OnLine Journal of Biological Sciences 3 (3): 329-334, 2003
ISSN 1608-4217

Agromelioration of Saline Sodic Soils

M. Anwar Zaka, Fakhar Mujeeb, Ghulam Sarwar, N.M. Hassan and G. Hassan
Soil Salinity Research Institute, Pindi Bhattian, Punjab, Pakistan

Abstract: Agromelioration is the approach for reclamation of salt-affected soils in which minimum possible quantity of chemical amendments is applied coupled with organic material/agronomic practices. A field study was conducted to reclaim saline sodic soil through the application of gypsum @ 25 % G.R. alone and in combination with FYM, rice straw, sesbania @ 10 t ha^{-1} and crust scraping. A standard treatment of 100 % G.R. was also included. Rice and wheat crops were grown in rotation for two years. Crops were harvested at maturity and soil status was monitored after the harvest of each crop. The rice straw and sesbania coupled with 25 % of G.R. were found to be superior to other treatments but were comparable with 100 % G.R. as far paddy yield of first rice crop was concerned. But in the subsequent wheat, the treatment of 100 % G.R. became inferior. However, the effect of FYM improved. The other treatments where organic matter (rice straw, FYM and sesbania) was applied along with 25 % G.R. became similar with 100 % G.R. at the end of 4th crop in terms of yields. The crust scrapping and gypsum @ 25 % G.R. alone were assessed as inferior techniques. Soil analysis also followed the same trends. The EC of the soil rapidly decreased due to light textured soil but the reduction in soil pH and SAR was gradual.

Key words: Saline sodic soil, Gypsum, organic materials

Introduction

In Pakistan, water logging and salinity threaten the irrigated agriculture. Out of 16.2 m ha. of land under irrigation, more than 40,000 ha of land lose their crop production potential each year. In Pakistan, 6.2 m ha land is salt-affected (Anonymous, 1996). High pH, accumulation of salts and exchangeable sodium cause serious reduction in crop yields. Amelioration of salt-affected soils involves site specific suitable techniques. It varies according to the nature and problem of soil, quality of irrigation water, soil permeability, availability and economics of reclaments. For reclamation of saline sodic soils, gypsum is commonly applied as amendment for rectifying sodium abundance by leaching down the excess sodium from clay particles as a sodium sulphate and thus, makes physical and chemical conditions conducive for plant optimum nutrient up take (Khan *et al.*, 1993).

Application of chemical amendments followed by leaching with canal water can reclaim these soils (Biggar, 1996). However, high initial cost of these amendments restricts their use. An alternative to this approach is the use of organic manures to economize the quantity of gypsum. The organic manure were found effective in increasing the yield and good physical condition of the soil (Ibrahim ***et al.***, 2000). Agromelioration is the approach of reclamation in which a starter dose of amendments is applied to bring the root zone of the salt-affected soil within tolerance limits of salt tolerant crops. Further reclamation is obtained through cultural practices and growing of crops. Such a strategy is economical and results in gradual enhancement of crop yields and overall improvement of soil properties. Therefore, this study was conducted to investigate some of such possibilities.

Materials and Methods

The experiment was conducted at Research Farm of Soil Salinity Research Institute, Pindi Bhattian in 1999-2001 on saline sodic sandy loam soil [pH = 9.54-9.92, EC = 10.81-13.13 dSm^{-1}, SAR = 72.2-78.3 $(m\ mol\ L^{-1})^{1/2}$ and gypsum requirements (G.R.) = 5.16-7.2 t $acre^{-1}$]. The experiment was laid out according to RCBD. Treatments applied were as under:

T_1 = control
T_2 = gypsum @ 100 % G.R.
T_3 = gypsum @ 25 % G.R.
T_4 = gypsum @ 25 % G.R. + FYM @ 10 t ha^{-1}
T_5 = gypsum @ 25 % G.R. + rice straw @ 10 t ha^{-1}
T_6 = gypsum @ 25 % G.R. + crust scraping
T_7 = gypsum @ 25 % G.R. + sesbania @ 10 t ha^{-1}

Gypsum and organic amendments were applied 15 days before rice transplanting for leaching of salts and decomposition of organic materials. The sesbania was grown on separate field, harvested, chopped and incorporated in its respective treatments. The crop rotation followed was rice-wheat. Rice variety PB-95 and wheat variety Inqlab-91 were planted in this study. Recommended doses of fertilizers were applied to rice (100-70-50 NPK Kg ha^{-1}) and wheat (120-100-50 NPK Kg ha^{-1}). Two rice and two wheat crops were harvested during this period. The effect of various treatments was recorded on the biomass and grain yield of both the crops. Soil samples were collected at the time of harvesting of each crop and analyzed for pH, EC and sodium adsorption ratio (SAR). Data were statistically analyzed and Duncan's multiple range test was applied to examine significance of differences between the treatment means (Little and Hills, 1978).

Results and Discussion

Biomass of rice and wheat

There was a significant increase in the biomass of both the crops with the application of amendments as compared to control (Table 1). The application of gypsum @ 100 % G.R. increased the biomass of rice 1999 significantly over all the treatments. But later on, gypsum @ 25 % G.R. + FYM or rice straw or sesbania @ 10 t ha^{-1} application remained at par with 100 % gypsum application. Better ameliorative response to gypsum compared with other treatments may be attributed to its rich calcium content which helps in the management of sodium saturated soils (Bresler ***et al.***, 1982). The gypsum application alone @ 25 % G.R. and in combination with crust scrapping also produced higher yield as compared to control. Relatively lesser response of rice crop to FYM application may be attributed to its slower decomposition over time (Anonymous, 1998) and that of gypsum alone @ 25 % G.R. due to its low solubility (Ghafoor and Muhammad, 1990).

Paddy and grain yield

The paddy and grain yield of wheat was increased with all the treatments and in all the four crops grown in sequence (Table 2). The yields in control plots were found to be the least in magnitude. Gypsum application @ 100 % G.R. indicated the highest numerical values but was

Table 1: Effect of amendments on the biomass (t ha^{-1}) of rice and wheat

Treatments	Rice 1999	Wheat 1999-2000	Rice 2000	Wheat 2000-01
Control (T_1)	7.31C	2.34E	8.19E	2.83C
Gypsum @ 100 % G.R. (T_2)	13.22A	3.20BC	14.13A	3.49A
Gypsum @ 25 % G.R. (T_3)	9.47B	3.10CD	10.78CD	2.88C
Gypsum @ 25 % G.R. + FYM @ 10 t ha^{-1} (T_4)	9.54B	3.60ABC	12.04BC	3.47A
Gypsum @ 25 % G.R. + rice straw @ 10 t ha^{-1} (T_5)	10.26B	3.67AB	12.60AB	3.22AB
Gypsum @ 25 % G.R. + crust scraping (T_6)	9.89B	2.60DE	9.73DE	3.04BC
Gypsum @ 25 % G.R. + sesbania @ 10 t ha^{-1} (T_7)	10.28B	3.90A	13.79A	3.22AB

Table 2: Effect of amendments on the grain yield (t ha^{-1}) of rice and wheat

Treatments	Paddy 1999	Wheat 1999-2000	Paddy 2000	Wheat 2000-01
Control (T_1)	1.40D	0.80C	1.50D	0.84C
Gypsum @ 100 % G.R. (T_2)	2.85A	1.17AB	3.05A	1.21A
Gypsum @ 25 % G.R. (T_3)	1.71C	0.86BC	2.01C	0.92B
Gypsum @ 25 % G.R. + FYM @ 10 t ha^{-1} (T_4)	2.57B	1.08AB	2.68B	1.16A
Gypsum @ 25 % G.R. + rice straw @ 10 t ha^{-1} (T_5)	2.73A	1.27A	2.83B	1.16A
Gypsum @ 25 % G.R. + crust scraping (T_6)	1.54CD	0.87BC	1.88C	0.93B
Gypsum @ 25 % G.R. + sesbania @ 10 t ha^{-1} (T_7)	2.80A	1.27A	2.94A	1.22A

Means sharing the same letter(s) are statistically non significant ($P < 0.05$)

assessed similar to organic matter treatments (sesbania, rice straw, and FYM) in statistical terms. The effect of FYM was found to be slower and remained inferior in the first crop (rice 1999). The most inferior treatment was gypsum application @ 25 % G.R. alone or after crust removal. However, both of these treatments were found to be better than control. Higher ameliorative response of gypsum compared with other treatments can be attributed due to rich calcium availability, which replaced exchangeable sodium from the soil exchange complex. The replaced sodium leached down as sodium sulphate in the excessive water during leaching and subsequent rice growing period. Sesbania was reported to be the most out standing species that occupied the pivotal position in any biological reclamation programme (Qureshi, 1998). Gypsum application at all levels significantly increased the yield of rice and wheat over control in studies of Singh (1990). Similarly, application of FYM increased the infiltration rate and reclamation process resulting in more paddy and wheat yield (Chaudhry, 2001). The results of this study confirm these hypotheses.

EC of soil

All the treatments reduced the EC of the soil after harvesting of rice crop (1999) up to 50 % and the effect was non significant within the treatments except control (Fig. 1). It might be due to light texture of soil. However, after harvesting of wheat (1999-2000), the EC reduced to a permissible limit of 4 dSm^{-1} (U.S. Salinity Laboratory Staff, 1954) except control. The EC was still at the margin of this limit in control plots even after the harvest of fourth crop (2 years). The application of gypsum and other cultural practices during reclamation of saline sodic soils, decreased pH and EC 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).

pH of the soil

Gypsum application reduced the pH significantly as compared to control (Fig. 2). Maximum reduction in pH occurred when gypsum was applied @ 100 % G.R. where it was reduced to the safe limit after the harvesting of first rice and wheat. This decrease in pH could be due to the removal of excess Na^{+} from the soil. The effect on pH was similar in later years in other treatments. The decrease in pH with organic materials might be due to the release of organic acids causing mobilization of native calcium present as $CaCO_3$ in the soil. After the harvesting of fourth crops, pH did not reduce to the safe limit in all the plots except where gypsum was applied @ 100 % G.R. It was statistically similar in all the treatments, except 100 % G.R which may be due to fading effect of rice straw and sesbania. The highest value was recorded in control.

SAR of soil

Reduction in soil SAR occurred in all the treatments after harvesting of rice crop 1999 and was significant than control (Fig. 3). But after harvesting of wheat (1999-2000) significant

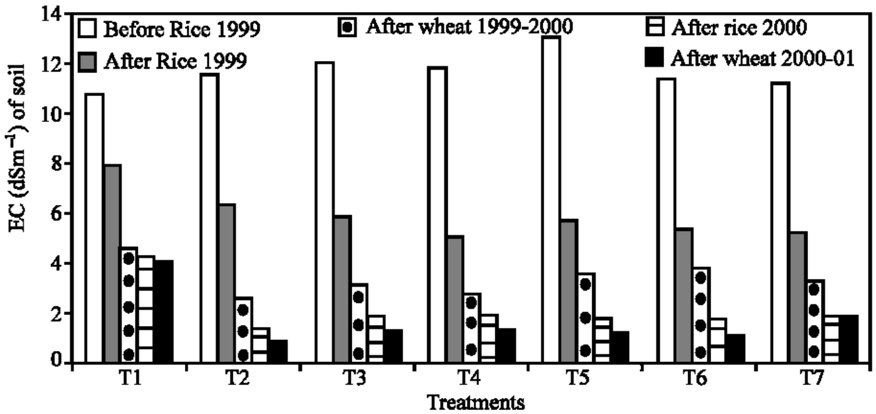

Fig. 1: Effect of amendments on the EC (dSm^{-1}) of soil

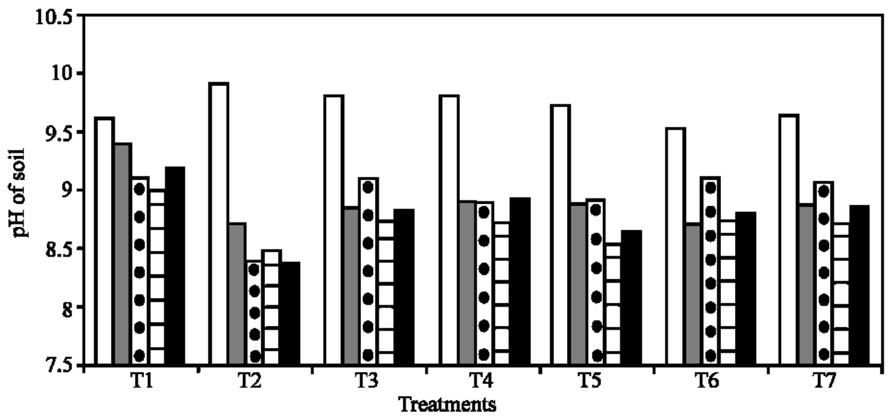

Fig. 2: Effect of amendments on pH of soil

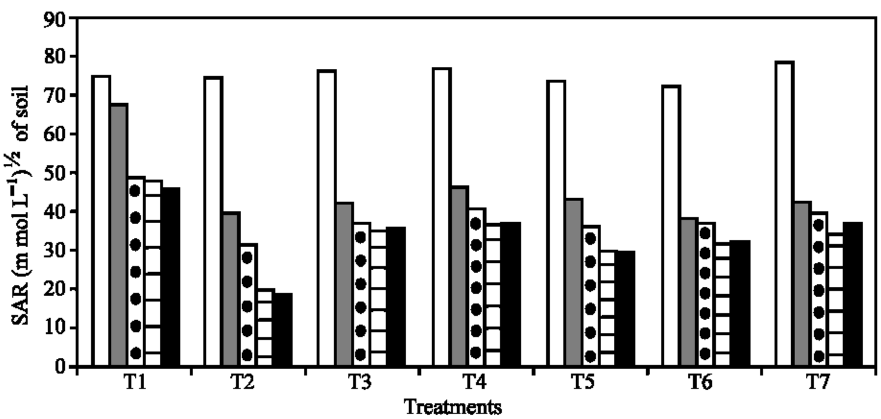

Fig. 3: Effect of amendments on SAR (m mol L^{-1})^{½} of soil

reduction was observed in treatments where gypsum was applied @ 100 % G.R. and other plots were non-significant with each other except control. The reduction in SAR was minimum in control even after the harvesting of fourth crop [46.4(m mol $L^{-1})^{1/2}$]. The application of gypsum @ 100 % G.R. reduced the SAR to maximum after harvesting of two crops followed by gypsum @ 25 % G.R. + rice straw. Decrease in SAR and residual effect of gypsum applied alone or in combination was quite obvious in the second year. The decrease in sodium and increase in calcium caused decrease in SAR of soil after reclamation with gypsum.

Gypsum application @ 100 % G.R. proved the most efficient in reclamation of saline sodic soil and increasing rice and wheat yields. Combining gypsum @ 25 % G.R. with FYM, rice straw or sesbania was also found to be useful strategy in reclamation.

References

Anonymous, 1996. Agricultural Statistics of Pakistan. Ministry of Food, Agriculture and Livestock. Economics Wing of Pakistan, Islamabad, Pakistan

Anonymous, 1998. Integrated Plant Nutrition System (IPNS). Combine use of organic and inorganics. Pakistan Perspective, NFDC, Islamabad, Pakistan.

Biggar, J.W., 1996. Regional salinity, sodicity issues in Punjab-Pakistan. Consultancy Report IIMI, Lahore, Pakistan, pp: 1-26.

Bresler, E.B., B.L. Mc Neal and D.L. Carter, 1982. Saline and Sodic soils. Principles Dynamics-Modeling Springer, N.Y., USA, Queriage Veriage, PP: 236.

Ghafoor, A. and S. Muhammad, 1990. Reclamation of Saline Sodic Soil as a Function of Gypsum Particle Size and Water Quality. Proc. 2nd National Soil Sci. Congress Faisalabad, Pakistan, Dec. 20-22, 1990, pp: 85-90

Ibrahim, M., M. Rashid, M.Y. Nadeem and K. Mahmood, 2000. Integrated use of green manuring, FYM, wheat straw and inorganic nutrients in rice-wheat crop rotation. Proc. Symp. IPNS., NFDC, Islamabad, Pakistan, pp: 186-195.

Khan, N.H., M.I. Haq and A. Rauf, 1993. Gypsum use efficiency in saline sodic soils as affected by water quality and organic matter. Soil for Agri. Dev. Proc. 2nd National Cong. Soil Sci. Faisalabad, Pakistan, Dec. 20-22, 1990, pp: 66-79.

Little, T.M. and F.J. Hills, 1978. Agricultural Experimentation, Design and Analysis. New York, John Wiley and Sons.

Qureshi, R.H., 1998. Management of salt-affected soils of Pakistan. Pak. J. Soil Sci., 14: 90-95.

Rao, D.L.N., N.T. Singh, R.K. Gupta and N.K. Tyagi, 1994. Salinity management for sustainable Agriculture, PP: 314. Central Soil Salinity Res. Institute, Karnal, India.

Singh, B., 1990. Nature, extent and reclamation of salt affected soils of Punjab. Proc. Indo-Pak Workshop on soil salinity and water management. Islamabad, Pakistan. Feb. 10-14, 1990, pp: 73-89.

U.S. Salinity Laboratory Staff, 1954. Diagnosis and Improvement of saline and alkali soils. Handbook, No. 60. USDA. U.S. Govt. Print. Office. Washington, DC, U.S.A.