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EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, YIELD AND YIELD CONTRIBUTING CHARACTERS OF BRINJAL (*Solanum melongena* L.) IN COASTAL ZONE OF BANGLADESH

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ABSTRACT

Salinity is a serious environmental issue that reduces the yield of vegetable crops. Brinjal is one of the world's most popular vegetable crops and its productivity and quality are heavily influenced by the salt content in the root area. Plant growth regulator management, however, is a key factor that can be used to increase brinjal production in moderate saline soils. The experiment was carried out at the Agricultural Research Field, Noakhali Science and Technology University, Noakhali, Bangladesh during the period from January to June 2022, to observe the effect of plant growth regulators on growth, yield, and yield contributing characters of brinjal (*Solanum melongena* L. V: Purple king). The experiment was followed Randomized Complete Block Design (RCBD) comprising four treatments with three replications. The treatments were T_0 (Control), T_1 (Salicylic acid @ 60 ppm), T_2 (Gibberellic acid @ 60 ppm), T_3 (Naphthalene acetic acid @ 60 ppm). Data were recorded from different stages of plant growth viz, plant height, number of leaves per plant, number of branches per plant, number of fruits per plant, fruit length, fruit diameter, fruit weight, and yield. The maximum plant height (100.00 cm), number of leaves per plant (197.17) , number of branches per plant (17.17), number of flowers per plant (62.67), number of fruits per plant (34.42), fruit length (25.50 cm), fruit diameter (3.33 cm), weight of fruit (92.67 g), yield per hectare (22.17 t ha^{-1}) were measured from treatment T_2 (GA_3 @ 60 ppm). Results conclude that the application of gibberellic acid @ 60 ppm for brinjal cultivation gave better growth and yield in moderate saline soils.

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INTRODUCTION

Brinjal (*Solanum melongena* L. 2n=24) commonly known as 'Eggplant' is one of the important vegetable crops of tropical and temperate parts of the world. It belongs to the Solanaceae family. It has been widely grown for hundreds of years throughout southern Europe, the Middle East, Africa, and Asia (Ullio and smith, 2003). Brinjal is a perennial but is cultivated economically as an annual crop. The varieties of brinjal show a wide range of oval shaped to long club-shaped and colors are white, yellow, green, purple pigmentation to almost black (Aminifard *et al*., 2010). Brinjal fruits are known for its low in calories and having a mineral composition beneficial for human health and it is rich source of potassium, magnesium, calcium and iron (Michalojc and Buczkowska, 2008). It is a popular and widely consumed vegetable in Bangladesh, with both rural and urban residents consuming it on a regular basis. In Bangladesh, vegetables are essential products of agriculture for the survival of humans and vegetables also contribute the national economy (Ali *et al*., 2023b; Ali *et al*., 2022a). Brinjal is the second most important vegetable crop in Bangladesh in terms of production area as well as yield and it is cultivated all over the country in Rabi and Kharif seasons. In 2021-22, it is cultivated in 84536 acres of land with an annual production of 409001 metric tons in Rabi seasons, respectively (BBS, 2022). However, the average brinjal yield in Bangladesh is relatively low compared to other advanced countries of the world. The low yield of brinjal in Bangladesh is primarily due to the lack of high yielding varieties, inadequate and imbalanced use of manure and fertilizers especially the nitrogenous ones (Sharmin and Rahman, 2019).

The maximal potential yield of brinjal is not obtained because to its poor physiological efficiency, poor plant architecture, poor fruit setting, and lack of synchronized maturity (Wakchaure *et al*., 2020). Plant growth regulators (PGRs) may play an essential role in appropriate blooming, fruit setting, synchronizing maturity and ripening, and therefore increasing crop physiochemical efficiency and yield (Choudhury *et al*., 2013). The plant growth regulators classified into different categories like Auxin, Gibberellins, Cytokinin etc. are involved with the physiological activities in plants (Singh, 2011). Among this, auxins, GAs, cytokinins are growth promoting hormones and abscisic acid and ethylene are growth inhibiting hormones (Bagale *et al*., 2022). Gibberellic acid is an important plant growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant (Ali *et al*., 2022a; Rafeekher *et al*., 2002). Naphthalene acetic acid (NAA) is a synthetic plant hormone that stimulates growth and helps to induce root development in various kinds of plants. Naphthalene acetic acid is widely used in horticultural crop production for various purposes (Netam and Sharma, 2014). Salicylic acid is generally known that phenolic compounds impact various biochemical and physiological functions, including photosynthesis, ion uptake membrane permeability, enzyme activities, flowering, transpiration, enhancement of chlorophyll level and plant growth and development (Amanullah *et a*l., 2010; Sahu, 2013; Souri and Tohidloo, 2019).

Flower and fruit drop is a serious issue with brinjal which resulting in low fruit production (Morales-Payan, 2000). Various biotic and abiotic stress factors have a significant impact on brinjal production. Soil salinity is one of the reasons that affect brinjal productivity. Soil salinity has a detrimental influence on crop quality, production, and growth. (Ali *et al*., 2023; Ali *et al*., 2022b; Dong, 2008). The market demand and consumer preference of brinjal determined by fruit colour, size, shape and stage of maturity. The use of PGRs may increase the productivity of brinjal in terms of quality and quantity, hence increasing the market price and profitability. Since brinjal is a popular vegetable in Bangladesh, therefore yield and quality improvement of the crop is of considerable importance. Plant growth regulators (PGRs) have a significant role in enhancing quality as well as productivity. Considering the above circumstances, the motive of this study was to evaluate effect of plant growth regulators on growth and yield of brinjal.

MATERIALS AND METHODS

Experimental site and soil

The experiment was conducted at Agricultural Research Field, Noakhali Science and Technology University, Noakhali, Bangladesh, during the period of January to June, 2022 in the agro-ecological zone Young Meghna Estuarine Floodplain (AEZ 18). The experiment field was a flat plot of land with sandy loam with having soil pH (7.5) and soil salinity of 4.32 dSm^{-1}.

Experimental treatments and design

The experiment was laid out in a Randomized Complete Block Design (RCBD) Comprising four treatments with three replications. The treatments were T_0 (Control), T_1 (Salicylic acid 60 ppm), T_2 (Gibberellic acid 60 ppm), T_3 (Naphthalene acetic acid 60 ppm). Therefore, the total number of plots was 12. The size of unit plot was 1.44 m^2 where block to block and plot to plot distance was 0.5m and 0.5m, respectively.

Seed collection

Purple king F_1 (variety) of brinjal was used as experimental planting material. The seeds of this variety were collected from Department of Agriculture, Noakhali Science and Technology University.

Raising of Seedling

By using seedling tray for rising of seedling, add moist coco-peat in the seedling tray. Seeds were sown in the seedling tray in January, 2022. The sprout of the seedlings took place with 6 to 8 days after sowing. When seedlings have four to six leaves, they were ready to be transplanted.

Land Preparation

The land was ploughed and left exposed to the sun for a week. Then one week after the land was harrowed, ploughed and cross-ploughed two times followed by laddering. To avoid water logging, drainage channels were made around the land and finally prepared the land five days before transplanting. Urea, TSP, and MOP were used as source of nutrients. The whole amount of well-rotten cow dung, TSP, and MOP were applied during the final land preparation.

Seedlings transplanting in the main bed

40 days old healthy seedlings were transplanted in the field. To prevent damaging the root system, the seedlings were gently removed from the cup. 4 seedlings were transplanted in each plot and plant-to-plant and row-to-row distances of 50cm were maintained.

Application of plant growth regulators

Salicylic acid, naphthalene acetic acid, and gibberellic acid were all utilized at 60 ppm. Plant growth regulators were applied in the brinjal plant in 4 equal installments at 35, 50, 65 and 80 days after transplanting.

Intercultural operation

Different intercultural activities were completed for optimal growth and development of the plant including irrigation, thinning, weeding, and top dressing. Weeding was done two times in plots to keep plots free from weeds. When the plants were well established, stalking was given to the plant by bamboo ticks for support to keep them erect. Irrigations were given by hand sprayer when needed. Pruning was carried out before blossoming. Azadirachtin, Spinosad, and Malathion 57EC was applied at 4 times for the control of insect. Bavistin was sprayed on brinjal fortnightly at a rate of 2g/L as preventative measures against disease infestation, particularly phomopsis fruit rot. Brinjal was harvested when the fruit reaches the appropriate size, colour, and stage before ripening. Fruit should be shiny and attractively brilliant in colour. Beginning on May 3, 2022, harvesting lasted until June 15, 2022.

Data collection

Data on plant height, number of leaves per plant, number of branch per plant, number of flowers per plant, number of fruit per plant, length of fruit, fruit diameter, fruit weight and yield of brinjal were recorded from randomly selected plant from each plot. Height of the brinjal plants were recorded at 70 days after transplanting. Randomly selected branches of brinjal plants were used for the measurement of leaves number per plant at 70 days after transplanting. The number of branches per plant was recorded at 70 days after transplanting. The number of flowers per plant was recorded at 80 days after transplanting. The number of fruits per plant was recorded at fruit harvesting time. The individual fruit weight (g) was done at fruit harvesting time.

Statistical analysis

The recorded data of different parameters in this study were analyzed statistically by using Microsoft excel and statistix 10 statistical software package to find out the significance of the differences among the treatments. The least significant difference (LSD) test was used to distinguish the significance of the difference between the pair means at 1% levels of probability. All obtained data were analyzed by following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant height

Plant heights of brinjal were significantly influenced by plant growth regulators (Table 1). The maximum plant height (100.00 cm) was recorded in treatment T_2 (GA_3 60 ppm) which was followed by treatment T_3 (80.12 cm) and the minimum plant height (51.38 cm) was recorded in the control plot receiving no plant growth regulators. This result showed that the application of plant growth regulators increased plant height of brinjal but application of gibberellic acid @ 60 ppm for brinjal cultivation gave better growth. Similar result was found in brinjal by Netam and Sharma, (2014). Ali *et al*. (2022a) reported that application of gibberellic acid increased the plant height of red amaranth.

Number of leaves per plant

Application of plant growth regulators showed statistically significant ($p<0.01$) variation on the number of leaves per plant (Table 1). The maximum number of leaves per plant (197.17) was recorded in treatment T_2 (GA_3 60 ppm) followed by treatment T_3 (183.17), T_1 (178.00) and T_0 (78.33), respectively. This result showed that the application of plant growth regulators increased the number of leaves per plant of brinjal but application of gibberellic acid @ 60 ppm for brinjal cultivation gave better growth. Netam and Sharma, (2014) suggested the increased number of leaves of brinjal by using of plant growth regulators.

Table 1. Effect of plant growth regulators on vegetative and reproductive growth stage of brinjal

Treatment	Plant height (cm)	Number of leaves per plant	Number of branch per plant	Number of flowers per plant
T_0	51.38^d	78.33^d	7.33^d	27.83^d
T_1	76.00^c	178.00^c	11.08^c	41.50^c
T_2	100.00^a	197.17^a	17.17^a	62.67^a
T_3	80.12^b	183.17^b	12.25^b	51.81^b
CV (%)	5.61	2.45	1.97	1.81
LSD	13.06	2.17	1.71	1.13
Level of Significance	**	**	**	**

T_0 (Control), T_1 (Salicylic acid 60 ppm), T_2 (Gibberellic acid 60 ppm), T_3 (Naphthalene acetic acid 60 ppm)
CV = Co-efficient of variation; LSD = Least Significant Difference; ** = Significant at 1% level of probability

Number of branch per plant

The effect of plant growth regulators on number of branch per plant was shown in Table 1. Considering the treatments, significant ($p<0.01$) variation was recorded in number of branch of brinjal. The highest number of branches per plant (17.17) of brinjal was measured in treatment T_2 (GA_3 60 ppm) followed by treatment T_3 (12.25), T_1 (11.08) and T_0 (7.33), respectively. This result showed that the application of plant growth regulators increased the number of leaves per plant of brinjal but application of gibberellic acid @ 60 ppm for brinjal cultivation gave better growth. Netam and Sharma, (2014) suggested the increased number of branches of brinjal by using of plant growth regulators.

Number of flowers per plant

The number of flowers per plant were statistically significant ($p <0.01$) in the case of four treatments (Table 1). The maximum number of flower per plant (62.67) was recorded in T_2 (GA_3 60 ppm) followed by T_3 (NAA 60 ppm) which was (51.81). While the minimum number of flower per plant was recorded in T_0 (control) which was 27.83. This result indicated that the application of plant growth regulators increased the number of flowers per plant of brinjal.

Number of fruit per plant

Application of plant growth regulators showed statistically significant ($p<0.01$) variation on the number of leaves per plant (Table 2).The maximum number of fruits per plant (34.42) was recorded in T_2 (GA_3 60 ppm) by T_3 (NAA 60 ppm) which was (26.25). And, the minimum number of fruits per plant was recorded in T_0 (control) which was (17.33). This result indicated that the application of plant growth regulators increased the number of fruit per plant per plant of brinjal. These results were supported by the findings of Moniruzzaman, (2015).

Length of fruit

The fruit length of brinjal was significantly influenced by plant growth regulators ($p<0.01$) (Table 2).The longest fruit length (25.50 cm) was recorded in T_2 (GA_3 60 ppm) and the shortest fruit length (19.92 cm) was recorded in in T_0 (control). This result showed that the application of plant growth regulators increased the fruit length of brinjal but application of gibberellic acid @ 60 ppm for brinjal cultivation gave better fruit length. Similar results were reported by Choudhury *et al*. (2013) in tomato.

Fruit diameter

Fruit diameter is a one of the important characteristic of brinjal. Fruit diameter of brinjal was significantly ($p<0.01$) influenced by the application of plant growth regulators (Table 2). The maximum fruit diameter of brinjal (3.33 cm) was recorded in treatment T_2 (GA_3 60 ppm) followed by treatment T_3 (3.25 cm), T_1 (3.22 cm) and T_0 (2.43 cm), respectively. This result showed that the application of plant growth regulators increased the fruit diameter of brinjal. Patel *et al*. (2022) reported that application of gibberellic and naphthalene acetic acid increased fruit diameter of brinjal.

Table 2. Effect of plant growth regulators on yield and yield contributing characters of brinjal

Treatment	Number of fruit per plant	Length of fruit (cm)	Fruit diameter (cm)	Fruit weight (g)	Yield (ton/ha)
T_0	17.33^d	19.92^d	2.43^c	76.10^d	10.05^d
T_1	24.63^c	23.08^c	3.22^b	80.75^c	14.40^c
T_2	34.42^a	25.50^a	3.33^a	92.67^a	22.15^a
T_3	26.25^b	24.25^b	3.25^b	88.87^b	16.38^b
CV (%)	1.27	1.52	5.47	1.89	3.94
LSD	1.99	1.06	0.51	4.83	1.88
Level of Significance	**	**	**	**	**

T_0 (Control), T_1 (Salicylic acid 60 ppm), T_2 (Gibberellic acid 60 ppm), T_3 (Naphthalene acetic acid 60 ppm)
CV = Co-efficient of variation; LSD = Least Significant Difference; ** = Significant at 1% level of probability

Fruit weight

Weight of individual fruit of brinjal was significantly ($p<0.01$) influenced by plant growth regulators (Table 2).The maximum weight of fruit (92.67 g) was observed in treatment T_2 (GA_3 60 ppm) followed by treatment T_3 (88.87 g), T_1 (80.75 g) where the lowest weight of individual fruit (76.10 g) was obtained from the treatment T_0 (control). This result indicated that the application of plant growth regulators increased the weight of fruit of brinjal. Netam and Sharma, (2014) suggested the increased weight of fruit of brinjal by using of plant growth regulators.

Yield

Application of plant growth regulators showed statistically significant ($p<0.01$) variation on yield of brinjal (Table 2). The maximum yield of brinjal (22.15 t ha^{-1}) was recorded from treatment T_2 (GA_3 60 ppm) followed by treatment T_3 (16.38 t ha^{-1}), T_1 (14.40 t ha^{-1}) where the minimum yield of brinjal (10.05 t ha^{-1}) was obtained from the treatment T_0 (control). This result showed that the application of plant growth regulators increased the fruit length of brinjal but application of gibberellic acid @ 60 ppm for brinjal cultivation gave better yield. Similar results were reported by Moniruzzaman, (2015) in brinjal.

CONCLUSION

The results of this study show that application of plant growth regulators has significant impact on the growth parameters of brinjal viz, plant height, number of leaves per plant, number of branch per plant and yield parameters. The maximum plant height (100.00 cm), number of leaves per plant (197.17) , number of branches per plant (17.17), number of flowers per plant (62.67), number of fruits per plant (34.42), fruit length (25.50 cm), fruit diameter (3.33 cm), weight of fruit (92.67 g), yield per hectare (22.17 t ha^{-1}) were measured from treatment T_2 (GA_3 @ 60 ppm). However, the present study was conducted in summer season (2021) at NSTU research field, and further experiment need to be studied in different environments. Based on the findings, it can be stated that application of gibberellic acid @ 60 ppm for brinjal cultivation gave better growth and yield.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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