Himachal Journal of Agricultural Research 48(1): 65-70 (2022)

Influence of GA_3 and NAA on growth, yield and quality of tomato (*Solanum lycopersicum* L.)

Muhammad Juma*, Parveen Sharma, Akhilesh Sharma, Shilpa and Neelam Bhardwaj

Department of Vegetable Science and Floriculture, College of Agriculture
CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur-176 062, India.

*Corresponding author: jumamohammadi27@gmail.com
Manuscript Received: 10.08.2021; Accepted: 23.02.2022

Abstract

GA_3 and NAA affect various aspects of plant physiology, mainly vegetative, flowering and quality attributes including yield. A field experiment was carried out during 2020-21 at vegetable farm of CSKHPKV, Palampur, Himachal Pradesh to evaluate the effects of foliar-applied plant growth regulators gibberellic acid (GA_3) and Naphthalene Acidic Acid (NAA) on tomato hybrid Palam Tomato Hybrid-1. Significant impact of GA_3 and NAA at different concentrations was observed on yield and quality parameters of tomato. Among the different treatments plant growth regulators GA_3 @75 ppm resulted maximum number of fruits per plant, fruit weight and marketable yield per plant, marketable yield per m^2 area, ascorbic acid content plant height and minimum number of days to 50 % flowering.

Key words: NAA, GA_3, protected, tomato, yield

Out of the total vegetable production, solanaceous group plays an important role. Among this group, tomato is one of the important crops. 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 2^{nd} in importance after potato in many countries. It is grown under wide range of climates. The leaves are compound pinnatifid with small leaflet Inflorescence is extra-axillaries cymes with dichotomous or polychotomous branching. The number of flowers per cluster varies from three to several. The flowers are bright yellow and are pentamerous, bisexual, regular, complete and hypogynous. 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 tomato 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). 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). NAA has been shown to greatly increase the cellulose 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). The adventitious root production was increased rapidly at lower NAA concentration, while the number of roots was decreased at higher concentration.

Materials and Methods

The present experiment was carried out under the naturally ventilated polyhouse having 250 m^2 areas at the Research Farm of Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during the year 2020-21. (Table.1). The experiment was conducted in a randomized block design with three replications having seventeen treatment combinations (two PGRs with two concentrations on four growth stages of plant & control). Sixteen tomato plants were planted at a spacing of 70 × 30 cm in each treatment under the protected environment. The variety used for the experimentation was Palam Tomato Hybrid-1. Crop was raised by following package of practice for tomato production under protected environment. Spray solutions of GA_3 and NAA were prepared at the concentration of 50 and 75 ppm by dissolving 50 mg and 75 mg of GA_3 & NAA in 20 ml ethanol, respectively and then 1.0 litre volume was made with distilled water prior to application of plant growth regulators. These growth regulators were applied at vegetative, flowering, fruiting and all of the three stages of the plant in the afternoon. The recorded data was analyzed following Gomez and Gomez (1984).

Result and Discussion

Tomato is a day neutral vegetable but requires more number of sunny days to regulate flowering and fruiting and growth regulators also plays important role to get early crop (Fig.1). It is clear from data presented in table 2 that when tomato crop was sprayed with GA_3 @ 75ppm on vegetative, flowering and fruiting stages was significantly early as compared to control. This might be attributed to that GA_3 application in tomato plants helped in synthesis of protein including various enzymes which resulted the increased rate of shoot elongation and photosynthetic capacity leading to increased physiological activities profuse flowering and chlorophyll content increased with increased concentrations of GA_3 (Mostafa and Saleh, 2006). Chaudhary *et al*. (2006) also found that gibberellins induced cell division, cell elongation and cell enlargement. Foliar application of GA_3 also reduced days for first flowering in cherry tomato as observed by Mehraj *et al*. (2014).

Number of fruits per cluster is an indication of more yield per plant and is generally dependent on better fruit set. Fruit setting in tomato is optimum, if agro techniques are employed effectively. In the present investigation number of fruits per plant were also significantly higher with the foliar application of GA_3 @ 75ppm on vegetative, flowering and fruiting stages. The result revealed that GA_3 also increased the number of flower cluster plant. (Ranjeet *et al*. 2014). Applications of NAA and GA_3 compounds causes increased synthesis of cytokinin, auxins and transport them to auxiliary buds that help boost transformation from vegetative phase to reproductive phase (Kannan *et al*. 2009; Sood et al. 2011).

Average fruit weight is the most important yield contributing character which has a key role in the acceptance of the produce for fresh market tomato. It is clear from the data that average fruit weight was significantly higher when tomato crop was sprayed with GA_3 @ 75ppm on vegetative, flowering and fruiting stages and was at par with treatment where NAA was applied @ 50 ppm on all the growing stages. Minimum fruit weight was recorded in the treatment where there was no application of growth regulators. The increased weight of the fruits for the treatments sprayed with GA_3 due to the fact that gibberellins application increases membrane permeability (Aloni *et al*. 1968; Ujjwal *et al*. 2018) that facilitate absorption and utilization of mineral nutrients and transport of assimilates which may result in higher weight of fruits. Another reason could be the increased individual fruit weight of tomato due to that the GA_3 treated plants having maximum fruit length and diameter, which are directly responsible for the higher fruit weight.

The ultimate objective of the study was to have maximum yield for better returns. Yield is responsible for commercial viability of a variety and is one of the important characters attaining highest consideration in the entire research programme. Scrutiny of data summarized in table 1 revealed that the significantly higher tomato fruit yield per plant as well as per square meter area was recorded with the application of GA_3 @ 75ppm on vegetative, flowering and fruiting stages. This might be due to the fact that it helps in controlling the pre harvest fruit drop which is a major problem and also increases fruit setting percentage, fruit yield and extend shelf life and could be a suitable reason for highest marketable yield per plant and per meter square area. GA_3 also plays an important role in cell division and elongation which ultimately have positive effect on plant growth.

The shape of fruit is an important trait of any vegetable crop which are predominantly determined by genetic character, but can be greatly influenced by different agricultural production practices viz., plant

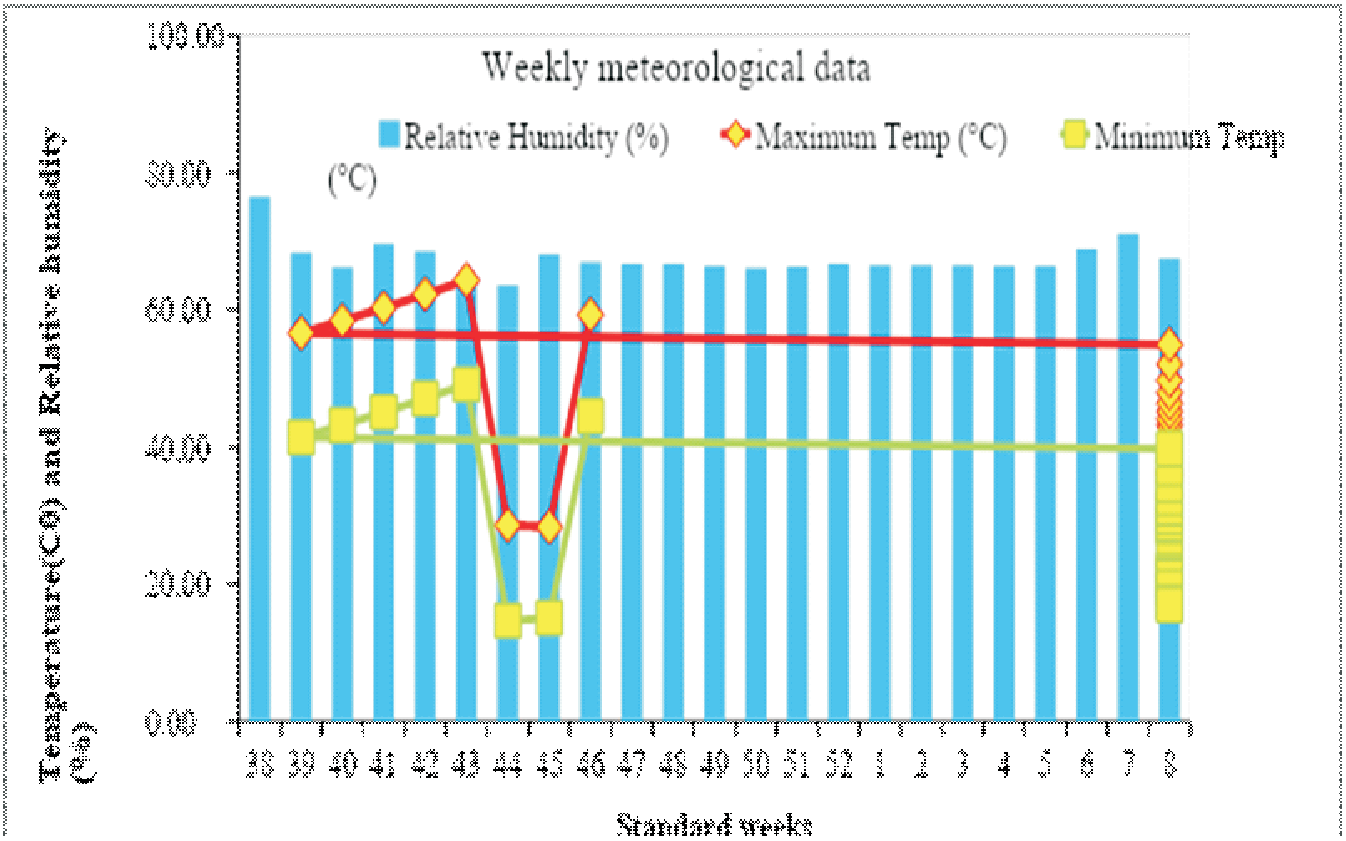

Fig. 1. Mean weekly meteorological data during the cropping season inside the polyhouse

Table 1. Details of the treatments

Growth regulator	Dose	No of Plot	Different stages of plant
GA_3	50ppm	1	Vegetative
		2	Flowering
		3	Fruiting
		4	All above three
	75ppm	5	Vegetative
		6	Flowering
		7	Fruiting
		8	All above three
NAA	50ppm	9	Vegetative
		10	Flowering
		11	Fruiting
		12	All above three
	75ppm	13	Vegetative
		14	Flowering
		15	Fruiting
		16	All above three
Control (Without any treatment)	-	17	No treatment

Table 2. Effect of different concentrations of GA3 and NAA on different growth stages of tomato plant

Treatment	Days to 50% flowering	Days to first harvest	Number of fruits per cluster	No of fruits per plant	Fruit weight (g)	Marketable yield per plant	Marketable yield per m^2 area	Fruit shape index	Inter nodal distance (cm)	Pericarp thickness (mm)	Total Soluble Solids (^{0}Brix)	Ascorbic Acid (mg/100g)	Plant height (cm)
GA_3 @ 50ppm + Vegetative stage (T_1)	26.33	77.67	6.27	52.33	55.87	2.91	17.49	0.90	9.03	0.63	6.73	24.61	252.47
GA_3 @ 50ppm + Flowering stage (T_2)	28.00	78.13	5.63	49.00	56.30	2.76	16.54	0.95	9.30	0.50	6.30	25.58	213.40
GA_3 @ 50ppm + Fruiting stage (T3)	28.33	78.27	6.03	46.67	59.20	2.76	16.56	0.85	9.80	0.50	6.20	28.57	203.00
GA_3 @ 50ppm + All above three stage (T4)	28.67	78.43	5.40	53.67	60.47	3.24	19.46	0.95	8.47	0.53	6.07	29.82	197.27
GA_3 @ 75ppm + Vegetative stage (T5)	27.33	78.23	6.07	56.33	48.87	2.75	16.50	0.90	10.17	0.57	6.70	30.97	218.80
GA_3 @ 75ppm + Flowering stage (T6)	28.33	77.17	5.77	58.00	66.37	3.85	23.09	0.80	9.23	0.57	6.00	29.17	220.00
GA_3 @ 75ppm + Fruiting stage (T7)	28.00	75.85	5.70	60.00	59.67	3.57	21.45	0.85	8.50	0.63	6.17	28.16	243.67
GA3 @ 75ppm + All above three stage (T8)	25.33	73.23	5.00	66.33	69.50	4.61	27.65	1.10	9.63	0.73	6.80	30.90	211.53
NAA @ 50ppm + Vegetative stage (T9)	29.33	79.22	7.20	48.67	68.43	3.33	19.97	0.85	9.40	0.67	6.30	25.38	196.73
NAA @ 50ppm + Flowering stage (T10)	29.00	78.75	7.47	50.67	67.27	3.41	20.44	0.90	8.07	0.63	6.60	28.92	189.07
NAA @ 50ppm + Fruiting stage (T11)	28.67	75.97	6.27	53.00	68.07	3.61	21.64	0.85	9.67	0.63	6.70	30.40	194.00
NAA @ 50ppm + All above three stage (T12)	28.33	78.55	6.13	52.00	61.03	3.17	19.04	0.90	9.53	0.70	5.63	30.83	204.07
NAA @ 75ppm + Vegetative stage (T13)	27.67	79.13	5.53	47.67	66.30	3.16	18.94	0.80	10.23	0.70	5.63	29.47	184.73
NAA @ 75ppm + Flowering stage (T14)	27.00	78.33	6.63	51.33	66.00	3.39	20.33	0.85	10.07	0.63	5.97	30.17	193.73
NAA @ 75ppm + Fruiting stage (T15)	28.67	79.67	5.90	49.33	68.00	3.35	20.12	0.85	10.37	0.67	5.97	27.84	189.00
NAA @ 75ppm + All above three stage (T16)	26.67	78.60	5.83	57.00	67.47	3.84	23.07	0.90	10.00	0.67	6.17	28.94	181.20
Control (without any treatment) (T17)	27.67	80.98	6.20	49.00	59.63	2.92	17.51	0.90	9.60	0.70	5.40	38.49	187.27
CD(P = 0.05)	1.628	N/A	1.16	2.779	3.809	0.073	0.436	N/A	N/A	N/A	N/A	2.315	8.054
SE (m)	0.563	54.208	0.401	0.96	1.316	0.025	0.151	0.049	0.731	0.051	0.327	0.8	2.783
SE (d)	0.796	76.662	0.567	1.358	1.862	0.036	0.213	0.069	1.034	0.072	0.462	1.131	3.936
C.V.	3.5	10.07	11.46	3.139	3.628	1.31	1.307	9.46	13.363	14.093	9.085	4.804	2.355

growth regulators at different crop growth stages . In the present study the shape of the fruits is desirable (but depends on plant growth regulators spray at various growth stages. Here in our study the design is Randomized complete block (factorial) design, so the character is non-significant in the particular treatment when tomato crop was sprayed with GA_3 @ 75ppm on vegetative, flowering and fruiting stages. Similarly, is the case with pericarp thickness. This might due to the fact that foliar spraying of PGRs and antioxidants was effectual as it might be contributed to more supply and accumulation of food materials in plants and its efficient mobility in plants resulting in increased growth stimulation, ultimately helped in earlier flower initiation, increased fruit set, rapid fruit development, fruit number, fruit length, fruit diameter and weight of fruits which all together enhanced fruit shape index and yield.

Total soluble solids of tomato were observed to be increased after treatment with GA_3 and NAA. Data presented in mean table 1 depicts that TSS was also highest in the treatment having GA_3 @ 75ppm on vegetative, flowering and fruiting stages. Ascorbic acid content (Vitamin C) is one of the major quality components in tomato as it improves the nutritional value of fruit. Ascorbic acid content varied significantly and application of growth regulators GA_3 @ 75 ppm produced maximum ascorbic acid and was significantly at par with treatment T_5, T_{12}, T_{14} & T_{17} (Table 2). The augment of ascorbic acid with GA_3 treatment might be either due to encouragement of biosynthesis of ascorbic acid or protection of synthesized ascorbic acid from oxidation through the enzyme ascorbic acid oxidise and gibberellins may promote the activity of acid invertase which causing an increase in hexose level in plant tissue.

Height of the plant is one of the important factor determining yield and harvest duration especially in plants with indeterminate type of growth habit under the protected structures. Taller plants are considered to be more desirable because they lead to more number of branches which ultimately bear more number of fruits and result in increased productivity. Data revealed that when NAA @ 50 ppm sprayed at vegetative stage) recorded maximum plant height which was significantly superior from all the other treatments. This might be due to the influence of plant growth regulators on the expansion and enlargement of meristematic cells. PGRs promote vegetative growth by active cell division and elongation especially in the apical portion of the plants.

From the present experiment, it has been concluded that tomato plants sprayed with GA_3 @ 75 ppm at vegetative, flowering and fruiting and stage recorded maximum marketable yield and its contributing characters.

Conflict of interest: The authors declare that there is no conflict of interest in this research paper.

References

Aloni B, Daie J and Wyse RE. 1968. Enhancement of (14C)-sucrose export from source leaves of Vicia faba by gibberellic acid. Plant Physiology **82**: 962-966.

Batlang V, VE Emongor, F Pule-Meulenburg. 2006. Effect of benzyladenine and gibberellic acid on yield and yield components of cucumber (*Cucumis sativus* L. cv. *'tempo'*). Journal of Agronomy **5**(3):418-423.

Chaudhary BR, Sharma MD, Shakya SM and Gautam DM. 2006. Effect of plant growth regulators on growth, yield and quality of chilli (*Capsicum annum* L.) at Rampur, Chitwan. Journal of Institute of Agriculture and Animal Science **27**: 65-68.

Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, New York pp 680.

Kannan K. Jawaharlal M and Prabhu M. 2009. Effect of plant growth regulators on growth and yield parameters of paprika cv. KtPl-19. Agricultural Science Digest **29**: 157-162.

Mehraj H, Sadia AA, Taufique T, Rashid M and Jamal Uddin AFM. 2014. Influence of foliar application of gibberellic acid on cherry tomato (*Lycopersicon esculentum Mill.* var. *Cerasiforme*). Journal of Experimental Bioscience **5**: 27-30.

Mostafa EAM and Saleh MMS. 2006. Influence of spraying with gibberellic acid on behavior of anna apple trees. Journal of Applied Sciences Research **2**: 477-483.

Rafeekher M, SA Nair, PN Sorte, GP Hatwal, PM Chandhan. 2002. Effect of growth regulators on growth and yield of summer cucumber. Journal of Soils Crops **12** (1):108-110.

Ranjeet, Ram RB, Jay P and Meena ML. 2014. Growth, flowering, fruiting, yield and quality of tomato (*Lycopersicon esculentum* Mill.) as influenced plant bio regulators. International Journal of Plant Science **9**: 67-71.

Sood S, Kumar Naveen, Chandel KS and Sharma Parveen. 2011. Determination of genetic variation for morphological and yield traits in bell pepper (*Capsicum annuum* var. *grossum*). Indian Journal of Agricultural Sciences **81**(7): 590-594.

Sun YL and Hong SK. 2010. Effects of plant growth regulators and L-glutamic acid on shoot organogenesis in the halophyte *Leymus chinensis* (Trin.). Plant Cell Tissue Organ Culture **100**:317-328.

Ujjwal Vivak, Singh Manoj Kumar, Dev Pavitra, Chaudhary Mohit, Kumar Ashish and Tomar Saurabh. 2018. Effect of different levels of GA_3 and NAA on vegetative growth and flowering parameters of tomato (*Solanum lycopersicum* L.). Journal of Pharmacognosy and Phytochemistry **SP1**: 146-148.