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Research Article

EFFECT OF PLANT GROWTH REGULATORS ON SEED YIELD AND ITS PARAMETERS IN TOMATO (*Solanum lycopersicon* L.)

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Abstract- A field experiment was conducted at the Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh, during *kharif* 2015-16 with an aim to study the plant growth regulators [G_0 (control), G_1 (50 ppm GA_3), G_2 (50 ppm NAA) and G_3 (500 ppm Cycocel)] on seed yield per plant, its components and seed parameters of tomato cv. Gujarat Tomato 3 (GT-3). One month old healthy seedlings were transplanted in the field. The experiment was laid out in field as per randomized block design (Factorial) with three replications. The characters *viz*., days to flowering, plant height (cm), number of branches per plant, number of fruit per plant, length of fruit (cm), diameter of fruit (cm), number of seeds per fruit, seed weight per fruit (g) and seed yield per plant (g) were recorded as field observations, while germination percentage, root length (cm), shoot length (cm), root fresh weight (g), shoot fresh weight (g), root dry weight (mg), shoot dry weight (mg), Vigour index-I and Vigour index-II were recorded in the laboratory of Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh.

Keywords- Plant growth regulator, Tomato, GA_3, cycocel, NAA.

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Introduction

Tomato (*Solanumly copersicum* L., 2n = 2x = 24) is one of the important vegetable crop belongs to solanaceae family and being cultivated throughout India. Tomato is one of the most important – "protective foods" because of its special nutritive value and widespread production. As far as the nutritive value is concerned with respect to human health, it has rich source of lycopene, minerals and vitamins such as ascorbic acid and β-carotene which are anti-oxidants and promote good health. Tomato is highly nutritious as it contains 94.1% water, 23 calories energy, 1.90 g protein, 1 g calcium, 7 mg magnesium, 1000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamin, 0.03 mg riboflavin, 0.8 mg niacin per 100g edible portion [1]. Tomato is a warm season crop and requires relatively long season to produce a profitable crop. In tomato, the process of fruit set of tomato and subsequent in fruit development and yield is highly affected to environment stresses such as frost, temperature and moisture etc [2]. The major tomato growing countries are China, India, USA, Turkey, Egypt and Italy.

Tomato is the world's third largest vegetable crop after potato and sweet potato, but it tops the list of capped vegetables. Tomatoes are used for soup, salad, pickles, ketchup, puree, sauces etc. It is now the most important and remunerative vegetable in India. In India, during 2014-15, tomato occupies an area of above 8.82 lakh hectares with production of 18.73 million tones with a productivity of 21.2 MT/ha Sikkim, Uttar Pradesh, Maharashtra, Karnataka, Bihar, Orissa are the major tomato growing states [3]. Because of suitable agro-climatic conditions of Sikkim, tomato is grown throughout year. In Gujarat, during 2014-15, it is cultivated in 44.57 thousand hectares giving a production of 12.59 lakh tones with a productivity of 28.2 MT/ha.

Material and Methods

The fresh seeds of tomato variety, "Gujarat Tomato 3" were obtained from Main Vegetable Research Station, Junagadh Agriculture University, Junagadh used in study. A field experiment was carried out during *kharif* season of the year 2015. Seedlings were raised in the big size pots at the Department of Seed Science and Technology. The tomato seeds were sown in pots on July 20, 2015. Healthy seedlings of about one-month old were used for transplanting. The field experiment was conducted at the Instructional farm, Department of Agronomy, Junagadh Agriculture University, Junagadh. The laboratory study was carried out in the laboratory of Department of Seed Science and Technology, College of Agriculture, Junagadh Agriculture University, Junagadh.Total 16 treatment combinations comprising 4 levels of plant growth regulators were included in the study. Four levels of plant growth regulators *viz*., G_0 = Control, G_1 = 50 ppm GA_3,G_2 = 50 ppm NAA and G_3= 500 ppm Cycocel. The observation on Days to flowering, Plant height (cm), Number of fruit 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 and Germination percentage, Root length (cm), Shoot length (cm), Root fresh weight (g), Shoot fresh weight (g), Root dry weight (mg), Shoot dry weight (mg), Vigour Index (length) and Vigour index (mass) was recorded in laboratory of Seed Science and Technology, J.A.U. Junagadh. Statistical analysis of the data was worked out using Randomized Block Design (Factorial) and Completely Randomized Block Design (Factorial) for each character and treatment were compared by critical difference at five percent and one percent levels of significance. The results are accordance with the results of field and laboratory levels in tomato [4].

Results and Discussions

Days to flowering: The data presented in [Table-1] revealed that the effect of

plant growth regulators was non-significant for days to flowering. However, numerically application of plant growth regulators @ 500 ppm CCC (G_3)recorded the higher days to flowering (46.25) in tomato. Sharma *et al.* (1992) also reported that growth regulators did not influence days to flowering in tomato [5].

Plant height (cm): The effect of plant growth regulators was significant for plant height. It was observed that application of different plant growth regulators increase plant height significantly as compared to control (74.05 cm). Application of GA_3 at 50 ppm (G_1) recorded the significantly the highest plant height (79.69 cm) and it was at par with application of CCC @ 500 ppm (77.65 cm) and NAA @ 50 ppm (76.86 cm) in tomato). Bokade *et al.* (2006) and Rahman *et al.*(2015) reported the maximum plant height with GA_3 50 ppm treatment compared to control in tomato [6].

Table-1 *Effect of nitrogen and plant growth regulators on days to flowering, plant height and number of branch per plant in tomato.*

Treatment	Days to flowering	Plant height (cm)	Number of branches per plant
Plant growth regulators			
G_0 = Control	46.07	74.05	8.31
G_1 = 50 ppm GA3	45.91	**79.69**	**9.39**
G_2 = 50 ppm NAA	45.99	76.86	8.33
G_3 = 500 ppm Cycocel	**46.25**	77.65	9.18
Mean	46.05	77.06	8.80
S.Em. ±	0.81	1.35	0.24
C.D. at 5 %	NS	3.89	0.69

Table-2 *Effect of nitrogen and plant growth regulators on number of fruit per plant, length of fruit (cm) and diameter of fruit (cm) in tomato.*

Treatment	Number of fruit per plant	Length of fruit (cm)	Diameter of fruit (cm)
Plant growth regulators			
G_0 = Control	27.20	3.96	4.03
G_1 = 50 ppm GA3	**31.06**	**4.36**	**4.32**
G_2 = 50 ppm NAA	29.12	3.94	3.68
G_3 = 500 ppm Cycocel	28.94	4.29	3.27
Mean	29.08	4.14	3.82
S.Em. ±	0.69	0.12	0.13
C.D. at 5 %	1.98	0.36	0.37

Number of branches per plant: The effect of plant growth regulators was significant for number of branches per plant. Application of GA_3 @ 50 ppm (G_1) produced significantly the highest number of branches per plant (9.39) and it was at par with G_3 treatment (9.18). Control (G_0)treatment produced significantly the lower number of branches per plant (8.18) in tomato. Tomar and Ramgiry (1997) and Rai *et al.* (2006) reported that tomato plant treated with 50 ppm GA_3 showed significantly higher number of branches per plant than untreated control [7,8].

Number of fruit per plant:
Number of fruit per plant was significantly influenced by plant growth regulators [Table-2], wherein significantly the highest number of fruit per plant (31.06) was produced by application of GA_3 50 ppm (G_1)and it was at par with NAA@ 50 ppm (G_2)(29.12). Significantly the lower number of fruits per plant was recorded in control (G_0) (27.20). Generally, fruit yield is dependent on the yield attributes such as number of fruit per plant. In present study, Maximum number of fruit per plant recorded with the application of GA_3 @ 50 ppm (G_1) and superior compared to other growth regulators and control in tomato. The results are in conformity with the finding of Kaushik *et al.* (1974), Mehta and Mathi (1975), Saha*et al.* (2009), Choudhury *et al.* (2013) and Tiwari and Singh (2014) in tomato [9-13].

Length of fruit (cm): The effect of plant growth regulators was significant for length of fruit. The length of fruit showed a gradual increasing trend for different plant growth regulators in comparison to control. Application of GA_3 50 ppm (G_1) exerted significantly the maximum length of fruit (4.36 cm) and it was remained at par with treatment cycocel 500 ppm (G_3) (4.29 cm). Control (G_0) treatment exerted significantly the minimum length of fruit (3.96 cm) in tomato. These results are in agreement with results of Sanyal *et al.* (1995) and Gelmasa *et al.* (2010) in tomato [14,15].

Diameter of fruit (cm): The effect of plant growth regulators was significant for diameter of fruit. Spraying of GA_3 50 ppm, (G_1) exerted significantly the maximum diameter of fruit (4.32 cm) and it was at par with control (G_0) (4.03 cm). The significantly minimum diameter of fruit (3.27 cm) was observed in CCC 500 ppm (G_3) in tomato. The results are in accordance with the finding of Tiwari and Singh (2014) in tomato.

Table-3 *Effect of nitrogen and plant growth regulators on number of seeds per fruit, seed weight per fruit (g) and seed yield per plant (g) in tomato*.

Treatment	Number of seeds per fruit	Seed weight per fruit (g)	Seed yield per plant (g)
Plant growth regulators			
G_0 = Control	117.51	0.34	15.40
G_1 = 50 ppm GA3	118.14	0.16	**18.94**
G_2 = 50 ppm NAA	**126.43**	**0.39**	16.64
G_3 = 500 ppm Cycocel	118.47	0.25	16.68
Mean	120.14	0.28	16.91
S.Em. ±	1.97	0.01	0.31
C.D. at 5 %	5.68	0.03	0.89

Number of seeds per fruit: The data on number of seeds per fruit as influenced by plant growth regulators are presented in [Table-3]. The effect of plant growth regulators was significant on number of seeds per fruit. The application of NAA 50 ppm (G_2) retained the first position by producing significantly the highest number of seed per fruit (126.43) and significantly the lowest number of seed per fruit was recorded in control (G_0) (117.51) in tomato.

Seed weight per fruit (g): The data of seed weight per fruit as influenced by plant growth regulators are presented in [Table-3].The effect of plant growth regulators was found significant for seed weight per fruit. Among the plant growth regulators treatments, NAA 50 ppm (G_2) registered first position by producing significantly the highest seed weight per fruit (0.39g). The minimum seed weight per fruit was observed in GA_3 50 ppm (G_1) (0.16g) in tomato.

Seed yield per plant (g): The data of seed yield per plant as influenced by plant growth regulators are presented in [Table-3].The effect of plant growth regulators was significant for seed yield per plant. Application of GA_3 @ 50 ppm (G_1) produced significantly the highest seed yield per plant (18.94 g). Significantly the minimum seed yield per plant was recorded in control (Go) (15.40g) in tomato. Results are in accordance with Uddain*et.al.* (2009) in tomato[16].

Seed germination (%): The results on seed germination in percentage as influenced by plant growth regulators are presented in [Table-4]. Effect of plant growth regulators was significant on seed germination. The application of plant growth regulators GA_3 50 ppm (G_1) recorded significantly the highest germination

percentage (96.25%) and it was at par with cycocel 500 ppm (G_3) (93.50%). Significantly the minimum seed germination was observed in NAA 50 ppm (G_2) (86.00%) in tomato.

Root length (cm): The data on root length as influenced by plant growth regulators are presented in [Table-4].The application of plant growth regulators GA_3 50 ppm (G_1) recorded significantly the highest root length (6.80 cm) and it was at par with cycocel 500 ppm (G_3) (6.64 cm). Significantly the lowest root length was recorded in control (G_0) (4.85cm) in tomato.

Shoot length (cm): The results on shoot length as influenced by plant growth regulators are presented in [Table-4]. Shoot length was significantly influenced by application of plant growth regulators which is presented in [Table-4]. The application of plant growth regulator GA_3 @ 50 ppm (G_1) recorded significantly the highest shoot length (8.76cm). Significantly the minimum shoot length was observed in CCC 500 ppm (G_3) (7.89cm) in tomato.

Table-4 *Effect of nitrogen and plant growth regulators on germination percentage, root length (cm) and shoot length (cm) in tomato.*

Treatment	Germination (%)	Root length (cm)	Shoot length (cm)
Plant growth regulators			
G_0 = Control	92.67	4.85	8.40
G_1 = 50 ppm GA3	**96.25**	**6.80**	**8.76**
G_2 = 50 ppm NAA	86.00	6.18	8.13
G_3 = 500 ppm Cycocel	93.50	6.64	7.89
Mean	92.10	6.12	8.29
S.Em. ±	0.98	0.11	0.12
C.D. at 5 %	2.84	0.30	0.34

Root fresh weight (g): Effects of plant growth regulators on root fresh weight are presented in [Table-5].The perusal of data presented in [Table-5] revealed that plant growth regulators significantly influenced root fresh weight. Application of plant growth regulator GA_3 @ 50 ppm (G_1) recorded significantly the highest root fresh weight (0.81g). The minimum root fresh weight (0.59g) was observed in control (G_0) in tomato.

Shoot fresh weight (g): Effects of plant growth regulators on shoot fresh weight are presented in [Table-5]. The perusal of data presented in [Table-5] revealed that plant growth regulators significantly influenced shoot fresh weight. The application of plant growth regulator GA_3 50 ppm (G_1) recorded significantly the highest shoot fresh weight (3.37g). The minimum shoot fresh weight (2.87g) was observed with control (G_0) as well as cycocel (G_3) in tomato.

Root dry weight (mg): The results on root dry weight as influenced by plant growth regulators are presented in [Table-5]. Root dry weight was significantly influenced by plant growth regulators, which is presented in [Table-5]. The application plant growth regulator GA_3 @ 50 ppm (G_1) recorded significantly the highest root dry weight (0.05mg). The minimum root dry weight was observed in NAA 50 ppm (G_2) (0.04mg) in tomato.

Shoot dry weight (mg): The results on shoot dry weight as influenced by plant growth regulators are presented in [Table-6]. Shoot dry weight was significantly influenced by plant growth regulators, which is presented in [Table-6]. The application of plant growth regulator GA_3 @ 50 ppm (G_1) recorded significantly the highest the shoot dry weight (0.20mg). The minimum shoot dry weight was observed in NAA 50 ppm (G_2) (0.16mg).

Vigour index I (length): The results on vigour index 1 (length) as influenced by nitrogen stages and plant growth regulators are presented in [Table-6]. Vigour index 1 (length) was significantly influenced by plant growth regulators, which is presented in [Table-6]. The application of plant growth regulator GA_3 @ 50 ppm (G_1) recorded significantly the highest vigour index 1 (length) (789.25). The minimum vigour index 1 (length) (666.35) was observed in treatment NAA 50 ppm (G_2) in tomato.

Vigour index II (mass): The result on vigour index 2 (mass) as influenced by plant growth regulators are presented in [Table-6]. Vigour index 2 (mass) was significantly influenced by plant growth regulators, which is presented in [Table-6]. The application plant growth regulator GA_3 @ 50 ppm (G_1) recorded significantly the highest vigour index 2 (mass) (22.66). The minimum vigour index 2 (mass) (18.98) was observed in treatment NAA 50 ppm (G_2) in tomato.

Table-5 *Effect of nitrogen and plant growth regulators on root fresh weight (g), shoot fresh weight (g) and root dry weight (mg) in tomato.*

Treatment	Root fresh weight (g)	Shoot fresh weight (g)	Root dry weight (mg)
Plant growth regulators			
G_0 = Control	0.59	2.87	0.05
G_1 = 50 ppm GA3	**0.81**	**3.37**	**0.05**
G_2 = 50 ppm NAA	0.68	2.99	0.04
G_3 = 500 ppm Cycocel	0.76	2.87	0.04
Mean	0.71	3.03	0.05
S.Em. ±	0.01	0.03	0.00
C.D. at 5 %	0.03	0.09	0.00

Table-6 *Effect of nitrogen and plant growth regulators on shoot dry weight (mg), vigour index- I (length) and vigour index- II (mass) in tomato.*

Treatment	Shoot dry weight (mg)	Vigour index- I (length)	Vigour index- II (mass)
Plant growth regulators			
G_0 = Control	0.17	696.68	21.16
G_1 = 50 ppm GA3	**0.20**	**789.25**	**22.66**
G_2 = 50 ppm NAA	0.16	666.35	18.98
G_3 = 500 ppm Cycocel	0.17	692.88	19.03
Mean	0.18	711.29	20.46
S.Em. ±	0.00	4.67	0.21
C.D. at 5 %	0.00	13.48	0.59

Conclusion: Application of CCC @ 500 ppm was found a best suited, as it has produced the maximum plant height, number of fruits per plant, diameter of fruit and seed yield per plant. Therefore, application of spraying of CCC @ 500 ppm (G_3) at 45 days after transplanting is suitable combination for the tomato seed production cv. GT 3.

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Abbreviations: GA3-Giberellic Acid, NAA-Napthelic Acetic Acid, CCC-Cycocel

Ethical approval: This studies is a plant science studies and does not required any testing on animals and human being. This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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