Effect of Zinc, Boron and Molybdenum Application on the Yield and Nutrient Uptake by BRRI Dhan 30

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Abstract: A field experiment was conducted to observe the effect of micronutrients (Zn, B and Mo) fertilization on the growth, yield, and nutrient uptake by Transplanted aman rice (CV. BRRI Dhan-30). The experiment was laid out with eight fertilizer treatments control, Zn, B, Mo, Zn + B, Zn + Mo, B + Mo and Zn + B + Mo. Rate of Zn was 5 kg ha\(^{-1}\), B 3 kg ha\(^{-1}\) and Mo 2 kg ha\(^{-1}\) from zinc sulphate, boric acid and ammonium molybdate, respectively. There was a significant positive effect of micronutrients on the yield of T. aman rice. The highest grain yield (4.8 t ha\(^{-1}\)) was obtained in the treatment where all the 3 micronutrients were applied. The individual effect of B and Zn was quite pronounced with respect to grain yield of the crop.

Keywords: Zinc, boron, molybdenum, yield, BRRI Dhan 30

Introduction
Fertilizers are indispensable for the crop production system of modern agriculture. Today inorganic fertilizers, hold the key to success for increased crop productivity under Bangladesh agriculture, being responsible for about 60% of the total production (PRG, 1987). In past, only three primary nutrients viz. N, P and K along with one secondary nutrient S are commonly used in Bangladesh. The importance of micronutrient nutrition of crops was almost overlooked. However, some micronutrients are essential plant nutrients and play a significant role in crop nutrition which finally leads to healthy growth and increased yield. Need for micronutrient fertilization in soil is increasing, yet the proportion of different fertilizer used in the country is quite balanced. Nitrogen alone constitutes about 80% of the total nutrients used in country (PRG, 1997) which only can help not to improve crop productivity unless other limiting nutrients are supplemented along with nitrogen.

In Bangladesh, nutrient stress on soils are progressively increasing due to high cropping intensity with high yielding crops. Besides, there are many soil reactions that immobilize the plant nutrients in soil and thus restrict their availability to plant. Zinc deficiencies are widely spread throughout the world, especially in the rice lands of Asia and deficiencies occur in neutral and calcareous soils (Tisdale et al., 1997). Deficiency of micronutrients with an emphasis to zinc in particular, has been reported in wetland rice soils of Bangladesh and spectacular response by application of 6 kg Zn ha\(^{-1}\) have been recorded (Rahman et al., 1978). It was reported that about 2.0 M ha\(^{-1}\) of agricultural land is zinc deficient under different agroecological zones (AEZ) of Bangladesh. Zinc is essential for numerous enzyme systems and is capable of forming many stable bonds with N and S ligands.

Boron deficiency is reported on some soils and crops (Jahiruddin et al., 1993, 1995; Mondal et al., 1992 and Islam et al., 1997). Boron deficiency may induce grain sterility in rice (Ambak and Tandano, 1991). Approximately 1 M ha of cultivable land in Bangladesh is suspected to have B deficiency problem (Ahmed and Hossain, 1997).

It was reported that molybdenum deficiency is usually common in acid sandy soils having pH < 5.5 where leaching losses, strong molybdate adsorption and low molybdenum minerals occur (Mengel and Kirkby, 1987). Soils high in metal oxides (Fe,Al,Fe) have low Mo availabilities (Miller and Donahue, 1997). Response of rice and mungbean to Mo application have been reported in the Brahmaputra floodplain soils of Bangladesh (Ahmed, 1982). Higher crop yields naturally have higher requirement of nutrients due to more pressure on the land for available forms of nutrients. Thus, the investigation was undertaken with a view to assess the effect of zinc, boron and molybdenum application on the yield and their uptake by BRRI Dhan 30 (Oryza sativa) for increased sustainable yield.

Materials and Methods
The experiment was conducted on non-calcareous Dark Grey Roodplain soil of Brahmaputra alluvium (Haplaquept) at Bangladesh Agricultural University (BAU) Farm, Mymensingh during July to December, 1998. The important physico-chemical characteristics of the experimental soils are presented in Table 1. The experiment was laid out in a Randomized Complete Block Design having eight treatments. The treatments were as (1) control, (2) Zn, (3) B, (4) Mo, (5) Zn + B, (6) Zn + Mo, (7) B + Mo and (8) Zn + B + Mo. The rate of Zn was 5 kg ha\(^{-1}\), B 3 kg ha\(^{-1}\) and Mo 2 kg ha\(^{-1}\) from zinc sulphate, boric acid and ammonium molybdate, respectively. A blanket doses of 75 kg N ha\(^{-1}\), 15 kg P ha\(^{-1}\), 25 kg K ha\(^{-1}\) and 30 kg S ha\(^{-1}\) from urea, triple super phosphate, muriate of potash and gypsum, respectively, were applied in every plots. The full doses of triple super phosphate, muriate of potash, gypsum, zinc sulphate, boron acid and ammonium molybdate were applied at the time of final land preparation. Urea was applied in three equal splits. The first split was added during final land preparation, the second split after 4 weeks of transplanting at tillering stage and the final split before panicle initiation stage of crop growth. 30 days old seedlings of BRRI Dhan-30 were transplanted in the experimental plots and were harvested at maturity. 10 plants were randomly collected from each plot before harvesting to record the data on yield contributing parameters. Grain and straw yields were recorded plot wise. The plant samples were oven dried at 65°C for 48 h and ground. Plant samples were chemically analyzed to determine N, P, K, S, Ca, Mg, Zn and B contents following standard analytical methods (Page, et al., 1989; Hunter, 1984).

Results and Discussion
Grain yield responded significantly to the application of micronutrients treatments (Table 2). The treatment containing Zn, B and Mo together produced the highest grain yield (4.79 t ha\(^{-1}\)).
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Table 1: Important physico-chemical characteristics of the experimental soil

<table>
<thead>
<tr>
<th>Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand (%)</td>
<td>25.0</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>65.0</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>10.0</td>
</tr>
<tr>
<td>pH (Soil: Water = 1:25)</td>
<td>7.20</td>
</tr>
<tr>
<td>Organic Matter (%)</td>
<td>1.37</td>
</tr>
<tr>
<td>Total N (%)</td>
<td>0.08</td>
</tr>
<tr>
<td>Available P (mg kg⁻¹)</td>
<td>12.8</td>
</tr>
<tr>
<td>Exchangeable K (meq 100g⁻¹ soil)</td>
<td>0.08</td>
</tr>
<tr>
<td>Exchangeable Ca (meq 100g⁻¹ soil)</td>
<td>6.30</td>
</tr>
<tr>
<td>Exchangeable Mg (meq 100g⁻¹ soil)</td>
<td>2.32</td>
</tr>
<tr>
<td>Available S (mg kg⁻¹)</td>
<td>17.5</td>
</tr>
<tr>
<td>Available Zn (mg kg⁻¹)</td>
<td>1.01</td>
</tr>
<tr>
<td>Available B (mg kg⁻¹)</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 2: Effect of micronutrients on yield and yield components of BRRI DHAN-30 as influenced by different treatments

| Treatments       | Grain yield (t ha⁻¹) | Straw yield (t ha⁻¹) | Plant height (cm) | Panicle length (cm) | 1000 grain wt (g) | Filled grain (%)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ (Control)</td>
<td>3.80f</td>
<td>5.10d</td>
<td>104d</td>
<td>20.47c</td>
<td>21.76c</td>
<td>75.63b</td>
</tr>
<tr>
<td>T₂ (Zn)</td>
<td>4.4b</td>
<td>6.09e</td>
<td>112c</td>
<td>23.96b</td>
<td>22.91b</td>
<td>87.37a</td>
</tr>
<tr>
<td>T₃ (B)</td>
<td>4.43d</td>
<td>6.27c</td>
<td>119c</td>
<td>23.37b</td>
<td>23.94c</td>
<td>89.32c</td>
</tr>
<tr>
<td>T₄ (Mo)</td>
<td>4.34d</td>
<td>6.10c</td>
<td>118c</td>
<td>23.83b</td>
<td>23.93c</td>
<td>89.45c</td>
</tr>
<tr>
<td>T₅ (Zn+Mo)</td>
<td>4.74d</td>
<td>6.50e</td>
<td>120b</td>
<td>24.3b</td>
<td>23.97b</td>
<td>89.06b</td>
</tr>
<tr>
<td>T₆ (Zn+Mo+B)</td>
<td>4.60d</td>
<td>6.30c</td>
<td>117c</td>
<td>22.80b</td>
<td>23.03b</td>
<td>89.37c</td>
</tr>
<tr>
<td>T₇ (Zn+Mo+B+N)</td>
<td>4.75a</td>
<td>7.07a</td>
<td>122a</td>
<td>24.4a</td>
<td>25.5a</td>
<td>92.52c</td>
</tr>
</tbody>
</table>

The figures having common letter in a column are not significantly different by DMRT at 5% level.

Table 3: Nutrient uptake (kg ha⁻¹) by BRRI DHAN 30 (grain + straw) rice as affected by different treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N</th>
<th>P</th>
<th>S</th>
<th>Ca</th>
<th>Mg</th>
<th>Zn</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁</td>
<td>86.48b</td>
<td>10.10a</td>
<td>8.18b</td>
<td>10.73</td>
<td>10.88</td>
<td>0.40</td>
<td>0.12</td>
</tr>
<tr>
<td>T₂</td>
<td>93.48b</td>
<td>0.65a</td>
<td>9.38b</td>
<td>0.74</td>
<td>10.64</td>
<td>0.75</td>
<td>0.16</td>
</tr>
<tr>
<td>T₃</td>
<td>86.78b</td>
<td>10.18a</td>
<td>9.44b</td>
<td>0.59</td>
<td>10.50</td>
<td>0.29c</td>
<td>0.132d</td>
</tr>
<tr>
<td>T₄</td>
<td>87.44b</td>
<td>10.74b</td>
<td>10.29a</td>
<td>0.23</td>
<td>16.86</td>
<td>0.95b</td>
<td>0.126c</td>
</tr>
<tr>
<td>T₅</td>
<td>86.43b</td>
<td>10.32b</td>
<td>10.51a</td>
<td>0.59</td>
<td>18.31</td>
<td>0.29c</td>
<td>0.141c</td>
</tr>
<tr>
<td>T₆</td>
<td>84.81a</td>
<td>11.07a</td>
<td>11.01a</td>
<td>11.01</td>
<td>21.71</td>
<td>0.420b</td>
<td>0.186c</td>
</tr>
</tbody>
</table>

The figures having common letter in a column are not significantly different by DMRT at 6% level.

Table 4: Correlation matrix (n=6)

<table>
<thead>
<tr>
<th>Characters</th>
<th>Grain yield</th>
<th>Straw yield</th>
<th>Plant height</th>
<th>Panicle length</th>
<th>Filler/1000 grain</th>
<th>N, P, S, Ca, Mg, Zn, B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain yield</td>
<td>0.921**</td>
<td>0.057</td>
<td>0.859**</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant height</td>
<td>0.953**</td>
<td>0.859**</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicle length</td>
<td>0.770**</td>
<td>0.819**</td>
<td>0.509**</td>
<td>0.305**</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Filler/1000 grain</td>
<td>0.562**</td>
<td>0.785*</td>
<td>0.640</td>
<td>0.924**</td>
<td>0.614**</td>
<td>1.00</td>
</tr>
<tr>
<td>N, P, S, Ca, Mg, Zn, B</td>
<td>0.472**</td>
<td>0.820**</td>
<td>0.737**</td>
<td>0.832**</td>
<td>0.823**</td>
<td>0.800**</td>
</tr>
</tbody>
</table>

*p<0.05, **p<0.01, NS = non significant

The yield (3.8 t ha⁻¹) was recorded in the control treatment. The next highest yield of 4.60 t ha⁻¹ was obtained with T₂, T₃, treatment recorded in T₄ (Table 2). Further more, it was observed that the yield demonstrated by Zn alone was statistically identical to that recorded in T₄ or T₃. The results recorded in the experiment indicated that among the three nutrients used, the effect of Zn was dominant, however for obtaining maximum yield, along with NPK and Zn, application of B and Mo is also essential. The combined treatment of Zn, B and Mo (T₇) resulted in a 26% yield increase over control as against 25% yield increase due to T₇, 21% due to T₃, and 20% increase for T₂. Such positive response of rice to B and Mo is also reported in other countries such as India (Divakar and Patnaik, 1994; Ramadas et al., 1996; Agrawal et al., 1997). China (Zou, 1992; Russia (Shevchenko et al., 1991) and Egypt (Mostafa, 1990). Although low grain yield in rice was recorded from individual application of Mo, it was found that the fall in yield of Mo at tillering stage produced increased grain yield of rice as compared to soil application alone (Hossain, 1982).

The available Zn and content of the soils under study were 1.01 and 0.16 mg kg⁻¹, respectively, which indicates a low status of Zn and B in that soil (FRG, 1997). Thus the crop response to added Zn and B in the soil is expected. The pronounced effect of Zn and B on grain yield of rice agrees well with the findings of Islam et al. (1997), Jahisdin et al. (1992) and Abedin et al. (1994).

Like grain yield, straw yield was also significantly affected by fertilizer treatments (Table 2). The yield of straw varied from 5.18 t ha⁻¹ to 7.07 t ha⁻¹ depending on the treatments used. The highest yield in T₇ treatment was statistically identical with T₃ and T₄. Next to those three treatments T₃, T₇, and T₄ produced higher yield. Similar to grain yield, the lowest straw yield (5.16 t ha⁻¹) was recorded in control which received no micronutrients (Table 2).

Plant height responded significantly to the fertilizer treatments (Table 2). The height of the plant depending on the treatment varied from 104 cm to 123 cm. The highest plant height (123 cm) was observed in T₃ treatment and the lowest (104 cm) in control which received none of the three elements.

Panicle length also responded significantly to the fertilizer treatments (Table 2). The panicle length ranged from 20.5 cm to 24.4 cm depending on different treatments. The longest panicle length was observed in T₇ treatment and the lowest value was observed in control treatment which receive none of the micronutrients. The highest panicle length was recorded in T₃ treatment which was statistically identical with that recorded in T₃, T₇, T₆, and T₇, treatments.

There was a significant effect of the applied nutrients on the per cent of filled grains, panicle, showing a variation from 76.6 to 90.4 (Table 2). Every micronutrient treatment like Zn, B, Mo and their combinations gave significantly higher per cent of filled grain as compared to control but they were statistically identical with each other. So it is clear that the effect of B was more pronounced (Table 2) than any other micronutrients. This result also indicated that the addition of B had a vital role on the grain set in rice.

Like other yield components, 1000 grains weight also showed significant influence of different treatments (Table 2). The 1000-grain weight varied from 21.76 g to 23.67 g. The highest 1000-grain weight was recorded in T₇ treatment which was statistically not different with that recorded with T₃, T₇, T₆, and T₇, treatments. The lowest 1000-grain weight (21.76 g) was obtained in control treatment.

The uptake of N, P, S, Mg, Zn and B by crop (grain + straw) were markedly influenced by different treatments. The lowest uptake of N, P, S, Mg, Zn and B were noted in control treatment and the highest uptake in combined micronutrient treatments i.e T₇. The total uptake of N, P, S, Ca, Mg, Zn and B ranged from 64.4-84.9 kg ha⁻¹, 7.98-11.07 kg ha⁻¹, 8.04-11.00 kg ha⁻¹, 8.19-11.84 kg ha⁻¹, 15.32-21.79 kg ha⁻¹.
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0.223-0.420 kg ha⁻¹ and 0.089-0.158 kg ha⁻¹, respectively. To examine the interrelationship among the yield and yield components, correlation statistics were done (Table 4). The values of correlation coefficient indicated that grain yield was dependent on grain/panicle (r = 0.872 **; P < 0.01), plant height (r = 0.933 **; P < 0.01) and panicle length (r = 0.770; P < 0.05). Grain yield was also significantly correlated with straw yield (r = 0.821 **; P < 0.01).

The foregoing results thus, suggested that application of micronutrients Zn, B and Mo along with NPKS is necessary for obtaining satisfactory yield of rice.

References