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EFFECT OF MICRONUTRIENTS ON THE UPTAKE OF N, P AND K IN RICE

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Abstract : A field experiment was conducted to study the effect of application of secondary and micronutrients on the uptake of N, P and K by rice continuously for two seasons in 1991. The total N uptake was significantly enhanced by the application of B, Cu and Mo. Application of B had a consistent influence on the uptake of P and K also. Phosphorus and Zn interacted negatively in the soil influencing the uptake of each other by the crop and the decreased P uptake as result of application of Zn indirectly reduced the yield. Antagonism was observed between K and Mg.

Key words: Micronutrients, NPK uptake, rice

INTRODUCTION

Micronutrients, even though needed only in smaller quantities compared to primary nutrients like N, P and K are as important as major nutrients. Each of the nutrients plays a specific role in the growth and development of tic plant. Without the use of micronutrients it would not he possible to get maximum benefit from applied NPK fertilizers and cultivation of high yielding varieties. The availability of a particular nutrient in the soil and its uptake by the crop often depend on nutrient interactions in the soil. Prabha *et al.* (1975) reported that higher levels of P led to Zn deficiency while Sami and Bhattacharya (1976) observed a significant reduction in the yield of paddy at higher rates of P + Zn. A negative interaction between K and Mg was reported by Varughese (1992). The present investigation was carried out to study the interaction effects of micronutrients in soil and plant with major plant nutrients and also to understand the pattern of uptake of major nutrients by the crop as influenced by the application of micronutrients.

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural Research Station, Mannuthy using rice variety Jyothi during the kharif and rabi seasons of 1991. The soil was sandy clay loam in texture, acidic and non-saline. The content of organic carbon was medium (0.68%) while available P (118.3 kg ha^{-1}) and available K (310.6 kg ha^{-1}) ratings were high. The experiment was laid out in a randomised block design with ten treatments replicated thrice. The treatments applied were:

T_1	Control (No micronutrients)
T_2	Zinc ($ZnSO_4$ 20 kg ha^{-1} in soil + 1% foliar)
T_3	Manganese (Manganous sulphate monohydrate 2.5 kg ha^{-1} in soil + 0.5% foliar)
T_4	Boron (Boric acid 750 g ha^{-1} in soil + 0.1% foliar)
T_5	Copper (Cupric sulphate 5 kg ha^{-1} in soil + 0.1% foliar
T_6	Molybdenum (Sodium molybdate 1.25 kg ha^{-1} in soil + 0.1% foliar)
T,	Sulphur (Biologically activated with *Thiobacillus* sp. and *Aspergillus avomerii* 10 kg ha^{-1} in soil + 1% foliar)
T_8	Magnesium ($MgSO_4.7H_2O$ 20 kg ha^{-1} in soil + 1% foliar)
T,	Combination of nutrients given in the above treatments
T_{10}	Stanes Microfood (12.5 kg ha^{-1} in soil + 1% foliar)

Application of N, P and K and the cultural practices were followed uniformly as per the package of practice recommendations of the Kerala Agricultural University (KAU, 1989). Soil application of treatments was done 15 days after transplanting and foliar application was effected at the active tillering stage with 250 1 of spray solution per hectare. Soil and plant samples were collected at different stages of crop growth for chemical analyses.

Total N content of the soil and plant samples was determined by microkjeldahl distillation method (Jackson, 1958). Available P of soil was extracted with Bray-I extractant and determined colorimetrically by ascorbic acid blue colour method (Watanabe and Olsen, 1965). Available K of soil was extracted with neutral *N* NH_4OAc and estimated by using an EEL flame photometer (Jackson, 1958). The triacid extract of plant samples was utilised for the estimation of P and K by molybdo-phosphoric yellow colour method and by using flame photometer respectively (Jackson, 1958). The nutrient uptake was calculated by multiplying the dry matter production with the percentage of particular nutrient in the straw or grain. The results obtained were subjected to analysis of variance technique for RBD and correlations between various factors were worked out (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

Uptake of N

The total N uptake by the crop varied significantly due to the application of micro-nutrients in both the seasons studied (Table 1). But the percentage of N in the soil after the application of treatments did not differ significantly. Among the treatments tried, application of B resulted in the highest N uptake in the first crop season followed by that of Cu. The yield of grain also followed a similar trend when the individual nutrients are considered (Table 2). Apart from the highest yield obtained by the application of Stanes Microfood, a micronutrient formulation, the yield varied almost in a similar pattern as that of the total N uptake. Thus it could be observed that the application of B resulted in the highest N uptake as well as the grain yield in the first crop season. In the second crop, the highest N uptake and grain yield were recorded by the application of Mo, among the individual nutrients. Here also the influence of B and Cu on the uptake of N and grain yield was evident. A significant positive correlation was obtained between the grain yield and total N uptake by the crop (r = 0.802**). The lowest N uptake in both the seasons was recorded by the application of Zn and it was well reflected in the grain yield of the crop.

Boron is said to function in carbohydrate metabolism and to facilitate the movement of sugars by forming a permeable boron-sugar complex or by joining the cell membrane in such a way that it is made more permeable to sugars. It is also believed to influence cell development and the rate of cell division (Tisdale *et al.*, 1985). Thus the increased availability of B would have resulted in enhanced cell development and consequent increase in the uptake of N which was reflected in the grain yield. Rao (1982) observed that the absorption of boron by rice plants ran parallel with the dry matter production.

It has been suggested that Cu is one of the metals concerned with the light reaction in plants and it is therefore possible that the increased availability of Cu would have resulted in a better uptake and utilization of N in the rice plant. Because of the essentiality of Mo in many important enzymes such as nitrate reductase and nitrogenase it may also enhance the uptake and utilization of N. Dasgupta and Basuchoudhary (1974) reported that rice may benefit from Mo application (40 g ammonium molybdate ha^{-1}) through its favourable effect on N metabolism.

Uptake of P

The uptake of P by rice as influenced by the application of micronutrients did not differ significantly in either of the seasons (Table 3). It could be observed that application of B resulted in comparatively higher uptake of P whereas the application Zn resulted in the lowest P uptake in both the seasons. Significant negative correlation was obtained between total P uptake and available Zn of the soil (r = 0.645*). The available P of the soil after the application of treatments did not show any significant variation but the highest values were recorded by plots applied with Zn. The lowest P uptake by the crop and the highest content of available P in the soil as a result of Zn application indicate a negative interaction of these nutrients in the soil with respect to uptake by the crop. It may be due to the formation of insoluble $Zn_3(PO_4)_2.4H_2O$ in the soil as a result of interaction. Total P

Table 1. Nitrogen in soil (%) and uptake by rice (kg ha^{-1}) as influenced by the application of micronutrients

Tr No	First crop				Second crop			
	Total N in soil	Uptake by straw	Uptake by grain	Total uptake	Total N in soil	Uptake by straw	Uptake by grain	Total uptake
T_1	0.217	61.47	26.87	88.34	0.135	36.75	45.92	82.67
T_2	0.206	53.63	28.85	82.48	0.103	38.47	32.35	70.82
T_3	0.212	62.72	25.95	88.67	0.125	33.19	45.77	78.96
T_4	0.195	60.14	40.38	100.52	0.114	40.33	48.23	88.56
T_5	0.201	65.42	33.88	99.30	0.125	40.36	43.09	83.45
T_6	0.195	55.47	33.95	89.42	0.135	46.53	48.89	95.42
T_7	0.196	59.18	32.00	91.18	0.130	41.91	34.98	76.89
T_8	0.190	59.86	37.03	96.89	0.119	38.97	44.08	83.05
T_9	0.185	54.34	29.04	83.38	0.119	43.26	41.74	85.00
T_{10}	0.195	46.80	36.05	82.85	0.109	34.09	33.21	67.30
CD (0.05)	NS			10.02	NS			12.21

Table 2 Yield of grain and straw of rice as influenced by the application of micronutrients, kg ha^{-1}

Tr. No	First crop		Second crop	
	Grain	Straw	Grain	Straw
T_1	2065	4049	2813	2808
T_2	1774	3663	2486	2628
T_3	2127	3731	2813	2551
T_4	2482	3961	2964	3100
T_5	2314	3770	2943	2757
T_6	2087	3416	3005	2907
T,	2460	4197	2689	3221
T_8	2276	3680	2709	2662
T,	2232	3712	3185	2955
T_{10}	2606	3755	2464	2620

F test : Not significant

uptake was significantly and positively correlated with grain yield (r = 0.842**) and total N uptake (r = 0.724*). So it was evident that the antagonism between P and Zn led to a lower P uptake by the crop which indirectly affected the total N uptake and the yield. In both seasons of the study, the plants applied with Zn recorded the lowest grain yield. This negative interactions of P and Zn at higher rates were earlier reported by Prabha *el al.* (1975) and Samui and Bhattacharya (1976).

Uptake of K

Significant difference in the total K uptake by the crop was not observed due to the application of secondary and micronutrients (Table 4). The highest total uptake was recorded by plots applied with biologically activated S, obviously due to the high rate of dry matter production achieved by this treatment. Application of B was found to have a coasistent influence on the uptake of K by straw and grain. Available K of soil was found to be significantly positively correlated with available B in soil (r = 0.744*) and total B uptake (r = 0.652*). Thus a strong positive interaction of K with B was revealed. Tisdale *et al.* (1985) observed that a balance between K and B seems to exist in plants and B uptake by tomato and corn was enhanced by high levels of K in combination with B. The lowest K uptake was recorded by plants applied with Mg in both the seasons. This indicates a possible antagonism between K and Mg in soil. Both Ca^{2+} and Mg^{2+} compete with K for entry into plants. According to the activity ratio concept, potassium uptake would be reduced as Ca and Mg are increased and conversely uptake of these two cations would be reduced as the supply of K increased. This is confirmed by a significant negative correlation between available K in soil and total Mg uptake by the crop (r = 0.770**). Antagonism between K and Mg has been earlier reported by Varughese (1992).

In the present study, the favourable effect of application of B on the uptake of N, P and K and indirectly on the yield of rice was observed. Copper and molybdenum were also

Table 3. Available P in soil and uptake by rice as influenced by the application of micronutrients, kg ha^{-1}

Tr. No	First crop				Second crop			
	Available P in soil	Uptake by straw	Uptake by grain	Total uptake	Available P in soil	Uptake by straw	Uptake by grain	Total uptake
T_1	76.07	10.04	6.73	16.77	69.03	4.55	10.35	14.90
T_2	90.17	8..94	5.67	14.61	83.38	3.92	9.22	13.14
T_3	77.48	10.52	7.30	17.82	73.26	4.46	10.13	14.59
T_4	80.30	8.67	8.99	17.66	70.44	5.58	10.73	16.31
T_5	73.26	9.31	7.36	16.67	71.14	5.54	9.36	14.90
T_6	73.26	8.68	7.30	15.98	73.26	5.15	10.52	15.67
T_7	74.66	7.68	8.73	16.41	76.07	5.57	9.55	15.12
T_8	77.48	9.38	7.29	16.67	71.85	5.16	8.67	13.83
T_9	74.66	7.50	7.45	14.95	70.44	5.17	10.72	15.89
T_{10}	69.03	7.62	8.65	16.27	67.62	4.64	9.17	14.11

F test : Not significant

Table 4. Available K in soil and uptake by rice as influence by the application of micronutrients, kg ha^{-1}

Tr. No	First crop				Second crop			
	Available K in soil	Uptake by straw	Uptake by grain	Total uptake	Available K in soil	Uptake by straw	Uptake by grain	Total uptake
T_1	388.3	93.13	11.38	104.5	324.8	33.90	14.11	48.01
T_2	418.1	99.52	10..68	110.2	352.8	39.42	12.43	51.85
T_3	350.9	96.37	9.53	105.9	283.7	35.71	12.66	48.37
T_4	377.1	96.37	13.63	110.0	345.3	43.40	16.30	59.70
T_5	354.7	93.61	12.69	106.3	324.8	38.60	16.18	54.78
T_6	365.9	72.86	11.48	84.3	324.5	40.04	16.53	56.57
T_7	384.5	115.40	13.48	128.9	330.4	45.09	14.79	59.88
T_8	395.7	69.92	11.38	81.3	354.7	34.61	13.54	48.15
T_9	393.0	86.60	10.04	96.6	289.3	39.89	14.44	54.33
T_{10}	347.2	98.87	16.93	115.8	300.5	36.68	14.04	50.72

F test : Not significant

found to enhance the total N uptake by rice. P and Zn interacted negatively in the soil, influencing the uptake of each other by the crop and a decreased P uptake as a result of Zn application indirectly lowered N uptake and the yield. Antagonism between K and Mg was also confirmed.

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