EFFECT OF APPLIED ZINC AND MANGANESE ON THE GROWTH OF RICE I. UNDER FLOODED AND NON-FLOODED CONDITIONS

M. S. BRAR AND G. S. SEKHON

Department of Soils, Punjab Agricultural University, Ludhiana

ABSTRACT

Rice plants were grown under flooded and non-flooded conditions. Dry weight of the plant increased with addition of zinc (up to 5 ppm) and manganese (upto 10 ppm) to the soil. Further increase in the rate of zinc and manganese application decreased the dry weight of the plant. Maximum yield was obtained by a combined application of 5 ppm zinc and 10 ppm manganese. Flooding significantly increased the dry weight of the plant, provided the limiting micronutrients such as zinc and manganese were also applied. Flooding increased the content of manganese and iron but decreased the content of zinc and copper in the plants.

INTRODUCTION

Micronutrient deficiencies have been reported to be wide spread throughout the world. Efforts are afoot to use micronutrient materials to correct this deficiency and augment crop production. Beneficial effects of flooding on the growth of rice have been reported (CHERIAN, PAULSEN & MURPHY, 1968; GIORDANO & MORTVEDT, 1972). Increased availability of manganese and iron in submerged soil has been associated with increased rice growth (AIYER, 1946). There are suggestions that availability of native zinc decreases on flooding (WELLS, THOMPSON, PLACE & SHOCKLEY, 1973). There is thus a possibility that flooding may accentuate zinc deficiency particularly on soils recently brought under rice cultivation.

This investigation seeks to study the effect of applied zinc and manganese on the growth of rice in saline sodic soils on which this information is lacking. It also examines if growth with the addition of these micronutrients under non-flooded conditions can compare with growth under flooded conditions.

MATERIALS AND METHODS

Laungowal loam, a (paraquic) Natric Camborthid from village Duggan in District Sangrur (Punjab, India) was the test soil. This soil, recently brought under rice cultivation, had a pH of 9.2, and contained 0.36, 4.00, 1.23, and 6.20 ppm DTPA-extractable zinc, manganese, copper, and iron respectively. A basal dose of NPK at the rate of 120 ppm N, 26.2 ppm P and 24.9 ppm K was supplied. N, P, K, Zn and Mn were applied in solution form, mixed thoroughly with three kg soil which was transferred to polythene lined earthen pots. Three levels of zinc 0, 5, and 10 ppm as $ZnSO_4.7H_2O$ and three levels of manganese 0, 10, and 20 ppm as $MnCl_2.4H_2O$ were applied. Each treatment was replicated six times. Three replications were kept under flooded and three under non-flooded conditions. Rice (*Oryza sativa* L., variety Jaya) seedlings were raised on the same soil for 15 days before transplantation to treated pots. Thirty days after transplanting plants were harvested, separated into roots and shoots, and were washed successively in

0.1 N HCl, distilled and redistilled water. Their dry weight was recorded, and the samples were prepared for subsequent analysis. These were digested in a triple acid mixture of nitric acid, perchloric acid and sulphuric acid in the ratio of 9 : 3 : 1. Digested extracts were analysed for zinc, manganese, iron and copper on atomic absorption spectrophotometer (Varian Techtron Model AA 120).

RESULTS AND DISCUSSION

Dry weight of the plant (Table 1) increased with application of 5 ppm zinc and 10 ppm manganese to the soil. However, further increase in rates of applied zinc and manganese slightly decreased the dry weight. Dry weight of roots and shoots increased to more than 300 and 150 per cent respectively over the control with the application of 5 ppm zinc. Application of manganese at the rate of 10 ppm increased the dry weight of roots and shoots to the extent of 41 and 39 per cent respectively over the control. Cox (1968) observed that the degree of yield response to manganese could be predicted from soil pH and extractable manganese. The level at which crop responds to the applied manganese increases with increase in pH of the soil. Since the soil was saline sodic with pH 9.2 and tested low in zinc, response to the application of both manganese and zinc was expected. The spectacular increase in yield of dry matter with addition of zinc to the soil indicates the essentiality of zinc application for good growth and yield of rice on these soils. Maximum yield was obtained, however, with an application of 5 ppm zinc and 10 ppm manganese.

Table 1—Effect of zinc and manganese application on the dry weight of root and shoot (g/pot)

Rate of Zn application (ppm)	Rate of manganese application (ppm)							
	Root				Shoot			
	0	10	20	Mean	0	10	20	Mean
0 ..	0.51	0.63	0.95	0.70	2.12	2.48	3.42	2.67
5 ..	2.15	3.30	3.18	2.87	5.48	8.47	6.47	6.80
10 ..	2.10	2.82	2.80	2.56	5.10	6.75	6.53	6.12
Mean ..	1.58	2.25	2.30	..	4.23	5.90	5.47	..

C.D. 5% Zn=0.53, Mn=0.53; Zn × Mn=NS (Root) Zn=0.75, Mn=0.75; Zn × Mn=NS (Shoot)

The data in Tables 2 and 3 show that zinc and manganese application increased the dry weight of plants under both the moisture regimes but yield was more under flooded than under non-flooded conditions. The non-flooded soil did not match the flooded soil in spite of fertilizer additions. Rice plants grown in flooded soils produced more dry weight than in non-flooded soils. Increase in dry weight of roots and shoots upon flooding of the soil was of the order of 200 and 50 per cent respectively. Cherian, Paulson and Murphy, (1968), Naphade and Ghildyal (1971) and Islam and Islam (1973) also observed better growth and yield under flooded than under non-flooded conditions. This has been attributed to higher root proliferation and greater uptake of nutrients by rice under flooding.

Flooding increased the dry weight of roots more than that of shoots which suggests that flooding caused relatively more favourable conditions for the development of roots.

Table 2—Effect of zinc application on dry weight of root and shoot (g/pot) under flooded and non-flooded conditions

Rate of Zn application (ppm)	Root		Shoot	
	Non-flooded	Flooded	Non-flooded	Flooded
0 ..	0.45	0.94	2.08	3.27
5 ..	1.41	4.33	5.88	7.73
10 ..	1.14	3.99	4.79	7.46
Mean ..	1.00	3.08	4.24	6.15
C.D. 5%	moisture=0.43 m×Zn=0.74		moisture=0.62 m×Zn=NS	

Table 3—Effect of manganese application on dry weight of root and shoot (g/pot) under flooded and non-flooded conditions

Rate of Mn application (ppm)	Root		Shoot	
	Non-flooded	Flooded	Non-flooded	Flooded
0 ..	0.66	2.50	3.36	5.10
10 ..	1.26	3.13	5.05	6.74
20 ..	1.08	3.53	4.32	6.62
Mean ..	1.00	3.08	4.24	6.15
C.D. 5%	moisture=0.43 m×Mn=NS		moisture=0.62 m×Mn=NS	

Flooding increased the content of iron and manganese, and decreased that of zinc and copper in the plants (Table 4). Increase in iron and manganese content of plants may be due to the reduction of higher oxides of iron and manganese upon flooding with a consequent increase in their availability to plants. A concomitant decrease in the content of zinc and copper is apparently due to an interference of increased available iron and manganese in the absorption of zinc and copper by the plants (Brar & Sekhon, 1976) and decreased availability of zinc upon flooding (Brar, 1975).

Aiyer (1946) alluded beneficial effect of flooding on the growth of rice to increased uptake of manganese. Results of this experiment showed that manganese content of rice observed in flooded soil could be obtained in non-flooded soil with an application of 10 ppm manganese to the soil. Even then the yield was more in flooded soil, which suggests that besides increasing manganese availability, flooding has some other beneficial effects also on the growth of rice.

Table 4—Effect of zinc and manganese application on the micronutrient content of rice plants grown under flooded and non-flooded conditions

Rate of zinc and manganese application		Roots				Shoots			
Mn (ppm)	Fe	Zn	Mn (ppm)	Cu	Fe	Zn	Mn (ppm)	Cu	Fe
				Non-flooded					
0	0	19	90	96	360	7	130	27	320
	5	72	80	78	327	50	117	19	210
	10	163	100	799	287	66	123	17	160
10	0	31	120	90	293	6	143	28	220
	5	93	140	78	273	48	147	18	207
	10	127	127	72	280	71	138	18	147
20	0	27	127	70	287	6	173	25	173
	5	83	167	70	240	46	172	19	173
	10	112	210	62	240	79	162	17	143
Mean	..	82	129	77	287	42	145	21	195
				Flooded					
0	0	19	143	75	720	7	202	23	416
	5	80	100	53	673	36	222	14	293
	10	127	143	46	590	58	210	14	227
10	0	18	247	57	580	5	253	23	323
	5	92	230	43	610	27	230	13	243
	10	125	243	41	580	42	220	10	207
20	0	31	333	54	557	6	293	20	297
	5	83	357	42	507	27	257	13	210
	10	92	360	40	503	55	265	7	170
Mean	..	74	240	50	591	29	238	15	265

C.D. at 5%								
Zn ..	14.7	NS	13.6	NS	7.3	NS	3.3	33.3
Mn ..	NS	53.8	NS	54.9	NS	NS	NS	NS
Zn × Mn ..	NS	NS	NS	NS	NS	NS	NS	NS
moisture (m)	NS	43.9	11.2	45.1	5.9	16.3	2.6	27.2
m × Zn ..	NS	NS	NS	NS	10.3	NS	NS	NS
m × Mn ..	NS	76.0	NS	NS	NS	NS	NS	NS
m × Zn × Mn ..	NS	NS	NS	NS	NS	NS	NS	NS

Zinc and manganese content in roots and shoots (Table 4) significantly increased with an increase in the rate of application of zinc and manganese in the soil. Iron content of the plants decreased with increasing rates of application of zinc and manganese. This may be due to the decreased absorption of iron by plants upon application of zinc (Lingle, Tiffin & Brown, 1963) and manganese (Tanaka & Navasero, 1966) or decrease in availability of iron consequent upon zinc application to the soil (Brar, 1975).

Copper content of shoots decreased to 56 per cent and that of roots to 76 per cent and yield decrease ensued with an application of 10 ppm zinc to the soil. The decrease in content of copper may be due to interference of zinc in its absorption. Chaudhry, Sharif, Latif and Qureshi (1973) also observed that zinc application to soil markedly decreased the copper content of rice plants and decreased the yield of rice on soils where available copper was marginal. The results of this study indicate that higher dose of one micronutrient may affect the absorption and utilisation of the others and hence affect the yield of the plant.

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