Pakistan Journal of Applied Sciences 3 (7): 530-536, 2003
ISSN 1607-8926

Effect of Zinc Application by Different Methods on the Chemical Composition and Grain Quality of Rice

M. Umar Khan, M. Qasim, M. Subhan, Riazud Din Ahmad and [1]Liaquat Ali
Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan
[1]Pakistan Academy of Rural Development of Peshawar, Pakistan

Abstract: A field experiment was conducted to evaluate the comparative effect of Zn levels applied by different methods 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. A significant increase in Zn content of rice leaf before and after flowering and a significant decrease in P content of straw and paddy and starch content of paddy was recorded for all the methods. N, K and Zn of paddy and straw and Zn contents of roots increased significantly with the application of zinc irrespective of the methods over control. Soil application of Zn was rated superior because it gave significantly higher content of N in rice paddy.

Key words: Zinc deficiency, rice, chemical composition, different methods

Introduction

Zinc deficiency is the most common problem in the flooded rice. The deficiency of Zn in rice soils of Pakistan has been observed (Tahir ***et al.***, 1979). Zinc deficiency is dramatically manifested by chlorosis, necrosis, early death of seedling or delayed development and reduced crop yields, an explicit information on micronutrient status of rice crop is urgently required. Various investigations have been carried out on the past in this aspect of micronutrient (Tahir ***et al.***, 1986). Zn applied at 100 ppm to nursery or 10 ppm after transplanting or 10 kg ha^{-1} as basal dressing (Yoshida and Tanaka, 1969) proved effective in alleviating its deficiency in rice. Dipping rice seedling roots in 1% ZnO suspension is noticed as the most practical method for curing Zn deficiency in rice (Yoshida ***et al.***, 1970). In a field study, $ZnSO_4$, $ZnCl_2$, ZnO and $ZnCO_3$ as effective materials for removing zinc deficiency in rice and 10-100 kg ha^{-1} Zn application was suggested its optimum rate (Tahir ***et al.***, 1979). In a green house and field experiments Zn-enriched nursery beds @ 20 kg Zn ha^{-1} proved equally effective or superior to conventional $ZnSO_4$ field broad cast method (Rashid ***et al.***, 2000). Rice growth was similarly affected with zinc applied as ZnO, $ZnSO_4$ and Zn-EDTA but Zn uptake in plants differed (Giardano and Mortvedt, 1972). Moreover, Zn applied to surface or mixed in soil affected yield and Zn uptake more favorably than that placed below the seed (Giardano and Mortvedt, 1973). Dipping the seedlings in 2% $ZnSO_4$ solution or 25 kg Zn ha^{-1}as basal dressing or spraying 0.5% $ZnSO_4$ solution once or twice to the transplanted crop were proved equally effective (Kumar ***et al.***, 1996). Soil application of Zn prior to flooding was more effective than its flood water application for rice (Giardano, 1977).

Keeping all these points on view, the study was carried out to know the chemical composition and grain quality of rice and the comparative effect of different methods of zinc fertilizer for managing Zn deficiency in transplanted flooded rice grown in 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 2m ×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 minute before transplanting

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, following the methods as described in Methods of Soil Analysis by Page ***et al.*** (1982).These measurement are presented in Table 1. Crop was harvested at maturity; grain and straw samples for all the treatment were oven dried at 70°C. Plant material was prepared by dry ash method as described by Issac and Johnson (1975) and Zn was determined by atomic

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
Avail Zn	ppm	0.42

absorption spectrophotometer. Ground rice straw and paddy samples were analyzed for nitrogen, phosphorous, potassium and zinc following standard procedures as given by Page ***et al.*** (1982). 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

Zinc content of rice leaf before flowering

The zinc content in rice leaf before flowering, is reported in Table 2 indicated that the highest zinc content of 62.50 ppm was recorded in the treatment receiving 0.20% $ZnSO_4$ by foliar spray followed by that receiving 10 kg Zn ha^{-1} by soil dressing and 1.0% $ZnSO_4$ by root dipping which might be owing to the direct application of zinc to plants and its absorption by the plant tissue thereby increasing the leaf zinc content. The lowest zinc content of 19.40 ppm was obtained in control. The results showed that all the doses of zinc applied by different methods significantly increased the leaf Zn content over control. Similar results were reported by Kumar ***et al.*** (1997).

Zinc content of rice leaf after flowering

The data for the zinc content of the rice leaf after flowering as affected by zinc applied by different methods are presented in Table 2. The highest zinc content of 45.10 ppm was recorded in the plots receiving 0.20% $ZnSO_4$ by foliar spray followed by that receiving 10 kg Zn ha^{-1} by soil dressing and 1.0% $ZnSO_4$ by root dipping. Significantly the lowest zinc content of 19.00 ppm was recorded in the plots where no zinc fertilization was done. However, the differences amongst the methods of zinc application were non-significant and the Zn content of rice leaf varied from 44.60 to 45.10 ppm. Similar results were reported by Kumar ***et al.*** (1997).

Zinc content of rice root

The influence of zinc doses applied by different methods on the Zn content of rice root is shown in Table 2. The zinc doses affected Zn content in root significantly over control. The highest Zn root content of 78.10 ppm was obtained from the plots receiving 10 kg Zn ha^{-1} by soil dressing which was statistically similar to the plots receiving 1.0% $ZnSO_4$ by root dipping but was significantly different from plots receiving 0.20% $ZnSO_4$ by foliar application which showed that soil application of Zn had more beneficial effect on the availability of soil Zn as compared to other methods. It was probably attributed to its synergetic effect on the enhancement of root development, which increased the uptake of the Zn from soil through diffusion from the immediate vicinity of the plant roots. The lowest Zn content of 37.15 ppm was recorded in control. Mehdi ***et al.*** (1990) also reported that an increase in the level of zinc applied through soil increased the zinc content of roots.

Carbohydrate content of rice paddy

The data presented in Table 2 manifested that significantly maximum value of 87.10% starch content was recorded in plots where no zinc fertilization was done which was at par with the

Table 2: Zn content of leaf, roots and starch content of paddy as influenced by different methods of Zn application.

Treatments	Zn in leaf before flowering	Zn in leaf after flowering	Zn in roots after harvest	Starch content of paddy
Control (no Zn)	19.40b	19.00b	37.15c	87.10a
10 kg Zn ha^{-1} (soil)	62.50a	45.00a	78.10a	81.30b
Root dipping (1.0% $ZnSO_4$)	60.00a	44.60a	73.14ab	81.90b
Foliar spray (0.2% $ZnSO_4$)	62.50a	45.10a	71.00b	82.23ab

Table 3: Nitrogen, Phosphorous, Potassium and Zinc content of rice paddy and straw

	Paddy				Straw			
Treatments	% N	%P	%K	Zn(ppm)	%N	%P	%K	Zn(ppm)
Control (N0 Zn)	0.76d	0.27a	0.170c	24.25c	0.38b	0.048a	1.250d	22.10b
10 kg Zn ha^{-1} (soil)	0.98a	0.24b	0.205a	31.70ab	0.53a	0.030b	1.913a	28.00a
Root dipping (1.0 % $ZnSO_4$)	0.94b	0.23b	0.203a	29.00b	0.50a	0.029b	1.650b	27.37a
Foliar spray (0.2% $ZnSO_4$)	0.91c	0.22b	0.185b	32.45a	0.49a	0.028b	1.480c	30.12a

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

plots receiving 0.20% $ZnSO_4$ by foliar spray. The lowest starch content of 81.30% was recorded in the plots receiving 10kg Zn ha^{-1} by soil dressing which was statistically at par with that receiving 1.0% $ZnSO_4$ by root dipping or 0.20% by foliar spray. The adverse effect of Zn application on starch content of rice paddy was probably due to either decrease in formation or an increase in utilization of carbohydrates in tissue. Rajub (1999) reported similar results.

Nitrogen content of rice paddy

The data on % N content of rice paddy shown in Table 3 indicated that nitrogen content in paddy under different methods of Zn application increased significantly over control. Significantly highest value of 0.98% N was obtained in the plots treated with 10 kg Zn ha^{-1} by soil dressing followed by that receiving 1.0% $ZnSO_4$ by root dipping (0.94%) and 0.20% $ZnSO_4$ by foliar spray (0.91%). The lowest N content of 0.76% was obtained in control. The increase in N content by application of Zn through broad casting might be ascribed to its beneficial effect on soil microorganism helpful in nitrogen recycling and its release from organic sources. Obata ***et al.*** (1990) and Yaseen ***et al.*** (1999) also reported somewhat similar results.

Phosphorous content of rice paddy

The data pertaining to P concentration in paddy are presented in Table 3. The results showed that application of zinc by different methods decreased the P content of paddy over control, which might be due to the antagonistic effect of Zn on P absorption. Significantly highest P content of 0.27% was recorded in control followed by the plot receiving 10 kg Zn ha^{-1} to soil and that receiving 1.0% $ZnSO_4$ by root dipping. The lowest P content of 0.22% was obtained from the plots receiving 0.20% $ZnSO_4$ by foliar application. The lowest P content in the paddy treated by foliar application was attributed to its higher Zn content which might have decreased the P translocation. Chaudhry ***et al.*** (1992) and Yaseen ***et al.*** (1999) also reported similar results.

Potassium content of rice paddy

The data regarding K content in paddy as shown in Table 3 indicated that significantly maximum K content of 0.205% was recorded in plots treated with 10 kg Zn ha^{-1} by soil dressing which was statistically at par with the plots treated with 1.0% $ZnSO_4$ by root dipping but was significantly higher than that of 0.20% $ZnSO_4$ by foliar spray. It showed that soil Zinc application method had more beneficial effect on the availability of soil K as compared to other methods. It might be attributed to its synergetic effect on the enhancement of root development, which increased the uptake of K from soil through diffusion and mass flow from the immediate vicinity of the plant roots. The lowest K content of 0.170% was recorded in the control. Yaseen ***et al.*** (1999) also reported somewhat similar results.

Zinc content of rice paddy

The data shown in Table 3 indicated that zinc application by different methods increased significantly the paddy Zn content over control. The highest zinc content of 32.45 ppm was recorded in the plots treated with 0.20% $ZnSO_4$ by foliar spray, which was statistically at par with the plots treated with 10 kg Zn ha^{-1} by broad casting but differed significantly from the treatment of 1.0% $ZnSO_4$ by root dipping. It might be attributed to its direct absorption in plant tissue resulting in increased grain content of zinc. Similar results were also reported by Devarajan and Ramanathan (1995) and Srivastava ***et al.*** (1999) who reported that zinc application to zinc deficient soil increased the total biomass, grain yield, zinc concentration in the grain and uptake of zinc by the straw and the grain.

Nitrogen content of rice straw

The data for the N content as affected by zinc levels is reported in Table 3. The results showed that the effect of Zn on the N content was significant. The highest value of 0.53% N in rice straw was recorded in the plots treated with 10 kg Zn ha^{-1} by soil dressing followed by that receiving 1.0% $ZnSO_4$ by root dipping and by that receiving 0.20% $ZnSO_4$ by foliar spray. The increase in N content of rice straw suggested that zinc application by soil dressing might be effective in the proliferation of roots, which increased the uptake of nutrient from the soil and ultimately supplied to the aerial parts of the plant. The lowest N content of 0.38% was noted in the plots where no zinc fertilization was done. Singh ***et al.*** (1990) and Yaseen ***et al.*** (1999) reported similar results.

Phosphorous content of rice straw

The data for P content as influenced by Zn, applied by different methods is shown in Table 3. The results showed that all the doses of zinc applied by different methods decreased the P content significantly over control, which indicated the antagonistic effect of Zn on P absorption. Significantly the maximum mean P content of 0.048% was recorded in control followed by the plots receiving 10 kg Zn ha^{-1} by soil dressing and that receiving 1.0% $ZnSO_4$ by root dipping. The lowest P content of 0.028% was obtained for the plots receiving 0.20% $ZnSO_4$ by foliar spray which might be attributed to the higher Zn content in straw which might have inversely decreased the

P translocation. As regards methods used to apply zinc, all were statistically similar. These results are in conformity with those of Chaudhry ***et al.*** (1992) and Yaseen ***et al.*** (1999).

Potassium content of rice straw

The data for K content as affected by Zn levels applied by different methods are reported in Table 3.The results showed that application of zinc by any method increased significantly the K content in straw over control. The maximum K straw content of 1.913% was obtained in plots treated with 10 kg Zn ha^{-1} by soil dressing which was followed by the plots treated with 1.0% $ZnSO_4$ by root dipping and that treated with 0.20% $ZnSO_4$ by foliar spray. It showed that soil application of Zn had more beneficial effect on the availability of soil K as than other methods. It was attributed to its synergetic effect on root proliferation, which increased the uptake of the K element from soil through diffusion and mass flow from the immediate vicinity of the plant roots. The lowest K content of 1.250% was observed in control, showing thereby the response of K to zinc application and the ability of zinc to enhance the availability of soil K. These results are in accordance with those reported by Yaseen ***et al.*** (1999).

Zinc content of rice straw

The data on zinc content of rice straw as influenced by different doses of zinc applied by different methods are presented in Table 3. Zinc application by various methods increased the Zn content of rice straw significantly over control but the differences among them were nonsignificant and the Zn content on an average varied from 27.37 to 30.12% against significantly the minimum of 22.10% in control. Srivastava ***et al.*** (1999) and Yaseen ***et al.*** (1999) reported similar results.

References

Chaudhry, R.A., D.M. Malik, T. Amin, G. Haque and S. Sabir, 1992. Rice Response to Micronutrients. In: Proc. 3rd National Congress of Soil Sci. Lahore, March 20-22, 1990. Soil Sci. Society of Pakistan, pp: 242-350.

Devarajan, R. and G., Ramanathan, 1995. Direct, Residual and Cumulative Effect of Applied Zinc for Rice in Red Soils. Madras Agri. J. Ind. 82: 90-92.

Giardano, P.M. and J.J. Mortvedt, 1972. Rice Response to Zn in Flooded and Non-flooded Soil. Agron. J., 61: 521-524.

Giardano, P.M. and J.J. Mortvedt, 1973. Zinc Sources and Methods of Application for Rice. Agron. J., 65: 51-53.

Giardano, P.M., 1977. Plant and soil, 48: 673.

Issac, R.A. and W.C. Johnson, 1975. Collaborative Study of Wet and Dry Ashing Techniques for Elemental Analysis of Plant Tissue by Atomic Absorption Spectroscopy. J. AOAC., 58: 436-440.

Kumar, B., S.P. Singh and B. Kumar, 1996. Zinc Management in Nursery and Transplanted Rice (***Oryza sativa*** L.). Indian J. Agro., 41: 153-154.

Kumar, B., V.P. Singh and B. Kumar, 1997. Zinc Status of Rice Plant as Influenced by Different Levels and Methods of Zinc Application. J. Soils and Crops, 7: 105-108.

Mehdi, S.M., A.M. Ranjha and T. Hussain, 1990. Relative Efficiency of Various Sources of Zinc. Sarhad J. Agric., 6: 103-106.

Page, A.I., R.H. Millar and D.R. Keeney, 1982. Methods of Soil Analysis. Part-2. Madison, Wisconsin, USA.

Obata, H., M. Umebayshi and K. Kitagishi, 1990. Transactions 14th International Congress of Soil science, Kyoto, Japan, August, 4: 140-145.

Rajub, A.S., 1999. Effect of Zn on the Chemical Composition of Rice. M.Phil Thesis. Agri. Fac. Uni. D.I. Khan, Pakistan.

Rashid, A., M.A. Kausar, F. Hussain and M. Tahir, 2000. Managing Zn Deficiency in Transplanted Flooded Rice by Nursery Enrichment. Trop. Agri. (Trinidad). 77: 156-162.

Sing, B.P., A. Singh and B.N. Singh, 1990. Response of Rice to Zn and B Application in Acid Alfisols Under Mid-altitude conditions of Meghalja. Indian J. Agri. Sci., 60: 70-71.

Srivastava, P.C., D. Gosh and V.P. Singh, 1999. Evaluation of Different Zn Sources for Lowland Rice Production. Biolo. Fert. of Soils, 30: 168-172.

Steel, R.G.D. and J.D. Torrie, 1984. Principle and Procedure of Statistics (2nd Ed.). McGraw Hill Book Co. Inc. New Yark, pp: 754.

Tahir, M., M.I. Pervaz, A.S. Bhatti and G. Sarwar, 1979. Response of Rice to Zinc and Copper in the Field. Pak. J. Sci. Ind. Res., 22: 152-155.

Tahir, M., A. Rashid, A. Latif and A.S. Bhatti, 1986. Proc. Nat. Semin. Rice Res. Proc., Islamabad, Pakistan.

Yaseen, M., T. Hussain, A. Hakeem and S. Ahmad, 1999. To Study the Effect of Integrated Nutrient use including Zinc for Rice. Pak. J. Bio. Sci., 2: 614-616.

Yoshida, S. and A. Tanaka, 1969. Zinc Deficiency of Rice in Calcareous Soils. Soil Sci. Pt. Nutr., 15: 75-80.

Yoshida, S., G.W. Melean, M. Shafi and K. E. Miller, 1970. Effects of Different Methods of Zn Application on Growth and Yields of Rice in a Calcareous Soil. West Pakistan Soil Sci. Pt. Nutr., 16: 147-149.