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Response of rice cultivars to zinc in sodic soil

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ABSTRACT

The response of rice cultivars to Zn in sodic soil were investigated. The treatments consisted of 3 levels of zinc in the main plot i.e. 0, 25 and 50 kg of $ZnSO_4$ ha^{-1} and two native land races Bejhari and Kalmuhil; two salt tolerant rice cultivars, Vikash and CSR-10 and two popular high yielding varieties Sarjoo-52 and PB-1 in the sub plots replicated four times. Yield of different rice cultivars increased significantly with increasing levels of zinc upto 50 kg ha^{-1}. The grain yield of Bejhari was at par with Kalmuhi during both the years whereas the grain yield of Vikash, CSR-10, Sarjoo-52 and PB-1 differed significantly from each other within their groups. The uptake of zinc by grain and straw increased significantly with increasing levels of zinc upto 50 kg $ZnSO_4$ ha^{-1} during both the years. The zinc utilization efficiency of different rice cultivars declined with increase in the rates of zinc application. Zinc utilization efficiency was higher in the varieties Bejhari,CSR-10 and Sarjoo-52. The two native land races Bejhari and Kalmuhi responded less to zinc application as compared to salt tolerant rice cultivars and HYVs.

Key words: *Sodic soil, native land races, salt tolerant rice cultivars, HYVs, yield attributes, zinc acquisition and ZnUE)*

Many studies have been focused to screen out Zn efficient varieties of different crops (Sakal *et al.,* 1984; Rathore *et al,* 1986; Takkar, 1993). As such cultivation of Zn efficient crop varieties provides an alternative to combat Zn deficiency. In India, sodic soils occupy an area of about 2.6 million ha (Chandra, 1985). Sodic soils in general are low in available Zn because of adverse conditions prevailing in the same. Among cereals, rice is most susceptible to Zn deficiency. $ZnSO_4$ is a common source of Zn under field conditions. Hence, the present study was conducted to screen Zn efficient rice cultivars under sodic soil conditions.

MATERIALS AND METHODS

Field experiments were conducted during wet season of 1999 and 2000 at Regional Research Station, Daleepnagar, Kanpur. The treatments consisted of 3 levels of zinc *i.e.* 0, 25 and 50 Kg of $ZnSO_4$ $ha^{-1}$and native land races *Bejhari* and *Kalmuhi,* salt tolerant rice cultivars Vikash and CSR-10; and HYV popular checks Sarjoo-52 and PB-1. The experiment was laid out in split-plot design with levels of zinc in main plots and varieties in sub-plots with four replications. The soil of the experimental field was typic natrustalf having pH 10.2, EC 6.5 (dSm^{-1}) ESP-78, CEC 12.30 cmol (p+) kg^{-1}, OC 1.9 g kg^{1}, available Zn 0.45 mg kg^{-1} soil. N, P_2O_5 and K_2O were applied @ 120, 60 and 40 kg ha^{-1} during both the years of study. Half of the dose of N and full doses of P and K were applied just before transplanting and the remaining N was applied in two equal splits at tillering and panicle initiation stages. The crop was harvested at full maturity and yield attributes and yield of grain and straw were recorded. Zinc was estimated in grain and straw samples separately by atomic absorption spectrophotometer and its uptake was computed. The zinc utilization efficiency (ZnUE) was calculated by employing the formula :

$$\text{Zn UE} = \frac{\text{Kg grain obtained over check}}{\text{rate of Zinc applied}}$$

RESULTS AND DISCUSSION

The data presented in Table 1 clearly revealed that yield attributes *viz.,* productive tillers m^{-2} and panicles $hill^{-1}$ increased significantly with increasing levels of $ZnSO_4$ application upto 25 kg ha^{-1} but they were at par with 50 kg ha^{-1} level. However, filled grains $hill^{-1}$ and weight of panicles $hill^{-1}$ increased significantly with increasing

Table 1. Yield and yield attributes of different rice cultivars as influenced by varying levels of zinc application

Treatments	Productive tillers m^{-2}		Panicles $hill^{-1}$		Filled grains $hill^{-1}$		Weight of panicles $hill^{-1}$ (g)		Test weight (g)		Grain t ha^{-1}		Straw t ha^{-1}	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Levels of $ZnSO_4$ (kg ha^{-1})														
0	177.68	187.73	12.39	12.57	846.8	860.8	15.44	16.35	29.43	29.14	2.54	3.01	3.33	4.12
25	191.77	206.17	15.06	15.33	938.8	953.5	17.42	17.27	28.71	28.46	2.74	3.56	3.56	4.87
50	198.92	216.00	16.58	16.77	992.0	1002.5	19.29	17.92	27.63	27.50	2.90	3.72	3.79	5.08
CD (P=0.05)	11.109	12.025	1.733	1.757	40.238	41.381	1.865	0.109	0.704	0.621	0.136	0.153	0.221	0.188
Varieties														
Bejhari	195.33	197.33	13.56	13.71	916.00	926.00	16.77	16.53	27.94	27.75	2.75	3.19	3.99	4.78
Kalmuhi	192.17	184.00	14.25	14.42	892.67	906.33	15.11	16.08	24.76	24.61	2.66	3.00	3.83	4.54
Vikash	165.60	170.67	12.98	13.25	850.67	865.33	14.69	15.70	31.49	31.33	2.25	2.66	3.21	3.61
CSR-10	198.67	220.67	16.63	16.86	959.00	969.33	17.15	18.12	29.92	29.74	2.81	3.87	2.99	3.80
Sarjoo-52	204.93	230.67	15.42	15.70	993.67	1007.33	17.83	19.28	29.33	28.96	3.31	4.27	3.78	5.76
PB-1	180.03	215.67	15.20	15.40	943.33	957.66	16.17	17.37	28.10	27.80	2.71	3.54	3.50	4.79
Mean	189.46	203.17	14.68	14.89	925.87	938.93	16.29	17.18	28.59	28.37	2.731	3.43	3.55	4.55
CD (P=0.05	10.653	8.291	2.236	2.246	43.394	44.225	1.961	0.145	1.070	1.051	0.319	0.291	0.393	0.234
Zn x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

levels of zinc sulphate upto 50 kg ha^{-1}. The test weight of grains declined significantly with increasing levels of zinc upto 50 kg ha^{-1}. With regards to varieties, the yield attributes bearing panicles $hill^{-1}$ of land races *Bejhari* and *Kalmuhi* were on par. Among salt tolerant rice cultivars, yield attributes differed significantly from each other noting higher values with CSR-10 in comparison to Vikash during both the years. Among the HYV popular checks, all the yield attributes differed significantly from each other except panicles $hill^{-1}$. The panicles weight was at par during first year but it differed significantly during second year. The test weight of grains of all the rice cultivars varied from 24.76 g in *Kalmuhi* to 31.49g in Vikash during first year. Similar trend was also recorded during second year of study. The test weight of varieties differed significantly from each other within their groups. The lower test weight is an indication of fineness of the varieties in question which might be due to their genotypic variability. The interaction effects of levels of zinc and varieties on yield attributes were non-significant in both the years of study. The increase in yield attributes of different rice cultivars with the rates of zinc application might be due to increased biomass accumulation. Similar findings have also been reported by Takkar *et al.* (1989) and Nayyar *et al.* (1990). The decline in test weight of grains with increase in the rates of zinc application might be due to reduction in the size of grains with increased biomass in the form of grain yield. The variation in yield attributes of different rice cultivars might be due to their genotypic variability.

Grain yield of different rice cultivars increased significantly with increasing levels of zinc sulphate application upto 50 kg ha^{-1} during both the years of experimentation (Table 1). Grain yield of *Bejhari* and *Kalmuhi* were at par during both the years. The CSR-10 had an edge over Vikash and Sarjoo-52 over PB-I which could be due to the influence of Zn which enhanced yield attributes thus contributing to increased grain yields significantly. The increase in grain and straw yield was clearly due to the fact that the experiment was conducted on zinc deficient soil.

The variation in grain yield of different rice cultivars from 2.25 to 3.31 t ha^{-1} during first year and from 2.66 to 4.27 t ha^{-1} during second year seemed to be due to variations in their genotypes. The optimum rates of zinc application varied with severity of its

Table 2. Zinc utilization efficiency and zinc uptake of different rice cultivars as influenced by varying levels of zinc application (kg grain obtained/kg zinc applied).

Treatments	Zn utilization efficiency		Uptake (g ha^{-1})	
Levels of $ZnSO_4$ (kg ha^{-1})	1999	2000	1999	2000
0	-	-	103.78	110.05
25	7.96	21.98	158.95	165.58
50	3.16	02.86	188.37	196.86
Mean	5.56	12.42	-	-
Varieties				
Bejhari	2.82	9.69	76.32	79.69
Kalmuhi	2.34	7.66	69.67	73.94
Vikash	7.80	6.87	58.69	63.74
CSR-10	7.06	16.87	76.65	79.52
Sarjoo-52	9.07	19.38	92.48	95.65
PB-1	4.30	14.07	77.28	80.45
Mean	5.565	12.423	75.18	78.83

deficiency and/or soil type. The rate of zinc application was higher (22 kg ha^{-1}) for rice in highly sodic (pH > 10) and flood plain soils as compared to 11 kg ha^{-1} in moderately alkaline soils of pH 9.4–9.7. Nayyar *et al.* (1990) reported 22.4 kg Zn ha^{-1} for obtaining optimum yield on a highly sodic soil (pH-10.4). The yield of straw too increased significantly with increasing levels of zinc sulphate application upto 50 kg ha^{-1} during both the years of study. Straw yield of *Bejhari* and *Kalmuhi* was at par during both the years. Similar trend was also noticed with salt tolerant rice cultivars Vikash and CSR-10. Straw yield of Sarjoo-52 was significantly higher than PB-1 during both the years. The interaction effects of zinc and varieties on grain and straw yield were non-significant in both the years.

The total zinc uptake increased significantly with increasing levels of zinc sulphate application upto 50 kg ha^{-1} during both the years of study (Table 2). Amongst the varieties, zinc uptake by native land race; salt tolerant rice cultivars; and HYVs differed significantly from each other within their groups during both the years. The highest amount of zinc uptake was by the variety Sarjoo-52 and lowest with Vikash during both the years of study. The interaction effects of levels of zinc and varieties were non-significant during both the years. The increase in uptake of zinc with increase in the rates of zinc application seemed to be due to increased availability of zinc in soil and its more absorption by crop plants. The variation in zinc acquisition by different rice cultivars might be due to their genotypic variability in absorption and accumulation of Zn by different rice cultivars. Soil applications of Zn SO_4 significantly increased the zinc uptake by rice crop (Prasad and Umar, 1993; Sakal *et al.* 1993 and Rathore *et al.* 1995).

Zinc utilization efficiency declined with increase in the rates of zinc sulphate application upto 50 kg ha^{-1} during both the years of study. On an overall basis, highest ZnUE was observed with Sarjoo-52 closely followed by CSR-10 and lowest with *Kalmuhi*. It was further noticed that the response to Zn application was lower in the two native land races *Bejhari* and *Kalmuhi* as compared to salt tolerant rice cultivars and HYVs. Prasad and Umar (1993) also reported that the variety which showed the least response to soil application of $ZnSO_4$ could meet most of its zinc requirements from the native sources in soil leaving the fertilizer zinc to affect it only marginally. The variations in ZnUE of different rice cultivars might be due to biodiversity in their genotypes.

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