

# Effect of plant growth regulators on seed yield and seed quality traits in tomato (*Solanum lycopersicum* L.) cv. Kashi Adarsh

## ABSTRACT

A field experiment was conducted at the College of Agriculture and Research Station, Kunkuri, Jashpur, Chhattisgarh, during *rabi* 2020-21 with an aim to standardize foliar spray of plant growth regulator for higher seed yield in tomato. The experiment was laid out in randomized complete block design having nine treatments and three replications. Seedling quality traits were recorded in laboratory in completely randomized design. Foliar application of Gibberellic acid (GA<sub>3</sub>), Naphthaleneacetic acid (NAA), Cycocel and Salicylic acid in various concentrations in tomato were applied as foliar spray at 30 and 45 days after transplanting of tomato seedlings of cultivar Kashi Adarsh. Results revealed that maximum plant height (121.89 cm), number of branches per plant (10.39), number of fruits per plant length of fruit (33.06), length of fruit (4.66 cm), diameter of fruit (4.52 cm), seed yield per plant (19.14 g) was recorded in treatment foliar spray of GA<sub>3</sub> at 50 ppm. In laboratory condition seedling traits were evaluated and the highest germination (96.25 %), root length (6.78 cm), shoot length (8.76 cm), root fresh weight (0.81 g), shoot fresh weight (3.37g), root dry weight (0.061 g), shoot dry weight (0.209 g), vigour index- I (789.25) and vigour index- II (22.66) was also recorded in GA<sub>3</sub> at 50 ppm.

**Keyword:** Tomato, Plant growth regulator, GA<sub>3</sub>, Seed yield

## 1. INTRODUCTION

“Tomato (*Solanum lycopersicum* L.,  $2n = 2x = 24$ ) is one of the important vegetable crop belongs to solanaceae family and is cultivated throughout India. Has rich source of lycopene, minerals and vitamins such as ascorbic acid and  $\beta$ -carotene which are anti-oxidants and promote good health. Chhattisgarh accounts for about 4.98% of the total production of tomato in the country. The productivity of tomato crop in Chhattisgarh is 16.42 MT/Ha. which is found lower to all India average of 21.99 MT/ha. The major tomato producing districts are Raipur, Durg, Bastar, Balod and Jashpur. In Chhattisgarh, total production of tomato is 11.33 lakh MT from an area of about 0.65 thousand ha” [1]. “Non-availability of quality seeds, absence of suitable seed production technology, heavy flower drop and heavy incidence of pest and diseases, inadequate post-harvest handling operations and lack of knowledge about varieties by farmers lead to fall in productivity of tomato in Chhattisgarh. It could be enhanced by developing suitable low-cost seed production technology by combining conventional and scientific practices for achieving the commercial success of the crop” [2]. Low seed yield is also attributed to shortening of growing season and its impact on reproductive phase which might decrease in the number of flowers [3]. Attempts are to be taken to develop the seed production technique of tomato under Chhattisgarh conditions which can flourish tomato seed production as well as to compensate high cost of seed.

Seeds may require special treatments like spray of growth regulators for improving germination and overcoming dormancy [4]. “However, the improvement in yield and quality of the crop mainly depends on the concentration of plant growth regulators, method and time of application. In the present study we are concerned with plants growth regulators like (NAA), (GA<sub>3</sub>), Cycocel and Salicylic acid. NAA is commonly used in horticultural crops. It

also affects the physiological process, hasten maturity and produces better quality fruits and some other aspects such as to increase the number of branches, increased fresh weight, and yield" [5]. "It may promote cell elongation and cell division thus helps in the growth and development of many plants species. Gibberellins affect shoot elongation initiation of flower, stigma position, and fruit set, breaking dormancy, fruit size and seed number in the fruit. Keeping these facts in view the present investigation was carried out to study the effect of naphthalene acetic acid (NAA) and Gibberellic acid ( $GA_3$ ) on growth and fruit quality of tomato. Salicylic acid (SA) can affect seed germination, cell growth, stomatal opening" [6]. Moreover, SA as vase solution of gladiolus caused a significant reduction in respiration rate, and improved the vase life [7]. "Cycocel has been reported to be very effective in improving yield and quality of certain vegetable crops, which causes retardation of vegetative growth and diversion of assimilates towards reproductive growth" [8]. Information regarding the effect of foliar application of plant growth regulators on seed production of tomato is meagre in Chhattisgarh. Considering the above facts, the present study was undertaken to investigate the effect of foliar application of plant growth regulators on seed production of tomato.

## 2. MATERIAL AND METHODS

The field experiment was conducted during rabi session at the Pandaripani Farm, College of Agriculture and Research Station, IGKV, Kunkuri, District Jashpur, Chhattisgarh during 2020-21. The pure seeds of tomato variety, "Kashi Adarsh" were obtained from Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh. Seedlings were raised in the nursery bed at the Pandaripani Farm. Healthy seedlings of 25 days old were used for transplanting. Four plant growth regulators with two concentrations of each ( $GA_3$ , 25 and 50 ppm; NAA, 25 and 50 ppm; Cycocel, 250 and 500 ppm; Salicylic acid, 150 and 300 ppm) were applied as foliar spray at 30 and 45 days after transplanting of tomato seedlings of cultivar Kashi Adarsh. One control ( $T_0$ ) was used as treatment for comparing the effect of PGR's with farmer's practice, thus total nine treatments were used during the investigation. The field trial was laid out in randomized complete block design with three replications. The seedlings were transplanted at a distance of 60x45 cm. Twenty plants were maintained in a plot of 5.40 m<sup>2</sup> area. All the cultural practices and plant protection measures were followed as standard cultivation practices. The harvested seeds were tested for seedling quality traits in laboratory conditions in completely randomized design.

The observation on days to flowering, plant height (cm), number of fruits per plant, number of branches per plant, length of fruit (cm), diameter of fruit (cm), seed weight per fruit (g) and seed yield per plant was recorded in field level. The harvested seeds from each treatment were analyzed for quality traits viz., germination percentage, root length (cm), shoot length (cm), root fresh weight (g), shoot fresh weight (g), root dry weight (g), shoot dry weight (g), vigour index-I (length) and vigour index-II (mass) during May 2022 in Horticulture Laboratory, College of Agriculture and Research Station, Kunkuri in completely randomized design with three replications. "Data were collected from five randomly selected plants from each plot. The means for all the treatments were calculated and the analyses of variance for all the characters were performed by F test. The significance of difference between the pairs of means was separated by LSD test at 5% and 1% levels of probability" [9].

**Table 1. Physical, chemical and biological properties of experimental soil (0-20 cm)**

Particulars	Value	Methods
Sand (%)	62	[10]
Silt (%)	17	[10]
Clay (%)	21	[10]
pH (1 : 2.5:: Soil : Water)	6.50	[10]
Organic carbon (%)	0.49	Walkley and Black's method [11]
N (kg/ha)	161	Alkaline potassium permanganate method [12]
P (kg/ha)	19.17	Olsen's method [13]
K (kg/ha)	184	Flame photometer [14]

### 3. RESULTS AND DISCUSSION

#### 3.1 Effect of plant growth regulators in growth and seed yield traits of tomato

Four different plant growth regulators at two different concentrations were assessed to see the effect on growth and seed yield **attributing** traits in tomato cv. Kashi Adarsh and data is presented in Table 2. All seed yield traits (days to flowering, plant height, branch numbers, fruit numbers, fruit length, fruit diameter, seed numbers, seed weight and seed yield) were found significant except days to flowering in tomato with respect to different plant growth regulators.

Effect of different plant growth regulators did not differ significantly for days taken for flowering in tomato and it varied from 35.43-36.87 days. However, control treatment took maximum days for flowering. **These results are in** conformity with the finding of Sharma et al. [15] **who** reported that growth regulators did not influence days to flowering in tomato. It was observed that application of different plant growth regulators significantly increased plant height as compare to control treatment ( $T_0$ ). Application of  $GA_3$  at 50 ppm ( $T_2$ ) **resulted in** the highest plant height (121.89 cm) over the rest of treatments and it was significantly superior overall other treatments. Results are in line with the finding of Rahman et al. [16] and Ramteke et al. [17]. Likewise, significantly highest number of branches per plant (10.39) **was** produced in  $T_2$ , where as **control** ( $T_0$ ) exhibited similar lowest trend for growth and seed yield traits viz; days to flowering (37.07 days), plant height (92.05 cm) and number of branches per plant (8.31). Tomato plant treated with  $GA_3$  **at** 50 ppm showed significantly higher number of branches per plant than untreated control. This might be due to the rapid increase in cell division and cell elongation in the meristematic region. Results are in line with the finding of Rai et al. [18].

Number of fruits per plant were maximum with application of  $GA_3$  **at** 50 ppm ( $T_2$ ) and it was significantly superior overall other used treatments. Significantly least number of fruits per plant **was** recorded in control ( $T_0$ ). The length of fruit showed a gradual increasing trend for different plant growth regulators in comparison to control ( $T_0$ ). Application of  $GA_3$  **at** 50 ppm ( $T_2$ ) exerted significantly highest length (4.66 cm) of fruit and it was remained superior over other treatments. Control ( $T_0$ ) treatment exerted significantly the minimum length (3.96 cm) of fruit in tomato.  $GA_3$  promote cell enlargement and cell division that enhance plant height, number of branches and number of leaves which results in higher accumulation of photosynthates in the plants. These results are in agreement with results of Sanyal et al. [19] and Gelmasa et al. [20] in tomato. Spraying of  $GA_3$  **at** 50 ppm, exerted significantly maximum diameter (4.52 cm) of fruit. The significantly least diameter (3.03 cm) of fruit was observed in control ( $T_0$ ). Generally, fruit yield is dependent on the yield attributes such as: number of fruits per plant, size (length and diameter) and weight of fruits. If such attributes contribute positively due to growth regulators resulting in higher yield. The results are in conformity with the findings of Tiwari and Singh [21] and Singh et al. [22] in tomato.

Application of both NAA at 50 ppm ( $T_4$ ) and salicylic acid at 300 ppm ( $T_8$ ) produced significantly maximum number of seed per fruit (126.43). While, significantly least number of seed per fruit (115.33) was recorded in Cycocel at 250 ppm ( $T_5$ ). Similar trend was recorded for seed weight which was significantly highest in both  $T_4$  and  $T_8$  (0.39g). The minimum seed weight per fruit was observed in Cycocel at 250 ppm (0.24 g). Application of  $GA_3$  at 50 ppm ( $T_2$ ) produced significantly highest seed yield per plant (19.14 g). Whereas, as other traits significantly minimum seed yield per plant (15.40g) also was produced in control ( $T_0$ ). The higher seed yield and number of seeds in plant growth regulators treatments might be due to an inhibition of vegetative growth and thus making available the food reserves for developing fruits, which was evident from the significantly increased number of fruits and seed yield per plant. Results are in accordance with findings of Uddain et al. [23] in tomato.

UNDER PEER REVIEW

**Table 2. Effect of plant growth regulators in growth and seed yield traits in tomato**

Treatment	Days to flowering	Plant height (cm)	Number of branches per plant	Number of fruits per plant	Length of fruit (cm)	Diameter of fruit (cm)	Number of seeds per fruit	Seed weight per fruit (g)	Seed yield per plant (g)
T <sub>0</sub> : Control	37.07	92.05	8.31	26.20	3.96	4.03	119.51	0.31	15.40
T <sub>1</sub> : GA <sub>3</sub> at 25 ppm	35.43	109.32	9.56	31.23	4.36	4.34	116.56	0.27	18.02
T <sub>2</sub> : GA <sub>3</sub> at 50 ppm	34.81	121.89	10.39	33.06	4.66	4.52	118.14	0.26	19.14
T <sub>3</sub> : NAA at 25 ppm	36.87	106.74	9.12	29.54	4.23	4.09	123.34	0.29	17.98
T <sub>4</sub> : NAA at 50 ppm	35.19	110.86	9.33	31.82	4.54	4.38	126.43	0.39	18.44
T <sub>5</sub> : Cycocel at 250 ppm	36.32	95.43	9.65	28.67	4.17	4.23	115.33	0.24	17.06
T <sub>6</sub> : Cycocel at 500 ppm	36.25	100.65	9.82	29.94	4.19	4.27	118.47	0.25	17.48
T <sub>7</sub> : Salicylic acid at 150 ppm	36.21	105.43	9.42	29.75	4.28	4.17	121.43	0.32	17.98
T <sub>8</sub> : Salicylic acid at 300 ppm	35.99	109.86	9.98	31.12	4.44	4.38	126.43	0.39	18.64
S.E.m ±	0.78	3.02	0.25	0.69	0.12	0.13	1.97	0.01	0.32
C.D. ( $p=0.05$ )		8.99	0.73	2.01	0.36	0.37	5.68	0.03	0.91

### 3.2 Effect of plant growth regulators in seed germination and seedling traits of tomato

Data pertaining to germination, root length, shoot length, root and shoot weight (fresh and dry) vigour index-I and II during subsequent growing found significant with respect to different plant growth regulators which are depicted in Table 2.

GA<sub>3</sub> at 50 ppm (T<sub>2</sub>) gave significantly highest (96.25%) germination followed by salicylic acid at 150 ppm (93.50%). While, significantly minimum seed germination (86.00%) was noticed in Cycocel at 250 ppm (T<sub>5</sub>). Endogenous GA<sub>3</sub> helps in breaking dormancy of seed. It also catalyzes different biochemical reactions inside the seed, which improves germination rate and its uniformity. Higher germination may be due to increased activity of redox enzyme in seeds harvested in GA<sub>3</sub> treatment, which helps in quick breakdown of complex food into simple soluble sugars and also increase germination. The present findings are in conformity with the findings of Patil et al. [24].

GA<sub>3</sub> at 50 ppm (T<sub>2</sub>) gave significantly longest root length (6.78 cm) and it was statistically at par with treatments NAA at 25 ppm and NAA at 50 ppm (T<sub>3</sub> and T<sub>4</sub>). While, significantly smallest root length (4.45cm) was recorded in control (T<sub>0</sub>). Shoot length was significantly influenced by GA<sub>3</sub> at 50 ppm (T<sub>2</sub>) which gave longest shoot length (8.76cm) and significantly minimum (5.78cm) shoot length was observed in control (T<sub>0</sub>). This might be due to synthesis of protein in plants get accelerated, which is indirectly exhibited by increase in size of different plant parts. GA<sub>3</sub> treatment helps to increase cell division, cell elongation and cell multiplication which might have reflected into maximum seedling shoot length. These results are in accordance with results obtained by Thorat et al. [25].

The data presented in Table 3 revealed that GA<sub>3</sub> at 50 ppm (T<sub>2</sub>) exerted significantly highest root fresh weight (0.81g). The minimum root fresh weight (0.59g) was observed in control (T<sub>0</sub>). Similarly, significantly highest shoot fresh weight (3.37g) was recorded in GA<sub>3</sub> at 50 ppm (T<sub>2</sub>). The minimum shoot fresh weight (2.65g) was observed in control (T<sub>0</sub>). Root dry weight was significantly influenced by GA<sub>3</sub> at 50 ppm (T<sub>2</sub>) and recorded maximum root dry weight (0.061g). The minimum root dry weight (0.042g) was observed in Cycocel at 250 ppm (T<sub>5</sub>). GA<sub>3</sub> at 50 ppm (T<sub>2</sub>) recorded significantly maximum shoot dry weight (0.209 g) and minimum shoot dry weight (0.162 g) was observed in control (T<sub>0</sub>). "The maximum dry weight of seedling with seed harvested in GA<sub>3</sub> treatment can be correlated with higher overall growth in the corresponding treatment of GA<sub>3</sub>. Hence, it can be stated that increase in overall growth of the seedling has led to the overall assimilation and redistribution of food material with the seedling" [26].

Vigour index showed similar trend in term of influence by different treatments and it was maximum in GA<sub>3</sub> at 50 ppm (T<sub>2</sub>) while it was minimum in control (T<sub>0</sub>). Vigour index-I (789.25) was significantly highest in T<sub>2</sub> and at with other all treatments. The minimum vigour index-I (656.64) was observed in treatment T<sub>0</sub>. Vigour index-II (22.66) was recorded significantly highest in T<sub>2</sub>. Whereas, minimum vigour index-II (18.16) was observed in T<sub>0</sub> in tomato. The vigour index I of seedlings is directly dependent on germination percentage and seedling length. Higher seedling vigour index I in GA<sub>3</sub> treated seeds might be due to the cumulative effect of higher seedling length and germination percentage which were greatly influenced by GA<sub>3</sub> in tomato. The similar results were reported by Thorat et al. [25] and Vaja et al. [27].

**Table 3. Effect of plant growth regulators in seed germination and seedling traits in tomato**

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)	Root fresh weight (g)	Shoot fresh weight (g)	Root dry weight (g)	Shoot dry weight (g)	Vigour index- I	Vigour index- II
T <sub>0</sub> :Control	89.67	4.45	5.78	0.59	2.65	0.042	0.162	656.64	18.16
T <sub>1</sub> :GA <sub>3</sub> at 25 ppm	92.34	6.42	8.29	0.71	3.09	0.054	0.187	731.39	20.96
T <sub>2</sub> :GA <sub>3</sub> at 50 ppm	96.25	6.78	8.76	0.81	3.37	0.061	0.209	789.25	22.66
T <sub>3</sub> :NAA at 25 ppm	89.00	6.48	8.23	0.71	2.99	0.051	0.173	696.31	18.98
T <sub>4</sub> :NAA at 50 ppm	92.10	6.76	8.29	0.73	3.13	0.057	0.185	721.29	20.46
T <sub>5</sub> :Cycocel at 250 ppm	86.00	6.18	7.89	0.64	2.89	0.041	0.167	666.35	18.98
T <sub>6</sub> :Cycocel at 500 ppm	90.10	6.34	8.02	0.67	3.02	0.046	0.181	704.22	20.46
T <sub>7</sub> :Salicylic acid at 150 ppm	93.50	5.64	7.89	0.64	2.87	0.048	0.171	692.88	19.03
T <sub>8</sub> :Salicylic acid at 300 ppm	92.10	5.24	8.22	0.70	3.08	0.053	0.182	701.19	21.24
S.E.m. ±	0.98	0.11	0.13	0.01	0.03	0.007	0.032	4.67	0.21
C.D. ( $p=0.05$ )	2.84	0.31	0.37	0.03	0.08	0.002	0.011	13.48	0.59

#### 4. CONCLUSION

Application of GA<sub>3</sub> at 50 ppm was found a best treatment, as it has produced the maximum parameters like plant height, number of fruits per plant, diameter of fruit and seed yield per plant except day to flowering. Day to flowering is non-significant means no effect in growth and development of plant and also seed production. Therefore, foliar application of GA<sub>3</sub> at 50 ppm at 30 and 45 days after transplanting can increase seed yield and seed quality of tomato cv. Kashi Adarsh.

#### REFERENCES

1. Anonymous. Area, production and productivity. Directorate of Horticulture, Government of Chhattisgarh, Raipur (C.G.). (Chhattisgarh State Horticulture Department). 2018.
2. Pramoda, Sajjan AS, Malabasari TA and Shashidhar TR. Seed and yield parameters as influenced by season and plant growth regulators in Dolichos Bean [*Lablab Purpureus* L. (Sweet)]. Legume Res. 2020;43(6):856-860.
3. Thakur K, Katiyar P and Ramteke V. Physiological and growth response of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] varieties to different growing seasons. The Ecoscan. 2016;9:651-657.
4. Momin J, Dikshit SN, Sharma GL, Panigrahi HK and Ramteke V. Effect of different seed treatments on seed germination and seedling vigour in tamarind (*Tamarindus indica* L.). J Agril Issues. 2018;23(2):45-52.
5. Revanappa NUG. Influence of NAA and cytokinin on growth and yield of chili. Karnataka J Agri Sci. 1998;11(4):1136-1139.
6. Klessig DF, Vlot CA and Dempsey DA. Salicylic acid, a multifaceted hormone to combat disease. Ann Revi Phytopathol. 2009;47:177-206.
7. Kashyap S, Shukla N, Ramteke V and Shukla A. Influence of citric acid, boric acid and salicylic acid on vase life of cut spikes of gladiolus (*Gladiolus grandiflorus* L.). Trends Biosci. 2017;10(25):5354-5355.
8. Nerson H, Cohen R, Edelstein M, Burger Y. Paclobutrazol. A plant growth retardant for increasing yield and fruit quality in Muskmelon (*Cucumis melo*). J Amer Soc Hort. Sci. 1989;114:762-766.
9. Gomez, KA and Gomez A. Statistical Procedure for Agricultural Research. Hand Book. John Wiley & Sons, New York;1984.
10. Jaiswal PC. Soil plant and water analysis, 2nd Edition Kalyani publisher Ludhiyana India. 2006.
11. Walkley AJ and Black AL. Estimation of organic carbon by chromic acid titration method. Soil Sci. 1934;37:29-38.
12. Subbiah BV and Asija GL. A rapid procedure for the estimation of available Nitrogen in soils. Current Sci. 1956;25:259-260.
13. Olsen SR. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture. 1954;939:1-19.
14. Jackson ML. Soil Chemical Analysis. Prentice Hall Pvt. Ltd., New Delhi. 1973;66-182.
15. Sharma AK, Rattan RS and Pathania NK. Effect of plant growth regulators on yield and morphological traits in brinjal. Agric. Sci. Digest. 1992;4:219-222.
16. Rahman MS, Haque MA and Mostofa MG. Effect of GA<sub>3</sub> on bio-chemical attributes and yield of summer tomato. J. Bios. Agric. Res. 2015;3(2):73-78.
17. Ramteke V, Paithankar DH, Kamatyanatti M, Baghel M, Chauhan J and Kurrey V. Seed germination and seedling growth of papaya as influenced by GA<sub>3</sub> and propagation media. Int. J. Farm Sci. 2015;5(3):74-81.

18. Rai N, Yadav DS, Patel KK, Yadav RK, Asati BS and Chaudey T. Effect of plant growth regulators on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill). Veg. Sci. 2006;33(2):180-182.
19. Sanyal D, Kar PL and Longkumar M. Effect of growth regulators on the physico-chemical composition of tomato (*Lycopersicon esculentum* Mill). J Horticult For. 1995;67-71.
20. Gelmesa D, Abebie B and Desalegn L. Effects of gibberellic acid and 2, 4-dichlorophenoxyacetic acid spray on fruit yield and quality of tomato (*Lycopersicon esculentum* Mill.). J. Plant Breed. Crop Sci. 2010;2(10):316-324.
21. Tiwari AK and Singh DK. Use of plant growth regulators in tomato (*Solanum lycopersicum* L.) under Tarai conditions of Uttarkhand. Indian J. Hill Farm. 2014;27(2):38-40.
22. Singh SK, Kumar A, Beer K, Singh VP and Patel SK. Effect of naphthalene acetic acid (NAA) and gibberellic acid (GA<sub>3</sub>) on growth and fruit quality of tomato (*Lycopersicon esculentum* Mill.). Int. J. Curr. Microbiol. App. Sci. 2018;7(3):306-311.
23. Uddain J, Hossain KMA, Mostafa MG and Rahman MJ. Effect of different plant growth regulators on growth and yield of tomato. Int. J. Sustain. Agric. 2009;1,58-63.
24. Patil SB, Merwade MN and Vyakaranahal BS. Effect of growth regulators and fruit load on seed yield and quality in brinjal hybrid seed production. Indian J. Agril. Res. 2008;42(1):25-30.
25. Thorat BS, Patil RR and Kamble AR. Effect of growth regulators on germination and vigour of cow pea (*Vigna unguiculata* L. Walp.) seeds. Int. J. Chem. Stud. 2017;5(6):766-769.
26. Brain PW and Hemming HG. The effect of GA<sub>3</sub> on shoot growth of pea seedlings. Physiolo. Planarum. 1955;8:669-681.
27. Vaja AD, Patel J.B, Daki RN, and Chauhan SA. Effect of nitrogen and plant growth regulators on seed yield per plant and seed quality parameters in brinjal (*Solanum melongena* L.). J. App. Nat. Sci. 2017;9:2338-2343.