__Original Research Article__

Impact of micronutrients and plant growth regulators on brinjalgrowth, yield and quality

ABSTRACT

The present research work conducted to find out the effect of plant growth regulators and micronutrients on growth, yield, and quality of brinjal under open field condition.The experiment was designed in a Randomized Complete Block Design (RCBD) with three replicates.The experiment was conducted on Horticulture farm at Sher-e-Bangla Agricultural University; Dhaka, Bangladesh from July 2022 to June 2023. The experimental treatments included three levels of PGR i.e. No PGR, 200 ppm GA_3 and 100 ppm NAA and three levels of micronutrients i.e.no micronutrients, 200 ppm Boron and 200 ppm Zn. The treatments had a substantial effect on growth, yield, and quality of brinjal. GA_3 treated plants performed better than NAA and no PGR treated plants and Zn produced higher yields and quality than Boron and no micronutrients treated plants in most of the parameters. Considering treatment combination of PGR and micronutrients, plant height, leaf area (471.33 cm^2), SPAD value (52.95), number of flowers plant^{-1}(65.33), number of fruits plant^{-1} (58.38), yield plant^{-1} (3312.8g), lipid (0.35%) were observed highest from the treatment combination of 200 ppm GA_3 with 200 ppm Zincwhereas dry weight of whole plant (158.80 g), individual fruit weight (67.33g) and fiber (12.28%) were observed from the treatment combination of 100 ppm NAA with 200 ppm zinc but in case of number of branch (14.00) and Ash (8.44%) were observed from the treatment of 100 ppm NAA application. Maximum parameter showed lowest value under no treatment combination. Consequently, Zn and GA_3 help to improve the quality, yield, and growth of brinjal plants.

Keywords: plant growth regulators, micronutrients, Brinjal, yield, quality

1. INTRODUCTION

Brinjal (Solanum melongena L.) is a popular vegetable crop throughout the world, including Bangladesh. Brinjal, commonly known as egg plants, is the second most important solanaceous fruit crop in the genus solanum, following tomato.It is native to southern India and is grown extensively in America, Europe, and Asia [1]. It is a flexible crop that may be produced all year and is suited to a variety of agroclimatic conditions. It is a perennial that is farmed economically as an annual crop. Bangladesh produces 110397.59 metric tons of Brinjal from 25779.95 acres of land [2]. Brinjal is regarded as one of the world's healthiest foods, due to its low calorie content and high levels of potassium, magnesium, calcium, and iron [3]. Brinjal growth and yield are primarily determined by a number of interacting elements. Brinjal, a long-duration crop with a high yield, drains a huge amount of nutrients from the soil. One of the most serious issues with brinjal is flower and fruit drop, which results in reduced fruit yield. Plant growth regulators (PGRs) can help with correct flowering, fruit setting, synchronizing maturity and ripening, and so increasing crop physiochemical efficiency and yield. It is apparent that the growth is closely related to the yield, hence the role of phytohormones is very crucial in brinjal as well[4]. Brinjal flowers with long or medium styles produce the most fruit. Pseudo-short and actual short-styled blooms do not produce fruit.When pseudo-short-styled and true-short-styled flowers are treated with various growth regulators, they transform into long-styled and medium-styled flowers, and fruits can be harvested from those flowers. Boron and zinc are micronutrients that can help increase the fruit and productivity of brinjal [5]. Boron plays a significant function in sugar transport, plasma membrane damage, and phytohormone metabolism. It also alters the chemical composition, cell wall structure, and metabolism of phenols. For the growth, development, and productivity of plants, zinc (Zn) is a necessary trace element [6].

In addition to increasing productivity, using phytohormones and micronutrients will boost brinjal crop yield and fertilizer usage efficiency [7]. Micronutrients and plant growth regulators are vital components of plants that have a variety of effects on their physiology. Plant growth regulators and micronutrients work together to play a significant part. They are essential to the development of foliage, flowers, fruits, and other quality products, as well as to both vegetative and reproductive growth. Considering the above mentioned facts, the present investigation was undertaken to investigate the effect of plant growth regulators on flowering, fruit setting and yield of brinjal and to study the effect of micronutrients on growth and yield of brinjal.

2.MATERIALS AND METHODS

2.1 Plant materials and growing conditions

The experiment was carried out using Brinjal cv. BARI Brinjal1 in an open field at Sher-e-Bangla Agricultural University, Dhaka 1207. Three replications and a completely randomized block design were used to set up the experiment. Nine treatments using a mix of micronutrient regime and plant growth regulators made up the field experiment. Various growth, yield and quality parameters were assessed during fruiting stage.

2.2 Treatments and sample collection

The brinjal seeds (cv. BARI started 1) were obtained from the Bangladesh Agricultural Research Institute (BARI) in Gazipur, Bangladesh. Seeds were sown in PVC tanks (1.2×0.6×0.6 m) using a soil combination and slow-release fertilizers. At 25 days after sowing (DAS), seedlings were transplanted to the maintained plot with recommended doses of fertilizer. The experimental treatments included three levels of PGR i.e. no PGR, 200 ppm GA3 and 100 ppm NAA and three levels of micronutrients i.e. No micronutrients,200 ppm Boron and 200 ppm Zn. Micronutrients and growth regulators were sprayed on the plant twice i.e. before flowering stage and 1 week after flowering.Various growth, yield and quality parameters were assessed during fruiting stage.

2.3Plant height, leaf area and number of branch

From the base of the plant to the tip of the main stem, the height of each plant in each treatment was measured in centimeters, and a mean value was computed. Every plant in the treatment had its total number of branches counted during the fruiting stage, and a mean value was determined. Every leaf sample was measured for its greatest width (W) and length (L) using a ruler. The breadth was measured on the widest leaflet, and the length was calculated as the distance from the rachis's distal end to the first leaflet's insertion.

2.4 SPAD value

Using a SPAD-502 chlorophyll meter (Minolta, Tokyo, Japan), the chlorophyll content of the first completely developed leaves was determined. The midpoint of the leaf lamina on both the treated and control plants was measured.

2.5 Plant fresh and dry weight

At the fruiting stage, three plants, both above and below ground, were randomly selected from each treatment and replication. Plant samples were weighed fresh and then stored for 72 hours at 65°C in an oven before the weight of dry matter was recorded.

2.6 Measurements of yield and yield traits

Yields per plant (g) were computed by averaging the harvests of all five plants in each treatment and replication to get the total. Brinjal picking was done once a week, for a total of six to eight pickings. On each harvest day, the weight of the fruits (g) from each selected plant was recorded using an electronic top pan balance.

2.7 Lipid, Fiber and Ash content (%)

Lipid was measured using the AOAC [8] technique. A mixture of 50 ml of chloroform:methanol (2:1 v/v) and five grams of ground brinjal was suspended in it. The mixture was well mixed and allowed to stand for three days. A table centrifuge was used to filter the solution and centrifugal it at 1000 g. Using a Pasteur pipette, the top layer of methanol was removed, and heating caused the chloroform to evaporate. The crude lipid was all that was left. Fiber content of brinjal was determined by using AOAC method. The dry ash method, AOAC [8] method was also used to determine the ash content of fresh and solar-dried brinjal.

Ash content (%) = Weight of ash × 100/ Weight of brinjal sample taken.

2.8Data analysis

The analysis of the data was done with SPSS 20.0. When $P < 0.05$, the value was deemed statistically significant. The mean ± SE of the replicates was used to present all the results. Microsoft Excel was used to create the graphs.

3. RESULTS AND DISCUSSION

3.1Plant height (cm)

Plant height of brinjal was varied significantly due to the effect of plant growth regulators and micronutrients (Table 1). The highest plant height (102.11cm) was observed when GA_3 at the rate of 200 ppm was applied with no micronutrients andstatistically similar result (99.44 cm) was found with 200 ppm zinc application as micronutrients. However,Bhattarai *et al*. [9] found similar findings and stated that plant height may be improved with GA_3 application by increasing photosynthetic activity. The application of GA_3 to brinjal plants promotes plant height by loosening of cell wall and increasing cell permeability [10]. Basavarajeshwari*et al*.,[11] observed that Zn increased plant height of brinjal. Zinc helps in the formation of auxin which improves the plant growth by forming auxinwhich involves in increasing cell division [12].

3.2 Leaf area (cm^2)

Different plant growth regulators showed significant variation on Leaf area (cm^2) of brinjal at fruiting stage (Table 1). Leaf area plant^{-1} of brinjal at fruiting stage was varied significantly due to combined effect of plant growth regulators and micronutrients (Table 1). The maximum leaf area plant^{-1} (471.33 cm^2) was observed from the treatment combination of 200 ppm GA3 and 200 ppm Zn micronutrients compared to other treatments. The minimum leaf area plant^{-1} (312.22 cm^2) was recorded in untreated plant.Ramesh *et al*.,[13] found similar findings and stated that leaf area may be increased by GA3 application. Bisht *et al*.,[14] found that the increase in leaf area of brinjal plant may be due the cell elongation in mature petiole of brinjal plant system. Leaf area increased with enhancement of Zn concentration [15].Tryptophan amino acid and indol acetic acid hormone, which are the primary factors in leaf area development, are increased by zinc foliar treatment [16].

3.3 Number of branchplant^{-1}

Plant growth regulators and micronutrients was significantly influenced the number of branches/plant (Table 1). The maximum number of branch (14.00) was recorded from the 100 ppm NAA application with no micronutrients and the minimum number of branch (9.50) was recorded from the 200 ppm boronapplication.Gogoi*etal*.,[17] reported that the use of NAA increased the number of branches in brinjal by increasing the rates of photosynthesis and photosynthetic supply for maximum branches.

3.4 SPAD value

The maximum SPAD value (52.95) was observed from the treatment combination of200 ppm GA_3 and 200 ppm Zn. The minimum SPAD value (43.90) was recorded from the plants under no treatment which was statistically similar(45.77) (Table 1) to the treatment combination of 200 ppm Boron with no GA_3 application. Obaid *et al*. [18]conducted an experiment and revealed that spraying of Zn resulted insignificant increase in chlorophyll percentage.GA_3 significantly increased the photosynthetic pigments [19].$GA_3$is responsible for higher chlorophyll content by boosting the process of photosynthesis[20].

Table 1: Effect of plant growth regulators and micronutrients on plant height (cm), leaf area (cm^2), number of branches per plant and SPAD value of brinjal

Treatments	**Plant height (cm)**	**Leaf area (cm^2)**	**No of branch**	**SPAD value**
Control	71.11e	312.22f	10.00c	43.90e
GA_3	102.11a	430.78cd	13.00ab	49.00bc
Boron	71.78de	386.55e	9.50c	45.77de
Zn	79.67c	401.11e	10.00c	47.42cd
GA_3+Boron	96.45b	444.33bc	13.00ab	50.30b
GA_3+Zn	99.44ab	471.33a	12.00b	52.95a
NAA	73.67de	423.00d	14.00a	49.33bc
NAA + Boron	74.89d	426.11d	13.89a	49.13bc
NAA + Zn	74.22de	454.11b	13.50ab	50.59ab
CV%	2.46	2.32	7.75	3.03
$LSD_{0.05}$	3.51	16.72	1.62	2.55

Means followed by same letter(s) in a column do not differ significantly at 5 % level of LSD

3.5 Plant fresh and dry weight(g)

The highest fresh weight of whole plant of brinjal (549.00 gm) was found from 200 ppm GA_3 with 200 ppm Boron application and the lowest fresh weight of whole plant of brinjal (287.00gm) was recorded from untreated plant. Foliar application of Boron significantly increased the fresh weight of plants stated by Taheri*et al*., [21]. HG *et al*. [22] observed that boron involves in forming and strengthening cell and in improving biomass which increases fresh weight of plant.These findings are in agreement with those reported by Ali *et al*.,[23]where application of GA3 increased the fresh weight compared to other treatments.

The maximum dry weight of whole plant (158.80 g) was recorded in100 ppm NAA application with 200 ppm Zinc and the minimum (54.38 g) was recorded when there is no application of PGR and micronutrients. Nandan *et al*.,[24] observed that the application of NAA significantly increased dry weight of whole plant. Semida*et al*.,[25] conducted an experiment that zinc increase dry weight of plant. This might be due to that zinc helps in cell division, meristematic activity of tissue and expansion of cell which ultimately resulted in improving the dry weight of plant [26].Gibberellic acid promotes the production of new RNA and proteins, raises the concentration of chlorophyll, speeds up photosynthesis, and increases shoot dry weight [27].

3.6 Yield and yield contributing parameters

Yield and yield contributing parameters of brinjal was varied significantly due to the effect of plant growth regulators and micronutrients (Table 2). The highest number of flowers plant^{-1} (65.33) was observed from the combined application of200 ppm $GA_3$and 200 ppm Zn which was statistically similar to the combined application of200 ppm GA_3 and 200 ppm Boron(62.33). The lowest number of flowers plant^{-1} (43.00) was recorded from Control. By increasing the number of flower clusters and branches, GA3 enhanced flower primordia and increased the quantity of blooms per plant [28]. The foliar application of zinc (Zn) resulted in a considerable increase in the number of flowers plant^{-1} by improving photosynthetic activity, which in turn boosted the production and accumulation of carbohydrates and had a positive influence on the number of flowers plant^{-1} [29].

The highest number of fruits plant^{-1} (58.38) was observed from 200 ppm GA_3 and 200 ppm Znapplicationand the lowest number of fruits plant^{-1} (33.03) was recorded under no treatment.According to Ramteke et al. [30], the GA3 treatment produced the greatest quantity of fruits. Gibberellic acid accelerates the differentiation of inflorescences and increases the amount of starch, carbohydrates, and photosynthates that accumulate in the fruit, which results in a larger number of fruits per plant under GA3 treatment [31]. The increased production and accumulation of carbohydrates as well as the beneficial effects on vegetative growth and the retention of flowers and fruits may be responsible for the increased number of fruits resulting from the foliar spraying of zinc [32].

The maximum fruit weight (67.33gm) was recorded from the combined application of 100 ppm NAA and 200 ppm zinc and minimum value(46.00gm) was recorded without anytreatment application. Application of NAA promoted cell elongation through enlargement of vacuoles and loosening of cell wall after increasing cell wall plasticity [33]. According to Saini*et al*. [34] increase in fruit weight might be attributed to the catalytic role of zinc.

The treatment with 200 ppm GA3 and 200 ppm Zinc resulted in the highest fruit yield plant-1 (3676.7gm), whereas the lowest fruit yield plant-1 (1520.1gm) was seen in the untreated plant. Meena and Dhaka [35] reported a similar finding in brinjal, showing that GA3 produced the most fruit per plant. Zn promotes pollen formation and sustains high pollen viability during the anthesis stage, resulting in increased yield [36].

Table 2: Effect of plant growth regulators and micronutrients on yield and yield contributing parameters of brinjal

Treatments	Flowers/plant	Fruits/plant	Individual fruit weight (g)	Yield/Plant(g)
Control	43.00e	33.03f	46.00e	1520.1f
GA_3	56.66bc	50.86c	56.66c	2883.0c
Boron	45.66e	34.98e	50.66d	1773.2e
Zn	46.33e	35.81e	52.66d	1885.4e
GA_3+Boron	62.33a	55.67b	60.66b	3378.6b
GA_3+Zn	65.33a	58.38a	63.00b	3676.7a
NAA	51.66d	47.47d	57.00c	2706.3d
NAA + Boron	53.66cd	47.41d	63.33b	3003.6c
NAA + Zn	58.33b	51.52c	67.33a	3468.5b
CV%	3.70	2.22	2.93	3.30
$LSD_{0.05}$	3.43	1.77	2.91	154.35

Means followed by same letter(s) in a column do not differ significantly at 5 % level of LSD

3.7 Percentage of Ash, lipid and fibre

Significant influence was observed for Ash, lipid and fibre content (%) of brinjal as influenced by plant growth regulators and micronutrients. The maximum ash content (8.44%) was found from the treatment of 200 ppm NAA with no micronutrientsand the minimum ash content (6.44%) was recorded from the treatment of control. Olaiya *et al*., [37] also found the similar result.Ali *et al*., [38] found that NAA increases the ash percentage by influencing its proximate composition.

The maximum Lipid (0.35%) was observed when 200 ppm GA3 and 200 ppm Zn was applied combined. The minimum Lipid (7.60%) was recorded from the untreated plants. Animashaun *et al*. [39] stated the similar result. This might be due to the fact that GA3 strengthen cell membrane and lipid is the major component of cell membrane so, application of GA3 increased the lipid content. Zn plays major role in growth of cells, metabolism of plant, enzyme function and ion transport which increases lipid content in plant [40].

The maximum Fiber (12.28%) was observed from the treatment of 100 ppm NAA with 200 ppm Zinc.which is statically similar to the treatment combinations of 200 ppm GA3 with 200 ppm zinc application(12.18 %) and the minimum Fiber (7.60%) was recorded under untreated plant. NAA promotes cell growth and elongation of the plant which ultimately increase fiber content of plant [41]. Fiber is made up of polymers, carbohydrates, and an edible plant cell wall [42]. This may be associated with a notable Zn buildup upon the plant's receipt of these micronutrients [43].

Table 3: Effect of plant growth regulators and micronutrients on quality parameters of brinjal

Treatments	**Ash (%)**	**Lipid (%)**	**Fiber (%)**
Control	6.44e	0.11h	7.60g
GA_3	8.38a	0.21e	8.96f
Boron	8.14ab	0.15g	8.84f
Zn	8.36a	0.22d	9.36e
GA_3+Boron	7.15d	0.30c	11.92b
GA_3+Zn	7.92b	0.35a	12.18ab
NAA	8.44a	0.18f	9.80d
NAA+Boron	7.89b	0.28c	11.52c
NAA+Zn	7.54c	0.32b	12.28a
CV%	2.25	3.37	2.20
$LSD_{0.05}$	0.30	0.01	0.35

Means followed by same letter(s) in a column do not differ significantly at 5 % level of LSD

4. CONCLUSION

Based on the findings of the current experiment, it is possible to conclude that (200 ppm GA3 + 200 ppm Zn) outperformed other treatments containing different PGR and micronutrients in terms of brinjal growth, yield, and quality. Similarly, the interactions of G1 (200 ppm GA3) and M2 (200 ppm Zn) demonstrated superiority in terms of growth, yield, and quality.

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