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Integrated Approach for Reclamation of Salt Affected Soils

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ABSTRACT

The combination of different reclaimatives approaches may not only increase the efficiency but also reduce the time of reclamation. A field experiment was conducted on saline sodic soil for its reclamation by combining different approaches. Gypsum was applied @ 100% GR alone and in combination with FYM @ 25 t ha^{-1} or chiseling as well as combination of all the three, followed by leaching with irrigation water. Rice and wheat crops were grown for two consecutive years. Gypsum application proved the best treatment giving highest grain yield of rice and wheat. However, this treatment followed statistically similar results with gypsum +FYM. Combination of gypsum and chiseling remained inferior to gypsum alone or gypsum + FYM. The combination of all the three did not prove more usefulness. The pHs was reduced to safe limit after harvesting of 2^{nd} crop (wheat 2002-03). ECe was reduced after growing of first rice crop in all the treatments except control. The reduction in SAR to the permissible limits was effected after the third crop. The soil parameters in control treatment did not improve. The combination of gypsum + FYM + chiseling was more effective in improving the soil condition.

Key Words: Soil reclamation; Gypsum; Farm yard manure; Chiseling; Wheat; Rice

INTRODUCTION

In arid and semiarid regions of the world, salinity and sodicity is a permanent problem inherited due to climatic conditions (high temperature and low rainfall). The net movement of the water is upward. The salts dissolved in the water accumulate slowly and gradually on the surface of the soil as the water evaporates. Soil salinity increases due to capillary rise from the saline water table and concentration of irrigation water in the field. In India, about 6.73 m ha are lying barren or produce very low and uneconomical yields of various crops due to excessive accumulation of salts (Sharma *et al*., 2004) but in Pakistan about 6.68 m ha area is salt affected out of which 3.77 m ha is saline and 2.91 m ha is saline-sodic / sodic (Khan, 1998). This area is expected to increase with spread of water logging and salinity due to increase in canal irrigation and extensive exploitation of poor quality water for agriculture in non-canal commands. Crops grown on these soils invariably suffer nutritional disorders (Na^+, Ca^{2+} and Zn^{2+} deficiency and Na^+ toxicity) resulting in low yields. The dominant cation in the exchange complex is the Na^+ due to which salt affected soils suffer deterioration in their physical properties. So soluble source of Ca^{2+} is essential for reclamation of such soils. For this purpose , gypsum is the source of Ca^{2+} most commonly used to reclaim the sodic soil and improve soil water infiltration (IF), (Gupta *et al*., 1985).

The appropriate management of the constrained soil resources for the economic agricultural production is the main emphasis in agriculture. There are different approaches for reclamation of salt affected soils. The prominent ones are chemical, biological and agronomic. The combination of these approaches not only increases the efficiency but also reduce the time of reclamation. The crop production and fertilizer use efficiency of these soils can be increased by integrated approach i.e. use of amendments preferably gypsum and organic / inorganic manures which helps in maximizing and sustaining yields, improving soil health and input use efficiency (Swarp, 2004).

The physical methods of soil reclamation include deep ploughing, subsoiling and sanding. Subsoiling alone (50 ± 5 cm crosswise furrows 120-150 cm apart) with rice – wheat crop rotation successfully reclaimed two calcareous saline sodic soil series (Khurrianwala–Typic Haplorthid; Gandhara – Halic Camborthid) with a period of three years. Thus, only subsoiling of some medium textured soils like Khurrianwala series may produce good crop of rice (Muhammed & Ghafoor, 1986). The objective of the study was to compare the efficiency of gypsum alone and in combination with FYM or / and chiseling.

MATERIALS AND METHODS

A saline sodic field having pHs: 9.21-9.55; ECe: 6.29-8.81 dSm^{-1}, SAR: 49.73-59.50 $(m\ mol\ l^{-1})^{1/2}$, and Gypsum Requirement: 4.25-8.2 t $acre^{-1}$ was selected at experimental farm of Soil Salinity Research Institute, Pindi Bhattian, district Hafizabad. The field was prepared, leveled and treatments were arranged in randomized complete block design (RCBD) with three replications. The soil samples were collected from 0-15 and 15-30 cm soil depths from each treatment for pHs, ECe, SAR and GR. The following treatments were used for the experiment: T1= Control ; T2= Gypsum @ 100 % GR; T3= T2 + Chiseling; T4= T2 + FYM @ 25 t ha^{-1}; T5= T2 + Chiseling + FYM @ 25 t ha^{-1}

The soil in treatment 3 and 5 was tilled with chisel plough where as other treatment was prepared with cultivator. The gypsum and FYM were applied with subsequent leaching. Rice (cv. Shaheen Basmati) and wheat (cv. Inqalab – 91) were grown in sequence for two years. The yield data was recorded at maturity and analyzed statistically using critical difference (CD) Test (Steel & Torrie, 1980). The soil samples were collected from 0-15 and 15-30 cm depth after harvesting of each crop, air dried, ground, passed through 2 mm sieve and mixed thoroughly. Soil reaction (pH) and soluble salt content (TSS), soluble Ca^{2+} + Mg^{2+} (titration with standard Versinate solution) and Na^{+} (flame photometer), gypsum requirement (Schoonover's method) were determined according to U. S. Salinity Laboratory Staff (1954). Means, Standard Deviation and Standard Error of all the figures were computed by Statistica Package, Version 5.5 (Anonymous, 1998).

RESULTS AND DISCUSSION

Effect of Gypsum Alone or in Combination with FYM and Chiseling on Soil Chemical Properties

Soil pHs. High soil pHs denotes the dominance of sodium among the cations and carbonates / bicarbonates from the anions. This important chemical parameter decreased in all the treatments as compared to control (Figs. 1 & 2).Crop cultivation and application of gypsum alone or in combination with FYM reduced this parameter. However, pH value was greater than 8.5 in control, gypsum + chiseling and gypsum + FYM + chiseling treatments.

The gradual decrease in pHs was observed after harvesting of each crop. The pHs value reduced to less than 8.5 in all the treatments except control. As far as the lower depth (15-30 cm) is concerned, the pH also reduced in all the treatments after harvesting the wheat 2002 – 03.

This may be attributed to the removal of carbonates and bicarbonates of sodium to a greater extent after reclamation. Similar results were obtained by Muhammed and Khaliq (1975).

Electrical conductivity (ECe). It indicates concentration of soluble salts in the soil solution. A significant decrease (Figs. 3 & 4) occurred when gypsum was applied alone or in combination with FYM and chiseling. The decrease in ECe might be due to light texture of the soil. However a little decrease was observed in non-treated plots (control). The best treatment found in these studies was the combination of all the treatments i.e., gypsum + FYM + chiseling. Among the possible reasons may be the improvement in porosity and hydraulic conductivity which resulted in enhancing the leaching of salts.

The decrease in ECe was also reported by Sharma *et al*. (1982). The application of gypsum @ 12 t ha^{-1} and other cultural practices during reclamation of dense sodic soil decreased pHs from 10.2 to 9.1 and ECe decreased from 2.1 to 0.8 d Sm^{-1} more rapidly during first year of reclamation but later on, the effect of amendments was still evident but the rate of amelioration was slow (Rao *et al.*, 1994). The ECe was higher in the lower depth than the upper depth indicating the downward movement of salt due to reclamation process after harvesting of first rice crop. It deceased gradually and reached to the safe limit in the lower depth also after wheat 2003-04.

Fig. 1. Original and Post crop soil analysis for pHs (0-15 cm)

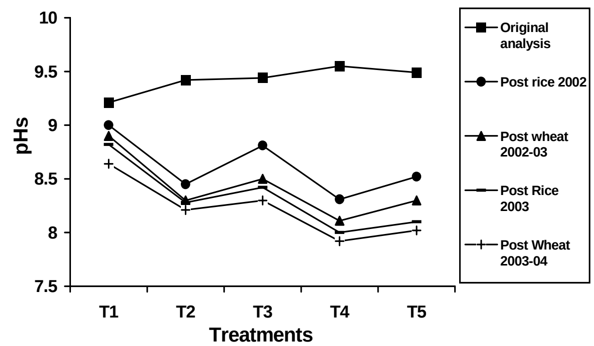


Fig. 2. Original and Post crop soil analysis for pHs (15-30 cm)

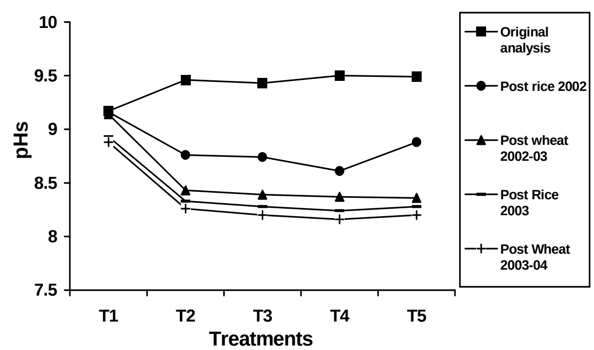


Fig. 3. Original and Post crop soil analysis for ECe (0-15 cm)

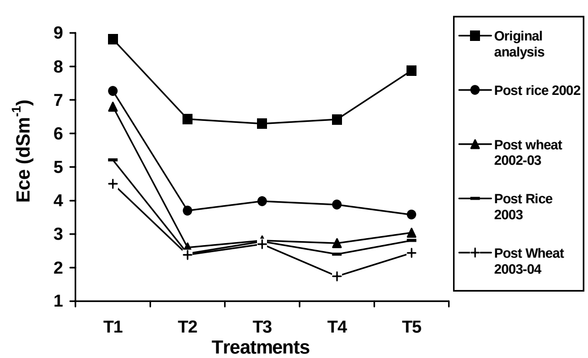


Fig. 4. Original and Post crop soil analysis for ECe (15-30 cm)

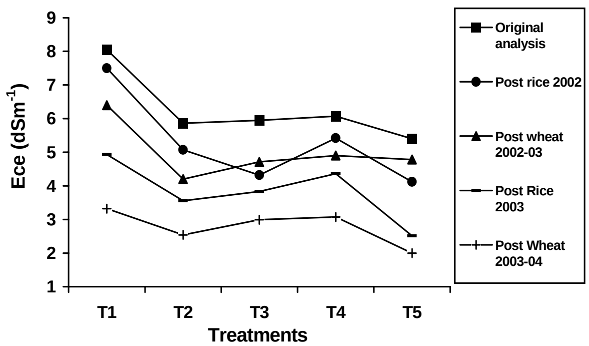
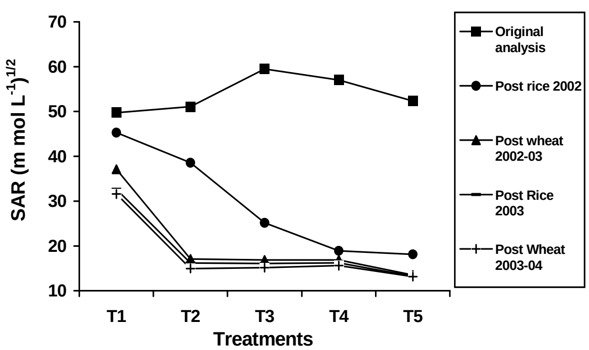


Fig. 5. Original and Post crop soil analysis for SAR (0-15 cm)

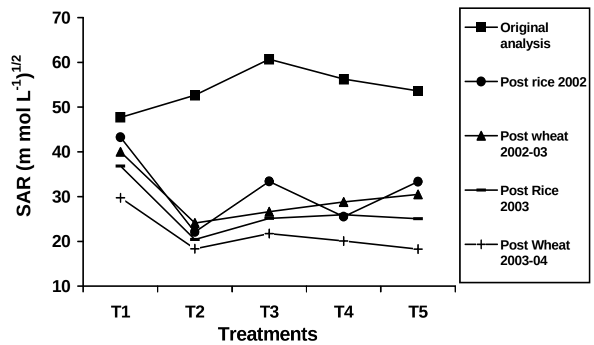


Sodium adsorption ratio (SAR). The SAR decreased significantly with the different treatments (Figs. 5 & 6). However, the decrease in SAR was more with gypsum + FYM + chiseling than gypsum + FYM and gypsum alone.

The less reduction in SAR in only gypsum treated plots might be due to slow reaction of gypsum. The most effective treatments were the combination of all the three practices and gypsum + FYM for reduction of SAR after harvesting of first rice crop. The soil was reclaimed and SAR decreased to permissible limits in all the treatments except the control after harvesting of third crop (Rice, 2003). The decrease in SAR was essentially due to removal of exchangeable sodium from the soil complex.

The results are in agreement with those of Hussain *et al.* (2001). The rate of decrease in SAR was greater in upper soil layer than in lower depth. This pattern was attributed to the decreasing Ca^{2+}: Na^{+} ratio in the soil solution as it moved down the profile displacing exchangeable Na^{+}.

Fig. 6. Original and Post crop soil analysis for SAR (15-30 cm)



Effect of gypsum alone or in combination with FYM and chiseling on crop yields. Data indicated that biomass of rice and wheat was significantly increased when different amendments and cultural practices were applied before transplanting of rice-2002 with subsequent leaching than control (Table I). This increase was higher in gypsum alone or gypsum + FYM as compared to gypsum + chiseling or gypsum + chiseling + FYM. Muhammed *et al.* (1990) also reported similar results on two calcareous sodic soils in 4 years of cropping, the average rice paddy yield from both the soils was in the order: gypsum (1.99 Mg ha^{-1} > gypsum + subsoiling (1.84 Mg ha^{-1}) > subsoiling (1.41 Mg ha^{-1}) > bioremediation (1.02 Mg ha^{-1}). Gypsum + subsoiling treatments had similar values for wheat grain yield (2.72 Mg ha^{-1}) followed by subsoiling (1.79 Mg ha^{-1}) and bioremediation (1.46 Mg ha^{-1}).

The wheat grain yield reduced during 2003-04 in FYM treatments as compared to gypsum alone. The reduction in yield might be due to fading effect of FYM with the passage of time. Gypsum + chiseling remained inferior in production of biomass, paddy and grain yield of wheat in all the years than gypsum alone and gypsum + FYM + chiseling. However, significant increases found in gypsum + chiseling than control. The gradual increase in biomass as well as in paddy and wheat grain yield in other

Table I. Biomass and grain yield of paddy and wheat (Mg ha^{-1}) during 2002-04

Treatments	Rice 2002		Wheat 2002-03		Rice 2003		Wheat 2003-04	
	Biomass	Paddy	Biomass	Grain	Biomass	Paddy	Biomass	Grain
T1	6.96 c	1.06 c	8.20 c	2.16 c	10.36 c	1.63 c	6.98 c	2.00 c
T2	13.34 ab	2.64 a	8.39 bc	2.55 a	18.33 a	2.99 a	10.62 a	3.04 a
T3	11.24 b	2.07 b	7.72 c	1.93 d	14.43 b	2.40 b	8.57 b	2.75 b
T4	13.82 a	2.70 a	10.19 a	2.60 a	17.04 a	3.12 a	10.28 a	2.94ab
T5	12.96 ab	2.48ab	9.05 b	2.40 b	17.86 a	2.94 a	8.87 b	2.84ab
LSD	2.479	0.5487	0.7194	0.1191	1.734	0.3859	0.3472	0.2147

Means sharing same letters are statistically at par at 5 % level of probability treatments may be the result of improved soil properties. The results were in line with those of Hussain *et al.* (2001) who concluded that most superior combination was gypsum + H_2SO_4 + FYM. The improvement in physical and chemical properties of salt affected soil was the major reason for enhancement of crop yield.

The following conclusions were drawn from this study.

1. The gypsum application @ 100 % G. R. proved the best treatment followed by gypsum + FYM in increasing the rice and wheat yield.
2. The gypsum + FYM + chiseling performed better in improving the soil properties.

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