Pak. J. Bot., 39(7): 2601-2606, 2007.

EFFECTIVE USE OF BRACKISH WATER ON SALINE-SODIC SOILS FOR RICE AND WHEAT PRODUCTION

SAEED A ABRO*, A. R. MAHAR AND K.H. TALPUR

Department of Botany, Shah Abdul Latif University, Khairpur

Abstract

The majority of ground water pumped through tube-well is brackish and unfit for irrigation. But this water can be utilized on problem soils if amendments are added. A field experiment was carried out to utilize the brackish water with pH 7.7, EC 2.93 dSm^{-1}, TSS 1875, SAR 5.4 on saline-sodic soil with pH 8.28-8.48, ECe 6.28-7.44 dSm^{-1} and SAR 17.25-23.37 in a randomized block design. The five amendments [T1=Brackish water only (control), T2= FYM @10 tons ha^{-1}, T3= RH @10 tons ha^{-1}, T4= FYM+RH @ 5+5 tons ha^{-1} and T5= gypsum100% soil requirements] were applied in rice-wheat cropping system. The effects of brackish water were assessed on the soil properties and on crop growth and yield. The pH remained unaffected by the treatments as well as crops while EC and SAR levels reduced significantly in all treatments after harvest of rice and wheat. ECe slightly increased after wheat harvest. The highest reduction of EC and SAR were found in T5 followed by T4 and T3. The grains $panicle^{-1}$, 1000 grain weight (g) and grain yield ($Kgha^{-1}$) in rice were significantly lowered in T1 (control) while maximum results were found in T5 followed by T2. Similarly, in wheat brackish water (T1) reduced number of grains $spike^{-1}$, 1000 grain weight (g) and grain yield (Kg ha^{-1}), while the maximum plant height and grains $spike^{-1}$ were found in T3 followed by T2 and maximum 1000 grain weight was found in T5 followed by T2 while maximum grain yield was in T5 followed by T4.

Introduction

Pakistan's 17 mha irrigated land forms backbone of the country's agriculture economy (Anon., 2002). About 6.3 mha, particularly in canal command is salt-affected (Khan, 1993) and need a source of calcium for amelioration (Qadir *et al*., 2000; Ghafoor *et al.*, 1998; Shainberg *et al.*, 1989), while rest is facing extreme shortage of water. Consequently the private tube-well installation is increasing and unfortunately 70-75% pumped ground water is unfit for irrigation owing to high EC, SAR and/or RSC which adversely affects the crops (Ghafoor *et al.*, 2001). The use of such water on problem soils can lead to a rapid increase in salt content of plant root zone in arid and semi-arid conditions where evaporation rates are high (Patel *et al*., 2000). This root zone salt build up can be deleterious for crops growing on such soils. Thus the brackish waters must be managed properly before irrigating the fields. There are two major approaches to improve soil health and sustaining crop production in a saline environment modifying the environment to suit the plant and modifying plant to suit the environment (Tyagi, 2003). Both these practices have been used either singly or in combination (Tyagi & Sharma, 2000), but the first approach has been used extensively (Tyagi, 2003). The development of management options requires the analysis of sensitivity parameters that affect interaction between salinity and crop yield (Zeng *et al.*, 2001). Most management approaches aim at keeping root zone salinity level below the threshold level which is variable for different plants (Maas, 1990).

*Current address: Institute of Botany, University of Sindh, Jamshoro, Pakistan.
*E-mail: akhsaeed@gmail.com

For initial reclamation of salt-affected soils, low quality irrigation waters are generally useful and sometimes even better than canal water owing to favourable effect of their electrolytes on soil infiltration rate and hydraulic conductivity (Shainberg & Letey, 1984; Rhoades, 1993). Relatively higher ratios of EC: SAR in such drainage and ground waters have been found to improve water conducting properties of soils which resulted in better and rapid amelioration of saline-sodic soils (Ghafoor *et al.*, 2000, 2001). Generally gypsum is used to replace sodium in saline-sodic soils which have low hydraulic conductivity and hardpan at certain depth in profile (Rehman *et al*., 2002). Along with gypsum and farmyard manure use, salt-tolerant crops can also be grown to manage brackish water on saline sodic soils (Qadir *et al*., 2001). This study was thus carried out to reveal the efficacy of different brackish water management approaches on saline-sodic soils and to assess their effects on the growth and yield of rice and wheat.

Materials and Methods

The experiment was conducted at the experimental site of Shah Abdul Latif University, Khairpur during two successive crop seasons of 2004-05 on saline-sodic silty-loam soil [pH 8.28-8.48, EC 6.28-7.44 dSm^{-1} and SAR 17.23-23.37]. Five soil management treatments were applied in randomized complete block design with four replications. The treatment were:
T1 = Control (No amendment)
T2 = Farm yard manure (FYM in compost formulation) @ 10 t ha^{-1}
T3 = Rice Husk (RH in compost formulation) @ 10 t ha^{-1}
T4 = FYM+RH (in compost formulation) @ 5+5 t ha^{-1}
T5 = Gypsum @ 100% soil requirement.

The farmyard manure and rice husk were selected because of their vast availability in the area and cheaper price. Farmyard manure, rice husk and FYM+RH were separately dumped in 6 m deep ditches for 35 days for decomposition. The ditches were covered with plastic and then clay in order to provide sufficient an-aerobic environment during decomposition process. The amendments were thoroughly mixed in soils 20 days before planting of crop, irrigated twice in order to facilitate initial leaching of salts. The rice variety SARSHAR was sown during Kharif 2004 followed by wheat variety TD1 during fall 2004-05 under rice-wheat crop rotation system. The nitrogen and phosphorus fertilizers were applied @ 168 kg ha^{-1} N and 84 kg ha^{-1} P_2O_5. All the treatments received 5 irrigations of brackish water in wheat [pH 7.7, EC 2.93 dS m^{-1}, TSS 1875, SAR 5.4] while rice received the 1.5” standing water through out its stand.

The soil samples were collected from each treatment after the harvest of rice (before wheat sowing) and after the harvest of wheat (final observation) and analyzed for pH, ECe and SAR according to the procedures given by Richard (1954). The agronomic crop data and soil analysis data were statistically analyzed. Multiple comparisons were made using LSD (least significant difference test) @ 5% probability (Little & Hills, 1978).

Results and Discussion

Growth and yield of rice: The results showed that the use of brackish water without amendments reduced rice growth and yield significantly. All treatments in general and gypsum followed by FYM in particular showed maximum increase in terms of plant height, 1000 grain weight and yield ha^{-1}over control (Table 1). The gypsum showed a maximum increase of 15% in plant height over that of control followed by 11% increase by FYM. The inter-treatment differences were also found significant at 5% probability. Maximum number of grains per panicle was recorded in gypsum followed by RH, giving increases of 30 and 26% respectively. Similarly 1000-grain weight and grain yield were maximum in gypsum treatment resulting in increases of 33 and 61%, respectively, over control. Gypsum was followed by FYM which gave an increase of 13 and 57% in 1000 grain weight and grain yield ha^{-1}, respectively. Gypsum and FYM both have ameliorative effects on the properties of saline-sodic soils resulting in a breaking of hardpan and increasing soil porosity which in turn allows easier root penetration and a better crop growth. Similar results were also reported by Hussain *et al*., (1995). The lower yield and growth in control treatment can be attributed with the minimum decrease in ECe and SAR values. Rehman *et al*., (2002) and Manzoor *et al.*, (2002) also found the positive effects of Gypsum on rice growth and yield although the differences were non-significant perhaps because they used water with high ECe.

Growth and yield of wheat: All the treatments remained equally effective in increasing plant height significantly over control however, there were no significant differences among the treatments. Their effect on increasing number of grains per spike was, however, non significant. The minimum number of grains $spike^{-1}$ was found in gypsum treatment which can be the result of increase in ECe after wheat harvest, coupled with the water table rise during the ear setting period. Grain yield and 1000-grain weight were both increased significantly in all the treatments. Combined use of FYM and RH turned out to be the most effective in improving grain yield whereas gypsum alone out yielded 1000-grain weight than other treatments. The increases in grain yield by the treatment of FYM + RH and 1000-grain weight by gypsum were 23 and 27% respectively over control. Application of manure alone remained 2^{nd} best treatment to improve yield parameters of wheat crop. Singh *et al*., (2002), found 221 $kgha^{-1}$ increased yields over canal water when FYM and gypsum were applied with brackish water. Gomes *et al*., (2000) also found similar results.

Soil properties

Soil pH: A slight increase has been observed in soil pH after the harvest of rice while the same decline occurred after wheat. The possible reason for this increase was the high number of irrigations with brackish water given with little leaching taking place in rice crop (Table 3). However the pH reduced significantly after the harvest of wheat crop (Table 3). Singh *et al*., (2002) found that use of brackish water increased pH considerably even up to the 90 cm soil depth. They also reported the increase in pH during following seasons.

Soil ECe: A drastic decrease in soil ECe was observed after the harvest of rice crop but it slightly increased after the harvest of wheat. The highest decrease was observed in FYM+RH treatment followed by gypsum (Table 3) while lowest decrease was found in control treatment. It is apparent from the finding that even in control treatment ECe decreased rather than increase. This shows that brackish water alone also have ameliorating effects and such waters can be used on for irrigation.

Table 1. Effects of amendments on the growth and yield of rice under brackish irrigation water.

Treatment	Plant height (cm)	Grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg/ha)
Control	80.85	138.31	29.24	6500
FYM @ 10 tons ha^{-1}	89.71	164.40	33.09	10200
RH @ 10 tons ha^{-1}	87.46	174.52	30.36	9000
FYM + RH (each 5 tons ha^{-1})	84.94	163.30	30.60	9300
Gypsum @ 100% GR	93.11	179.64	38.91	10500
Mean	87.21	164.03	32.44	9100
$LSD_{(0.05)}$	1.48	3.09	2.31	1000

Table 2. Effects of amendments on the growth and yield of wheat under brackish irrigation water.

Treatment	Plant height (cm)	Grains spike^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})
Control	68.50	38.50	44.85	3268.75
FYM @ 10 tons ha^{-1}	70.25	44.00	52.62	3987.50
RH @ 10 tons ha^{-1}	70.50	44.50	52.50	3643.75
FYM + RH (each 5 tons ha^{-1})	70.00	43.00	51.35	4206.25
Gypsum @ 100% GR	70.00	37.25	56.97	4262.50
Mean	69.85	42.90	51.66	3873.75
$LSD_{(0.05)}$	1.36	7.09	4.26	154.35

Table 3. Effects of Brackish water on soil pH under different management treatments.

Treatments	pH			EC (dS m^{-1})			SAR		
	Before sowing	After rice	After wheat	Before sowing	After rice	After wheat	Before sowing	After rice	After wheat
T1	8.32	8.48	8.16	6.29	5.49	6.07	17.53	13.20	10.80
T2	8.29	8.48	8.07	7.44	3.12	4.59	20.75	10.14	6.25
T3	8.29	8.37	8.08	7.15	2.96	4.52	18.52	11.11	7.75
T4	8.34	8.44	8.11	7.42	2.67	4.52	20.12	9.27	6.07
T5	8.48	8.38	8.10	7.44	2.93	4.54	10.20	8.20	4.34
Mean	8.34	8.43	8.10	7.15	2.83	4.45	17.42	9.78	6.44
$LSD_{(0.05)}$ for treatment		0.03			0.08			0.17	
$LSD_{(0.05)}$ for crops		0.02			0.05			0.1	

Soil SAR: The soil sodium adsorption ratio (SAR) decreased after rice significantly and this decrease was continuous even after the wheat harvest. The highest decrease was observed in gypsum treatment followed by FYM+RH treatment (Table 3).

Acknowledgments

This work is an output of a national coordinated project on the **"**management of salt affected soils and brackish waters in Pakistan" under ALP (Agriculture Linkage Program) at Shah Abdul Latif University Khairpur (component IV). The authors acknowledge the financial support of the project by Pakistan Agriculture Research Council (PARC), Islamabad.

References

Anonymous. 2002. *Pakistan Statistics year book*. Federal Bureau of statistics, Statistics division, Govt. of Pakistan, Islamabad.

Ghafoor, A., M. Qadir, G. Murtaza and H.R. Ahmad. 1998. Strategies to harvest sustainable rice and wheat yields using brackish water for irrigation. *J. Arid Land Studies*, 7S: 165-169.

Ghafoor, A., M.A. Gill, A. Hassan, G. Murtaza and M. Qadir. 2001. Gypsum: An economical amendment for amelioration of saline-sodic waters and soils for improving crop yields. *Int. J. Agri. and Biol*., 3: 266-275.

Ghafoor, A., M. Rizwan and G. Murtaza. 2000. Utilization of brackish waters for reclaiming different textured saline-sodic soils having different EC_e to SAR ratios. p.121-128. In: *Natl. Seminar on Drainage in Pakistan.* 16-17, 2000, Jamshoro, Hyderabad, Pakistan.

Ghafoor, A., S.M. Nadeem, A. Hassan and M. Sadiq. 2001. Reclamation response of different textured saline-sodic soils to EC_{iw}:SAR_{iw}. *Pak. J. Soil Science*, 19: 92-99.

Gomes, E.M., H.R. Gheyi and S.E.F. Franca. 2000. Improvement in chemical properties of a saline-sodic soil and rice yield under different treatments. *Revista Brasileira de Engenharia Agricola e Ambiental*, 4(3): 355-361.

Hussain, N., G.D. Khan, S.M. Mehdi, G. Sarwar, M.S. Dogar, T. Hussain and F.R. Lamm. 1995. Use of brackish water for sustained crop production. Microirrigation for a changing world: conserving resources-preserving the environment. *Proc. 5th Int'l Micro-irrigation Congress, Orlando, Florida*, USA, 2-6 April. 129-134.

Khan, G.S. 1993. *Characterization and genesis of salt-affected soils in Indus Plains of Pakistan*. Ph.D. Dissertation, Dept. Soil Sci., Univ. Agri., Faisalabad, Pakistan.

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

Maas, E.V. 1990. Crop salt tolerance. In: *Agricultural salinity Assessment and management*. (Ed.): K.K. Tanji. Am. Soc. Civil Engineers. N.Y. pp. 262-304.

Manzoor, M.I., A. Ghafoor, G. Murtaza and M.Z. Rehman. 2002. Use of poor quality tube well water for reclaiming salt-affected soils and growing rice-wheat crops. *Pak. J. Soil Sc*., 21(4): 72-76.

Patel, R.M, S.O. Prasher and R.B. Bonnell. 2000. Effects of water table depth, irrigation water salinity and fertilizer application on root zone salt buildup. *Canadian Agri. Engg*., 42(3): 111-115.

Qadir M., A. Ghafoor and G. Murtaza. 2001. Use of saline-sodic waters through phytoremediation of calcareous saline-sodic soils. *Agri. Water. Manage*., 1647: 1-14.

Qadir, M., A. Ghafoor and G. Murtaza. 2000. Amelioration strategies for saline soils: A review. *Land Degradation and Development*, 11: 501-521.

Rehman, M.Z, A. Ghafoor, G. Murtaza and M.I. Manzoor. 2002. Management of brackish water for reclamation of a saline-sodic soil and rice wheat production. *Pak. J. Soil Sci*., 21(4): 89-94.

Rhoades, J.D. 1993. Practices to control salinity in irrigated soils. p. 379-387. In: *Towards the Rationale Use of High Salinity Tolerant Plants*. (Eds.): H. Lieth and A. Al Masoom. (Vol. 2). Kluwer Academic Pub., The Netherlands.

Richards, L.A. 1954. *Diagnosis and Improvement of Saline and Alkali Soils*. Handbook No. 60. United States Department of Agriculture, Washington DC. pp. 160.

Shainberg, I. and J. Letey. 1984. Response of soils to sodic and saline conditions. *Hilgardia*, 52: 1-57.

Shainberg, I., M.E. Sumner, W.P. Miller, M.P.W. Farina, M.A. Paran and M.A. Few. 1989. Use of gypsum on soils: A review. *Adv. Soil Sci*., 1: 1-11.

Singh, C.J., M.S. Aujla, K.S. Saini, G.S Buttar and J.S. Bras. 2002. Conjuctive use of fresh and salty water in cotton and wheat in South West Punjab. 17^{th} WCSS, 14-21 August 2002, Thailand.

Tyagi, N.K. 2003. Managing saline and alkaline water for high productivity. In: *Water productivity in Agriculture*: *Limits and opportunities for improvement*. (Eds.): W. Kinji, R, Barker and D. Molden. CAB international.

Tyagi, N.K. and D.P. Sharma. 2000. Disposal of drainage water: recycling and reuse. In: *Proc. 8^{th} Int. Dran. Wrksp, New Delhi*, Jan 31^{st} –Feb 4^{th} 2000. Vol. 3. pp. 199-213.

Zaka, M.A., F. Mujeeb, G. Sarwar, N.M. Hassan and G. Hassan. 2003. Agromelioration of saline-sodic soils. *Online J. Biol. Sci*., 3(3): 329-334.

Zeng, L., M.C. Shannon and S.M. Lesch, 2001 Timing of salinity stress affects rice growth and yield components. *Agricultural Water Management*, 48: 191-206.

(Received for publication 14 February 2006)