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EFFECTS OF MICRONUTRIENT ON GROWTH AND MICRONUTRIENT CONTENT OF HYBRID MAIZE (*ZEA MAYS* L.)

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Abstract

Requirement of micronutrients for yield maximization of BARI Hybrid Maize 5 was studied under field condition. The highest grain yield of maize of 10.1 t/ha was obtained with the application of Zn along with recommended NPKS. The Zn application alone produces about 50% yield benefits compared to control. The concentration of macronutrients (N, P, K and S) in maize grain and straw remained unaffected while concentration of micronutrients (Zn, B, Cu, Mn and Fe) increased significantly due to their application. The result clearly indicated the necessity of applying 3 kg Zn/ha along with recommended doses of NPKS for yield maximization of BARI Hybrid Maize 5 in Old Brahmaputra Floodplain soil.

Being an important “Kharif” crop in Bangladesh, maize is grown in about 3.96 lakh hectares of land with a total production of about 27.49 lakh metric tons (Anonymous 2016). Timsina and Majumdar (2010) indicated that maize grain yields in Bangladesh have been decreasing where maize was grown on the same land for the last 5 to 10 years. The authors attributed the yield decline to imbalanced and inadequate nutrient application by farmers. For managing plant nutrients in maize systems, N, P and K remain the major ones for increased and sustained productivity. However, cultivation of high yielding maize systems will likely exacerbate the problem of secondary and micronutrient deficiencies, not only because larger amounts are removed, but also because the application of large amounts of N, P and K to achieve higher yield targets often stimulates the deficiency of secondary and micronutrients (Johnston *et al.* 2009). Micronutrients are trace elements which are needed by the maize crop in small amounts and play an active role in the plant metabolic functions in shortage of which show deficiency symptoms and crop yields are reduced, they are therefore to be added into the soil before crop planting or applied directly to the crop to increase maize productivity (Adhikary *et al.* 2010).

Until 1980, deficiencies of three nutrients *viz.* N, P and K were identified in Bangladesh soils. In early 1980s, S and Zn deficiencies in rice are observed. In early 1980s, the B deficiencies of some crops are reported by Jahiruddin and Satter (2010). There is sporadic information of Cu, Mo and Mn deficiencies in crops (Ferdoush *et al.* 2003). Generally, micronutrient-deficient soils do not support optimum crop yields because plant growth becomes retarded by the deficiency, leading to low yields (Chude *et al.* 2004). Thus, the present research work was undertaken to examine the effect of different micronutrients on the yield and nutrient concentration of maize and to find out the requirement of one or more micronutrients for maximization of maize yield.

The experimental site falls under the Agro-ecological Zone 9 (Old Brahmaputra Floodplain) (UNDP and FAO 1988). Before land preparation, initial soil samples were collected at 0-15 cm

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depth. The physical and chemical properties of the collected soil samples were analyzed by using the method of Black (1965) for particle-size, Jackson (1962) for soil pH, Nelson and Sommers (1982) for organic carbon, Piper (1950) for organic matter, Bremner and Mulvaney (1982) for total N content in soil was determined by Kjeldahl method (Bremner and Mulvaney 1982), Olsen *et al.* (1954) for available P, Knudsen *et al.* (1982) for exchangeable K, Tabatabai (1982) for available S, Hunter (1984) for available B, and Lindsay and Norvell (1978) for available Zn, Fe, Mn and Cu.

Table 1. Chemical characteristics of soil of the experimental field.

Characteristics	Value	Interpretation
pH (soil : water =1 : 2.5)	6.36	Near neutral
Organic matter (%)	1.72	Low
Total N (%)	0.058	Very low
Available P (ppm)	9.62	Low
Available K (me/100g)	0.14	"
Available S (ppm)	5.67	"
Available Ca (me/100g)	7.89	Very high
Available Mg (me/100g)	2.28	"
Available Zn (ppm)	0.78	Low
Available B (ppm)	0.22	"
Available Cu (ppm)	2.98	Very high
Available Mn (ppm)	19.36	"
Available Fe (ppm)	86.31	"

Seeds of BARI Hybrid Maize 5 (BHM 5) were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. The treatments were: T_1 (control), T_2 (Zn), T_3 (Zn + B), T_4 (Zn + B + Cu), T_5 (Zn + B + Cu + Mn), T_6 (Zn + B + Cu + Mn + Fe), and T_7 (Zn + B + Cu + Mn + Fe + Mo). After uniform land preparation, the experiment was laid out in a RCBD with three replications. The size of each unit plot was 5m × 4m. The treatments were randomly distributed to the plots in each block. The rates of Zn, B, Cu, Mn, Fe and Mo were applied @ 3kg, 2, 2, 3, 5 and 1 kg/ha as ZnO, H_3BO_4, $CuSO_4$, $MnCl_2$, $FeSO_4$ and Na_2MO_4, respectively. All the plots received the basal application of N, P, K and S fertilizer at the rate of 190 kg N, 50 kg P, 90 kg K and 30 kg S/ha from urea, TSP, MoP and gypsum, respectively. The full amount of TSP, MoP, gypsum, ZnO, H_3BO_4, $CuSO_4$, $MnCl_2$, $FeSO_4$ and Na_2MO_4 were added during the final land preparation. In case of urea, one third urea was applied during the final land preparation and the rest two thirds was applied in two equal splits, one at 25 and 65 days after sowing (DAS). Seeds were sown in 75 cm distance between the rows by dibbling 3 cm to 4 cm deep furrow with country plough and two seeds were placed within the furrow for in 25 cm apart. After sowing the seeds were covered with soil. Weeding was done at 25, 45, and 65 DAS. Only one healthy seedling/hill was kept and the rest were thinned out at 40 DAS. The crop was irrigated twice during growth period. The first irrigation was done 25 DAS and second at 70 DAS. Earthing up was done at 60 DAS. Sixteen plants were randomly selected and marked from each plot for collecting data on yield and three plants for yield components. The crop was harvested plot-wise when they attained maturity. Data on the yield and yield components (plant height, cobs/plant, cobs length, cob diameter, seeds/cob, and 100-seed weight) were collected. Seeds and stalk from 16 randomly selected plants in each unit plot was sun dried and weighed to estimate the yield as t/ha. The grain and stalk samples were dried in an oven at 65°C for about 48 hrs and then ground by a grinding machine to pass through a 20-mesh sieve. Phosphorus, K, S, B, Zn, Cu, Mn and Fe were determined by nitric-perchloric acid digestion method (Yoshida *et al.* 1976). The N contents were measured following the Kjeldahl method (Bremner and Mulvane 1982). The ANOVA for various crop characters and also for nutrients concentrations and uptake were done following the principle of F-statistics. Mean comparisons of the treatments were made by the Duncan's Multiple Range Test (Gomez and Gomez 1984).

The effect of micronutrient application on plant height, number of seeds/cob and 100-seed weight of BARI Hybrid Maize 5 were statistically significant (Table 2). The tallest plant (262 cm) was recorded at T_2 (Zn) treatment which was statistically superior to over all other treatments and the shortest plant (227.8 cm) was recorded at T_1 (control) treatment. The addition of all other micronutrients with Zn reduced the plant height of maize. The second highest plant height was found in T_5 (Zn + B+ Cu + Mn). Similarly, a satisfactory effect of B and $ZnSO_4$ on maize plant growth was reported by Lisuma *et al.* (2006). Hossain *et al.* (2008) also observed that plant height of maize responded positively to Zn application to soil. The number of seeds/cob ranged from 323 in control treatment to 412 in T_2 treatment. The number of seeds/cob found in T_2 treatment was statistically superior to those found in all other treatments. The addition of other micronutrients (B, Cu, Mn, Fe and Mo) with Zn in different treatments reduces the number of seeds/cob of maize compared to T_2 (Zn). The addition of B with Zn (T_3) treatment significantly reduces the number of seeds/cob. The 100-seed weight ranged from 24.6 g in T_1 to 30.0 g in T_2 treatment. The 100-seed weight recorded in T_2 and T_7 (Zn + B + Cu + Mn + Fe + Mo) treatments were statistically identical. The addition of B, Cu, Mn, Fe and Mo to BARI Hybrid Maize 5 had negative effect on 100-seed weight. Hossain *et al.* (2008) observed that 100-seed weight of maize responded positively to Zn application to soil. The mutual use of Zn, Fe and Mn significantly enhanced seeds/cob and weight of corn seed (Hussain *et al.* 2011). Application of $ZnSO_4$, $MnSO_4$ and Cu increased 100 seed weight (Shabaan 2001).

The number of cobs/plant, cob length and cob diameter were not statistically significant by micronutrient application (Table 2). Numerically the highest value of cobs/plant (1.9), cob length (18.4 cm), and cob diameter (15.3cm) were recorded from T_2 (Zn) treatment and that of lowest (1.2, 16.5 cm and 14.1cm, respectively) were noticed from control.

The application of different micronutrients exerted significant effect on grain and stalk yield of maize (Table 2). The grain yield ranged from 6.7 t/ha in T_1 treatment to 10.1 t/ha in T_2 treatment. The highest grain yield of maize recorded in T_2 which was statistically higher to all other treatments. The addition of other micronutrients (B, Cu, Mn, Fe and Mo) with Zn had no beneficial effect on grain yield of maize. The grain yield obtained in T_3 (Zn + B), T_4 (Zn + B + Cu), T_5 (Zn + B + Cu + Mn), T_6 (Zn + B + Cu + Mn + Fe) and T_7 (Zn + B + Cu + Mn + Fe + Mo) treatments were statistically greater to T_1 control. The increase in grain yield of maize due to Zn application is expected because the status of available Zn in the experimental field was low (0.78 μg/g). Although the status of available B in the experimental field was low (0.22 μg/g) but the crop did not respond to B application. The status of available Cu, Mn and Fe in the soil was very high hence the crop did not respond to their application to soil. It was found that the production of corn enhanced by the use of the trace elements significantly (Jaroslaw 2007). Sharma *et al.* (1992) also observed that grain yield of maize increased by 11.4% with increasing Zn levels from 0 to 25 kg $ZnSO_4$ per hectare. The highest straw yield (12.3 t/ha) was also obtained from T_2 treatment which was significantly different over all other treatments and the lowest stalk yield (7.9 t/ha) was found at T_1 treatment. Stalk yield of other treatments were statistical similar. Hossain *et al.* (2008) reported significant straw yield response to Zn application. Significant influence of B and Zn on the dry matter production was also reported by Jahiruddin *et al.* (2001).

Table 2. Effect of micronutrients on grain yield components and yield of BARI Hybrid Maize 5.

Treatment	Plant height (cm)	Cobs/ plant (no.)	Cob length (cm)	Cob diam. (cm)	Seeds/ cob (no.)	100-seed weight (gm)	Grain yield (t/ha)	Stalk yield (t/ha)
T_1	227.9d	1.2	16.5	14.2	323f	24.6e	6.7c	7.9c
T_2	262.0a	1.9	18.4	15.3	413a	30.0a	10.1a	12.3a
T_3	251.4c	1.8	18.3	15.1	410b	29.1b	9.6b	11.4b
T_4	250.7c	1.8	16.6	15.2	395d	28.7c	9.4b	11.3b
T_5	256.7b	1.6	18.2	15.2	351e	27.7d	9.9b	11.4b
T_6	253.7c	1.8	18.1	14.9	394d	28.6c	9.4b	11.0b
T_7	252.0c	1.7	18.1	15.1	403c	29.6ab	9.7b	11.3b
SE (±)	5.343	0.181	0.491	0.253	7.982	0.9231	0.701	0.211
CV (%)	3.70	18.06	4.80	2.91	3.54	5.64	7.33	3.35
Significant level	*	NS	NS	NS	**	*	**	**

CV = Co-efficient variance, NS = Non significant, * = 5% level of significance, ** = 1% level of significance; SE = Standard error. In a column, means followed by the same letter are not significantly different.

Compared to control there was a significant positive effect of added micronutrients application on the grain-Zn, B, Mn and Fe content (Table 3). The highest concentration of grain-Zn (28.5 ppm) was found in T_5 (Zn + B + Cu + Mn) treatment which were statistically similar to all other treatments and significantly higher than T_1 (control) treatment. Tariq *et al.* (2014) narrated that Zn concentration in grains was significantly increased by the application of $ZnSO_4$. Foliar and soil application of zinc fertilizers seems to be an effective way of maximizing grain zinc concentration in maize (Johnson *et al.* 2005). The B concentration of maize grain ranged from 12.16 ppm in T_1 (control) treatment to 23.81 ppm in T_3 (Zn + B) treatment. The concentration of grain-B in T_3 treatment was significantly higher than all other treatments. The concentration of grain-B (20.15 ppm) obtained from T_4 and T_7 treatments were statistically similar. The highest value (16.48 ppm) of straw B was also found in T_3 treatment which was statistically higher from all other treatments. The lowest value (5.5 ppm) was found in T_1 treatment. Shaaban *et al.* (2004) reported that B concentration of plant increased with increasing B application. Other scientists also found that supplemented boron fertilizer increases plant's dry matter amount and boron concentration (Sezer 2014). The highest concentration of grain-Mn (92.4 ppm) found in T_7 treatment which was statistically similar to T_4, T_5 and T_6 treatments. The lowest value (80.3 ppm) found in T_3 which was similar to T_1 and T_2 treatments. The highest concentration of grain-Fe (11.0 ppm) found in T_7 treatment followed by T_6 treatment which was statistically superior to all other treatments. The lowest value (4.5 ppm) found in T_2 treatment which was similar to T_1 treatment. The concentration of grain-Fe found in T_3, T_4 and T_5 treatments were statistically identical. On the contrary, there was no significant effect of micronutrients on Cu concentration of maize grain and stalk (Table 3). The Cu concentration in maize grain ranged from 11.5 ppm in T_1 (control) treatment to 15.9 ppm in T_5 treatment. Grzebisz *et al.* (2008) reported that nutrient application is an easy and simple method for improvement of plant nutritional condition for maize and wheat.

Table 3. Effect of micronutrients on nutrient contents of maize grain.

Treatments	Zn (ppm)	B (ppm)	Cu (ppm)	Mn (ppm)	Fe (ppm)
T_1	19.0b	12.16 f	11.5	19.0b	5.0cd
T_2	25.5a	14.65e	12.5	25.5a	4.5d
T_3	26.0a	23.81a	12.2	26.0a	6.4bc
T_4	23.0a	20.15b	14.8	23.0a	7.1b
T_5	28.5a	16.49d	15.9	28.5a	6.8b
T_6	26.5a	18.31c	11.6	26.5a	11.0a
T_7	25.5a	20.15b	13.5	25.5a	11.0a
SE(±)	1.519	1.724	1.390	1.519	0.477
CV (%)	8.65	13.58	14.96	8.65	9.13
Significant level	*	**	NS	*	**

CV = Co-efficient variance; NS = Non significant, * = 5% level of significance = 1% level of significance; SE = Standard error. In a column, means followed by the same letter are not significantly different by least significant differences.

The yield and yield contributing characters of BARI Hybrid Maize 5 were increased when Zn was added to the soil. The other micronutrients did not show any beneficial effect on the grain yield of maize. It appears that cultivation of BARI Hybrid Maize 5 at Old Brahmaputra Floodplain soil needs Zn application along with recommended NPKS.

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