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Article

Effect of zinc supplied from two different sources on the growth, yield and zinc uptake of rice (cv. BRRI dhan49)

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Abstract: The field experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during Aman season of 2014 to study the influence of different levels of zinc applied from two sources on the yield and Zn uptake of BRRI dhan49. The soil was silt loam in texture having pH 6.8, organic matter 2.72%, total N 0.151 %, available P 4.00 mg kg^{-1}, available K 0.08 cmol kg^{-1}, available S 15.9 mg kg^{-1} and available Zn 0.90 mg kg^{-1}. The experiment was laid out in a randomized complete block design with three replications. There were seven treatments with different rates of Zn viz. T_1: Zn0, T_2: Zn1 as ZnO, T_3: Zn2 as ZnO, T_4: Zn3 as ZnO, T_5: Zn1 as $ZnSO_4$, T_6: Zn2 as $ZnSO_4$, and T_7: Zn3 as $ZnSO_4$ where 0, 1, 2 and 3 represent the rate of Zn in kg ha^{-1}. Recommended doses of N, P, K and S fertilizers were added to all plots and they were used in the form of urea, TSP, MoP and gypsum, respectively. Addition of Zn had significant effect on the grain and straw yields of BRRI dhan49. Application of ZnO at 3 kg ha^{-1} (T_4) produced the highest grain (5294 kg ha^{-1}) and straw (6567 kg ha^{-1}) yields. The control treatment (Zn0) produced the lowest grain (3183 kg ha^{-1}) and straw (3614 kg ha^{-1}) yields. The other plant parameters such as panicle length, tillers $hill^{-1}$ and grains $panicle^{-1}$, but not plant height and 1000-grain weight were also influenced significantly by the application of zinc. Zn concentration and uptake by BRRI dhan49 were also influenced by the addition of Zn. The total Zn uptake by the BRRI dhan49 varied from 173 g ha^{-1} in control to 353 g ha^{-1} in T_4. Thus, results suggest that application of ZnO @ 3 kg ha^{-1} along with NPKS at recommended rates needs to be applied for achieving higher yield of aman rice in Old Brahmaputra Floodplain Soil.

Keywords: zinc; yield; Zn uptake; BRRI dhan49

1. Introduction

Rice (*Oryza sativa*) is a leading cereal crop in the world. It is the staple food crop in Bangladesh contributing to above 90% of total grain production and covering more than 65% of the total calorie intake of people. An average yield rate of rice in financial year 2013-14 was estimated 3.97metric tons per hectare which is 0.58% higher than that of previous year (BBS, 2014).

Soil is an original supplier of nutrients for plant growth and it is a very important factor determining rice yield. As the population pressure to grow more rice from the limited agricultural land, the soils have become under the threat of nutrient depletion and thus, the sustainability of the cropping systems under the present soil and crop management practices face a great challenge. For adoption of high production technology followed by high cropping intensity, the soils of Bangladesh are depleted of many essential nutrients including micronutrients with almost no return from organic recycling. The use of chemical fertilizer as a supplemental source of nutrients has been increasing steadily in Bangladesh, but usually they are not applied in balanced proportions by most of the farmers (FRG, 2012). Increasing cropping intensity, cultivation of modern varieties, use of imbalanced doses of chemical fertilizers, nutrient leaching and soil erosion are mainly responsible for nutrient depletion in soils.

Fertilizer is playing a vital role in crop production in Bangladesh because deficiency of several nutrients viz. N, P, K, S and Zn is now widespread. Before 1980s, deficiency of NPK was a major problem in Bangladesh soils, and thereafter along with NPK, deficiency of Zn is frequently reported (Hossain *et al*., 2008). Although requirement of micronutrients is small compared to macronutrients, still any micronutrient deficiency can limit crop production with deterioration of crop quality. Need for micronutrient fertilization in soil is increasing, yet the proportion of different fertilizer used in the country is not quite balanced. An imbalance (deficiency or toxicity) of an element results in nutritional disorder or abnormality as retarded growth or low grain yield.

Zinc plays an important role in different metabolic processes in plant. Zinc deficiency is widespread in Bangladesh and is prominent in calcareous and wetland rice soils (Alam *et al*., 2000). The use of both macro and micro nutrients including Zn is an important factor for rice cultivation and these essential nutrients should be used in correct doses for increasing soil fertility and crop productivity.

Soil is not an inexhaustible store of plant nutrients. The goal of sustainable crop productivity in an area can be achieved through a constant monitoring and correcting the existing and emerging nutrient deficiencies. So we need efficient fertilizer management practices to achieve a profitable yield of rice.

Chemical fertilizers are likely to be even more costly in near future. The actual recommended rates of N, P, K, S and Zn not only maintain soil health for sustainable agriculture but also save part of the cost of crop production. In addition, global environmental pollution can be reduced by application of reduced rates of fertilizers.

Hence, the prevailing situation underscores the need for a research to investigate the effects of micronutrients, especially zinc on the growth, yield and nutrient content of rice. Considering the above facts, the present study was undertaken to evaluate the influence of different sources of Zn application on the growth and yield components of T. Aman rice (BRRI dhan49) and to examine the effect of added Zn from different sources on the yield and zinc uptake by BRRI dhan49.

2. Materials and Methods

2.1. Experimental site and soil

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University farm, Mymensingh in T. Aman season of 2014. The soil was silt loam in texture having pH 6.8, total N 0.15%, available P 4 ppm, available S 15.9 ppm, available K 0.08 cmol kg^{-1}, available Zn 0.90 ppm and soil organic matter 2.72 %.

2.2. Experimental design, crop and treatment combinations

The experiment was laid out in a randomized complete block design with three replications of each treatment. T. Aman rice cv. BRRI dhan49 was used as a test crop. Thirty-five-days-old seedlings were transplanted in the experimental plots. There were three Zn rates – 1, 2 and 3 kg ha^{-1} supplied from ZnO and $ZnSO_4$ which formed seven treatment combinations; T_1 (Zn0), T_2 (Zn1 as ZnO), T_3 (Zn2 as ZnO, T_4 (Zn3 as ZnO), T_5 (Zn1 as $ZnSO_4$), T_6 (Zn2 as $ZnSO_4$) and T_7 (Zn3 as $ZnSO_4$).

2.3. Fertilizer application and intercultural operations

Full amount of TSP, MoP, gypsum, zinc and sulphate were added during final land preparation. Urea was applied in three equal splits - the first split after seven days of transplanting, the second split at active tillering stage and the third split at panicle initiation stage. Weeding and other management practices were performed as and when required. Irrigation was also done whenever required.

2.4. Crop harvesting and data recorded

The crop was harvested at full maturity. Grain and straw yields and plant parameters were recorded.

2.5. Laboratory analysis

Chemical analysis of plant and soil samples was done in the Department of Soil Science, BAU. All the elements i.e. P, K, S and Zn were determined from the single digest (Yoshida *et al.*, 1976). The concentration of Zn in the digest was measured directly by atomic absorption spectrophotometer (AAS) at 213.9nm wavelength.

2.6. Statistical analysis

Data were compiled and tabulated in proper form for statistical analysis. All plant data were analyzed statistically by F-test to examine the treatment effects and the mean differences were adjudged by Duncan’s Multiple Range Test (DMRT) at 5% level (Gomez and Gomez, 1984) and their ranking was indicated by small letters.

3. Results and Discussion

3.1. Growth and yield components of rice

All yield attributes of BRRI dhan49 except plant height and 1000-grain weight were significantly influenced by the zinc application (Table 1). The maximum number of effective tillers hill^{-1} of 17.4 was observed in T_6 (Zn2 as $ZnSO_4$) which was statistically similar with T_3 (Zn2 as ZnO) while the minimum number of tillers hill^{-1} of 12.0 was found in T_1 (Zn0). Panicle length due to different rates of Zn application varied from 15.17 to 21.77 cm. The highest panicle length (21.77 cm) was observed in T_5 (Zn1 as $ZnSO_4$) which was identical with all other treatments except control and the lowest panicle length (15.17 cm) was noted in the control (Zn0). The highest number of grains panicle^{-1} was observed in T_7 (Zn3 as $ZnSO_4$) which was statistically similar with T_4 (Zn3 as ZnO) and the lowest value was found in T_1 (Zn0). So, the addition of Zn had a positive effect on the number of grains per panicle. This parameter largely contributed to the grain yield of the BRRI dhan49. The results are in agreement with Panhwar *et al. (*2015) who demonstrated that most of the yield components of rice were influenced significantly by the application of Zn, Cu and Mo.

3.2. Grain yield

The grain yield of BRRI dhan49 responded significantly to application of Zn supplied from ZnO and $ZnSO_4$ (Table 2). The highest grain yield of 5294 kg ha^{-1} was obtained in T_4 (Zn3 as ZnO) which was 43.7% higher than control .The lowest grain yield (3683kg ha^{-1}) was found in T_1 (control). The grain yield obtained from all the treatments except T_4 and T_1 were statistically similar. The grain yield produced by different treatments may be ranked in the order of $T_4>T_2>T_7>T_3>T_6>T_5>T_1$. The Zn supplied from ZnO performed better than that supplied from $ZnSO_4$. These findings are well corroborated with a number of researchers who reported positive effect of added Zn on rice yield (Hoque *et al.*, 1994; Akhter *et al.*, 1994; Panhwar *et al.,* 2015). Islam *et al.*, (1997) also observed that application of Zn increased the grain yield of rice by 15%.

3.3. Straw yield

Like grain yield, the straw yield of BRRI dhan49 also responded significantly to application of Zn. The straw yield showed comparable variation among the treatments (Table 2). The highest straw yield (6567 kg ha^{-1}) was observed in T_4 (Zn3 as ZnO) which was 63.6% higher over control whereas the lowest straw yield (3614kg ha^{-1}) was found in T_1 (Zn0). The straw yield produced by different treatments had the following order: $T_4>T_2>T_6>T_5>T_7>T_3>T_1$.

3.4. Zinc content and uptake

The Zn content and uptake by BRRI dhan49 grain and straw were significantly influenced due to added Zn (Table 3). The grain Zn content was found to vary from 26.85 to 54.38 ppm while in straw it varied from 44.25 to 62.77 ppm. The zinc uptake by rice grain and straw ranged from 110 to 287 g ha^{-1} and 165 to 353 g ha^{-1}, respectively. The total uptake of Zn by BRRI dhan49 also demonstrates an increase due to Zn addition over control. This result is supported by Saddika (2013), Carolina *et al*. (2011) and Wankhade *et al*. (1996) who observed that application of Zn markedly increased their respective concentration and uptake by the rice crops.

Table 1. Effects of Zn application on the growth and yield parameters of BRRI dhan49.

Treatments	Plant height (cm)	Tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000-grain weight (g)
T_1 (Zn0)	73.00	12.07e	15.17b	53.30d	21.64
T_2 (Zn1 as ZnO)	74.67	14.87bc	20.87a	59.00bc	21.83
T_3 (Zn2 as ZnO)	73.73	16.07ab	21.63a	57.70bcd	21.73
T_4 (Zn3 as ZnO)	75.60	12.20e	20.03a	62.40ab	21.65
T_5 (Zn1 as $ZnSO_4$)	75.87	14.20cd	21.77a	55.93cd	21.65
T_6 (Zn2 as $ZnSO_4$)	75.73	17.40a	20.63a	54.96cd	22.24
T_7 (Zn3 as $ZnSO_4$)	74.27	12.87de	21.16a	65.16a	22.10
CV	2.41	6.22	4.59	4.98	4.11
SE(±)	1.045	0.512	0.536	1.678	0.517
Sig. Level	NS	***	***	**	NS

In a column, the values having common letters are not significantly different at 5% level by DMRT.
The values with Zn (1, 2, 3) represent the rate of Zn in kg ha^{-1}
CV = Coefficient of variation, SE (±) = Standard error of means
** = Significant at 1% level *** = Significant at 0.1% level; NS = not significant

Table 2. Grain and straw yields of BRRI dhan49as influenced by Zn fertilizers.

Treatments	Grain yield (kg ha^{-1})	%increase over control	Straw yield (kg ha^{-1})	%increase over control
T_1 (Zn0)	3683e	_	4014d	_
T_2 (Zn1 as ZnO)	4820d	30.8	5666b	41.1
T_3 (Zn2 as ZnO)	4387cd	19.1	4603c	14.7
T_4 (Zn3 as ZnO)	5294a	43.7	6567a	63.6
T_5 (Zn1 as $ZnSO_4$)	4317d	17.2	4675c	26.9
T_6 (Zn2 as $ZnSO_4$)	4374cd	18.7	5640e	40.5
T_7 (Zn3 as $ZnSO_4$)	4636bc	25.9	4667c	16.2
CV	3.56	-	2.93	-
SE(±)	91.03	-	85.62	-
Sig. level	***	-	***	-

In a column, the values having common letters are not significantly different at 5% level by DMRT.
The values with Zn (1, 2, 3) represent the rate of Zn in kg ha^{-1}
CV = Coefficient of variation, SE (±) = Standard error of means
*** = Significant at 0.1% level

Table 3. Effects of zinc application on the Zn content and uptake by BRRI dhan49.

Treatments	Zn content (ppm)		Zn uptake (g ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_1 (Zn0)	26.86e	44.25c	110.97e	165.00c	275.93e
T_2 (Zn1 as ZnO)	34.82cd	57.44ab	129.40dc	325.07a	454.53c
T_3 (Zn2 as ZnO)	27.19e	57.59ab	119.73dc	264.80b	384.53d
T_4 (Zn3 as ZnO)	54.38a	51.97b	287.67a	341.33a	629.03a
T_5 (Zn1 as $ZnSO_4$)	45.45b	59.79a	196.20b	279.13b	475.37c
T_6 (Zn2 as $ZnSO_4$)	36.91c	62.76a	161.17c	353.87a	515.03b
T_7 (Zn3 as $ZnSO_4$)	30.19dc	56.26ab	140.33d	262.63b	402.97d
CV (%)	7.52	7.21	7.09	6.69	4.07
SE (±)	1.59	2.32	6.70	10.90	10.53
Sig. level	***	**	***	***	***

CV = Coefficient of variation, SE (±) = Standard error of means
** Significant at 1% level; *** Significant at 0.1% level
In a column, the values having common letter are not significantly different at 5% level by DMRT

4. Conclusions

The present study demonstrates that application of zinc supplied from ZnO and $ZnSO_4$ markedly influenced the growth and yield of BRRI dhan49. The effect of ZnO was better than that of $ZnSO_4$ in increasing yield of BRRI dhan49. The results suggest that application of ZnO @ 3 kg ha^{-1} along with NPKS at recommended rate is imperative to achieve higher yield of BRRI dhan49 at BAU farm and the adjacent areas under AEZ 9. Such field trials need to be carried out across the country to recommend the optimum rates of Zn application for rice and other crops.

Conflict of interest

None to declare.

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