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EFFECTS OF SECONDARY AND MICRO NUTRIENTS ON RICE (*Oryza Sativa* L.) GROWTH, DEVELOPMENT AND YIELD

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Abstract
A replicated field trial was carried out at the research field of CSIR- Savanna Agricultural research Institute (CSIR-SARI) Nyankpala during the 2016 cropping season, to determine the integrated effects of macro (N,P,K), secondary (S and Mg) and micro nutrients (B, Zn and Cu) on rice growth, development and yield using omission trial. The experiment was laid out in a randomized complete block design. The results revealed that the maximum number of tillers per square meter, dry weight of biomass and paddy yield was obtained when all the nutrients (NPK, S, Mg, B, Zn and Cu) were used. Yield decreased with the omission of K, S, Mg, B, Zn and Cu. Sulphur exclusion promoted panicle development, but caused 20% paddy yield loss; could it be that some of the panicles were not productive. Further experiment should be conducted to ascertain why the omission of Sulphur promoted panicle development but decreased grain yield.

Keywords: Rice, Secondary nutrients, micronutrients, NPK

Introduction

Cereals form the bulk of the food staple in Ghana and the main cereals produced are maize, rice, millet and sorghum. Among these cereals, rice offers the best opportunity to rapidly increase food production, because current yields are far below the potential yield due to low productivity on most rice farms. The quest to attain self-sufficiency in rice production in Ghana has led to the introduction of copious policy interventions by successive governments of Ghana. These have however not yielded the desired results and currently, rice productivity and self-sufficiency are still low (MoFA, 2009). Urbanization, population growth and changes in consumer habits account for the persistent increase in rice consumption in Ghana over the years. In 2013, Ghana imported 644,334 tons of rice worth $392.30 million (MoFA, 2014). Such over reliance on rice imports has grave implications for Ghana's quest to attain food security, increased income and reduced poverty. It also puts pressure on Ghana's foreign reserves and inhibits investment in other sectors of the economy. According to Asuming-Brempong (1998), Ghana has good agronomic conditions to produce rice throughout the year. Nonetheless, much has not been done about the use of micronutrients which seem to limit the yield of rice in Ghana. Micronutrients deficiency is considered as one of the major causes of the declining productivity trend in rice growing countries. The submergence of rice cultivation influences electrochemical and biochemical reactions and alters P^H, PCO_2, and the concentration of certain ions, sodic, upland and calcareous coarse-textured soils with low organic matter content suffer from Fe deficiency, besides Zn^{+2} and Cu^{+2}. Application of only NPK has led to depletion of some secondary and micro nutrients in soils. For balanced plant nutrition and optimum yields, there is need to include all essential nutrients in fertilization of the crop. An experiment conducted in 815 irrigated wheat growing regions of Iran to determine the impact of micronutrients showed an increase of 4 to 11% in wheat grain yield by the application of each micronutrient (Fe, Zn, Cu, and B) or a combination of Fe +Zn + Cu + B to NPK fertilizer increased grain yield (Malakouti, 2000). Omission trials are very useful to determine nutrients that are essential for production of a particular crop at a specific site. Many studies have been conducted on the use of organic and inorganic fertilizers to improve soil fertility in rice cultivation, however, there has been less effort to improve secondary and micro-elements composition of soil, and this probably has resulted in low yields obtained. This study aims to determine the effects of secondary and micro nutrients in rice growth, development and yield using omission trial.

Materials and Methods

Experimental Site

The trial was conducted from June to October 2016 during the cropping season, at the rice improvement section of the Savannah Agricultural Research Institute (SARI), Nyankpala, in the Northern Region of Ghana. With one rainy season in the year from April to October, the area/site receives over 1000 mm of rainfall annually. The mean annual temperature distribution is a minimum of 23.4°C and a maximum of 34.5°C with a minimum relative humidity of about 46% and maximum of 76.8% (SARI, 2013).

Experimental Design and Treatments

The field was laid out in a Randomized Complete Block Design (RCBD) with nine treatments and each treatment replicated three times. Individual experimental plots measured 5m × 3m with 2m alley left between each replication and 1m alley left between plots to prevent fertilizer drifts and inter-interference. A total of 665m^2 area size of 19m × 35m was covered. The major, some secondary and micro nutrients were combined to constitute positive check treatments. Subsequently, potassium, secondary and micro nutrients were removed from the check treatment combination, one at a time, so the effects could be determined. (Table1). The treatments were applied starting from 30 days after planting and some day intervals.

Table 1: Nutrient treatments (Kg/ha) combination applied on the field

Trt No	Treatment	N	P	K	Mg	S	Zn	B	Cu
1	All	90	60	60	30	10	0.6	0.2	0.38
2	All-K	90	60	0	30	10	0.6	0.2	0.38
3	All-Mg	90	60	60	0	10	0.6	0.2	0.38
4	All-S	90	60	60	30	0	0.6	0.2	0.38
5	All-Zn	90	60	60	30	10	0	0.2	0.38
6	All-B	90	60	60	30	10	0.6	0	0.38
7	All-Cu	90	60	60	30	10	0.6	0.2	0
8	NPK	90	60	60	0	0	0	0	0
10	Control	0	0	0	0	0	0	0	0

Planting

The rice variety used was AGRA – rice which is an improved variety with maturity of 120 days. The yield potentials of this variety is estimated to be 10,000kg/ha. The variety is popular with consumers. The seeds were planted directly in the field at four seeds per hill; the planting distance was 20cm x 20cm between rows.

Cultural practices

The plots were kept weed-free throughout the growing period. Weeding was done manually at two weeks interval using the hand hoe and making effort to incorporate the weeds into soil. Chemically produced herbicide was also used to control weeds when the plant was about to flower.

Number of panicles

The number of panicles produced in the 2m x 2m plots was counted and the average of the five plants was determined.

Tiller number

Data on number of tiller per plants was recorded at maturity from yield plots. Five plots of 2m × 2m were pegged out each plot for yield measurement. The number of productive tillers was determined by counting the numbers of tillers that produced paddy. Tiller number per m^2 at 60 days after planting was determined by finding the average of the tillers produced by the five (5) 2m x 2m plots at 60 days after planting (Yoshida, 1981).

Rice paddy yield

At maturity, yield plots of 2m^2 were taken at five different plants (five samples) per plot. Harvested paddy was threshed, winnowed, dried and weighed to estimate paddy yield.

Dry weight of biomass

The straw produced by the yield plots was measured using a top pan balance and estimated in kg/ha.

Yield loss

Yield loss was calculated after we had taken the weight of the yield of the plot treated with all the nutrients and subtracting that of the weight of yield of the plot where individual nutrients were omitted from it, measured in kg/ha.

Statistical analysis

Data collected were analyzed using GENSTAT for analysis of variance and the treatment means separated with least significant difference (LDS) at 5% probability level.

Results and Discussion

Tiller number and Panicle number

The tiller number was significantly influenced (P = 0.001) by the treatments. It was noticed that the plot which received all the nutrients produced the highest number of tillers (Figure 1). The plots treated with (ALL-K) was the next to produce higher tiller number and NPK was statistically at par with (ALL-B) and (ALL-Zn) which was in turn higher than (ALL-S) and the control produced the least number of tillers (Figure 1). There was a significant difference in the number of panicles (P = 0.001) among the treatments with the plot lacking Sulphur producing the highest number of panicles followed by (ALL-Cu), then the plot treated with all the secondary and micro nutrients. The plot treated with NPK produced greater number of panicles than (ALL-K) and (ALL-Mg) and the control produced the least number of panicles

Paddy yield

Biomass production was significantly affected (P = 0.001) by the treatments. It can be seen in this results that the exclusion of potassium (ALL-K) did not affect biomass as it produced statistically the same amount of biomass as when all the nutrients were present (Figure 2). The result on paddy yield showed that the exclusion of some nutrients had significant effect (P = 0.001) on yield (Figure 2). The plots treated with all the nutrients produced the highest paddy yield. It is important to note that the treatment in which the primary nutrient (K) was excluded recorded second highest paddy yield. Application of NPK alone reduced yield substantially as it was only better than no fertilizer application (Control). The exclusion of other nutrients performed similarly. It was observed that the control had the highest yield loss. Aside the control, application of NPK alone caused a yield loss of about 34.9% over when all nutrients were present (Figure 3), Sulphur exclusion caused a yield loss of 20%.

Yield and yield components

In rice, the final yield is mainly a function of the number of tiller bearing panicle per unit area. Lack of sulphur (ALL-S) promoted panicle development as the treatment produced the highest number of panicles. This means that, Cu, Zn, B and two other nutrients K and Mg were the nutrients needed to give optimum panicle yield. If S exclusion could lead to high panicle development then it is surprising that its exclusion led to a whooping loss of 20% yield. Could it be that some panicles were not productive. The application of micronutrients as a single or in a combination has been reported to improve panicle number (Johnson *et al.,* 2005).

Tillering of a plant depends on the genotype, environment and plant nutrition. The data showed that secondary and micro nutrients had significant effect on number of tillers per unit area. The maximum number of tillers was recorded in treatments receiving all the secondary and micro nutrients together with NPK. However Hussain *et al*. (2005) reported that micronutrients had no significant effects and observed non-significant difference in total number of tillers per plant and number of fertile tillers per plant in response to applied micronutrients. But, the studies carried out in IRRI (2000) indicated that zinc application activates and increases tillering capacity in rice due to improved enzymatic activity. Dell and Huang (1997) reported that boron application increases leaf expansion and thereby the photosynthetic capacity of plants. Correa *et al*. (2006) observed that appropriate boron availability in soils favor root growth, and a sufficient supply of this micronutrient is very important for adequate rice development.

This study has also shown that secondary and micro nutrients greatly influenced number of tillers in rice production. Paddy yield is composed of various yield components such as number of panicles, spikelet per panicle, normal kernels and 1000-grain weight. The supplementation of micronutrients and Mg to the NPK improved yield than when only one is lacking. The traditional application of NPK to rice is not adequate to give optimal yield as yield loss up to 35% was recorded. If micronutrients are not available; the application of sulphur alone should not be avoided as it can lead to loss of up to 20%. It appears that potassium exclusion in lowland rice production will not be harmful to rice. The biomass production also followed the pattern of paddy yield. The pronounced effects of Zn on straw yield of rice agreed with the finding of Abedin *et al.* (1994). Caphale and Badole (1999) reported higher paddy yield when NPK was applied with Zn in combination. Previous findings also revealed that the application of zinc fertilizer not only increased yield, but also zinc concentration in rice seed (Genc *et al*., 2004). Boron is basically involved in several biochemical processes including carbohydrate metabolism, sugar transport, nucleotide synthesis, respiration and pollen viability; therefore its deficiency directly affect panicle production and enhance paddy yield. The sole application of boron is reported to as effective as its combination with NPK or other micronutrients. Dunn *et al.* (2005) obtained higher paddy yield with the sole application of boron. Chaudry *et al*. (2007) stated that boron application along with basal dose of NPK significantly increased yield. Moreover, by supplying plants with secondary and micronutrient, either through soil application, foliar spray, or seed treatment, increases yield and quality and macronutrients use efficiency (Imtiaz *et al.,* 2006). Salim *et al.* (2011) recommended that adequate boron supply is necessary for obtaining high yields and good quality of agricultural crops.

Conclusion

Paddy yield and biomass increased with application of secondary nutrients and micronutrients together with NPK. Sulphur is the single most important secondary nutrient whose exclusion caused yield loss of 20%. Sulphur exclusion promoted panicle yield development and caused 20% yield loss. Therefore, further experiment should be conducted to find the reason behind this.

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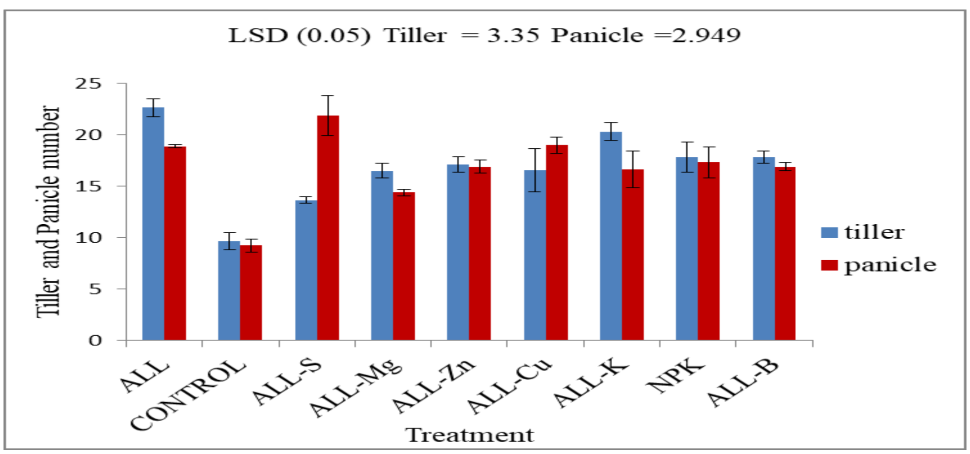

Figure 1: Treatments impact on panicle and tiller number

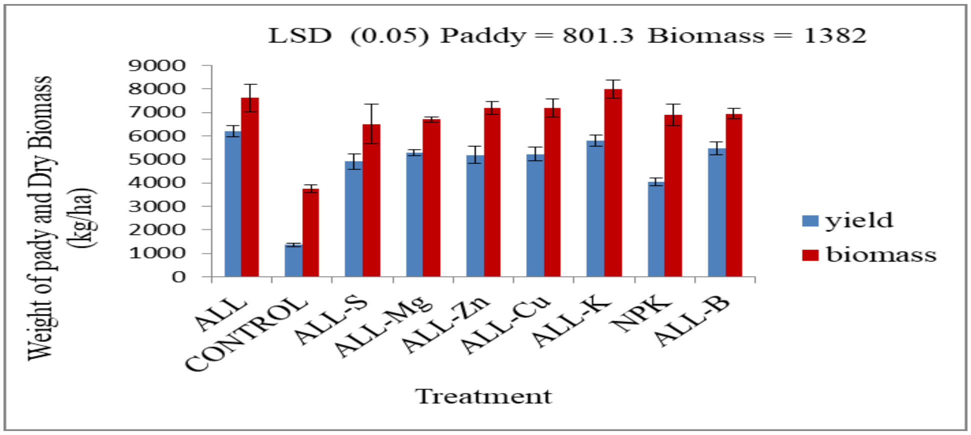

Figure 2: Treatments impact on Paddy and biomass yield

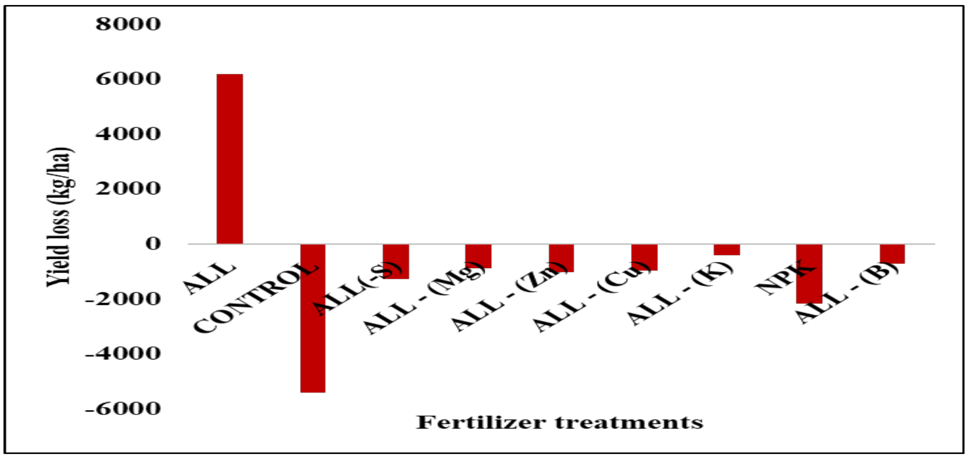

Figure 3: Yield loss on secondary and micronutrient omission from fertilizer application