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Impact of Exogenous Application of Indole-3-Acetic Acid on Growth, Yield and Nutritional Quality of Tomato

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Abstract

Four distinct dosages of indole-3-acetic acid (IAA) were used in a single-factor experiment to examine the effects of exogenous IAA administration on tomato growth, yield, and quality. The dosages of IAA were as follows: (i) Control (no IAA), (ii) 50 ppm IAA, (iii) 100 ppm IAA, and (iv) 150 ppm of IAA. Three replications of the experiment were set up using a randomized complete block design. The BARI Tomato-15 had was utilized as the test material. Fruit yield and growth, as well as its nutritional value were significantly impacted by IAA. The 150 ppm of IAA treatment generated the tallest plant (85.49 cm), the maximum number of leaves (26.00), the minimum number of days (29.34 days) needed for the first flowering, the maximum number of flower clusters per plant (15.17), the number of flowers per plant (37.50), and the number of fruits per plant (32.17). The fruit length, weight and yield (96.44 t/ha) were the highest in 100 ppm of IAA. 86.29% (96.44 t/ha) more yield was obtained when treated with 100 ppm of IAA than control (51.77 t/ha). On the other hand, 12.98% (45.05 t/ha) yield reduction occurred in BARI Tomato-15 when treated with 150 ppm of IAA as compared to control (51.77 t/ha). Results revealed that 29.03% TSS, 35.71% TA of fruit increased in 150 ppm of IAA than control and 8.16% pH value decreased in 150 ppm of IAA than control.

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Introduction

The tomato, the second most produced and consumed vegetable in the world, is a key vegetable in Bangladesh (Willcox *et al.,* 2003). According to the BBS, Bangladesh produced 442 thousand metric tons of tomato during 2021-2022 (BBS, 2023). Given that they are high in antioxidants and bioactive compounds, tomatoes are one of the primary sources of food that human beings consume to obtain vitamins and minerals. Among the beneficial substances present in tomatoes are phenolic compounds, ascorbic acid, and lycopene (Rocha and Silva, 2011). Numerous epidemiological studies have demonstrated the protective effects of tomato consumption against long-term conditions like cancer and heart diseases (Giovannucci *et al*., 2002). Therefore, it is pivotal to consume high nutritious food to main good health.

Crop nutritional quality has been found to be significantly influenced by agronomic techniques (Barrett *et al.*, 2007). Numerous pre- and postharvest factors, including cultivar, harvest ripening stage, and agricultural practices, might influence the amount of bioactive chemicals in tomatoes (Dumas *et al.,* 2003). According to Slimestad and Verheul (2009), tomato cultivars have a considerable impact on the amounts of carotenoid and phenolic compounds as well as a partial impact on ascorbic acid. The ripening stage at harvest influences the concentration of phenolic compounds in particular and has a beneficial effect on the carotenoid content (Gautier *et al.,* 2008). Similarly, the addition of

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nitrogen (N) fertiliser raised the tomato's levels of phenolic compounds and vitamin C (Benard et al., 2009). According to Ilahy *et al.* (2011), tomato antioxidant components are influenced by the cultivar, growth conditions, growing season, postharvest and production maturity stages, and mineral nutrition.

Plant physiological functions are regulated by mineral nutrition, which also affects the concentration of certain organic and inorganic substances (Hassan *et al*., 2012).

To increase tomato growth and yield, plant growth regulators (PGRs) are extensively to tackle different biotic and abiotic stresses, such as extremely high or low temperatures, low soil fertility, water deficiency, inadequate cultivation techniques, pest and disease attacks (Roy *et al*., 2018; Karim *et al.,* 2015). Research has indicated that varying nitrogen fertilizer dosages have a substantial impact on tomato's levels of ascorbic acid, carotenoid, and phenolic compounds (Handrian *et al*., 2013; Adli *et al*., 2019). Information on the effects of PGRs on nutritive value of tomato in Bangladesh is insufficient in scientific literature. Therefore, the current study was taken to examine the effects of exogenous IAA treatment on tomato growth, yield, and nutritional quality.

Materials and Methods

Plant materials and growth conditions

Seeds of BARI Tomato-15 were collected from BARI, Gazipur. The Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, was the site of the field experiment. Seedlings were raised in seed bed and transfer to experimental plot at 35-day-old.

Treatments of the experiment

The experiment consisted of four dosages of IAA was used such as I0: 0 ppm IAA (control,), I1: 50 ppm IAA, I2: 100 ppm IAA, and I3: 150 ppm IAA.

Design and layout of the experiment

Three replications and a randomized complete block design were used to set up the single-factor experiment. The unit plot size was 10 m × 10 m and the plants were spaced 60 cm × 60 cm on beds.

Application of IAA

Indole-3-acetic acid was dissolved in 5% ethanol and 0.1% Tween 20 was applied according to treatments. First application of IAA was applied at 15 days after transplanting (DAT) at 7 days interval and continued until 65 DAT.

Parameters studied

Flower and fruit settings, number of flowers and fruits per plant, fruit parameters (average height and average diameter), fruit weight and yield per plant and per plot.

Analysis of nutritional quality

Tomato fruits from the first and second trusses were collected for nutritional analysis. Each plant's tomatoes were collected at the red ripening stage of the experiment.

Total soluble solids (TSS): A handheld refractometer was used to measure the total soluble solids (TSS) in the juice obtained from pressing the flesh of tomato fruits (Astuti *et al.,* 2015).

Tritatable acidity (TA): For a titrable acidity assay, five grams of flesh tissue and five milliliters of distilled water were combined, centrifuged for ten minutes at 10,000 g, and the resulting supernatant was titrated with 0.01 M NaOH (Majidi *et al.,* 2011).

pH content: A digital pH meter was used to record the pH after 10 g of pulp was added to 10 mL of distilled water and homogenised.

Statistical analysis

Data were analyzed with Minitab 17.0 statistical software. The effect of the treatments on tomato plants under salinity stress was analyzed by analysis of variance (ANOVA) for each parameter either at 5 or 1% level of probability. The differences among the treatment means were compared using Fisher's LSD test (Steel *et al.,* 1997).

Results and Discussion

Plant height

No significant difference was found on plant height at 10 DAT as it was measured before the application of any treatment. At 30 DAT the maximum and the minimum plant height (26.42 cm and 19.56 cm, respectively) were recorded at T3 and T0, respectively. Similarly, at 50 DAT the maximum plant height (61.52 cm) was recorded at T3, while the minimum (49.76 cm) was recorded at T0. At 70 DAT the maximum plant height (84.32 cm) was recorded at T3 followed by T2 (81.77 cm), T1 (73.89 cm), respectively, and the minimum plant height (64.18 cm) was recorded from T0 (Figure 1). The increment in the morphological parameters due to the application of IAA may be because of its effects on respiration, cell growth, elongation, and nucleic acid metabolism. The current study's findings concur with the studied by Singh *et al*. (2019).

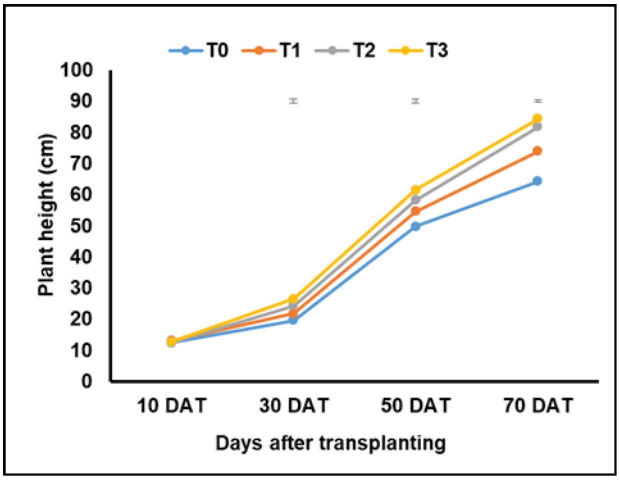

Figure 1. Effect of plant growth regulators on plant height at different days after transplanting of tomato. Vertical bars indicate LSD at 5% level of significance. Here, T_{0} = 0 ppm, T_{1} = 50 ppm IAA, T2 = 150 ppm IAA and T_{3} = 150 ppm of IAA

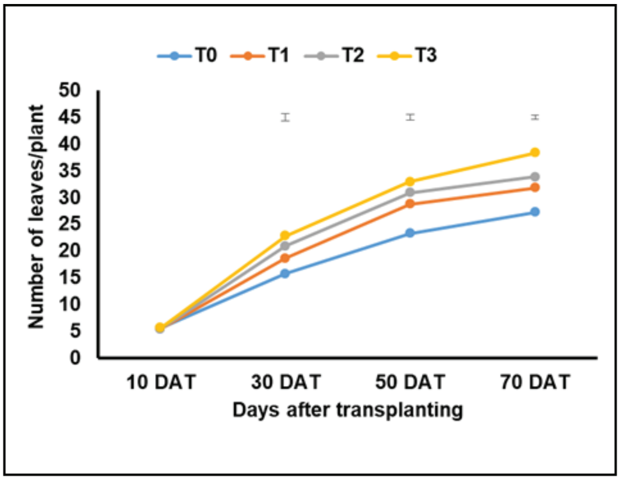

Figure 2. Effect of plant growth regulators on number of leaves at different days after transplanting of tomato. Vertical bars indicate LSD at 5% level of significance. Here, T_{0} = 0 ppm, T_{1} = 50 ppm IAA, T2 = 150 ppm IAA and T_{3} = 150 ppm of IAA

Number of leaves per plant

There was no significant difference on the number of leaves per plant at 10 DAT as it was measured before any other treatment application. But significant difference was found at different days after the application of treatment. At 30 DAT the highest number of leaves (22.87) was recorded in T3 followed by T2 (20.97), and T1 (18.71), respectively, and the lowest number of leaves per plant (15.75) was recorded from T0. Similarly at 70 DAT the highest number of leaves per plant (38.33) was recorded in T3 while the lowest number of leaves (27.29) was recorded from T0 (Figure 2).

Number of flowers clusters per plant

The total number of flower clusters was significantly impacted the application of IAA at varying DAT. At 40 and 50 DAT, the maximum number of flower clusters per plant was recorded in T3 (5.54 and 9.04, respectively) and the minimum number (2.41 and 4.20, respectively) was recorded in T0. At 60 DAT maximum number of flower clusters per plant (14.71) was recorded in T3 followed by T1 (13.30), T2 (12.29), respectively, and the minimum number (8.37) was recorded in T0 (Table 1).

Number of flowers per plant

At 40, 50, and 60 DAT, a significant difference in the number of flowers per plant was noted among the treatments. T3 had the highest number of flowers per plant (17.28) at 50 DAT, whereas T0 had the lowest number of flowers (4.96). T3 produced the most flowers per plant (37.12) at 60 DAT, followed by T1 (35.79) and T2 (34.59), in that order, whereas T0 produced the fewest flowers per plant (24.54) (Table 1).

Number of fruits per plant

The number of fruits per plant significantly influenced by IAA treatments at various DAT. At 80 DAT the maximum number of fruits per plant (30.75) was obtained from T3 followed by T1 (28.71), T2 (25.58), respectively, and the minimum number (19.41) was recorded from T (Table 1).

Table 1. Effect of IAA on number of flower clusters plant-1, number of flowers plant-1 and number of fruits plant-1 at different days after transplanting

Treatment	No. of flower clusters per plant at DAT			No. of flowers per plant at DAT			No. of fruits per plant at DAT		
	40	50	60	40	50	60	60	70	80
T_0	2.41	4.20	8.37	5.10	10.96	24.54	6.54	11.62	19.41
T_1	4.66	8.33	13.30	9.91	15.41	35.79	10.45	19.45	28.71
T_2	4.08	6.66	12.29	8.94	14.25	34.59	9.32	16.87	25.58
T_3	5.54	9.04	14.71	10.98	17.28	37.12	11.78	21.44	30.75
$LSD_{0.01}$	0.95	1.34	0.82	1.69	1.40	0.84	1.02	1.28	2.88
Level of Significance	**	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; T0 = 0 ppm, T1 = 50 ppm IAA, T2 = 100 ppm IAA and T3 = 150 ppm of IAA

Fruit length and diameter

The fruit length varied significantly due to IAA treatments. The maximum fruit length (5.28 cm) was observed at T1, and the lowest (4.42 cm) was recorded from T3 (Table 2). The analysis of variance highlighted that there was significant variation among the IAA treatments in respect of fruit diameter. The maximum fruit diameter (5.09 cm) was observed in T1, and the lowest (3.99 cm) was recorded in T3 (Table 2).

Weight of individual fruit and fruits plant-1

The impact of IAA caused significant variations in the weight of individual fruits. According to Table 2, the highest weight of individual fruit (81.04 g) was found in T1, while the lowest weight (62.87 g) was found in T3. Significant differences were found among the IAA treatments with regard to the weight of fruits produced per plant, according to the analysis of variance. T1 had the highest weight of fruits plant-1 (2.35 kg), whereas T3 had the lowest (1.06 kg) (Table 2).

Significant differences were observed amongst the IAA treatments with regard to the weight of fruits produced per plant, according to the analysis of variance. T1 had the highest weight of fruits plant-1 (2.35 kg), whereas T3 had the lowest (1.06 kg) (Table 2).

Fruit yield plot-1 and ha-1

Significant difference in fruit yield plot-1 among the plant growth regulators was recorded. The maximum fruit yield plot-1 (37.25 kg) was observed in T1 and the minimum (16.93 kg) was recorded in T3 (Table 2). The analysis of variance highlighted that there was significant variation among the plant growth regulators in respect of fruit yield per ha. T1 had the highest fruit output per hectare (93.19 tons), while T3 had the lowest (42.32 tons) (Figure 3).

According to Kumar et al. (2018), plant growth regulators that stimulate vegetative development and increase the number of leaves may be the cause of early anthesis. Fruit production per plant increased dramatically with increasing amounts of plant growth ingredient (Ali et al., 2012; Mukati et al., 2019). In contrast, 50 ppm IAA was used to measure fruit length, fruit diameter, weight of individual fruits, weight of fruits per plant, fruit yield per plot, and fruit output per hectare. Auxin is carried to the roots via the stem, where it promotes the roots' general growth. The yield can be increased by the longer, branching roots' ability to absorb more nutrients from the soil that have accumulated in the plant sink (Wang et al., 2005). According to Verma et al. (2014), using NAA to tomatoes successfully increased fruit set. Mukharji and Roy (1966) discovered that the tomato plant's length of fruit size had increased and that the use of IAA had protected the blossom and prevented premature fruit drop.

Table 2. Effect of IAA on fruit length, fruit diameter, weight of individual fruit, weight of fruits plant-1 and fruit yield plot-1

Treatment	FL (cm)	FD (cm)	IFW (g)	FYP (kg)	FYP/plot (kg)
T_0	4.85	4.52	67.82	1.32	21.09
T_1	5.28	5.09	81.04	2.35	37.25
T_2	5.22	4.95	79.57	2.04	32.67
T_3	4.42	3.99	62.87	1.06	16.93
$LSD_{0.05}$	0.35	0.33	2.06	0.24	3.76
$LSD_{0.01}$	0.48	0.47	2.86	0.34	5.21
Level of Significance	**	**	**	**	**

** = Significant at 1% level of probability; T0 = 0 ppm, T1 = 50 ppm IAA, T2 = 100 ppm IAA and T3 = 150 ppm of IAA, FL; fruit length, FD; fruit diameter, IFW; individual fruit weight, FYP, fruit yield/plant

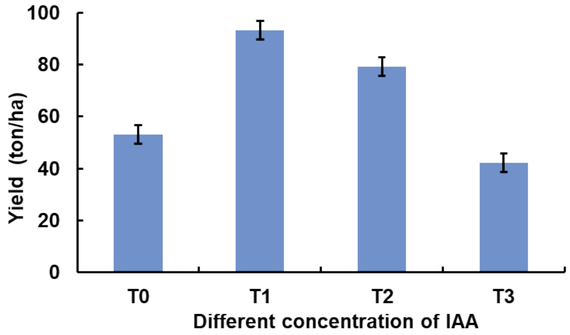

Figure 3. Effect of IAA on fruit yield per ha. Vertical bar indicates LSD at 5% level of significance. Here, T0 = 0 ppm, T1 = 50 ppm IAA, T2 = 100 ppm IAA and T3 = 150 ppm of IAA

Total soluble solids

The effect of IAA on total soluble solids (TSS) content of fruit was statistically significant. The highest TSS content of fruit (3.00 ºBrix) was observed at T3 and the lowest TSS content of fruit (1.95 ºBrix) was observed at T0 (Table 3).

Titratable acidity

The IAA exerted significant influence on titratable acidity (TA) percentage of fruit at 1% level of significance. The highest percentage of TA of fruit (0.67 %) was recorded at T3 (150 ppm of IAA) while the lowest percentage of TA of fruit (0.53 %) was recorded at T0 (Table 3).

pH of tomato fruit

Plant growth regulators influenced the pH significantly at 1% level of probability. The maximum pH content of fruit (4.42) was recorded at T0 (0 ppm) and the minimum (4.09) was recorded at T3 (Table 3).

Table 3. Effect of IAA on TSS, TA and, pH of tomato fruits

Treatment	TSS (ºBrix)	TA (%)	pH
T0	1.95	0.53	4.42
T1	2.10	0.60	4.27
T2	2.65	0.64	4.20
T3	3.00	0.67	4.09
$LSD_{0.05}$	0.13	0.02	0.08
$LSD_{0.01}$	0.18	0.030	0.11
Level of Significance	**	**	**

** = Significant at 1% level of probability; T0 = 0 ppm, T1 = 50 ppm IAA, T2 = 100 ppm IAA and T3 = 150 ppm of IAA, FL; fruit length, FD; fruit diameter, IFW; individual fruit weight, FYP, fruit yield/plant

Conclusions

Applying IAA to tomatoes was found to have positive impacts on their growth, yield, and nutritional quality. Results revealed that 50 ppm of IAA had the maximum (93.19 t/ha) yield than ontrol (42.32 t/ha). Besides, TSS and TA contents were increased in highest doses of IAA. The study concluded that a judicial IAA produced the maximum crop yield with advanced nutritional quality of fruits.

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