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Influence of Zinc on the yield and nutrition of wet season rice (*Oryza sativa*) grown under aeric endoaquept

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ABSTRACT

A field experiment on wet season *kharif* rice (*Oryza sativa* L.) cv IET 4094 was conducted during the year 2010-11 and 2011-12 in an aeric endoaquept to study the influence of applied zinc on the growth, yield and nutrition of rice. The results show that the application of chelated zinc (Zn-EDTA) increased N, P, K and Zn concentration in dry matter and grains of rice. The highest amount of N, P,K and Zn in rice dry matter and grain have been found to be recorded in the treatment where the recommended levels of NPK (80:40:40) and chelated zinc in two splits (one at basal and the second one at grand tillering stage) were applied. The percent increase in the yield of grain (43.20) and straw (68.50) were also recorded highest in the treatment where Zn-EDTA was applied in two splits (0.5 kg/ha as basal + 0.5 kg/ha at grand tillering stage) over that of the control, while that of the same percent increase of the applied Zn–EDTA was highest in rice grain yield (18.40) over that of the corresponding highest level of $ZnSO_4.7H_2O$ (20 kg/ha) at two splits.

Key words: Nutrition, Rice, Yield, Zinc

To maintain self-sufficiency in rice (*Oryza sativa* L.) because of India's increasing population it is important to boost the production of rice. The production of rice should be increased by 50% within 2025.

This additional production of rice will have to be done on less land with less water, labour and chemicals (Zheng *et al.* 2004). But the soils of India have become poor in fertility status because of continual and steady nutrient mining from the soil with the use of modern agro techniques coupled with high yielding varieties. As a result of which , soils are becoming deficient in not only with major and secondary nutrients but also with micronutrients especially with zinc for rice grown under submerged puddled conditions. Therefore, it was felt necessary to undertake the study on the influence of zinc on the yield and nutrition of wet season rice.

MATERIALS AND METHODS

A field experiment was conducted on rice cv IET 4094 (Khitish) during wet season of 2010-2011 and 2011-2012 in an aeric endoaquept under submerged puddled condition of old alluvial soil of the Kandi Sub-Divisional Adaptive Research Farm, Murshidabad with different doses and sources of Zn along with recommended doses of NPK application. The traditional method of rice cultivation was followed where 30 days old seedlings were transplanted in flooded plots with 2-3 seedlings per hill at 20 cm × 10 cm spacing. Initially the soil sample was collected at 0-15 cm depth and recorded a pH value of 7.01 and 7.00, EC - 0.11 and 0.15 dS/m, organic carbon 0.48 and 0.54% , 215.88 and 221.61 kg/ha available nitrogen, 42.07 and 47.01 kg/ha available phosphorus, 96 and 113 kg/ha available potassium, 0.52 and 1.53 mg/kg DTPA extractable zinc during 2010-2011 and 2011-2012 respectively. The site of the experiment was divided into three distinct blocks within which each treatment was replicated thrice in a randomized block design (RBD). The eight treatments were ; T_1 - control (no Zn) with recommended doses of NPK, T_2 - NPK as recommended + Zn as $ZnSO_4.7H_2O$ at 10 kg/ha as basal, T_3-NPK as recommended + Zn as $ZnSO_4.7H_2O$ at 5 kg/ha as basal + Zn as $ZnSO_4.7H_2O$ at 5 kg/ha as top dressing at grand tillering stage, T_4 - NPK as recommended +20 kg/ha Zn as $ZnSO_4.7H_2O$ as basal, T_5 - NPK as recommended +10 kg/ha Zn as $ZnSO_4.7H_2O$ as basal+ 10 kg/ha Zn as $ZnSO_4.7H_2O$ as top dressing at grand tillering stage, T_6 - NPK as recommended + Zn at 0.5 kg/ha as Zn-EDTA as basal, T_7 - NPK as recommended + Zn at 1 kg/ha as Zn-EDTA as basal and T_8 - NPK as recommended +Zn at 0.5 kg/ha as Zn-EDTA as basal + 0.5 kg/ha Zn as Zn-EDTA as top dressing at grand tillering stage. Urea, SSP (Single

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superphosphate) and MOP (Muriate of potash) along with $ZnSO_4.7H_2O$ and Zn-EDTA were used as sources of N, P, K and Zn respectively. The recommended dose of N: P_2O_5 : K_2O were 80:40:40 kg/ha respectively. The uptake of nutrients by rice dry matter were periodically analyzed. The plant samples were analyzed for N, P, K and Zn following the method described by Jackson (1973). Fisher's (1960) method of analysis of variance was applied for the analysis of the data.

RESULTS AND DISCUSSION

Nutrient Uptake by rice dry matter

Nitrogen

The results (Table 1) revealed that the pooled uptake of nitrogen by rice dry matter had been found to be progressively increased up to maturity stage irrespective of treatments. However, the magnitude of such increase varied with the treatments, being highest in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA . Such increase might be due to the consistent supply of Zn resulting from its split application. At the later growth stages of rice , the amount of N uptake was recorded an increase which might be due to the greater biomass production of as well as increased absorption. Sreenivas *et al.* (2000) and Bokhtiar and Sakurai (2005) also reported similarly.

The results further envisaged that although the absolute amount of nitrogen uptake had been found to be increased progressively, but the percent increase of the nitrogen uptake had been found to be decreased progressively over that of the control, no application of Zn. The highest percent increase of nitrogen uptake by rice dry matter was maintained at panicle initiation (116.23) , grain filling (103.45) and at maturity stage (95.13) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA.

With regards to sources of Zn, it was observed that the application of Zn-EDTA was always found superior for the uptake of nitrogen over that of $ZnSO_4.7H_2O$ irrespective of modes of application. Relatively higher uptake of nitrogen was recorded as 193.82 kg/ha at the panicle initiation stage in the treatment T_7 where NPK was applied as recommended along with basal application of Zn at 1 kg/ha as Zn-EDTA over that of T_4 treatment where NPK was applied as recommended along with the basal application of 20 kg/ha Zn as $ZnSO_4.7H_2O$ which suggested that the chelated form of Zn played a greater role for the increased uptake of nitrogen compared to $ZnSO_4.7H_2O$. The greater efficiency of chelated form of Zn (Zn – EDTA) for the nitrogen uptake by rice dry matter might be due to the greater availability of Zn in the soil solution interacting with the nitrogen positively causing its greater absorption by rice dry matter (Das 1996).

Phosphorus

The results (Table 2) revealed that the pooled uptake of phosphorus by rice dry matter had been found to be progressively increased up to maturity stage irrespective of treatments. However, the magnitude of such increase varied with the treatments, being highest in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA which was closely followed by the treatment T_7 where NPK was applied as recommended along with the basal application of Zn at 1 kg/ha as Zn-EDTA. The magnitude of such increase was attributed to the steady supply of Zn resulting from its split application. Sahu *et al.* (1996) and Duhan and Singh (2002) also reported similarly which confirmed the results of the present investigation where the application of Zn significantly increased the uptake of P by the rice dry matter.

The results further revealed that although the absolute amount of phosphorus uptake was found to be increased progressively, but the percent increase of the phosphorus uptake has been found to be decreased progressively over that of the control, no application of Zn. The maximum percent increase of phosphorus uptake by rice dry matter was maintained at panicle initiation (301.06) than that of the grain filling (262.04) and maturity stages (221.51) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA.

With regards to the sources of Zn it was observed that the application of Zn-EDTA application was found superior than that of $ZnSO_4.7H_2O$ irrespective of modes of application. The results further show that the amount of P uptake was recorded highest as 103.27, 108.74 and 114.92 kg/ha at panicle, grain filling and maturity stages respectively in the treatment T_8 where NPK was applied as recommended (80 : 40 : 40) along with two split application of Zn – EDTA on 50 : 50 basis. The results suggests that the chelated form of Zn played a significant role for the uptake of P by rice dry matter compared to $ZnSO_4.7H_2O$ which might be attributed to the greater biomass production due to Zn – EDTA application (Das 2007).

Potassium

The results (Table 3) showed that the pooled uptake of potassium by rice dry matter has been found to be progressively increased up to maturity stage irrespective of treatments. However, the magnitude of such increase varied with the treatments, being maintained highest (157.02, 200.35 and 271.39 kg/ha at panicle initiation, grain filling and maturity stages respectively) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA which was closely followed by the treatment T_7 where NPK was applied as recommended along with the basal application of Zn at 1 kg/ha as Zn-EDTA . The magnitude of such increase in potassium might be attributed to the consistent supply of Zn resulting from its split application. The results were in conformity with the results reported by Sur (2007) who found that the pooled uptake of K by rice dry matter was increased due to combined application of K and N along with Zn – EDTA resulting from the synergistic effects among themselves.

The results further envisaged that although the absolute amount of potassium uptake increased progressively, but the percent increase of the potassium uptake has been found to be decreased progressively over that of the control, no application of Zn. The highest percent increase of potassium uptake by rice dry matter was also maintained at panicle initiation (70.28) followed by grain filling (29.86) and at maturity stage (20.85) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage @ 0.5 kg/ha) as Zn-EDTA.

With regards to sources of Zn, it was observed that the application of Zn-EDTA was always found superior over that of $ZnSO_4.7H_2O$ irrespective of modes of application for maintaining K in the rice dry matter. The results also suggest that the chelated form of Zn played a greater role for the increase in the uptake of potassium by rice dry matter compared to $ZnSO_4.7H_2O$. The greater efficiency of chelated form of Zn (Zn – EDTA) for the potassium uptake by rice dry matter might be due to the greater availability of Zn in the soil solution interacting with the potassium positively causing its greater absorption (Das 2007).

Zinc

The results (Table 4) revealed that the pooled uptake of zinc by rice dry matter has been found to be progressively increased up to maturity stage irrespective of treatments. However, the magnitude of such increase varied with the treatments, being highest (136.88, 144.78 and 148.03 mg/kg at panicle initiation, grain filling and maturity stages respectively) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA . The magnitude of such increase might be attributed to the consistent supply of Zn as well as greater amount of available Zn in the soil solution resulting from its split application. Naik and Das (2008) also reported similarly who showed greater Zn concentration in rice dry matter when Zn – EDTA was applied.

The results further revealed that although the absolute amount of zinc uptake increased progressively, but the percent increase of the zinc uptake has been found to be decreased progressively over that of the control, no application of Zn. The maximum percent increase of zinc uptake by rice dry matter was maintained at panicle initiation (131.41) closely followed by grain filling (121.53) and at maturity stage (115.11) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA.

With regards to sources of Zn it was observed that the application of Zn – EDTA was superior than that of $ZnSO_4.7H_2O$ application irrespective of the modes of application. The results suggest that the chelated form of Zn played a great role for the increase in the uptake of zinc compared to $ZnSO_4.7H_2O$. Split application of Zn – EDTA was found superior with respect to the Zn content in rice dry matter compared to split application of $ZnSO_4.7H_2O$. The results also find support from the results reported by Karak *et al* (2006). The possible explanation for the greater efficiency of Zn – EDTA for the uptake of Zn by rice dry matter might be ascribed by the greater amount of Zn in the soil solution causing its greater absorption (Das 2007).

Uptake of N, P, K, Zn by rice grain and yield of rice

The results showed that the pooled uptake of N, P, K and Zn by rice grain had been found to be increased significantly with different treatments, being highest uptake of N (75.82 kg/ha), P (139.10 kg/ha), K (246.83 kg/ha) and Zn (147.64 g/ha) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA which was closely followed by the treatment T_7 where NPK was applied as recommended along with the application of Zn (at 1 kg/ha as basal) as Zn-EDTA . Such increase might be due to the higher grain yield resulting from the greater uptake of those nutrients.

As regards to sources of Zn and modes of their applications (both the split and basal application of Zn – EDTA and $ZnSO_4.7H_2O$) the uptake of N, P , K and Zn was higher with both basal and split application of Zn – EDTA compared to $ZnSO_4.7H_2O$. The results of the present investigation were in agreement with the findings of Das *et al.* (2002) and Karak *et al*. (2005 and 2006) who showed that the application of Zn-EDTA at its different levels and modes exhibited greater Zn uptake by rice .

The results (Table 5) revealed that the pooled grain and straw yield of rice was recorded highest (at 6.05 and 8.27 t/ha respectively) in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one as basal at 0.5 kg/ha and the other at grand tillering stage with 0.5 kg/ha) as Zn-EDTA. It is interesting to note that the application of Zn – EDTA as basal and split application was recorded always higher with respect to the grain and straw yield of rice compared to that of the basal and split application of $ZnSO_4.7H_2O$ which might be ascribed by the greater amount of Zn available in the soil solution at the former Zn fertilizer . The results (Table 6) further show that the highest benefit:cost ratio was recorded as 4.98 in the treatment T_8 where NPK was applied as recommended along with two splits of Zn (one at basal at 0.5 kg/ha and the other at grand tillering stage at 0.5 kg/ha) as Zn-EDTA which was followed by treatments T_6 and T_7 where NPK was applied as recommended along with the basal applications of Zn at 0.5 and 1 kg/ha Zn as Zn- EDTA respectively. The results are in conformity with the results reported by Naik and Das (2007 b) and Naik and Das (2008) who showed that the highest yield of grain and straw was 5.5 and 7.3 tonnes/ha respectively due to basal application of Zn at 1 kg/ha as Zn-EDTA with the benefit cost ratio of 1.69.

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