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MICRONUTRIENT MANAGEMENT IN AN ADVANCED LINE OF RICE (CN6) TO INCREASE THE SPIKELET FERTILITY UNDER AMAN SEASON

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The experiment was conducted in the Aman season of 2016, at Bangladesh Rice Research Institute farm under the Agro Ecological Zone (AEZ 28) Modhupur Tract. The CN6 is a high spikelet bearing advanced line of rice but low in spikelet fertility. Micronutrient management was examined to increase its spikelet fertility. Five treatments were used in this experiment. The treatments were as follows: T_1= BRRI recommended fertilizer dose + MgO @ 0.05%, T_2 = BRRI recommended fertilizer dose + 60 g MoP + 60 g elemental S (80% wp) + 20 g $ZnSO_4$, T_3 = BRRI recommended fertilizer dose + Boron @ 5ppm, T_4= BRRI recommended fertilizer dose + Copper @ 5ppm) and T_5 = BRRI recommended fertilizer dose alone. The experiment was conducted in Randomized Complete Block design with three replications. The results indicated that Treatment T_3 (BRRI recommended fertilizer dose + Boron @ 5ppm) produced the more number of grains per panicle with an average of 194 which is higher number of grains per panicle over the control treatment T_5 (BRRI recommended fertilization alone). Treatment T_4 produced the highest number of 1000- grains weight (17.9 g). However, highest grain yield was recorded in the treatment T_4 with an average of 3.94 t ha^{-1} compare to the control treatment T_5 (BRRI recommended fertilization alone). Second highest grain yield (3.70 t ha^{-1}) was found under the treatment T_2 followed by T_1 (3.57 t ha^{-1}) and T3 (3.57 t ha^{-1}). The lowest grain yield was recorded in the control treatment T_5 (BRRI recommended fertilization alone). Taken together, our results suggested that micronutrient management, especially copper and zinc, improved the spikelet fertility of an advanced line CN6 resulting higher yield.

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INTRODUCTION

In Bangladesh, rice is the most important dietary food for the people and with about 50% of the world's population depending on rice as their staple food, particularly in fast growing and population-dense regions of the world (Fageria and Baligar, 2003). Rice is not only the main source of carbohydrate but also provides 69.61% of calories and 56.15% of the proteins in the average daily diet of the people (FAO, 2011). Food security is a major/ important concern in our country because rice food requirement is increasing at an alarming rate due to increasing population and food security is under threat due to stagnant yields of the main staple food crops (FAO, 2016). It is necessary to enhance rice production to meet the increasing food demand for the vast growing population of the country which increases at the rate of 1.32 percent per annum (BER, 2009-2010).

In Bangladesh farmers apply N, P, K and S fertilizers widely and application of micronutrients such as copper, boron and Zn is not a usual practice. In order to improve crop productivity, limiting micronutrient(s) must be identified and the soils should be enriched with the addition of those micronutrients in properly balanced .The importance of micronutrients in rice production is increasing in recent years to use of high yielding verities and hybrid cultivars in Bangladesh. Micronutrients are needed in trace amounts but their adequate supply improves nutrient availability and positively affects the cell physiology that is reflected in yield as well (Taiwo at al. 2001). Micronutrients have crucial role in various plant metabolic processes and have direct role in photosynthesis. Micronutrients also enhances plant productivity, leaf area and grain yield as result of enhancing the enzymatic system of plants. Copper play an important role in activating the enzymatic activities and is required for lignin synthesis. Copper also helps in pollination and seed setting (BFRG, 2012). Application of Cu in rice can also increase dry matter production and yield of rice (Fageria et al, 2002). Boron (B), a nonmetal micronutrient, is essential for normal growth and development of plants, including rice (Gupta, 1979; Dunn et al., 2005); its essentiality was first reported in 1933 (Warington, 1933). Boron (B) is used in small amounts as a micronutrient either alone or within macronutrient fertilizers. Grain yield is depressed by adverse effects of B deficiency on reproductive growth even while the effect on vegetative growth is imperceptible. Micronutrients including Zn and B are very important for better reproductive growth and development of crop plants.

Two time foliar applications of micronutrient was efficiency and economy (Savithri et al., 1999; Singaraval et al.,1996; Ali et al., 2003; Johnson et al.,2005; Sultana et al.,2001). Foliar and soil application are common but often costly methods for micronutrient addition. Foliar fertilization alone may not fulfill the long-term demand of crops and should be considered a supplementary approach to soil application (Belland Dell, 2008).Foliar applications of B and Cu serve as a good source, particularly in supplying rice plants with the nutrients that are crucially needed in growth stage. CN6 is a high spikelet bearing early maturing advanced line of rice with low spikelet fertility, it is hypothesis that, micronutrient plays an important role for increasing spikelet fertility of CN6. With this view a field experiment was conducted to find out appropriate micronutrients that would be effective for increasingspikelete fertility of CN6.

MATERIALS AND METHOD

Experimental site and soil

The experiment was conducted in the Aman season of 2016 at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur. The experimental area was under the agro-ecological zone Modhupur Tract (AEZ 28).The location previously had a 3-season rice. The field was cleared and manually ploughed to provide a fine tilth for cultivation. Each plot was demarcated with a 40 cm walk way and a plot size of 3.2 m x 2.2 m. The texture of the soil was silty clay loam. The initial soil were analyzed and found the following records: organic carbon 1.04%, N 0.11%, P 7.10%, K 0.14 meq/100 g soil, S 28.82 ppm, Mg 0.5 meq/100 g soil, Cu 0.2 ppm, Zn 0.4 ppm and B 0.2 ppm.

Experimental design and treatments

There were five treatments in the experiment. The experiment was conducted following RCB design with three replications with three replications. The treatments combinations were as follows: T_1 = BRRI recommended fertilizer dose + MgO @ 0.05%), T_2 = BRRI recommended fertilizer dose + 60 gMoP + 60 g elemental S(80% wp + 20 g $ZnSO_4$, T_3 = BRRI recommended fertilizer dose + Boron @ 5ppm, T_4 = BRRI recommended fertilizer dose +Copper @ 5ppm and T_5 = BRRI recommended fertilizer dose alone.

Fertilizer management

BRRI recommended fertilizer doses were used as N-P-K-S-Zn @120-19-60-20-4 kgha^{-1} and N was spitted as 1/3rd at 20 DAT + 1/3rd at 35 DAT + 1/3rd at 56 DAT (before panicle initiation stage) (BRRI, 2015). Urea, TSP, MoP, Gypsum, $ZnSO_4.H_2O$, $CuSO_4$, and H_3BO_3 were applied as the sources of N-P-K-S-Zn-Cu-B. Full dose of P, K, S and other macronutrient fertilizers were applied at final land preparation. The experiment was conducted in Randomized Complete Block design with three replications. The soil at the study site is of fine silty clay loam type. All the micronutrients were foliar sprayed at PI (panicle initiation stage) and grain soft dough stage.

Crop husbandry and data collection

The advanced line of CN6 was used in the experiment. The CN6 is a high spikelet bearing and early maturing advanced line of rice having low spikelet fertility. Sterility, grains per panicle and 1000 grains per panicle were taken from panicles of ten hills. Heading was considered as 80% of the tillers had more than 50% of the panicle exerted. The crop reused maturity when 90% of the spikelet turned from green to yellowish. At maturity, a 5.0 m^2 area was harvested for grain yield. Grain yield and 1000 grains weight was adjusted to 14% moisture content. Weeds were manually controlled (2 times) 20 days after sowing and at maximum tillering stage. And all other agronomic and pest management practices were followed as and when necessary. Temperature data was collected from plant physiology division, BRRI, Gazipur.

Growing degree days (GDD)

Phonological stages include seedling establishment, maximum tillering, booting, heading, anthesis and maturity.

Cumulative growing degree days were determined by summing the daily mean temperature above base temperature, expressed in degree day. This was determined by using the following formula as per (Nuttonson, 1995). The weather data was collected from the physiology division of BRRI, Gazipur.

$$GDD = \frac{(Tmax + Tmin)}{2} - T\ base$$

Where,

T base = Minimum threshold/base temperature (10°C), T max = Daily maximum temperature (°C), T min = Daily minimum temperature (°C)

The HUE was calculated following as per (Rajput1980).

Heat use efficiency (HUE) = Grain yield (kg/ha)/GDD

Temperature from heading to maturity

The maximum and minimum temperature of the flowering stage was observed. Average minimum and maximum temperatures were recorded 25.4 º C and 33.8º C, respectively (Figure 1). Temperature did not exceed 35º C during flowering stage (26 April-03 October).

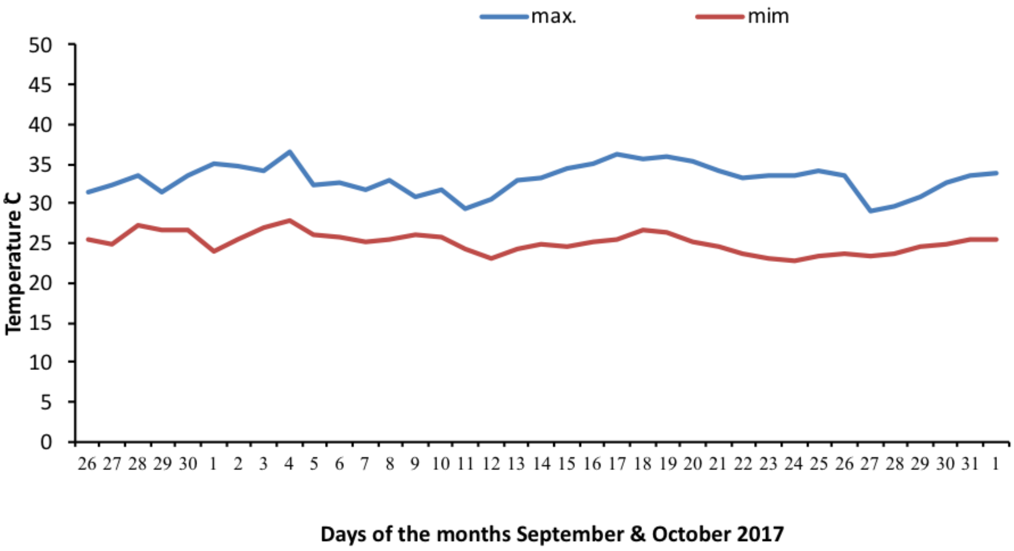

Figure 1. Temperature from heading to maturity of CN6, Aman, 2016, BRRI, Gazipur

Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique and the mean differences were adjudged by LSD test using the statistical computer package program, Statistix 10.

RESULTS AND DISCUSSION

Improvement of tiller and panicle number through nutrient supplementation of an advanced line CN6

In the T. Aman season there was no significant difference among the treatments on tiller/m^2 (Table 1). The highest number of tiller per meter square belonged to the treatment T_5 (BRRI recommended fertilizer dose) with an average of 203 and the lowest number of tiller per meter square belonged to the treatment T_2 (BRRI recommended fertilizer dose + 80% S @ 0.006% +ZnSO4 @ 0.025%) with an average of 198. The highest number of panicles per meter square was observed in the treatment T_4 (BRRI recommended fertilizer dose +Copper @ 5ppm) with an average of 194 and the lowest number of panicles per meter square was observed in T_5 (BRRI recommended fertilizer dose) and T_2 (BRRI recommended fertilizer dose + 80% S @ 0.006% +ZnSO4 @ 0.025%) with an average of 188 (Table1). The results might be due to the supplementation of different nutrients, especially micronutrients.

Table 1. Effect of micronutrient supplementation on tiller/m^2 and panicle/m^2 of advanced line CN6 under Aman Season

Treatments	Tiller/m2	panicle/m2
T_1= BRRI recommended fertilizer dose + MgO @ 0.05%	201	191
T_2= BRRI recommended fertilizer dose + 80% S @ 0.006% +ZnSO4 @ 0.025%	198	188
T_3= BRRI recommended fertilizer dose + Boron @ 5ppm	202	189
T_4=BRRI recommended fertilizer dose +Copper @ 5ppm	202	194
T_5= BRRI recommended fertilizer dose	203	188
LSD(0.05)	10.32	13.62
CV(%)	1.82	2.54

Role of micronutrients on improvement of grains per panicle and thousand grain weight

There was significant difference among the treatments in the grains per panicle. Treatment T_3 (BRRI recommended fertilizer dose + Boron @ 5ppm) and T_1 (BRRI recommended fertilizer dose + MgO @ 0.05%) produced about 20% and 16% more grains over the control treatment, T_5, (BRRI recommended fertilizer dose alone) respectively. There was no significant difference among the treatments in the 1000 grains weight. Treatment T_4 (BRRI recommended fertilizer dose + Copper @ 5 ppm) produced the highest number of 1000-grains weight (17.9 g). The second height 1000-grains weight (17.7 g) was found in the control treatment T_5 followed by the treatment T_2 (17.6 g). The lower number of 1000-grains weight (17.5 g) was found in the treatments T_1 (BRRI recommended fertilizer dose + MgO @ 0.05%) and T_3 (BRRI recommended fertilizer dose + Boron @ 5ppm). Zayed et al (2011) suggested that yield components such as panicle numbers, panicle weight, filled grains per panicle and 1000-grain weight can be significantly increased in rice by application of micronutrients.

Table 2. Effect of micronutrient supplementation on yield and yield components of an advanced line CN6 under Aman Season

Treatments	**Grains panicle^{-1}**	**1000-grain weight (g)**	**Grain yield t ha^{-1}**
T_1= BRRI recommended fertilizer dose + MgO @ 0.05%	186	17.5	3.57
T_2= BRRI recommended fertilizer dose + 80% S @ 0.006% +ZnSO4 @ 0.025%	172	17.6	3.70
T_3= BRRI recommended fertilizer dose + Boron @ 5ppm	194	17.5	3.57
T_4=BRRI recommended fertilizer dose +Copper @ 5ppm	167	17.9	3.98
T_5= BRRI recommended fertilizer dose	161	17.7	3.29
LSD(0.05)	13.04	NS	0.363
CV (%)	2.70	2.58	9.77

D/S: 15 July D/TP: 04 August D/MA: 31 October TGD= 109 days

T_1= BRRI recommended fertilizer dose + MgO @ 0.05%; T_2= BRRI recommended fertilizer dose + 80% S @ 0.006% +ZnSO4 @ 0.025%; T_3= BRRI recommended fertilizer dose + Boron @ 5ppm; T_4=BRRI recommended fertilizer dose +Copper @ 5ppm; T_5= BRRI recommended fertilizer dose

Grain yield improvement and micronutrient supplementation

There was significant difference among the treatments in grain yield. Higher grain yield 3.98 t ha^{-1}and 3.70 t ha^{-1}were recorded in the treatment T_4 (BRRI recommended fertilizer dose + Copper @ 5ppm) and in the treatment T_2 (BRRI recommended fertilizer dose + 80% S @ 0.006% +ZnSO4 @ 0.025%) compare to the control treatment T_5 3.29 t ha^{-1}) (BRRI recommended fertilizer dose) (Table 2). Other two treatmentsT_1 and T_3 produced slight lower same yield 3.57 t ha^{-1}compare to the control treatment T_5 (3.29 t ha^{-1}). Fageria et al. (2002) found that application of Cu in rice can increase dry matter production and yield of rice. Hundal et al. (2008) also observed that combined application of micronutrients (Zn, Cu and Mn) can eventually control to increase grain yield of rice. Imtiaz et al. (2010) reported that micronutrients applied alone or together with micronutrients have a significant effect on crop yield. Siddika et al. (2016) reveal that application of micronutrients including Zn Cu, Mn and B exerted more or less a significant positive effect on grain and straw yield of rice (BRRI dhan29) with applied with NPKS. Nawaz et al. (2004) in this study the combined application of Zn with other micronutrients including cu and Mn on growth and yield performance of was better compared to single application of Zn.

The results might be due to the spikelet fertility sensitive advanced line where B fertilization was not applied. Whereas, the grain yield increased in the treatments T_3 might be due to the role of micronutrients that regulates pollen viability and seed formation. Repeated sprays can effectively sustain B supply to improve flowering (Wang et al., 1999). Boron fertilizer use (0.75 kg B ha^{-1}) reduces panicle sterility and increases productive tillers, which result in higher paddy yields (Rashid et al., 2004, 2007). Boron fertilization (1.0 kg B ha^{-1}) improved paddy yields in several rice genotypes (Super Basmati, Basmati-385, KS-282), which was attributed to reduced spikelet sterility and an increased number of productive tillers (Rashid et al., 2004, 2007). Zayed et al (2011) suggested that grain yield can be significantly increased in rice by application of micronutrients.

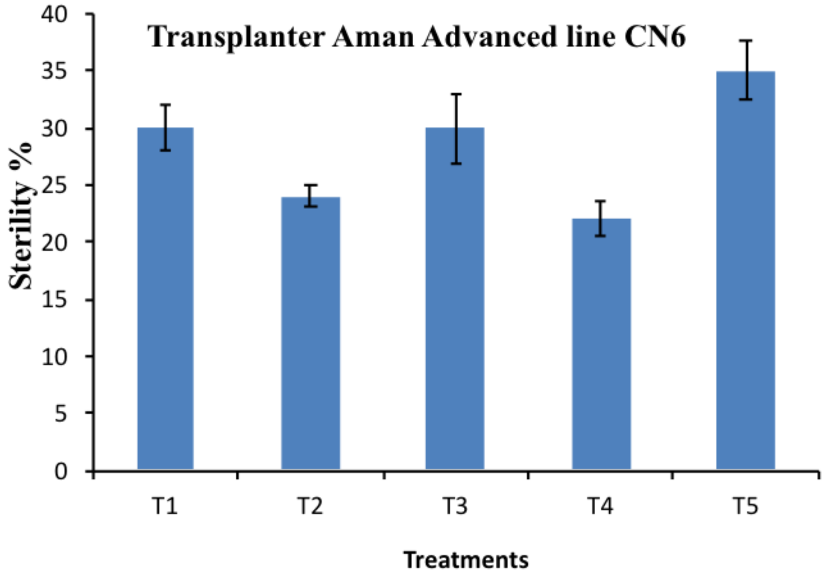

Figure 2. Sterility of CN6 as influenced by different micronutrients supplementation, Aman, 2016, BRRI, Gazipur

Improvement of spikelet fertility of an advanced line CN6 under Aman Season

In the T. Aman season, there were significant differences among the treatments regarding sterility percentage of the CN6 line. All micronutrient supplemented plot had statistically lower sterility percentage than the control treatment, T_5. Maximum spikelet sterility percent (34.67%) was found in the control treatment (T_5) of the CN6 line which is a serious problem to release the cultivars in Bangladesh. Treatment T_1, T_2, and T_4 had about 8.77%, 7.32%, 13.67% and 3.84% lower spikelet sterility, respectively than the control treatment T_5 (Fig. 2). The used management practices improve the spikelet fertility significantly. Narimani et al. (2010) found higher spike per unit area and El-Nahhal et al. (2004) observed increased weight of 1000- kernel in durum wheat due to combined application of Zn and Cu. Parallel to the macronutrient, micronutrient management improves the spikelet fertility in the advanced line CN6.

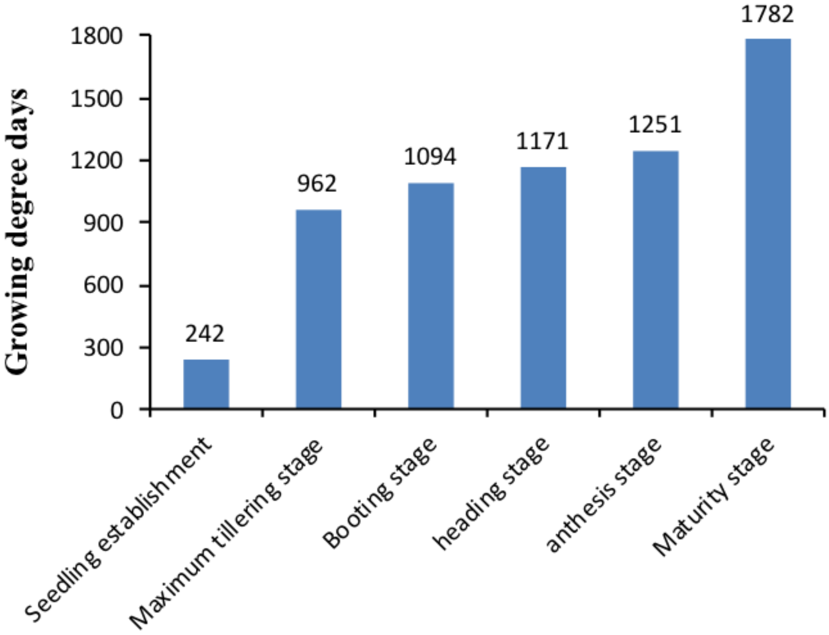

Figure 3. Growing degree days at different phonological stages of the advanced line CN6

Table 3. Yield response of CN6 to heat use efficiency under different nutrient management

Treatments	Yield (kg/ha)	Heat use efficiency (HUE)
T1	3570	2.00
T2	3700	2.07
T3	3570	2.00
T4	3980	2.23
T5	3290	1.84

Growing Degree Days (GDD) and Heat use efficiency (HUE):

Growing degree days accumulated at different phonological stages were calculated during growth of rice is presented in Fig. 3. The lowest heat unit, Growing Degree Days (GDD) requirement was found/ observed in CN6 at seedling establishment stage, where as in the successive phonological stages like maximum tillering, booting, heading, anthesis and maturity the heat unit (GDD) increased. The highest heat unit, Growing Degree Days (GDD) requirement was found/ observed in CN6 at maturity stage. The lowest heat unit, heat use efficiency (HUE) was found/ observed in treatment T_5 (Table 3). The highest heat unit, Heat use efficiency (HUE) was found/ observed in T_4.

CONCLUSION

From the above results can be concluded that on an average 34.67% sterility was observed in the advanced line of rice, CN6, and which is not influenced by high temperature at flowering stage. Among the nutrient management, Cu and Zn had positive effects on increasing the spikelet fertility in Aman season resulting higher yield.

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