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EFFECTS OF TWO GROWTH REGULATORS ON YIELD, STORAGE BEHAVIOUR AND QUALITY OF TOMATO (*LYCOPERSICON ESCULENTUM* MILL.)

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Abstract

An experiment was conducted to evaluate the effect of NAA (single spray of 200 and 400 ppm, double spray of 200 and 400 ppm) and TIBA (single spray of 100 and 200 ppm, double spray of 100 and 200 ppm) on the yield, yield attributes, storage behaviour and quality of BARI tomato-4 fruits. Plant heights and number of branches/plant decreased due to all the treatments. Number of fruits per plant increased for single spray of 400 ppm and double spray of 200 ppm NAA, which were higher than control by 26.92 and 15.38%, respectively. Fresh weight/fruit increased over control for all the treatments except for double spray of 400 ppm NAA. Yield/plant was significantly increased due to single spray of 400 ppm and double spray of 200 ppm NAA and following both single and double spray of 100 ppm TIBA. Maximum shelf-life of fruits was recorded due to four treatments *viz.* single and double spray of 200 ppm NAA, single spray of 100 ppm and double spray of 200 ppm TIBA. Also the minimum loss of fresh weight during storage was obtained due to double spray of 400 ppm NAA which was 51.09% lower than control. Moisture content increased whereas, ash, dietery fibre and energy content decreased with all the NAA treatments. For all the TIBA treatments protein, and energy content increased whereas dietery fibre decreased. Ascorbic acid content of fresh fruit was lower than the control following both NAA and TIBA treatments but after being stored for 30 days at ± 26ºC increased for single spray of 200 ppm NAA, double spray 400 of ppm NAA and double spray of 100 ppm TIBA which were 83.77, 71.29 and 4.43% higher than control respectively.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular and nutritious vegetable crops grown in Bangladesh and is generally cultivated during the winter season. Tomatoes contain a wide array of beneficial nutrients and antioxidants, including alpha-lipoic acid, choline, lycopene, folic acid, beta-carotene and lutein which promote good health. Tomato 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 1987). In Bangladesh, the average yield of tomato was 13.46 metric ton per hectare (BBS 2015), which is very low in comparison to that of other countries, namely India. 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. The shelf-life of tomato is very short and therefore, these cannot be transported to distant places for marketing. This causes a great loss, depriving the farmers to realize a remunerative price.

Growth regulators have been reported to enhance certain physiological processes in order to increase or decrease yield of different crop plants (Howlett 1941, Jahan and Fattah 1991, Ahmed *et al.* 2010, Jahan and Adam 2013). NAA and TIBA are two synthetic growth regulators used for the improvement of growth and yield in various crop plants. NAA affects growth, development and other physiological and biochemical processes of plants (Jahan and Fattah 1991, Alam and Khan 2002, Adam and Jahan 2011, Abbasi *et al*. 2013). TIBA is used for checking excessive vegetative growth and lodging tendency, reducing the abscission of flowers and immature pods

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and for modification of crop canopy to improve production. Application of TIBA induces greater growth, yield and yield attributes of various economically important crop plants *viz*. okra (Begum *et al*. 1991), tomato (Mondal and Dutta 2002), mung bean (Adam and Jahan 2014) and soybean (Jahan and Khan 2014).

Although reports regarding increases in growth and yield of tomato plants following NAA and TIBA application are available but no report is yet available showing their effect on the storage behaviour of any variety of tomato cultivated in Bangladesh. Experiments are going on to develop genetically modified tomato plants for higher yields and increasing the storage time of fruits. However, the expense of creating transgenic tomato to increase yield and shelf-life is too high and cannot be afforded by our farmers. Besides, to increase the storage time of of the fruits people have subjected themselves in using carbides, which is very harmful chemical substance and is highly carcinogenic. Thus, to prevent these unfortunate things to be happening, the present investigation was undertaken to study the effect of NAA and TIBA on yield, quality and storage behaviour of a variety of tomato, BARI tomato-4 grown in Bangladesh.

Materials and Methods

A field experiment was conducted in the Research Garden of the Department of Botany, University of Dhaka following a randomized block design with five replications. Fertilizers were applied at doses recommended by BARI (Urea, triple super phosphate, muriate of potash @ 120, 80 and 50 kg/ha, respectively) at the time of final land preparation. Cow-dung was also mixed homogenously at the rate of 20 ton/ha. Four weeks old seedlings of BARI tomato-4 was collected from BARI, Joydepbur, Gazipur and was transplanted directly in the field on 11th November, 2014. Plant to plant and row to row distances were 0.60 m and 0.75 m, respectively. Weeding was done at 15, 30 and 45 days after transplantation (DAT). Nine treatments T_0, T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8 *viz.* control, single spray of 200 and 400 ppm NAA, double spray of 200 and 400 ppm NAA, single spray of 100 and 200 ppm TIBA, double spray of 100 and 200 ppm TIBA respectively, were applied as foliar spray at the age of 30 DAT.

Five plants from each treatment were selected for data collections. Data on plant height and number of branches per plant were recorded at an interval of two weeks starting from the day of spraying to final harvest i.e. 56 days after spray (DAS). Number of fruits per plant and fresh weight per fruit was recorded on the day of the harvest. The fruits were harvested at colour turning stage of maturity. Yield per plant was recorded by adding the fresh weight of all the harvested fruits for each treatment and was expressed in average of five plants. Shelf-life and total loss of weight of fruits were recorded by storing the fresh fruits at normal room temperature ($\pm 26^0$C) in perforated wooden crates of size 35 cm × 25 cm × 18 cm in two layers. Biochemical parameters - moisture, ash, fat, protein and fiber content of the fruits were determined on dry weight basis by proximate analysis (AOAC 2000), while vitamin C was determined by reverse phase C18 HPLC (High Pressure Liquid Chromatography) method according to Martin (2007). Data were analyzed statistically and treatment means were compared by LSD test at 5% level of significance (Steel *et al*. 1997).

Results and Discussion

Results presented in Table 1 indicated that initially i.e. at 14 DAS plant height of BARI tomato-4 was recorded maximum due to T_6 followed by T_5 treatment and the increases were 7.47 and 1.38%, respectively over the control. But from 28 DAS up to harvest, plant height decreased for all the treatments. Reports regarding increases in plant height following NAA application are available in tomato (Prasad *et al*. 2013, Pargi *et al*. 2014). Both increases and decreases in plant

height following NAA application have been reported by Alam and Khan (2002) in tomato and Ullah *et al.* (2007) in cowpea. Begum *et al*. (1992) observed that plant height of okra increased significantly due to TIBA application. Decreases in plant height following TIBA applications have been reported in cotton (Djanaguiraman *et al*. 2005), mungbean (Adam and Jahan 2014), and soybean (Jahan and Khan 2014).

Table 1. Effects of NAA and TIBA on height (cm) of BARI tomato-4 plants at different days after spray.

Treatments	Days after spray				At harvest
	0	14	28	42	
T_0	53.6	72.2	91.4	115.0	115.0
T_1	50.0	59.4	78.0	107.0	107.6
T_2	51.8	65.4	90.4	108.4	109.6
T_3	52.4	65.2	85.8	109.0	110.6
T_4	47.8	57.8	75.8	103.0	104.4
T_5	56.0	73.2	83.4	103.6	105.2
T_6	59.2	77.6	90.2	100.2	102.0
T_7	49.0	71.2	84.4	92.6	93.8
T_8	47.6	66.8	80.4	97.0	98.8
CV (%)	0.07	0.10	0.07	0.07	0.06
LSD (0.05)	NS	NS	NS	NS	NS

Number of branches per plant followed the same pattern as in plant height (Table 2). On 14 DAS, higher number of branches per plant was recorded only in plants treated with T_6. But from 28 DAS up to harvest the highest number of branches per plant were found in control. Prasad *et al*. (2013) reported increase in number of branches in tomato following different concentrations of NAA treatment. Alam and Khan (2002) observed that number of branches in tomato decreased following NAA application. Reports regarding decrease in number of branches per plant following TIBA applications are found in alfalfa (Ravichandran and Ramaswami 1991), in okra (Begum *et al*. 1992) and in mungbean (Adam and Jahan 2014).

Table 2. Effects of NAA and TIBA on number of branches per plant of BARI tomato-4 at different days after spray.

Treatments	Days after spray				At harvest
	0	14	28	42	
T_0	6.4	21.0	41.8	77.8	127.8
T_1	7.0	15.0	36.0	63.0	108.4
T_2	6.8	14.4	30.4	52.6	64.2
T_3	8.8	17.6	35.6	36.8	93.8
T_4	7.8	14.4	31.4	54.6	82.4
T_5	6.6	19.4	37.6	58.4	80.2
T_6	7.6	23.4	35.4	47.0	54.6
T_7	5.6	19.2	38.4	68.4	111.4
T_8	6.0	18.4	34.0	59.0	95.0
CV (%)	0.14	0.17	0.10	0.21	0.26
LSD (0.05)	NS	NS	NS	NS	NS

Data represented in Table 3 show that yield attributes and yield per plant were both positively and negatively influenced following application of NAA and TIBA. The highest number of fruits per plant was obtained from plants following single foliar spray of 400 ppm NAA (T_2) followed

by double foliar spray of 200 ppm NAA (T_3) and the increases were 26.92 and 15.38% respectively, over the control. Fresh weight/fruit increased over control for all the treatments except for double spray of 400 ppm NAA (T_4), which was significantly not different from control. Yield/plant increased by 54.16, 50.99, 44.65 and 10.65% over control in plants following application of T_2, T_5, T_7 and T_3 treatments respectively. Similar results of increased and decreased yield due to NAA application in tomato (Prasad *et al.* 2013, Pargi *et al.* 2014) and due to TIBA application in mung bean (Adam and Jahan 2014) and soybean (Jahan and Khan 2014) were also observed. Thus, the results are in conformity with the findings of the previous workers.

Table 3. Effects of NAA and TIBA on yield attributes, yield and storage behaviour of BARI tomato-4.

Treatments	Number of fruits/plant	Fresh weight/ fruit (g)	Yield/plant (kg)	Shelf-life (days)	Total loss of weight in fruits (%)
T_0	130 a	70.93 b	11.81 a	39	17.38 a
T_1	90 a	74.98 a	8.45 ab	42	12.28 ab
T_2	165 a	74.49 ab	18.20 a	39	22.61 a
T_3	150 a	83.91 a	13.07 a	45	14.34 a
T_4	92 a	52.00 b	4.93 b	30	10.36 b
T_5	89 a	180.25 a	17.83 a	45	18.91 a
T_6	45 b	160.00 a	9.24 a	30	29.20 a
T_7	82 ab	151.85 a	17.08 a	30	14.78 a
T_8	49 b	135.33 a	9.22 a	45	15.58 a
CV (%)	0.42	0.42	0.39	0.207	0.36
LSD (0.05)	99.11	105.98	12.22	NS	17.05

*Means in a vertical column followed by same letter do not differ significantly at 5% level.

Storage behaviour was also seen to be both positively and negatively influenced following different treatments (Table 3). Maximum shelf-life (45 days) was recorded due to foliar application of three treatments *viz.* T_3, T_5 and T_8 which were 15.38% higher than the control. The second highest was obtained due to T_1 which was 7.69% higher than control. Total loss of fresh weight (%) of tomato fruits reduced except for T_2, T_5 and T_6 treatments. The maximum loss of fruit weight during storage was obtained due to T_6 which was 68.01% higher than the control and the minimum was obtained due to T_4 which was 51.90% lower than the control and was significant. Although different other growth regulators are known to increase the shelf-life of vegetables and fruits (Gupta *et al.* 1986 a,b), no such report is yet available on the effect of NAA and TIBA.

Table 4 revealed that different biochemical parameters of fruits responded differently due to application of NAA and TIBA. Moisture content increased for all the treatments except for T_6 and T_7. The maximum moisture content for NAA was found from the fruits of T_2 which was 1.32% higher than control and for TIBA the maximum was obtained from those of T_5 and T_8 treatments. The results are in accordance with the findings of Harhash and Al-Obeed (2007) in date palm following NAA application. Ash content in fruits increased only due to T_7 treatment which was 21.05% higher than the control. Protein content of fruits increased following all the treatments except T_2 and T_4. Maximum protein content for NAA treatment was recorded in T_3 which was significant ($p < 0.05$) and 300% higher than the control and maximum for TIBA was obtained from T_7 which was 108.11% higher than control. Similar observations were found by other workers in tomato following NAA application (Pargi *et al.* 2014) and following TIBA application (Razzaque and Rahman 2004). Only decrease in fat content was recorded due to T_3 treatment which was not significant, while total dietary fiber decreased significantly ($p < 0.05$) for all the

treatments. For available carbohydrate the only increase for NAA was obtained from T_1 treatment whereas, the only decrease for TIBA was recorded due to T_8. NAA has been reported to increase carbohydrate in different plants *viz*. rice (Adam and Jahan 2011) and *Eruca sativa* (Al-Wahaibi *et al*. 2012). The energy content decreased for all the NAA treatments while it increased for all the TIBA treatments. Though there was increase in ascorbic acid content during the period of storage, the rate of increase was much lower in control. In comparison to control, ascorbic acid content in freshly picked tomatoes decreased for all the treatments and the decreases recorded due to T_4 and T_8 were significant ($p < 0.05$) but, increased greatly due to NAA by 83.77 and 71.29% in 30 days old tomato fruits from T_1 and T_4 treatments respectively. However, the only increase (4.34%) in ascorbic acid content following TIBA application was due to T_7. The change in ascorbic acid content between the freshly picked tomatoes and one month old tomatoes may be due to the percent loss of fresh weight of fruits during the storage period. The results are in agreement with the findings of Abbasi *et al*. (2013) and Pargi *et al*. (2014) who reported that in tomato ascorbic acid increased with NAA application.

Table 4. Effects of NAA and TIBA on biochemical parameters of BARI tomato - 4 fruits.

Treat-ments	Moisture content (per 100 g)	Ash content (per 100 g)	Protein content (per 100 g)	Fat content (per 100 g)	Total dietary fiber (per 100 g)	Available CHO (per 100 g)	Energy kcal/ 100 g	Ascorbic acid (mg per 100 g)	
								Freshly picked	30 days old
T_0	93.90	0.57 a	0.37 b	0.04 b	1.8400 a	3.28 a	18.64	35.26 a	36.54 a
T_1	94.84	0.04 b	0.42 b	0.07 a	1.3060 e	3.32 a	18.20	31.67 a	67.15 a
T_2	95.14	0.35 ab	0.33 bc	0.08 a	0.9898 i	3.10 a	16.44	26.19 a	31.01 a
T_3	94.99	0.39 a	1.48 a	0.03 b	1.4275 c	1.68 b	15.81	15.67 a	26.04 b
T_4	94.51	0.52 a	0.06 c	0.09 a	1.5998 b	3.22 a	17.16	6.96 b	62.59 a
T_5	94.11	0.36 a	0.71 b	0.14 a	1.1020 h	3.59 a	20.61	15.58 ab	30.64 ab
T_6	93.72	0.44 a	0.60 b	0.04 b	1.2070 f	4.00 a	21.17	20.96 a	20.66 b
T_7	93.24	0.69 a	0.77 b	0.13 a	1.1500 g	4.10 a	22.98	19.995 a	38.16 a
T_8	94.11	0.56 a	0.62 b	0.06 ab	1.4257 cd	3.22 a	18.74	13.22 b	24.28 b
CV (%)	0.01	0.43	0.69	0.52	0.20	0.21	0.12	0.44	0.44
LSD (0.05)	NS	0.44	0.60	0.08	0.01	3.28	NS	20.61	37.45

*Means in a vertical column followed by same letter do not differ significantly at 5% level.

Thus on the whole, NAA and TIBA can be fruitfully utilized for obtaining higher yield and better quality of BARI tomato-4 fruits with longer shelf-life depending on concentrations of chemicals used and also on the mode of application.

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