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DIFFERENTIAL UPTAKE AND GROWTH RESPONSE TO MICRONUTRIENTS IN VARIOUS RICE CULTIVARS*

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Field and pot experiments were conducted to study the growth and uptake responses to Zn, Cu and Fe application in various rice cultivars to check their suitability to be grown in the deficient soils. In the 34 rice varieties grown without micronutrient applications in the field, leaf concentration of Zn ranged from 11.0 – 29.5, Cu from 3.5 – 9.5, Fe from 75 – 210 and Mn from 45 – 165 ppm showing a coefficient of variation as 21.8, 21.5, 27.9 and 37.9, respectively among the varieties.

Both concentration and uptake of Zn, Cu and Fe in the shoots of 5 rice varieties grown in pots significantly varied in the presence and absence of their applications. Without Zn, Cu and Fe addition, Zn in shoots ranged from 13.3 – 14.9, Cu from 8.5 – 9.3 and Fe from 127 – 198 ppm showing a difference in concentration among cultivars as 12.0, 9.4 and 55.8% which increased on an average to 44.1, 30.7 and 22.5%, respectively with 5 ppm of their applications. Similarly, the difference in dry matter yield of cultivars grown with or without Zn, Cu and Fe was significant also showing differential nutrient requirements of cultivars.

Moreover, the differential response or susceptibility to Zn, Cu and Fe deficiency did not seem to be associated with any particular plant group nor the yield depresion with their deficiencies could be significantly correlated with Zn, Cu, Fe and P concentration in the plants of various rice cultivars.

INTRODUCTION

Deficiency of micronutrients particularly that of Zn in rice has been widely reported in various regions (Lafever, 1981; Safaya and Gupta, 1979; Tanaka and Yoshida, 1975; Tahir, 1978). Unless the deficiencies are corrected by their applications, rice yields are greatly depressed (Reddy and Prasad, 1986;Tahir 1978). Due to strong emphasis on increasing yields and bringing more areas under cultivation, fertilizer demands are going to multiply. This could induce further constraints on the existing supplies, causing most crops to be grown without fertilizer.

Not only the various crops but also the cultivars of the same crop differ in their capacity to exploit soils for nutrients due to their gene-

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tic variabilities (Shukla and Raj, 1976). These may as well differ in their absorption and /or translocation within the plants (Bowen, 1986 and Forno et al., 1975). Therefore, cultivars of crops with stronger nutrient extracting power are less liable to be affected by the nutrient deficiency in soils and could be grown in deficient soils to avoid adverse effects on yields (Reddy and Prassad, 1986). Information on this aspect of rice production is, however, lacking. This study was undertaken to screen out rice cultivars for their resistibility or susceptibility to the deficiency of Zn, Cu, and Fe.

MATERIALS AND METHODS

1. Field experiment: Top most, fully maturd, leaves of the plants at boot stage were collected from 34 rice cultivars (Table 1) grown at the Institute Farm under flooding with a uniform basal dose of N (100 kg/ha) and P (60 kg. P_2O_5/ha). The leaves were washed thoroughly with deionized water, dried at 65°C and ground in a wiley type micro–mill fitted with a stainless steel sieve and the blades. One gram portion of the ground samples was digested in HNO_3–$HClO_4$ (4:1) mixture. Zinc, Cu, Fe and Mn concentrations in the digests were determined on atomic absorption spectrophotometer (AAS).

2. Pot experiment: Four kilograms of soil (0 – 15 cm depth) collected from Warburton rice area were placed in polythene–lined plastic pots. The soil was clayey in exture having 23.4% clay determined by Bouyoucos hydrometer method, 1.3 mmhos/cm electrical conductivity, 0.73% organic matter estimated by Walkley and Black's method and a pH of 8.2 determined in 1:2 soil/water suspension with glass electrode method as described by Jackson (1965). Carbonate ($CaCO_3$) contents were 2.9% as determined by Puri's method (Puri, 1966). Diethylene triamine pantaacetic acid (DTPA) – extractable (Lindsay and Norvell, 1978) Zn, Cu and Fe in the soil, determined on AAS, were 0.6, 4.0 and 60 ppm, respectively.

After the basal application of N at 75 ppm as urea and that of P at 37 ppm as KH_2PO_4, Zn, Cu and Fe were applied, except the control, at 5 ppm as their sulphates. Fifteen day–old six seedlings of Basmati–370, Kashmir–Basmati, IR–6, IR–8 and Jhona–349 were transplanted in each pot which were thinned to four after a fort–night. The experiment was replicated three times in a completely randomized design. The plants were grown for 43 days under flooding using deionized water. After harvesting, the plants were washed with deionized water and dried to record their dry matter yields. One gram portions of the ground plants were digested in acid mixture and Zn, Cu and Fe contents in the digests were determined on AAS.

RESULTS AND DISCUSSION

Ion contents

1. Field experiment: In leaves, zinc concentration ranged from 11.0 – 29.5, Cu from 3.5 – 9.5, Fe from 75 – 210 and Mn from 45 – 165 ppm showing a coefficient of variation as 21.8, 21.5, 27.9 and 37.9, respectively in the various rice cultivars (Table1). Since the plants of all the varieties were of the same age and

Table 1. Zinc, copper, iron and manganese concentration in various rice cultivars grown in the field

Cultivars	Zn	Cu	Fe	Mn
	ppm			
Jhona–349	29.5	9.5	157	82
Basmati–197	26.0	9.5	112	97
Basmati–198	23.5	7.0	82	45
Basmati–Pak	25.0	7.5	105	71
Kashmir Basmati	21.0	7.0	210	75
Basmati–370	20.0	6.0	90	71
No. 2448	20.0	7.5	165	86
No. 2543	23.5	5.5	120	120
No. 2487	28.1	6.5	105	97
Bengalo	16.0	6.5	120	60
D.M.2.	15.0	4.0	150	150
D.M.6	16.5	3.5	–	–
Sunari Kangani	18.0	7.0	112	60
Palman–246	20.0	6.5	105	60
K x T	20.0	6.0	75	75
S. Sugdasi	19.0	6.5	90	71
Kangani–27	19.0	7.5	105	60
Kumari	18.0	6.5	112	60
Ratria	20.0	8.5	97	82
Tajia	16.5	5.0	112	78
IR–6	22.0	6.0	90	165
IR–8	21.0	6.5	112	124
Hang Ban	17.5	5.0	90	75
Chung Chiang	19.0	5.5	82	82
NP–130	21.0	8.0	97	82
Habij Boro–IV	17.5	6.0	195	64
Marich Bati	16.5	6.5	82	60
Basmati–320	24.5	6.0	127	82
T.N.1	22.0	3.5	–	120
Charnock	18.0	8.0	157	64
Reimei	13.0	6.5	–	–
Habij Boro–II	11.0	6.0	135	49
Habij Boro–VI	12.0	7.0	105	49
Duler	14.0	5.5	120	49

*Coefficient of variation among cultivars with respect to Zn, Cu, Fe and Mn concentration were 21.8, 21.5, 27.9 and 37.9, respectively.

were grown in the same field under similar cultural conditions, the vast differences in the nutrient concenteations of cultivars reflect differences in their abilities to absorb micronutrient ions from the soils and translocation in the plants. Similar results have been reported by other workers (Forno et al., 1975; Lafever, 1981 and Shukla and Raj, 1976).

2. Pot experiment.

(i) Concentration: At zero level of micronutrient application shoot Zn concentration (Table 2) ranged from 13.3 – 14.9, Cu from 8.5 – 9.3 and Fe from 127 – 198 ppm showing difference in concentrations as 12.0, 9.4 and 55.8%, respectively. The same was evidenced from various investigations (Bowen, 1986 and Forno *et al.*, 1975). The extent of difference in the micronutrient ion concentrations of cultivars grown without these fertilizers in the field from

Table 2. Effect of Zn, Cu and Fe application to the soil on their respective concentrations and uptake in various rice cultivars grown in pots

Cultivar	Zn level, ppm		Cu level, ppm		Fe level, ppm	
	0	5	0	5	0	5
Conc. ppm	Zn		Cu		Fe	
Basmati–370	14.5	21.6 (.19)	8.5	9.7 (.21)	198	205 (.19)
Kashmir–Basmati	14.9	20.2 (.22)	9.3	8.5 (.22)	198	194 (.22)
IR–6	13.5	19.8 (.19)	8.9	12.1 (.22)	164	183 (.21)
IR–8	13.9	18.4 (.17)	9.1	14.5 (.18)	138	187 (.21)
Jhona–349	14.9	23.4 (.18)	8.9	10.1 (.19)	127	176 (.19)
Uptake, ug/pot						
Basmati–370	139	282	81	98	1900	1537
Kashmir–Basmati	89	241	55	67	1195	1578
IR–6	101	243	67	76	1233	1334
IR–8	83	222	57	81	859	988
Jhona–349	154	392	93	91	1318	1786

L.S.D. (P = 0.05)		Conc.	Uptake
Treatment	Zn	0.66	29.59
	Cu	1.00	9.09
	Fe	21.70	N.S.
Variety	Zn	1.00	46.48
	Cu	1.60	14.38
	Fe	34.30	423.64
Treatment x variety	Zn	2.09	N.S.
	Cu	3.19	N S.
	Fe	N.S.	N.S.

Figures in parenthesis are of phosphorus percentages.

those grown in the pots was perceptible. It could be attributed to the variation in type of soils and their nutrient supplying capabilities as well as environmental conditions.

Compared with the concentrations of Zn, Cu and Fe in control plants, the concentrations of ions in the shoots of various cultivars at 5 ppm were increased on an average by 44.1, 30.7 and 22.5%, respectively (Table 2). Similar results have been reported by several investigators (Bowen, 1986; Safaya and Gupta, 1979). The large difference in concentrations in the presence of fertilizers indicated that the differential abilities of cultivars to absorb nutrients were related more to their differential susceptibilities than to their genetic variabilities.

(ii) Uptake: Similar to their concentration in plants, the uptake of Zn, Cu and Fe in different rice plants grown with and without micronutrients significantly varied (Table 2) and this may be supported by the findings of other workers (Bowen, 1986 and Safaya and Gupta, 1979). In all the varieties given micronutrients, only the uptake of Zn and Cu in plants was significantly increased above that applied no micronutrients; with an average increase of 147, 24 and 20% for Zn, Cu and Fe, respectively. However, the varieties generally differed among themselves significantly in their power for exploiting soils for micronutrients.Relative resistance in Basmati_370 and Jhona–349 might have developed, possibly due to their long time cultivation in soil and climatic conditions of the region as suggested by Forno *et al.* (1975) and Tanaka and Yoshida (1970). Though the above varieties showed less response to the applications of Zn, Cu and Fe, they, however, accumulated higher amounts of micronutrients than that from the responsive ones. This may be attributed to their higher capacity for efficient utilization of ions under both favourable and unfavourable conditions.

(iii) Dry matter yield: The response in terms of increased dry matter yield of cultivars grown with 5 ppm of micronutrients compared to that grown without that was noticed to vary from 36.1 to 99.8% with Zn, from –11.4 to 32.4% with Cu and from –4.1 to 27.7% with Fe. This has an abundant support from the literature Safaya and Gupta, 1979; Tahir, 1978). Coversely, the percentage depression in the dry matter yield without micronutrients compared to their applications ranged from 26 (Basmati–370) to 50 (Kashmir–Basmati) for Zn, –19 (Basmati–370) to 24 (Kashmir–Basmati) for Cu and –20 (Basmati–370) to 21% (Kashmir–Basmati) for Fe, respectively. From the yield response/depression data an order of susceptibility of cultivars to deficiency of Zn could be obtained as: Kashmir–Basmati > IR–8 > IR–6 > Jhona–349 > Basmati–370, to that of Cu as: Kashmir–Basmati > Basmati–370 > IR–6 = IR–8 > Jhona–349 and to that of Fe as: Kashmir–Basmati > Jhona–349 > IR–6 > IR–8 > Basmati–370. This suggests that the varieties have differential requirements of nutrients for their growth that has generally been related to genotypic influence of crops (Forno *et al.*, 1975; Lafever, 1981 and Reddy and Prasad, 1986).

It is evident from the results that the cultivars which were susceptible to the deficiency of micronutrients particularly that of Zn, differed in their growth response in relation to their rate and capacity to exploit and/or absorb soil Zn, Cu and Fe. Genotypic influence of Zn uptake by rice (Bowen, 1986; Forno *et al.*, 1975; Reddy and Prasad, 1986 and corn (Safaya and Gupta, 1979) has been reported. The variations were of such a magnitude that it might be useful to take them into account when making fertilizer recommendations for crops.

It is generally construed that the genetic make–up of the plants controls their capabilities of soil nutrient utilization. The susceptibility to Fe deficiency in crop varieties is thought to be governed by a single recessive gene. In the present study the cultivars selected were indigenous (Basmati–370 and Jhona–349), hybrid (IR–6 and IR–8) and mutant (Kashmir–Basmati) but differential response/susceptibility did not seem to be associated with any particular plant group. The resistant varieties (Basmati–370 and Jhona–349) generally translocated more Zn, Cu and Fe from roots to the shoots than the other susceptible varieties. This could be related to their differential capacity in exploiting soils particularly under Zn deficient conditions (Shukla and Raj, 1976 and Forno *et al.*, 1975).

Simple correlation studies (Table 4) between yield depression and these variables under Zn, Cu and Fe treated conditions were made. It did not show significant correlation between yield depression and Zn, Cu, Fe and P concentrations in tissue probably due to a small number of cultivars stud-

Table 3. Effect of Zn, Cu and Fe applications to the soil on dry matter production of various rice cultivars grown in pots (within brackets = percent increase)

Cultivar	*Treatment			
	Control	Zn, 5ppm	Cu, 5ppm	Fe, 5ppm
	------------------- g/pot -------------------			
Basmati–370	9.58	13.04 (36.1)	10.13 (5.7)	9.49 (–0.9)
Kashmir–BAsmati	5.98	11.95 (99.8)	7.92 (32.4)	7.64 (27.7)
IR–6	7.48	14.29 (91.0)	7.22 (–3.5)	7.17 (–4.1)
IR–8	6.24	12.07 (93.4)	5.57 (–10.7)	6.82 (9.3)
Jhona–349	10.36	16.68 (61.0)	9.18 (–11.4)	10.35 (–0.1)

*L.S.D. (P = 0.05) for difference in Zn levels was 1.3 while that in Cu and Fe was not significant, for differences among varieties with respect to Zn, Cu, and Fe treatments were 2.0, 1.1 and 1.8 respectively and for differences among varieties x element levels interaction, except that of Cu (2.1), were not significant.

Table 4. Correlation between dry matter yield depression and Zn, Cu, Fe and P concentrations in Zn, Cu and Fe treated plants of various rice cultivars grown in pots

Variable	Yield depression		
	Zn treated	Cu treated	Fe treated
	---------- 'r' values* ----------		
Zn conc.	–0.469	0.505	0.354
Cu conc.	–0.212	–0.770	–0.449
Fe conc.	–0.539	0.441	0.322
P conc.	0.162	0.618	0.557

* – non–significant.

ied. However, it helps to develop an understanding that the genetic formation of plants as a whole rather than a single gene factor could be important. Moreover, the combined effect of nutrient interactions in the soil and within the plants may have an additional influence on the differential susceptibility of rice varieties to the deficiency of these micronutrient elements.

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