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RESPONSE OF HYBRID MAIZE TO BORON APPLICATION

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Abstract

An experiment was carried out at farmer's field of Kushtia district under High Ganges River Floodplain Soil (AEZ-11) during Rabi seasons of 2013-14, 2014-15 and 2015-16. The objectives of the study were to evaluate the effect of boron on the yield of hybrid maize (cv. BARI Hybrid Bhutta-9) and to find out the optimum dose of boron for higher yield and economic return. There were 6 treatments comprising 6 levels (0, 0.5, 1.0, 1.5, 2.0 and 2.5 kg B ha^{-1}) of boron along with a blanket dose of N_{256} P_{65} K_{45} S_{27} Zn_3 kg ha^{-1} and cowdung 5 tha^{-1}. Boron fertility of the initial soil was in medium level (0.33 µg g^{-1}). The experiment was conducted in RCB design with three compact replications. Results of three years study revealed that hybrid maize responded significantly to added boron for the first two years but for the third year the effect was statistically non significant. The highest grain yield was obtained with 2.5 kg B ha-1, which was marginally significant with boron control but statistically identical to rest of the boron levels. Although, the yield increased linearly up to 2.5 kg ha^{-1} but the effect was relatively better fitted with quadratic response function (R^2 = 0.943). The mean highest grain yield found to be 8.55 t ha^{-1} for 2.5 kg B ha^{-1} against 8.20 t ha^{-1} from 0.5 kg B ha^{-1} and 7.84 t ha^{-1} from boron control. Considering the boron fertilty of soil, response of maize to boron and economic return, the optimum dose of boron may be 0.5 kg ha^{-1} for the cultivation of hybrid maize for medium level boron fertile soil under AEZ-11 of Kushtia district or alike.

Keywords: Response, maize, boron, yield, return, MBCR.

Introduction

Maize (*Zea mays* L.) is the most important silage plants in the world because of its high yield, high energy forage produced with lower labor and machinery requirements than other forage crops (Roth *et al.,* 1995). Many environmental, cultural and genetic factors influence maize forage yield and quality. In Bangladesh, maize is cultivated mainly for grain; the agricultural area devoted annually to maize was 334975 hectare which was about 2.75% of cereal cultivating area and average grain production was 2445578 metric ton with an

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average yield of 7.30 t ha^{-1} during the year 2015-16 (BBS, 2017). For its high yielding capacity and diversified uses, demand of maize is increasing day by day in the world as well as in Bangladesh. It is now widely used in the poultry farms as animal feed, as well as the people consume roasted and fried maize in Bangladesh. Maize has an immense potential to reduce shortage of food, poultry feed and malnutrition. Because, it is a high yielding and low- cost crop compared to rice and wheat (Rahman, 2011).

Bangladesh Agricultural Research Institute (BARI) has been conducting research activities for varietal development of maize since 1960. Initially, thrust was given for development of composite varieties. So far, BARI has developed seven open pollinated and fifteen hybrid maize varieties. The yield potentiality of the released composite varieties varied from 5.5 - 7.0 t/ha and the hybrid varieties ranged 7.4 – 12.0 t/ha (Rahman, 2011). In Bangladesh, maize farmers cultivate imported commercial hybrid seed (900M, 981, 987, NK 40, Pinnacle, 759, Pioneer-96, Elite, Miracle, Super Gold, Sunshine, Pioneer-V-92 etc.) which is imported by different private seed companies. The grain yield of BARI varieties was lower compared to imported commercial varieties (Khan, *et al.*, 2016; BARI, 2015). Due to tallness of the BARI maize varieties, farmers faced problems with top dressing and intercultural operation (Miah, *et al.,* 2013).

Boron plays an important role in cell-wall synthesis, sugar transport, cell division, differentiation, membrane functioning, root elongation, regulation of plant hormone levels, and generative growth of plants (Marschner, 1995). Boron is taken up as a boric acid, which is translocated slowly within the plant. Deficiency symptoms can include a failure of root tips to elongate, inhibition of DNA and RNA synthesis and inhibition of cell division in the shoot apex of young leaves. Boron is also known to be critical in the elongation of the pollen tube (Salisbury and Ross, 1992). One of the challenges in corn production is its sensitivity to B deficiency (Salisbury and Ross, 1992; Soylu *et al.*, 2004). Boron, a micronutrient, is essential for pollen viability and seed production of crops as well as flowering and fruiting. It also plays vital role in nitrogen metabolism, hormonal action and cell division (BARI, 2006).

Maize has been previously considered to have a relatively low boron (B) requirement as compared to other cereals (Martens and Westermann, 1991). However, based on field responses to B application, its deficiency has been reported in maize across five continents (Bell and Dell, 2008; Shorrocks, 1997; Shorrocks and Blaza, 1973). For example, maize yield increase of 10% were reported in Rhodesia (now Zimbabwe), up to 26% in India (Shorrocks and Blaza, 1973), more than 10% in Switzerland (cited by Mozafar, 1987) and by 9% in China (Li and Liang, 1997). Deficiency of B in field grown maize was first observed in the 1960s in the United States (Shorrocks and Blaza, 1973), and yield increase of more than 10% were observed in response to B application (Woodruff *et al.*, 1987).

Limited studies on B deficiency of various crops including maize suggest a critical soil solution content ranging from 0.15 mg of B kg^{-1} to 1.0 mg of B kg^{-1} and 2.0 mg B kg^{-1} and a critical leaf B concentration of 30 mg kg^{-1} (FAO, 1990). However, additional studies are needed as soil chemical and physical properties and species selection influence B availability to and uptake by plants possibly resulting in large variability in optimum economic B rates for various crops and soils.

Sarkaut *et al.* (2013), Akhter and Mahmud (2009), BARI (2009), Akhter and Khan, 2007 and Singh, 1998 found significant response of hybrid maize to boron application. Akhter and Mahmud, 2009 reported that the yield of maize grain increased significantly due to added boron up to 2.0 kg B ha^{-1} and yield components like plant height, ear height and straw yield were influenced significantly due to application of boron. Singh (1998) found that Rabi maize gave the optimum yield at 1.5 kg ha^{-1} B application and Kharif maize produced the best yield at 2.0-2.5 kg B ha^{-1} rate. Boron application increased maize yield, indicating B deficiency (Gunes *et al.*, 2011).

In mustard, chickpea, mungbean, soybean, groundnut, cauliflower, tomato, papaya and wheat, positive response to boron fertilization were found (Rashid *et al.*, 2012; Hossain *et al.*, 1995; Islam, 2005; Saha *et al.*, 2003; Sinha *et al.*, 1991; Shen *et al.*, 1998). These studies revealed that boron is very important in cell division and in pod and seed formation. Rate of water absorption and carbohydrate transaction is restricted due to boron deficiency. Thus, boron fertilization is necessary for improvement of crop yield and nutritional quality. There is a good scope to introduce hybrid maize with proper management of fertilizer. This will help increase the present production and requirement. The response of hybrid maize to boron has not yet been tested under different agro-climatic conditions especially for calcareous soils under greater Kushtia region. Considering the above perspectives, the present experiment was undertaken to evaluate the effect of boron on the yield of hybrid maize and to findout the optimum dose of B application for the cultivation of hybrid maize with greater economic profitability.

Materials and Methods

The study was conducted at Multi Location Testing (MLT) site of Kushtia sadar (Latitude: 23.87736^0 N Longitude: 89.09126^0 E) during the periods (November to April) of 2013-14 to 2015-16 at farmers' field condition. Its altitude is 17m. The average high temperature is 37.8° C and the average low is 9.2° C. Annual rainfall averages 1,467 millimeters. The soil is calcareous in nature under High Ganges River Floodplain (AEZ-11). Before setting up of the experiment, soil samples were collected at depth of 0-15 cm to determine baseline its properties. Soil samples were air-dried, crushed, and sent to SRDI laboratory for analysis. The nutrient status of initial soil is presented in Table 1. The content of B in the initial soil was in medium level (0.33 µg g^{-1}). Based on the soil properties, the blanket dose of all nutrients except boron was estimated following FRG, 2012.

Table 1. Chemical properties of initial soil (0-15 cm depth) of the experimental field at Bottoil, Kushtia sadar, Kushtia during 2013-14.

Replication	pH	Organic matter (%)	K	Total N (%)	P	S	Zn	B
			meq/100 g soil		µg g^{-1}			
R_1	7.8	1.87	0.24	0.09	11.70	20.40	0.72	0.34
R_2	8.1	1.88	0.27	0.10	10.70	18.21	0.74	0.31
R_3	7.9	1.82	0.28	0.09	8.80	18.40	0.72	0.35
Mean/Range	7.8-8.1	1.86	0.26	0.09	10.40	19.00	0.73	0.33
Critical limit	-	-	0.12	0.12	10	10	0.60	0.20
Interpretation	Slightly Alkaline	Medium	Medium	Low	Low	Medium	Low	Medium

The experiment was laid out in randomized completely block design with three compact replications. There were 6 levels of B (0, 0.5, 1.0, 1.5, 2.0 and 2.5 kg ha^{-1}) applied in the form of boric acid. In addition, a blanket dose of N_{256} P_{65} K_{45} S_{27} Zn_3 kg ha^{-1} was applied in the forms of urea, TSP, MoP, gypsum and zinc oxide. Cowdung was applied @ 5 t ha^{-1}. As such, 6 treatments were used in this study. BARI hybrid butta-9 variety was used as the test crop. The unit plot size was 4 m x 5 m. Seeds were sown on 20 November, 2013, 07 November, 2014 and 16 November, 2015 with a spacing of 60 cm × 20 cm and the seed rate was 20 kg ha^{-1}. All P, K, S, Zn, B and one third of N were applied as basal dose at the time of final land preparation and the remaining two third of N was top dressed in two equal splits at 8-10 leaf stage and teaseling stage. Weeding was done two times at 31 days after sowing (DAS) and 51 DAS. The crop was irrigated 4 times at 31, 62, 77 and 103 DAS. Common cutworm was attacked in the maize filed in seedling stage. Dursban was applied in maize field @ 5 ml L^{-1} of water to control common cutworm. No disease was noticed in the maize field. The maize grain was harvested on 22 April, 2014, 10 April, 2015 and 18 April, 2016. The necessary data on different parameters were recorded from 1 m^2 in 3 areas from each treatment. Then it was computed and analyzed statistically using R package. The analyzed data was adjusted with Least Significant Difference (LSD) test at 5% level. Per hectare gross return, total variable cost, gross margin and marginal benefit cost ratio (MBCR) was calculated.

Results and Discussion

Yield components

There was no significant effect of boron on the yield components like plant height, ear height, number of grain per cob (2015-16) and 100 grain weight (except 2013-14) of hybrid maize although a positive trend of improvement was noticed (Table 2). The number of grain per cob increased significantly with the increased rate of boron application up to 2.5 kg B ha^{-1} during the year 2013-14 and 2014-15. Hundred grains weight increased significantly due to higher boron application during 2013-14. Numerically, the studied parameters showed the highest result with 2.5 kg B ha^{-1} and the lowest from boron control in most of the cases. The highest plant height was recorded in T_6 treatment in all the years except 2014-15 (Table 2). The ear height was the highest in T_6 treatment during 2013-14 and 2014-15. Numbers of grain per cob and 100 grain weight were maximum in T_6 treatment in all the year. Similar positive responses were found by Sarkaut, *et al.*, 2013; Gunes *et al.*, 2011; Akhter and Mahmud, 2009; Akhter and Khan, 2007 and Singh, 1998.

Grain yield

The yield of hybrid maize responded significantly to added boron for the first 2 years of the study but in the third year the effect was statistically non significant (Table 2). Residual effect of boron for a medium B fertile soil might have resulted in non-significant effect. However, the highest grain yield (8.40 and 8.77 t ha-1 for 2013-14 and 2014-15, respectively) was obtained with 2.5 kg B ha-1, which was narrowly ($p > 0.05$) significant with boron control but statistically identical to rest of the boron levels. The mean highest grain yield (8.55 tha^{-1}) was found in T_6 and the lowest yield (7.84 tha^{-1}) was in T_1. In fact, the yield of hybrid maize in T_6 was 9 percent higher than that of T_1. Boron fertility of initial soil was in medium level, which in presence of added cowdung might have resulted in relatively lower contribution of boron to the yield of hybrid maize. The yield was the highest in T_6 treatment due to its higher number of grain per cob and 100 grain weight. For straw yield, the effect of B showed similar trend although it was statistically non-significant. Similar findings of positive response were reported by Sarkaut *et al.* (2013), Gunes *et al.* (2011), Akhter and Mahmud (2009), Akhter and Khan (2007) and Singh (1998).

Cost and return of maize

The cost of maize cultivation for different treatments is shown in Table 3. The average highest gross return (Tk. 147249 ha^{-1}) was obtained from T_6 (2.5 kg B ha^{-1}). About 8.83 percent more return was found in T_6 treatment compared to T_1. The average highest total variable cost (Tk. 80942 ha^{-1}) was calculated on T_6. As a result, the average gross margin was also the highest in T_6 treatment (Tk. 66277 ha^{-1}). The marginal benefit cost ratios (MBCR) found to be positive and varied from 4.47 to 11.45. The highest MBCR (11.45) was obtained from T_2 treatment (0.5 kg B ha^{-1}) indicating that it was the most economically viable treatment among all other treatments.

Table 2. Yield and yield components of maize at different treatments of B application rates at MLT site, Kushtia during 2013-14 to 2015-16

Treatments	Plant height (cm)			Ear height (cm)			No. of grain cob^{-1}			100 grain wt (g)			Grain yield (tha^{-1})			Stover yield (tha^{-1})		
	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16	2013-14	2014-15	2015-16
T_1	224.10	215	220	118.33	114	118	488	500	441	31.67	33.00	32.00	7.83	7.89	7.85	9.60	10.34	9.10
T_2	225.27	214	220	120.00	115	121	519	516	440	32.00	33.33	33.50	8.07	8.33	8.20	9.73	10.50	9.20
T_3	224.83	217	219	119.33	117	119	524	519	442	32.00	34.00	32.00	8.07	8.40	8.27	9.70	10.47	9.08
T_4	225.80	217	222	118.67	118	119	523	522	452	32.67	34.67	33.67	8.20	8.53	8.29	9.73	10.43	9.22
T_5	224.80	219	223	120.00	114	121	535	537	450	33.67	35.00	34.00	8.30	8.67	8.37	9.70	10.53	9.07
T_6	227.50	218	224	120.00	119	120	541	538	452	33.33	35.33	34.50	8.40	8.77	8.49	9.80	10.50	9.13
CV (%)	6.75	3.95	6.99	5.41	4.61	5.18	4.53	3.17	7.39	3.35	6.78	7.76	3.82	5.47	5.67	5.83	7.18	5.14
LSD (0.05)	NS	NS	NS	NS	NS	NS	42.96	30.07	NS	1.98	NS	NS	0.57	0.84	NS	NS	NS	NS

T_1 = 0 kg ha^{-1} B, T_2 = 0.5 kg ha^{-1} B, T_3 = 1 kg ha^{-1} B, T_4 = 1.5 kg ha^{-1} B, T_5 = 2 kg ha^{-1} B and T_6 = 2.5 kg ha^{-1} B

Table 3. Mean yield, cost and return of maize at different treatments of B application rates at MLT site, Kushtia during 2013-14 to 2015-16

Treatments	Mean yield (t ha^{-1})	Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	MBCR
T_1	7.84	135303	78267	57036	0
T_2	8.20	141428	78802	62626	11.45
T_3	8.25	142201	79337	62864	6.45
T_4	8.34	143681	79872	63809	5.22
T_5	8.45	145297	80407	64891	4.67
T_6	8.55	147249	80942	66277	4.47

T_1 = 0 kg ha^{-1} B, T_2 = 0.5 kg ha^{-1} B, T_3 = 1 kg ha^{-1} B, T_4 = 1.5 kg ha^{-1} B, T_5 = 2 kg ha^{-1} B and T_6 = 2.5 kg ha^{-1} B.

Conclusion

Considering the boron fertilty of soil, maize response to boron and economic return, it can be concluded that boron played significant role in augmenting the yield of hybrid maize and the optimum dose of boron may be 0.5 kg ha^{-1} for the study area. Therefore, for medium level boron fertile soil under AEZ-11 of Kushtia district or alike, application of 0.5 kg B ha^{-1} may be recommended for the cultivation of hybrid maize. Besides, a blanket dose of other nutrients (N_{256} P_{65} K_{45} S_{27} Zn_3 kg ha^{-1} and cowdung 5 t ha^{-1}) should also be applied on the basis of soil test following FRG -2012.

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