



Plant growth regulators promote growth and yield of summer tomato (*Lycopersicon esculentum* Mill.)

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Abstract

An experiment was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to test the impact of plant growth regulators on growth and yield of summer tomato. The experiment consisted of two tomato varieties viz. BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8 and four types of plant growth regulator (PGR) viz., (i) control (without PGR), (ii) 4-CPA (4-chlorophenoxy acetic acid), GA₃ (gibberellic acid) and 4-CPA + GA₃. The two-factor experiment was laid out in randomized complete block design with three replications. The results of the experiment revealed that significant variations were observed for most of the characters studied. At 75 DAT, the tallest plant (79.35 cm), number of flowers and fruits (38.11 and 19.04, respectively) plant⁻¹, individual weight (58.44 g) and fruit yield (22.75 t ha⁻¹) were found in BARI Hybrid Tomato-8. At 75 DAT the maximum plant height (87.90 cm), number of flowers and fruits (49.04 and 21.9, respectively) plant⁻¹, individual fruit weight (61.16 g), and fruit yield (27.28 t ha⁻¹) were found when 4-CPA + GA₃ applied together, whereas the minimum for these characters were recorded from control plants. In case of combined effect of variety and plant growth regulator, the maximum plant height (87.90 cm), number of flowers and fruits (49.04 and 21.91, respectively) plant⁻¹, individual fruit weight (61.16 g) and fruit yield (27.28 t ha⁻¹) were observed in BARI Hybrid Tomato-8 when treated with 4-CPA + GA₃ together, and the minimum for all these parameters were found in control plants. The results of the present study suggest that both 4-CPA and GA₃ together can be practiced for increasing summer tomato production for both the varieties.

Key words: Gibberellin, 4-chlorophenoxy acetic acid, growth, yield, summer tomato

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae and is a self-pollinated crop. It is one of the popular, nutritive and important vegetable crops in Bangladesh which is receiving increased attention of the growers and consumers and made its position within few of the highest cultivated vegetables. Its food value is very rich because of higher contents of vitamins A, B and C and also minerals like calcium which promote good health (Wilcox *et al.*, 2003).

November-February is the period when congenial atmosphere remains for tomato cultivation in Bangladesh. Although tomato plants can grow under

a wide range of climatic conditions, they are extremely sensitive to hot and wet growing conditions, the weather which prevails in the summer season in Bangladesh (Ahmad, 2002). Tomato cultivation during March to September in Bangladesh is constrained due to the adverse weather of summer along with absence of heat tolerant varieties. Tomato requires day temperature of 21–28°C and moderately cool night temperature of 15–20°C for proper fruit setting. High temperature (both day and night), humidity, rainfall and light intensity are the limiting factors of tomato production (Abdulla and Verkerk, 1968). High day and night

temperature above 32°C and 21°C, respectively, was reported as limiting factor to fruit-set due to an impaired complex of physiological process in the pistil, which results in floral or fruit abscission (Picken, 1984). Because of adverse weather especially high temperature and rainfall during March to September, traditional variety of tomato cannot be grown during summer in Bangladesh.

In some countries, tomatoes are commercially growing even at high temperature through application of plant growth regulators (PGRs). Gemici *et al* (2006) reported that application of auxin and gibberellins are effective in increasing both yield and quality of tomato. Application of certain PGRs like auxin and gibberellic acid (GA₃) bring the possibility of tomato production under adverse environmental conditions. Those PGRs are used extensively in tomato to enhance yield by improving fruit set, size and number of fruits (Batlang, 2008; Serrani *et al*, 2007). Tomato fruit set was promoted by GA₃ at low concentration (Khan *et al*, 2006). Synthetic auxin 4-CPA (4-chloro phenoxy acetic acid) reduced pre-harvest fruit drop with increased number of fruits per plant and yield (Sasaki *et al*, 2005). Application of 4-CPA is more effective during anthesis period than one week after anthesis (Poliquit *et al*, 2007). In fact the use of growth regulators had improved the production of tomato including other vegetables in respect of better growth and quality, which ultimately led to generate interest between the scientists and farmers for commercial application of growth regulators. Tomato production in Bangladesh is largely affected due to adverse environmental conditions during summer season. However, information regarding the practical use of plant growth regulators in summer tomato production is not adequate. The present study was, therefore, undertaken to investigate the effect of different PGRs on the growth and yield of summer tomato.

Materials and Methods

The experiment was carried out at the Horticultural Farm of Bangladesh Agricultural University, Mymensingh during June 2014 to October 2014. Two-

factor experiment consisted of four different levels of 4-chlorophenoxy acetic acid (4-CPA) i.e., T₀ = control (without 4-CPA), T₁ = 4-CPA @ 20 ppm, T₂ = 4-CPA @ 40 ppm and T₃ = 4-CPA @ 60 ppm; and two varieties of summer tomato namely, BARI Hybrid Tomato-4 and 8 were used in this study. The experiment was laid out in a randomized complete block design with three replications. Thirty-day-old seedlings were transplanted at the spacing of 60cm × 50cm. Manures and fertilizers were applied at the rate of cowdung 12 t/ha, urea 450 kg/ha, Triple Super Phosphate (TSP) 350 kg/ha and Muriate of Potash (MoP) 300 kg/ha (BARC, 2012). Both 4-CPA and GA₃ were applied at a concentration of 20 ppm. Spraying was performed early in the morning to avoid rapid drying of the spray solution due to transpiration. Data were collected from five randomly selected plants from each plot and were statistically analyzed to find out the statistical significance of the experimental results. 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 (Gomez and Gomez, 1984).

Results and Discussion

Plant height

Different plant growth regulators showed statistically significant variations on the plant height at 25, 50 and 75 days after transplanting (DAT). Plant height of two varieties of summer tomato under field conditions at 75 days after transplanting also showed significant difference (Table 1). BARI Hybrid Tomato-8 produced taller (79.35) plants than BARI Hybrid Tomato-4 (77.20).

In case of plant growth regulators, plant height at 75 DAT was significantly affected by the treatments (Table 2). The maximum (86.75 cm) plant height was measured in the combined application of plant growth regulators (GA₃ + 4-CPA) where control treatment gave the minimum plant height (63.90 cm). Tomato variety and plant growth regulators had significant interaction effects on plant height at 50 and 75 DAT (Table 3). At 75 DAT, the highest

(87.90 cm) plant height was measured in V₂T₃ whereas V₁T₀ showed the lowest (63.00 cm) plant height. This might be due to the effect of plant growth regulators on the vegetative part of the plant or may be helped more photosynthesites supplied to the fruits as number of fruits increased by plant

growth regulators. Phookan and colleagues (1990) reported that when grown tomato in summer under plastic house conditions, the plant height ranged from 46.00 cm to 95.00 cm in an experiment with 29 hybrids of tomato and also found variations in plant height among the hybrids.

Table 1. Main effect of variety on growth, yield contributing characters and yield of summer tomato

Variety	Plant height at			No. of flowers. Plant ⁻¹	No. of fruits. plant ⁻¹	Individual Fruit. weight (g)	Yield (t ha ⁻¹)
	25 DAT	50 DAT	75 DAT				
V ₁	22.48	58.05	77.20	33.51	18.33	56.42	21.23
V ₂	22.95	60.60	79.35	38.11	19.04	58.44	22.75
LSD (0.05)	0.305	0.384	0.192	0.393	0.175	0.092	0.274
(0.01)	0.425	0.534	0.266	0.547	0.243	0.128	0.381
Level of significance	**	**	**	**	**	**	**

V₁ and V₂ indicate BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8, respectively; ** indicates level of significance at 1% level of probability; DAT indicates days after transplanting.

Table 2. Main effect of plant growth regulators (PGRs) on growth, yield contributing characters and yield of summer tomato

Treatment	Plant height (cm) at			No. of flowers. Plant ⁻¹	No. of fruits. plant ⁻¹	Individual Fruit. weight (g)	Yield (t ha ⁻¹)
	25 DAT	50 DAT	75 DAT				
T ₀	21.70	45.05	63.90	22.52	12.09	54.16	13.35
T ₁	22.55	60.40	77.85	35.67	19.34	56.83	22.40
T ₂	23.00	64.85	84.60	39.16	21.52	58.37	25.46
T ₃	23.60	67.00	86.75	45.88	21.79	60.36	26.77
LSD (0.05)	0.432	0.544	0.271	0.556	0.247	0.130	0.387
(0.01)	0.601	0.756	0.377	0.773	0.344	0.180	0.539
Level of significance	**	**	**	**	**	**	**

T₀, T₁, T₂ and T₃ indicate control i.e. without PGRs, 4-CPA, GA₃ and 4-CPA + GA₃, respectively; ** indicates significant at 1% level of probability; DAT indicates days after transplanting.

Number of flowers per plant

The number of flowers per plant is an important character which determines the yield of tomato fruit. Significant variation was observed between two varieties in case of number of flowers per plant. Higher number of flowers per plant was observed in BARI Hybrid Tomato-8 (38.11) compared to BARI Hybrid Tomato-4 (33.51) (Table 1).

There were significant variations in respect of the number of flowers per plant due to the application of plant growth regulators (Table 2). The maximum number of flowers per plant (45.88) was found in T₃ treatment which was combined application of GA₃ and 4-CPA. The minimum number of flowers per plant (22.52) was found in T₀ treatment (control). There was no significant difference among the treatments and variety combination in respect of number of flowers per plant (Table 3). The

production of flowers per plant may be affected by the cultivars and temperature. The variation between the two varieties in the present investigation is supported by Aung (1976) who reported an association of flower number with cultivars. The number of flowers per plant increased due to the application of plant growth regulators.

Number of fruits per plant

Significant variation was found on number of fruits per plant between two summer tomato varieties (Table 1). Higher number of fruits (19.04) was produced by BARI Hybrid Toamto-8 compared to BARI Hybrid Tomato-4 (18.33). The plant growth regulators had significant influence on the number of fruits per plant (Table 2. The highest numbers (21.79) of fruits per plant were obtained from combined spraying of GA₃ and 4-CPA while the lowest (12.09) numbers of fruits per plant were obtained from the control. The inter action effects of the treatments on the number of fruits per plant were significantly different (Table 3). The treatment V₂T₃ gave the highest (21.91) number of fruits per plant over the treatment V₁T₀ (12.07) followed by the rest which were statistically different from each other. The treatment V₁T₃ (21.66) and V₂T₂

(21.54) were the second and third highest number of fruits per plant respectively. The lowest (12.07) number of fruits per plant was at V₁T₀ treatment.

Tomato plants exposed to high temperature reduce fruit set. Spraying with plant growth regulators increased the number of fruits per plant. Results of the study showed that under high temperature the combination of 4-CPA and GA₃ induced higher number of fruit set to some extent. It has been reported that in an experiment with 20 F₁ crosses, the tomato tone (trade name of 4-CPA) treatment had an appreciable effect on the number and weight of fruits of all lines (AVRDC, 1982). High temperature treatment decreases the levels of auxin and gibberellins-like substance, especially in floral buds and developing fruits of tomato. Therefore, shortage of auxin and gibberellins could cause the reduction of fruit set under high temperature. Application of 4-CPA and GA₃ presumably reduced the effect of high temperature and thus would have increased fruit set of tomatoes. Synthesized auxin and gibberellins are often used for promotion of fruit set in some fruit and vegetable production including tomatoes (Gemici *et al*, 2006; Khan *et al*, 2006; Serrani *et al*, 2007; Batlang, 2008).

Table 3. Interaction effect of plant growth regulators (PGRs) on growth, yield contributing characters and yield of summer tomato

Treatment combination	Plant height (cm) at			No. of flowers. Plant ⁻¹	No. of fruits. plant ⁻¹	Individual Fruit. weight (g)	Yield (t ha ⁻¹)
	25 DAT	50 DAT	75 DAT				
V ₁ T ₀	21.50	43.50	63.00	19.82	12.07	53.01	13.05
V ₁ T ₁	22.30	58.90	76.90	33.20	18.08	55.87	20.56
V ₁ T ₂	22.70	63.50	83.30	38.28	21.50	57.22	25.05
V ₁ T ₃	23.40	66.30	85.60	42.72	21.66	59.56	26.25
V ₂ T ₀	21.90	46.60	64.80	25.22	12.11	55.31	13.64
V ₂ T ₁	22.80	61.90	78.80	38.13	20.60	57.79	24.23
V ₂ T ₂	23.30	66.20	85.90	40.03	21.54	59.51	25.86
V ₂ T ₃	23.80	67.70	87.90	49.04	21.91	61.16	27.28
LSD (0.05)	0.612	0.770	0.384	0.788	0.351	0.184	0.549
(0.01)	0.849	1.068	0.533	1.093	0.486	0.255	0.761
Level of significance	NS	*	*	**	**	**	**

V₁ and V₂ indicate BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8, respectively; T₀, T₁, T₂ and T₃ indicate control i.e. without PGRs, 4-CPA, GA₃ and 4-CPA + GA₃, respectively; NS, indicates non-significant; * and ** indicate significance at 5% and 1% level of probability; DAT indicates days after transplanting.

Individual fruit weight

Significant variation was observed between the two summer tomato varieties in respect of yield (Table 1). The higher fruit weight (58.44g) was obtained from BARI Hybrid Tomato-8 than BARI Hybrid Tomato-4 (56.42g). Plant growth regulators also had significant influence on individual fruit weight. The maximum yield (60.36 g) was obtained from combined application of 4-CPA and GA₃, whereas the minimum (54.16 g) was from the control (Table 2). In case of combined effect, the treatment V₂T₃ gave the highest yield (61.16g) whereas V₁T₀ gave the lowest (53.01g). (Table 3). Ahmad (2002) also found variation in single fruit weight from 5.25 g to 43.38 g among 25 heat tolerant varieties which supports the findings of the present study.

Yield

Significant variation was observed between the two summer tomato varieties in respect of yield per hectare (Table 1). BARI Hybrid Tomato-8 gave higher fruit yield (22.75 t ha⁻¹) compared to BARI Hybrid Tomato-4 (21.23 t ha⁻¹). Application of plant growth regulators had significant influence on fruit yield (t/ha) (Table 2). The highest (26.77 tha⁻¹) fruit yield was obtained from the combined application of 4-CPA and GA₃ and the lowest (13.35 tha⁻¹) fruit yield was found in control treatment.

The interaction effects of varieties and plant growth regulator on the yield of tomato per hectare were highly significant (Table 3). It was observed that the highest (27.28 tha⁻¹) fruit yield per hectare was found from the treatment combination of V₂T₃, and the lowest yield (13.05 t ha⁻¹) was found from control plants.

Application of GA promoted cell growth and elongation leading to bigger plants with longer shoots and leaves which ultimately resulted with higher crop yields. Combined application of GA₃ and 4-CPA increased the number of fruits per plant, single fruit weight and thus increased in yield of tomato.

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