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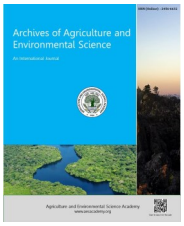

ORIGINAL RESEARCH ARTICLE

Interaction effect of seedling age and different doses of GA_3 on growth and yield of tomato (*Lycopersicon esculentum* Mill.)

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ABSTRACT

An experiment was conducted in the Horticultural Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2010 to March 2011 to find out the effect of GA_3 and seedling age on the growth and yield of tomato. The experiment was laid out in randomized complete block design (RCBD) with three replications. The experiment consisted of four concentration of GA_3 such as control G_0 = no GA_3, G_1= 75 ppm GA_3, G_2 = 100 ppm GA_3 and G_3 =125 ppm GA_3; three different seedling ages such as S_1= 20 days, S_2= 25 days and S_3= 30 days old seedling. All parameter varied significantly at different concentration of GA_3 in different DAT. The combined effect of G_3S_3 (125 ppm GA_3 with 30 days old seedling) gave the maximum yield (90.28 t ha^{-1}), on the other hand combined effect of G_0S_1 (no GA_3 with 20 days old seedling) gave the minimum yield (59.83t ha^{-1}). The maximum yield (2.79 kg) $plant^{-1}$was recorded from treatment combination of G_3S_3 and the minimum yield (1.20 kg) was recorded from treatment combination G_0S_1. The maximum yield (32.47 kg) $plot^{-1}$ was recorded from treatment combination G_3S_3 and the minimum yield (21.52 kg) $plot^{-1}$ was recorded from treatment combination G_0S_1. The maximum yield (90.28 t ha^{-1}) was recorded from treatment combination of G_3S_3 and the minimum yield (59.83 t ha^{-1}) was recorded from treatment combination of G_0S_1. Therefore, 125 ppm GA_3 with 30 days old seedling was found suitable combination for tomato production.

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.), under the family Solanaceae is one of the important, popular and nutritious vegetable crop grown in Bangladesh during rabi season (Mondal *et al.,* 2011). 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; Chopra *et al.,* 2017). It ranks next to potato and sweet potato in the world vegetable production and tops the list of canned vegetable (Choudhury, 1979). 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 100 g edible portion (Rashid, 1983) in comparison to its requirement (Aditya *et al.,* 1999; Chopra *et al.,* 2017). The low yield of tomato in Bangladesh, however, is not an indication of low yielding ability of this crop, but of the fact that low yielding variety, poor crop management practices and lack of improved technologies. Tomato is cultivated generally in winter season. There is considerable interest in extending the cultivation of tomato over a longer period. In the dry season with high temperature, flower abortion occurs and fruits drop frequently, which causes very poor yield of tomato (Nahir and Ullah, 2012; Chopra *et al.,* 2017). However, high temperature before and after the short winter season inhibits the flower and fruit development, use of plant growth regulators, viz. gibberellin and auxin has been reported to be very effective to overcome the problems of flower and fruit development in tomato (Adlakha and Velma, 1965; Groot *et al.,* 1987). GA_3, particularly, is known to promote fruit development in pollinated ovaries that undergoes dormancy due to high temperature (Johnson and Liverman, 1957). Fruit set in tomato can be increased by applying plant growth regulators to compensate the deficiency of natural growth substances required for its development (Singh and Choudhury, 1966). Therefore, it was

thought that it is necessary to find out the effective dose of growth regulators viz. GA_3 in promoting the fruit set that will eventually lead to enhanced increasing yield of tomato even in higher temperature that prevails in the later part of the growing season under Bangladesh condition. Gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant (Rafeekher *et al.,* 2002).

The age of seedlings to be transplanted is very important for proper establishment in the field and production of good quality fruits as well as high yield. Tender aged or over aged seedlings are not suitable for better yield. Medium aged seedlings results in greater leaf area, high yield and number of fruits per plant and greater average fruit weight (Hassan, 1967). The optimum age of seedling is generally varied with variety and season. Comparatively more aged but not over aged seedlings perform better in the late season (Rafeekher *et al.,* 2002; Mondal *et al.,* 2011; Nahir and Ullah, 2012). Therefore, the present investigation was conducted to study the interaction effect of seedling age and different doses of GA_3on growth and yield of tomato (*Lycopersicon esculentum* Mill.).

MATERIALS AND METHODS

The field experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka -1207 during the period from October 2013 to March 2014 to find out the effect of different doses of GA_3 as plant growth regulator and seedling ages on the growth and yield of tomato. The location of the experimental site was at 23.75^0 N latitude and 90.34^0 E longitude with an elevation of 8.45 meter from the sea level. Soil of the study site was silty clay loam in texture. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, ECE 25.28 (Haider, 1991). The tomato variety BARI Tomato-14 was used in the experiment. Tomato seedlings were raised in three seedbeds situated on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3 m × 1 m. The seeds were sown on the seedbed at three different dates on 27th October, 2nd November and 5th November, 2013 to get 30, 25 and 20 days old seedlings, respectively.

The experiment consisted of two factors as four different concentration of GA_3 (Gibberellic Acid); G_0= 0 ppm (Only water), G_1= 75 ppm, G_2= 100 ppm and G_3= 125 ppm and the other factor three seedling ages; S_1= 20 days, S_2= 25 days, and S_3= 30 days old seedling. The experiment was laid out in randomized complete block design **(**RCBD) having two factors with three replications. The size of each plot was 2 m × 1.8 m. The distance between two blocks and two plots were 1m and 0.5m respectively. Seedlings were transplanted on the plots with 60 cm x 40 cm spacing. Cowdung 10 t ha^{-1}, Urea 550 $kgha^{-1}$, TSP 450 $kgha^{-1}$, MOP 250 $kgha^{-1}$. The entire amount of cowdung applied as basal during land preparation. Urea and TSP were applied at the rate of 550$kgha^{-1}$ and 450$kgha^{-1}$. The quantity of manure, cow dung was also determined at the rate of 10 ton/ha as recommended (BARC, 2005). GA_3 at different concentration *viz.,* 0 ppm, 75 ppm, 100 ppm and 125 ppm were prepared following the procedure mentioned below and spraying was done during the noon using hand sprayer. Spraying was done 25 days after transplanting. 75 ppm solution of GA_3 was prepared by dissolving 75 mg of it with distilled water. Then distilled water was added to make the volume 1 liter 75 ppm solution. In similar way 100 ppm and 125 ppm concentration were made. An adhesive Tween-20 @ .1% was added to each solution. Control plots were treated only with distilled water. Healthy and uniform 20, 25 and 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 30 November, 2013 maintaining a spacing of 60 cm x 40 cm between the rows and plants, respectively.

Five plants were selected at random and uprooted carefully at the time of collecting data of root from each plot and mean data on the following parameters namely plant height, number of leaves per plant, number of branches per plant, number of clusters per plant, number of flowers per plant, number of fruits per plant, length of fruit, diameter of fruit, dry matter content, yield per plant, yield per plot and yield of tomato per hectare were recorded. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the treatment means was evaluated by least significant difference (LSD) test (Gomez and Gomez, 1984) at 5% level of probability.

RESULTS AND DISCUSSION

Plant height: The variation was found due to combined effect of GA_3 application and seedling age on plant height at different date after transplantation (DAT). The maximum plant height (50.87 cm) was recorded from treatment combination of G_3S_3 (30 days old seedling with GA_3 application at 125 ppm), while the treatment combination of G_0S_1 (20 days old seedling with no GA_3 application) gave the minimum (26.40 cm) plant height. GA_3 application enhances cell growth and cell elongation that helps to increase plant height. So, 30 days old seedling with optimum level of GA_3 is beneficial for plant growth.

Number of leaves $plant^{-1}$: At 70, the maximum number of leaves $plant^{-1}$ (86.05) was found from the treatment combination of G_3S_3 (125 ppm with 30 days old seedling) and the treatment combination of G_0S_1 gave minimum number of leaves $plant^{-1}$ (63.41). It was observed that higher concentration (125 ppm) of GA_3 and 30 days old seedling performed the maximum number of leaves $plant^{-1}$. About Similar results was observed by Gabal *et al.* (1999) in tomato and Kannan *et al.* (2009) in paprika.

Number of branches $plant^{-1}$: The variation was found due to combined effect of GA_3 application and seedling age on branches $plant^{-1}$. The maximum branches $plant^{-1}$ (12.33) was recorded from treatment combination of G_3S_3 (30 days old seedling with 125 ppm GA_3), while the treatment combination of G_0S_1 (no application of GA_3 with 20 days old seedling) gave the lowest (7.00) number of branches $plant^{-1}$, which was statistically similar to G_1S_1 (7.67) (Table 1).

Dry matter content of leaves: At combined effect of different concentration of GA_3 and seedling age showed significant variation on dry matter content of leaves. The maximum dry matter of leaves (15.10%) was found from the treatment combination of G_3S_3 (30 days old seedling with 125 ppm GA_3) whereas the minimum (11.50%) was performed by G_0S_1 (no application of GA_3 with 20 days old seedling). Masroor *et al.* (2006) also reported that GA_3 had appreciably increased the protein synthesis in the leaves of tomato.

Dry matter content of stem: Combined effect of different concentration of GA_3 and seedling age showed significant variation on dry matter content of stem. The maximum dry matter of stem (11.90%) was found from the treatment combination of G_3S_3 (30 days old seedling with 125 ppm GA_3) whereas the minimum (8.10%) was performed by G_0S_1 (no application of GA_3 with 20 days old seedling) (Table 1).

Dry matter content of root: Due to combined effect of different concentration of GA_3 and seedling age showed significant variation on dry matter content of root. The maximum dry matter of root (34.30%) was found from the treatment combination of G_3S_3 (30 days old seedling with 125 ppm GA_3) whereas the minimum (18.30%) was performed by G_0S_1 (no application of GA_3 with 20 days old seedling) (Table 1).

Diameter of fruit: The variation was found due to combined effect of GA_3 application and seedling age on fruit diameter. The maximum fruit diameter (5.50 cm) was recorded from treatment combination of G_3S_3 (30 days old seedling with GA_3 application at 125 ppm), while the treatment combination of G_0S_1 (20 days old seedling with no GA_3 application) gave the minimum (4.00 cm) fruit diameter (Table 2). However, the report by Khan *et al.* (2006) indicated the significant role of GA_3 in tomato plant increase fruit set that leads to larger number of fruits per plant and increased fruit size.

Yield plant^{-1} (kg): Due to combined effect of GA_3 application and seedling age showed significant variation on yield plant^{-1}. The maximum yield plant^{-1} (2.79 kg) was recorded from treatment combination of G_3S_3 (30 days old seedling with GA_3 application at 125 ppm), while the treatment combination of G_0S_1 (20 days old seedling with no GA_3 application) gave the minimum yield (1.20 kg) plant^{-1} (Table 2). Application of GA_3 increases cell growth and elongation and leads to bigger plants with longer shoots and leaves in many plants of high temperature inhibition in tomato fruit set by with higher crop yields. Application of GA_3 increased the number of fruits per plant, single fruit weight and thus increased in yield of tomato.

Yield plot^{-1} (kg): Combined effect of GA_3 application and seedling age showed significant variation on yield plot^{-1}. The maximum yield plot^{-1} (32.47 kg) was recorded from treatment combination of G_3S_3 (30 days old seedling with GA_3 application at 125 ppm), while the treatment combination of G_0S_1 (20 days old seedling with no GA_3application) gave the minimum yield (21.52 kg) yield plot^{-1} (Table 2).

Yield per hectare: The variation was found due to combined effect of GA_3 application and seedling age on yield per hectare (t ha^{-1}). The maximum yield (90.28 t ha^{-1}) was recorded from treatment combination of G_3S_3 (30 days old seedling with GA_3 application at 125 ppm) and the treatment combination of G_0S_1 (20 days old seedling with no GA_3 application) gave the minimum yield (59.83 t/ha) yield (Table 2). Khan *et al.* (2006) reported that irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters. Souma *et al*. (1976) reported that seedlings transplanted 30 days after sowing grow the best and give more yield. Benedictos *et al*. (2000) reported that 5 weeks old transplants of tomato had the highest fruit setting rate.

Table 1. Combined effect of GA_3 and seedling age on different plant characteristics of tomato.

Treatments	Plant height (cm) at				Leaves plant^{-1} at				Branches plant^{-1}	Dry matter content (%) of leaf	Dry matter content (%) of stem	Dry matter content (%) of root
	30 DAT	50 DAT	70 DAT	90 DAT	30 DAT	50 DAT	70 DAT	90 DAT				
G_0S_1	26.40	54.47	65.93	72.71	8.67	29.33	63.42	69.00	7.00	11.50	8.10	18.30
G_0S_2	28.87	55.33	66.78	73.46	9.00	31.00	65.07	72.72	8.33	11.90	8.90	19.50
G_0S_3	35.33	57.27	67.80	74.86	10.67	31.33	67.89	75.59	9.00	12.90	9.60	25.30
G_1S_1	27.27	56.33	71.63	75.705	8.67	30.00	66.43	71.27	7.67	11.70	9.10	20.00
G_1S_2	29.80	59.83	72.48	76.45	9.33	31.33	68.09	74.99	8.67	12.30	9.50	20.70
G_1S_3	41.60	60.53	73.50	77.85	10.33	31.67	70.91	77.86	9.6	13.07	10.00	25.70
G_2S_1	30.33	60.80	76.20	91.09	9.67	32.00	72.22	76.56	8.33	12.10	9.60	20.90
G_2S_2	32.47	63.60	77.02	91.84	10.33	32.33	73.88	80.28	9.67	12.90	9.90	23.90
G_2S_3	41.00	65.87	78.07	93.24	11.67	33.33	76.71	83.15	10.33	13.50	10.70	26.00
G_3S_1	35.53	66.30	92.02	100.34	10.33	33.67	81.56	86.23	10.33	13.90	10.50	26.30
G_3S_2	38.40	66.70	92.87	101.09	11.33	35.00	83.22	89.95	11.33	14.30	11.30	28.70
G_3S_3	50.87	68.40	93.89	102.49	12.00	38.00	86.05	92.82	12.33	15.10	11.90	34.30
CV (%)	7.48	4.59	9.87	8.91	4.92	3.32	8.42	9.25	7.04	0.96	0.01	0.01
LSD $_{(0.05)}$	4.406	4.760	0.062	0.032	0.847	1.823	0.1312	0.0981	1.119	0.207	0.017	0.017

G_0= no GA_3, G_1= 75 ppm GA_3, G_2 = 100 ppm GA_3 and G_3=125 ppm GA_3; S_1= 20 days, S_2= 25 days and S_3= 30 days old seedling. DAT = Days after transplanting.

Table 2. Combined effect of GA_3 and seedling age on different yield contributing characteristics of tomato.

Treatments	Dry matter content in fruit (%)	Flowers plant^{-1}	Fruit clusters plant^{-1}	Fruits plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1} (kg)	Yield plant^{-1} (kg)	Yield (t ha^{-1})
G_0S_1	4.30	65.80	6.33	39.40	5.70	4.00	1.20	21.52	59.83
G_0S_2	4.47	70.73	7.33	41.87	5.80	4.30	1.34	23.62	65.67
G_0S_3	5.50	83.67	8.67	48.33	5.80	4.30	1.81	26.62	74.01
G_1S_1	4.50	70.87	7.67	41.20	5.80	4.30	1.32	22.72	63.17
G_1S_2	4.80	72.60	8.67	42.80	5.80	4.50	1.49	24.82	69.01
G_1S_3	5.10	96.20	9.33	54.60	6.00	4.50	2.03	27.82	77.35
G_2S_1	6.30	73.67	8.67	43.33	6.00	4.80	1.43	23.85	66.30
G_2S_2	6.30	83.00	9.67	46.00	6.63	5.00	1.80	25.95	72.14
G_2S_3	6.80	103.70	11.00	56.00	6.63	5.10	2.05	28.95	80.48
G_3S_1	6.10	87.40	11.67	49.53	6.67	5.10	1.72	27.37	76.10
G_3S_2	6.23	101.50	13.00	53.73	6.97	5.33	2.17	29.47	81.94
G_3S_3	6.53	125.10	14.67	66.00	7.03	5.50	2.79	32.47	90.28
CV (%)	3.61	5.99	14.73	4.82	2.82	1.08	10.30	8.881	9.027
LSD $_{(0.05)}$	0.343	8.739	2.425	3.960	0.298	0.093	0.307	0.176	5.060

G_0= no GA_3, G_1= 75 ppm GA_3, G_2 = 100 ppm GA_3 and G_3=125 ppm GA_3; S_1= 20 days, S_2= 25 days and S_3= 30 days old seedling.

Conclusions

In conclusion of the present investigation, the maximum yield (2.79 kg) plant^{-1}was recorded from treatment combination of G_3S_3 and the minimum yield (1.20 kg) was recorded from treatment combination G_0S_1. The maximum yield (32.47 kg) plot^{-1} was recorded from treatment combination G_3S_3 and the minimum yield (21.52 kg) plot^{-1} was recorded from treatment combination G_0S_1. The maximum yield (90.28 t ha^{-1}) was recorded from treatment combination of G_3S_3 and the minimum yield (59.83 t ha^{-1}) was recorded from treatment combination of G_0S_1. It may be concluded that 125 ppm GA_3 and 30 days old seedlings are suitable for getting higher yield of tomato.

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