**Short Research Article**

**Effect of Foliar Boron on the Growth and Yield of Maize**

**ABSTRACT**

Maize (*Zea mays* L.) plays a critical role in ensuring food security and supporting rural livelihoods in Bangladesh. Despite its importance, maize production is constrained by factors such as low soil fertility, water scarcity, and pest pressures. This study aimed to evaluate the effects of foliar boron application on the growth and yield of maize, and was conducted during the Rabi season of 2023-24 at the Agricultural Laboratory, SARD, Bangladesh Open University. The experiment employed a randomized complete block design (RCBD) with three replications. The treatments included six boron levels (B1, B2, B3, B4, B5, B6 ranging from 0 to 30 mg L-1) applied as a foliar spray at the six-leaf stage. Significant differences were observed in growth parameters such as plant height, dry matter, crop growth rate (CGR), and relative growth rate (RGR). The highest plant height (194.3 cm), dry matter (185.8 g), CGR (7.23), and RGR (0.006) were recorded with 25 mg L-1 boron application. Yield attributes, including cob diameter, seeds per row, 100-seed weight, seed yield, and stover yield, also showed significant improvements. The highest seed yield (5.65 t/ha) and stover yield (9.9 t/ha) were achieved with 30 mg L-1 boron application. The study demonstrates that boron application, particularly at 25-30 mg L-1, significantly enhances maize growth and yield. These findings underscore the potential of precise nutrient management to address production constraints and improve the profitability of maize cultivation in Bangladesh. Further research into combined nutrient applications and varied environmental conditions is recommended.

***Key words: Zea mays* L.*, foliar application, growth stages, maize yield, boron***

1. **INTRODUCTION**

Maize *(Zea mays* L.) is one of the most important cereal crops globally and holds immense potential in Bangladesh as a versatile crop supporting food security, livestock feed, and industrial uses. Despite its adaptability and growing importance, maize production in Bangladesh faces challenges such as soil fertility issues and nutrient imbalances. Given that it possesses the largest genetic yield potential of all the cereals, maize is considered as the "queen of cereals" internationally. Nutrient management is the key variable impacting maize productivity [14]. Among essential micronutrients, boron plays a pivotal role in crop development, influencing cell division, pollen viability, nutrient translocation, and seed formation [8]. Unfortunately, boron deficiency is widespread in Bangladesh's agricultural soils due to intensive farming, erratic rainfall, and improper fertilizer management, leading to reduced crop growth and yields [17].

Foliar application of boron has emerged as an efficient and cost-effective method to address micronutrient deficiencies in maize. Unlike soil application, foliar feeding ensures targeted delivery of boron, especially during critical growth stages, improving its bioavailability [2]. Studies from similar agro-climatic regions have demonstrated the potential of boron in enhancing maize yield components such as plant height, cob setting, grain weight, and overall productivity. However, systematic research on its effects in Bangladesh is limited, leaving significant scope for optimization and adoption of boron-based interventions in maize cultivation.

With increasing population pressure and a growing demand for maize in livestock and poultry industries, optimizing maize yield is crucial for Bangladesh's agricultural sustainability [15]. The application of boron aligns with modern precision farming practices, promoting nutrient use efficiency and environmental stewardship [16]. This study investigates the effects of foliar boron application on the growth and yield of maize, aiming to provide actionable insights for Bangladeshi farmers. By understanding the role of boron in enhancing productivity, this research seeks to contribute to sustainable agriculture and food security, ensuring economic benefits for smallholder farmers while addressing the nation's rising maize demand.

1. **MATERIALS AND METHODS**

An experiment was conducted at the Agricultural Laboratory in the School of Agriculture and Rural Development (SARD), Bangladesh Open University, Gazipur, during Rabi season from November 2023 to March 2024. The soil texture consisted of 11.28% clay, 26.72% silt, and 62% sand. The soil of the experimental site was clay loam in texture and the physicochemical properties of the surface soil (0–20 cm) were as follows: pH, 7.13; Organic matter, 2.08; EC, 135 (Msm-1) total N, 0.095%; total P, 12.41mg kg-1; total K, 17.10 mg kg-1; total S, 17.13 mg kg-1; total Zn, 0.553 mg kg-1, total B, 0.234 mg kg-1. The experiment was designed in a randomized complete block design (RCBD) with three replications. The treatments consisted of five foliar boron levels i.e., B1 = control (water spray), B2 = 10 mg L-1, B3 = 15 mg L-1, B4 = 20 mg L-1, B5 = 25 mg L-1 and B6 = 30 mg L-1 solution; Boron from the source of boric acid (H3BO3) was foliar sprayed at six leaf stages of maize with the help of a knapsack sprayer. The maize variety ‘BARI hybrid maize- 7’ was used in this experiment. The maize seeds were collected from the Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The seedbed was prepared with the help of a power tiller, twice plowing followed by a rotavator as required for maize cultivation. The subplot has a width of 2m and a length of 1.5m, which accommodates 4 rows. Plant and row distances were kept at 20 and 35cm, respectively. Recommended doses of fertilizers were 120- 60 - 40 kg N – P2O5 – K2O. The source of N – P2O5 – K2O were Urea, Triple Super Phosphate, and Muriate of Potash. All of the Triple Super Phosphate, Muriate of Potash and half of the Urea were used as a basal dose during land preparation. The remaining Urea was applied as top dressing at 35 days after sowing. The experimental plots were irrigated with surface irrigation according to the requirements of crop and weather conditions. A total of four irrigations were applied along natural seasonal precipitation. Weeds were manually eradicated during the crop cycle; the first weeding was conducted after twenty-five days and the second after forty-five days of maize emergence. All other cultural practices, i.e. thinning, herbicide and insecticide application, were kept uniform for all experimental units. The plants were harvested at maturity to record various growth, yield and yield attributes by using standard procedures. The recorded data will be compiled and tabulated for statistical analysis. The analysis of variance (ANOVA) and means of the parameters will be compared using Statistix-10.0. The mean differences among the treatments will be adjudged by least significant differences (LSD) at 5% level of significance.

1. **RESULTS**

The research concerning the effect of boron on growth and yield of maize was done under field conditions. Significant differences were observed among the treatments on the different growth parameters of maize *viz*. plant height (*F* = 205.4, *P* < 0.0001 and *df* = 5, 17), dry matter (*F* = 205.4, *P* < 0.0001 and *df* = 5, 17), CGR (*F* = 282.43, *P* < 0.0001 and *df* = 5, 17) and RGR (*F* = 99999.99, *P* < 0.0001 and *df* = 5, 17) as compared with their respective controls; but there was no significant difference among the treatments, except stem diameter (*F* = 1.99, *P* = 0.152 and *df* = 5, 17) as compared with control (Table 1). The highest plant height, dry matter, CGR, and RGR were investigated for the 25 mg L-1 boron with average mean values of 194.3 cm, 185.8 g, 7.23 and 0.006, respectively (Table 1). The highest stem diameter was observed when 15 mg L-1 boron was applied with average mean value of 1.43 cm (Table 1). The lowest plant height, dry matter, stem diameter, CCR and RGR were observed for control with average mean values of 172.5 cm, 172.2 cm, 1.20 cm, 5.27 and 0.005, respectively (Table 1).

**Table-1: Effect of boron on growth characteristics of maize**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant height (cm)** | **Dry matter (g)** | **Stem diameter (cm)** | **CGR** | **RGR** |
| |  | | --- | | B1 (Control) | | 172.5d ± 0.7 | 172.2b ± 2.0 | 1.20b ± 0.1 | 5.27e ± 0.1 | 0.005a ± 0.0 |
| B2 (10 mg L-1) | 180.8c ± 0.3 | 173.1b ± 1.2 | 1.37ab ± 0.0 | 5.69d ± 0.0 | 0.006a ± 0.0 |
| |  | | --- | | B3 (15 mg L-1) | | 183.7b ± 0.6 | 175.8b± 1.8 | 1.43a ± 0.0 | 6.42b ± 0.0 | 0.006a ± 0.0 |
| B4 (20 mg L-1) | 193.6b ± 0.6 | 183.5a ± 0.9 | 1.40ab ± 0.1 | 7.12a ± 0.0 | 0.006a ± 0.0 |
| B5 (25 mg L-1) | 194.3a ± 1.0 | 185.8a ± 1.0 | 1.40ab ± 0.0 | 7.23a ± 0.1 | 0.006a ± 0.0 |
| B6 (30 mg L-1) | 182.8b ± 0.3 | 175.7b ± 0.6 | 1.23b ± 0.1 | 6.23c ± 0.0 | 0.006a ± 0.0 |
| df | 5,17 | 5,17 | 5,17 | 5,17 | 5,17 |
| F Value | 205.4 | 205.4 | 1.99 | 282.43 | 99999.99 |
| P Value | 0.0001 | 0.0001 | 0.152 | 0.0001 | 0.0001 |

Data points represent the mean of four replicates for each treatment, denoted by V1 (control, 0gm vermicompost), V2 (150g), V3 (300g), V4 (500g), P1 (control, hydro prime), P2 (2% KCL), P3 (1% KNO3), and P4 (10% PEG6000). Error bars indicate standard error (SE). Treatments with unique letters differ significantly (p < 0.05) based on least significant differences tests and two-way ANOVA analysis.

Significant differences were also observed among the treatments on the yield parameters of maize *viz*. cob diameter (*F* = 4.75, *P* = 0.0127 and *df* = 5, 17), seeds/row (*F* = 8.25, *P* = 0.0014 and *df* = 5, 17), 100 seed wt. (*F* = 7.35, *P* = 0.0023 and *df* = 5, 17), seed yield (*F* = 7.87, *P* = 0.0017 and *df* = 5, 17), stover yield (*F* = 4.58, *P* = 0.014 and *df* = 5, 17) and harvest index (*F* = 4.74, *P* = 0.0127 and *df* = 5, 17) as compared with their respective controls (Tables 2 & 3). The yield parameters of cob/plant (*F* = 1.51, *P* = 0.256 and *df* = 5, 17), cob length (*F* = 0.79, *P* = 0.576 and *df* = 5, 17) and row/cob (*F* = 1.00, *P* = 0.45 and *df* = 5, 17) were not significantly different as compared with their respective controls (Table 2).

**Table-2: Effect of boron yield components of maize**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Cob/plant** | **Cob length (cm)** | **Cob diameter (cm)** | **Seeds/row** | **Row/cob** |
| |  | | --- | | B1 (Control) | |  | | 1.00a± 0.0 | 13.4a± 0.6 | 13.0b± 0.2 | 23.7c± 1.3 | 13.7a ± 0.0 |
| B2 (10 mg L-1) | 1.05a± 0.0 | 14.1a± 0.9 | 13.1b± 0.1 | 29.7b± 1.2 | 14.0a ± 0.0 |
| |  | | --- | | B3 (15 mg L-1) | | 1.11a± 0.0 | 14.7a± 0.8 | 13.2b± 0.3 | 31.0ab± 1.2 | 14.0a ± 0.0 |
| B4 (20 mg L-1) | 1.15a± 0.0 | 14.8a ± 0.1 | 13.6ab± 0.2 | 29.7b ± 0.9 | 14.0a ± 0.0 |
| B5 (25 mg L-1) | 1.17a± 0.0 | 15.0a ± 0.8 | 14.2a ± 0.3 | 33.3ab ± 2.0 | 14.0a ± 0.0 |
| B6 (30 mg L-1) | 1.03a± 0.0 | 15.3a ± 0.9 | 14.3a ± 0.3 | 33.7a± 1.7 | 14.0a ± 0.0 |
| df | 5,17 | 5,17 | 5,17 | 5,17 | 5,17 |
| F Value | 1.51 | 0.79 | 4.75 | 8.25 | 1.00 |
| P Value | 0.256 | 0.576 | 0.0127 | 0.0014 | 0.45 |

Data points represent the mean of four replicates for each treatment, denoted by V1 (control, 0gm vermicompost), V2 (150g), V3 (300g), V4 (500g), P1 (control, hydro prime), P2 (2% KCL), P3 (1% KNO3), and P4 (10% PEG6000). Error bars indicate standard error (SE). Treatments with unique letters differ significantly (p < 0.05) based on least significant differences tests and two-way ANOVA analysis.

The individual treatment of boron 30 mg L-1 performed the highest result of most of the yield parameters viz. cob length, cob diameter, 100 seed wt., seed yield and stover yield with average mean values of 15.3 cm, 14.3 cm, 33.7, 34.0 g, 5.65 t/ha and 9.9 t/ha, respectively (Tables 2 & 3). All the treatments were not significantly different in case of row/cob with the average highest mean value of 14.0 (Table 2). The highest harvest index was observed for the individual treatment of 30 mg L-1 boron (Table 3).

**Table-3: Effect of boron on yield of maize**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments**  **(mg L-1)** | **100SW**  **(g)** | **Seeds yield (t/ha)** | **Stover yield (t/ha)** | **HI%** |
| |  | | --- | | B1 (Control) | |  | | 28.7d ± 0.3 | 4.60c ± 0.0 | 8.2c ± 0.4 | 33.9c ± 0.4 |
| B2 (10 mg L-1) | 30.7cd ± 0.9 | 5.24b ± 0.1 | 8.6cd ± 0.3 | 34.8cd ± 0.2 |
| |  | | --- | | B3 (15 mg L-1) | | 33.0abc ± 0.6 | 5.23b ± 0.1 | 9.4ab ± 0.4 | 35.2ab ± 0.5 |
| B4 (20 mg L-1) | 32.3cd ± 1.2 | 5.22b ± 0.2 | 9.1abc ± 0.2 | 35.5ab ± 0.4 |
| B5 (25 mg L-1) | 34.7a ± 0.6 | 5.43ab ± 0.2 | 9.8a ± 0.3 | 36.1a ± 0.5 |
| B6 (30 mg L-1) | 34.9a ± 1.2 | 5.65a ± 0.1 | 9.9a ± 0.3 | 36.1a ± 0.3 |
| df | 5, 17 | 5, 17 | 5, 17 | 5, 17 |
| F Value | 7.35 | 7.87 | 4.58 | 4.74 |
| P Value | 0.0023 | 0.0017 | 0.014 | 0.0127 |

Data points represent the mean of four replicates for each treatment, denoted by V1 (control, 0gm vermicompost), V2 (150g), V3 (300g), V4 (500g), P1 (control, hydro prime), P2 (2% KCL), P3 (1% KNO3), and P4 (10% PEG6000). Error bars indicate standard error (SE). Treatments with unique letters differ significantly (p < 0.05) based on least significant differences tests and two-way ANOVA analysis.

1. **DISCUSSION**

Foliar application of boron significantly improved maize plant height, particularly when applied at optimal concentrations at growth stages. Data on plant height was changed due to different foliar application of boron while plots were treated with 25 mg L-1 boron. The plant height was 21.8cm taller than the non-treated with boron. The application of boron may contribute to the increase in plant height, as it lengthens the plant's internodal length by increasing the number of cells. Additionally, boron plays a role in cell differentiation and cell wall production, fostering plant growth, root and shoot elongation [4]. According to [2], foliar application of boron significantly enhances the height of maize plants, specifically at a concentration of 1%. In this study, dry matter yield of shoots and roots varied in the test cultivar. A concentration of 20 mg L-1 of boron greatly enhanced dry matter production in both shoots and roots. [10] reported that the significant increase in dry weight per plant in maize, which aligns with the findings of the current study, indicating that boron application greatly enhanced maize growth. The application of boron at the rate of 15 kg/ha significantly increased the dry matter yield of sorghum hybrids compared to lower concentrations [1]. This suggests that adequate boron levels are essential for maximizing forage yields, especially in environments with variable salinity.

Boron deficiency in cereal crops, as highlighted by [7], often results in reduced dry matter yield owing to morphological abnormalities, impaired photosynthesis, and disrupted metabolic processes, underscoring the critical role of boron in promoting optimal plant growth. Boron significantly influences maize crop growth rate (CGR), which plays a crucial role in plant development. Adequate boron levels enhance growth, yield, and overall productivity. In this study, the application of 25 mg L-1 boron notably increased the maize CGR. A related finding was that foliar application of 0.3% boron resulted in a CGR of 22.1 g/m²/day during a specific growth period, highlighting its effectiveness in boosting sweet corn growth [6]. Studies have shown that foliar application of boron can increase the number of cobs per plant, particularly in reproductive processes such as flowering, pollen tube growth, and seed formation. In maize, foliar application of boron significantly influences various growth parameters, including cob formation per plant [5]. Boron is essential for pollen tube elongation and pollen viability. The current study demonstrated that higher doses of boron increased the number of cobs per plant and cob length, though these improvements were not statistically significant; however, 30 mg L-1 of boron showed the best performance in cob setting per plant and cob length. On the other hand, boron significantly influenced kernel setting per cob, with 30 mg L-1 identified as the most advantageous dose. Sufficient supply ensures effective pollination and fertilization, leading to a better kernel set on the cobs. [3] reported that boron plays a key role in pollen tube elongation, which directly affects successful cob setting in maize. Adequate boron availability supports proper pollen tube growth, allowing it to reach the female gametophyte effectively, which is critical for double fertilization. Without sufficient boron, pollen tubes may fail to grow properly, leading to fertilization issues, lower seed set, and reduced cob formation. Another study on pine trees (*Picea meyeri*) has shown that boron is crucial for pollen germination and pollen tube growth. When boron is deficient in the growth medium, pollen germination rates have been significantly lower, and the pollen tubes that have grown have exhibited abnormal development [13]. Regarding the foliar spray of boron application, the 100 seed weight, seed yield, stover yield, and harvest index significantly increased with increasing doses of boron. Among them, 30 mg L-1 of foliar boron showed the highest results, which were statistically similar to that of 25 mg L-1 of boron. The increase in boron intake led to an increase in grain weight, because higher boron availability enhanced enzyme activation, which resulted in an increase in the partitioning of nutrients from leaves to grains and an increase in grain weight. This process contributed to the overall improvement in crop yield, demonstrating the significant role of boron in plant development and nutrient distribution. Regarding foliar application of boron at different concentrations, [2] revealed that the application of 1% boron produced the maximum thousand-grain weight. The increase in seeds per cob is attributed to the application of boron, which improves the seed filling process by enhancing seed setting and thereby reducing male sterility often observed under boron-deficient conditions [12]. These results are consistent with the findings of [11], who reported that an improvement in seeds per cob is achieved through boron application. Similar results were reported by [9], indicating that foliar application of boron increases the number of seeds per cob. A significant and higher stover yield was observed with the application of boron at 30 mg L-1, which may be attributed to the increased biomass build-up from having more leaves and yield features, such as a higher number of seeds per cob. This consistent application of boron led to enhanced uptake of major nutrients, resulting in improved photosynthetic activity and greater vegetative growth in plants. Accelerated growth due to proper metabolic activities produced a higher stover yield. These findings were consistent with those reported by [6]. The application of boron (B) had a significant positive effect on the harvest index of maize, enhancing both yield and quality. Research has indicated that foliar application of boron, at 25 mg L-1 and 30 mg L-1, had led to improved growth parameters and yield components, ultimately increasing the harvest index. Foliar application of boron at various growth stages has been found to improve the harvest index of maize. Studies had indicated that applying a 1% boron solution could have led to increases in harvest index by 12.77% to 13.31% compared to untreated plots, as reported by [2].

1. **CONCLUSION**

The study highlights the critical role of boron in enhancing maize growth, yield, and productivity through its foliar application. Optimal concentrations, such as 25 mg L-1 and 30 mg L-1, improved plant height, dry matter yield, cob formation, and grain weight. Boron facilitates cellular differentiation, pollen tube elongation, and nutrient partitioning, contributing to better pollination, seed setting, and biomass accumulation. These findings emphasize the importance of boron in boosting growth parameters like crop growth rate (CGR) and harvest index, supporting sustainable agricultural practices. The consistent results across studies validate boron's efficacy in promoting maize growth and maximizing yield.

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