	12.610	12.683	13.237	13.583
GA_3 @ 100 ppm	10.900	11.560	12.507	11.957	12.523	12.526
NAA @ 20 ppm	7.113	7.457	7.510	8.173	8.510	8.470
NAA @ 30 ppm	8.317	8.720	8.760	9.233	9.823	9.843
NAA @ 40 ppm	7.830	8.237	8.273	8.770	9.140	9.373
4-CPA @ 20 ppm	7.509	7.807	8.180	8.610	8.757	8.747
4-CPA@ 30 ppm	8.820	9.280	9.313	9.917	10.360	10.243
4-CPA@ 40 ppm	9.240	10.777	10.823	11.160	11.860	11.900
SEm±	0.113		0.098			
CD 5%	0.321		0.280			

days after transplanting (three sprays) while, maximum fruit yield (9.793 and 10.656 kg/plant) was observed with the spray schedule of 30, 45, 60 and 75 days after transplanting (four sprays) (Table 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). 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.

Interaction effect between plant growth regulators and 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 (12.610 and 13.583 kg/plant) were recorded with the foliar application of GA_3@ 75 ppm at 30, 45, 60 and 75 days after transplanting while, the lowest with the application of NAA @ 20 ppm at 30 and 45 days after transplanting during both the years (Table 3). Based on mean value of two years study, the highest fruit yield of 13.096 kg/plant 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.

Conclusion

On the basis of results of the present investigation, it may be inferred that the foliar application of GA_3@ 75 ppm at 30, 40, 60 and 75 DAT had significant effect on growth parameters and 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.

References

Baby, R., Saravanan, S., Prasad, V.M., Baby, S. and Geethu, B.L. 2018. Effect of GA_3 and NAA on plant growth and yield of cherry tomato (*Lycopersicon esculentum* var. cerasiforme) under polyhouse condition. *The Pharma Innovation Journal.* 7(7): 79-82.

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

Gocher, A.K., Dwivedi, D.H. and Bairwa, R.K. 2017. Effect of Foliar Application of GA_3 and Homa Ash on Vegetative Growth and Yield of Cape Gooseberry (*Physalis peruviana* L.) Grown under Subtropical Conditions. *Int. J. Pure App. Biosci*. 5(3): 499-504.

Imran Md. Al, Md. Nazrul Islam and Sharmin Jahan, 2018. Morphological and Yield Attributes of Brinjal (*Solanum melongena* L.) Varieties in Response to Gibbellic Acid, *World Journal of Agricultural Sciences,*14 (2): 56-61.

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.

Meena, V.K., Dubey, A.K., Jain, V.K., Tiwari, A. and Negi, P. 2017. Effect of plant growth promoters on flowering and fruiting attributes of okra [*Abelmoschus esculentus* (L.) Moench]. *Crop Research*. 52(1to3): 37-40.

Mukati, S., Raidas, D.K. and Choudhary, B. 2019. Effect of gibberellic acid on growth, quality and yield of tomato varieties (*Lycopersicon esculentum* Mill.), *Journal of Pharmacognosy and Phytochemistry.* 8(2): 737-740.

Naeem, N., lstiaq, M., Khan, P., Mohammad, N., Khan, J. and Jamiher, B. 2001. Effect of gibberellic acid on growth and yield of tomato cv. Roma. *Journal of Biological Sciences.* 1(6): 448-450.

Nibhavanti, B., Bhalekar, M.N., Gupta, N.S. and Anjali, D. 2006. Effect of growth regulators on growth and yield of tomato in summer. *Maharastra Journal of Agriculture.* 31(1) : 64-65.

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 Meenakashi, 2023. Protected cultivation of high value vegetable crops under changing climate. In: Advaces 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.

Reza, M., Islam, M., Hoque, A., Sikder, R.K., Mehraj, H. and Uddin, A.J. 2015. Influence of Different GA 3 Concentrtions on Growth and Yield of Broccoli. *American-Eurasian Journal of Scientific Research*. 10(5): 332-335.

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.

Tomar Saurabh, Rajiv, Beniwal Deepa and Sourabh 2019. Effect of transplanting dates and mulching on growth and yield of tomato (*Solanum lycopersicum* L.). *Vegetable Science.* 46 (1&2) : 39-43.

Tomar Saurabh, Rajiv, Singh, D.P. and Kumari, M. 2020a. Effect of GA_3 and NAA on Growth and Yield of Tomato (*Lycopersicon esculentum* Mill.)- A Review. *Plant Archives.* 20 Special Issue (AIAAS-2020): pp. 71-72.

Tomar Saurabh, Beniwal Deepa, Rajiv, Sourabh and Kumar Puspendra 2020b. Effect of time of planting and mulching on weed intensity in the tomato (*Solanum lycopersicum*) crop. *Indian Journal of Agricultural Sciences*. 90(10) : 1921–1924.

Tomar Saurabh, Rajiv, Singh, D.P., Srivastava, A.K., Jawla, S.K., Kumari, M., Malik, A. and Dev, P. 2021. Influence of weed management practices and dates of transplanting in tomato (*Solanum lycopersicum*). *Indian Journal of Agricultural Sciences*. 91(6) : 824-27.