Effects of micronutrient and spacing on growth and chlorophyll content of rice

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Abstract—An experiment was carried out at the research field of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU). There were four nutrient treatments i.e., $E_1$ = NPKS recommended dose; $E_2$ = NPKS + Zn (5 Kg ha$^{-1}$) + B (3 Kg ha$^{-1}$) $E_3$ = NPKS + Zn (5 Kg ha$^{-1}$) + B (3 Kg ha$^{-1}$) + Mo (2 Kg ha$^{-1}$) and three spacing $S_1$ = 20 x 10 cm$^2$; $S_2$ = 20 x 15 cm$^2$ and $S_3$ = 20 x 20 cm$^2$. Micronutrient and spacing combined had a distinct positive response in crop growth attributes and chlorophyll content of rice. The tallest plant height (147.0 cm) and root length (13.50 cm) highest panicle length (22.56 cm) was attained in the treatment $E_2S_3$ but the maximum tillers per hill (14.95) and effective panicle per hill (14.17) were recorded in treatment $E_2S_2$. Physiological parameter i.e., LAI, CGR, RGR, NAR, total chlorophyll content of rice also responded significantly and the appropriate combination was $E_2S_2$ treatment. Based on vegetative growth, physiological parameters and yield attributes the treatment combination $E_2S_2$ showed the best performance.

Keywords—Growth, chlorophyll, yield attributes and nutrients.

I. INTRODUCTION

Rice is the main food for the people of Bangladesh. Bangladesh is the 4th largest country in Asia with respect to rice production (BBS, 2004). It occupies 74% of the total cropped area, accounts for 70% of the value of crop output and contributes 20% to GDP (BBS, 2001). The average yield of rice in Bangladesh is around 2.74 tons per hectare (Anon, 2007) which is so lower than the world average of 4.25 tons per hectare. Peoples of Bangladesh have been facing shortage of rice yield for a long time. The horizontal expansion of rice area in the country is not possible due to increasing population pressure. Khan et al.(1999) reported that improper use of fertilizers and no use of micronutrients are limiting factors towards the higher rice yield. Micronutrients statuses have been decreasing day by day and finally fertility status of Bangladesh soils become declining. Micronutrients play a vital role in the yield improvement (Rehm and Sims, 2006). Micronutrients deficiency is widespread in many Asian countries due to the calcareous nature of soils, high pH, low organic matter, salt stress, prolonged drought, high bicarbonate contents in irrigation water and imbalanced application of NPK fertilizers. Micronutrient deficiency has become a major constraint for crop growth. Micronutrients help in chlorophyll formation (Reddy, 2004). Farmers of Bangladesh are habituated with the use of macro-nutrients for crop production. Kumar et al.(2002) stated that an optimum plant density is an important factor to achieve better growth of different rice varieties. Hamidulet al.(2002) reported that the growth and yield of rice plant is known to be affected quantitatively and qualitatively by plant spacing. So, the only option left to increase rice production is use of improved varieties and optimum spacing. Research on the use of micronutrients and spacing in increasing rice production is limited in Bangladesh. So due to lack of proper information on spacing the farmers are not getting proper yield. Considering the above mentioned facts, the present study was designed to ascertain - the combined effect of different micronutrient in presence of N, P, K, S and spacing on growth of rice, to find out suitable micronutrient combination along with N, P, K, S and spacing for rice production.

II. MATERIALS AND METHODS

An experiment was conducted at the research field of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur. Soil of this experimental site was a silty clay loam under the Salina series of Shallow Red Brown Terrace. The experimental design was split plot having three replications. Experimental variables were consisted different combination of three micronutrients

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along with N, P, K and S arranged as main plots and three spacing as sub-plots for rice production. Micronutrients and spacing were arranged as follows:

- Micronutrient treatments (Main Plot)
  - E1= NPKS recommended dose, E2= NPKS + Zn 5 Kg ha⁻¹, E3= NPKS + Zn (5 Kg ha⁻¹) + B (3 Kg ha⁻¹), E4= NPKS + Zn (5 Kg ha⁻¹) + B (3 Kg ha⁻¹) + Mo (2 Kg ha⁻¹)

- Spacing treatments (Sub-Plot)
  - S1= 20 x 10 cm², S2 = 20 x 15 cm² and S3 = 20 x 20 cm²

A blanket dose of 65 kg N ha⁻¹ as Urea, 7 kg P ha⁻¹ from TSP, 28 kg K ha⁻¹ as MP and 8 kg S/ha as Gypsum were applied to each treatment. All fertilizers applied as base dose except N fertilizer and N fertilizer applied as installments. Five hills per plot were selected randomly in the net plot and tagged for recording observations at four stages (30th, 60th, 90th day after transplanting and at harvest). For computing leaf area, numbers of tillers per hill were counted. The length and maximum width of each leaf on the middle tiller was measured and leaf area of each leaf was computed as follows:

Leaf area per hill (sq.cm) = Total leaf area of middle tiller × total number of tillers per hill

It was recorded for five hills separately and averaged to get leaf area per hill.

This physiological growth parameter was computed by using the following formulae:

\[
LA1 = \frac{\text{Leaf area of plant}}{\text{Land area covered by the plant}}
\]

\[
\text{CGR} = \frac{W2 - W1}{T2 - T1} \times \frac{1}{GA}
\]

Where; W1 = Dry weight at time T1, W2 = Dry matter at time T2, T2 - T1 = Time interval between second and first measurement, GA = ground area of sample.

\[
\text{RGR} = \frac{\ln W2 - \ln W1}{T2 - T1}
\]

\[
\text{NAR} = \frac{(W2 - W1)}{(T2 - T1)} \times \left(\frac{\ln LA2 - LA1}{(LA2 - LA1)}\right)
\]

Where, ln = natural logarithm, W1 = Dry weight at time T1, W2 = Dry weight at time T2, LA1 = Leaf area at time T1, LA2 = Leaf area at time T2, (T2 - T1) = Time interval between second and first measurement.

### III. RESULTS AND DISCUSSION

Combined effects of different Micronutrient and spacing on rice have been tested which deals with the presentation of the experimental results along with their interpretation and discussion.

#### Plant height

Plant height indicates the influence of various nutrients on plant metabolism. The plant height of rice was significantly unaffected due to the application of different treatment combinations (Table 1). However, it was found that application of micronutrient along with macronutrient increased the plant height over macronutrients when applied separately. But maximum plant height (147.0 cm) was obtained in E2S3. These results were statistically similar with the treatment E2S3 (Table 1). The lowest plant height was recorded for only macronutrients application for all spacing. The increase in plant height in response to combined application of macro and micro nutrients along with different spacing might be due to enhanced availability of macro nutrients as well as micro nutrients. These results are supported by the findings of Islam et al. (2010) who reported that the use of secondary and micronutrients maximized the plant growth and yield of T. aman.

#### Root length

Applications of micronutrients along with macronutrients and spacing had significant effect on the root length of rice (Table 1). The maximum root length (13.50 cm) was obtained from the treatment E2S3. The lowest root length maintained by the application of macronutrient only in all spacing. This result was very close with the finding of Alam et al. (2010).

#### Tiller number per hill

Number of tillers per plant or per unit area is the most important component of yield. More the number of tillers, especially fertile tillers, the more will be the yield. Tilling capacity of a plant depends on the genotype and environment. The data pertaining to number of tillers revealed that micronutrients alone with macro nutrients and spacing had positive effect on number of tillers (Table 1). Among various treatments, the treatment E2S3 produced the maximum number of tillers per hill (14.95) which was followed by the treatment E2S1 (14.83). The minimum number of tillers was recorded in solely macronutrient application among the three spacing. So, these finding suggests that micronutrients had a positive influence on the increase of tillering number of rice (Sohelet al. 2009).

#### Panicle number per hill

The panicle number per hill was appreciably increased due to addition of micronutrients along with macronutrients and variation of spacing (Table 1). The maximum panicle (14.17) was recorded in E2S2 treatment which was statistically similar with all other treatments except E1S3. However, the lowest panicle per hill (10.17) was recorded in E1S3. Rahman et al., (2008) found that application of S and Zn had a significant impact on the panicle number of rice.

#### Panicle length

Panicle length responded significantly to micronutrients
along with macronutrients and variation of spacing (Table 1). Among different treatments, the treatment E2S1 produced the highest panicle length (22.56 cm) which was statistically similar with the second highest treatment E3S2 (22.14 cm). The lowest panicle length (16.53 cm) was observed in the treatment E1S1. Rahman et al. (2008) found that the treatment containing 100% of the recommended dose of S and Zn produced the highest panicle length and the control did the lowest.

**Number of grains panicle**
One of the basic yield components of rice is the number of grains panicle which is affected by various factors including balanced nutrition. As shown in Table 1, micronutrients application along with basal dose of NPKS and spacing substantially improved the number of grains panicle in rice. Maximum number of grains per panicle (98.70) was produced in the treatment E2S1 which was statistically similar with E2S2 and E3S1 with 97.50 and 95.85 grains panicle. Since micronutrient is responsible for the translocation of food materials in plants therefore it played vital role in grain setting as well as higher number of grains in rice. Present results are in line with Uddin et al. (2008) who obtained higher number of grains by the application of boron @ 2 kg ha⁻¹. Minimum number of grains (52.40) was recorded in treatment E1S1. Similar finding was reported by the Hamid et al., (2011) that highest plant spacing gave the maximum number of grain per panicle.

**Filled grain panicle**
Filled grain panicle of rice was highly accelerated by the micronutrients application along with macronutrients and spacing (Table 1). Among different treatments, the treatment E2S2 was produced the maximum filled grain per panicle (87.62) which was statistically similar with E2S3 (87.05) and E3S2 (85.43). The minimum grain per panicle (45.15) was recorded in the treatment E1S1. This results agreed with the finding of Nadim et al., (2011) that with application of micronutrient along with basal dose of macronutrient provide the maximum grain number per panicle.

**1000-grain weight (g)**
The data presented in Table 1 revealed that micronutrients application and spacing had significant effect on the grain weight. Maximum 1000 grain weight (12.07g) was recorded in the treatment E2S2 which was statistically similar at par (11.37g) and (11.17g) with grain weight obtained in E2S1 and E3S3 treatment respectively. The minimum grain weight (10.12g) was recorded in E1S1treatment. This might be due to zinc and proper spacing enhanced accumulation of assimilates in the grains, which resulted in heavier grains of rice.

| Treatment | Plant height (cm) | Root length (cm) | Tiller No./ hill | Panicle No./hill | Panicle length (cm) | Kernel/plant | Filled kernel /plant | 1000 seed weight (g) |
|----------|------------------|------------------|-----------------|-----------------|---------------------|-------------|---------------------|---------------------|
| E2S1     | 131.5            | 11.17bc          | 11.17           | 10.33ab         | 16.53d              | 52.40cd     | 45.15d              | 10.12b              |
| E2S2     | 135.7            | 12.00abc         | 12.33           | 11.83ab         | 18.30bcd            | 65.15bcd    | 55.23bcd            | 11.37ab             |
| E3S1     | 133.8            | 12.00abc         | 14.83           | 13.33ab         | 21.24ab             | 77.85abc    | 63.90abc            | 10.28b              |
| E3S2     | 134.2            | 11.83bc          | 14.17           | 12.67ab         | 17.53cd             | 65.36bcd    | 55.65bcd            | 11.62ab             |
| E1S1     | 131.7            | 10.83bc          | 12.83           | 12.17ab         | 17.63cd             | 62.90cd     | 46.85cd             | 10.27b              |
| E1S2     | 136.3            | 12.17ab          | 14.95           | 14.17a          | 22.14a              | 97.50a      | 87.62a              | 12.07a              |
| E2S1     | 140.2            | 11.83abc         | 13.50           | 12.67ab         | 19.71abcd           | 76.45abc    | 64.73abc            | 10.97ab             |
| E2S2     | 139.8            | 12.00abc         | 13.17           | 12.83ab         | 18.62bcd            | 88.40ab     | 68.12abc            | 10.88ab             |
| E3S1     | 133.5            | 10.83bc          | 10.67           | 10.17b          | 19.46abcd           | 69.00bcd    | 58.72bc             | 10.03ab             |
| E3S2     | 147.0            | 13.50a           | 13.33           | 12.33ab         | 22.56a              | 95.85a      | 87.05a              | 11.17b              |
| E1S1     | 142.2            | 12.00abc         | 12.33           | 12.33ab         | 20.13abc            | 80.95abc    | 67.75abc            | 10.53b              |
| E1S2     | 143.1            | 11.00bc          | 12.50           | 12.00ab         | 19.65abcd           | 98.7a       | 85.43a              | 10.15b              |
| CV(%)    | 8.21             | 8.94             | 22.12           | 20.23           | 8.97                | 19.68       | 19.51               | 7.48                |
| SE (±)   | 6.51             | 0.60             | 1.65            | 1.42            | 0.99                | 8.53        | 7.14                | 0.47                |

**Leaf area index (LAI)** at 45 and 90 days after Transplanting
The ratio of total leaf area to ground cover is termed as LAI. It is typically increases to maximum after the crop emergence (Reddy, 2004). The data presented in Fig.1. revealed that micronutrients and spacing had significant effect on leaf area index at 45 and 90 DAT. The maximum LAI (0.33 and 3.53) was recorded in treatment E₂S₂ at 45...
and 90 DAT respectively. The lowest LAI was observed in solely macronutrient and closer spacing. In general, the application of Micronutrient especially boron and medium spacing had boosted up the tissue formation with better plant growth which increases its concentration in leaves and results in higher leaf area index.

**Crop growth rate (g m-2 day-1)**

Crop growth rate is the dry matter production per unit time. The data in Fig.3. revealed that combined effect of micronutrient and spacing significantly affected the crop growth rate. Micronutrients application enhanced the plant growth through increased plant photosynthesis and other physiological activities whereas, proper spacing has positive influence on nutrient uptake of plant. Among various treatments, E₄S₂ accelerated crop growth rate (33.78 g m-2 day-1). The use of micronutrient and proper spacing helped the plants to better utilize the available nutrients with increased leaf area, high photosynthesis and dry matter accumulation which enhanced crop growth rate. These results satisfy the findings of Asad and Rafique (2002) who reported that boron fertilization increased the dry matter production of wheat. The minimum crop growth rate (24.43) was recorded in macronutrient application with closer spacing (E₁S₁).

**Relative growth rate (mg g-1 day-1)**

Relative growth rate (RGR) expresses the dry weight increase in time interval in relation to the initial weight. Since crop growth rate is an absolute measure of growth, similar values could be expected for different initial weights (Reddy, 2004). The data presented in Fig.4. revealed that
application of different micronutrients and spacing had significant effect on the relative growth rate of rice. Maximum RGR (88.45 mg g⁻¹ day⁻¹) was produced in treatment E₄S₂ which was followed by (87.58, g g⁻¹ day⁻¹) E₂S₂. The reason might be the high concentrations of boron and zinc in the leaves increased plant food accumulation which resulted in more relative growth rate (Card et al. 2005). The sole application of macronutrient (E₁S₂) produced the minimum relative growth rate (76.30 mg g⁻¹ day⁻¹).

Net assimilation rate (mg m⁻² day⁻¹)
The plant capacity to increase dry weight in terms of area of its assimilatory surface expresses the net assimilation rate. The data given in Fig. 5 revealed that different micronutrients and spacing had significant effect on net assimilation rate. Among various treatments, E₄S₂ produced the significantly maximum net assimilation rate (2.95 mg m⁻² day⁻¹) which was statistically closer with E₂S₂ treatment. Shukla and Warsi (2000) also obtained the highest net assimilation rate with the application of Zn along with NPK. The minimum net assimilation rate of 1.91 mg m⁻² day⁻¹ was produced at E₁S₁ treatment.

Chlorophyll Content (mg/g)
The response of growth and yield parameter depends upon the photosynthetic rate, which in turn is dependent on chlorophyll contents. In the present study, a significant increment in chlorophyll contents (a, b and total chlorophyll) was recorded in combined effects of micronutrient and spacing along with macronutrient. The chlorophyll “a” and “b” contents was found to be correlated with each other and the treatment Zn @ 5kg ha⁻¹, B @ 3kg ha⁻¹, Mo @ 2kg ha⁻¹ along with different macronutrients along with 20x 15 cm² spacing (E₄S₂) showed highest. However, the treatment contains solely macronutrients with lowest spacing (E₁S₁) showed the lowest chlorophyll content. The chlorophyll “a” and “b” contents varied from 1.98 to 1.37 mg g⁻¹ and 0.69 to 0.46 mg g⁻¹, respectively with different combination of micronutrient and spacing. The highest chlorophyll contents (a, b and total) was recorded in (E₄S₂) treated plant. However, all other
treatments also had increased chlorophyll contents significantly (Table 2). The chlorophyll “a”, “b” and total chlorophyll contents increased up to 33.78, 30.19 and 32.34%, respectively for the treatment Zn @ 5 kg ha⁻¹, B @ 3kg ha⁻¹ and Mo @ 2 kg ha⁻¹ along with different macronutrients along with 20x 15 cm² spacing (E₃S₂) over the similar spacing control. This trend was observed because the chlorophyll contents increased considerably in Zn and B treated group of plants (Hatware et al. 2003).

| Treatment | Chlorophyll Content (mg/g) |  |
|-----------|---------------------------|---|
|           | Chl. a | Chl. B | Total Chl. |
| E₁S₁      | 1.15h  | 0.36g  | 1.51f      |
| E₂S₁      | 1.55d  | 0.47f  | 2.02d      |
| E₃S₁      | 1.37g  | 0.49ef | 1.86e      |
| E₄S₁      | 1.41fg | 0.46f  | 1.87e      |
| E₁S₂      | 1.48e  | 0.53de | 2.01d      |
| E₂S₂      | 1.50e  | 0.57cd | 2.06d      |
| E₃S₂      | 1.63c  | 0.56cd | 2.19c      |
| E₄S₂      | 1.98a  | 0.69ª  | 2.66ª      |
| E₁S₃      | 1.40fg | 0.47f  | 1.87e      |
| E₂S₃      | 1.78b  | 0.64ab | 2.43b      |
| E₃S₃      | 1.78b  | 0.61bc | 2.39b      |
| E₄S₃      | 1.54ef | 0.48f  | 2.02d      |
| CV(%)     | 2.03   | 4.20   | 2.08       |
| SE (±)    | 0.02   | 0.02   | 0.03       |

Table 2: Effect of Micronutrient and spacing on Chlorophyll content (mg/g) of rice.

**IV. CONCLUSION**

The tallest plant height (147.0 cm), longest root length (13.50 cm) and highest panicle length (22.56 cm) were attained in the treatment E₂S₃, though the maximum tillers per hill (14.95) and effective panicle per hill (14.17) were obtained in the treatment E₂S₂. Although, the maximum number of grains per panicle (98.7) was produced in the treatment combination E₂S₂, the maximum filled grains per panicle (87.62) was observed in the treatment E₂S₂. The maximum LAI, CGR, RGR, NAR and total chlorophyll content were produced by the E₂S₂ treatment. Based on vegetative growth, crop growth attributes treatment combination E₂S₂ may be specified as the best performer.

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