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USE OF HIGH MAGNESIUM BRACKISH WATER FOR RECLAMATION OF SALINE–SODIC SOIL. 1. SOIL IMPROVEMENT

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To monitor the feasibility of using brackish water for soil reclamation, synthetic brackish waters with Ca:Mg ratios of 4:1, 2:1, 1:1, 1:4 and 1:6 were used to grow wheat and rice crops in pots filled with 10 kg of calcareous sandy loam saline–sodic soil. The results indicated that with equal amount of irrigation water applied to wheat, similar leaching fractions were achieved but were lower than those achieved during rice. Leaching of TSS, Na, Mg, HCO_3 and Cl were higher during rice than those during wheat crop. The soil reclamation was maximum with canal water, while there was less but almost similar soil improvement (EC_e, SAR, pH_s) with brackish water (EC 2 dSm^{-1}, SAR 12, RSC 3 me L^{-1}) having different Ca:Mg ratios.

INTRODUCTION

In Pakistan, 5.7mha of soils are salt–affected, out of which 80% in Punjab are saline–sodic and require application of a Ca–source before putting under plough. Similarly to augment the canal irrigation water, 40 MAF groundwater is pumped annually (NCA, 1987), of which 75% is hazardous (Ahmad and Chaudhry, 1988) according to the classification of US. Salinity Lab. Staff (1954).

The hazardous groundwaters alongwith higher EC and SAR, also contain Mg higher than Ca which progressively increases further as EC and SAR increases. Such a higher Mg in irrigation water has shown increased dispersion/crusting and decreased hydraulic conductivities in normal productive soils (Keren, 1989; Khan, 1975; Girdhar and Yadav, 1980). Of course, the electrolyte concentration (EC) of the irrigation waters will tend to affect a decrease in soil dispeysion and an increase in hydraulic conductivity (Reeve and Doering, 1966; Muhammad *et al.*, 1969). However, almost there is no study where effects of Ca:Mg ratios in brackish irrigation water has been studied on soil properties during its reclamation. On similar grounds, the present preliminary experiment was planned to monitor the feasibility for using high Mg brackish waters for reclaiming saline–sodic soils.

MATERIALS AND METHODS

A bulk sample of a moderately calareous sandy loam saline–sodic soil having gypsum requirement of 5.16 me $loog^{-1}$ (Table 1) was collected from a field near the Khurrianwala town. After passing it through 2mm sieve, 10 kg soil was placed in glazed pots. Canal water @ 3 times

Table 1. Volume of applied water and leachate (L) during wheat and rice irrigated with brackish water having different Ca:Mg ratios

Ca:Mg ratio in water	Wheat Water added*	Wheat Leachate	Wheat LF	Rice Water added	Rice Leachate	Rice LF
4:1	16.5	2.9	0.18	43.1	10.2	0.24
2:1	16.5	3.1	0.19	45.6	11.3	0.25
1:1	16.5	2.7	0.16	38.3	6.9	0.18
1:4	16.5	2.6	0.16	40.9	9.1	0.22
1:6	16.5	2.8	0.17	39.7	9.0	0.23
Canal water	16.5	2.2	0.13	63.5	11.5	0.18

* Include about 7 litre canal water applied as presowing soaking irrigation

of the soil saturation as presowing soaking irrigation was applied. Then wheat cv. LU 26S was planted on Dec. 12, 1988 when the soil was at "watter" condition. Nitrogen, phosphorus and potassium @ 75, 25 and 25 mg kg^{-1} soil were applied as urea, TSP and potassium sulphate. Nitrogen was applied in there equal splits while P and K were basal applied.

Synthetic brackish water (EC 2 dS m^{-1}, SAR 12, SAR_{adj} 14.5, RSC 3 me L^{-1}) was prepared using $NaHCO_3$, NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$ with Cl: SO_4 ratio of 1:1 and Ca:Mg ratios of 4:1, 2:1, 1:1, 1:4 & 1:6 were maintained. These waters were used to grow the crops up to maturity. At harvest, soil samples were drawn and analysed for pH_s, EC_e and soluble ions.

In these pots, rice KS 282 was trans–planted and grown under submerged conditions. The rate of NPK was 100, 75 25 mg kg^{-1} soil. One half N and all the P and K were basal applied. The remaining N was applied in two equal splits, i.e. one month after transplanting and at earing.

During growth of both the crops, leachates were collected, measured and analysed for EC, SAR, CO_3, HCO_3, Cl, Na, Ca and Mg (Page *et al.*, 1982). At harvest, again the soil samples were taken and analysed. The data were analysed statisticaly by the ANOVA technique following CRD (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

During wheat and rice growth, higher leaching fractions (LF) were achieved with synthetic water compared to that with canal water (Table 1) which could be attributed to higher electrolyte concentration in synthetic waters (Reeve and Doering, 1966). The LF remained higher for the Ca:Mg ratios of 4:1 and 2:1 than those for the other waters which reflects beneficial effects of Ca in maintaining better hydraulic conductivity (HC) and /or decreased dispersion comparaed to the Mg (Khan, 1975, Girdhar and Yadav 1980).

Total soluble salts (TSS) removed in leachates remained higher during rice and wheat seasons with the synthetic waters, except Ca:Mg ratio of 1:1 water during wheat, compared to that with the canal water (Table 2). With the higher LF for the synthetic waters, it appears a natural consequence. Removal of Na showed almost a pattern similar to that of the TSS. Amount of Ca decreased while that of Mg increased as the Ca:Mg ratio in the synthetic water decreased but both the cations in leachate were lower for the canal water during wheat and rice seasons. During rice, the higher amount of Mg leached compared to that of Ca indicates some preferential Na–Ca exchange over the Na–Mg exchange in a saline–sodic soil (Paliwal and Gandhi, 1976).

Amounts of HCO_3 and Cl leached during wheat crop were almost similar. During the growth period of rice, leaching of CO_3, HCO_3 and Cl were much higher and treatment differences were also conspicuous compared to those leached during wheat. Higher amount of applied water as well as leaching fraction attained during submergence of rice period might be responsible for these differences.

Soil analyses reveal (Table 3) that EC_e, pH_s and SAR gradually decreased while Ca and Mg increased during the period of studies. By the end of rice harvest, maximum soil improvement took place with canal water. With all the Ca:Mg ratios in brackish water, ECe remained statistically similar but higher than that with canal water. SAR decreased to almost safe levels with statistical differences among the treatments, though higher than the SAR_{adj} (14.5) of the synthetic water at the begining of the experiment. Increased and prevailing concentration of soluble Ca

Table 2. Amount of solutes removed during the growth of wheat and rice as affected by Ca:Mg ratios in brackish irrigation water

	Wheat						Rice						
Ca:Mg ratio in water	TSS	Na	Ca	Mg	HCO_3	Cl	TSS	Na	Ca	Mg	CO_3	HCO_3	Cl
	(me treatment^{-1})												
4:1	660	618	22	6	4.2	86	840	751	23	60	59	82	226
2:1	692	644	25	8	4.4	90	908	804	25	73	54	135	211
1:1	664	611	22	8	4.3	85	685	623	9	48	83	155	303
1:4	634	589	19	9	4.1	80	970	880	12	72	75	172	280
1:6	703	649	21	10	4.3	85	958	872	12	68	65	177	291
Canal water	658	596	19	6	4.2	83	429	395	17	56	47	124	57

* CO_3 were in traces and has been combined with HCO_3

me treatment^{-1} = $\frac{\text{meL}^{-1} \times \text{vol. of leachate}}{1000}$

Table 3. Soil characteristics after wheat and rice irrigated with brackish water having different Ca:Mg ratios

Ca:Mg ratio in water	pHs	ECe (dsm^{-1})	SAR	Ca	Mg	Na
				------- ($me\ L^{-1}$)	---------------	
Original soil*	8.6	21.0	183.2	2.7	1.3	261.9
			Post wheat			
4:1	8.2	12.5	59.7	7.3 a	3.5 cd	138.9
2:1	8.2	12.8	61.3	6.6 ab	4.5 c	143.9
1:1	8.3	14.5	68.5	6.0 ab	5.8 bc	166.6
1:4	8.2	13.9	64.9	4.2 cd	7.8 ab	158.8
1:6	8.3	14.3	66.3	3.4 d	8.7 a	163.7
Canal water	8.3	13.0	77.2	5.5 bc	1.9 d	148.5
SE	1.13^{NS}	0.04^{NS}	4.64^{NS}	0.50^{*}	0.71^{*}	15.34^{NS}
			Post rice			
4:1	8.2	7.4 a	15.1 ab	10.5	9.8	47.7 b
2:1	8.3	7.6 a	12.2 b	14.2	12.4	44.2 b
1:1	8.4	9.2 a	19.4 a	8.5	12.6	63.0 a
1:4	8.3	7.4 a	13.0 b	11.9	13.8	46.4 b
1:6	8,3	7.5 a	14.5 b	10.1	15.6	50.7 ab
Canal water	8.2	3.7 b	5.3 c	10.8	8.3	16.4 c
SE	0.12^{NS}	0.57^{*}	1.43^{*}	1.65^{NS}	$1.86^{N.S}$	4.67^{*}

$$SAR = Na \sqrt{\frac{Ca + Mg}{2}}$$

and Mg (each > 8 me L^{-1}) appears to be sufficient to counteract the adverse effects of soil SAR on soil perperties. However, EC_e values are still higher, but less than the levels where 50% yield reduction of agricultural crops can occur (Rhoades and Loveday, 1990). Indirectly, this higher ECe appears useful for further decreasing SAR through maintaining soil hydraulic conductivity. However, because of coarse texture, the soil was easy to reclaim and practically has happened so.

The results of this preliminary experiment has demonstrated a feasibility for using brackish water with Ca:Mg ratios from 4:1 to 1:6 for reclaiming course textured saline–sodic soils.

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