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Sodic Water Management with Gypsum Application for Sustainable Crop Production

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Abstract: The experiment was conducted in the field on a normal soil. Brackish tube well water was used for irrigating wheat and rice crops without any amendment and with gypsum (equal to sodium contents of irrigation water and two times its sodium contents). Wheat and rice crops were grown from Rabi 1995-96 to Rabi 1998-99. Grain and paddy yield along with Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and pH of the soils were recorded. Use of brackish water without any amendment resulted in an increase in EC and SAR of the soil and caused a decrease in crop yield. Use of the same water in combination with two times its sodium contents resulted in normal yield of both the crops without any harmful effect on the soil. Gypsum equal to sodium contents of the irrigation water proved comparatively less effective.

Key words: Sodic, Brackish, Irrigation, Gypsum

Introduction

Water is one of the basic requirements for crop production. In Pakistan, rainfall is quite insufficient and erratic and is unable to meet the crop water requirements. Surface water supplies are also not sufficient to meet the requirements of intensive cropping. Hence use of poor quality under ground waters for crop production is increasing with the passage of time to meet the ever-increasing demand for food and fibre. The sub-surface waters available for this purpose are mostly of questionable quality. According to WAPDA (1979) estimates, about 71% water samples in the surveyed area were of marginal to hazardous quality. Farmers are using poor quality under ground waters indiscriminately for increasing their crop production. Use of these poor quality irrigation waters is causing severe soil deterioration problem (Chaudhry *et al.*, 1990). The adverse effects of high Na^+ on the physical and chemical properties of soils can be mitigated by the use of different amendments (Minhas, 1996), which contain soluble Ca^{2+} e.g. gypsum. Chaudhry and Rafiq (1985) investigated the effect of different doses of gypsum in a soil irrigated with brackish tube well water (TDS = 1728 ppm, SAR = 19) on soil and crop yield. In general, a decreasing trend in wheat grain and paddy yield was observed with passage of time. The results of their study showed that increase in soil SAR can be controlled by using gypsum from 75 to 100 percent gypsum requirement. Rain *et al.* (1987) reported that yield of cotton and safflower increased with the use of drainage water up to 6000 ppm when a presowing irrigation with good quality irrigation water was applied. There was no effect on the electrical conductivity (EC) and Sodium Adsorption Ratio (SAR) of the upper 15 cm of a normal silty clay loam soil irrigated with brackish water (TDS = 1850, SAR = 19.3 and RSC = 2.8 meq. per litre), amended with gypsum at 50% gypsum requirement (Chaudhry *et al.*, 1990). Wheat grain yield remained unaffected during the two year study period. Ghafoor *et al.* (1991) reviewed the research work on the use of brackish water for irrigation and concluded that further studies are needed regarding management techniques on a wider scale particularly on farmer's level. The presence of high sodium in relation to calcium content in the soils increases the pH and ESP which decreases the soil permeability to water and can also disturb the plant nutrition (Minhas, 1996).

The present study was conducted to investigate the effect of long-term use of brackish water under farmers conditions, on crop production under a wheat-rice cropping system.

Materials and Methods

The experiment was conducted at Soil Salinity Research Institute, Pindi Bhattian on a normal soil (Texture = clay loam, EC_e = 4.41 dS m^{-1}, pH_s = 8.38, SAR = 9.85), using brackish tube well water for irrigation (EC = 0.84 dS m^{-1}, SAR = 8.86, RSC = 4.25 meq. per litre). Rice (KS-282) and wheat (cv. Inqlaab) crops were grown in sequence starting from wheat 1995-96 up to wheat 1998-99 under a wheat-rice-wheat system. Uniform doses of fertilizer (rice = 100-70-0 and wheat = 120-100-0 NPK kg/ha) were used. Crops were harvested at maturity, yield data recorded and soil samples obtained for analysis. Post harvest soil samples were analysed for Electrical Conductivity (EC in dS m^{-1},), pH and Sodium Adsorption Ratio (SAR). Treatments of the experiment were as follows.

T1 = Control i.e. Tube well water (TW) alone
T2 = TW water + Gypsum equiv. to Na^+ in irrigation water
T3 = TW water + Gypsum equiv. to 2 Na^+ in irrigation water

The experiment consisted of 3 replications and was layed out according to randomized complete block design (RCBD). Net plot size was 15 × 20 metres. The collected data was statistically analysed for Analysis of Variance. Duncon,s Multiple Range Test was applied for mean separation. The means sharing the same letters are statistically non-significant at $\alpha = 0.05$.

Results and Discussion

Effect on Grain and Paddy Yield: There was statistically non-significant effect of brackish tube well water on crop yield of initial three crops. However, losses became significant afterwards in subsequent crops. There was a significant increase in the yield of wheat and rice in the year 1995, 1996, 1997 and 1998-99 (Table 1), with the application of gypsum applied according to T2 (TW water + Gypsum equiv. to Na^+ in irrigation water) and T3 (TW water + Gypsum equiv. to 2 Na^+ in irrigation water) as compared to T1 where brackish water was used for irrigation without gypsum amendment. With continuous irrigation with brackish water, the yield of wheat decreased by 6.4% in the year 1998-99 as compared to year 1995-96, while in rice, decrease in paddy yield was 16% in 1998 as compared to 1996. Lower dose of gypsum (T2) produced almost similar yields to those obtained under higher gypsum dose (T3); except wheat 1998-99 where the later produced significantly higher yields ($p < 0.05$) as compared to the former.

Effect on Soil Properties: The brackish water irrigation had adverse effect on soil properties. There was a successive and significant increase in EC of the soil (Table 2) starting from year 1995-96 to 1998-99, under irrigation with tube well water (T1). In T2 (TW water + gypsum equiv. to Na^+ content of TW water), the increase in EC was there but it was much lesser in magnitude and was not significant. In T3, there was no increase in EC of the soil. At the time of termination of the experiment in the year 1998-99, it was almost similar to the EC recorded at start of the experiment. The EC remained significantly lower than T1 and constant through out the duration of the experiment.

The SAR of the soil also increased significantly under irrigation with tube well water (T1) and increased from about 10 in the year 1995-96 to about 14 in the year 1998-99 (Table 3). In T2, SAR of soil after the harvest of wheat 1995-96 was less than T1.

Table 1: Effect of gypsum on yield of wheat and rice (t/ha)

Crops	Tubewell water	TW water + gypsum equiv. to Na^+	TW water +2 times gypsum equiv. to Na^+
Wheat 1995-96	2.64c	2.87 b	3.14 a
Rice 1996	2.96c	3.48 b	4.41 a
Wheat 1996-97	2.00b	2.17 b	2.97 a
Rice 1997	3.14b	3.81 a	3.95 a
Wheat 1997-98	2.56c	2.34 b	3.50 a
Rice 1998	2.50c	3.34 b	3.33 a
Wheat 1998-99	2.47b	2.53 b	3.68 a

Table 2: Effect of gypsum on EC (dS m^{-1}) of the soil

Crops	Tubewell water	TW water + gypsum equiv. to Na^+	TW water + 2 times gypsum equiv. to Na^+
Wheat 1995-96	4.57a	3.85b	3.62b
Rice 1996	4.78a	3.92b	3.67c
Wheat 1996-97	4.97a	4.09b	3.69b
Rice 1997	4.23a	3.68b	3.28c
Wheat 1997-98	4.32a	3.70b	3.32c
Rice 1998	4.48a	3.72b	3.39c
Wheat 1998-99	4.61a	3.74b	3.42c

Table 3: Effect of gypsum on SAR of the soil

Crops	Tubewell water	TW water + gypsum equiv. to Na^+	TW water + 2 times gypsum equiv. to Na^+
Wheat 1995-96	10.48a	9.75b	8.64c
Rice 1996	11.54a	10.58b	8.77c
Wheat 1996-97	12.42a	11.42b	8.82c
Rice 1997	12.33a	8.94b	8.12c
Wheat 1997-98	12.99a	9.06b	8.26c
Rice 1998	13.64a	9.16b	8.35c
Wheat 1998-99	14.56a	9.24b	8.44c

Table 4: Effect of gypsum on pH of the soil

Crops	Tubewell water	TW water + gypsum equiv. to Na^+	TW water + 2 times gypsum equiv. to Na^+
Wheat 1995-96	8.43a	8.38a	8.32a
Rice 1996	8.45a	8.39ab	8.33b
Wheat 1996-97	8.49a	8.40a	8.34a
Rice 1997	8.42a	8..34b	8.19c
Wheat 1997-98	8.43a	8.35b	8.24c
Rice 1998	8.45a	8.36b	8.25c
Wheat 1998-99	8.46a	8.36b	8.29c

There was an increase in SAR with continuous irrigation and passage of time, but it remained significantly lesser in magnitude as compared to T1. In T3, SAR remained significantly lower than T1 and T2 and almost constant and similar to the original soil during the study period.

Effect of irrigation with amended (T2 and T3) and unamended water (T1) on pH of the soil is presented in Table 4. There was a slight decrease in pH in T2 and T3 as compared to the soil irrigated with tube well water alone (T1) but the effect was not significant throughout the duration of this study. The pH increase of the soil with continuous use of brackish tube well water was only 2.0, 1.0 and 0.5% of the initial soil pH in T1, T2 and T3 respectively.

Irrigation of the soil with brackish water resulted in impairment of the physical properties of the soil and an increase in the soil salinity due to its high SAR and EC. SAR of the soil solution can increase due to high SAR of the irrigation water as a result of precipitation of $CaSO_4$ or $CaCO_3$ and thus increasing the proportionate concentration of Na^+ (Rhoades, 1968). SAR of the water may also have an indirect effect on buildup of soil salinity due to its effect on the soil permeability. Decrease in yield of wheat and rice could be due to an increase in osmotic effects due to salt buildup (Sharma and Khosla, 1984). Under-irrigation with brackish water having high EC and SAR, may increase sodicity, and result in decreased uptake of N, P, K, Mg, Zn, Cu, Mn, Cu, Fe and an increased uptake of Na^+ (Richards, 1969; Padole *et al.,* 1995). Oster and Schroer (1979) obtained a high correlation between exchangeable Na^+ and RSC of irrigation water. Poor physical conditions of the soil resulting from use of irrigation water with high EC and SAR and resulting Na^+ accumulation will also affect the crop yield adversely. Chaudhry and Rafiq (1985) also reported similar effect of gypsum while studying the crop responses to brackish water irrigation. The adverse effects of high sodium on the physical and chemical properties of the soil were alleviated with gypsum (Minhas, 1996) in T2 and T3. This had a favourable effect on the crop growth and improved the yields of wheat and rice as compared to T1 where tube well water was applied without gypsum amendment. The lower pH, SAR and EC of the soil amended with gypsum application was helpful in maintaining the crop nutrition (Minhas, 1996) and hence higher crop yields were obtained in T2 and T3 as compared to T1.

Indiscriminate and continuous use of brackish water for crop production result in deterioration of soil properties and decrease in crop yields. Irrigation of crops with brackish water in combination with gypsum amendment equal to double the sodium contents of this water, was the most effective treatment in maintaining soil health and crop yields on sustainable basis. Application of this water with gypsum equal to its sodium contents was economical but less effective.

References

Chaudhry, M.R. and M.S. Rafiq, 1985. Ameliorative effect of gypsum on soil properties and crop yield irrigated with high SAR water. Publication No. 144, Mona Reclamation Experimental Project, WAPDA, Bhalwal.

Chaudhry, M.R., B. Ahmad and M. Abaidullah, 1990. Management of Brackish water and its impact on soil properties and crop yield. Proceedings of Indo-Pak Workshop on Soil Salinity and Water Management, Volume 2, February 10-14, 1990, Islamabad, Pakistan, pp: 311-324.

Ghafoor, A., M. Qadir and R.H. Qureshi, 1991. Using brackish water on normal and salt-affected soils in Pakistan: A review. Pak. J. Agric. Sci., 28: 273-288.

Minhas, P.S., 1996. Saline water management for irrigation in India. Agric. Water Manage., 30: 1-24.

Oster, J.D. and F.W. Schroer, 1979. Infiltration as influenced by irrigation water quality. J. Am. Soc. Soil Sci., 43: 444-447.

Padole, V.R., D.V. Bhalkar and V.B. Kale, 1995. Effect of quality of irrigation water on wheat grown under conditions of salinity-sodicity. Punjabrao Krishi Vidyapeeth Res. J., 19: 34-38.

Rain, D.V., S. Goyal, R. Weyrauch and A. Lauchli, 1987. Saline drainage water reuse in a cotton rotation system. California Agric., 41: 24-26.

Rhoades, J.D., 1968. Mineral-weathering correction for estimating the sodium hazard of irrigation waters. Soil Sci. Soc. Am. J., 32: 648-652.

Richards, L.A., 1969. Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook No. 60, United States Department of Agriculture, Govt. Printing Office, Washington, DC..

Sharma, D.R. and B.K. Khosla, 1984. Leaching of a sodic water deteriorated salty soil. J. Indian Soc. Soil Sci., 32: 344-348.

WAPDA., 1979. Soil salinity and water table survey. Publication No. 3, Survey and Research Organization, Lahore.