

OPTIMIZING ZINC AND BORON REQUIREMENTS FOR THE T. AMAN - BORO RICE CROPPING PATTERN

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ABSTRACT

The intensification of agricultural land use, along with the cultivation of modern crop varieties, has witnessed a significant upswing in Bangladesh. Unfortunately, this surge has taken a toll on soil fertility, leading to the emergence of deficiencies in both macro- and micro-nutrients for crops. In light of these concerns, a study was conducted to assess the impact of applying zinc (Zn) and boron (B) on the yield of T. Aman and boro rice while determining the optimal Zn and B application rates for the T. Aman - boro cropping pattern in AEZ 9. Soil samples from the experimental site were collected and subjected to analysis for fundamental soil properties, including pH and organic matter content, macronutrients such as nitrogen (N), phosphorus (P), potassium (K), and sulfur (S), as well as micronutrients like Zn and B. All analyses were conducted in accordance with established standard methods. For T. Aman, there were four treatments, denoted as (T₁: Zn₀B₀, T₂: Zn₂B_{1.5}, T₃: Zn₄B₂, and T₄: Zn₆B₃), while six treatments were applied to Boro rice, named T_{1.1} (Zn₀B₀), T_{2.1} (Zn₂B₂), T_{2.2} (Zn₀B₀), T_{3.1} (Zn₄B₂), T_{3.2} (Zn₀B₀) and T_{4.1} (Zn₀B₀), with subscripts indicating the application rate in kg per hectare. Each treatment was replicated three times, and consistent rates of nitrogen, phosphorus, potassium, and sulfur were applied to all plots. Zn and B treatments were imposed during both the first and second crop cycles, as indicated above, with Zn being supplied as ZnSO₄ and B as H₃BO₃. The results indicate that applying Zn @4 kg ha⁻¹ and B @ 2 kg ha⁻¹ to the first crop, or Zn@2 kg ha⁻¹ and B @2 kg ha⁻¹ for both the first and second rice crops, can yield the highest grain production in the rice-rice cropping pattern.

Key words: Zn and B requirements, T. aman, Boro rice.

Introduction

Soil is the greatest resource of Bangladesh. Over the last 2-3 decades, enormous pressure has been exerted on the soil resource to produce more food for its population. Intensification of agricultural land use has increased remarkably and the cropping intensity has increased from 143% in 1971-72 to about 191% in 2014-2015 (Krishi Diary, 2016). In addition, cultivation of high yielding varieties for all crops has increased remarkably. Consequently, this has resulted in deterioration of soil fertility with emergence of micronutrient deficiency. In this country, chronologically N, P, K, S, Zn and B deficiencies have appeared in soils and crops of Bangladesh (Islam, 2008). Among the micronutrients, next to zinc, boron deficiency is prominent in soils of Dinajpur, Rangpur, Bogra, Sirajganj, Mymensingh, Comilla and Sylhet district (SRDI, 2010). 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 determine the requirement of selected micronutrients (Zn and B) for crops and cropping pattern (T. Aman-Boro) in the Old Bhahmaputra Floodplain (AEZ 9) soil at BINA farm. The bench line survey indicated that the zinc (Zn) and boron (B) status of soils was 'low'. In year-1, the field trials were done with four treatments for T. Aman and six treatments for Boro rice. Two micronutrients, Zn and B were taken into the experiment and designed in a way to determine whether 1-crop and/or 2-crop application is necessary to achieve satisfactory crop yield. Zinc and B application were added as fertilizers such as ZnSO₄ and H₃BO₃, respectively. Other nutrients viz. N, P, K and S were applied at recommended rates to all plots. Research is needed to determine all the deficient elements, whether macronutrients or micronutrients. Fertilizer management is needed on sustainable basis. Fertility management systems that profitable for short-term and sustainable for long-term should be formulated and it needs to be confirmed by on-farm research trials. Keeping the above points in view, the present study was carried out to achieve the following

objectives: i) to evaluate the effect of Zn and B application on the yield of T. *Aman* and boro rice and ii) to find out the optimum rate of micronutrients for the T. *Aman*-boro cropping pattern in AEZ 9 of Bangladesh.

Materials and Methods

For T. *Aman*-Boro rice cropping pattern experiment soil samples were collected and analyzed for some basic properties, macronutrients and micronutrients. The basic properties of soils included pH and organic matter contents, macronutrients included N, P, K, S contents and micronutrients included Zn and B contents. All analysis was done following standard methods. The results are presented in Table 1.

Table 1. Characteristics of initial soil in the experimental field at BINA farm Mymensingh

Properties	Value	Interpretation class
Sand (%)	27.06	
Silt (%)	63.3	Silt loam
Clay (%)	9.64	
pH	6.5	Slightly acidic
OM (%)	1.57	Medium
Total N (%)	0.098	Low
Available P (mg kg ⁻¹ soil)	13	Low
Exchangeable K (meq 100 g ⁻¹ soil)	0.10	Low
Available S (mg kg ⁻¹ soil)	12.1	Low
Available Zn (mg kg ⁻¹ soil)	0.82	Low
Available B (mg kg ⁻¹ soil)	0.23	Low

There were for treatments for the T. *Aman* (1st crop) (T₁: Zn₀B₀, T₂: Zn₂B_{1.5}, T₃: Zn₄B₂, T₄: Zn₆B₃, and six treatments for Boro rice (2nd crop) T_{1,1} (Zn₀B₀), T_{2,1} (Zn₂B₂), T_{2,2} (Zn₀B₀), T_{3,1} (Zn₄B₂), T_{3,2} (Zn₀B₀), T_{4,1} (Zn₀B₀). Subscripts of Zn and B represent kg ha⁻¹. Each treatment replicated three times. Six plots were prepared in each block. Nitrogen, P, K, S were recommended and equal rates for all plots. The Zn-B treatments were imposed on the first and second crop, as shown above. The Zn was added as ZnSO₄ and B was as H₃BO₃. After completion of 1-year crop cycle, effects of Zn and B on the yield of crops are presented. The objective is to see the direct and residual effects of Zn and B on crops as to determine the requirement of Zn and B for the cropping pattern.

Results and Discussion

Grain yield of T. *Aman* rice: Significant effect of Zn-B treatments on the grain yield of T. *Aman* (var. Binadhan-20) was recorded from the the 1st crop in 1-year crop cycle (Table 2). The grain yield varied from 4.67 to 4.92 t ha⁻¹ across the treatments. The maximum grain yield was observed (4.92 t ha⁻¹) in T₃ treatment. Looking at the effects of Zn-B treatments on the 1st crop (T. *Aman* rice) appeared that the Zn application at Zn at 4 kg ha⁻¹ and B at 2 kg ha⁻¹ to the first crop showed superior yield performances of T. *Aman*rice. The control treatment having no Zn-B had the lowest yield (4.67 t ha⁻¹).

Straw yield of T. *Aman* rice: The straw yield of T. *Aman* rice (Binadhan-20) was also significantly influenced by the Zn-B treatments. The straw yield ranged from 5.37 t ha⁻¹ by control to 6.62 t ha⁻¹ by T₃ treatment. Treatment T₃ performed the maximum straw yield (5.62 t ha⁻¹) indicating superior straw yield. Applications of recommended rate of macronutrients with no micronutrient addition (control) showed the minimum straw yield (5.37 t ha⁻¹) of rice (Table 2).

Grain yield of Boro rice: There was a significant and positive effect of Zn-B application on the grain yield of Boro rice (Binadhan-25). The grain yield ranged from 6.12 -7.29 t ha⁻¹ (Table 3). The maximum grain yield (7.29 t ha⁻¹) was observed in T_{3,2} (Zn₀B₀) treatment indicating that when the first crop (T. *Aman*) received Zn at 4 kg ha⁻¹ and B at 2 kg ha⁻¹ to T. *Aman* there was no need to supply further Zn+B to the

second crop (boro rice). Treatment T_{2.1} (Zn₂B₂) (Zn 2 kg ha⁻¹ and B 2 kg ha⁻¹ to the 1st crop, T. Aman and again Zn 2 kg ha⁻¹ and B 2 kg ha⁻¹ to the 2nd crop, 7.21 t ha⁻¹), T_{3.1} (Zn₂B₂) (Zn at 4 kg ha⁻¹ and B at 2 kg ha⁻¹ to the 1st crop, T. Aman and again Zn 2 kg and B at 2 ha⁻¹ to the 2nd crop, 7.53 t ha⁻¹), and T₄ (Zn₆B₃) (Zn 6 kg ha⁻¹ and B 3 kg ha⁻¹ to the 1st crop, 7.42 t ha⁻¹) were found statistically identical yield. The significant influence of the treatments established a residual effect of the Zn-B on the following crop.

Straw yield of Boro rice: The straw yield of boro rice was significantly influenced by the residual and renewal application of Zn-B treatments ranging from 6.40-7.66 t ha⁻¹ (Table 3). The T_{2.1} (Zn₂B₂) (Zn at 2 kg ha⁻¹ and B at 2 kg ha⁻¹ and again Zn at 2 kg ha⁻¹ and B at 2 kg ha⁻¹ to T. Aman, 7.66 t ha⁻¹) treatment gave the maximum straw yield followed by treatment T_{3.1} (Zn₂B₂) (Zn 4 kg ha⁻¹ and B at 2 kg ha⁻¹ to the 1st crop and again 2 kg ha⁻¹ Zn and 2 kg ha⁻¹ to the 2nd crop, boro rice, 7.63 t ha⁻¹), T_{4.1} (Zn₆B₃) (Zn at 6 kg ha⁻¹ and B at 3 kg ha⁻¹ to the 1st crop and again no need to supply Zn+B to 2nd crop, 7.51 t ha⁻¹) over control T_{1.1} (Zn₀B₀). Application of recommended rates of macronutrients with no micronutrient addition T_{1.1} (Zn₀B₀), control showed the minimum straw yield (6.40 t ha⁻¹).

Table 2. Effect of Zn and B on the yield of T. Aman rice (Binadhan-20) as 1st crop in T. Aman - Boro cropping pattern

Treatment	Plant height	Panicle length	Tiller/hill	Seed/Panicle	1000 seed wt. (gm)	Grain yield (t/ha)	Straw yield (t/ha)
T ₁ (Zn ₀ B ₀)	115.23b	24.93b	9.4b	82.73	25.81	4.67b	5.37b
T ₂ (Zn ₂ B ₂)	116.1ab	25.33a	10.2ab	88.66	25.97	4.72b	6.41a
T ₃ (Zn ₄ B ₂)	117.13a	25.36a	10.67a	93.26	26.62	4.92a	6.62a
T ₄ (Zn ₆ B ₃)	116.47a	25.33a	10.59a	87.73	26.13	4.90a	6.61a
Level of significance	*	*	*	NS	NS	*	*
CV	0.45	3.10	2.08	2.09	1.30	2.43	4.89

Table 3. Effects of residual and renewed application of Zn and B on the yield of Boro rice (Binadhan-25) as 2nd crop in the T. Aman - Boro cropping pattern

1 st crop Treatment	Treatment for Boro rice	Plant height (cm)	Panicle length	Tiller/hill	Seed/Panicle	1000 seed wt. (gm)	Grain yield (t/ha)	Straw yield (t/ha)
T ₁ (Zn ₀ B ₀)	T _{1.1} (Zn ₀ B ₀)	113.1	25.3b	9.2	171b	20.40	6.12b	6.40b
T ₂ (Zn ₂ B ₂)	T _{2.1} (Zn ₂ B ₂)	115.1	26.3ab	10.5	214a	20.54	7.21a	7.66a
	T _{2.2} (Zn ₀ B ₀)	116.2	26.6ab	9.9	214a	20.18	7.02ab	7.27ab
T ₃ (Zn ₄ B ₂)	T _{3.1} (Zn ₂ B ₂)	116.6	27.9a	10.5	215a	20.42	7.53a	7.63a
	T _{3.2} (Zn ₀ B ₀)	115.1	27.4a	10.4	210a	20.45	7.29a	7.46ab
T ₄ (Zn ₆ B ₃)	T _{4.1} (Zn ₀ B ₀)	116.1	27.0ab	10.5	205a	20.12	7.42a	7.51a
Level of significance		NS	*	NS	*	NS	*	*
CV		2.73	2.34	1.33	5.40	3.11	5.40	5.15

T₁-T₄ = Treatments; subscripts of Zn & B represent kg ha⁻¹

T_{1.1} - T_{4.1} = Treatments; subscripts of Zn & B represent kg ha⁻¹

Means followed by same letter in a column are not significantly different at 5 % level by DMRT.

NS = Non significant, CV= Coefficient of variation, *= Significant at 5% level

The significance of Zn in crop nutrients has received large interest throughout 1980s in Bangladesh. Zinc deficiency is particularly glaring in calcareous and wetland rice soils (SRDI, 2008; Islam, 2008). The critical level of Zn in rice plant tissue is generally considered as 20 µg g⁻¹ (Islam, 2008). Zinc deficiency in vegetation reduces not best the crop yield, however also hampers dietary nice (Cakmak, 2008). Zinc allows protein synthesis (Marschner, 1995). Ryan and Moneim (2007) found that

Zn complement increased seed yield as well as decreased toxin degree of grasspea (*Lathyrus sativus*). Welch (1993) said that about 50% of worldwide soils have Zn deficiency, and high share of cereal-based ingredients with low tiers of Zn inside the eating regimen may be a prime aspect for good sized prevalence of Zn deficiency in human. Despite the fact that taken up in small portions, boron deficiency may additionally result in severe outcomes regarding economic yield of various crops. Light textured soils of the country are deficient in plant to be had boron wherein massive leaching lack of borate ions takes place. Deficiency of each Zn and B normally occurs in excessive pH and light textured soils. Gupta (1979) states that due to non-ionic nature, boron is once released from soils it may be leached out from soils pretty unexpectedly. In Bangladesh, boron deficiency is extra commonplace in rabi crops (dry season), as found in wheat (Jahiruddin, 2011) and mustard (Hossain, 2007).

Conclusion/Recommendation

The study provides valuable insights into optimizing Zn and B application for enhancing rice production in AEZ 9, where soil fertility is threatened by intensified agriculture. This information can assist farmers and agricultural practitioners in making informed decisions to improve crop yields and address nutrient deficiencies in the region.

For the two rice cropping pattern system (Binadhan-20 and Binadhan-25), Zn @ 4 kg ha⁻¹ and B application @ 2 kg ha⁻¹ to the first crop or, Zn @ 2 kg ha⁻¹ and B application @ 2 kg ha⁻¹ to the first and again in the second rice crop can give maximum grain yield in rice - rice cropping pattern.

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