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RESPONSE OF WHEAT TO DIFFERENT MICRONUTRIENTS IN TISTA MEANDER FLOODPLAIN SOIL OF BANGLADESH

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ABSTRACT

Intensification of agricultural land use coupled with cultivation of modern varieties has remarkably increased in Bangladesh. This in turn has resulted in deterioration of soil fertility, with emergence of macro- and micro-nutrient deficiency of crops. With this point in view, a study was undertaken to evaluate the effect of different micronutrients on wheat. Experiments were conducted at BINA substationfarm (Site-A) and farmers' fields (Site-B) of Rangpur district with in AEZ 3. Field trials were done with six micronutrients (B, Zn, Cu, Mn, Fe and Mo), designed in an additive manner. The rates of Zn, B, Cu, Mn, Fe and Mo application were 3, 2, 2, 3, 5 and 1kg ha^{-1}, respectively. Other nutrients viz. N, P, K and S were applied at recommended rates to all plots. The results revealed that across the experimental sites, the crop was quite responsive to the added Zn and B. Positive effect of Cu and Mn was also noted. Fe and Mo did not show the quite positive responses to wheat in AEZ 3 of Bangladesh.

Key words: Micronutrients, wheat, Tista Meander Floodplain.

Introduction

Micronutrients are required for supporting normal growth and development of plants. If any element is lacking in the soil or not adequately balanced with other nutrients, growth suppression or even complete inhibition may result (Mengel *et al*., 2001). Micronutrients that are essential for crops include Fe, Mn, Zn, Cu, Mo, Co and B. Zinc and Fe have been identified as the most commonly deficient micronutrients in both human and crops. Zinc and iron deficiency is ranked as the 5^{th} and 6^{th} leading risk factors, respectively, among the ten leading cause of disease in humans, specifically in low-income countries (WHO, 2002). Indeed; micronutrient has received less attention in fertilizer management research. Micronutrient trials have been made principally on rice (Jahiruddin *et al*., 1994), wheat (Hossain, 2005) and maize (Hossain *et al*., 2008). Zinc deficiency is particularly evident in calcareous and wetland rice soils (Islam, 2008). Ryan and Moneim (2007) observed that Zn supplement increased seed yield as well as reduced toxin level of grasspea (*Lathyrus sativus*) and thus mitigating the problem of neurolathyrism. Although taken up in small quantities, boron deficiency may lead to serious consequences regarding economic yield of various crops. Light textured soils of the country are deficient in plant available boron where significant leaching loss of borate ions occurs. In Bangladesh, boron deficiency is more common in *Rabi* crops (dry season), as observed in wheat (Jahiruddin, 2011) and mustard (Hossain, 2007). Boron deficiency depresses wheat yield primarily through grain set failure, caused by male sterility which is associated with poorly developed pollen and anthers (Rerkasem and Jamjod, 2004). The most important functions of B in plants are thought to be its structural role in cell wall development and stimulation or inhibition of specific metabolism pathways (Ahmad *et al*., 2012). The available boron content of the major soils of Bangladesh varies between 0.1 and 1.9 $\mu g\ g^{-1}$. But most of the light textured soils of Rangpur, Dinajpur and terrace soils of Gazipur and hill soils of Srimangal contain low level of available B (0.1-0.3 μg B g^{-1}). Thus, a careful and judicious application of boron is essential. Iron deficiency is a common nutritional disorder in many crop plants, causing chlorosis, poor yields and reduced nutritional quality. Iron and Mn are involved in metabolic processes and these are considered activators of important enzymatic reactions (Mengal and Kirkby, 1987). Manganese deficiency is frequently associated with Zn deficiency (Zekri and Obreza, 2009). The rate of Cu uptake in plants is among the lowest of all essential elements and immobilized in the root part of the plants (Maiti and Jaiswal, 2008). Tista Meander Floodplains (AEZ 3) are moderately acidic throughout, low in organic matter content on the high land, but moderate in the low lands. Fertility level, in general, is low to medium but the status of K and CEC is medium in most of the places (Banglapedia, 2015). Agricultural productivity is directly linked to nutrient availability and its uptake. To sustain higher crop yields, application of nutrient deficient in soil is required. Sufficient fertility level of a soil can play a significant role in achieving higher crop yields. Research is needed to determine all the deficient elements, whether macronutrients or micronutrients. Fertilizer management is needed on sustainable basis. Keeping the above points in view, the present study was carried out to evaluate the effect of micronutrients application on the yield of wheat in Tista Meander Floodplain of Bangladesh.

Materials and Methods

Experiments on wheat (BARI Gom 25) were conducted in two sites BINA sub-station farm (Tajhat, Rangpur sadar): site-A & farmer's field (Village- Shabajpur, Union– Lahirirhat, UZ- Rangpur sadar): site-B at Rangpur sadar during 2011-12 to evaluate the effects of different micronutrients on wheat. The soil characteristics of the experimental sites are given in Table 1. The experiments were laid out in a Randomized Complete Block Design (RCBD). There were seven treatments with six micronutrients, as follows: T_1: Control (No use of micronutrients), T_2: Zn, T_3: Zn + B, T_4: Zn + B + Cu, T_5: Zn + B + Cu + Mn and T_6: Zn + B + Cu + Mn + Fe. The rates of micronutrients were 3 kg Zn, 2 kg B, 2 kg Cu, 3 kg Mn, 5 kg Fe and 1kg Mo ha^{-1}. The elements were added as $ZnSO_4.7H_2O$, H_3BO_3, $CuSO_4.5H_2O$, $MnCl_2$, $FeSO_4.7H_2O$ and Na_2MoO_4, respectively. Other nutrients viz. N, P, K & S were used @ N:P:K:S=100:20:60:10 for all plots. The unit plot size was 5 m x 3 m having inter-plot distance 0.30 m and inter-block distance 0.75 m. Wheat seed (cv. BARI Gom-25) was sown continuously along the furrow with a line to line distance of 20cm. Seeds were sown on 19 November of 2011 in Site-A and 21 November in Site-B @120 $kgha^{-1}$. Intercultural operations (earthing up, weeding, irrigation, insecticide & fungicide spray etc.) were done as and when required for the crops. The crops were harvested at maturity. Plot-wise grain/straw yield were recorded. The grain yield was adjusted to 14% moisture content. The straw yield was recorded on sun-dry basis. Data on the growth and yield attributes were recorded from 10 randomly selected representative plants or hills for all the crops from outside the harvested area within a plot. Plant data were subjected to statistical analysis by computer based statistical program Mstat-C (Michigan State University, East Lansing, MI, USA) following the basic principles, as outlined by Gomez and Gomez (1984). Significant effects of treatments were determined by analysis of variance (ANOVA) and treatment means were compared at 5% level of significance by Duncan's Multiple Range Test (DMRT).

Table 1. Chemical properties of the experimental sites

Experimental site	pH	OM (%)	Total N (%)	Ex. K (cmol kg^{-1})	P	S	Zn	B	Cu	Mn	Fe
					($\mu g\ g^{-1}$)						
Site-A	5.28	0.83	0.04	0.13	30.40	23.05	0.80	0.17	2.47	27.10	47.60
Site-B	4.85	1.03	0.054	0.14	30.5	35.6	1.21	0.17	3.04	57.0	114.7

Results and Discussion

Crop response study is needed to confirm the soil test results. In the present study, effects of Fe, Mn, Cu, Zn, Mo and B application on the yield of crops were investigated.

Yield attributes of wheat: The yield of crop is the result of combined effect of various yield contributing attributes. Plant height was significantly affected by the treatments. The height of plant ranged from 91.61-95.65 cm and 87.04 - 91.36 cm across the treatments at site-A and site-B, respectively. Stunted plant growth was recorded by T_4 (Zn+B+Cu) treatment in both locations. The 1000-grain weight of wheat did not vary significantly with the treatments, showing a range from 49.4-52.1 g and 43.2-47.4 g in site-A and site-B, respectively (Tables 2-3). The number of fertile tillers in wheat is more important instead of total number of tillers because the increase in yield is determined by the increase in fertile tillers. In BINA substation

(Site-A), the number of fertile tillers m^{-2} significantly varied showing a range of 253-276 tillers m^{-2} and in farmer's field it ranged from 229.6-280.3 tiller m^{-2}. The maximum numbers of tillers were noted in T_3 (Zn+B) which corresponded to the maximum grain yield at substation farm (Tables 2-3).

Table 2. Effects of micronutrients on the growth and yield attributes of wheat at BINA Substation farm (Siet-A)

Treatments	Plant height (cm)	Tillers $hill^{-1}$	Tillers m^{-2}	Spike length (cm)	Spikelets $spike^{-1}$	Grains $spike^{-1}$
T_1: Control	95.65a	4.13bc	259bcd	10.19c	16.72c	38.96c
T_2: Zn	95.36a	4.97a	271abc	10.42bc	17.52b	40.83b
T_3: Zn+B	92.38d	5.00a	276a	11.03a	17.29b	40.28b
T_4: Zn+B+Cu	91.61e	4.40abc	273ab	10.15c	17.44b	39.29c
T_5: Zn+B+Cu+Mn	93.90c	4.70ab	261a-d	10.75ab	18.24a	42.49a
T_6: Zn+B+Cu+Mn+Fe	92.64d	4.7ab	253d	10.38bc	17.21bc	41.09b
T_7:Zn+B+Cu+Mn+Fe+Mo	94.78b	4.03c	255cd	10.35bc	16.72c	38.95c
CV	0.31	6.89	3.29	2.72	1.70	1.37
F test	**	*	*	*	**	**

Table 3. Effects of micronutrients on the growth and yield attributes of wheat at Farmer's field (Site-B)

Treatments	Plant height (cm)	Tillers $hill^{-1}$	Tillers m^{-2}	Spike length (cm)	Spikelets $spike^{-1}$	Grains $spike^{-1}$
T_1: Control	91.36a	3.67	229.6	9.89	15.48e	37.77d
T_2: Zn	89.13b	4.33	234.6	10.97	16.64abc	39.61bc
T_3: Zn+B	87.81c	4.33	249.0	10.45	16.21cd	39.39bc
T_4: Zn+B+Cu	87.04c	4.10	253.0	10.34	16.25bcd	38.52cd
T_5: Zn+B+Cu+Mn	89.56b	4.20	262.3	10.18	17.02a	41.36a
T_6: Zn+B+Cu+Mn+Fe	89.79b	3.93	262.3	10.62	16.67ab	40.51ab
T_7:Zn+B+Cu+Mn+Fe+Mo	90.3ab	3.87	280.3	10.27	16.09d	39.1bcd
CV	0.81	6.59	2.04	3.70	1.46	1.90
F test	**	NS	NS	NS	**	**

In a column, the figures having same letter(s) do not differ significantly at 5% level probability by DMRT. NS = Not significant. CV= Coefficient of variation.

Spikelet length was the maximum (11.03 cm) in T_3 (Zn+B) at site-A, and was the minimum (10.2 cm) in T_1 (control). Treatment effect on spike length was insignificant at the site-B (Tables 2-3). The number of spikelets $spike^{-1}$ had a major contribution to the grain yield of the crop. The number of spikelets $spike^{-1}$ significantly ranged from 16.7-18.24 and 15.48-17.02 over the treatments at site-A and site-B, respectively. The highest number of spikelets $spike^{-1}$ (18.2 and 17.0) was observed in T_5 (Zn+B+Cu+Mn) treatment in both locations. The control treatment (T_1) showed the minimum spikelets $spike^{-1}$. Micronutrients application had significant influence on the number of grains $spike^{-1}$. It ranged from 39.29-42.49 and 37.77-41.36, the maximum number of grains $spike^{-1}$ was observed in T_5 (Zn+B+Cu+Mn) treatment in site-A and site-B, respectively. The control (T_1) exhibited the minimum number of grains $spike^{-1}$ (Tables 2-3).

Grain yield of wheat: The grain yield was significantly influenced by different treatments in both locations (Table 4). In site-A, the grain yield varied from 4.11-4.81 tha^{-1} over the treatments. The maximum yield (4.8tha^{-1}) was observed with the T_3 treatment (Zn+B) which was followed by other treatments except control. This result correlated well with low soil test value of Zn (0.78 µg g^{-1}) and B (0.15 µg g^{-1}) which was at deficient level. In the farmer's field (Site-B), the grain yield ranged from 3.61-4.61 tha^{-1} across the treatments. The highest grain yield (4.61tha^{-1}) was recorded with the T_7 treatment. The results further demonstrated that the grain yields over T_3-T_7 treatments were statistically similar indicating that the grain yield responded significantly only to Zn+B treatment. The lowest grain yield (3.61 t ha^{-1}) was noted in T_1 (control) treatment which did not receive any micronutrient. The grain yield benefits due to application of micronutrients 8.3-17.0 % increase over control in site-A and 11.6-27.7% increase in site-B (Fig.1).

Table 4. Effects of micronutrients on the grain and straw yields of wheat

Treatments	BINA Sub-station farm (Site-A)		Farmer's field (Site-B)	
	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1: Control	4.11c	5.66c	3.61c	4.94c
T_2: Zn	4.65ab	6.43ab	4.03b	5.52b
T_3: Zn+B	4.81a	6.66a	4.32a	5.93ab
T_4: Zn+B+Cu	4.63ab	6.40ab	4.39a	6.03a
T_5: Zn+B+Cu+Mn	4.50b	6.23b	4.46a	6.13a
T_6:Zn+B+Cu+Mn+Fe	4.57ab	6.33ab	4.60a	6.32a
T_7:Zn+B+Cu+Mn+Fe+Mo	4.45b	6.15b	4.61a	6.32a
CV (%)	3.53	2.98	3.70	3.94
F test	**	**	**	**

Means followed by same letter in a column are not significantly different at 5 % level by DMRT; CV= Coefficient of variation, **= Significant at 1% level

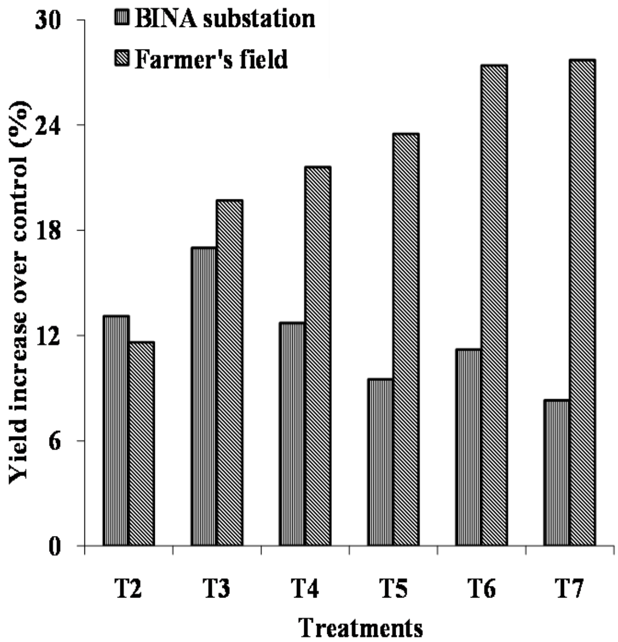

Fig. 1 Percent grain yield increase of wheat due to micronutrients application over control

Straw yield of wheat: The straw yield of wheat was found to vary from 5.66-6.66 tha^{-1} at BINA sub-station and 4.94-6.32 tha^{-1} at farmer's field. Like grain yield, the highest straw yield (6.66 t ha^{-1}) was observed in T_3 treatment (Zn+B) followed by other treatments at Site-A. In the farmer's field (Site-B), the equal and maximum straw yield (6.32tha^{-1}) was obtained in T_6 and T_7 treatments showing T_4-T_7 treatments were statistically alike. The lowest straw yield was recorded by T_1 (control) treatment receiving no micronutrients in both locations (Table 4).

Regarding effects of different micronutrients, it appeared that there was a significant positive effect of micronutrient application on the grain yield of wheat. At both locations, the effect of Zn was pronounced and next to Zn, the effect of B was remarkable. There are many reports on the positive response of B in Bangladesh for wheat (Jahiruddin, 2011). Ahmad *et al*. (2012) in an extensive review observed an increase in yield of 14% in wheat with B fertilization by using appropriate rates, methods and sources on B-deficient soils. Khanom (2013) observed B application at 1.5 kg ha^{-1} to the 1st crop can meet up their requirement for the subsequent crops in a pattern. In farmer's field, though soil available status was high, positive effect of Cu and Mn was also found in wheat. As evidenced in site-A trial, among the micronutrients used, the Zn effect was very positive and significant. In both locations, the lowest yield was recorded with micronutrient control treatment. Islam (2008) stated that other micronutrients like Fe, Mn, Cu, Mo and Cl have attracted less attention in Bangladesh agriculture. Generally they are seldom needed to be applied in crop production in most soils. Copper and Mn application in calcareous soils have performed to be beneficial for higher yield in some field trials.

The field experiments showed a clear response of crops to Zn and B application. Crop response to Zn supplement was higher than that to B supplement indicating that Zn was more deficient than B in soils.

Conclusion

Intensification of agricultural land use has increased remarkably, along with increasing use of modern crop varieties, which in turn have resulted in deterioration of soil fertility. Significant positive effect of Zn and B application is noticed in wheat. Though soil available status is high, there is an indication of Cu and Mn deficiency in wheat. Therefore, field trials with Zn, B, Cu and Mn need to be initiated at farm level in the high cropping intensity area.

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