Asian Australas. J. Biosci. Biotechnol. 2016, 1 (3), 514-520

Asian-Australasian Journal of Bioscience and Biotechnology
ISSN 2414-1283 (Print) 2414-6293 (Online)
www.ebupress.com/journal/aajbb

Article

Morphological characters and dry mass production in winter tomato as affected by foliar application of plant growth regulators

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Received: 06 November 2016/Accepted: 14 December 2016/ Published: 28 December 2016

Abstract: A field experiment was conducted at the field laboratory of Crop Botany Department, Bangladesh Agricultural University, Mymensingh to study the effect of different levels of plant growth regulators, PGRs (GA_3, NAA) on the growth and yield in two tomato varieties. The experiment was laid out in a three factorial randomized completely block design (RCBD) with 16 treatments viz. 2 varieties (Ratan and Roma V.F.) × 2 PGRs (GA_3, NAA) × 4 concentration levels of PGRs (0, 25, 50 and 100 ppm). The result showed that tomato variety Ratan produced higher yield (3.92 kg plant^{-1}) by increasing plant height, stem diameter at base, branch plant^{-1}, leaves plant^{-1}, fresh and dry weight of leaves, number of flowers plant^{-1} than the variety Roma V.F. (3.71 kg plant^{-1}). PGRs enhanced plant height, number of leaves plant^{-1}, fresh and dry weight of leaves, etc. A higher yield was observed in plants treated with GA_3 (4.07 kg plant^{-1}) than in the plants treated with NAA (3.55 kg plant^{-1}). Among the concentrations of PGRs, 50 ppm exhibited better performances producing higher yield (5.02 kg plant^{-1}). Interaction effects of variety, PGR and concentration showed that higher yield (5.06 kg plant^{-1}) was derived from the variety Ratan when treated with 50 ppm of GA_3.

Keywords: Plant growth regulators (PGR); winter tomato; foliar application; yield

1. Introduction

Tomato (*Lycopersicon esculentum* L.) is one of the most important and popular vegetables in Bangladesh. It is cultivated in almost all home gardens and also in the field due to its adaptability to wide range of soil and climate (Ahmed, 1976). It ranks next to potato and sweet potato in respect of vegetable production in the world (Hossain *et al*., 2010). It is the most popular salad vegetable and is taken with great relish. It is also widely used in cannery industry for manufacturing soups, conserves, pickles, ketchup, sauces, juices etc. It is the major source of vitamins and minerals (Bose and Sons, 1990).

In Bangladesh, tomato is cultivated mostly in winter season. There is considerable interest in extending the cultivation of tomato over a longer period although high temperature before and after short winter inhibits flower and fruit development. Use of plant growth regulators might be very effective to overcome the problems of flower and fruit development in tomato.

Plant growth regulators play an important role in flowering, fruit setting, ripening and physiochemical changes during storage of tomato. Khan *et al*. (2006) indicated the significant role of GA_3 in tomato plant. He suggested that GA_3 increase fruit set that leads to larger number of fruits plant^{-1} and increased fruit size and final yield. Gibberelic acid (GA_3) also played role on controlling fruit setting, pre-harvest fruit drop, increasing fruit yield and extending self-life (Alabadi *et. al.*, 1996). It is commonly known that the tomato production in the late growing season in Bangladesh is difficult due to rise in atmospheric temperature. Therefore it was thought that the use of growth regulators viz., GA_3 and NAA might be effective in promoting the fruit set that will eventually lead to enhance increasing yield of tomato even in higher temperature that prevails in the later part of the growing season under Bangladesh condition. Though the morphological characters and dry mass production directly influence the yield. The literature on the influence of growth regulators on morphology and TDM production in tomato is very scant especially under Bangladesh condition. Therefore, the present piece of research work was undertaken to study the effect of GA_3 and NAA on morphology and dry mass production in late transplanted tomato.

2. Materials and Methods

The experiment was conducted at the Field Laboratory of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh (25°75′N latitude and 90°75′ E longitude). The experimental site was medium high land belonging to the Sonatola series of gray flood plain of AEZ-9 of Old Brahmaputra Flood Plain (FAO, 1988). The soil of the experimental site was fertile silty loam having a pH of 6.5, organic carbon 13 g kg^{-1}, total nitrogen 1.1 g kg^{-1}, available phosphorus 27 mg kg^{-1}, and exchangeable potassium 46.8 mg kg^{-1} soil. The experimental area experiences sub-tropical climate characterized by high temperature, high humidity and heavy precipitation in the 'Kharif' season (April–September), and scanty rainfall associated with moderately low temperature during 'Rabi' season (October–March). The tomato crop was grown in winter (Nov–March). The maximum and minimum temperature of the site varied from 25 to 30°C and from 13 to 20°C, respectively, during the cropping season of study period.

The field experiment was designed in a randomized complete block design (RCBD) with 3 replicates. The experiment consisted of 3 factors—variety (2; Ratan and Roma), plant regulator (2; GA_3 and NAA) and concentration of plant regulator (4; 0, 25, 50 and 100 ppm). Total number of plots was 48 and size of each plot was 3.0 m^2 (2m×1.5m). The seedlings (30 days old) of the two cultivars, collected from Horticulture Farm, BAU were transplanted in lines 60 cm apart and 50 cm between plants. Intercultural practices such as gap filling, stalking, weeding, and irrigation were done as and when necessary. Manures and Fertilizers were applied as basal dressing as follows: Cowdung, Urea, TSP, and MP @ 15000, 250, 175, and 150 kg ha^{-1}, respectively.

Four concentrations (0, 25, 50 and 100 ppm) of growth regulators, GA_3 and NAA were applied at 45, 75 and 95 days after transplanting (DAT). The growth regulators (100 mg) were dissolved first in a little quantity of absolute alcohol and finally in distilled water (1000 mL) to make 100 ppm stock solution. The solutions of different concentrations were made by diluting the stock solution.

Three plants were sampled randomly from each plot at 65, 95 and 115 DAT. The data on different morphological characters, viz., plant height, stem diameter, branch and leaves $plant^{-1}$, fresh and dry weight of leaves were recorded. For recording the data on leaf dry weight, the leaf samples were oven dried at 80° C for 72 h.

Collected data were analyzed and the mean differences were compared by Duncan's Multiple Range Test (DMRT) using the statistical computer package program MSTAT-C (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Effects on vegetative characters

3.1.1. Plant height

The plant of variety Ratan was taller than that of the variety Roma V.F. PGRs had significant role on plant height in both cultivars (Table 1). The highest plant height (65.50 cm) was observed in plants treated with GA_3. The highest plant height (61.75 cm) in NAA was shorter than the GA_3 (65.50 cm) at 95 DAT. Wu *et al.* (1983) found that GA_3 at 100 ppm increased plant height and leaf area.

At different levels of PGRs the plant height increased upto 115 DAT. The height of the plants treated with PGRs of 50 ppm was higher (73.88 cm) than that in the control plnts. Tomar and Ramgiry (1997) observed that plants treated with GA_3 increased plant height. Interaction effects of two varieties, two PGRs and 4 different concentration level show significant variations at different DAT except 65 and 95 DAT. Variety Ratan exhibited higher plant height (74.55 cm) in response to the foliar application of NAA of 50 ppm concentration at 115 DAT than the variety Roma V.F. (70.22 cm) (Table 1). Earlier workers (Chhonkar and Jha, 1963; Chhonkar and Ghufran, 1968 and Vajender *et al.*, 1979) reported that the moderate concentration (0.1 and 0.2 ppm) of NAA was found to be more effective. They indicated that 0.1 ppm was better than 0.2 ppm. The results of the investigation indicate that the concentration of NAA used, significantly influenced the growth of tomato plants. Such influence is probably due to the possible stimulation of the meristematic tissues, resulting in greater cell division, cell enlargement and cell differentiation. Campanoni and Nick (2005) also reported that NAA triggers cell elongation in plants.

3.1.2. Base diameter (cm)

Base diameter of tomato plants was measured at the lower portion of 3 selected plants from each plot with a slide callipers at different DAT. The variety Ratan significantly produced the higher base diameter (19.03 cm plant^{-1}) than the variety Roma V. F. (18.06 cm plant^{-1}) at 115 DAT (Table 1). Base diameter was increased in both the variety Ratan and Roma V. F. upto 115 DAT.The GA_3 produced significantly higher base diameter (19.56 cm) plant^{-1} than the NAA (17.53cm) at 115 DAT. Base diameter was increased up to 115 DAT at four levels of PGRS. The highest base diameter (20.02 cm) was obtained from 50 ppm concentration.There was no significant variations in respect of base diameter due to the interaction effects of variety, PGRs and 4 concentration level.

3.1.3. Branch plant^{-1}

The number of branch plant^{-1} was increased gradually as the days advanced both in the Ratan and Roma V.F. variety. The highest number of branches (46.08) was observed from variety Ratan whereas Roma V.F. produced 36.60 at 115 DAT. Tomar and Ramgiry (1997) observed that the plants treated with GA_3 exhibited significantly greater number of branches plant^{-1} than untreated controls. Significant variations were also found due to the effect of two PGRs. The branch plant^{-1} increased progressively with upto 115 DAT and then decreased in both PGRs. The GA_3 produced higher branch plant^{-1} (46.1) than the NAA (36.6) at maximum growth stage. Branch plant^{-1} at four levels of PGRs was increased upto 115 DAT. The highest branch plant^{-1}(47.23) was obtained from 50 ppm concentration of PGRs than the control (0 ppm). Plants treated with GA_3 produced increased number of branches plant^{-1} than untreated controls (Tomar and Ramgiry, 1997). Ratan exhibited the highest number of branches plant^{-1} (13.10) due to the foliar application of GA_3 of 50 ppm at 65 DAT than the Roma V.F. (11.99) under the same treatments.

3.1.4. Number, and fresh and dry weights of leaves

The effects of PGRs at different concentrations on number and weight of leaves in two varieties, Ratan and Roma V.F. is presented in Table 2. Data was recorded at 115 DAT. Variety Ratan (136.91), GA_3 (130.07) and 50 ppm concentration of PGRs (64.75) perform superior performance in respect of leaves number plant^{-1} than the variety Roma V. F. (91.58), NAA (98.41) and control concentration (65.74). Similar results were also found in case of the parameter fresh weight and dry weight of leaves. So, Variety Ratan produces more fresh weight (243.03 g) and dry weight 49.24 g) of leaves than the Roma V. F. (191.81 and 41.14 g respectively). Giberellic acid (GA_3) also showed better performance than NAA in respect of fresh weight (253.77 g), dry weight (52.18 g) than the Roma V. F. (181.07 g, 42.47 g and 41.52 cm respectively) at 115 DAT. Among the four concentrations of PGRs, tomato plant produces more leaves (179.66), higher fresh weight of leaves (258.43 g) and higher dry weight of leaves (80.52 g) in 50 ppm concentration than the control (65.74, 38.42 cm, 195.72 g and 26.45 g respectively).

3.1.5. Number of flower plant^{-1}

The effects of PGRs at different concentrations on number of flowers in two varieties, Ratan and Roma V.F. is presented in Table 3. The varity Ratan produced higher number of flower plant^{-1} (44.32) than Roma V.F. (43.96) at 95 DAT. The highest number of flower plant^{-1} **(**42.75) was obtained from the application of GA_3 at the concentration of 50 ppm over the control (Table 3). Bima *et al.* (1995) reported that GA_3 and NAA (5-10 ppm) induced early flowering. However, Saleh and Abdul (1980) applied GA_3(25 or 50 ppm) 3 times and found the reduced number of flowers plant^{-1}. Combined effect of variety,PGRs and concentration level also showed significant variations. The highest number of flower plant^{-1}(52.55) recorded in Ratan variety at $GA_3$with 50 ppm than the Roma V.F. (50.80) at the same PGRs and concentration level at 95 DAT. The Ratan variety produced higher flower plant^{-1}(50.99) at NAA with 50 ppm than the Roma V.F. (50.77) at NAA with 50 ppm at 95 DAT.

3.1.6. Average weight of green fruit (g)

Ratan, GA_3 and 50 ppm concentration showed superior performance (17.25g, 19.45g and 23.60g) than the variety Roma V. F., NAA and control concentration (13.24g, 15.62g and 9.74g respectively) at 95 DAT. Highly significant variations in respect of weight of a green fruit plant^{-1} was observed due to the combined effect of variety, PGRs and concentration level. The highest weight of a green fruit (29.75g) was found in Ratan variety at GA_3 with 50 ppm than the Roma V.F. (19.72g) at GA_3 with 50 ppm at 95 DAT.

3.1.7. Number of ripened fruit plant^{-1}

The highest number of ripened fruit (42.21) plant^{-1} was recorded at Ratan variety and Roma V. F. produced 39.13 at 115 DAT. In India, Kaushik *et al.*(1974) reported that GA_3 increased the number of fruits plant^{-1} at highest concentration. PGRs was found to be significantly effective in increasing number of ripened fruit of tomato when it had been applied singly. The highest number of ripened fruit plant^{-1} (46.27) was obtained from 50 ppm concentration of PGRs whereas the lowest (34.46) from control (0 ppm). Similar result was observed by Tomar and Ramgiri (1997) and Amer *et al.* (1995). The highest number of ripened fruit plant^{-1} (46.22) was observed in Ratan variety at GA_3 with 50 ppm than the Roma V.F. (58.55) at GA_3 with 50 ppm at 115 DAT.

3.1.8. Average seed per ripened fruit

The highest seed per ripened fruit (110.17) was obtained from the Ratan variety where as the Roma V.F. produced 108.59 seeds per fruit. The highest seed per ripened fruit (110.82) was obtained from the GA_3 at 115 DAT whereas the NAA produced 107.93 at the same range of time. In Netherlands, Groot *et al.* (1987) reported that GA_3 was indispensable for the development of fertile flowers and for seed germination, but only stimulated in later stages of fruit and seed development. Concentration level was found to be significantly effective in decreasing seed per ripened fruit when it had been applied singly. The lowest seed per ripened fruit (50.21) was obtained from 50 ppm than the control. Control (0 ppm) concentrations of PGRs gave highest seed per ripened fruit (230.93). Abad *et al.* (1986) reported that GA_3 reduced the number of seeds per fruit and increased the number of seedless fruit which is in agreement with this research work. Highly significant variations were observed in respect of seed per ripened fruit due to the combined effect of variety, PGRs and concentration level (Table 3). The lowest seed per ripened fruit (58.55) was found in Ratan at GA_3 with 50 ppm than the Roma V. F. (55.55) at the same PGRs and concentration. Ratan produced lower seed per ripened fruit (50.88) at NAA with 50 ppm than the Roma V.F. (35.88) at the game PGRs and concentration and 115 DAT.

3.1.9. Average weight of ripened fruit (g)

The highest weight of ripened fruit (91.34 g) was recorded at Ratan variety. Roma V.F. gave the lowest weight (86.97 g). Kaushik *et al.* (1974) found that GA_3 increased the weight of fruits plant^{-1} at highest concentration. The highest weight of ripened fruit (93.98 g) was recorded at GA_3, NAA gave the lowest weight 84.938 at 115DAT. Adlakha and Verma (1964) reported that the application of GA_3 at 100 ppm could appreciable increase fruit size and weight which is similar with the research work.

Weight of ripened fruit plant^{-1} increased at different concentrations of PGRs. The highest weight of ripened fruit plant^{-1} (98.90 g) was obtained from 50 ppm concentrations of PGRs over the control 0 ppm (78.59g). Combined effect of variety, PGRs and concentration level was significant. The highest weight of ripened fruit (104.74 g) was found in Ratan variety at GA_3 with 50 ppm than the Roma V. F. (103.15g) at the same PGRs concentration level and 115 DAT.

3.1.10. Yield plant^{-1}

The highest yield (3.92 kg plant^{-1}) was obtained from the variety Ratan whereas the Roma V.F. produced only 3.71 kgplant^{-1}. Metha and Mathi (1975) reported that GA_3 treatments at 10 or 25 ppm improved the yield of tomato cv. PusaRuby irrespective of planting date. The yield of tomato was (4.07 kgplant^{-1}) obtained from the GA_3; whereas the NAA produced only 3.55 kg plant^{-1}. Hossain (1974) observed increased yield plant^{-1} with higher concentration of GA_3 which is parallel to the present research work. PGRs was found to be significantly effective in increasing yield of tomato when it had been applied singly (Table 3). The highest yield (5.02 g) was obtained from 50 ppm of PGRs whereas the lowest 3.08 from control (C_0). Chhonkon *et al*. (1959) recorded increase in yield of tomato by treatments with growth substances which is corresponding with the present research work. Combined effect of variety, PGRs and concentration level was significant in case of yield (Table 3). The highest yield of tomato (5.60 kg plant^{-1}) was found in Ratan variety at GA_3 with 50 ppm than the Roma V.F. (4.95 kg) at the same PGR and concentration level. Ratan also produced higher yield (4.56 kg plant^{-1}) at NAA with 50 ppm than the Roma V.F. (4.45 kg plant^{-1}). Therefore, it is concluded that GA_3 and NAA is very much essential for the growth, development and yield of tomato.

Table 1. Effect of plant growth regulators (PGRs) at different concentrations on plant height, stem diameter, and number of branches plant^{-1} at different days after transplanting (DAT) in two tomato cultivars, Ratan (V_1) and Roma V.F. (V_2).

Treatment	Plant height (cm)			Stem diameter at base (cm)			Branch plant^{-1}		
	65DAT	95 DAT	115 DAT	65DAT	95 DAT	115 DAT	65DAT	95 DAT	115 DAT
Variety (n=24, data are the means of 2 PGRs and 4 concs.)									
V_1	27.0	64.7 a	64.9 a	0.48 a	10.4 a	19.0 a	10.5 a	41.8 a	46.1 a
V_2	26.7	62.6 b	63.7 b	0.45 b	9.6 b	18.1 b	8.8 b	39.6 b	36.6 b
PGRs (n=24, data are the means of 2 cultivars and 4 concs.)									
GA_3	27.4 a	65.5 a	65.4	0.52 a	10.7 a	19.6 a	10.1 a	41.1 a	46.1 a
NAA	26.3 b	61.8 b	63.3	0.42 b	9.4 b	17.5 b	9.2 b	40.3 b	36.6 b
Concentration (n=12, data are the means of 2 PGRs and 2 cultivars)									
C_1 (0 ppm)	24.758 c	52.3 d	54.9 d	0.38 d	8.2 d	16.9 d	7.1	30.9 d	30.4 c
C_2 (25 ppm)	27.5 ab	67.3 b	66.3 b	0.50 b	10.7 b	18.9 b	10.7	44.6 b	42.7 b
C_3 (50 ppm)	28.6 a	70.9 a	73.9 a	0.55 a	11.5 a	20.0 a	12.1	47.2 a	47.2 a
C_4(100 ppm)	26.8 b	64.0 c	62.3 c	0.43 c	9.7 c	18.4 c	8.6	40.0 c	45.1 ab
Variety ×PGRs×Conc. (n=3)									
$V_1 \times GA_3 \times C_1$	25.7	53.2	51.6 h	0.45	8.8	18.4	7.8 gh	34.4	30.0
$V_1 \times GA_3 \times C_2$	28.9	65.0	72.0 bc	0.50	11.8	20.1	12.6 b	48.0	53.7
$V_1 \times GA_3 \times C_3$	30.0	72.2	75.7 a	0.52	12.4	21.4	13.1 a	48.5	68.3
$V_1 \times GA_3 \times C_4$	28.0	65.8	65.8 de	0.48	10.7	19.9	10.7 d	37.1	67.7
$V_1 \times NAA \times C_1$	24.2	48.7	59.6 f	0.42	8.4	16.2	7.9 fg	30.3	29.7
$V_1 \times NAA \times C_2$	26.7	65.9	62.3 f	0.52	10.6	18.7	10.9 g	45.4	39.7
$V_1 \times NAA \times C_3$	27.2	67.9	74.6 ab	0.53	11.2	19.7	12.4 bc	47.7	41.4
$V_1 \times NAA \times C_4$	25.7	62.2	61.0 f	0.46	9.3	17.9	8.3 f	42.8	38.9
$V_2 \times GA_3 \times C_1$	24.0	57.2	52.8 gh	0.41	8.2	17.9	6.3 i	30.1	43.9
$V_2 \times GA_3 \times C_2$	27.1	70.6	68.7 cd	0.60	11.0	19.3	10.4	43.9	40.1
$V_2 \times GA_3 \times C_3$	29.0	74.3	75.1 ab	0.70	11.8	20.6	11.9 c	46.9	40.3
$V_2 \times GA_3 \times C_4$	26.9	65.9	62.8 ef	0.50	10.6	18.9	7.9 fg	40.1	38.4
$V_2 \times NAA \times C_1$	24.4	50.3	55.7 ge	0.27	7.3	15.1	6.33 i	28.9	30.9
$V_2 \times NAA \times C_2$	27.6	67.8	62.0 f	0.43	9.4	17.6	9.0 e	41.3	37.7
$V_2 \times NAA \times C_3$	28.5	69.1	70.2 c	0.46	10.4	18.4	10.9 d	45.7	38.9
$V_2 \times NAA \times C_4$	25.8	62.2	59.6 f	0.30	8.1	16.8	7.4 h	40.1	35.8

Between variety, PGRs or concentrations treatments, means followed by the same letter(s) or without letter(s) are not significantly diferent (P=0.05) as per DMRT.

Table 2. Effect of plant growth regulators (PGRs) at different concentrations on leaf number plant^{-1}, fresh and dry weights of leaves in two tomato cultivars, Ratan (V_1) and Roma V.F. (V_2).

Treatment	Leaf number plant^{-1}			Leaf fresh weight (g plant^{-1})			Leaf dry weight (g plant^{-1})		
	65DAT	95 DAT	115 DAT	65DAT	95 DAT	115 DAT	65DAT	95 DAT	115 DAT
Variety (n=24, data are the means of 2 PGRs and 4 concs.)									
V_1	11.2 a	56.8 a	136.9 a	11.4 a	147 a	243.0 a	2.41	27.8 a	49. 2 a
V_2	10.5 b	53.9 b	91.6 b	10.9 b	133 b	191.8 b	2.20	20.1 b	41.1 b
PGRs (n=24, data are the means of 2 cultivars and 4 concs.)									
GA_3	11.3 a	57.0 a	130.1 a	12.2 a	152 a	254 a	2.49 a	25.5 a	48.7 a
NAA	10.4 b	53.8 b	98.4 b	10.2 b	127.8 b	181 b	2.12 b	22.4 b	41.7 b
Concentration (n=12, data are the means of 2 PGRs and 2 cultivars)									
C_1 (0 ppm)	9.6 c	45.9 d	65.7 d	8.7 d	105.6 d	195.7 c	1.31 c	14.8 d	38.4 c
C_2 (25 ppm)	11.3 b	58.4 b	110.2 b	11.6 b	136.4 b	216.4 b	2.39 b	23.8 b	43.3 b
C_3 (50 ppm)	13.2 a	62.0 a	179.7 a	14.5 a	199.1 a	258.4 a	3.24 a	35.9 a	59.8 a
C_4(100 ppm)	9.4 c	55.2 c	101.3 c	9.8 c	118.4 c	199.1 c	2.29 b	21.3 c	39.4 c
Variety ×PGRs×Conc. (n=3)									
$V_1 \times GA_3 \times C_1$	10.9 cd	43.3 f	79.7 h	9.5 fg	120.7 f	248.3	1.04 g	14.2 g	39.1 cde
$V_1 \times GA_3 \times C_2$	12.9 ab	62.3 a	125.3 c	12.9 c	15.6 d	255.2	2.85 b	22.7 d	44.1 bc
$V_1 \times GA_3 \times C_3$	13.7 a	63.2 a	357.3 a	18.1 a	215.1 a	276.1	3.90 a	56.7 a	103.2 a

Treatment	Plant height (cm)			Stem diameter at base (cm)			Branch plant^{-1}		
	65DAT	95 DAT	115 DAT	65DAT	95 DAT	115 DAT	65DAT	95 DAT	115 DAT
$V_1 \times GA_3 \times C_4$	11.1 cd	59.6 ab	102.3 d	10.7 ef	140.1 d	250.6	2.73 bc	20.6 e	37.2 de
$V_1 \times NAA \times C_1$	8.2 ef	45.8 ef	74.0 i	8.9 gh	101.3 h	200.7	1.71 ef	20.7 e	39.1cde
$V_1 \times NAA \times C_2$	10.3 d	60.9 a	107.0 de	10.9 de	144.7 d	231.6	2.21 d	30.8 e	44.1 bc
$V_1 \times NAA \times C_3$	13.6 a	62.8 a	147.7 b	12.9 c	202.3 b	282.1	2.91 b	31.5 b	46.8 b
$V_1 \times NAA \times C_4$	9.1 e	56.8 bc	102.0 g	9.7 efg	108.3 g	201.7	2.20 d	25.0 c	40.2 cde
$V_2 \times GA_3 \times C_1$	9.1 e	50.9 d	69.3 j	8.6 gh	119.7 f	233.5	1.34 fg	13.4 g	39.5 cde
$V_2 \times GA_3 \times C_2$	11.7 c	60.1 ab	106.3 def	12.1 c	144.1 d	250.7	2.38 cd	24.2 d	42.1 bcd
$V_2 \times GA_3 \times C_3$	12.9 ab	61.1 a	110.0 d	15.2 b	200.0 b	275.4	3.65 a	31.5 b	44.1 bc
$V_2 \times GA_3 \times C_4$	8.1 f	55.3 c	100.7 g	10.4 ef	130.0 e	242.3	2.10 de	20.8 e	140.2 cde
$V_2 \times NAA \times C_1$	10.3 d	43.7 f	40.0 k	7.8 h	80.7 j	100.4	1.15 g	10.8 h	35.9 e
$V_2 \times NAA \times C_2$	10.2 d	50.3 d	102.3 fg	10.8 ef	111.2 g	130.2	2.15 de	17.3 f	42.7 bcd
$V_2 \times NAA \times C_3$	12.6 b	60.9 a	103.7 efg	11.9 cd	178.9 c	200.1	2.51 bcd	24.1 cd	45.0 bc
$V_2 \times NAA \times C_4$	9.1 e	49.2 de	100.3 g	8.7 gh	95.4 i	101.8	2.13 de	18.1 f	40.0cde

Between variety, PGRs or concentrations treatments, means followed by the same letter(s) or without letter(s) are not significantly diferent (P=0.05) as per DMRT.

Table 3. Effect of plant growth regulators (PGRs) at different concentrations on reproductive characters and yield in two tomato cultivars, Ratan (V_1) and Roma V.F. (V_2).

Treatment	Flower plant^{-1}		Average weight of green fruit (g)	Ripened fruit plant^{-1}	Average seed/ripened fruit	Average weight of ripened fruit (g)	Yield plant^{-1} (kg)
	65 DAT	95 DAT	95 DAT	115 DAT	115 DAT	115 DAT	
Variety (n=24, data are the means of 2 PGRs and 4 concs.)							
V_1	3.16a	44.32a	17.25a	39.48a	98.21a	89.68a	3.92a
V_2	2.96b	43.96b	13.24b	37.59b	96.87b	87.52b	3.71b
PGRs (n=24, data are the means of 2 cultivars and 4 conc.)							
GA_3	3.17a	42.75a	19.45a	43.14a	110.82a	93.98a	4.07a
NAA	2.95b	41.49b	15.62b	38.20b	107.93b	84.33b	3.55b
Concentration (n=12, data are the means of 2 PGRs and 2 cultivars)							
C_1 (0 ppm)	1.96d	30.93d	9.74d	34.46d	230.93a	78.59d	3.08d
C_2 (25 ppm)	3.46b	46.40b	20.47b	42.60b	64.10c	92.71b	3.92b
C_3 (50ppm)	4.05a	51.29a	23.60a	46.27a	50.21d	98.90a	5.02a
C_4(100ppm)	2.77c	40.65c	16.34c	39.34c	93.27b	86.42c	3.23c
Variety ×PGRs×Conc (n=3)							
$V_1 \times GA_3 \times C_1$	2.33g	35.44f	10.33j	39.44c	234.22a	86.97ef	3.10f
$V_1 \times GA_3 \times C_2$	3.55c	47.99c	24.13c	45.77a	62.33ef	98.20bc	4.66b
$V_1 \times GA_3 \times C_3$	4.44a	52.55a	29.75a	46.22a	55.55g	104.74a	5.60a
$V_1 \times GA_3 \times C_4$	3.10d	40.99e	18.34ef	44.77ab	95.55c	97.29c	3.47e
$V_1 \times NAA \times C_1$	2.66ef	28.66h	11.39i	45.22d	227.10b	78.56h	3.50e
$V_1 \times NAA \times C_2$	2.99d	45.88d	17.88f	40.11c	64.33e	88.49de	3.41e
$V_1 \times NAA \times C_3$	3.55c	50.99b	19.72d	46.44a	50.88h	93.86cd	4.56bc
$V_1 \times NAA \times C_4$	2.88e	40.74e	16.26g	39.73c	93.33e	82.67fgh	3.15f
$V_2 \times GA_3 \times C_1$	1.44h	30.88g	8.00l	35.10d	227.66b	80.92gh	2.90g
$V_2 \times GA_3 \times C_2$	3.66c	45.10d	23.7c7	44.44ab	63.99e	95.10c	4.21d
$V_2 \times GA_3 \times C_3$	4.22a	50.88b	26.07b	46.77a	58.55fg	103.15ab	5.49a
$V_2 \times GA_3 \times C_4$	2.66ef	40.33e	15.27h	42.66b	88.77d	85.54efg	3.15f
$V_2 \times NAA \times C_1$	1.44h	28.77h	9.26k	28.11e	234.77a	67.92i	2.83g
$V_2 \times NAA \times C_2$	3.66c	45.66d	16.11gh	40.11c	65.77e	89.08de	3.40e
$V_2 \times NAA \times C_3$	3.99b	50.77b	18.87c	45.66a	35.88i	93.88cd	4.45c
$V_2 \times NAA \times C_4$	2.44fg	40.54e	15.51gh	30.22e	91.44cd	80.18gh	3.15f

Between variety, PGRs or concentrations treatments, means followed by the same letter(s) or without letter(s) are not significantly diferent (P=0.05) as per DMRT.

4. Conclusions

The result of the experiment was revealed that all the parameters were significantly influenced by the variety. Ratan showed best performances in respect of plant height (cm), stem diameter at base (cm), branch plant^{-1}, leaves plant^{-1}, fresh and dry weight of leaves, flower plant^{-1}, Average weight of green fruit (g), Ripened fruit plant^{-1}, Average seed per ripened fruit, Average weight of ripened fruit (g), yield plant^{-1}. Similar performances were recorded from the application of GA_3 than NAA. Different concentration levels of PGRs also showed significant influence. Better performances of all parameters except number of seed per ripened fruit were derived from 50 ppm concentration. Highest number of seed per ripened fruit was recorded in 0 ppm concentration. Interaction effect of variety, growth regulators and concentration level was significant on all the characters except diameter at base, fresh weight of leaves and branch plant^{-1}. From the above observation it can be concluded that the Ratan variety of tomato responded better with 50 ppm GA_3 as compared to Roma V. F.

Conflict of interest

None to declare.

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