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Response of Rice to Zinc Fertilizer in Calcareous Soils of D. I. Khan

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Abstract: Response of rice variety IRRI-6 to various levels of zinc was studied in a pot culture experiment. Zinc was applied at the rate of 0, 5, 10 and 15 kg ha^{-1} in the form of $ZnSO_4$ along with a basal dose of 175 kg N, 110 kg P_2O_5 and 100 kg K_2O ha^{-1}. The results showed that all the yield and yield components of rice increased significantly with increasing level of zinc fertilizer. However, significantly maximum plant height, average number of productive tillers per plant, panicles per plant, spikelets per panicle, 1000 paddy weight and grain and straw yield were obtained where Zn was applied at the rate of 10 kg ha^{-1} which was statistically at par with the treatments receiving Zn at the rate of 15 kg ha^{-1} except number of spikelets per panicle of rice.

Key words: Rice yield, zinc, calcareous soil

Introduction

Rice (*Oryza sativa*. L) is one of the most important food crops of Pakistan. Besides its importance as a food crop, about 23 % of the total foreign exchange is shared by rice (Khokhar and Soomro, 1976) and thus called as golden grain of Pakistan (Ahmad, 1976). During 1999, the rice crop was grown in Pakistan over an area of 2.515 million hectare with the production of 5.156 million tons. In NWFP, it occupied an area of 67100 hectare with production of 0.129 million tons (Anonymous, 2000). In D. I. Khan, rice is the second most important cereal crop grown under canal and tubewell irrigated conditions and the acreage is expanding rapidly due to the Chashma Right Bank Canal (CRBC) irrigation project which will eventually occupy 20 to 25 % of the command area of 1.4 million hectares.

Zinc deficiency the most common nutrient disorder constraining rice productivity worldwide is effectively controlled by field application of zinc sulphate (Rashid, 1996). Due to clayey, alkaline and calcareous nature of soils in Pakistan (Tahir *et al*., 1991), fertilizer zinc is mainly adsorbed by soil and very little is available and recovered by plants. Paddy soil conditions are usually not favorable for the availability of zinc and hence zinc deficiency has been reported countrywide in rice soils (Bhatti and Rashid, 1985). Most soils of NWFP are deficient in major nutrients but some of them have also been reported to be deficient in one or more trace elements (Khattak *et al*., 1983). It has been reported that out of 45 soil samples from Dir, Swat and Malakand, 45 % of the samples were either in the deficient or marginal ranges
(Khan *et al*., 1980 and Shah *et al*., 1986). It is therefore, imperative to apply zinc to such soils in addition to major nutrients for obtaining maximum yields. Sarwar and Mian (1972) reported the highest paddy yield when Zn and P_2O_5 were applied at the rate of 12.5 and 168 kg ha^{-1}, respectively. Malik (1985) reported deficiency of Zinc in rice, Fe in wheat, Mn in potatoes and Boron in cotton at various locations in Punjab. Rashid *et al*. (1988) reported that research conducted by different organizations on micronutrient revealed that crops like cereals, cotton, vegetables, fruits and fodder had shown deficiency of different micro nutrients and their application caused substantial increase in their yields.

In view of the role of micro nutrients in present day agriculture and the repeated deficiencies of some trace elements in the soils of NWFP, the present study was conducted to evaluate the performance of rice to different zinc doses and to find out the most appropriate rate of zinc fertilizer to improve the yield of rice (IRRI-6) grown under D. I. Khan conditions.

Materials and Methods

A pot experiment to study the effect of various levels of zinc on the rice 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 as described by Page *et al*. (1982). These measurement 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. All 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. The data on plant height, paddy and straw yield, number of productive tillers/plant, number of panicles/plant, number of spikelets/panicle and 1000 grains weight were recorded. The data pertaining to various characters were 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

Plant Height: The data shown in Table 2 indicated that significantly maximum plant height of 82.5 cm was recorded in treatment receiving 10 kg Zn ha^{-1} which was statistically at par with treatment where Zn application was @ 15 kg ha^{-1} and the lowest plant height of 65.0 cm was obtained in control. The increase in plant height might be attributed to the adequate supply of zinc which contribute to accelerate the enzymatic activity and auxin metabolism in plants. These results are in line with those of Maqsood *et al*. (1999) who reported that the application of $ZnSO_4$ @ 15 kg ha^{-1} through soil to rice crop under Faisalabad condition affected significantly all the yield components like plant height, number of tiller/m^2, number of panicle/m^2, paddy and straw yields and 1000-grain weight.

Table 2: Effect of Zn application on the yield component of rice.

Treatments (kg Zn ha^{-1})	Plant height (cm)	Tillers/ plant	Panicles/ plant	Spikelets/ panicle
0	65.00b	12.00c	11.00c	75.25d
5	74.00ab	15.50b	15.00b	85.00c
10	82.50a	20.75a	18.50a	103.75a
15	82.00a	19.00a	18.33a	96.50b

Values followed by the same letter are not significantly different at 5% level of probability.

Number of tillers per plant: The data revealed that all the treated pots produced more tillers per plant as compared to control. Among the

treated pots, treatment receiving 10 kg Zn ha^{-1} produced the maximum number of 20.75 tillers/plant which, however, did not significantly differ from the treatment receiving 15 kg Zn ha^{-1}. The lowest number of tillers/plant were obtained in control. The increase in tillering could also be attributed to the improved enzymatic activity and auxin metabolism in plants by zinc. Similar results were reported by Ionov and Ionova (1977), Ghani *et al*. (1990), Hung *et al*. (1990) and Yaseen (1999).

Number of Panicles per plant: The data showed that the number of panicles/plant were influenced significantly by the application of different levels of Zn. The maximum number of 18.50 panicles/plant were produced in the treatment receiving 10 kg Zn ha^{-1} followed by the treatment receiving 15 and 5 kg Zn ha^{-1}. The lowest number of 11.0 panicles/plant were obtained in control. The increase in panicles/plant could be ascribed to adequate supply of Zinc that might have increased the availability and uptake of other essential nutrients resulting in improvement in the growth of rice crop. The results support the findings of Ionov and Ionova (1977) and Sanzo *et al*. (1984) who suggested that adequate supply of Zn results in greater number of panicles/plant.

Number of spikelets/panicle: The data shown in Table 2 indicated that the maximum number of spikelets/panicle were recorded in treatment receiving 10 kg Zn ha^{-1} which was significantly higher from the treatment where Zn application was @ 15 and 5 kg ha^{-1}. The lowest number of 75.25 spikelets/panicle were obtained in the control. The increase in spikelets/panicle due to zinc fertilizer might be its effect on enhancing the physiological functions of the crop, like photosynthesis and translocation of plant nutrients and thus increased the number of spikelets/panicle. Similar results were reported by Maqsood *et al*. (1999).

1000 grain weight: The data pertaining to 1000-grain weight are presented in Table 3. It revealed that it increased with an increase in zinc levels and the maximum 1000-grain weight of 24.71g was recorded in treatment receiving 10 kg Zn ha^{-1} which was statistically at par with the treatments where Zn was applied @ 15 and 5 kg ha^{-1}. While the minimum 1000-grain weight of 17.14 g was obtained in control. The comparative increase in 1000-grain weight with the application of zinc might be due to more efficient participation of the trace element in various metabolic processes for the production of healthy seeds. These results are supported by the findings of Ionov and Ionova (1977), Khan *et al*. (1986), Ghani *et al*. (1990) and Maqsood *et al*. (1999).

Paddy yield (g/pot): All the different doses of zinc fertilizer significantly increased the paddy yield over control (Table 3). Among the treated pots, treatment receiving 10 kg Zn ha^{-1} produced the maximum paddy yield of 149.9 g/pot which, however, did not significantly differ from the treatment receiving 15 kg Zn ha^{-1}. The minimum paddy yield recorded in control might be due the non availability of zinc while the higher paddy yield due to Zn application might be due to the combined effect of many yield components, like number of tiller, number of panicles, 1000 grain weight etc. Similar results were reported by Singh *et al*. (1995) and Rahman *et al*. (2001).

Table 3: Effect of Zn application on 1000-grains weight, paddy and straw yield of rice

Treatments (kg Zn ha^{-1})	1000-grain weight(g)	paddy yield (g/pot)	Straw yield (g/pot)
0	17.14b	93.83c	130.40c
5	21.36a	112.80b	159.60b
10	24.71a	149.90a	175.70a
15	23.93a	147.30a	175.20a

Values followed by the same letter are not significantly different at 5 % level of probability.

Straw yield: The data showed that the straw yield was influenced significantly by the application of different zinc levels (Table 3). The maximum number of straw yield 175.70 g/pot was produced in the treatment receiving 10 kg Zn ha^{-1} which was statistically at par with the treatment receiving 15 kg Zn ha^{-1}. The lowest straw yield of 130.40 g/pot was recorded for control. The increase in straw yield might be due to the effect of zinc on the proliferation of roots which increased the uptake of plant nutrients from the soil, ultimately supplied to the aerial parts of the plant and enhancing the vegetative growth. These results are in agreement with that of Ghani *et al*. (1990), Rattan and Shukla (1991), Maqsood *et al*. (1999) and Rahman *et al*. (2001).

It was concluded from this study that the rice crop responded well to Zn application. So it is advisable to the rice growing farmers in the area to apply Zn upto 10.0 kg ha^{-1} along with the basal doses of N, P and K at the rate of 175 kg N, 110 kg P_2O_5 and 100 kg K_2O ha^{-1} in order to obtain a fair yield of paddy crop.

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