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Evaluation of Gypsum Application in Split Doses on Sodic Soils in N.W.F.P.

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ABSTRACT

A number of field experiments were conducted at different sites in Peshawar and Charsadda districts to evaluate the application of different doses of gypsum (100 and 50% GR) by single shot and/or two splits under sodic soil conditions. Maize, rice, wheat and dhancha crops were grown during Rabi 1995-96 and Kharif 1996. Wheat crop failed in these areas due to very poor germination during 1995-96. Application of gypsum had reduced the pH, EC_e and GR of the soil significantly. The reduction in the values of soil properties studied was maximum in the 100% GR gypsum treatment compared to 50% GR. Grain and straw yield significantly increased in 100% gypsum application in single shot. Gypsum applied @50% GR in two splits gave the minimum yield. At Kholey site, the maize yield was statistically similar in all the treatments. Fodder yield of dhancha at Aman Kot was significantly low where 50% gypsum was applied in a single shot compared to 100%. The straw and grain yield of rice was significantly higher at Dosehera when gypsum was applied @100% in a single shot. The improvement in the uptake of P and K was not observed, but micronutrients showed a variable trend in their uptake.

Key Words: Gypsum; Maize; Rice; Dhancha; Sodic soil

INTRODUCTION

Of the total cultivated area in Pakistan about 3.2 million hectares are salt affected (Muhammad, 1993) while in NWFP, 0.514 million hectares area is salt affected (Chaudhri *et al*., 1978). These soils are lying barren due to high salt concentration and if cultivated they give an uneconomical production (Mashhaddy & Heakal, 1983; Khattak, 1987). Therefore, they had been subjected to the process of reclamation and using different techniques and reclament, some achievements have been made in getting economic yields from them. Most of the amendments used imposed heavy economic burden on the farmer. Gypsum as a cheapest source of reclamation has been reported by many workers (Mohammad *et al.*, 1969; Ghafoor & Muhammed, 1981; Ramzan *et al.*, 1982).

Pakistan has big reserves of gypsum in the provinces of Punjab, NWFP and Sind. It is being successively used for the reclamation of salt affected soils. The use of gypsum as a reclaimant is the most economic one compared to rest of the chemical reclaiments. Its rate of dissolution in the irrigation water is very low and therefore its application needs large amount of irrigation water (Richards, 1954). Oster and Halvorson (1978) have, however, shown that the solubility of gypsum may increase more than tenfold when an amendment is mixed with highly sodic soils. To make the use of gypsum more economic it must be applied to the soil in different doses at different convenient times. Keeping in view the above facts, the present study was probed.

MATERIALS AND METHODS

The experiment was conducted at four sites i.e. Kholey (Charsadda), Aman Kot (Peshawar), Dosehra (Charsadda) and Muftiabad (Charsadda) on sodic soils with normal canal irrigation. The design used was Randomized Complete Block with four treatments (Gypsum @ 100% GR in one split, Gypsum @ 50% GR in one split, Gypsum @ 100% GR in two splits and Gypsum @ 50% GR in two splits) in three replications. Two crops were scheduled to be grown in this experiment. After the failure of germination of wheat seed, Dancha was cultivated in the same plots at Aman Kot. The size of each experimental plot varied from location to location. Physico-chemical characteristics of the soil are given in Table I. In case of two splits, half amount of gypsum was applied at the start of first crop while the second half was added to the fields at the time of sowing of second crop. All the fertilizers were applied at sowing time except N, which was applied in two splits i.e. half during planting time while the remaining half at early growth stage. NPK was applied to the fields as recommended doses of respective crops. Soil samples were collected before sowing and after harvest. Appropriate yield data were collected for various crops studied. The data obtained were subjected to statistical analysis according to Gomez and Gomez (1976).

RESULTS AND DISCUSSION

Results of the trials conducted at various locations during Kharif 1996, Rabi 1996-97 and Kharif 1997 on maize, dhancha, rice and wheat crops are presented in this paper. At Kholey, Charsaddah production of maize during Kharif 1996 was though non-significant, the data indicated a trend among the treatment means which showed an increase in grain and straw yield from 50% gypsum application of the required to 100% of gypsum requirement of these soils (Table II). It is in

Table I. Soil properties of the experimental plots before sowing and after the harvest

Site	Soil Property	Before sowing	After harvesting			
			One shot		Two splits	
			100 % GR	50 % GR	100 % GR	50 % GR
Kholey (Charsadda)	pH	8.70	8.20	8.20	8.30	8.20
	EC_e dS m^{-1}	1.40	0.93	0.77	0.60	0.50
	GR t ha^{-1}	9.00	1.52	2.98	2.75	4.13
Aman Kot (Peshawar)	pH	10.00	8.80	9.10	9.10	9.30
	EC_e dS m^{-1}	2.10	1.40	1.33	1.37	1.63
	GR t ha^{-1}	14.00	4.40	6.60	6.90	8.90
Dosehra (Charsadda)	pH	9.70	7.80	8.00	8.10	8.80
	EC_e dS m^{-1}	0.35	0.23	0.37	0.27	0.12
	GR t ha^{-1}	8.00	2.50	3.50	3.30	4.90
Muftiabad (Charsadda)	pH	8.90	8.60	8.80	8.60	8.80
	EC_e dS m^{-1}	0.24	0.25	0.30	0.31	0.20
	GR t ha^{-1}	5.50	2.58	4.41	3.44	4.47

conformity to the results obtained by Singh (1990) who conducted experiments on rice and wheat and reported significant increase in their yield at all levels of gypsum applied. Data in Table I show that pH, EC_e and gypsum requirements of these soils decreased after gypsum application. Greater reduction in the gypsum requirement of soil was found in treatment receiving 100% gypsum. The sodic soils are characterized by high pH, EC_e and SAR, which play pivotal role in reducing the yield of crops (Muhammad, 1993). Application of gypsum reduces the values of these soil characteristics thus supporting the plant growth. At Aman Kot (Peshawar), the first wheat crop sown in 1995-96 after gypsum application failed due to very poor germination. With the same treatments the next crop of dancha was sown in 1996 Kharif.

Table II. Effect of various levels of gypsum on the grain and stalk yield of maize under sodic conditions in 1996 at Kholey (Charsadda)

Gypsum applied % GR	Splits	Yield, kg ha^{-1}	
		Grain	Stalk
100	1	426	1340
50	1	401	1197
100	2	373	1263
50	2	354	1096

Statistically the grain and straw yields are not significantly different among the treatments.

The data in Table III showed that mean values for the treatments were significantly different among them at both probability levels while maximum yield was recorded in 100% gypsum application in one shot and minimum yield was observed by 50% in two splits. Application of gypsum in split doses provided an opportunity to its dissolution and exchange of Na^{+} ions with those of Ca^{+2} ions. The soil parameters showed that the pH, EC_e and gypsum requirements of the soil decreased which indicates an improvement in the soil properties. Which in turn helped in better crop growth and production. At Dosehra (Charsadda) the rice grown during

Table III. Effect of various levels of gypsum on the fodder yield of dhancha under sodic conditions at Aman Kot in 1996

Gypsum applied % GR	Splits	Fodder yield, kg ha^{-1}			
		R1	R2	R3	Means
100	1	26000	24000	25000	25000 A
50	1	24000	21500	20000	21833 B
100	2	21500	18000	15000	18167 C
50	2	20000	16500	17500	18000 C

Means bearing the same letter are statistically non-significant at $p < 0.05$

Kharif 1996 showed maximum grain and straw yield of rice by 100% gypsum application in one shot and lower values were recorded by 50% gypsum applied in two splits. The trend of the crop is same as observed in the study with that of dhancha at Aman Kot (Table IV).

Table IV. Effect of various levels of gypsum on the grain and straw yield of rice under sodic conditions in 1996 at Dosehra (Charsadda)

Gypsum applied % GR	Splits	Yield, kg ha^{-1}	
		Grain	Stalk
100	1	881 A	4479 A
50	1	613 B	2708 B
100	2	646 AB	2813 B
50	2	432 B	1771 B

Statistically the grain and straw yields are significantly different among the treatments by different letters ($p < 0.05$)

The experiment conducted on maize at Muftiabad during Kharif 1997 revealed that the grain and stalk yield significantly increased with the application of 100% gypsum in one shot which is in accordance with Niazi *et al*. (2000), while the yield was low by the application of 50% gypsum application in two splits (Table V). Increasing the number of splits of gypsum delays the reclamation of the soil and thus grain and stalk yield were less for treatments in which gypsum was applied in two splits compared to treatments in which gypsum was applied in a single dose. It is evident from the data in Table I, that gypsum requirement and pH of the soil decreased with the application of gypsum. The decrease in gypsum requirement and pH was more in the treatments where there was 100% gypsum application compared to treatments in which there was 50% gypsum application.

Table V. Effect of various levels of gypsum on the grain and stalk yield of maize under sodic conditions in 1997 at Muftiabad (Charsadda)

Gypsum applied % GR	Splits	Yield, kg ha^{-1}	
		Grain	Stalk
100	1	1598 A	4595 A
50	1	1033 B	1967 A
100	2	1450 A	4250 A
50	2	852 B	2522 B

Statistically the grain and straw yields are significantly different among the treatments by different letters ($p < 0.05$)

Uptake of nutrient. Gypsum application at the full required rate improved the uptake of K and suppressed the uptake of P by maize plants compared with that of 50% gypsum application (Table VI). However, there were no significant differences recorded in the uptake of different nutrients by the rice crop. There was no clear trend observed in the uptake of micronutrients in maize. Uptake of Zn was enhanced with the 50% gypsum applied in single shot, however, when applied in two splits the uptake was reduced. Uptake of Cu ions reduced with 50% gypsum application compared to 100% GR. There was no difference noted in the uptake of ions due to split application with the same GR. A non significant increase in the uptake of Mn has been observed in single shot application of gypsum compared to 100% GR. Reduction in the uptake of Fe has been significant in 50% split application of gypsum (Table VI). In rice the uptake of P and K remained the same at different gypsum treatments. However, uptake of Mn and Fe showed some significant results. The concentration of Mn increased with 50% gypsum application in single shot or two splits. While Uptake of Fe has shown reverse trend in both the treatments (Table VII). The results of these studies re-emphasize the utility of gypsum application at full GR for improved crop growth and accelerated soil improvement.

Table VI. Nutrient status of maize plants grown under different gypsum treatments

Nutrients	Splits			
	1	1	2	2
	Gypsum applied % GR			
	100	50	100	50
P %	0.35 A	0.4 A	0.39 A	0.41 A
K %	3.5 A	3.4 A	3.1 A	3 A
Zn mg kg^{-1}	24 B	52 A	44 A	21 B
Cu mg kg^{-1}	13 A	8 B	17 A	8 B
Mn mg kg^{-1}	89 B	118 A	95 B	92 B
Fe mg kg^{-1}	471 B	486 B	512 A	357 C

Means bearing the same letter are statistically non-significant at $p < 0.05$ in the same row

Table VII. Nutrient status of rice plants grown under different gypsum treatments

Nutrients	Splits			
	1	1	2	2
	Gypsum applied % GR			
	100	50	100	50
P %	0.22 A	0.18 A	0.25 A	0.23 A
K %	2.5 A	2.9 A	2.6 A	2.8 A
Zn mg kg^{-1}	47 B	67 A	50 B	44 B
Cu mg kg^{-1}	16 B	17 B	15 B	21 A
Mn mg kg^{-1}	309A	320 A	251 B	301 A
Fe mg kg^{-1}	180 A	138 B	155 B	100 C

Means bearing the same letter are statistically non-significant at $p < 0.05$ in the same row

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