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Effect of Split Application of Gypsum on Wheat Yield and Properties of a Saline-Sodic Soil Irrigated with Brackish Water

B.H. NIAZI, N. HUSSAIN†, M. SALIM, G. HASSAN† AND A. ALI
Land Resources Research Institute, National Agricultural Research Center, Park Road, Islamabad, Pakistan.
†*Soil Salinity Research Institute, Pindi Bhattian, Pakistan*

ABSTRACT

Field experiments were conducted at farmer's field, in Pindi Bhattian, district Hafizabad to study the impact of different doses of gypsum application in split to saline sodic soil (pH_s 9.38, EC_e 12.34 dS m^{-1}, SAR 33.76 (mmol $L^{-1})^{1/2}$, texture clay loam) on soil amelioration and wheat crop production. The experimental lay out was RCBD with three replications. The field was irrigated with moderately saline but highly brackish water (EC_w 1.4 dS m^{-1}, SAR 8.7 and RSC 4.8 $mmol_c$ L^{-1}). The gypsum treatments were Control (No gypsum), Gypsum @ 50% soil GR, Gypsum @ 100% GR, Gypsum @ 50% GR in two splits and Gypsum @ 100% GR in two splits. A conventional rice-wheat crop rotation was practiced during the experimental period. Rice cv. Basmati PB-95 was selected as test crop during summer and wheat cv. Inqalab-91 as winter crop. A basal dose of N, P_2O_5, K_2O @ 150-100-50 kg ha^{-1}, respectively was applied alongwith Zinc @ 20 kg ha^{-1}. Two wheat crops were harvested at maturity, but the rice crop was completely damaged due to severe flooding before flowering. The data obtained were subjected to statistical analysis. Analyses of soil for pH_s, EC_e and SAR were carried out at the time of harvest of crops. Application of gypsum @ 100% GR in split doses improved the wheat yield significantly. The maximum increase in the yield (132%) was observed in gypsum treated plots @ 100% GR in one shot. A significant decrease in pH was noted with the application of gypsum @ 100% GR. A maximum of 8% decrease in pH was observed by gypsum application @ 100% GR. The EC_e of the soil was linearly decreased with time. Maximum decrease in EC_e was noted in treatment receiving 100% GR in one shot. The cummulative decrease in EC_e at the end of experiment was 66% compared to control. Same was the trend with SAR. A 45% decrease in SAR was recorded during the experiment in gypsum treated plots @ 100% GR in two splits.

Key Words: Split application; Gypsum; Brackish water; Wheat yield; Soil properties

INTRODUCTION

About two third of the underground water of Punjab province has been reported to be unfit for irrigation (Hussain *et al.*, 1991). The underground water quality in lower Sindh is worse than that of Punjab and unfit for irrigation due to high RSC (Chaudhry, 1977). Dry matter yield of rice and wheat crops are variably affected by the use of brackish water irrigation (Khatak *et al.,* 1973). However, the type of salts present in irrigation water may affect crop yield (Khatak *et al.,* 1973).

Gypsum has been used in the past to reclaim the saline-sodic soils (Hussain & Asghar, 1984), which helped to improve the soil properties and better crop production. Cultivation of suitable crops on salt-affected soils are more useful as compared to summer/winter fallowing (Hussain & Ahmad, 1973). Different techniques have been used in the application of gypsum e.g. rate and mesh size (Chaudhry & Haq, 1983). The rate of dissolution of gypsum is around 30 me L^{-1} in water (Richard, 1954). So the application of full recommended/required dose of gypsum may not be fully dissolved. Therefore, the required amount of gypsum may be applied in different doses at the time of cultivation of different crops to utilize its maximum quantity to obtain full benefit out of its application. In this paper, results of field experiments to study the effects of different doses of gypsum application in splits to a saline-sodic soil irrigated with brackish water on soil properties and wheat yield are presented.

MATERIALS AND METHODS

Field experiments were laid out to evaluate the efficiency of split application of gypsum to improve a saline-sodic soil during 1995-97 in Pindi Bhattian area, district Hafizabad. Moderately saline but highly brackish water was used for irrigation during the experiment. Rice (cv. Basmati PB-95) was grown in saline-sodic, clay loam soil, having pH_s 9.38, EC_e 12.34 dS m^{-1}, SAR 33.76 (mmol $L^{-1})^{1/2}$. Gypsum requirement of the soil was 6.0 Mg ha^{-1}. Highly brackish underground water with slight to moderate degree of salinity restriction, having EC_w 1.4 dS m^{-1}, SAR 8.7 and RSC 4.8 ($mmol_c$ $L^{-1})^{1/2}$, was used to raise the rice and wheat crops. The treatments under investigation were as follows:

T_1 = Control
T_2 = Gypsum @ 100% GR
T_3 = Gypsum @ 50% GR
T_4 = Gypsum @ 100% GR in two Splits
T_5 = Gypsum @ 50% GR in two Splits

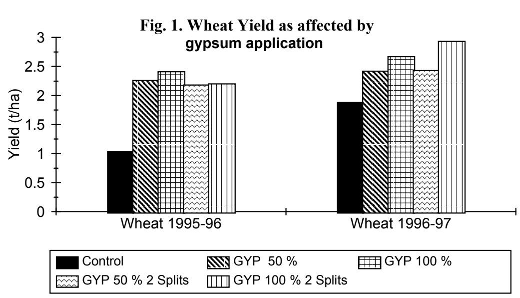
After layout of the experiment, gypsum application was made and thoroughly mixed. Plot size was 12m x 15m. The study was organized using randomized complete block design (RCBD) with three replications. Composite soil samples were collected from each plot to determine pH_s, EC_e and SAR. Rice seedling of 35 days age were transplanted by keeping row to row and hill to hill distance of 22.5 cm. A basal dose of N, P_2O_5, and K_2O @ 100-70-70 kg ha^{-1}, respectively was applied. Half of N as urea and full doses of P_2O_5, and K_2O were applied at the time of transplanting rice seedling. Zinc @ 20 kg ha^{-1} was also applied. Harvesting was done at maturity. Crop growth characteristics *viz.* paddy and straw yields were recorded. After rice harvesting, composite soil samples were collected from each plot. These were analyzed for pH_s, EC_e and SAR according to the methods of Page *et al*. (1982).

After the rice crop, the field was prepared for wheat sowing. Wheat cv. Inqalab-91 was sown by using seed rate of 100 kg ha^{-1} and row to row distance of 20 cm. A basal dose of N, P_2O_5 and K_2O @ 150-100-50 kg ha^{-1}, respectively, was applied. Half of N and full dose of DAP and K_2O as SOP were applied at the time of sowing. The rest of N was applied with the second irrigation. Harvesting was done at maturity and crop growth characteristics *viz.* grain and straw yield were recorded. The grain, paddy and straw yield data from both rice and wheat experiments were statistically analyzed according to the procedures given by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Crop yield. During 1995-96 the wheat yield in the control plots was 1.04 Mg ha^{-1}. A significant increase of 132% yield in wheat was observed in the plots treated with 100% GR in one shot as compared to control. Rest of the treatments were non significant in this respect among themselves but significant difference of about 112% average yield was recorded as compared to control (Fig. 1).

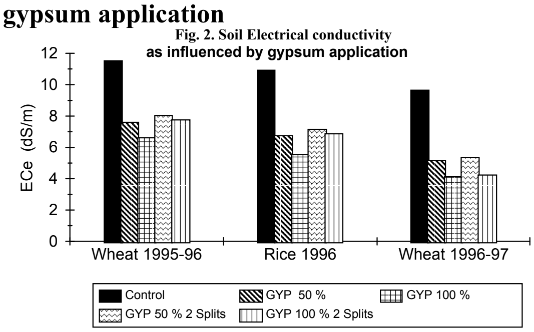
Fig. 1. Wheat yield as affected by gypsum application



During 1996-97, 81% increase in yield of control plots was observed compared to previous year. An interesting development has also been noted in the yield of wheat during 1996-97. This time the treatment of 100% gypsum in two splits produced the maximum wheat (2.93 Mg ha^{-1}) it was 10% higher than that of gypsum applied @ 100% GR in single shot. The application of gypsum @ 100% GR in one shot may have caused increase in EC_e of the soil solution due to release of Na^+ from the soil exchange complex resulting in low wheat yield as reported by Hussain *et al*. (1993). The yield for 1996-97 was significantly better than previous year. There was an 11% increase observed in gypsum @ 100% GR in one shot, 7% in 50% GR in one shot, 33% in 100% GR in two splits and 11% in 50% GR in two splits. The time interval between the split doses may have improved the soil by dissolution and availability of Na^+ at a comparatively slower rate, providing time to leach down Na^+. The second dose may have improved the conditions further and favoured the plant growth resulting in better production. Yield of rice could not be taken due to flood in the area which damaged the crop badly before flowering.

Soil properties. Soil pH of original soil was 9.38, which decreased linearly with the consecutive cultivation of crops. It decreased 1, 2 and 3.5% in control plots with wheat, rice and wheat cultivation, respectively compared to original soil. Application of different doses of gypsum had lowered the pH significantly. The lowest pH was recorded in the presence of gypsum @ 100% GR in one shot during first wheat crop. However, gypsum @ 100% GR in two splits proved best for maximum decrease in the pH at the time of the harvest of second wheat crop. A 7% decrease in pH has been recorded with the application of 100% GR in one shot during first wheat crop compared to original soil. One per cent further decrease in the pH was recorded at the time of final harvest leading to over all 8% decrease since the beginning of experiment. The decrease in the pH may be related to exchange of Ca^{2+} on the soil complex and removal of Na^+. A significant reduction in pH of the soil with gypsum application was consistently observed during the entire experimental period (Table I). Hussain *et al.* (1993) have also noticed a significant reduction in soil pH during a long term reclamation experiment with gypsum and other amendments. However, maximum decrease in pH was recorded in the first year of this study. However, Rashid *et al.* (1994) during a long term experiment on gypsum application for brackish water irrigation did not observe any significant change in pH of the soil, but they reported variable changes during different crop seasons.

Fig. 2. Soil Electrical conductivity as influenced by gypsum application



Electrical conductivity of the original soil was quite high (12.34 dS m^{-1}). It significantly decreased with the application of different doses of gypsum. A maximum decline in the EC_e (43%) was observed in 100% gypsum applied in one shot. The EC_e continuously decreased with the later harvests and a maximum of 66% decrease was noted after the harvest of second wheat crop in the plots where gypsum was applied @ 100% GR in one shot as well as two splits (Fig. 2).

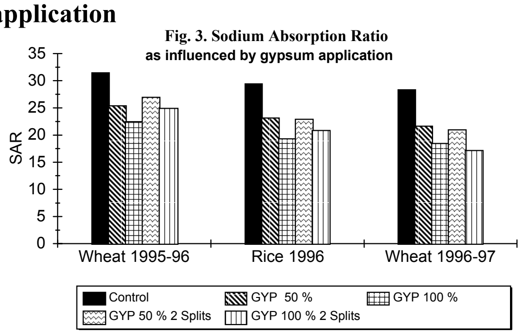
Table I. Soil pH as affected by gypsum application

Crops	Control	Gyp @ 50% GR One split	Gyp @ 100 % GR One split	Gyp @ 50% GR Two splits	Gyp @ 100 % GR Two splits
Wheat 1995-96	9.26 A	8.97 B	8.86 C	8.89 C	8.72 D
Rice 1996	9.13 A	8.88 B	8.72 C	8.84 B	8.67 C
Wheat 1996-97	9.05 A	8.84 B	8.56 C	8.78 B	8.62 C

Figures followed by different letters are significantly different for the same crop at $P < 0.01$

The magnitude of decrease in EC_e was more pronounced with time. Although, Rashid *et al.* (1994) claimed an increase in the EC_e of soil after harvesting of wheat crop. However, application of gypsum significantly decreased the EC_e even during the first crop period and the trend of lowering EC_e continued till the second wheat crop was harvested. Soil EC_e after the harvest of second wheat crop was almost in the range of non saline soils (Fig. 2).

Fig. 3. Sodium absorption ratio influenced by gypsum application



Rao *et al.* (1994) have reported a 95% decrease in the EC_e of a sodic soil with the application of gypsum @ 12 Mg ha^{-1} and croping wheat-rice-wheat within nine years. Bhatti (1986) did not observe any contribution of gypsum towards amelioration of soil, which is contradictory to the present studies. The low EC_e may be related to dissolution of Na^+ from the soil complex and its leaching to the deeper soils. Flooding during 1997 may have facilitated the removal of the solubilized Na^+ from the field, thus lowering the EC_e of the soil.

Sodium adsorption ratio of original soil was 33.76. A minimum of 18.44 SAR was recorded at the final crop harvest in gypsum applied @ 100% GR in two splits, which reflects 45% reduction in SAR of the original soil. A linear reduction in SAR was noted through out the experiment. Rate of decrease in SAR enhanced with time and application of highest gypsum dose (Fig. 3).

Gypsum application in the two splits proved better in the long run in lowering soil SAR. Although, maximum decrease in SAR value was observed when treated with 100% GR in one shot during the first wheat and rice cropping seasons. Similar results have already been published where gypsum is reported to be the most successful chemical reclamation agent used in Pakistan (Qureshi, 1998).

In general, various gypsum treatments resulted in better yield of wheat crops and improved soil chemical properties by lowering its pH_s, EC_e and SAR. Therefore, gypsum application in split doses could be regarded as effective and useful for the management of salt-affected soils.

REFERENCES

Bhatti, H.M., 1986. Management of irrigation water qualities for crop production. *Final Technical Report of PL-480 Project*. AARI, Faisalabad.

Chaudhry, T. M., 1977. Survey and quality of irrigation water in Sind. *In: Proc. Water Manag. Agri. Sem.,* Lahore. Nov. 15-17, pp: 348–51.

Chaudhry, A. and M.I. Haq, 1983. Effect of gypsum rate and fineness on precipitation of CO_3 and HCO_3 in saline sodic soils. *Pakistan J. Soil Sci.,* 1: 25–8.

Hussain, M.A. and M. Asghar, 1984. Gypsum as an amendment for the reclamation of saline-sodic lands. *Pakistan Engg. Cong. Proc*., 60: 193–9.

Hussain, M. and B. Ahmad, 1973. Crop rotation for salinity control. *Pakistan Soc. for Advancement of Sci. Proc*., 15: A 11.

Hussain, N.A., A. Khan, M.K. Tanveer, M. Ahmad and A. Sattar, 1991. Suitability of Punjab underground water. *J. Agric. Res.,* 29: 519–29.

Hussain, T., G. Jilani, A. Haq and R. Ahmad, 1993. Management of brackish irrigation water with chemical amendment in conjunction with rice culture. *Pakistan J. Soil Sci*., 8: 42–7.

Khattak, J.K., A Rashid and M. Akram, 1973. Effect of saline irrigation water on the growth, yield and protein content of Maxi-Pakistan. *J. Agric. Res*., 25: 162–6.

Page, A.L., R.H. Miller and D. R. Keeney, 1982. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. No. 9. *American Society of Agron.* Madison, Wisconsin, USA.

Qureshi, R.H., 1998. Management of salt affected soils of Pakistan. *Pakistan J. Soil Sci*., 14: 90–5.

Rao, D.L.N., N.T. Singh, R.K. Gupta and N.K. Tyagi, 1994. Salinity Management for Sustainable Agriculture. Central Soil Salinity Research Institute, Karnal, India, p. 314.

Rashid, M., M.Y. Shakir and M. Jamil, 1994. Effect of brackish water on crop yields and properties of a soil treated with amendments. *Pakistan J. Soil Sci.,* 9: 86–90.

Richard, L.A., 1954. Diagnosis and Improvement of Saline and Alkali Soils. United States Department of Agriculture, Washington, D.C. USA, Hand book 60, p. 160.

Steel, R.G.D. and J. H. Torrie, 1980. Principles and Procedures of Statistics. 2nd ed. McGraw Hill, Book Co. Inc. New York, USA.

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