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RESEARCH ARTICLE

EFFECT OF FOLIAR APPLICATION OF GIBBERELLIC ACID ON GROWTH AND YIELD OF TOMATO (*Lycopersicon esculentum* Mill.) UNDER MODERATE SALINE SOIL CONDITIONS

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ABSTRACT

Soil salinity is a significant environmental problem that decreases the productivity of vegetable crops. One of the most commonly grown vegetable crops worldwide is the tomato and the salt concentration in the root area significantly affects its production and quality. Gibberellic acid plays a vital role in increasing tomato production in slightly salty soil conditions. An experiment was conducted at the Agricultural Research Field, Noakhali Science and Technology University, Noakhali, Bangladesh, from November 2020 to April 2021, to assess the impact of gibberellic acid on the growth, yield and yield-contributing characters of tomato. The experiment was laid out in a Randomized Complete Block Design with four treatments and replicated three times. The treatments were, T_0 = (0 ppm GA_3), T_1 = (50 ppm GA_3), T_2 = (75 ppm GA_3), T_3 = (100 ppm GA_3). The maximum plant height (129.72 cm), number of leaves per plant (66.03), number of branches per plant (10.33), number of flowers per plant (89.18), number of fruit clusters per plant (13.46), number of fruits per plant (50.74), fruit weight (67.41 g), fruit length (8.22 cm), yield per plant (2.45 kg) and yield per hectare (70.36 t/ha) were obtained from T_3 (100 ppm GA_3), whereas the lowest data was recorded from control T_0 (0 ppm GA_3). Observing the results, it can be stated that application of gibberellic acid @ 100 ppm improved growth and yield of tomato in moderate saline soil.

KEYWORDS

Gibberellic acid, Tomato, Plant height, Yield, Salinity

1. INTRODUCTION

The tomato (*Lycopersicon esculentum* Mill.) is one of the most widely recognized and valuable vegetable crops grown in Bangladesh under the Solanaceae family (Hossain and Abdulla, 2015). It has originated from tropical America, particularly from the Andean area of Bolivia, Ecuador, Peru and Bolivia (Kallo, 1986; Salunkhe et al., 1987). In the world, it is the most popular vegetable and it is ranked next only to sweet potatoes and potatoes in the vegetable production (Choudhury, 1979). In the global context, tropical and sub-tropical areas are major producers of tomatoes (Ahmed, 1976).

Tomatoes are typically grown in the winter crop (Hossain and Abdulla, 2015). To be more precise, the nutritional value of the fruit contributes to tomato quality and consumers' interest in them. Because of their rich calcium, carotene and vitamin A, B and C contents, tomatoes are rated highly for containing a lot of nutrients (Bose and Som, 1990). Lycopene is an antioxidant found in tomatoes, has been linked to a reduced risk of developing prostate cancer. Based on the information received until 2022-2023, tomatoes are cultivated on 31,338 hectares of the cultivable land in Bangladesh. This was based on the total production estimates of 46,9205 metric tons of tomato production and an average yield of 15.06 t/ha as envisaged by the BBS (2022-2023). Nevertheless, the tomato production in Bangladesh is relatively lower than that of other developed countries globally. The main reason for the low tomato production in Bangladesh is the absence of high-yielding tomato varieties, inadequate crop management practices and a lackof access to advanced technologies.

Gibberellic acid is a vital plant growth regulator with numerous applications for modifying plant development, yield and yield-contributing characteristics (Ali et al., 2022; Misu et al., 2023). Research has shown that the application of plant growth regulators, such as gibberellins and auxins, can significantly address issues related to flower and fruit development, thereby improving overall tomato productivity. These regulators offer a promising approach to overcoming the existing production challenges and maximizing yield potential. However, high temperatures occurring early and late in the brief winter growing season significantly impede flower and fruit development in tomatoes. These elevated temperatures interfere with the critical physiological processes involved in successful reproductive development, ultimately constraining yield and quality (Adlakha and Verma, 1965; Gorguet et al., 2005).

In instance, gibberellic acid has been found to encourage fruit growth in pollinated ovaries that go into dormancy as a result of high temperatures (Johnson and Liverman, 1957). Fruit set in tomatoes can be induced in a number of ways to overcome insufficiency of natural growth substances necessary for the development of fruit set (Singh and Choudhury, 1966). Once again, gibberellic acid is essential to healthy tomato production. When compared to the untreated controls, the gibberellic acid treatment significantly increased the number of fruits on the plant. Fruit weight increased when GA_3 was applied on flower clusters, as reported by (Tomar and Ramgiry, 1997; Adlakha and Verma, 1964). Applying GA_3 at the proper dosage and duration is crucial to boosting yield and preventing fruit and blossom drop. According to GA_3 is a pivotal plant growth regulator with a broad spectrum of applications that can significantly influence plant growth, increase yield, and modify yield-contributing characteristics

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(Rafeekher et al., 2002). Soil salinity is a significant environmental problem that decreases the productivity of vegetable crops (Khatun et al., 2023). Tomato is one of the most widely cultivated vegetable crops all around the world and its production and quality are significantly influenced by the salt concentration in the root area. Gibberellic acid plays a vital role in increasing tomato production in slightly salty soils. Considering the above circumstances, the motive of this study was to evaluate the effect of Gibberellic acid on growth and yield of tomato.

2. Materials and Methods

2.1 Experimental site and soil

The experiment was carried out at the Agricultural Research Field of Noakhali Science and Technology University, Noakhali, Bangladesh, from November 2020 to April 2021. The study took place in the Young Meghna Estuarine Floodplain agro-ecological zone (AEZ 18). The experimental site consisted of a flat plot of sandy loam soil, characterized by a pH of 7.5 and soil salinity of 4.32 dS/m (Rahaman et al., 2023).

2.2 Experimental Treatments And Design

The study was conducted using a Randomized Complete Block Design (RCBD) with four treatments and three replications. The treatments were T_0 = (0 ppm GA_3), T_1 = (50 ppm GA_3), T_2 = (75 ppm GA_3), T_3 = (100 ppm GA_3). A space of 15.2 m was split into three equal sections. Each block was separated into 4 plots with 4 treatments randomly assigned. Therefore, the experiment field contained a total of 12 unit plots, calculated by multiplying 4 and 3. Each plot measured 1.2× 0.9 meters in size. The spaces between blocks and between plots were maintained at 0.25 m each.

2.3 Materials

Roma VF (variety) was used as experimental plant material. The seeds of this variety were collected from "Saimon Seed Store", Sonapur, Noakhali. The seeds were treated with Carbendazim 50 WP at a rate of 2 g/kg.

2.4 Seedling Raising, Land Preparation, Transplanting And Application Of Manure And Fertilizers

Seedlings were raised using seedling trays filled with moist coco-peat and seeds were sown in November 2020. Germination occurred within 5 to 7 days and seedlings were ready for transplanting once they developed four to six leaves. The field was initially ploughed and left to sun-dry for one week followed by harrowing, ploughing, cross-ploughing and laddering. To prevent waterlogging, drainage channels were established around the plot. The land was ready for transplanting five days before the planting took place. Fertilizers were applied as follows: nitrogen (urea), phosphorus (TSP), potassium (MOP), calcium (gypsum) and boron. During land preparation, well-rotted cow dung, TSP, boron and gypsum were uniformly applied. Healthy, 25-day-old seedlings were carefully uprooted from a pre-watered seedbed to minimize root damage and transplanted into the experimental plots on the afternoon of November 25, 2020. The seedlings were spaced 60 cm apart in rows and 50 cm between plants, with four plants per plot. Additional seedlings were planted around the plot borders to fill gaps. Fertilization with urea and MOP was applied in three equal doses: at final land preparation and 25 and 45 days after transplanting.

2.5 Preparation And Application Of GA_3

A solution with a concentration of 50 ppm of GA_3 was made by mixing 50 mg of GA_3 with distilled water. Next, water without impurities was included to achieve a total volume of 1 liter as a 50 parts per million solution. 75 ppm and 100 ppm concentrations were prepared in the same manner. GA_3 was applied at 25 and 55 days after transplantation (DAT).

2.6 Intercultural Operation And Crop Development

Following seedling transplantation, several intercultural operations were conducted to ensure optimal growth and development of the tomato plants. These included irrigation, weeding, staking and top-dressing. Weeding was performed twice to maintain weed-free plots. Staking was done using bamboo sticks to support the plants and maintain their erect posture. Irrigation was applied as needed using a hand sprayer. Pruning was carried out prior to flowering. To manage pests, Malathion 57 EC was applied at 2 ml/L for control of cutworms, leafhoppers and fruit borers. Ridomil Gold was used at 2 g/L to combat tomato blight. Tomatoes were harvested based on appropriate fruit size, color and ripeness from March 12, 2021 to April 6, 2021.

2.7 Data Collection

The following information was collected from randomly chosen plants in each plot: plant height, number of leaves per plant, number of branches per plant, number of flowers per plant, number of fruit clusters per plant, number of fruits per plant, fruit length, fruit weight and tomato yield.

2.8 Statistical Analysis

The data for various study parameters were analyzed statistically using Minitab 17. Analysis of variance (ANOVA) was conducted using the F-test, and significant differences among means were determined using the LSD test at a 1% level of significance. Data analysis followed the methodology outlined by (Gomez and Gomez, 1984).

3. Results and Discussion

3.1 Plant height

The effect of selected treatments on plant height was recorded at 40 and 70 DAT (Table 1). The plant height ranged from 50.54 cm to 129.72 cm, which were significantly influenced by different treatments. At 40 DAT, the highest plant height (89.23 cm) was recorded in T_3 (100 ppm GA_3) and the lowest plant height (50.54 cm) was recorded in T_0 (0 ppm GA_3). At 70 DAT, the maximum plant height (129.72 cm) was recorded in treatment T_3 (GA_3 100 ppm), which was followed by treatment T_2 (113.82 cm) and the minimum plant height (83.20 cm) was recorded in the control plot receiving no plant growth regulators. The present finding also agreed with the result of (Wu et al., 1983; Akand et al., 2015). They observed that plant height was increased by application of GA_3 @100 and 125 ppm. Similar results reported that plant height of tomato increased by using GA_3 @ 25 and 50 ppm (Rai et al., 2006; Nibhavanti et al., 2006).

Table 1: Effect of gibberellic acid on vegetative stage of tomato

Treatment	Plant height (cm)		Leaves per plant		Branches per plant	
	40 DAT	70 DAT	40 DAT	70 DAT	40 DAT	70 DAT
T_0	50.54^d	83.20^d	28.13^d	43.17^d	2.38^d	4.04^d
T_1	65.67^c	97.98^c	37.03^c	51.40^c	3.02^c	6.77^c
T_2	78.46^b	113.82^b	43.40^b	59.12^b	5.93^b	8.46^b
T_3	89.23^a	129.72^a	48.26^a	66.03^a	7.97^a	10.33^a
CV (%)	1.01	3.34	1.36	1.66	3.32	3.32
LSD(0.01)	2.17	10.74	1.61	2.75	0.45	0.88
Level of Significance	**	**	**	**	**	**

Legends: T_0 = 0 ppm GA_3, T_1 = 50 ppm GA_3, T_2 = 75 ppm GA_3, T_3 = 100 ppm GA_3, CV = Co-efficient of variation, LSD = Least Significant Difference, ** = Significant at 1% level of probability

3.2 Leaves Per Plant

Application of plant growth regulators showed statistically significant variation on the number of leaves per plant (Table 1). Number of leaves was recorded 40 and 70 days after transplanting. At 40 DAT, the maximum number of leaves per plant (48.26) was recorded from T_3 (100 ppm GA_3), while the minimum number of leaves per plant (28.13) was found from T_0 (0 ppm GA_3). Also, the number of leaves per plant (37.03) was recorded from T_1 (50 ppm GA_3) and the number of leaves per plant (43.40) was recorded from T_2 (50 ppm GA_3. At 70 DAT, the maximum number of leaves per plant (66.03) was recorded in treatment T_3 (100 ppm GA_3), followed by treatment T_2 (59.12), T_1 (51.40) and T_0 (43.17), respectively. The result also supported the finding previously observed that GA_3 increased the number of leaves per plant at 125, 50 and 25 ppm (Akand et al., 2015; Rai et al., 2006: Nibhavanti et al., 2006).

3.3 Branches Per Plant

Number of branches of tomato varied significantly due to the application of different levels of GA_3 at 40 and 70 DAT (Table 1). At 40 DAT, the maximum number of branches per plant (7.97) was recorded from T_3 (100 ppm GA_3), while the minimum number of branches per plant (2.38) was found from T_0 (0 ppm GA_3). Also, the number of branches per plant (3.02) was recorded from T_1 (50 ppm GA_3), and the number of branches per plant (5.93) was recorded from T_2 (75 ppm GA_3). At 70 DAT, the maximum number of branches per plant (10.33) was recorded in treatment T_3 (100 ppm GA_3), followed by treatment T_2 (8.46), T_1 (6.77) and T_0 (4.04), respectively. Number of branch was significantly increased by the application of GA_3 (Kumar et al., 2014).

3.4 Flowers Per Plant

There was a significant difference in the number of flowers per plant across different concentrations of GA_3. The highest number of flowers per plant (89.18) was seen in T_3 (100 ppm GA_3) while the lowest count (52.77) was found in T_0 (0 ppm GA_3) (Table 2). The impact of applying GA_3 on the number of flowers per plant was highest at 100 ppm, followed by 75 ppm, 50 ppm and 0 ppm. The current discovery also concurred with the findings of (Akand et al., 2015). It was noticed that the amount of flowers per plant increased when GA_3 was applied at a concentration of 125 ppm.

3.5 Fruit Clusters Per Plant

Number of fruit clusters per plant showed significant variation for different concentrations of GA_3 (Table 2). The maximum number of fruit clusters per plant (13.46) was obtained from T_3 (100 ppm GA_3), while the minimum (7.65) was recorded in T_0 (0 ppm GA_3) which was statistically similar to T_1. The most effective result was observed in the number of fruit clusters per plant following the application of 100 ppm GA_3. The current discovery also supported the outcome of (Akand et al., 2015). They noted that there was an increase in the number of fruit clusters per plant at a concentration of 125 ppm of GA_3.

Table 2: Effect of gibberellic acid on reproductive stage of tomato

Treatment	Flowers perplant	Fruit clusters per plant	Fruits per plant
T_0	52.77^d	7.65^d	29.92^d
T_1	64.43^c	8.86^c	37.07^c
T_2	77.65^b	10.13^b	44.62^b
T_3	89.18^a	13.46^a	50.74^a
CV (%)	3.48	2.99	1.17
LSD	7.47	0.91	1.43
Level of Significance	**	**	**

Legends: T_0 = 0 ppm GA_3, T_1 = 50 ppm GA_3, T_2 = 75 ppm GA_3, T_3 = 100 ppm GA_3, CV = Co-efficient of variation, LSD = Least Significant Difference, ** = Significant at 1% level of probability

3.6 Fruits per plant

The use of plant growth regulators resulted in significant differences in the number of fruits per plant (Table 2). The maximum fruits per plant (50.74) was achieved in treatment T_3 (100 ppm GA_3), while the minimum (29.92) was observed in treatment T_0 (0 ppm GA_3). The impact of applying GA_3 on the number of fruits per plant was highest at 100 ppm, followed by 75 ppm, 50 ppm and 0 ppm. (Akand et al., 2015) observed that plants treated with GA_3 had a notably higher quantity of fruits per plant compared to plants that were not treated.

3.7 Fruit length

There was a significant variation in fruit length depending on the different concentration of GA_3 used. The highest fruit length (8.22 cm) was achieved with T_3 (100 ppm GA_3), while the lowest (6.78 cm) was seen in T_0 (0 ppm GA_3) which was statistically similar to T_1 (Table 3). The impact of applying GA_3 on fruit length was strongest at 100 ppm, with 75, 50 and 0 ppm following in effectiveness. Adlakha and Verma (1964) stated that the application of 100 ppm of GA_3 could significantly enhance the size of the fruits.

3.8 Fruit Weight

Application of GA_3 significantly affected the weight of each tomato fruit (Table 3). The maximum weight of fruit (67.41 g) was observed in treatment T_3 (100 ppm GA_3), followed by treatment T_2 (62.65 g), T_1 (58.39 g) where the lowest weight of individual fruit (53.73 g) was obtained from treatment T_0 (control). The study found that the use of gibberellic acid resulted in an increase in fruit weight (Misu et al., 2023).

Table 3: Effect of gibberellic acid on yield and yield-contributing characters of tomato

Treatment	Fruit length (cm)	Fruit weight (g)	Yield per plant (kg)	Yield per ha(t ha^{-1})
T_0	6.78^d	53.73^d	1.05^d	40.50^d
T_1	7.42^c	58.39^c	1.63^c	49.40^c
T_2	7.95^b	62.65^b	2.11^b	58.87^b
T_3	8.22^a	67.41^a	2.45^a	70.36^a
CV (%)	0.95	0.56	8.23	1.27
LSD	0.23	1.00	0.45	2.11
Level of Significance	**	**	**	**

Legends: T_0 = 0 ppm GA_3, T_1 = 50 ppm GA_3, T_2 = 75 ppm GA_3, T_3 = 100 ppm GA_3, CV = Co-efficient of variation, LSD = Least Significant Difference, ** = Significant at 1% level of probability

3.9 Yield per plant

The yield per plant showed significant variation with different concentrations of GA_3. The highest yield per plant (2.45 kg) was obtained from T_3 (100 ppm GA_3), while the lowest (1.05 kg) was recorded in T_0 (0 ppm GA_3) (Table 3). The most positive impact on yield per plant was observed when using a concentration of 100 ppm of GA3, with 75 ppm, 50 ppm and 0 ppm following sequentially. Research observed that plants treated with GA_3 exhibited a significantly higher yield per plant compared to plants that did not receive treatment (Tomar and Ramgiry, 1997). Observed a gradual rise in plant yield when using a higher concentration (125 ppm) of GA_3 (Akand et al., 2015).

3.10 Yield per hectare

Various levels of GA_3 showed significant differences in the yield per hectare (Table 3). The maximum yield per hectare (70.36 t/ha) was obtained from T_3 (100 ppm GA_3), and minimum (40.50 t/ha) was recorded from T_0 (0 ppm GA_3) which was statistically similar to T_1 (50 ppm GA_3). The most favorable impact of GA_3 treatment on crop yield per hectare was observed at the 100 ppm concentration, with slightly lower effects noted at 75 ppm, 50 ppm, and 0 ppm. The research spraying gibberellic acid was beneficial for most parameters regardless of its concentration (Akand et al., 2015; Khan et al., 2006).

4. Conclusion

Based on the experimental results, it can be concluded that gibberellic acid (GA_3) had a substantial impact on the growth, quality, and yield of tomatoes. Among the different levels of gibberellic acid, the plants treated with the application of GA_3 @ 100 ppm showed an increased the plant height, number of leaves per plant, number of branches per plant, number of flowers per plant, number of fruit clusters per plant, number of fruit per plant, length of fruit, fruit weight, yield per plant (kg), yield per hectare (ton). The highest yield per hectare of 70.36 t/ha was achieved with the 100 ppm GA_3 treatment, demonstrating its effectiveness in optimizing tomato production. According to the results, it can be concluded that using gibberellic acid at a rate of 100 ppm resulted in improved growth and yield in tomato farming.

Conflict of Interest

The authors declare no conflict of interest.

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