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Response of Rice to Different Methods of Zinc Application in Calcareous Soil

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Abstract: In a field experiment, comparative effect of three different methods of zinc application was studied, aimed at alleviating Zn deficiency in transplanted flood rice (cv.IRRI.6) grown in alkaline calcareous soil. Three methods were tried i.e. nursery root dipping in 1.0% $ZnSO_4$, 0.20% $ZnSO_4$ solution spray after transplanting and 10 kg Zn ha^{-1} by field broad cast method. Zinc content of soil before flowering and after harvest was increased significantly for all the methods. The yield and yield parameters increased significantly by the application of Zn by any method. Among the methods the effect of Zn was non-significant on yield components like tillers m^{-2}, spikelets $panicle^{-1}$, % filled grains, 1000-grain weight and straw yield. However, soil application of Zn @ 10 kg ha^{-1} was rated superior because it produced significantly higher paddy yield.

Key words: Zinc deficiency, rice, diverse methods, calcareous soil

Introduction

Micronutrient deficiencies are known in Pakistan since more than two decades (Yoshida and Tanaka, 1969; Rashid and Qayyum, 1990). Rice being grown under submergence is strongly affected with micronutrient deficiency particularly with that of Zn (Tahir, 1978; Yoshida and Tanaka, 1969). Due to clayey, alkaline and calcareous nature of soils in Pakistan, fertilizer zinc is mainly adsorbed by soil and very little is available and recovered by plants (Tahir ***et al.***, 1991). Zinc being an expensive fertilizer, must, therefore be applied in such a way that may enhance its availability as well as efficiency in soils. Broadcast and top dressing of Zn along with ZnO coating of seedling root and foliar spray in rice have been found effective methods in earlier investigation (Yoshida ***et al.***, 1970). Dipping the seedlings in 2% $ZnSO_4$ or 25 kg Zn ha^{-1} as basal dressing or spraying 0.5% $ZnSO_4$ solution once or twice to the transplanted crop proved equally effective (Kumar ***et al.***, 1996). The application of $ZnSO_4$ and ZnO have been reported better than fritz for rice and barley production while in light soil, $ZnSO_4$ was better than ZnO for wheat production (Ketyal, 1981). The use of seed bed application of Zn @ 20 kg Zn ha^{-1} in field and green house experiment was proved equally effective or superior to the conventional $ZnSO_4$ broad cast method (Rashid ***et al.***, 2000).

This study was carried out to evaluate the comparative value of three different technologies for managing zinc deficiency in transplanted flooded rice grown in alkaline calcareous soil.

Materials and Methods

A field experiment was conducted at the research area of Faculty of Agriculture, Gomal University D.I.Khan. Thirty days old nursery of a rice variety IRRI-6 was transplanted in standing water. The Randomized Complete Block Design (RCBD) was used with three replication and a plot size of 2 × 5m. Row to row and plant to plant distance was maintained at 20 cm. Following experimental treatments were applied.

Treatments	Description
Control	NPK only @ 120-90-60 kg ha^{-1}
NPK+ $ZnSO_4$	Zn @ 10 kg ha^{-1} as $ZnSO_4$ through soil application.
NPK + $ZnSO_4$	0.20% $ZnSO_4$ solution spray 10 days after transplanting.
NPK + $ZnSO_4$	Root dipping in 1% $ZnSO_4$ solution for five minutes before transplanting.

Table 1: Physico-chemical characteristics of soil

Parameter	Unit	Values
Sand	%	30
Silt	%	50
Clay	%	20
Textural class		Silt loam
pH		8.0
EC	dS/m	3.1
CEC	meq/100g	12.6
CO_3	meq/L	0.5
HCO_3	meq/L	1.7
Cl	meq/L	3.5
$Ca^{++}+Mg^{++}$	meq/L	6.8
Organic matter	%	0.83
Lime	%	22.0
Total nitrogen	%	0.041
Available P	ppm	5.0
Available K	ppm	90.0
Available Zn	ppm	0.42

Half of the nitrogen as urea and whole of phosphorous as TSP and potassium as K_2SO_4 was incorporated before transplanting while remaining N was used at panicle emergence. Physical and chemical characteristics of composite soil samples taken from experimental field were determined according to the methods as described in Methods of Soil Analysis by Page ***et al.*** (1982). DTPA was used to extract available Zn in soil, which was subsequently determined by atomic absorption spectrophotometer. Crop was harvested at maturity and yield parameter was recorded. Paddy yield was calculated at the 14% moisture content. Statistical analysis of all the data was done using Fisher Analysis of Variance Technique and least significant difference test was applied at 5% probability level to determine the difference among treatment means (Steel and Torrie, 1984).

Results and Discussion

Plant height

The data for the plant height of rice as affected by different methods of Zn applications are reported in Table 2. The results showed that application of zinc fertilizer by different methods, increased significantly the height of plants over control. The maximum plant height of 101.0 cm was recorded from the treatment receiving 10 kg Zn ha^{-1} by soil Zn application which did not differ significantly from that of foliar spray receiving 0.20% $ZnSO_4$ but differed significantly from that of root dipping receiving 1.0% $ZnSO_4$ solution. Minimum plant height was recorded in control. Among the methods of zinc application, significantly the maximum plant height of 101.0 cm was obtained with soil dressing which clearly indicated the beneficial effect of soil application of Zn as compared to other methods. Maqsood ***et al.*** (1999) also reported similar results.

Number of tiller m^{-2}

The data regarding the number of tillers m^{-2} presented in Table 2 indicated that the zinc applied by different methods significantly increased the number of tillers m^{-2} over control but were statistically at par with one another. Maximum number of 415.67 tillers m^{-2} was recorded where zinc was applied @ 10 kg ha^{-1} by soil dressing followed by that of 1.0% $ZnSO_4$ by root dipping and 0.2% $ZnSO_4$ by foliar spray. Minimum number of 380.33 tiller m^{-2} was recorded in control. As regards the methods of zinc application, all were statistically similar. The increase in tillering capacity by soil dressing might be due to increase in availability of essential nutrients as compared to other methods. Savithri ***et al.*** (1999) and Yaseen ***et al.*** (1999) reported similar results.

Number of panicle m^{-2}

The data given in Table 2 manifested that the variation in the number of panicle as affected by various methods of Zn application was significant. The results showed that all the methods of zinc application increased the number of panicle m^{-2} as compared to control. Maximum number of 355.67 panicles m^{-2} was recorded in plots receiving 10 kg Zn ha^{-1} by soil dressing which was statistically different from the plots receiving 1.0% $ZnSO_4$ by root dipping and that receiving 0.20% $ZnSO_4$ by foliar spray. The lowest number of 330 panicles m^{-2} was recorded in control which differed significantly from all other treated plots. The maximum number of panicle m^{-2} obtained soil dressing showed the superiority of this method under D.I.Khan conditions. These results are in agreement with those of Savithri ***et al.*** (1999) and Yaseen ***et al.*** (1999).

Table 2: Effect of Zn on the yield components of rice

Treatments	Plant height (cm)	Tiller m^{-2}	Panicles m^{-2}	Spikelets/ panicle	% filled grain
Control (no Zn)	83.5c	380.33b	330.00d	115.33b	80.2b
10 kg Zn ha^{-1} (soil)	101.0a	415.67a	355.67a	131.33a	84.5a
Root dipping (1.0% $ZnSO_4$)	92.4b	405.33a	345.33b	130.67a	84.3a
Foliar spray (0.2% $ZnSO_4$)	96.0ab	400.33a	336.67c	129.33a	84.3a

Mean values with same letters are non-significant at $p \leq 0.05$

Table 3: Effect of Zn on 1000-paddy weight, paddy and straw yield and extractable Zn of soil

Treatments	1000-paddy weight	Straw yeild ton ha^{-1}	Paddy yield ton ha^{-1}	Zn content of soil before flowering	Zn content of soil after harvest
Control (N0 Zn)	20.1b	12.335b	6.116d	0.42c	0.30c
10 kg Zn ha^{-1} (soil)	24.8a	12.480a	9.762a	0.84a	0.74a
Root dipping (1.0% $ZnSO_4$)	24.2a	12.469a	9.180b	0.79ab	0.68b
Foliar spray (0.2% $ZnSO_4$)	23.5a	12.476a	8.583c	0.73b	0.73ba

Mean values with the same letters are non-significant at $p \leq 0.05$

Number of spikelet panicle^{-1}

The results regarding number of spikelets panicle^{-1} (Table 2) manifested that the variation among the various methods was non-significant while zinc fertilization by all the three methods increased the number of spikelets panicle^{-1} significantly over control. The maximum number of 131.33 spikelets panicle^{-1} was recorded where zinc was applied @ 10 kg Zn ha^{-1} by soil dressing followed by that of 1.0% $ZnSO_4$ by root dipping and 0.2% $ZnSO_4$ by foliar spray. The lowest number of 115.33 spikelet panicle^{-1} was recorded in control. Somewhat similar trend has been found in the findings of Hernadez ***et al.*** (1988).

Percent filled grains

The data for percent filled grains as affected by zinc levels applied by different methods presented in Table 2 indicated that zinc fertilization by all the three methods increased the number of percent filled grains significantly over control. The maximum value of 84.5% filled grains was recorded where zinc was applied @ 10 kg Zn ha^{-1} by soil dressing followed by that of 1.0% $ZnSO_4$ by root dipping and 0.2% $ZnSO_4$ by foliar spray. The lowest value of 80.2% filled grains was recorded in control. As regards methods of zinc application, all were statistically at par with one another. Somewhat similar trend has been found in the findings of Hernadez ***et al.*** (1988) and Jalil ***et al.*** (1990).

1000-paddy weight

The data shown in the Table 3 indicated that the effect of Zn applied by different methods on 1000-paddy weight was significant as compared to control. Maximum 1000-paddy weight of 24.8 g was recorded where zinc was applied @ 10 kg Zn ha^{-1} by soil dressing followed by that of 1.0% $ZnSO_4$ by root dipping and 0.2% $ZnSO_4$ by foliar spray. Minimum 1000-paddy weight of 20.19 g was recorded in control. However, there was no significant difference among the methods of Zn application. These results are in agreement with those of Yaseen ***et al.*** (1999).

Straw yield (tones ha^{-1})

The data on the straw yield reported in Table 3 showed that the Zn application by different methods significantly increased the straw yield over control. However, all the methods were statistically at par to one another. The highest straw yield of 12.480 tones ha^{-1} was recorded in the treatment receiving 10 kg Zn ha^{-1} by soil dressing followed by that of 0.2% $ZnSO_4$ by foliar spray and 1.0% $ZnSO_4$ by root dipping. The lowest straw yield of 12.335 tone ha^{-1} was recorded in control. Similar results were reported by Yaseen ***et al.*** (1999).

Paddy yield (tones ha^{-1})

The data on the paddy yield as presented in Table 3 indicated that the maximum paddy yield of 9.762 t ha^{-1} was recorded in plots receiving 10 kg Zn ha^{-1}by soil dressing which was significantly higher than the plots treated with 1.0% $ZnSO_4$ by root dipping and 0.2% $ZnSO_4$ through foliar spray. The increase in paddy yield by soil dressing method was probably attributed to its more effectiveness under conditions of D.I.Khan. Minimum yield of 6.116 tone ha^{-1} was recorded in control, which was due to the non-availability of zinc. Similar results were reported by Shamim ***et al.*** (1991) who reported greater grain yield with soil application of Zn than foliar application. Kumar ***et al.*** (1997) and Savithri ***et al.*** (1999) also reported somewhat similar results.

Zinc content of soil before flowering

Data on zinc content of soil before flowering as influenced by different methods of Zn application (Table 3) revealed that the response to different methods was significant. The highest soil zinc content of 0.84 ppm was recorded in plots treated with 10 kg Zn ha^{-1} to soil which was statistically at par with the plots treated with 1.0% $ZnSO_4$ by root dipping but significantly higher than that of 0.20% $ZnSO_4$ by foliar spray. It showed that soil Zn application increased the soil Zn availability than other methods. The lowest zinc content of 0.42 ppm was recorded in plots where no zinc fertilization was done. All the zinc fertilization applied by different methods increased the soil zinc content over control significantly. Similar results were reported by Ram ***et al.*** (1995).

Zinc content of soil after harvest

The data in Table 3 indicated that response to different method was significant. Maximum soil Zn content of 0.74 ppm was recorded in plots treated with 10 kg Zn ha^{-1} to soil which was statistically at par with the plots treated with 1.0% $ZnSO_4$ by root dipping but significantly higher than that of 0,20% $ZnSO_4$ by foliar spray. It showed that soil Zn application increased the soil Zn availability more than other methods. The lowest Zn content of 0.30 ppm was noted in control. However, the Zn content in the soil was reduced at harvest. Similar result was reported by Ram ***et al.*** (1995) and Asad and Rafique (2000).

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