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EFFECT OF GYPSUM ALONE AND IN CONJUNCTION WITH GREEN MANURE AND ZINC ON THE RICE VARIETIES IN SODIC SOILS

B.N. TRIPATHI, U.C. MISHRA AND K.K. MAURYA

Soil Salinity Scheme, Department of Soil Science and Agril. Chemistry Chandra Shekhar Azad University of Agriculture and Technology, Kanpur – 208 002 (U.P.)
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ABSTRACT

Field ecperiments were conducted during kharif season 2006 and 2007 Bojha Farm, Dalipnagar, Kanpur to evaluate the ameliorative response of gypsum alone and in conjunction with green manure and zinc on production potential, nutrient content and uptake along with the relationships of yield with yield component and nutrient content of CSR-13 and Sarjoo-52 rice genotypes under sodic soil. The results revealed that CSR-13 genotype registered its superiority over Sarjoo-52 in respect of yield attributes and yield and nutrient content. The mean yield response of CSR-13 was 25.8% more over Sarju-52. However, application of gypsum (50 and 100% GR) alone significantly enhanced the yield and yield components, nutrient content but magnitude of response was more pronounced when 50% GR was applied in conjunction with 10t green manure ha^{-1} and 60 kg $ZnSO_4$ ha^{-1}. By and large, the response of 50% GR +10t G.M. ha^{-1} on the yield and yield attributes did not differ significantly from that of 50% GR + 60 kg $ZnSO_4$ ha^{-1} during both years. The correlation coefficients between yield and yield attributes along with nutrient content were positive and significant.

Keywords: Gypsum, green manure, zinc, yield nutrient content, rice cultivars sodic soil.

INTRODUCTION

Salt affected soils are wide spread in northern part of the country. These soils bear distinctive characters of containing excessive concentration of soluble salts of sodium. 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 availability of certain major and micro nutrients. Availability of N and Zn to plants in these soils is extremely poor (Chaudhary *et al.* 2003 and Tripathi *et al.* 2012). Rice crop is preferred to be grown on sodic soil because it is tolerant to sodicity and has reclamation effect on sodic soil. Rice the stable food of more than 60% of world population, is primarily a high energy food containing 78-79% carbohydrate, 6-7% protein, 2-2.5% fat, 1-3% mineral matter and well with other cereals in respect of amino acid and vit. B complex. It is grown on 44.8 million ha with 86.9 million tones of annual production with productivity of 19.40 q ha^{-1}. In U.P. it is grown on an area of 60 lakh ha with annual production 131 lakh tones. The productivity being low (21.70 qha^{-1}) it ranks 7^{th} position in India (Singh and Tripathi 2008 and Tripathi *et al.* 2012). Zinc deficiency has been recognized as an important and wide spread nutritional disorder of rice in such type of soils (*Tripathi and Kumar 2013*). The physico-chemical condition of sodic soil is also a serious problem in plant nutrition because these soils are very poor in organic matter (Ray and Gupta 2001, Chaudhary *et al.* 2003 and Singh and Tripathi 2005). Green manuring improves soil physical properties, such as water stable aggregates (0.1 to 0.5 mm) size by 62% and reduction in bulk density as well as improving in soil structure. Although, the response of various levels of gypsum alone and in conjunction with zinc and green manure had been studied on various crops (Tripathi and Kumar 2013) but the information gathered on interaction effect amongst these factors on upland rice in sodic soils is scanty. Taking these facts in view, the present investigation has been planned and conducted.

MATERIALS AND METHODS

The present investigation was conducted during *Kharif* seasons of 2006 and 2007 as a fixed layout in sodic soil at, C.S. Azad University of Agriculture and Technology, Kanpur. The texture of soil was clay loam with pH 10.4, EC 0.98 dSm^{-1} exchangeable Na 80%, CEC 12.25 c mol (P^+) kg^{-1}, organic carbon 1.8 g kg^{-1} soil, hydraulic conductivity 0.20 cm hr^{-1}, water holding capacity 30.5%, permeability 0.76 cm hr^{-1} and volume expansion 12.2%. The soil Typic Natrustalf, taxonomical class having available N, P_2O_5 and K_2O 145, 28.8 and 260 kg ha^{-1}, respectively. DTPA extractable Zn was 0.20 mg kg^{-1} soil. Gypsum requirement was 21t ha^{-1}. The treatments viz., two rice cultivars (v_1 CSR 13 and V_2 Sarjoo 52) and conbination of gypsum, green manure and $ZnSO_4$ namely T_1- control (no amendments), T_2- 50% GR, T_3- 100% GR, T_4- 50% GR + 60kg $ZnSO_4ha^{-1}$, T_5- 50% GR + 10t GM ha^{-1}, T_6- 50% GR + 10t GM ha^{-1} + 60kg $ZnSO_4ha^{-1}$ and T_7- 100% GR +

Corresponding author Email:dr.bnt1957@gmail.com

10 t GM ha^{-1} had been applied in sub plots and 35 days old seedlings of rice cultivars *viz.*, CSR-13 (V_1) and Sarjoo-52 (V_2) were transplanted in second week of July of each year in main plots. Green manure (*Sesbania acculeata*) crop of 30 days old having C: N ratio 12.8 was incorporated in the experimental plots. The GM contained N-1.62%, P- 0.47%, K-2.00% and organic carbon 38.50% on dry weight basis. The experiment was conducted in split plot design with four replication. N, P_2O_5 and K_2O were applied @ 150, 60 and 40kg ha^{-1}, respectively through urea, diammonium phosphate and muriate of potash. Zinc sulphate was added @ 60 kg ha^{-1}. Phosphorus, potassium, zinc sulphate and gypsum were applied at the time of transplanting of seedling. Nitrogen was applied in three equal splits at basal, maximum tillering and pre-flowering stages of rice cultivars. Agronomical cultural practices such as irrigation, weeding and plant protection measures were performed as per requisite. At maturity yield and yield components were recorded. Grain and straw were analyzed for N content by modified Kjeldahl method (Jackson 1973). Phosphorus was determined by vanadomolybdnate yellow colour method and potassium by flame photometric in di-acid digest. Zinc was estimated on atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Yield and yield components

Both genotypes (CSR-13 and Sarjo-52) showed wide variation in yield and yield attributing characters (Table 1). The grain and straw yield of CSR-13 and Sarjoo-52 were recorded as 32.25 and 25.20 q ha^{-1} and 41.80 and 37.39 q ha^{-1}, respectively during first year and 34.40 and 27.73 q ha^{-1} and 45.53 and 40.63 q ha^{-1} during second year, respectively. Under the influences of various treatments, yield components viz., productive tillers m^{-2}, average length of plants and panicles along with test weight of panicles $hill^{-1}$ of CSR-13 were observed 367, 80.5 cm, 24.5 cm and 25.38 g hll^{-1} in first season and 379, 82.9 cm, 25.9 cm and 29.74 g $hill^{-1}$ in 2007, respectively. In sodic soil CSR-13 rice cultivar showed its superiority to Sarjoo-52 in the respect of yield attributes during both the years in conjunction with various doses of gypsum, zinc sulphate and green manure. It could be due to genetical variations and adoptability on sodic condition of soil of both rice varieties. The mean responses to over control were 67.4 and 85.9% of CSR-13 and Sarjoo-52, respectively under the impact of various treatments. Thus, it can be concluded from these results that the tolerant capacity towards sodicity of CSR-13 rice cultivar was stupendous followed by Sarjoo-52 in sodic soils. Having comparatively lower tolerant capability to alkalinity the mean response of various treatments was higher in Sarjoo-52. These values of yield and yield components to both cultivars are comparable of those obtained by Tripathi *et al.* (2012) and Chakraborty *et al.* (2009).

Table 1: Effect of gypsum alone and in conjunction with green manure and zinc on the yield and yield attributes of various rice cultivars in sodic soil

Treatments	Grain yield (qha^{-1})		Straw yield (qha^{-1})		Productive tiller		Height of plants (cm)		Length of panicles (cm)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Rice cultivars										
V_1 CSR-13_1	32.25	34.40	41.80	45.53	367	379	80.5	82.9	24.5	25.9
V_2 Sarjoo52	25.20	27.73	37.39	40.63	349	362	76.4	78.6	22.8	24.3
CD (P = 0.05)	3.10	3.21	3.46	3.58	15.63	15.98	2.86	2.98	1.47	1.53
Gy + GM + $ZnSO_4$										
T_1	16.35	17.80	23.00	28.37	228	319	70.2	72.24	16.3	17.9
T_2	23.50	25.55	33.69	36.30	314	325	73.4	75.7	1.96	20.9
T_3	27.40	29.75	37.69	40.70	347	360	76.5	78.5	22.4	23.7
T_4	30.67	33.34	41.94	45.35	365	379	79.1	81.4	24.4	26.0
T_5	31.90	34.35	43.88	47.35	377	390	80.6	82.8	25.7	27.3
T_6	34.75	37.36	47.41	50.75	419	431	83.8	86.1	27.8	29.4
T_7	36.60	39.50	49.53	52.72	427	438	85.4	87.8	28.9	30.5
Mean	28.72	31.09	39.59	42.98	358.2	370.5	78.4	80.3	23.6	25.1
CD (P = 0.05)	2.60	2.85	2.81	2.98	14.32	14.48	1.16	1.94	1.36	1.40

The grain and straw yield of both rice cultivars under the influence of 50 and 100% GR of gypsum alone and conjunction with 60kg $ZnSO_4ha^{-1}$, or 10t green manure ha^{-1} was significantly increased over that of control. Although addition of 10t green manure ha^{-1} along with 50% gypsum markedly enhanced the yield and yield attributing characteristics of both varieties but could not differ significantly than that obtained under 50% gypsum + 60kg $ZnSO_4$ ha^{-1}. Maximum yield of grain, productive tillers m^{-2}, average length of plant and panicles and weight of panicles $hill^{-1}$ were recorded with 100% gypsum + 10t GM ha^{-1} (T_7) followed by 50% gypsum +10t GM ha^{-1} + 60kg $ZnSO_4$ ha^{-1} (T_6) and 50% gypsum + 10t green manure ha^{-1} (T_5). Application of 60 kg $ZnSO_4$ ha^{-1} in combination with 50% gypsum + 10t GM ha^{-1} (T_6) registered more pronounced response on yield attributing components. Thus, it can be concluded from these results that the effect of 50% gypsum + 10t GM ha^{-1} + 60kg $ZnSO_4$ ha^{-1} was markedly more beneficial followed by other treatments in sodic soil. The mean response of treatments over control varied from 43.6 to 122.9% with a mean value of 75.2%. Overall, on the basis of effect on the yield and yield component, treatments may be arranged as $T_7>T_6>T_5>T_4>T_3$ and T_2. This trend again confirmed the results of Tripathi and Rawat (2002), Chaudhary *et al.* (2003) and Pandey *et al.* (2009) on the effect of gypsum, green manure and zinc addition in sodic soil.

Content and uptake of nutrients

The content of N, P, K and Zn in grain and straw of CSR-13 were recorded 1.34, 0.37, 0.46 % and 22.5 $mgkg^{-1}$ and 0.87, 0.15. 1.53 % and 16.6 $mgkg^{-1}$, respectively. On other hand, the nutrient content in Sarjoo-52 recorded lower than CSR-13 with mean values of 1.32, 0.36, 0.46 % of N, P and K and 22.4 $mgkg^{-1}$ zinc (Table 2). In rice straw of Sarjoo-52 N, P, K and zinc content were found 0.83, 0.15, 1.52 % and 16.02 $mgkg^{-1}$. In general, the mean values of uptake of N,P,K and Zn by grain of CSR-13 were 45.0, 12.3, 15.5 kg ha^{-1} and 75.5 gha^{-1} and 38.2, 6.7, 67.0 $kgha^{-1}$ and 73.1 gha^{-1} by straw, respectively. The uptake of all aforesaid nutrients by both grain and straw of Sarjoo-52 was recorded significantly lower than that of CSR-13 genotype (Table 3). It might be due to genetical variations of these cultivars to avert possible disaster of sodicity of soils. These findings are comparable to those reported by Tripathi and Rawat (2002) and Tripathi *et al.* (2012).

Table 2: Effect of gypsum alone and in conjunction with green manure and zinc on nutrients content in rice cultivars. (Mean of 2 years)

Treatments	Grain				Straw			
	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Zinc ($mgkg^{-1}$)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Zinc ($mgkg^{-1}$)
Rice cultivars								
V_1 CSR-13_1	1.34	0.37	0.46	22.5	0.87	0.15	1.53	16.64
V_2 Sarjoo-52	1.32	0.36	0.46	22.4	0.83	0.15	1.52	16.02
CD (P = 0.05)	0.015	0.005	0.006	0.85	0.026	0.005	0.016	0.506
Gy + GM + $ZnSO_4$								
T_1	1.24	0.34	0.40	21.66	0.80	0.14	1.44	15.44
T_2	1.28	0.35	0.45	21.95	0.83	0.15	1.49	15.84
T_3	1.31	0.36	0.47	22.11	0.85	0.15	1.51	16.16
T_4	1.34	0.36	0.46	22.79	0.86	0.15	1.53	16.80
T_5	1.35	0.37	0.47	22.46	0.86	0.15	1.54	16.38
T_6	1.39	0.38	0.47	23.50	0.87	0.16	1.57	17.12
T_7	1.40	0.38	0.48	22.93	0.88	0.16	1.58	16.54
CD (P = 0.05)	0.013	0.004	0.004	0.067	0.007	0.004	0.008	0.115

The N, P and K content in grain and straw of rice cultivars under influence of various treatments varied from 1.24 to 1.39, 0.34 to 0.38 and 0.44 to 0.48 and 0.80 to 0.88, 0.14 to 0.16 and 1.44 to 1.58, respectively (Table 2). Addition of gypsum 100% GR responded more than 50% GR on nutrient contents of rice CSR-13 and Sarjoo-52. Although application of gypsum (50 and 100% GR) alone and in combination of 60kg$ZnSO_4$ ha^{-1} and 10t green manure ha^{-1} markedly improved the nutrient contents of both rice cultivars than control. However, application of 50% GR with 60 kg $ZnSO_4$ ha^{-1} and 50% GR or with10 t G.M. ha^{-1} were at par in respect of N,P, K and Zn content of grain and straw of both rice varieties. Maximum nutrient contents in grain and straw of both rice varieties were noticed at addition of 10t green manure ha^{-1} with 100% GR. It might be due to comparatively more inclusive impact of higher quantity of gypsum in conjunction with optimum level of green manure on the physico-chemical manipulation of sodic soil to enhance the availability of these nutrients. These results are in line with those reported by Kumar *et al.* (2010) and Tripathi *et al.* (2012). The average uptake of N, P, K and Zn by grain of both genotypes varied from 21.2 to 53.2, 5.8 to 14.4, 7.5 to 17.1 $kgha^{-1}$ and 37.0 to 87.3 gha^{-1}. The mean uptake of these nutrients by straw of CSR-13 and Sarjoo-52 ranged from 20.6 to 44.9, 3.6 to 8.2, 36.9 to 80.8 kg ha^{-1} and 39.8 to 84.9 g ha^{-1}, respectively. In general, increasing the quantity of gypsum from 50 to 100 GR alone and in combination with 10t green manure or 60kg$ZnSO_4ha^{-1}$ markedly enhanced the nutrients uptake by both rice cultivars but effect was more pronounced at 100 GR + 10t green manure ha^{-1} (Table 3). These findings were in conformity with those reported by Tripathi *et al.* (2012) and Tripathi and Kumar (2013).

Table 3: Effect of gypsum alone and in conjunction with green manure and zinc on the nutrients uptake in rice cultivars (Mean of 2 years)

Treatments	Nitrogen ($kgha^{-1}$)		Phosphorus ($kgha^{-1}$)		Potassium ($kgha^{-1}$)		Zinc (gha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Rice cultivar								
V_1 CSR-13_1	45.0	38.2	12.3	6.76	15.5	67.0	75.5	73.1
V_2 Sarjoo-52	35.3	32.6	9.5	5.86	12.2	59.5	59.6	62.9
CD (P = 0.05)	1.89	1.76	0.97	0.75	1.23	3.08	2.17	2.85
Gy + GM + $ZnSO_4$								
T_1	21.2	20.6	5.8	3.57	7.5	36.9	37.0	39.7
T_2	31.5	29.0	8.5	5.15	10.9	52.0	53.8	55.5
T_3	38.0	33.2	10.1	5.81	13.0	59.2	63.0	63.4
T_4	42.8	37.5	11.6	6.62	14.8	66.9	72.9	73.4
T_5	44.7	39.4	12.2	7.01	15.5	70.2	74.1	74.8
T_6	50.0	42.9	13.5	7.76	17.1	77.0	84.7	84.1
T_7	53.1	44.9	14.4	8.18	18.1	80.8	87.2	84.8
CD (P =0.05)	1.61	1.49	0.89	0.63	1.14	2.85	2.08	2.10

Grain yield of CSR-13 and Srjoo-52 cultivars were highly influenced by test weight (0.962** and 0.822**, followed by filled grains $panicle^{-1}$ (0.885** and 0.777**), ear bearing tillers $hill^{-1}$ (0.798** and 0.691**) and productive tillers m^{-2} (0.783** and 0.678**), respectively. Single plant yield had significant positive association with plant height, ear length, grains ear^{-1} and test weight. These yield components had significant correlation among themselves (Nadarayan and Kumar Velu 1994). Grain yield showed positive correlation with contents of N, P, K and Zn in both genotypes. Highest and positive correlation related to grain yield was recorded with phosphorus content (0.894**and 774**) in both rice cultivar followed by K, N and Zn.

Table 4: Effect of gypsum alone and in conjunction with green manure and zinc on the relationship between yield and yield components and nutrient concentration of rice cultivars (Mean of 2 years)

Relationship between	Rice varieties	Correlation coefficient	Regression equation (y)
Productive tillers (x) and grain yield (y)	V_1	0.783**	y =1.34 x +5.17
	V_2	0.678**	y =1.45 x +2.67
Ear bearing tillers $hill^{-1}$ (x) and grain yield (y)	V_1	0.798**	y =1.68 x +6.58
	V_2	0.691**	y =1.62 x +7.46
Field grains $panicle^{-1}$ (x) and grain yield (y)	V_1	0.885**	y =0.91 x +8.03
	V_2	0.777**	y =0.84 x +8.93
Test weight (x) and grain yield (y)	V_1	0.962**	y =0.87 x +8.41
	V_2	0.822**	y =0.82 x +10.96
Nitrogen content (x) and grain yield (y)	V_1	0.868**	y =104.2 x +34.01
	V_2	0.786**	y =101.4 x +31.79
Phosphorus content (x) and grain yield (y)	V_1	0.894**	y =107.6 x +23.03
	V_2	0.774**	y =105.0x+27.21
Potassium content (x) and grain yield (y)	V_1	0.877**	y =110.1 x +19.94
	V_2	0.753**	y =106.0 x +20.45
Zinc content (x) and grain yield (y)	V_1	0.857**	y =76.86 x +8.44
	V_2	0.713**	y =74.71 x +5.15
Grain yield (x) and straw yield (y)	V_1	0.971**	y =23.81 x +19.61
	V_2	0.878**	y =22.58 x +16.45

** = Significant at 5% level ** = Significant at 1% level*

It is concluded that the combined use of 50% GR +10 t green manure + 60 kg zinc sulphate ha^{-1} significantly enhanced the yield, of CSR-13 and Sarjoo-52. Although, increasing levels of gypsum upto 100% GR alone and in conjunction with green manure showed maximum yield and nutrient contents of both rice cultivars. CSR-13 was more tolerant than Sarjoo-52 in salt affected soil.

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