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Effect of Rate and Method of Zinc Application on Growth and Yield of Aus Rice

[1]Mahmoda Begum, Mohammad Noor, [2]Hossain Miah and [3]Md. Mainul Basher
[1]Bangladesh Agriculture Development Center, Sylhet,
[2]Bangladesh Institute of Nuclear Agriculture, P.O. Box No. 4, Mymensingh 2200,
[3]Soil Resource Development Institute, Mymensingh, Bangladesh

Abstract: A field experiment was conducted during the Kharif, 1999, to see the effects of rate and method of Zn application in transplant aus rice (cv. BR26). There were nine treatments viz., 0, 2.5, 5, 7.5 kg ZnO ha^{-1} as soil application, seedling root dipping in 1, 2 and 3% ZnO solution and foliar spraying of 0.65 and 0.80 kg ZnO ha^{-1}. Recommended doses of NPK fertilizers were applied. The Zn treatments increased significantly the grain and straw yields over control. Dipping seedling roots in 2% ZnO suspension for 24 hours gave the best economic return and its grain yield was 3.80 t ha^{-1} which was statistically identical to the yields (3.82 and 3.81 t ha^{-1}) of soil application of 5 and 7.5 kg ZnO ha^{-1}, respectively. Dipping seedling roots in Zn suspension was found to be a good practice for its easy and less cost.

Key words: Zinc, application, rate, method, aus rice

Introduction

Intensification of cropping system with only higher doses of major NPK fertilizers has resulted in heavy mining of soil leading to deficiencies of micro as well as macro nutrients. Improper, unbalanced and injudicious application of fertilizers is one of the major hurdles to increase rice yield. In this situation zinc is now-a-days becoming a growing concern for rice field. On the other hand, Zn is one of the essential plant nutrients needed in sufficient and balanced amount for the normal growth of plants particularly for rice. It serves as enzyme dehydrogenase, carbonic anhydrate and various peptidases and is essential for normal chlorophyll formation, carbohydrate metabolism and synthesis of protein in plants. It is also related to seed production in several plants (Singh and Mitra, 1975). Zinc deficiency has been detected as the third major nutritional problem in the soil of Bangladesh after nitrogen and phosphorus Ahmed *et al.*(1981). Its importance and growth limiting effects on wetland rice are said to be increasing in Asian agriculture (Ponnamperuma, 1982). To mitigate this limiting effect, Zn may be applied by different methods, such as soil application, foliar application, dipping seedling roots in solution etc. Generally it is believed that its absorption in rice occurs at an early growth stage. If sufficient quantity of zinc is taken up by rice seedling before transplanting, it may not require supplementary zinc application and for this reason perhaps roots of rice seedling are treated with Zn solution before transplanting (Katyal and Ponnamperuma, 1974). Yoshida *et al.* (1970) studied several methods for correcting Zn deficiency in rice and concluded that soil or foliar application of $ZnSO_4$ was as effective as dipping seedling roots in 1% ZnO suspension but the cost of the later method was cheaper. Besides, dipping seedling roots in ZnO solution before transplanting reduced the incidence of “Kresek” (Mew *et al.*, 1979). Reports are available that foliar spraying of $ZnSO_4$ is also useful against ‘Khaira’ disease in rice (Nene, 1966). However, a very few research works has been carried out in relation to Zn application rate and method in Bangladesh especially in aus rice. In view of the above mentioned importance of Zn for rice the present study has been under taken to know the proper rate and method of Zn application and to see its beneficial effect on yield and yield components of aus rice (cv. BRRI Dhan26) under field conditions.

Materials and Methods

The experiment was conducted at the Field Laboratory of the Department of Agronomy, Bangladesh Agricultural University, Mymensingh during Kharif I, 1999. The test crop was BRRI Dhan26 a recommend variety for aus season (BRRI, 2000). The experimental field is located at 24°75′ N latitude and 90°50′ E longitude at a height of 18m above the mean sea level. There were nine Zn treatments viz. T_1 = No Zn application (Control); T_2 = Soil application @ 2.5 kg ZnO ha^{-1} as basal; T_3 = Soil application @ 5.0 kg ZnO ha^{-1} as basal; T_4 = Soil application @ 7.5 kg ZnO ha^{-1} as basal; T_5 = Foliar spraying @ 0.65 kg ZnO ha^{-1} at 3 weeks after transplanting; T_6 = Foliar spraying @ 0.80 kg ZnO ha^{-1} at 3 and 5 weeks after transplanting; T_7 = Dipping seedling roots in 1% ZnO suspension for 24 hours just before transplanting; T_8 = Dipping seedling roots in 2% ZnO suspension for 24 hours just before transplanting and T_9 = Dipping seedling roots in 3% ZnO suspension for 24 hours just before transplanting. The soil was sandy loam and its organic carbon, CEC, total nitrogen, available P, S and Zn were 0.69, 8.2me, 0.11, 11.95, 15 and 2.15ppm, respectively. The soil texture and organic carbon were determined following pipette sampling method and Walkley and Black's wet oxidation method, respectively (Piper, 1950). Total nitrogen was estimated following Semi-Micro Kjeldahl method. The CEC of soil was determined by Na saturation method as outlined by Jackson (1962). Available P was determined from soil with 0.05M $NaHCO_3$ at a nearly constant pH of 8.5 following the methods as outlined by Olsen *et al.* (1954). Available Zn in soil of the experiment field was determined on 0.5 M HCL extractable Zn (IRRI, 1973). The experiment was laid out in RCBD with 4 replications. The unit plot size was 4mx5m. The NPK fertilizers were applied @ 60, 20 and kg ha^{-1} from the sources of urea, triple super phosphate and muriate of potash, respectively. Except N fertilizer, the whole amount of P and K were applied as basal. One third of urea was applied as basal and the rest in two equal splits at 30 days after transplanting (DAT) and at panicle initiation stage (PI) stage, respectively. The crop was harvested at full maturity. Just before harvest, 10 random hills were cut at soil surface level to collect agronomic data on plant height, number of total and effective tillers $hill^{-1}$, panicle length, number of spikelets $panicle^{-1}$, filled and unfilled spikelets $panicle^{-1}$, 1000 grain weight. Grain and straw yields were recorded from the whole plot harvest at maturity. For biochemical analysis of plant parts, three random hills were collected from each plots. Oven dry grain and straw samples were taken in equal amount from four replications of each treatment. These samples were used for chemical analysis to know the levels of protein, N, P and Zn as affected by the treatments. Soil samples were collected one time before transplanting and analyzed following standard methods mentioned earlier. All the data were statistically analyzed using computer package MSTAT and the means were compared by DMRT (Gomez and Gomez, 1984).

Results and Discussion

Plant height: Plant height increased significantly due to application of Zn. The plant height varied from 114.4 cm in soil application of ZnO @ 5 kg ha^{-1} (T_3) to 99.5cm in control (T_1). Soil application of ZnO either as T_3 or @ 7.5 kg ha^{-1} (T_4) or dipping seedling roots in 1 (T_7), 2 (T_8) and 3% solution (T_9) and foliar spraying @ 0.65 kg ha^{-1} (T_5) produced statistically similar plant height. Again foliar spraying of ZnO at as in T_5 and 0.85 kg ha^{-1} (T_6) were found to be statistically identical. The plant height of treatment T_6 and soil application of ZnO @ 2.5 kg ha^{-1} (T_2) were similar but were higher compared to control (Table 1). Yoshida *et al.* (1970) reported similar results.

Total tiller $hill^{-1}$: Effect of different Zn application rate and method significantly affected total tiller production. It varied from 9.15 $hill^{-1}$ in control to 14.25 $hill^{-1}$ in T_3. It could be observed from the results that all Zn treatments produced significantly higher number of tiller $hill^{-1}$ over control (Table 1). These results are in full agreement with those of Ahn *et al.* (1976) and Chowdhury *et al.* (1978). However, dipping seedling roots in 2% ZnO solution (T_8) was at par with soil application as inT_3 and T_4 but superior to rest of the treatments in respect of total tiller production $hill^{-1}$.

Number of effective tiller $hill^{-1}$: Different methods and rates of Zn application had significant influence the number of effective tiller $hill^{-1}$. The highest number of effective tiller $hill^{-1}$ (13.85) was recorded in T_3 while the lowest (7.90) in control. It could be seen from data in Table 1 that the treatments T_3, T_4 and T_8 produced statistically identical effective tiller $hill^{-1}$ whereas treatments T_2, T_5, T_6, T_7 and T_9 had similar number of effective tiller $hill^{-1}$. But all Zn treatments produced significantly higher number of effective tiller $hill^{-1}$ over control (Table 1).

Number of grain $panicle^{-1}$: The number of grain $panicle^{-1}$ of the crop markedly increased due to Zn application. It varied from 115.7 $panicle^{-1}$ in control to 148.8 $panicle^{-1}$ in soil application @ 5 kg ZnO ha^{-1} (Table 1). Besides, other Zn treatments produced significantly higher number of grain $panicle^{-1}$ over control but there were no statistical significant differences among the treatments T_3, T_8 and T_4 although there were only numerical differences.

Grain yield: Grain yield is the main target of crop production. The results of the experiment showed that Zn application exhibited variations on grain yield. The maximum yield was obtained with soil application of 5 kg ZnO ha^{-1} (T_3) but it was statistically identical to the grain yields of the treatments T_4, T_7 and T_8. It revealed that soil application @ 5 and 7.5 kg ZnO ha^{-1} were equally effective as seedling root dipping in 2 and 1% ZnO suspension. These results were in agreement with those obtained by Yoshida *et al.*(1970) and Sharma *et al.* (1982). Dipping seedling roots in 3% ZnO suspension (T_9) produced statistically similar grain yield to the foliar application @ 0.80 kg ha^{-1} (T_6) although there were

Table 1: Effects of rate and method of Zn application on the yield and yield components of aus rice (cv. BR26) and benefit cost ratio (BCR)

Treatments	Plant height(cm)	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Grains panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	B C R
T_1	99.5d	9.15c	7.90c	19.72c	115.7e	17.34	2.55e	3.18f	5.73f	0.398
T_2	110.1c	12.05b	11.19b	21.69b	139.3e	17.60	2.90d	3.25f	6.15e	0.540
T_3	114.4a	14.25a	13.85a	22.85a	148.8a	17.82	3.82a	4.60a	8.38ab	1.035
T_4	113.9ab	13.79a	13.58a	22.85a	147.9a	17.79	3.81a	4.60a	8.49a	1.008
T_5	112.1bc	12.24b	11.65b	21.75b	140.0cd	17.76	3.35c	3.70e	7.05d	0.790
T_6	112.0ab	12.20b	11.27b	22.09ab	140.2bcd	17.72	3.39bc	3.85d	7.24d	0.800
T_7	113.2ab	12.25b	12.00b	22.29ab	142.3b	17.72	3.68abc	3.95c	7.64c	0.965
T_8	113.5abc	13.75a	13.58a	22.79a	146.9a	17.80	3.80ab	4.50b	8.21b	1.049
T_9	112.8ab	12.50b	11.71b	22.12ab	141.9bc	17.71	3.44bc	4.02c	7.71c	0.843
CV(%)	1.28	3.71	4.66	1.74	0.99	1.21	5.04	1.20	1.62	

In a column, figures having similar or no letter(s) do not differed significantly whereas dissimilar letter(s) differed significantly according to DMRT.

Table 2: Effects of rate and method of Zn application on protein, N, P and Zn contents in grain and straw of aus rice (cv. BR26)

Treatments	Grain				Straw		
	Protein (%)	N(%)	P(%)	Zn(ppm)	N(%)	P(%)	Zn(ppm)
T_1	5.95c	1.00c	0.21	30.08c	0.50d	0.09	37.8c
T_2	6.06c	1.02c	0.21	32.87b	0.53cd	0.10	39.3b
T_3	7.14a	1.20a	0.27	34.39a	0.64a	0.15	40.7a
T_4	7.13a	1.20a	0.26	34.25a	0.64a	0.14	40.54a
T_5	6.24bc	1.05bc	0.24	33.60ab	0.56bcd	0.12	39.68b
T_6	6.12c	1.03c	0.23	34.32a	0.53cd	0.13	40.61a
T_7	6.60b	1.11b	0.24	33.79a	0.56bcd	0.14	39.72b
T_8	7.08a	1.19a	0.26	34.03a	0.61ab	0.14	40.49a
T_9	7.08a	1.19a	0.25	33.89a	0.58abc	0.13	39.76b
CV(%)	3.18	3.20	5.64	1.14	2.18	10.42	5.69

In a column, figures having similar or no letter(s) do not differed significantly whereas dissimilar letter(s) differed significantly according to DMRT.

Table 3: Effects of rate and method of Zn application on the total uptake of N, P and Zn in grain, straw and whole plant of aus rice (cv. BR26)

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			Zn uptake (kg ha^{-1})		
	Grain	Straw	Whole plant	Grain	Straw	Whole plant	Grain	Straw	Whole plant
T_1	25.46f	15.80f	41.36g	5.30f	2.86f	8.22d	0.077	0.120	0.197c
T_2	29.56e	17.22e	46.78f	6.09f	2.25ef	9.35d	0.095	0.127	0.222bc
T_3	46.68a	29.58a	76.26a	10.50a	6.94a	17.44a	0.135	0.188	0.321a
T_4	46.45a	29.58a	76.02a	10.06ab	6.49ab	16.54a	0.132	0.187	0.319a
T_5	34.95d	20.72d	55.95e	8.04de	4.44de	12.48c	0.112	0.147	0.259abc
T_6	34.88d	20.41d	55.29e	7.81e	5.01cd	12.82c	0.116	0.156	0.272ab
T_7	40.88c	22.14c	63.01d	8.83cd	5.53bcd	14.36b	0.124	0.157	0.281ab
T_8	44.51ab	27.27b	71.79b	9.73abc	6.26abc	15.98a	0.127	0.181	0.300a
T_9	43.92b	23.31c	67.23c	9.24bc	5.21bcd	14.45b	0.125	0.160	0.284ab
CV(%)	3.13	2.74	2.60	5.33	11.85	5.64	1.64	1.46	1.15

In a column, figures having similar or no letter(s) do not differed significantly whereas dissimilar letter(s) differed significantly according to DMRT.

numerical differences indicating that dipping seedling roots in ZnO suspension influenced the grain yield more than foliar application. The results of the treatments T_3, T_4, T_8, T_7 were statistically identical to each other. But considering cost factor and easier method of application, the treatments T_8 and T_7 would be preferable because when soil application is done following recommended fertilizer doses, it would not be fully utilized as some will be lost by leaching and some will be unutilized. It may not always be available to the crop due to some soil factors and by other means. Moreover, the amount of fertilizer needed much for soil application and there would be some possible environment pollution by Zn as it is a heavy metal.

Straw yield: Data on straw yield showed significant positive response to Zn application. The straw yield of the treatments T_4 and T_3 was identical (4.6 t ha^{-1}). These results were conformity with the results obtained by Gill and Singh (1978). Dipping seedling roots in Zn solution (T_7, T_8, T_9) resulted in statistically higher yields than foliar application (T_5 and T_6). Again, two times foliar spraying @ 0.80 kg ha^{-1} (T_6) gave statistically higher straw yield than one spraying @ 0.65 kg ha^{-1} (T_5). The lowest straw yield was recorded in control (3.18t ha^{-1}). These results indicated that 5.0 kg ZnO ha^{-1} was optimum for the soils of the experimental field and higher or lower than that would give no better response.

Biological yield: Biological yield of rice (cv.BRRI Dhan26) was significantly influenced by different rates and methods of Zn whether they were applied as seedling roots dipping, soil or foliar spraying. The highest biological yield was (8.49 t ha^{-1}) observed when the plot was treated with soil application @ 7.5 kg ha^{-1}. But it was identically followed by soil application @ 5 kg ZnO ha^{-1} and dipping seedling roots in 2% ZnO suspension (T_8). Bilogical yield of dipping seedling root showed differences with soil application method but the former showed statistically similar results with the foliar spraying method.

Protein content: The highest protein content in grain (7.14%) was found in those plots which received ZnO @ 5 kg ha^{-1} as soil application but was statistically similar to the plots fertilized with soil application of 7.5 kg ha^{-1}, dipping seedling roots in 2 and 3% ZnO solution. Foliar spraying @ 0.60 and 0.80 kg ha^{-1} and soil application @ 2.5 kg ha^{-1} and control showed statistically similar results in respect of protein content in grain (Table 2).

N, P and Zn content and uptake in grain and straw: Various treatments had significantly influenced the contents of N, P and Zn in grain and straw. The results on mineral constituents in grain and straw revealed that N, P and Zn varied from 1- 1.20, 0.21- 0.27%, 30.08- 34.39 ppm and 0.50 - 0.64%, 0.09- 0.15%, 37.87 - 40.78 ppm, respectively (Table 2). It was found that Zn application methods more or less increased the concentration of the above elements in grain and straw over control treatment. It was observed that the effects of rate and method of Zn on the uptake of N, P and Zn both in grain and straw as well as by the whole plant were statistically significant (Table 3). The highest grain N uptake was 46.68 kg ha^{-1} (83.35 % increased over control) noted in T_3 treatment which received soil application @ 5 kg ha^{-1} and this value was statistically similar to T_4 (soil application of 7.5 kg ZnO ha^{-1}) and T_8 (dipping seedling roots in 2 % ZnO suspension). The highest N uptake by straw was 29.38 kg ha^{-1} (86.08 % increased over control) was recorded both in T_3 and T_4. It was also observed that the highest N uptake was 76.26 kg ha^{-1} (84.38 % increased over control) in the treatment T_3 but statistically identical to T_4. The highest grain P and Zn uptake were 10.50 and 0.135 kg ha^{-1}, respectively noted in T_3 and it was statistically similar to T_4 but significantly higher than rest of the treatments. The highest P and Zn uptake in straw were 6.94 kg ha^{-1} (142.84% increased over control) and 0.188 kg ha^{-1}, respectively obtained in T_3 treatment and closely followed by T_4. The other treatments had lower uptake of P and Zn in straw.

Benefit to Cost Ratio (BCR): It was found that high BCR of all treatments were higher over control. It ranged from 0.389 in control to 1.049 in T_8 (Table 1). Among the application methods of Zn, dipping seedling root in 2 % ZnO suspension had the highest BCR followed by T_3 and T_4. Soil application method recorded significantly higher grain yield but failed to show benefit and it might be due to a lot of ZnO wastage through leaching. As dipping seedling roots in ZnO suspension produced similar yield to soil application method and its BCR was high, it could be used to over come Zn deficiency in irrigated rice crop.

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