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EFFECT OF ZINC AND SULPHUR LEVELS ON RICE IN PARTIALLY RECLAIMED TYPIC NATRUSTALFS SODIC SOIL

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ABSTRACT

Individual and interactive effects of different levels of zinc and sulphur on the yield, yield attributes, nutrients uptake and statistical relationship among various parameters of rice were studied during kharif seasons of 2006 and 2007 at Kanpur. Application of 40 kg zinc sulphate ha^{-1} enhanced significantly grain and straw yield along with yield attributes and zinc uptake. Similarly, significant response of rice to sulphur addition was also recorded up to 40 kg S ha^{-1}. Increasing levels of zinc and sulphur increased significantly their uptake by rice crop. The uptake of nitrogen and phosphorus by rice crop enhanced markedly with zinc and sulphur addition. The uptake of nutrients and yield attributes along with quality parameter of grain were found to be significantly correlated with each other.

Keywords: Rice, yield, nutrients uptake, quality characteristics, zinc, sulphur

INTRODUCTION

Salt affected soils are widespread in U.P, Haryana and Punjab. These soils bear distinctive characters of containing excessive concentration of either soluble salt or exchangeable sodium or both. Sodic soils pose many limitations to crop growth by way of the toxic effects of sodicity and certain nutrients element as well as poor fertility due to restriction on availability of certain other nutrients. These soils are formed under the influence of high exchangeable sodium salts, which in presence of $CaCO_3$ imparts the soils high pH, poor physico-chemical condition due to dispersing action of exchangeable Na^+ affecting soil air and water permeability. Availability of N, Zn and S to plants in these soils is extremely poor (Rakesh et al. 2003, Dubey and Chauhan 2002, Hundal et al. 2006). Rice (*Oryza sativa*) is a crop, which is preferred to be grown on sodic soil because it is tolerant to sodicity and has reclamation effect on soil. Zinc deficiency has been recognized as an important and wide spread nutritional disorder of rice (Tripathi and Rawat, 2002, Singh and Tripathi, 2005). Sulphur availability is also a serious problem in plant nutrition in such soils which are poor in organic matter. The response of combined application of zinc and sulphur had been studied by Singh and Singh (2002) and Jena et al. (2006) on various crops but the information gathered on interactions between Zn and S on upland rice in partially reclaimed sodic soils is scanty. Therefore, the present study was undertaken to evaluate the effect of various levels of zinc and sulphur on the rice in partially amended Typic Natrustalf of Uttar Pradesh.

MATERIALS AND METHOD

A field experiment was conducted during kharif seasons of 2006 and 2007 as a fixed layout with partially amended sodic soil of Regional Research Station, Dalipnagar, C.S. Azad University of Agriculture and Technology, Kanpur using high yielding rice cultivar 'Sarjoo-52'. The soil was classified as Typic Natrustalf. The initial physico-chemical characteristics of the soil were pH 9.8, EC 6.75 dSm^{-1}, exch. sodium 45%, CEC 13.25 cmol (p+) kg^{-1} and organic carbon 2.5g kg^{-1} soil. The hydraulic conductivity was 0.28 cm ha^{-1}. The soil was clay loam in texture having available N 132, P 8.55 and K 290 kg ha^{-1}, S 9.2 mg kg^{-1} and DTPA-Zn 0.32 mg kg^{-1}, respectively. The treatments consisted of four levels each of Zn and S (0, 20, 40 and 60 kg ha^{-1}) through zinc oxide and elemental sulphur, respectively. Nitrogen, phosphorus and potassium were applied @ 120, 60 and 60 kg ha^{-1}. Initially full dose of P_2O_5 and K_2O were applied at the time of transplanting of 35 days old seedlings through diammonium phosphate and muriate of potash, respectively. Urea was applied in three equal doses, one third as basal and remaining half dose was applied in two equal splits at maximum tillering and pre-flowering stages of the crop. At maturity grain and straw yields were recorded. Grain and straw samples were analyzed for N content by modified Kjeldahl method. Phosphorus in di acid extract was determind by vanadomolybdate yellow colour method (Jackson 1973). Sulphur was determined in acid extract turbidimetrically (Chesnin and Yien 1951) and zinc by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Yield and yield attributes

The maximum productive tillers/m^2, number of filled grains/panicle and test weight were noticed with 40 kg $ZnSO_4$ ha^{-1} followed by 60 and 20 kg $ZnSO_4$ ha^{-1}. Increasing levels of sulphur significantly increased these attributing characters up to 40 kg S ha^{-1}. Response of sulphur levels was more pronounced than that of zinc levels on these components. The average values of productive tillers/m^2, number of filled grains/panicle and test weight ranged from 248.0 to 325.5, 76.5 to 154.5 and 26.0 to 38.4 g, respectively due to various levels of sulphur application (Table 1). Although each level of zinc and sulphur significantly enhanced the dry matter accumulation in plants up to 40 kg ha^{-1} respectively. Application of each zinc and sulphur @ 60 kg ha^{-1} respectively could not differ significantly from that of 40 kg ha^{-1} zinc sulphate and 40 kg ha^{-1} sulphur. The accumulation of dry matter in plants of rice at flowering stage under the influence of each level of zinc and sulphur was more than that of tillering stage of crops. These results corroborate with the findings of Tripathi and Rawat (2002) and Dwivedi *et al.* (2002).

Table 1: Response of zinc and sulphur levels on the yield components and dry matter accumulation of rice

Treatments	Productive tillers/m^2		Number of filled grains/panicle		Test weight (g)		Dry matter accumulation (g/m^2)			
							Tillering stage		Flowering stage	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Zinc sulphate (kg ha^{-1})										
0	230	245	72	92	23.2	25.5	540	550	582	591
20	265	277	95	120	28.7	31.0	585	602	620	630
40	290	309	128	155	35.2	39.3	618	638	649	665
60	305	320	134	160	37.3	41.4	630	645	656	673
CD (P=0.05)	12.3	13.4	3.6	4.5	NS	NS	26.3	27.5	28.0	29.3
Sulphur (kg ha^{-1})										
0	242	254	68	85	25.3	26.7	532	540	575	583
20	269	278	98	117	29.9	31.6	580	595	616	635
40	309	323	133	167	34.7	38.7	623	636	661	670
60	320	331	138	171	36.1	40.8	635	643	672	684
CD (P=0.05)	13.0	14.2	3.9	4.7	NS	NS	26.8	27.7	28.8	30.8

Increasing levels of zinc significantly increased the average grain yield of rice from 42.45 to 52.92 q ha^{-1} during first year and from 44.95 to 55.47 q ha^{-1} in second year with 40 kg $ZnSO_4$ ha^{-1} .The average grain yield of rice was at par obtained with 40 and 60 kg $ZnSO_4$ ha^{-1}. Hence, 40 kg $ZnSO_4$ ha^{-1} may be suitable dose for enhancing the grain yield of rice 'Sarjoo-52'. The straw yield under the influence of various doses of zinc varied from 53.05 to 64.60 q ha^{-1} in the first year and 56.17 to 67.62 q ha^{-1} in the second year. The average grain and straw yield response at 40 kg zinc sulphate level was 10.49 and 11.50 q ha^{-1} with corresponding per cent yield response of 24.1 and 21.0, respectively. Singh and Tripathi (2005) also reported that basal addition of zinc sulphate up to 50 kg ha^{-1} increased the yield, nutrient uptake markedly in comparison to that of control. Application of varying levels of sulphur in partially reclaimed sodic soil showed significantly beneficial effect on grain and straw yield of rice. The grain and straw yield increased progressively with increasing levels of sulphur up to 40 kg ha^{-1} during both seasons. The average grain and straw yield response due to sulphur application varied from 4.17 to 8.47 and 5.14 to 10.38 q ha^{-1}, respectively. However, the corresponding percentage yield response of zinc was more pronounced than that of sulphur. Corresponding percentage of yield response due to sulphur addition ranged from 9.3 to 18.8 and 9.7 to 19.3 in grain and straw, respectively. Singh and Singh (2002) and Jena *et al* (2006) also revealed that application of sulphur in various levels markedly increased the yield and yield components and nutrient uptake by rice cultivars in partially reclaimed sodic soil.

Uptake of nutrients

It is evident from the data (Table 3) that increasing levels of zinc application increased the uptake of nitrogen, phosphorus, sulphur and zinc by grain and straw during both crop seasons. Uptake of

Table 2: Response of zinc and sulphur interaction on the grain and straw yield of rice

Zinc sulphate (kg ha^{-1})	2006					2007					Average yield response (q ha^{-1})		Percentage yield response	
	Sulphur (kg ha^{-1})					Sulphur (kg ha^{-1})								
	0	20	40	60	Mean	0	20	40	60	Mean	Zn	S	Zn	S
Grain yield (q ha^{-1})														
0	37.6	41.0	45.3	45.9	42.45	40.2	43.5	47.7	48.4	44.95	-	-	-	-
20	42.0	46.0	50.9	51.2	47.52	45.0	49.3	53.9	54.4	50.65	5.38	4.17	12.3	9.3
40	47.6	52.0	56.4	55.8	52.92	50.3	54.8	58.6	58.2	55.47	10.49	8.47	24.0	18.8
60	46.8	51.6	56.1	55.2	52.42	49.7	54.3	58.0	57.0	54.75	9.88	8.37	22.6	18.6
Mean	43.5	47.6	52.1	52.0	48.82	46.3	50.5	54.5	54.5	51.45	8.58	7.60	19.6	15.6
CD (P=0.05)	Zn-1.43, S-1.43, SxZn-1.96					Zn-1.51, S-1.51, SxZn-2.02								
Straw yield (q ha^{-1})														
0	47.0	51.20	56.6	57.4	53.05	50.2	54.4	59.6	60.5	56.17	-	-	-	-
20	51.2	56.1	62.1	62.5	57.97	54.9	60.1	65.7	66.3	61.75	05.25	5.14	9.6	9.7
40	57.9	63.4	68.8	68.3	64.60	61.3	66.8	71.4	71.0	67.62	11.50	10.38	21.0	19.3
60	56.66	62.6	67.9	66.8	63.47	60.1	65.7	70.1	68.9	66.20	10.22	10.31	18.7	19.2
Mean	53.17	58.32	63.85	63.75	59.77	56.6	61.7	66.7	66.7	62.93	08.99	8.61	16.4	16.1
CD (P=0.05)	Zn-1.63, S-1.64, SxZn-2.39					Zn-1.82, S-1.82, SxZn-2.43								

nitrogen by grain and straw with zinc application varied from 90.7 to 118.4 and 30.0 to 39.8 during first year and 97.8 to 123.2 and 33.6 to 42.2 kg ha^{-1} during second year. Phosphorus uptake by grain ranged between 14.3 and 18.9 and 15.0 and 19.2 kg ha^{-1} during first and second year, respectively and uptake by straw ranged from 6.0 to 8.0 kg ha^{-1} during first and 6.8 to 8.3 kg ha^{-1} during second year. The sulphur uptake also increased due to zinc application. It varied from 16.8 to 25.7 during first and 18.0 to 26.3, kg ha^{-1} in second year. Maximum sulphur uptake was recorded with its application @ 60 kg ha^{-1} by grain and straw during both the seasons. Increasing zinc level increased the Zn uptake by grain up to 60 kg $ZnSO_4$ ha^{-1} during both the years. On the other hand, uptake of Zn by straw was highest at 40 kg Zn ha^{-1}.

Table 3: Response of zinc and sulphur on the uptake of N, P, S (kg ha^{-1}) and zink (g ha^{-1}) by rice

Treatments	Nitrogen				Phosphorus				Zinc				Sulphur			
	Grain		Straw		Grain		Straw		Grain		Straw		Grain		Straw	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Zinc sulphate(kg ha^{-1})																
0	90.7	97.8	30.0	33.6	14.3	15.0	6.0	6.8	104.2	107.2	73.8	78.3	16.8	18.0	13.2	13.9
20	103.0	109.7	34.7	37.8	17.4	18.6	7.5	7.8	133.7	137.6	100.2	108.8	23.8	24.2	22.2	23.7
40	115.5	120.0	38.9	43.8	18.9	19.2	7.7	8.2	153.8	159.6	132.5	139.8	25.7	26.3	28.0	28.9
60	118.4	123.2	39.8	44.2	17.4	17.9	8.0	8.3	182.5	188.4	127.3	132.9	20.0	20.8	27.3	28.0
CD (P=0.05)	1.90	2.8	0.43	0.48	0.22	0.26	0.16	0.18	2.23	2.62	1.81	1.93	0.30	0.40	0.25	0.32
Sulphur (kg ha^{-1})																
0	92.0	96.2	31.0	34.2	15.0	15.8	6.7	6.9	144.2	148.0	112.2	114.7	15.0	16.8	9.3	10.0
20	13.7	108.8	32.5	37.8	17.8	18.7	7.0	7.3	147.3	150.4	118.5	122.6	22.3	22.9	14.6	14.8
40	116.5	121.7	35.6	34.4	18.2	19.1	7.5	7.9	152.5	155.7	122.4	127.2	27.0	28.0	20.2	21.0
60	119.0	125.4	39.0	46.6	17.8	17.6	7.7	8.0	150.6	153.0	119.0	124.3	29.5	30.2	21.4	21.9
CD (P=0.05)	1.90	2.08	0.43	0.42	0.22	0.26	0.16	0.18	2.23	2.62	1.81	1.93	0.30	0.40	0.25	0.32

These approaches are in accordance with the findings of Dubey and Chauhan (2002) and Singh and Tripathi (2005). The increase in N uptake may be attributed to increased N content in grain and straw yield. However, phosphorus uptake by grain was also increased with zinc application up to 40 kg ha^{-1} level during both crop season but it decreased at higher level which might be due to antagonistic effect of zinc. Tripathi and Rawat (2002) and Rakesh *et al. (2003)* also reported similar results. Increasing levels of sulphur significantly increased the uptake of nitrogen, phosphorus, zinc and sulphur by grain and straw of rice Sarjoo-52. The increase in sulphur uptake may be attributed to enhanced sulphur content in rice plants along with dry matter accumulation. The uptake of sulphur was also affected markedly by the addition of zinc sulphate. The uptake of sulphur by grain and straw increased up to 40 kg zinc sulphate ha^{-1} and decreased at higher level due to antagonistic effect of zinc on the sulphur. The increase in nitrogen and phosphorus uptake might be attributed to increase in N and P content in plant and grain of rice 'Sarjoo-52' due to rising sulphur levels. Such types of synergistic relationships among N, P and S have been observed by Singh and Singh (2002) and Jena *et al.*, (2006).

Table 4: Relationship between yield and yield attributes with chemical characteristics of rice

S.N	Relationship between	Correlation coefficient (r)		Regression equation (y)	
		2006	2007	2006	2007
1.	Productive tillers (χ) and grain yield (y)	0.785**	0.789**	Y=1.34 χ+5.50	Y=1.37 χ+5.20
2.	Ear bearing tillers (χ) and grain yield (y)	0.799**	0.81**	Y=1.68 χ+6.5	Y=1.71 χ+7.22
3.	Filled grains (χ) and grain yield (y)	0.887**	0.890	Y=0.32 χ+7.21	Y=0.39 χ+7.17
4.	Test weight (χ) and grain yield (y)	0.962**	0.969**	Y=0.27 χ+7.31	Y=0.33 χ+7.70
5.	Total uptake of N (χ) and grain yield (y)	0.865**	0.870**	Y=102.30 χ 30.39	Y=105.10 χ-34.0
6.	Total uptake of P (χ) and grain yield (y)	0.890**	0.897**	Y=108 χ-18.7	Y=1.10 χ-22.7
7.	Total uptake of Zn (x) and grain yield (y)	0.852**	0.860**	Y=78.2 χ+6.70	Y=80.1 χ+8.10
8.	Total uptake of S (χ) and grain yield (y)	0.877**	0.884**	Y=85.3 χ+9.20	Y=87.7 χ+10.27
9.	Grain yield (χ) and straw yield (y)	0.967**	0.972**	Y=20.2 χ+16.20	Y=22.5 χ+17.3
10.	Protein (χ) and starch content (y)	-0.625**	-0.630**	Y=39 χ+20.2	Y=39.9 χ+23.0
11.	Protein (χ) and mineral matter(y)	0.957**	0.962**	Y=0.70 χ+9.20	Y=0.79 χ+10.30
12.	Protein (χ) and nitrogen content (y)	0.972**	0.978**	Y=2.37 χ+12.0	Y=3.0 χ+13.5

Data (Table 4) revealed that grain and straw yields of rice were significantly correlated with number of tillers, ear bearing tillers filled grains and test weight. Total uptake of nitrogen, phosphorus, zinc and sulphur by grain and straw showed positive correlation with yields. The protein and nitrogen content in grain was significantly and positively correlated but starch and protein were negatively correlated. Application of zinc and sulphur indicated positive response on the content of protein, starch and mineral matter of rice grain, probably because of their prime role in synthesis of these chemical compounds (Tripathi and Tiwari, 2002 and Singh 2000).

Conclusion

From the results, it is evident that the addition of various levels of zinc and sulphur either alone or in conjunction markedly enhanced the production of rice "Sarjoo 52". Integrated use of Zn and S resulted in higher nutrients uptake and grain yield. The results provided direct evidence of appreciable gain in the crop production under the influence of different levels of Zn and S.

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