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NUTRITIONAL STUDIES FOR DRY MATTER YIELD AND MINERAL CONCENTRATION OF CROPS

Part I. Effect of Nutrients on Rice *(Oryza stiva)*

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The results of a fertilizer experiment conducted in a calcareous soil revealed that the rice crop responded well to the addition of nitrogen, phosphorus, copper and zinc. The effect of nitrogen was more pronounced than phosphorus in macronutrients and copper was more effective among micronutrients, in raising the dry matter yield of the crop. Treatments like NPCuZn, NPCu, NPCuMn, NPZn, NPCuZnMn and NPZnMn were comparatively more suitable than other combinations. A tendency called antagonism, among nitrogen, phosphorus, copper, zinc and manganese is observed in mineral concentrations of the crop. The antagonistic trend was more clear in copper, zinc and manganese than other nutrients.

INTRODUCTION

With the introduction of high yielding varieties of crops in Pakistan, the use of nitrogen and phosphorus fertilizers have greatly increased. Though this practice has enhanced the crop yields, but at several places even after the addition of higher doses of these major plant nutrients, the required yield targets are not obtained. This behaviour of crops is recognised to be due to luxurious vegetative growth which is produced by the liberal supply of basic fertilizer [21]. Moreover, the soil and climatic conditions of this country are such that most of the micronutrients are in marginal release [13, 19]. Latest studies, with the addition of micronutrients at various localities, also revealed the demand of zinc and copper for crops specially rice and wheat [15]. Further experimental observations in this respect showed that soil treatment with either copper or zinc mutually inhibited their absorption by plants [2]. Keeping in view, therefore, the importance of micronutrients in crop production, the present research work was conducted. The investigation is carried out not only to observe the response and interactions among some major and minor elements, but also to determine the best combinations of macro and micronutrients for better plant growth and ultimately for greater crop yield.

EXPERIMENTAL

Five kilogram soil was taken into plastic containers (19 cm dia and 18.5 cm height) and the following treatments were given:

1. Nitrogen at the rate of 168.00 kg/hectare as urea. 2. Phosphorus at the rate of 50.00 kg/hectare as single superphosphate. 3.Copper at the rate of 5.00 p.p.m. as copper sulphate 4. Zinc at the rate of 8.00 p.p.m. as zinc sulphate. 5. Manganese at the rate of 5.50 p.p.m. as manganese sulphate.

The combinations used were: (1) Control. (2) N. (3) P. (4) NP (5) NCu (6) NZn (7) NMn (8) NCuZn (9) NCuMn. (10) NZnMn (11) NPCuZn (12) NPCuMn. (13) NPZnMn. (14) NCuZnMn and (15) NPCuZnMn.

Nitrogen was applied in split doses whereas phosphorus, copper, zinc and manganese were added in single dose at the time of transplanting. The treatments were replicated thrice and completely randomized design was employed.

Twenty-day-old rice (IRRI-8) seedlings which were previously sown in the same soil, were transplanted in the pots. Irrigation was done with deionized water and crop was kept flooded throughout the growth period. Five plants per pot were maintained and the harvesting was done at preflowering stage.

Soil Analysis. To characterize the soil used, the texture of the soil was determined by Bouyoucos hydrometer method [8]. Electrical conductivity and pH were measured by standard techniques [18]. Lime, percentage organic matter and total nitrogen were determined by the methods described by Jackson [4]. Olsen's method was used to evaluate the available phosphorus of the soil [9]. Available copper, zinc and manganese were determined by the method developed by Lindsay and Norvell [7]. The physical and chemical values of the soil used are as follows: Texture, sandy loam; saturation (28%); electrical conductivity of saturationextract (EC $\times$ 10^3), 8.81; pH of the saturated soil paste, 8.2; potassium of saturation extract (me/l); 1.60; sodium of the saturation extract (me/l), 97.82; chloride of the saturation extract (me/l), 25.04; line (9.50%); organic matter (0.74%); cation exchange capacity (me/100 g), 8.92; available phosphorus (ppm), 10.50; available copper (ppm), 0.90; available Zn (ppm), 2.15; available manganese (ppm), 7.39; total nitrogen (0.026%).

Plant Analysis. The harvested plant material was washed first with deionize water and later with distilled water. The plant samples now obtained were dried in the air and finally put into the oven at 60^{0} for complete dryness. After this, the samples were weighed to find the dry matter yield. Then for total plant analysis the plants samples were cut into small pieces and later ground in a mill fitted with stainless-steel blades.

To measure phosphorus, copper, zinc and manganese, the plant material was digested in nitric acid (concd) and perchloric acid. Then from the digested matter phosphorus was determined by yellow colour method [18] whereas, copper, zinc and manganese by atomic absorption spectrophotometrically [6]. The results obtained for various characteristics were subjected to analysis of variance and means were compared with each other by Duncan Multiple Range Test.

RESULTS AND DISCUSSION

The Effect of Treatments on Dry Matter Yield. The data regarding the yield is presented in Tables 1–3. It is clear from the results that application of nitrogen both singly (N) and in combination with phosphorus (NP) significantly raised the dry matter yield of the crop. However, when phosphorus was added alone (P), it did not produce significant effect as compared to control. The effect of nitrogen could be attributed to the soil used that contained a little quantity of organic matter which was unable to provide sufficient amount of nitrogen to the plants [20]. Now, when nitrogen was supplied alone or in combination with phosphorus produced in plants a dark green colour appears which might have increased the photosynthesis and resulted in the production of greater dry matter yield [16].

Application of copper, zinc and manganese separately in the presence of nitrogen treatment, kept as control, (Table 2) did not show any clear difference in the yield of the rice crop. But,when these nutrient elements were added in combination with each other they (i.e. NCuZn, NCuMn, NZnMn and NCuZnMn) markedly enhanced the yield of crop and the yield was 38.48, 33.98, 25.48 and 35.15% higher respectively as compared to control (N alone).

In the presence of NP as control (Table 3), addition of copper and zinc both singly and in combination distinctly increased the yield of the rice crop, but the effect of manganese treatment was discourating through nonsignificantly towards the quantity of dry matter yield NPCuZn combination produced highest yield which was 38.7% more than control (NP). Treatment NPCuZn was followed by NPCu, NPCuMn, NPZn, NPCuZnMn and NPZnMn in descending order.

The increase in the yield of the crop due to the treatments of the trace elements, could be regarded to the formation of auxins which otherwise were destroyed by the

Table 1. Effect of nitrogen and phosphorus application on the dry matter yield and mineral concentration in rice at preflowering stage.

Treatments	Dry matter yield (g/pot)	Mineral concn in tops			
		P (%)	Cu (p.p.m.)	Zn (p.p.m.)	Mn (p.p.m.)
Control	5.834 b	0.142 b	5.00 a	19.33 a	362.21 b
N	27.417 a	0.111 c	4.99 a	19.53 a	303.40 c
P	7.448 b	0.159 a	3.22 b	16.74 b	287.83 d
NP	30.019 a	0.117 c	4.95 a	20.13 a	380.44 a
S.E.	0.936	0.003	0.100	0.80	1.02

Table 2. Effect of nitrogen, copper, zinc and manganese application in various combinations on the dry matter yield and mineral concentrations of rice at preflowering stage.

Treatments	Dry matter yield (g/pot)	Mineral concn			
		P (%)	Cu (p.p.m.)	Zn (p.p.m.)	Mn (p.p.m.)
N	27.417 c	0.111 bcd	4.99 c	19.53 e	303.40 f
NCu	29.856 c	0.101 e	8.50 b	15.34 g	362.05 d
NZn	28.840 c	0.114 abc	3.76 d	23.84 c	347.72 e
NMn	27.436 c	0.116 ab	3.18 c	15.67 g	435.64 a
NCuZn	37.968 a	0.102 de	9.90 a	27.53 a	347.40 e
NCuMn	36.723 ab	0.104 cde	8.23 b	16.75 f	409.57 b
NZnMn	34.394 b	0.113 abc	3.29 e	26.50 b	390.96 c
NCuZnMn	37.048 ab	0.122 a	9.73 ab	22.58 d	428.78 a
S.E.	1.178	0.003	0.14	0.28	2.97

Table 3. Effect of NP, copper, zinc and manganese application in various combinations on the dry matter and on mineral concentrations of the rice at preflowering stage.

Treatments	Dry matter yield (g/pot)	Mineral concn			
		P (%)	Cu (p.p.m.)	Zn (p.p.m.)	Mn (p.p.m.)
NP	30.019 c	0.117 b	4.95 c	20.13 b	380.44 d
NPCu	39.524 ab	0.097 c	10.03 a	18.95 c	304.66 f
NPZn	38.863 ab	0.119 b	4.79 dc	21.84 ab	285.46 g
NPMn	27.750 c	0.133 a	4.72 d	16.61 d	409.57 b
NPCuZn	41.658 a	0.100 c	10.02 a	22.32 a	317.25 e
NPCuMn	39.346 ab	0.125 ab	9.85 a	16.75 d	399.74 c
NPZnMn	37.712 b	0.130 a	4.58 d	22.49 a	439.60 a
NPCuZnMn	38.366 b	0.120 b	8.48 b	21.49 ab	409.57 b
S.E.	1.058	0.003	0.100	0.530	2.750

high light intensity of the summer season [19]. Moreover, the alkaline and calcareous nature of the soil used, was responsible for the low availability of the trace elements [22]. For the above reason, when these elements were added as fertilizers, the crops significantly responded. The findings were fairly in agreement with the works described earlier [12, 11, 6].

Interaction Studies for Nitrogen, Phosphorus, Copper, Zinc and Manganese. Application of nitrogen alone significantly reduced the phosphorus concentration in rice straw (Table 1). This could be explained as dilution effect of greater plant growth, resulting from liberal supply of nitrogen to the plants [17]. Similarly, the phosphorus concentration was decreased by the addition of copper, zinc and manganese (Tables 2,3) when added in various combinations. The data revealed that highest depression in phosphorus concentration was observed in case of NCu treatment whereas, treatment NCuZnMn significantly increased the phosphorus in plants as compared to control (N treatment). With NP as control, addition of micronutrients has variable effect on phosphorus concentration in the crop. Treatments NPZnMn, NPCuMn increased, NPZn and NPCuZnMn had no effect, while NPCu and NPCuZn decreased the P concentration. The negative effect of the copper could possibly be due to the interference of this element with the ability of plants to absorb phosphorus from the soil [14].

The addition of phosphorus in single treatment (P) significantly depressed the concentration of copper, zinc and manganese in the plants (Table 1). The effect was highest with that of manganese concentration where, there was 362.21 and 287.83 p.p.m. in case of control and phosphorus treatment, respectively. This tendency of phosphorus application could be characterized to the precipitation or inactivation of trace elements as phosphates [2]. A similar antagonistic trend as that of phosphorus was observed among copper, zinc and manganese, for their concentrations. The findings presented in Tables 2 and 3 clearly depicted that in the presence of N and NP as check, when copper was added it reduced Zn and Mn concentrations, zinc reduced Cu and Mn and manganese application decreased the concentrations of Cu and Zn. These findings fairly tally with the previous studies on the same lines [13, 9].

A typical performance for NP, NCuZnMn and NPCuZnMn was observed. These treatments instead of any negative effect on P, Cu, Zn and Mn, increased their concentration in plants. Treatment NP had 380.44 p.p.m. Mn and 20.13 p.p.m. Zn as against 362.21 and 19.33 p.p.m. respectively, in case of control. Phosphorus concentration was highest in case of NCuZnMn followed by NPCuZnMn treatment. These observations could belong to the higher vigour of the crop, where greater root activity solubilized the minerals and better uptake of the elements resulted [21].

CONCLUSIONS AND SUGGESTIONS

Besides, nitrogen and phosphorus, the rice responded well to the application of copper and zinc. Consequently, such combinations as NPCuZn, NPZn, NPCu, and NCuZn were found most suitable. Considering the antagonistic behaviour among nutrient elements, it is suggested that fertilization with any one of them must be done with great care and necessarily be supplemented with other elements.

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