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Effect of Foliar Application of Boron on the Growth and Yield of Green Chili (*Capsicum annum* L.)

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Abstract: A field study was performed at the Bangladesh Institute of Nuclear Agriculture (BINA) sub-station farm, Rangpur during Rabi season of 2021-22 to determine the effect of varieties and foliar application of boron on the growth and yield of green chili. The treatments were laid out in a Split-plot and replicated three times. Different concentrations of foliar Boron were applied as foliar sprays. The experiment comprised of nine treatments: T_1= 0.5 g $BL^{-1}H_2O$ at vegetative stage, T_2= 1.0 g $BL^{-1}H_2O$ at vegetative stage, T_3= 0.5 g $BL^{-1}H_2O$ at vegetative stage + 1.0 g $BL^{-1}H_2O$ at Fruiting stage, T_4= 1.0 g $BL^{-1}H_2O$ at vegetative stage + 1.0 g $BL^{-1}H_2O$ at Fruiting stage, T_5= 1.5 g $BL^{-1}H_2O$ at vegetative stage & T_6= 1.5 g $BL^{-1}H_2O$ at vegetative stage + 1.5 g $BL^{-1}H_2O$ at Fruiting stage, T_7= 2.0 g $BL^{-1}H_2O$ at vegetative stage, T_8= 2.0 g $BL^{-1}H_2O$ at vegetative stage + 2.0 g $BL^{-1}H_2O$ at Fruiting stage & T_9 = Control and two chili varieties/lines viz. Binamorich-2 & RCL-1. From the present study, it was concluded that the highest fresh chili yield (18.11 tha^{-1}) produced Binamorich-2 compared to RCL-1 which gave 14.52 tha^{-1}. Among the nine treatments of foliar boron, B @ 2.0 g/L H_2O at vegetative stage + B @ 2.0 g/L H_2O at fruiting stage exhibited the highest fresh chili yield (21.22 tha^{-1}). In respect of the interaction effect of foliar boron and variety, the Binamorich-2 was giving the highest fresh chili yield (25.00 tha^{-1}). However, further research will be needed with different doses of foliar boron for promising production of chili at different locations of Bangladesh.

Keywords: Effect, Varieties, Foliar boron, Growth, Yield, Green Chili

INTRODUCTION

Chili (*Capsicum annum* L.) is the major cash crop cultivated in the year round over the country except low lying and water stagnant area in Bangladesh. It has high demand among spices crops due to its high nutritional and spice value. In our country farmers are grown it as a scattered perennial crop in their homestead area. It has great demand in home as well as aboard for various culinary preparations. Green chilies have rich in Vit-A and Vit-C. Among the most significant Solanaceae spice crops grown worldwide is this one. In addition to its high phytochemical content, it is valued for its pungency, color, and aroma (Asnin and Park, 2015). According to Silva and Uchida, (2000) sixteen elements are known to be essential for growth and development, and a lack of these nutrients lowers yield. As a result, to increase yield, plants should be fed nutrients on a constant basis. Plants receive their nutrients from the soil as well as from their leaves. Using foliar application is the most efficient and fastest way to give plant nutrients. But it requires frequent applications, is rain-resistant, and requires a sufficient amount of leaf area on the plants; a higher concentration could harm the leaves (Fageria *et al.*, 2009). Plant roots absorb boron (B) as the neutral molecule H_3BO_3. B is necessary for the development of flowers, the first fruit or seed set (Borghi and Fernie, 2017), and the preservation of the cell wall and cell membranes' structural integrity (Zhang *et al.*, 2014). By encouraging pollen germination and pollen tube elongation, it raises the proportion of fruit-set (Abdalla, 2007). A reduction in seed or fruit set is the first indication of a B deficiency. A reduction in seed or fruit set is the first indication of a B deficiency. Capsaicin ($C_{18}H_{27}NO_3$) has a pungent principal compound found in the placenta of *C. frutescences* that makes hot. In Bangladesh, during 2020-21 chili production was only 2.03 tha^{-1} and occupies 19.40% area under cultivation of spices in Bangladesh (BBS, 2021). Comparatively yield of chili has low in Bangladesh other

than chili growing countries in the world. Reduced yield as a result of the lack of good seed and the variety of chilies, which can be improved with proper fertilizer management. Bangladesh's low yield may be caused by a dearth of widely used varieties. Being a very exhaustive crop chili needs proper nutrient management for expressing its genetic yield potential. Apart from the major nutrient management, inadequate supply of micronutrients not only decreases their field performance but also enhance the quality for this reason the application of micronutrients along with major nutrients is often essential depending on the soil conditions. Micronutrient deficiencies are linked to a number of production issues with chili (*Capsicum frutescens* L.) (Bose and Tripathi, 1996). Although they are extremely rare, micronutrients are crucial for healthy plant growth (Mousavi, 2009). A lesser yield of chilies (*Capsicum frutescens* L.) could also result from the soil in the areas that produce chilies having insufficient levels of zinc and boron. According to reports, the lack of necessary micronutrients in the soil has an impact on the yield of chilies (*Capsicum annuum* L.) (Abdou *et al.*, 2011). One of the crucial and delicate micronutrients required for healthy plant growth and development is boron. Different plant species and soil types have different requirements for boron. Compared to other micronutrients, managing boron is exceedingly challenging because the range of optimum boron addition is so narrow (Shol'nik, 1965; Haque *et al.*, 2011). Enhances pollen viability and absorption with boron on the other hand, exact information about how foliar boron application and variety affect green chili growth and yield is lacking. Based on the importance of variety and foliar boron for maximum chili production, this study was undertaken to find out the effect of variety and foliar application of boron on growth and yield attributes of chili.

MATERIALS AND METHODS

Study Location

The study was carried out at the BINA Substation Farm, Rangpur under AEZ-2 (Active Tista Floodplain) during Rabi seasons from November to April in 2021-22 to study the effect of variety and foliar boron on growth and the yield of green chili. The initial soil samples from the experiment field are shown in Table 1 after being collected and examined in accordance with standard laboratory protocols.

Table 1. Analytical result of Initial soil for Boron

Sample No.	Analytical result of soil sample						
	P	S	B	Zn	Cu	Fe	Mn
	(mg/gm)						
Initial soil	-	-	0.48	-	-	-	-

Climatic Condition

The experimental area experienced a subtropical climate with substantial rainfall from November 2021 to May 2022. During the growing period highest temperature was found in April 2022 (36°C) and the lowest temperature in February 2022 (16°C), where the average temperature was found 24°C (Fig 1).

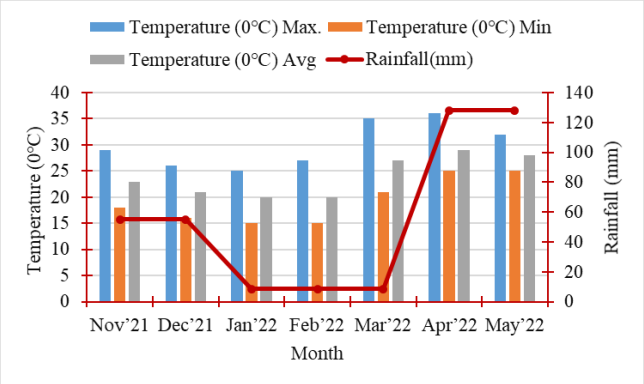

Figure 1: Average Weather data of the chili growing season during November'2021 to May'2022

Experimental design and Data Collection

The treatments were laid out in a Split-plot and replicated three times. Different concentrations of foliar Boron were applied as foliar sprays. The experiment comprised of nine treatments: T_1= 0.5 g $BL^{-1}H_2O$ at vegetative stage, T_2= 1.0 g $BL^{-1}H_2O$ at vegetative stage, T_3= 0.5 g $BL^{-1}H_2O$ at vegetative stage + 1.0 g $BL^{-1}H_2O$ at Fruiting stage, T_4= 1.0 g $BL^{-1}H_2O$ at vegetative stage + 1.0 g $BL^{-1}H_2O$ at Fruiting stage, T_5= 1.5 g $BL^{-1}H_2O$ at vegetative stage & T_6= 1.5 g $BL^{-1}H_2O$ at vegetative stage + 1.5 g $BL^{-1}H_2O$ at Fruiting stage, T_7= 2.0 g $BL^{-1}H_2O$ at vegetative stage, T_8 = 2.0 g $BL^{-1}H_2O$ at vegetative stage+ 2.0 g $BL^{-1}H_2O$ at Fruiting stage & T_9= Control and two chili varieties/lines viz. Binamorich-2 & RCL-1. At the vegetative stage, the first application was made, and at the fruiting stage, the second. 20% of the boron came from solubor boron. Early morning foliar applications were applied to improve nutrient absorption. Every agronomic technique was used in an experimental plot. Measurements were made of the following parameters: plant height, number of branches per plant, fruit length, fruit width, weight of each individual fruit, and yield of green chilies per plot and ha. Four (4) picks were used to record the fresh weight of the fruits. Statistical tool Statistics-10 was used to statistically analyze the data and the LSD value was compared to the means.

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RESULTS AND DISCUSSION

Effect of variety

The variety/line had a significant impact on all of the yield and yield contributing characteristics of chili. Table 2 shows that the plant heights at Binamorich-2 and RCL-1 were, respectively 55.07 cm and 52.77 cm high and low, respectively. The genetic makeup may be the cause of this. At Binamorich-2, the highest individual fruit weight of 4.98 g was recorded, while at RCL-1, the lowest weight of 3.72 g. Regarding variety, Binamorich-2 yielded the highest fresh chili yield (18.11 tha^{-1}) while RCL-1 produced 14.52 $tha^{-1.}$

Effect of foliar boron

Plant height, the number of branches per plant, fruit length, fruit width, individual fruit weight, green fruit yield (kg/plot), and green chili yield (t/ha) were all positively impacted by foliar boron. According to Table 3, T_8 had the most branches per plant (3.23), while T_9 had the fewest (2.76). T_8 had the longest fruit length (9.92 cm), while T_9 had the shortest (8.55 cm). Regarding foliar boron, T_8 (B @ 2.0 gm/LH_2O during the vegetative stage + B @ 2.0 gm/LH_2O during the fruiting stage) produced the highest fresh chili yield (21.22 tha^{-1}), while T_9 (Control) produced the lowest (10.27 tha^{-1}).

Table 2. Effect of variety on the growth and yield of green chili

Variety/line	Plant height (cm)	No. of branch/plant	Fruit length (cm)	Fruit breadth (cm)	Individual fruit weight (g)	Green chill yield (kg $plot^{-1}$)	Green chili yield (tha^{-1})
V_1	55.07	16.35	10.87	4.92	4.98	5.43	18.11
V_2	52.77	13.90	7.35	3.89	3.72	4.35	14.52
CV (%)	1.17	5.40	2.75	9.11	6.62	5.92	5.90
LSD (0.05)	0.74	0.19	0.29	0.47	0.33	0.33	1.12

(V_1= Binamorich-2 & V_2= RCL-1)

Table 3. Effect of foliar boron on the growth and yield of green chili

Treatments	Plant height (cm)	No. of branch/plant	Fruit length (cm)	Fruit breadth (cm)	Individual fruit weight (g)	Green chili yield (kg $plot^{-1}$)	Ggreen chili yield (tha^{-1})
T_1	52.87	14.66	8.87	4.35	4.00	3.65	12.16
T_2	55.40	15.15	8.63	4.38	4.07	4.65	15.50
T_3	54.03	16.05	9.07	4.48	4.38	4.02	13.38
T_4	53.27	14.90	9.17	4.35	4.26	5.07	16.89
T_5	54.47	15.35	9.07	4.25	4.07	5.50	18.35
T_6	54.67	16.00	9.47	4.45	4.67	5.90	19.67
T_7	54.13	14.00	9.27	4.43	4.62	5.82	19.39
T_8	55.97	16.15	9.92	4.81	5.13	6.37	21.22
T_9	50.47	13.80	8.55	4.17	3.97	3.08	10.27
CV (%)	1.17	5.40	2.75	9.11	6.62	5.92	5.90
LSD (0.05)	1.91	0.31	0.40	0.21	0.27	0.67	2.26

(T_1 = B @ 0.5 gm/LH_2O at vegetative stage, T_2= B @ 1.0 gm/LH_2O at vegetative stage, T_3= B @ 0.5 gm/LH_2O at vegetative stage + B @ 1.0 gm/LH_2O at Fruiting stage, T_4= B @ 1.0 gm/LH_2O at vegetative stage + B @ 1.0 gm/LH_2O at Fruiting stage, T_5= B @ 1.5 gm/LH_2O at vegetative stage & T_6= B @ 1.5 gm/LH_2O at vegetative stage + B @ 1.5 gm/LH_2O at Fruiting stage, T_7 = B @ 2.0, gm/LH_2O at vegetative stage, T_8 = B @ 2.0 gm/LH_2O at vegetative stage + B @ 2.0 gm/LH_2O at Fruiting stage & T_9 = Control).

Interaction effect of varieties and foliar boron

Plant height (cm)

Since plant height is a major factor in both growth and yield, it serves as a proxy for the rate of growth of chili plants. Table 4 shows a significant variation in the effect of various treatment combinations on plant height. In the vegetative stage (V_1T_2) treatment combination, Binamorich-2 produced the highest plant height (58.40 cm), while the minimum plant height (50.40 cm) was obtained from Binamorich-2 with the control (V_1T_9) treatment combination (Table 4). A 2% concentration of organic micronutrient chelate applied topically to chili plants produced a maximum plant height of 60.1 cm (Baloch *et al.*, 2008). The chili plant's plant height increased with the foliar application of the "Higrow" macro- and micronutrient solution, which was established in the leaves (Deore *et al.*, 2010). Consequently, it was discovered that most treatments varied greatly in terms of plant height (cm), which would be highly advantageous for growers of chilies. More flowers were produced by chili plants with greater height (cm), which ultimately resulted in a higher yield per plant. El-Mohsen *et al.*, (2007) found that applying zinc and boron foliarly at a rate of 1.0 $gL^{-1}H_2O$ to a chili crop increased plant height and leaf count. My current results are consistent with the findings of Fakir *et al.*, (2016) in wheat, Halder *et al.*, (2007) in ginger (3 kg ha^{-1}), and Haleema *et*

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al., (2018) (0.25%) in tomato, which also showed an increase in plant height due to boron application. Additionally, it was noted that adding foliar boron to pepper plants at a 75 ppm rate resulted in taller plants (Shnain *et al;* 2014).

Number of branches Plant^{-1}

The number of branches Plant^{-1} characteristic was significantly influenced by boron. The traits associated with this property (number of branches per plant) are provided in table 4. In comparison to the other treatments evaluated, the treatment combinations V_1T_8 (18.35), V_1T_6 (17.35), and V_1T_3 (17.15) produced the maximum number of branches Plant^{-1}. On the other hand, control plots, in which foliar nutrients were not provided, produced the least number of branches Plant^{-1} (12.00). The number of branches was shown to be significantly affected by the application of boron, as reported by Basavarajeswari *et al.,* (2008) in tomato, Saha *et al.,* (2010) in broccoli and saptari, and Dewi (2013) in chili. More branches on chile plants result in more blooms, which ultimately increase the yield per plant. This is consistent with research by Venkatramana (2012), which showed that applying 40 g of $MgSO_4$ and 4 g of borax had a noticeable impact on the number of branches Plant^{-1}.

Fruit length (cm)

Since fruit length (cm) is a major factor in yield contribution, it expresses the marketability rate of chili fruit. Table 4 presents the outcomes associated with this characteristic (fruit length), highlighting the notable variations in fruit length across all treatments. It was discovered that chili fruits with a maximum length of 11.73 cm were generated by treatment V_1T_8, whereas fruits with a minimum length of 6.67 cm were produced by treatment V_2T_9. According to Deore *et al.,* (2010), foliar treatment of Higraw in chili plants increases fruit length. Shil *et al.,* (2013) put zinc and boron on chili crop in addition to boron application, which had a major influence on fruit length.

Table 4. Interaction effect of variety and foliar boron on yield and yield contributing characters of green chili

Variety× Treatments	Plant height (cm)	No. of branch/plant	Fruit length (cm)	Fruit breadth (cm)	Individual fruit weight (g)	green chili yield (kg plot^{-1})	Green chili yield (tha^{-1})
V_1T_1	57.40	14.35	10.43	4.77	4.67	3.57	11.89
V_1T_2	58.40	16.65	10.27	4.63	4.50	5.93	19.78
V_1T_3	54.67	17.15	10.43	4.87	4.60	3.83	12.78
V_1T_4	55.00	17.00	10.87	4.70	4.90	5.27	17.55
V_1T_5	55.93	16.35	11.17	4.93	4.60	6.17	20.56
V_1T_6	55.67	17.35	11.43	5.00	5.77	6.73	22.45
V_1T_7	55.00	16.00	11.33	5.10	5.30	6.57	21.89
V_1T_8	53.13	18.35	11.73	5.43	6.00	7.50	25.00
V_1T_9	50.40	13.65	7.00	3.57	3.50	3.33	11.11
V_2T_1	54.53	14.00	7.30	3.93	3.47	3.47	11.56
V_2T_2	52.40	14.00	7.35	4.13	3.43	3.37	11.22
V_2T_3	51.07	14.65	7.97	4.10	4.27	4.70	15.67
V_2T_4	51.53	14.00	7.47	4.00	3.63	4.87	17.55
V_2T_5	52.13	14.35	6.97	3.65	3.53	4.83	20.55
V_2T_6	53.67	13.65	7.50	3.90	3.57	4.90	16.33
V_2T_7	53.27	12.00	7.20	3.77	4.03	5.23	17.45
V_2T_8	55.80	15.00	8.10	4.20	4.27	5.23	17.44
V_2T_9	50.53	13.35	6.67	3.47	3.40	2.60	8.66
CV (%)	3.02	8.77	3.76	5.47	4.10	11.8	11.81
LSD (0.05)	2.62	0.44	0.59	0.51	0.47	0.95	3.17

(V_1= Binamorich-2 & V_2= RCL-1; T_1 = B @ 0.5 gm/LH_2O at vegetative stage, T_2= B @ 1.0 gm/LH_2O at vegetative stage, T_3= B @ 0.5 gm/LH_2O at vegetative stage + B @ 1.0 gm/LH_2O at Fruiting stage, T_4= B @ 1.0 gm/LH_2O at vegetative stage + B @ 1.0 gm/LH_2O at Fruiting stage, T_5= B @ 1.5 gm/LH_2O at vegetative stage & T_6= B @ 1.5 gm/LH_2O at vegetative stage + B @ 1.5 gm/LH_2O at Fruiting stage, T_7 = B @ 2.0 gm/LH_2O at vegetative stage, T_8 = B @ 2.0 gm/LH_2O at vegetative stage + B @ 2.0 gm/LH_2O at Fruiting stage & T_9 = Control)

Fruit breadth (cm)

Regarding fruit breadth, a significant difference was noted (Table 4). The available data, however, made it abundantly evident that the majority of the treatments were found to have more than, with the exception of six treatments (V_1T_9, V_2T_1, V_2T_5, V_2T_6, V_2T_7, and V_2T_9), all of which were found to have fruit breadths of less than 4 cm. The fruits with the greatest fruit breadth, 5.43 cm, were generated by treatment V_1T_8, per the results. Furthermore, under the specified experimental conditions, treatment T_9

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generated fruits with a minimum fruit width of 3.47 cm. More fruit width (cm) on chili plants results in more weighted fruits, which ultimately yields a higher yield per plant. In addition to applying NPK to the chili crop, Shil *et al.*, (2013) also added zinc and boron, and they saw an increase in fruit length, which intriguingly corroborated this finding.

Individual fruit weight (g)

The weight of each individual fruit was dramatically affected by the foliar application of Boron (Table 4). The plants receiving the treatment V_1T_8 had the remarkably greatest individual fruit weight (6.00 g), which was followed by the plants receiving the treatment V_1T_6 (5.77 g) and the plants receiving the treatment V_1T_7 (6.00 g) (Table 4). The fruit weight of the control group was the lowest at 3.40 g. According to Venkatramana (2012), applying 0.5% borax and 1% magnesium oxide topically enhanced pepper yield. This resulted from the fact that boron was essential for vegetative growth and that it greatly enhanced the development and production of seeds, fruits, and pollen tubes, as well as the elongation of pollen tubes and germination (Oosterhuis, 2001). More individual fruit weight (g) on chili plants results in higher yields per plant, which in turn increases yields per hectare. Our results are consistent with those of Shil *et al.*, (2013).

Green chili yield (Kg plot^{-1})

Among all treatments, a notable degree of variation was noted in the green chili yield attribute. The least amount of green chili produced under the experimental conditions was 2.66 kg plot^{-1} from V_2T_9, while the largest amount came from V_1T_8, which produced a yield of 7.50 kg plot^{-1}. Thus, in order to maximize the yield (kg) of green chilies, peasants cultivating pepper crop would add a dose of zinc and boron. Application of zinc and boron to the chili crop increased the amount of fruit produced per plant (Shil *et al.*, 2013; Naga-sivaiah *et al.*, 2013; Manna, 2013; Ali *et al.*, 2015). As a result, their findings provided additional support for the traits found in this research.

Green chili yield (tha^{-1})

The lowest amount of fruit produced was 8.66 tha^{-1}, while the maximum output of green chilies per hectare was 25 tons, according to the results. The projected green chili production of twelve treatments was therefore 15 tons per hectare, whilst the remaining treatments were less than 15 tons per hectare.

Correlation among the yield and yield contributing traits for interaction effect

The association between fruit yield and fruit yield per plot was positive and statistically significant (Fig 2). Similarly, fruit length showed substantial and positive associations with fruit breadth was significant and favorable. Branch per plant and fruit yield also made a positive correlation along with individual fruit weight. But a substantial negative association (Fig 2) was observed among plant height and fruit yield along with fruit yield. According to pujar *et al.*, (2017) reported that, higher vegetative growth reduces the yield potential of chili germplasm.

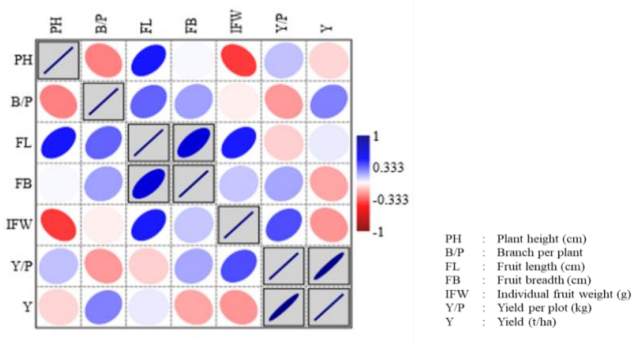

Figure 2: Correlation among the yield and yield contributing traits for variety and treatment interaction

CONCLUSION

From the present study, it was concluded that the highest fresh chili yield (18.11 tha^{-1}) produced Binamorich-2 compared to RCL-1 which gave 14.52 tha^{-1}. Among the nine treatments of foliar boron, B @ 2.0 gm/LH_2O at vegetative stage + B @ 2.0 gm/LH_2O at fruiting stage exhibited the highest fresh chili yield (21.22 tha^{-1}). In respect of the interaction effect of foliar boron and variety, the Binamorich-2 was giving the highest fresh chili yield (25.00 tha^{-1}). But further study is needed to determine more precise combination of foliar boron at different locations of Bangladesh for promising production.

Conflict of Interest

The authors have no relevant financial or non-financial interests to disclose.

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