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Effect of Different Levels of Zinc on the Extractable Zinc Content of Soil and Chemical Composition of Rice

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Abstract: A pot experiment was carried out to study the effect of different levels of Zn viz., 0, 5, 10 and 15 kg ha^{-1} along with a basal dose of NPK (175 kg N, 110 kg P_2O_5 and 100 kg K_2O ha^{-1}) on the Zn content of soil and chemical composition of rice Zn content of soil, leaves, roots, grain and straw of rice increased significantly with an increase in Zn fertilization. Similarly, significant maximum N and K content of rice grain and straw were found where zinc was applied @ 15 kg Zn ha^{-1}. However, a decrease in its P concentration was found with the application of zinc.

Key words: Rice, zinc, chemical composition

Introduction

Zinc is an essential micronutrient required for the normal growth and development of crop plants (Jones and Jarvis, 1981). It act as a divalent cation in plants metabolic system and essential constituent of certain metallo enzymes taking part in metabolism of plant (Romheld and Marschiner, 1991). In rice plants, zinc is associated with the production of auxin, nitrogen metabolism and activation of many enzymatic reactions (Tisdale *et al.*, 1993). Zinc deficiency causes complex metabolic changes and adversely affect the growth and yield of plant. Hudda, a rice disease in Pakistan was identified as a disorder due to zinc deficiency (NFDC, 1979).

Availability of zinc to plant is a problem. The soils of Pakistan are clayey, alkaline and calcareous in nature (Tahir *et al.*,1991). High pH and high calcareousness or alkalinity reduce zinc availability (Tisdale *et al.*, 1993). Zinc nutrition of rice in Pakistan has in recent years assumed great importance. However, little is done, so far, to improve its availability. The zinc status of soils and crops, therefore, needs to be considered and improved. Results of earlier experiments (Ghani *et al.*, 1990 Maqsood *et al.*, 1999) showed increase in rice yield by zinc application on alkaline and calcareous soils. Zinc, therefore, is considered essential element for rice crop which requires to be supplemented with the use of Zn fertilizer. The present study was carried out to know the effect of zinc fertilizer on the extractable zinc content of soil and chemical composition of rice variety IRRI-6 under the prevailing conditions of D. I. Khan.

Materials and Methods

A pot experiment, was conducted on loam calcareous soil. Bulk soil samples from 0-30 cm depth were collected from experimental field area before sowing of crop and analyzed for physico-chemical characteristics according to the methods described by Page *et al.* (1982). These measurements are presented in Table 1.

Rice variety IRRI-6 was used in these studies. The experiment was laid out in a randomized block design with three replications. N, P and K were applied as basal dressing at the rates of 175 kg N, 110 kg P_2O_5 and 100 kg K_2O ha^{-1}. Zinc was applied at the rate of 0, 5, 10 and 15 kg Zn ha^{-1} as zinc sulphate.

Full dose of P, K, Zn and half dose of N was applied at the time of puddling and thoroughly mixed into the soil. The remaining half of N was applied 30 days after transplanting. The crop was transplanted in the last week of June and harvested in the 1st week of October. Leaf and soil samples were collected potwise at the panicle initiation stage and after harvest. Plant material was digested in nitric acid and sulphuric acid and zinc was determined by atomic absorption spectrophotometer. Ground rice straw and paddy samples were analyzed for total nitrogen, phosphorous, potassium and zinc following standard procedures as given by Page *et al.* (1982). The data pertaining to various characters under study was analyzed statistically using Fisher's 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).

Table 1: Physico-chemical properties of soil

Characteristics	Values
Clay (%)	26
Silt (%)	43
Sand (%)	31
Textural Class	Loam
pH	7.9
ECe (mmhos/cm)	3.8
$CaCO_3$ (%)	12.0
Organic matter (%)	0.78
Total N (%)	0.45
Available P (ppm)	4.98
Available K (ppm)	120
Available Zn(ppm)	0.45

Results and Discussion

Zinc Concentration in leaves: The zinc contents of rice leaf increased significantly with zinc addition both before flowering and after harvest over control (Table 2). Maximum zinc accumulation was noted with 15 kg Zn ha^{-1} application followed by 10 and 5 kg Zn ha^{-1}. The higher Zn content before flowering could be attributed to high vigor of plants and greater root activity for better uptake of Zn. The results corroborate the findings of Sanzo *et al.* (1989), Rashid (1996), Sahu *et al.* (1996) and Iqbal *et al.* (2000). The Zn content of leaves after harvest were reduced than before flowering which may be due to the transfer of zinc to flowering and aerial parts of the plant.

Zinc concentration in roots: Application of zinc enhanced its concentration in roots significantly over control (Table 2). Significantly higher Zn concentration was obtained in roots treated with 15 kg Zn ha^{-1} followed by treatment receiving 10 and 5 kg Zn ha^{-} .^{1} The increase in Zn concentration of roots may be attributed to increase in root proliferation due to greater availability of the cation Zn which enhanced its uptake from the soil through diffusion and mass flow from the immediate vicinity of plant roots. Gangwar *et al.* (1977) and Mehdi *et al.* (1990) also reported that increase in level of Zn increases the zinc content of roots than that of shoots.

Zinc concentration in soil: Available zinc content of soil increased significantly with the addition of zinc over control at both panicle initiation and after harvest of rice (Table 2). The zinc content in treated pots showed progressive increase with the additional application of zinc fertilizer in a linear pattern which might be due to increase in available zinc by increasing its levels. Maximum zinc accumulation both before flowering and after harvest in the soil was noted in treatment receiving 15 kg Zn ha^{-1} followed by treatment receiving 10 and 5 kg Zn ha^{-1} while least Zn concentration was obtained from control. However, Zn content of soil were reduced after harvest of rice probably either by uptake of plants or by leaching and absorption by the soil particles. Similar results were reported by Sanzo *et al.* (1989).

Nitrogen concentration in grain and straw: Statistical analysis of data showed (Table 3) that paddy and straw N contents increased significantly by the application of zinc. Highest N concentration was obtained in paddy treated with 15 kg Zn ha^{-1} while least nitrogen concentration was noted in control, which might be due to the increased enzymatic activity and the organic recycling of the plant nutrients in response to available zinc supply to plants and showed the importance of zinc application for nitrogen availability and uptake by plants. Moreover, all the treatment were significant with one another. In straw the highest N concentration was obtained with treatment receiving 15 kg Zn ha^{-1} while least nitrogen concentration was with control but treatment receiving 10 and 5 kg Zn ha^{-1} were statistically similar to each other. Takkar (1996) and NFDC (1979) reported that soil application of 8 kg $ZnSO_4$ ha^{-1} supported nitrogen absorption of paddy. However, Yaseen *et al*. (1999) reported that soil application of 15 kg $ZnSO_4$ ha^{-1} increased significantly the nitrogen content both in paddy and straw.

Table 2: Zn content of leaf, soil and root of rice as influenced by levels of zinc.

Treatments Zn (kg/ ha)	Zn in leaf before flowering	Zn in leaf after flowering	Zn in soil before flowering	Zn in soil after harvest	Zn in roots after harvest
0	29.66d	23.58d	0.5100d	0.4000d	42.61d
5	47.48c	34.45c	0.7200c	0.5900c	63.60c
10	67.10b	58.15b	0.9600b	0.8600b	83.15b
15	85.74a	80.24a	1.030a	0.9900a	104.20a

Values followed by similar letters do not differ significantly from one another.

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

Treatments	Paddy				Straw			
Zn(Kg/ ha)	% N	% P	% K	Zn(ppm)	% N	% P	% K	Zn(ppm)
0	0.840d	0.2250a	0.180b	20.20d	0.440b	0.026a	1.900b	23.58d
5	0.910c	0.1617b	0.200b	32.26c	0.480ab	0.024b	1.910b	34.45c
10	1.030b	0.0983c	0.240a	38.04b	0.520b	0.019c	2.140a	58.15b
15	1.120a	0.0350d	0.246a	46.64a	0.540a	0.015d	2.170a	85.10a

Values followed by similar letters do not differ significantly from one another.

Phosphorous content of paddy and straw: The perusal of the data in Table 3 shows that significantly higher P concentration both in paddy rice and straw was obtained in control treatment compared to zinc treated pots while the least P was recorded in the treatment receiving 15 kg Zn ha^{-1}in straw and paddy grain with increase in zinc levels. It might be due to antagonistic effect of Zn on P absorption. Choudhry *et al*. (1992) and Yaseen (1999) also reported significant decrease in P concentration of rice at various levels of zinc.

Potassium content in paddy and straw: The data in Table 3 revealed that zinc fertilizer application had a significant effect on the K content of paddy and straw of rice. The content in all the Zn fertilizer treatments were significantly more as compared to control. The maximum K concentration was observed when Zn was applied at the rate of 15 kg ha^{-1}. The concentration of K was higher in straw than in paddy grain. The results are in accordance with those of Rashid (1983) and Rehman (1991) who reported significant increase in the K content of rice with Zn fertilization.

Zinc concentration in paddy and straw: The results indicated that application of different levels of zinc fertilizer enhanced zinc concentration both in paddy and straw of rice significantly over control (Table 3). The content increased significantly with increase in the level of Zn. Highest Zn concentration was obtained in treatment receiving 15 kg Zn ha^{-1} both for straw and paddy (85.10 and 46.64 ppm, respectively). Stunted rice growth in the absence of zinc, perhaps depressed zinc uptake in plants. Tahir and Kausar (1994) reported similar findings in case of rice crop.

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