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RESPONSE OF WET LAND RICE TO COPPER AND ZINC IN THE PRESENCE OF NPK

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Grain and straw yields, number of fertile tillers, plant height, paddy to straw ratio and thousand grain weight of rice cv. IR-6 increased by applying copper (5 and 10 kg ha^{-1}) and zinc (10 and 20 kg ha^{-1}) either alone or in combination with NPK (100-50-50 kg ha^{-1}) to the soil marginal in available zinc and copper. The treatment comprising 20 kg Zn ha^{-1} plus 5 kg Cu ha^{-1} proved superior to all other treatments except 20 kg Zn plus 10 kg Cu ha^{-1} in respect of paddy yield. Analysis of paddy and straw indicated a decrease in phosphorus but increase in nitrogen and potassium concentrations by applying the micronutrients in soil. Copper and zinc inhibited the concentration of each other in both straw and paddy.

INTRODUCTION

Among the factors affecting yield of rice crop deficiency of micronutrients particularly of zinc and to some extent copper is turning out to be a serious problem as the soil and climatic conditions of the region are such that most of the micronutrients are in marginal release (Saif and Rana, 1980). Moreover, the introduction of high yielding varieties coupled with increased use of micronutrient free fertilizers has further increased the mining of trace elements from these soils (Kausar et al., 1979). Studies on the addition of micronutrients at various localities also reveal the demand of zinc and copper for rice crop (Tahir et al., 1979). Further observations in this respect show that soil applications of either copper or zinc mutually inhibited their absorption by plants (Tahir et al., 1982).

Keeping in view the importance of micronutrients in crop production, the present research work was conducted to determine the best possible combination of copper and zinc for rice crop alongwith normal NPK fertilization.

MATERIALS AND METHODS

The experiment was conducted in glazed pots (25 cm dia. and 27 cm height) lined with polythene, in the wire house of the Department of Soil Science, University of Agriulture, Faisalabad during 1985. A non-saline non-sodic soil was collected from plough layer, air dried, passed through 2 mm sieve and added to the pots at the rate of 10 kg pot^{-1}. Nitrogen, phosphorus and potassium were applied as ammonium sulphate, single superphosphate and potassium sulphate, respectively while zinc and copper were applied as their sulphates. The various fertilizer combinations were as follows:

1. Control.
2. NPK (100-50-50 kg ha^{-1})
3. NPK + Zn_1 (10 kg Zn ha^{-1})
4. NPK + Zn_2 (20 kg Zn ha^{-1})
5. NPK + Cu_1 (5 kg Cu ha^{-1})
6. NPK + Cu_2 (10 kg Cu ha^{-1})
7. NPK + Zn_1 + Cu_1 (10 kg Zn + 5 kg Cu ha^{-1})
8. NPK + Zn_1 + Cu_2 (10 kg Zn + 10 kg Cu ha^{-1})
9. NPK + Zn_2 + Cu_1 (20 kg Zn + 5 kg Cu ha^{-1})

10. NPK + Zn_2 + Cu_2 (20 kg Zn + 10 kg Cu ha^{-1})

Whole of phosphorus, potassium and micronutrients and half of nitrogen were applied at transplanting while the 2nd half of N was applied just before panicle initiation stage. Copper and zinc levels were made up after including the original contents of the soil.

Five twenty-day old seedlings of IR-6 were transplanted in each pot and thinned to three after seven days of transplanting. The uprooted plants were burried in the respective pots. Distilled water was applied to keep the soil submerged throughout the growing period of the crop. Harvesting was done at maturity.

Total nitrogen, available phosphorus and micronutrients were determined from the soil according to the methods described by Jackson (1962), Watanabe and Olsen (1965) and Lindsay and Norvell (1978), respectively while soil texture was determined by Bouyoucos hydrometer method (Moodie et al., 1959). The remaining analysis was done according to the standard methods described by U.S. Salinity Laboratory Staff (1954). The data collected were analysed statistically using Completely Randomized Design and comparison of mean values was made by applying Duncan's Multiple Range Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Soil analysis

The soil used in this study was clay loam in texture without any salinity/sodicity hazard (EC_e 1.6 dS m^{-1}; pHs 7.9) with CEC of 8.8 cmol kg^{-1} soil. It was poor in total nitrogen (0.042%), marginal in available phosphorus (9.1 mg kg^{-1}) and adequate in available potassium (125 mg kg^{-1}). The micronutrients (copper, 0.92 mg kg^{-1} and zinc, 0.56 mg kg^{-1}) were marginal according to the limits established by Kausar et al., (1979) for Pakistan soils.

Table 1. *Plant growth and yield characteristics of rice cv. IR-6 as influenced by the application of copper and zinc.*

Treatments	Fertile tillers (No. pot^{-1})	Plant height (cm)	Paddy yield (g pot^{-1})	Straw yield (g pot^{-1})	1000-grain weight (g)	Paddy to straw ratio
Control	22.7 g	64.3 h	29.7 g	38.0 c	22.1 f	0.78 e
NPK	26.7 fg	70.3 g	36.5 f	44.7 bc	22.4 ef	0.82 de
NPK + Zn_1	31.0 de	77.2 de	41.3 de	45.1 bc	23.1 cd	0.92 bc
NPK + Zn_2	34.7 cd	80.2 cd	44.9 cd	49.8 ab	23.5 bc	0.90 bc
NPK + Cu_1	28.3 ef	75.3 ef	38.5 ef	44.4 bc	22.8 de	0.87 bc
NPK + Cu_2	27.7 ef	72.2 fg	37.1 f	43.9 bc	22.7 de	0.85 cd
NPK + Zn_1 + Cu_1	37.0 bc	83.5 bc	49.3 b	52.7 a	23.6 ab	0.94 ab
NPK + Zn_1 + Cu_2	35.0 c	81.3 c	47.5 bc	51.4 ab	23.4 bc	0.93 ab
NPK + Zn_2 + Cu_1	41.7 a	89.2 a	54.2 a	55.5 a	24.0 a	0.98 a
NPK + Zn_2 + Cu_2	39.3 ab	86.7 ab	51.6 ab	54.1 a	23.7 ab	0.95 ab

Means with different letters differ significantly according to Duncan's Multiple Range Test ($P = 0.05$).

Table 2.. Chemical composition of paddy and straw as influenced by the application of copper and zinc.

Treatment	Nitrogen		Phosphorus		Potassium		Zinc		Copper	
	%						mg kg^{-1}			
	Paddy	Straw	Paddy	Straw	Paddy	Straw	Paddy	Straw	Paddy	Straw
1. Control	0.747 f	0.280 f	0.277 g	0.030 e	0.473 e	1.440 e	17.1 fg	9.5 fg	5.0 d	2.9 de
2. NPK	0.910 e	0.355 e	0.399 a	0.049 a	0.493 de	1.480 de	18.1 f	10.4 ef	5.3 d	3.0 d
3. NPK+Zn_1	0.966 cd	0.411 bc	0.374 d	0.047 ab	0.533 bcd	1.513 cd	28.7 b	15.3 b	4.8 de	2.5 ef
4. NPK+Zn_2	1.008 ab	0.443 a	0.351 cd	0.045 abc	0.540 bc	1.533 bcd	32.4 a	17.4 a	4.4 e	2.2 f
5. NPK+Cu_1	0.933 de	0.392 cd	0.360 bc	0.045 abc	0.513 cde	1.493 cde	16.1 gh	9.1 g	7.4 b	5.0 b
6. NPK+Cu_2	0.919 e	0.387 d	0.342 d	0.043 bc	0.520 bcd	1.507 cd	15.5 h	8.5 g	9.5 a	5.9 a
7. NPK+Zn_1+Cu_1	0.980 bc	0.420 b	0.350 cd	0.042 cd	0.553 abc	1.540 abc	23.7 d	12.1 d	6.1 c	4.2 c
8. NPK+Zn_1+Cu_2	0.975 bc	0.415 bc	0.341 d	0.041 cd	0.560 ab	1.547 abc	21.3 e	11.1 de	6.6 c	4.5 c
9. NPK+Zn_2+Cu_1	1.022 a	0.462 a	0.320 e	0.038 d	0.586 a	1.573 ab	26.0 c	13.5 c	6.0 c	4.1 c
10. NPK+Zn_2+Cu_2	1.013 ab	0.448 a	0.301 f	0.037 d	0.593 a	1.593 a	24.7 cd	12.2 d	6.3 c	4.3 c

Means with different letters differ significantly according to Duncan's Multiple Range Test ($P = 0.05$).

Plant growth and yield characteristics

Number of fertile tillers, plant height, thousand grain weight, yield of paddy and straw and paddy to straw ratio increased with the application of zinc to the soil (Table 1). Zinc perhaps influenced the uptake of major plant nutrients by rice plant through enzymatic effect on the metabolic process which ultimately caused higher yield (Panda and Nayak, 1974). Addition of copper to the soil alongwith NPK also increased the plant growth and yield characteristics over control, however, a slight but non significant decrease in crop response was noticed when the application of copper was increased from 5 to 10 kg ha^{-1}. It agreed with the findings that rice responded well to lower applications of copper (Alam, 1983).

The crop exhibited better yield response in the treatments where copper and zinc were applied in different combinations. Treatment NPK + Zn_2 + Cu_1 emerged to be the best combination. This probably was due to the more pronounced effects of macronutrients and micronutrients when used in optimum ratios and quantities (Chaudhry and Ali, 1986).

Chemical composition

The data regarding chemical composition of paddy and straw (Table 2) indicate that the percentage of nitrogen and potassium increased with increasing levels of copper and zinc, however, the increase was comparatively greater in the treatments where zinc was applied at high rate (20 kg ha^{-1}). Phosphorus concentration in paddy and straw depressed with the addition of copper and zinc to the soil, possibly due to the insolubilizing effect of zinc on phosphorus (Rashid, 1983) and the interference of copper with the ability of plants to absorb this element from the soil (Saif and Rana, 1980).

As regards interaction of the trace elements, stimulatory effect of zinc and inhibitory effect of copper on zinc concentration of paddy and straw was observed in the treatments where these micronutrients were applied alone. Copper concentration in both parts of the plant increased with increasing levels of copper while decreased with increasing rates of zinc. These results are similar to the observations of Chaudhry et al., (1973) regarding copper-zinc antagonism in the nutrition of rice.

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