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Effects of variety and application frequency of 4-chlorophenoxy acetic acid on growth and yield of summer tomato

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ABSTRACT

A field experiment was conducted at the Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from March to August, 2016 to investigate the effect of variety and frequency of application of 4-chlorophenoxy acetic acid (4-CPA) on growth and yield of tomato. The experiment was consisted of two factors viz., Factor A: two varieties of summer tomato namely, BARI Hybrid Tomato 4 and BARI Hybrid Tomato 8 and Factor B: frequency of application of 4-CPA i.e., (i) T_0 (control) (ii) T_1 (at 5 day interval) (iii) T_2 (at 10 day interval) and (iv) T_3 (at 15 day interval). The concentration of 4-CPA was 60 ppm. The experiment was laid out in randomized complete block design with three replications. The results of the experiment revealed that there were significant variations for most of the characters studied. The higher plant height (91.47 cm) at 75 DAT, flowers per plant (27.22), fruits per plant (9.43), individual fruit weight (84.54 g), fruit weight per plot (7.21) and yield (28.38 t/ha) were found from BARI Hybrid Tomato 4 and the lower for all parameters were found from BARI Hybrid Tomato 8. The maximum plant height (94.45 cm) at 75 DAT, flowers per plant (32.41), fruits per plant (11.41), individual fruit weight (86.89 g), fruit weight per plot (8.92 kg) and yield (35.12 t/ha) were found when 4-CPA applied at 5 day interval whereas the minimum for these characters were recorded from control treatments. In case of combined effect of variety and 4-CPA, the maximum plant height (95.10 cm) at 75 DAT, flowers per plant (33.47), fruits per plant (11.77), individual fruit weight (87.19 g), fruit yield per plot (9.24 kg) and yield (36.36 t/ha) were observed from BARI Hybrid Tomato 4 when treated with 4-CPA at 5 day interval and the minimum for all these characters were found from BARI Hybrid Tomato 8 at 10 day interval. The results of the present study suggest that application of 60 ppm of 4-CAP at 5 day interval can be practiced for increasing summer tomato production for both the varieties.

Key Words: 4-chlorophenoxy acetic acid, plant growth regulator, frequency of application and summer tomato.

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I. Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important and popular vegetable crops in Bangladesh and usually is grown from November to March (cool season). It is cultivated all over the country; however, the yield is very low in summer-rainy season (from April to October). The maximum temperature in summer reaches 34-38°C and causes very poor fruit set. Due to the excellent nutritional and processing qualities of tomato, demand in general is growing throughout the year, but production is far below the demand, especially in the summer season. Most recently, Bangladesh Agricultural Research Institute (BARI) released tomato varieties, for example, BARI Hybrid Tomato-3, 4, 8 which are suitable for growing in summer season, but their improved production technology has not yet been established. Therefore, it is urgent to explore the heat tolerant tomato varieties with improved production technology that will ensure higher yield under high temperature. Tomato fruit set is very sensitive to environmental conditions, particularly to too high temperature that affects pollen development and anther dehiscence. As a consequence, efficient tomato production in Bangladesh is mainly confined during winter (November-March) season. At higher temperature, the probability of floral abscission is high after anthesis (Iwahori, 1967). High day and night temperatures above 32°C and 21°C, respectively, reported as limiting fruit-set due to an impaired complex of physiological process in the pistil, which results in floral or fruit abscission. In Bangladesh, temperature during summer remains high both in the day and at the night which affect fruit-set of tomatoes. Fruit set depends on the successful completion of pollination and fertilization (Gillaspy *et al.*, 1993). Although the influence of plant growth regulators (PGRs), such as auxin and gibberellin, over fruit development already acknowledged back in the early 20th century (Gustafson, 1936, 1939; Witter *et al.*, 1957). In summer, tomato fruit set can be increased by applying plant growth regulators (Sasaki *et al.*, 2005; Khan *et al.*, 2006; Gemeci *et al.*, 2006; Serrani *et al.*, 2007; Batlang, 2008; Karim *et al.*, 2015; Rahman *et al.*, 2015).

The use of plant growth regulators improved the production of tomato which attracts the scientists and farmers for commercial application of growth regulators for summer tomato production. But very limited research has been conducted in respect of type and concentration of PGRs needs to be used to improve the yield and quality of summer tomato. 4-chlorophenoxy acetic acid (4-CPA) is an important PGR which increased fruit set and yield of tomato at high temperature (Sasaki *et al.*, 2005). However, no research has been conducted on the effect of frequency of application of 4-CPA on fruit set and yield of heat tolerant tomato varieties released by BARI. Frequency of application of plant growth regulator is necessary for obtaining the better performance of the variety. To achieve the better result, plant growth regulators must be applied at the right stage of plant growth with appropriate concentration and this could be achieved by adjusting the frequency of application. Because the less or over dose causes no effect or adverse effect, respectively on the growth and yield of summer tomato. Therefore, the study was undertaken to investigate the effect of frequency of application of 4-CPA on growth, fruit set and yield of summer tomato varieties.

II. Materials and Methods

The experiment was carried out at the Horticultural Farm of the Department Horticulture, Bangladesh Agricultural University, Mymensingh during the period from March to August, 2016. Two factor experiment consisted of four different intervals of 4-chlorophenoxy acetic acid (4-CPA) application i.e., T₀ = control (without 4-CPA), T₁ = 4-CPA applied at 5 day interval, T₂ = 4-CPA applied 10 day interval and T₃ = 4-CPA applied at 15 day interval; 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. The size of unit plot was 1.50 m x 1.20 m. The space kept between blocks was 100 cm and between the plots was 50 cm. Tomato seeds of BARI Hybrid Tomato-4 and 8 were collected from Vegetable Research Division of Bangladesh Agricultural Institute, Joydebpur, Gazipur. Twenty one-day-old seedlings were transplanted at a spacing of 60 cm x 50 cm. 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 (FRG, 2012). The 4-CPA was applied at the rate of 60 mgL⁻¹. Spraying of 4-CPA was done early in the morning to avoid rapid drying of the spray solution due to evaporation. 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 1% levels of probability (Gomez and Gomez, 1984).

III. Results and Discussion

Plant height

Two varieties showed a statistically significant variation on the plant height at harvest. BARI Hybrid Tomato-4 produced the taller (91.47 cm) plants than BARI Hybrid Tomato-8 (90.25 cm; [Table 1](#)). Plant height at harvest was significantly affected by the different frequency of application of 4-chlorophenoxy acetic acid (4-CPA) ([Table 2](#)). The maximum plant height (85.57 cm) was produced by the application of 4-CPA at 5 day interval, whereas the control treatment produced plants with shorter height (86.78 cm). Significant influence was found in plant height due to the combined effect of tomato variety and different concentrations of 4-CPA application ([Table 3](#)). The highest plant height (88.90 cm) was measured in V_2T_3 whereas V_1T_0 showed the lowest (86.15 cm) plant height. This might be due to the effect of plant growth regulators on the vegetative part of the plant. [Phookan *et al.*, \(1990\)](#) reported that when tomato grown in summer under plastic house conditions, the plant height ranged from 46.00 cm to 95.00 cm in an experiment with 29 hybrid of tomato and also showed variations among the hybrids in plant height.

Days required for 50% flowering

Significant variation was observed between two varieties in case of days required for flowering ([Table 1](#)). The maximum (32.08 days) required to 50% flowering by BARI Hybrid Tomato-8 which is more than BARI Hybrid Tomato-4 (31.25 days). Days to 50% flowering was increased with the increasing of frequency of application 4-CPA. The maximum time to 50% flowering was observed in T_0 treatment (33.00 days), whereas the minimum time (31.33 days) was observed with T_1 treatment ([Table 2](#)). The combined effect of variety and frequency of application of 4-CPA was highly significant ([Table 3](#)). The maximum (33.33 days) time was required in treatment combination of V_2T_0 and the minimum (30.67 days) time was needed to 50% flowering in treatment combination of V_1T_1 ([Table 3](#)). The observed result closed to the findings of [Rahman *et al.* \(2015\)](#) and [Karim *et al.* \(2015\)](#). They reported that application of plant growth regulators at higher concentration plant flowered earlier than no-treated plants.

Table 01. Effects of variety on growth, fruit set and yield of yield of summer tomato

Variety	Plant height (cm) at harvest	Days required to 50% flowering	Number of flowers plant ⁻¹	Number of fruits plant ⁻¹	Fruit diameter (cm)	Fruit yield (kg) plot ⁻¹	Fruit yield (t ha ⁻¹)
V ₁	91.47	31.25	27.22	9.43	4.85	7.21	28.38
V ₂	90.25	32.08	24.92	8.63	4.78	6.54	25.78
LSD (0.01)	0.49	0.69	0.67	0.21	0.07	0.18	0.69
Level of significance	**	**	**	**	**	**	**

V₁ and V₂ indicate BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8; ** indicates significant at 1% level of probability.

Number of flowers per plant

The number of flowers per plant is an important character which has the importance to determine the yield of tomato. Significant variation was observed between two varieties in case of number of flowers per plant. The maximum number of flowers (27.22) per plant was observed in BARI Hybrid Tomato-4, whereas the minimum number of flowers (24.92) per plant was found in BARI Hybrid Tomato-8 ([Table 01](#)). There was significant variation in respect of the number of flowers per plant due to the application of 4-CPA at different intervals ([Table 02](#)). The maximum number of flowers (32.41) per plant was found in T_1 treatment i.e. plant treated with 4-CPA at 5 day interval. The minimum number of flowers (9.01) per plant was found in control treatment. There was also significant difference among the treatments and variety combination in respect of number of flowers per plant ([Table 03](#)). The maximum number of flowers (33.47) per plant was observed in treatment combination of V_1T_1 and the minimum (19.62) was found in in treatment combination of V_2T_0 . The production of flowers per plant may be affected by the cultivars and temperature. [Aung \(1976\)](#) reported that an extent of decreased flower number depends on cultivars.

Number of fruits per plant

Significant variation was found on number of fruits per plant between two tomato varieties (Table 1). The maximum (9.43) fruits were produced in BARI Hybrid Tomato-4 which was statistically different from BARI Hybrid Tomato-8 (8.63). Application of 4-CPA at different intervals significantly influenced the number of fruits per plant (Table 02). The highest number of fruits (11.41) produced by the T₁ treatment and the minimum (6.35) from T₀ treatment. The combined effect on the number of fruits per plant was significantly different (Table 03). The treatment with V₁T₁ gave the highest (11.77) number of fruits per plant, whereas the minimum (5.98) fruits was obtained from V₂T₀.

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, application of 4-CPA induced higher number of fruit set to some extent. It has been reported that in an experiment with 20 *F*₁ crosses, the tomatotone (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 (Gustafson, 1937&1939; Witter *et al.*, 1957). Therefore, shortage of auxin and gibberellins could cause the reduction of fruit set under high temperature. Then it assumed that the treatments with 4-CPA reduced the effect of high temperature. Auxin and gibberellin are often used for promotion of fruit set in some fruits and vegetables including tomato (Gemeci *et al.*, 2006; Khan *et al.*, 2006; Serrani *et al.*, 2007; Batlang, 2008; Rahman *et al.*, 2015; Karim *et al.*, 2015).

Table 02. Effect of frequency of application of 4-CPA on growth, yield contributing characters and yield of summer tomato

Treatment	Plant height (cm) at harvest	Days required to 50% flowering	Number of flowers plant ⁻¹	Number of fruits plant ⁻¹	Fruit diameter (cm)	Fruit yield (kg) plot ⁻¹	Fruit yield (t ha ⁻¹)
T ₀	86.78	33.00	9.01	6.35	4.55	4.64	18.26
T ₁	94.45	31.33	32.41	11.41	5.11	8.92	35.12
T ₂	92.13	31.33	28.70	10.04	4.88	7.70	30.40
T ₃	90.08	31.00	24.16	8.31	4.72	6.23	24.54
LSD (0.01)	0.69	1.35	1.32	0.30	0.09	0.25	0.97
Level of significance	**	**	**	**	**	**	**

T₀, T₁, T₂ and T₃ indicate control (without 4-CPA), 4-CPA at 5, 10 and 15 day interval, respectively; ** indicates significant at 1% level of probability.

Fruit diameter

Two varieties exhibited significant variation in respect of fruit diameter which ranged from 4.78 cm to 4.85 cm (Table 01)). The higher fruit diameter (4.85 cm) was obtained from BARI Hybrid Tomato 4 variety than BARI Hybrid Tomato 8 (4.78 cm) (Table 01). There was a significant effect of 4-CPA on fruit diameter which is shown in. The maximum fruit diameter (5.11 cm) was found at T₁ which is treated with 5 day interval and the minimum fruit diameter (4.55 cm) was found at control treatment (Table 02). In case of combined effect, the significant variation was observed among 4-CPA and variety combination which are shown in Table 03. The treatment V₁T₁ gave the highest fruit diameter (5.15 cm) among the other treatment combinations. The second highest (5.07 cm) fruit diameter was measured in V₂T₁ and the third highest (4.90 cm) was found in V₁T₂. The treatment V₂T₀ gave the minimum (4.51 cm) fruit diameter among the others (Table 03).

Fruit yield per plot

There was a significant effect of two varieties on fruit yield per plot which ranged from 6.54 to 7.21 kg per plot (Table 01). The higher fruit yield (7.21 kg) was obtained in BARI Hybrid Tomato-4 which was statistically different from BARI Hybrid Tomato-8 (6.54 kg). It was revealed that frequency of application of 4-CPA had a great effect on the fruit yield per plot. Application of 4-CPA 5 day interval provided significantly higher fruit yield (8.92 kg) per plot over control plants which produced on an average 4.64 kg fruit per plot (Table 02). The second highest (7.70 kg) was obtained due to the application of 4-CPA at 10 day interval. The combined effect of fruit per plant was significant among the treatment combinations (Table 03). It was observed that the highest fruit yield (9.24 kg) per plot

was recorded in V_1T_1 whereas the lowest (4.35 kg) was obtained in V_2T_0 . The second highest (8.61 kg) was found in V_2T_1 followed by V_1T_2 (7.79 kg) and V_2T_2 (7.43 kg), respectively.

Table 03. Interaction effect of variety and different concentration of 4-CPA on growth, yield contributing characters and yield of summer tomato

Treatment	Plant height (cm) at harvest	Days required to 50% flowering	Number of flowers plant ⁻¹	Number of fruits plant ⁻¹	Fruit diameter (cm)	Fruit yield (kg) plot ⁻¹	Fruit yield (t ha ⁻¹)
V_1T_0	87.40	32.67	19.62	6.71	4.59	4.93	19.40
V_1T_1	95.10	30.67	33.47	11.77	5.15	9.24	36.36
V_1T_2	92.63	31.00	29.94	10.34	4.90	7.97	31.38
V_1T_3	90.75	30.67	25.86	8.88	4.76	6.70	26.37
V_2T_0	86.15	33.33	18.41	5.98	4.51	4.35	17.11
V_2T_1	93.80	32.00	31.35	11.05	5.07	8.61	33.88
V_2T_2	91.63	31.67	27.46	9.74	4.86	7.43	29.41
V_2T_3	89.40	31.33	22.46	7.74	4.68	5.77	22.72
LSD (0.01)	0.89	1.91	1.86	0.43	0.13	0.35	1.37
Level of significance	**	**	NS	**	**	**	**

V_1 and V_2 indicate BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8, respectively; T_0 , T_1 , T_2 and T_3 indicate control (without 4-CPA), 4-CPA at 5, 10 and 15 day interval, respectively; ** indicates significant at 1% level of probability.

Fruit yield per hectare

Significant variation was observed between the two summer tomato varieties in respect of yield (t ha⁻¹). BARI Hybrid Tomato-4 gave higher fruit yield (28.38 t ha⁻¹) and the lowest fruit yield (25.78 t ha⁻¹) was obtained in BARI Hybrid Tomato-8. Different frequency of application of 4-CPA significantly influenced fruit yield over control plants (Table 02). The highest fruit yield (35.12 t ha⁻¹) was obtained from the application of 4-CPA at 5 day interval and the lowest fruit yield (18.26 t ha⁻¹) was found in control treatment. The second highest (30.40 t ha⁻¹) was found in T_2 treatment. The combined effect of varieties and different intervals of 4-CPA application on yield of tomato per hectare showed a significant variation (Table 03). It was observed that the highest fruit yield (36.36 t ha⁻¹) was found from the treatment combination of V_1T_1 , and V_2T_1 gave the second highest yield (33.88 t ha⁻¹). The lowest yield (19.40 t ha⁻¹) was found from control plants.

IV. Conclusion

4-chlorophenoxy acetic acid (4-CPA) had significant influence on growth and yield of tomato. Application of this hormone at 5 day interval gave the highest yield with BARI Hybrid Tomato-4. Therefore, this study provides a strong support that application of 4-CPA at 5 day interval may have more positive effects on the growth and yield of summer tomato. However, it is suggested that similar study can be conducted to determine the effects of higher frequency of application of 4-CPA on fruit set and yield of tomato with other summer tomato varieties released by BARI and BINA (Bangladesh Agricultural Research Institute and Bangladesh Institute of Nuclear Agriculture, respectively) as well as other agro-ecological zones of the country. In addition, the practice of using synthetic chemicals like 4-CPA should be used only at tested and recommended concentrations to ensure quality products that is safe and healthy for the human health and eco-friendly.

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V. References

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