Pak.J.Bot., 29(2): 305-311, 1997.

USE OF SALINE/SODIC WATER FOR IRRIGATION

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Abstract

Experiments were undertaken to see the prospects of using saline/sodic water for irrigation. The brackish water was amended with biological ameliorants like sesbania, pressmud or poultry manure or used with good quality canal water in blended or cyclic modes. All the organic manures were almost equally effective in sustaining the yield. Cyclic use of canal and brackish water showed better results than the blend use. These studies suggested a possibility for using saline/sodic water for irrigating crops under specified management conditions.

Introduction

One of the major constraints on agricultural production is the limited supply of quality water for surface irrigation with the result that 11.9 m ha are lying as culturable waste (Anon., 1987). The increase in canal water supplies is not possible in Pakistan due to the limited supply of resources. However, the canal water supplies are being supplemented by using the groundwater but the quality of this groundwater is questionable due to the high concentration of salts (Khan *et al.*, 1990).

It is a common practice among the farmers in Pakistan to use brackish groundwater after mixing it with the available canal water. The mixing of brackish water with canal water often deteriorates water quality without contributing additional water for crop production. The idea of cyclic use of waters of low and high salinity as conceived by Rhoades (1984) prevents the soil from becoming saline and allows for the substitution of a brackish water for 50% of the irrigation needs. The quality of brackish water can be improved by the use of certain amendments like gypsum, sulfuric acid, hydrochloric acid and other acid formers etc., (Qureshi *et al.*, 1975; Ahmad *et al.*, 1979; Ayers & Westcot, 1985; Ghafoor *et al.*, 1987). Moreover regular additions of organic materials to the soil are extremely important in maintaining good soil physical conditions and fertility when using brackish or blended water (Bhatti *et al.*, 1985; Chaudhry *et al.*, 1985; Hornick & Parr, 1987). The present studies were undertaken with a view to study the possibilities of using brackish water for crop production under the agro-ecological conditions of Pakistan.

Materials and Methods

The project studies were conducted on a farmer's field 2km upstream Madhuana Drain near Khurrianwala on Faisalabad-Lahore Road, Faisalabad. Methodology of the experiments is described below:

Table 1. Effect of cyclic vs blended use of canal and brackish water on crop yield.

Treatments	Rice (1992)	Wheat (1992-93) ($t\ ha^{-1}$)	Rice (1993)
Canal water alone	5.59 a	2.61 a	5.67 a
Cyclic use	5.13 ab	2.56 b	5.17 b
Blend use-I	4.95 bc	2.38 b	4.35 b
Blend use-II	---	2.47 b	---
Tubewell water alone	4.76 c	1.87 b	3.83 c

(Blend use-I): Not applied to rice.

Study-I. Cyclic vs. blend use of canal and brakcish water for crop production: The experiment was initiated during summer (1992) in a rice-wheat cropping system. In first crop of rice, there were 4 treatments; canal water (CW) alone; the cyclic use of canal and tubewell water, the blend use of canal and brackish tubewell water and tubewell water (TW) alone. The ratio of blend was adjusted to achieve an EC of 2.0 $dS\ m^{-1}$ in the water. For the wheat crop (1992-93), the ratios of the blend were used to adjust the SAR/RSC of brackish water. Thus, there were two blends i.e., Blend I (40% CW, 60% TW) with SAR 10.0 $(mmol\ L^{-1})^{1/2}$ and Blend II (80% CW, 20% TW) with RSC 2.5 me L^{-1}. In case of cyclic use, irrigation with tubewell was applied and the resulting change in ECe in the soil was determined theoretically as Diw/Ds = ds/dw. SP/100. $\triangle$ECe/ECiw (Anon., 1954). Then canal water required to bring the ECe to original level was determined by Dieleman *et al.*, (1979)'s formula

$$diw/Ds = C\log (ECeo - ECiw)/(ECex - ECiw)$$

where: Dw = required depth of leaching water (cm).
Ds = depth of soil to be reclaimed (cm).
C = leaching co-efficient, a constant whose value is 1.1.
ECeo = salinity of the soil saturation extract before leaching.
ECiw = EC of irrigation water to be applied for leaching.
ECex = required salinity of the soil saturation extract.

The experiment was replicated thrice following a RCB Design. Individual plot size was 5 m x 8 m. In both the rice and wheat crop, pre plant irrigations with canal water were applied in all the treatments. Canal water had EC 0.28 $dS\ m^{-1}$, SAR 2.10 $(mmol\ L^{-1})^{1/2}$ and RSC 0.8 me L^{-1}, whereas the corresponding values for tubewell water were 2.72 $dS\ m^{-1}$, SAR 12.05 $(mmol\ L^{-1})^{1/2}$ and RSC 10.4 me L^{-1}, respectively. Sixteen *irrigations were applied to rice crop with a week interval (7.5 cm each time) whereas 5* irrigations were applied to the wheat crop. Recommended plant protection and agronomic practices like fertilization etc., were adopted equally in all the treatments. Data on the yield parameters was collected at maturity. Soil samples upto depth of 30 cm after the harvest of each crop were analysed for pHs, ECe and SAR determinations, whereas plant tissue analysis was performed for the uptake of various ions (Anon., 1954).

Study-II. Utilization of brackish water through organic amendments: The experiment was conducted on rice-wheat cropping rotation. There were again 4 treatments with 3 replications using RCB design. The treatments were TW (same quality as in study-1), TW plus *Sesbania* green manure @ 10 t ha^{-1}, TW plus pressmud (sugar industry waste with EC 2.2 dS m^{-1}, pH 6.6 (soluble Ca + Mg 4%) added on the basis of its (Ca + Mg) amount and TW plus poultry manure (Ca + Mg = 5.2%) @ 10 t ha^{-1}. Green manure and poultry manure were incorporated before transplanting while pressmud was applied with each irrigation. Other production practices were similar to that described in study-I.

Results and Discussion

Study-I. Crop yield: Maximum response of significantly higher crop yield was achieved with canal water treatment (Table-1). Data further revealed that blend use of canal and brackish water resulted in lower yield as compared to their use in cyclic mode. Better yield from cyclic treatment can be attributed to the proper maintenance of salt balance under this treatment. In case of blend use, plant can extract only good quality water

Table 2. Effect of cyclic vs. blended use of canal and brackish water on concentration of various ions (%) in plant grain samples.

Treatments	Na	K	Ca	Cl
		a) Rice Crop (1992)		
CW	0.035^{NS}	0.297 a	0.254 a	0.240 c
Cyclic	0.037	0.274 a	0.233 b	0.270 bc
Blend-I	0.037	0.226 b	0.210 c	0.310 ab
Blend-II	---	---	---	---
TW	0.048	0.226 b	0.192 d	0.350 a
		b) Wheat Crop (1992-93)		
CW	0.025 d	0.338 a	0.297 a	0.177 b
Cyclic	0.029 c	0.280 b	0.266 ab	0.197 b
Blend-I	0.032 b	0.210 a	0.233 bc	0.253 ab
Blend-II	0.030 c	0.263 c	0.265 ab	0.237 a
TW	0.036 a	0.214 a	0.212 c	0.287 a
		c) Rice Crop (1993)		
CW	0.034 b	0.322 a	0.285 a	0.213 d
Cyclic	0.035 b	0.292 b	0.280 b	0.240 c
Blend-I	0.040 b	0.234 c	0.253 b	0.296 b
Blend-II	0.041 b	---	---	0.288 b
TW	0.051 a	0.227 c	0.225 c	0.340 a

Means sharing similar letter (s) are statistically non-significant at 0.05% probability.
(Blend-II): Not applied to rice.

Table 3. Effect of cyclic vs. blended use of canal and brackish water on the soil chemical characteristics.

Treatments	Before Rice-I	After Rice-I	After Wheat-I	After Rice-II
		a) ECe (dS m^{-1})		
CW	3.01	2.92 c	3.07 d	3.17 c
Cyclic	2.97	3.30 b	3.89 c	3.99 bc
Blend-I	3.19	3.80 b	4.27 b	4.26 b
Blend-II	---	---	3.72 c	---
TW	3.75	4.42 a	5.00 a	5.62 a
		b) SAR (mmol $L^{-1})^{½}$		
CW	8.95	8.89 c	8.61 c	9.13 c
Cyclic	8.94	9.96 c	11.24 b	11.19 b
Blend-I	9.85	11.23 b	11.61 b	11.24 b
Blend-II	---	---	10.33 b	---
TW	9.75	13.39 a	14.10 a	14.63 a
		c) pHs		
CW	8.21	8.18^{NS}	8.12 c	8.16 c
Cyclic	8.17	8.19	8.20 c	8.29 c
Blend-I	8.20	8.24	8.34 b	8.44 b
Blend-II	---	---	8.31 b	---
TW	8.19	8.25	8.40 a	8.53 a

(Blend-II): Not applied to rice.

from the mix. This extraction is done by the expenditure of energy which otherwise can be utilized by plants for biomass production. Bradford & Letey (1992) reported that cyclic use strategy produced higher simulated yield than the blend strategy.

Irrigation with tubewell water alone showed lowest yield which was due to the higher sodic hazard of irrigation water (high RSC). Reduction in crop yield under stress has also been reported by Maas & Hoffman (1977) and Aslam *et al.* (1988).

Plant Tissue Analysis: Rice/wheat grain samples were analysed for the concentrations of Ca, Na, K, and Cl etc. A higher uptake of Na and Cl by plants were observed in the plots irrigated continuously with brackish water (Table 2). This was due to the relatively high sodic hazard of water. The uptake of Ca and K was reduced due to the increased competition between Na and Ca (Suarez & Grieve, 1988). Maximum uptake of K and Ca was observed from canal water treatment. The cyclic use strategy, resulted generally in lower uptake of Na and Cl as compared with the blend use strategy. Although the data, infers that blend use extends water supplies, comparatively better results can be obtained from the cyclic use strategy.

Soil Characteristics: Ionic contents of the soil extracts increased appreciably with the application of tubewell water which resulted in increased solute concentration ECe and SAR in the soil solution (Table 3). There was however, less development in soil salinity/sodicity in cyclic or blend use treatments, thus indicating a possibility for the limited substitution of good quality canal water with the brackish tubewell water.

Table 4. Effect of various brackish water management strategies with biological amendments on the grain yield of crops.

Treatments	Rice-I ($t\ ha^{-1}$)	Wheat-I	Rice-II
Tubewell water	4.6 c	2.22 c	3.48 c
TW + GM Sesbania	5.5 ab	2.38 bc	4.08 b
TW + Pressmud	5.0 b	3.15 a	5.50 a
TW + PM	5.7 a	2.68 b	5.70 a

Study II Crop yield: Maximum yield of the first crop of rice i.e. rice (1992) was obtained from the treatment where brackish water was amended with poultry manure followed by the green manure treatment (Table 4). The differential response to various biological manures may be attributed to their different decomposition rates and % concentration of various nutrients in the manures.

Faster the decomposition of manure in soil, faster various nutrients are taken up by the plants. Maintaining adequate fertility under salt stress conditions to increase crop yield has been reported by many workers (Ravikoritch & Porat, 1967; Aslam & Muhammad, 1972). During the first crop of rice (1992), maximum yield was observed from the poultry manure, treatment which contained 3.4% Ca. However, in the follow-

Table 5. Effect of various brackish water management strategies with biological amendments on the concentration of various ion (%) in grain samples

Treatments	Na	K	Ca	Cl
	a) Rice Crop (1992)			
Tubewell water	0.040 a	0.1356 b	0.156 b	0.401 a
TW+GM Sesbania	0.034 b	0.187 a	0.193 ab	0.384 ab
TW+Pressmud	0.031 b	0.175 a	0.200 ab	0.374 b
TW + PM	---	0.183 a	0.226 a	0.369 b
	b) Wheat Crop (1992-93)			
Tubewell water	0.029 a	0.270 b	0.146 b	0.282 a
TW+GM Sesbania	0.024 b	0.338 a	0.173 a	0.237 b
TW+Pressmud	0.019 c	0.351 a	0.200 a	0.256 b
TW + PM	0.021 bc	0.323 ab	0.186 a	0.252 b
	c) Rice Crop (1993)			
Tubewell water	0.050 a	0.184 c	0.186 b	0.425 a
TW+GM Sesbania	0.036 b	0.239 a	0.326 a	0.374 b
TW+Pressmud	0.036 b	0.247 a	0.360 a	0.367 b
TW + PM	0.033 c	0.215 b	0.336 a	0.357 b

Means sharing similar letter (s) are statistically alike at 0.05% probability level.

Table 6. Effect of brackish water management strategies with biological amendments on the soil chemical characteristics

Treatments	Before Rice-I	After Rice-I	After Wheat-I	After Rice-II
		a) ECe (dS m^{-1})		
TW 3.42	2.18 a	4.23	5.25	
TW+GM	3.49	3.14 b	3.55	4.19
TW+Pressmud	3.40	3.50 b	3.75	4.32
TW+Poultry manure	3.17	3.24 b	3.43	4.08
		b) SAR (mmol $L^{-1})^{½}$		
TW 13.29	16.22 a	17.17 a	18.23 a	
TW+GM	13.45	15.35 ab	13.02 b	12.33 b
TW+Pressmud	13.83	13.36 b	12.96 b	8.22 c
TW+Poultry manure	11.05	11.11 b	11.74 b	8.96 c
		c) pHs		
TW 8.25	8.28^{NS}	8.33^{NS}	8.78 a	
TW+GM	8.20	8.13	8.21	8.47 b
TW+Pressmud	8.94	8.14	8.11	7.98 c
TW+Poultry manure	8.09	8.18	8.21	8.21 bc

ing crops, pressmud treatment became progressively better compared to the other treatments indicating more residual effects from the pressmud treatment. Pressmud contained enough phosphorus in addition to 3.8% Ca. Since the pH of the saturated paste of pressmud was 6.6 it produced more residual acidity and increased availability of more micronutrient and also that of P. It would therefore suggested that brackish water of varying qualitities can successfully be used for crop production using various organic management strategies.

Plant Tissue Analysis: Rice/wheat grain samples were analysed for their ionic uptakes (Table 5). Sodium as well as chloride uptakes were reduced by the application of manures. Decrease in the ionic concentration of Na can be attributed to the release of Ca from the decomposition of green manures and further the solubilization of native $CaCO_3$ (Gupta *et al.*, 1989; Robbins, 1986). Calcium competes with Na for ion exchange reactions at root-soil interface. Calcium being divalent in nature, possesses a higher affinity than Na for absorption on the plant root surface. Brackish water with higher SAR and RSC reduced the Ca uptake. Suarez & Grieve (1988) reported that as the activity of Na^+ in the substrate increases the system which becomes less discriminating and the selectivity of Ca^{2+} is impaired. Increased root permeability, caused by reduction in the availability of external Ca^{2+} may lead to the increased Cl^{-1} uptake; Cl^{-1} uptake increased in the brackish water treatment.

Soil Characteristics: Soil samples analysed for ECe, SAR and pH determination after the harvest of each crop showed a considerable development in soil salinity/sodicity as a result of brackish water irrigation without the application of any amendment (Table 6). There was less developement in soil sodicity with the application of various manures due to the increase in Ca^{2+} concentration in the soil solution resulting from the decomposition of manures. As a result the permeability of the soil was improved as Na accumulated in the soil profile when the brackish water was leached downward.

References

Ahmad, B., W.D. Kemper, G. Haider and M.A. Niazi. 1979. Use of gypsum to lower the SAR of irrigation water. *Soil Sci. Soc. Am. J.*, 43: 698-702.

Anonymous. 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. USDA Hand Book 60. USDA, Washington, DC.

Anonymous. 1987. *Agricultural Statistics of Pakistan*. Federal Bureau of Statistics. MINFAL, Govt. of the Pakistan, Islamabad.

Aslam, M., R.H. Qureshi, N. Ahmad and S. Muhammad. 1988. Response of rice to salinity shock at various growth stages and type of salinity in rooting medium. *Pak. J. Agri. Sci.*, 25: 199-205.

Aslam, M. and S. Muhammad. 1972. Effect of various nitrogen carriers at various salinity levels. *Pak. J. Sci. Res.*, 24: 244-251.

Ayers, R.S., and D.W. Westcot. 1985. *Water Quality for Agriculture*. FAO irrigation and drainage paper 29. Rev. 1. FAO, Rome.

Bhatti, H.M., M. Yaseen and M. Rashid. 1985. Evaluation of *Sesbania* green manuring in rice-wheat rotation. *Proc. Int. Symp. on Nitrogen and Environment*. Lahore, Pakistan. July 7-12, 1984. 99: 275-284.

Bradford, S., and J. Letey. 1992. Cyclic and blending strategies for using non saline and saline waters for irrigation. *Irrigation Science*, 13: 123-128.

Chaudhry, M.R., M.S. Rafiq, A. Haider and L.A. Shahid. 1985. *Ameliorative effect of gypsum on soil properties and crop yield irrigated with high SAR water*. Mona Rec. Expt. Project. WAPDA, Pub. No. 144: 8-14.

Dieleman, P.J. 1979. *East Khairpur Tile Drainage Project*. Revised Plan Report, WAPDA, South ILACO. 96p.

Ghafoor, A., S. Muhammad and M. Yaqub. 1987. Use of saline-sodic water for reclamation of a salt affected soil and for crop production. *Pak. J. Soil Sci.*, 2: 17-21.

Gupta, R.K., R.R. Singh and I.P. Abrol. 1969. Influence of simultaneous changes in sodicity and pH on the hydraulic conductivity of an alkali soil under rice culture. *Soil Sci.*, 147: 28-33.

Hornick, S.B. and J.F. Parr. 1987. Restoring the productivity of marginal soils with organic amendments. *Amer. J. Alt. Agric.*, 11: 64-68.

Khan, G.S., M.T. Afzal and M. Ikram. 1990.. Quality of groundwater, land form and drainage relationship in semi-arid tract around Lahore (Pakistan)-1. *Pak. J. Soil Sci.*, 5: 25-28.

Maas, E.V. and G.J. Hoffmann. 1977. Crop salt tolerance-current assessment. *J. Irrigation and Drainage Div. Asce*, 103: 115-134.

Qureshi, R.H., M. Hanif, M.I. Rajoka and G.R. Sandhu. 1975. Use of saline sodic waters for crop production. In: *The Optimum Use of Water in Agriculture*, CENTO Sci. Program, Turkey. pp. 123-197.

Ravikoritch, S. and A. Porat. 1967. The effect of nutrients on salt tolerance of crop. *Plant and Soil*, 26: 49-71.

Rhoades, J.D. 1984. Use of saline water for irrigation. *California Agricutlure*, 38: 42-43.

Robbins, C.W. 1986. Sodic calcareous soil reclamation as affected by different amendments and crops. *Agron. J.* 78: 916-920.

Suarez, D.L. and C.M. Grieve. 1988. Predicting cation ratios in corn from saline solution composition. *J. Exp. Bot.*, 39: 605-612.

(Received for publication 24 September, 1995)