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EFFICIENCY OF Ca CONCENTRATION IN IRRIGATION WATER FOR RECLAMATION OF A SALINE-SODIC SOIL

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In PVC pipes (40 x 5 cm), 30 cm columns using silt loam soil samples were prepared and bulk density of 1.35 g cm^{-3} was achieved. Canal water (control) and Ca concentrations of 6, 10 and 14 me L^{-1} were created in canal water by dissolving $CaSO_4.2H_2O$ equivalent to 100% GR of 3.5 kg soil, filled in each PVC pipe. The columns were leached under submergence and leachates collected at different times, and post-experiment soil samples were analysed. The results showed that leaching with canal water and Ca concentration of 6 me L^{-1} practically stopped after the second leachate. However, with 10 and 14 me Ca L^{-1}, the volume of leachate, removal of TSS, Ca, Na and Mg (me 24 hr^{-1}) increased with time. All the treatments lowered EC_e and pHs to safe limits while the SAR decreased with Ca addition only. However, SAR values were slightly higher in the lower half of the columns than the upper ones. The Ca concentration of 10 me L^{-1} appeared optimum for the reclamation of this soil.

INTRODUCTION

The soils of Pakistan have lower CEC because of the dominance of illite type clay minerals (Ranjha, 1988; McNeal, 1966) and low organic matter. As a result, Na-Ca exchange might take place at a slower rate (Bear, 1964). Hence, high amounts of soluble Ca may not cause a proportional increase in the Na-Ca exchange in the native saline-sodic soils during their reclamation and the unreacted Ca might get leached below the amendment receiving soil depth (Ghafoor *et al.*, 1988).

Gypsum has been proved to be the cheapest source of Ca to reclaim sodic soils (Ghafoor *et al.*, 1985 a, b; Hoffman, 1986). However, major objection is of its low solubility, soluble Ca seldom exceeds 15 me L^{-1} for -100 mesh agricultural grade soil-applied gypsum (Rhoades, 1982). It appears that gypsum coarser than 100 mesh probably will not create Ca concentration of 15 me L^{-1} in soil solution but will be cost-effective since grinding to finer grades is an expenditure incurring process. The present study was planned to determined the threshold concentration of Ca in soil solution for optimum Na-Ca exchange during reclamation of sodic soils.

MATERIALS AND METHODS

In PVC pipes (40 x 5 cm), 30 cm soil columns were prepared using 3.5 kg silt loam soil sample (pHs 8.5, EC_e 16.0 dS m^{-1}, SAR 32.6, ESP 30.1, lime 15.7%, OM 0.6%). By taping the soil-filled pipes, bulk density of 1.35 g cm^{-3} was achieved. There was a hole at bottom of each pipe for drainage. The holes were covered with glass wool and sand to avoid the clay removal.

Gypsum powder @ 100% soil GR was dissolved in canal water (EC = 0.4 dS m^{-1}, SAR = 2.0, Ca = 1.25 me L^{-1}, Mg = 0.95 me L^{-1}) to achieve Ca concentrations of 6,

Table 1. Post-experimental soil saturation extract analysis

Soil characteristics		Ca (me L^{-1}) in irrigation water			
		1.25	6	10	14
		0-15 cm soil column			
pHs		8.4 a	8.1 ab	8.1 ab	7.9 bc
EC_e	(dS m^{-1})	2.6 a	2.4 a	2.2 a	2.1 a
Ca^{2+}	(me L^{-1})	2.6 b	3.4 b	3.2 b	10.2 a
Mg^{2+}	(")	1.6 b	1.4 b	1.4 b	2.7 a
Na^{+}	(")	20.5 a	19.5 a	10.9 b	7.4 b
HCO_3^-	(")	11.7 a	10.7 ab	9.8 b	9.3 b
Cl^-	(")	8.5 a	9.3 a	7.0 ab	4.2 b
SAR	-	14.1 a	12.6 ab	10.5 b	2.9 c
		15-30 cm soil column			
pHs		8.2 a	8.1 a	8.1 a	8.1 a
EC_e	(dS m^{-1})	2.7 a	2.4 ab	2.4 ab	2.2 b
Ca^{2+}	(me L^{-1})	4.3 a	5.6 a	5.5 a	5.6 a
Mg^{2+}	(")	2.5 a	2.2 a	2.5 a	2.1 a
Na^{+}	(")	18.8 a	18.9 a	15.0 ab	14.6 b
HCO_3^-	(")	10.7 a	11.0 a	10.3 a	7.7 b
Cl^-	(")	9.8 ab	10.7 a	10.8 a	8.7 b
SAR	-	18.6 a	19.6 a	17.5 a	7.4 b

Figures sharing the same letter(s) in a row differ statistically at P = 0.05.

10 and 14 me L^{-1} (T_2, T_3 and T_4, respectively) while canal water (T_1) served as the control. The calculated amounts of water with designed Ca concentrations were applied to leach the columns under submergence. The leachates were collected, measured and analysed for EC, soluble Na, Ca, Mg, CO_3, HCO_3 and Cl (Page *et al.*, 1982). Then removal of solutes was computed per unit time. After termination of the experiment, columns were divided into 0-15 and 15-30 cm sections for soil analyses according to the methods of Page *et al.* (1982). The data collected were subjected to statistical treatment (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The volume of leachate (ml 24 hr^{-1}) decreased in the first two leachates, thereafter practically stopped with T_1 and T_2 (Fig. 1) perhaps due to more removal of soluble salts and dispersion of soil (Arora and Singh, 1980). For the other treatments, rate of leaching gradually increased but pattern of increase was similar throughout the studies to that observed at the beginning of the experiment. However, the increase was more for Ca concentration of 14 me L^{-1} than that with 10 me L^{-1} concentration; this was perhaps due to solute concentration of water (Agassi *et al.*, 1981) and favourable

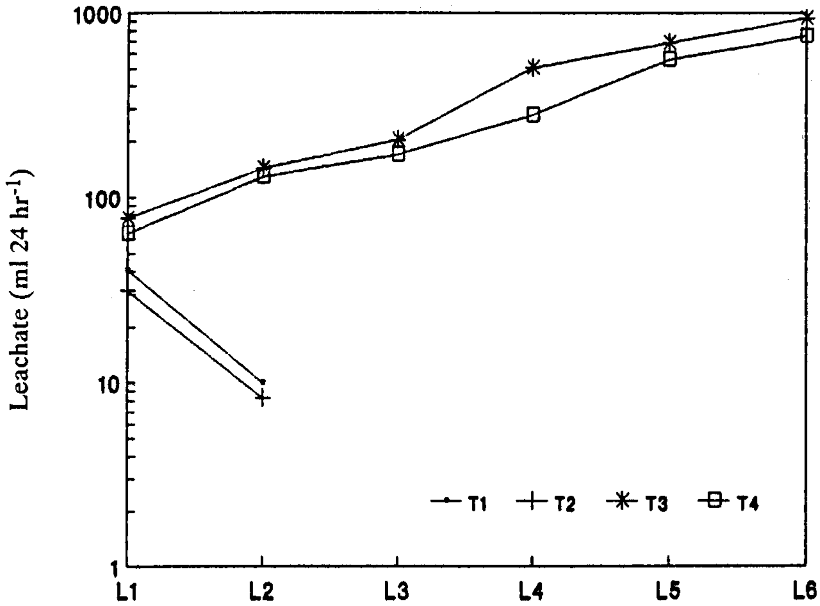

Fig. 1. Volume of leachate during soil reclamation using water with different Ca concentrations.

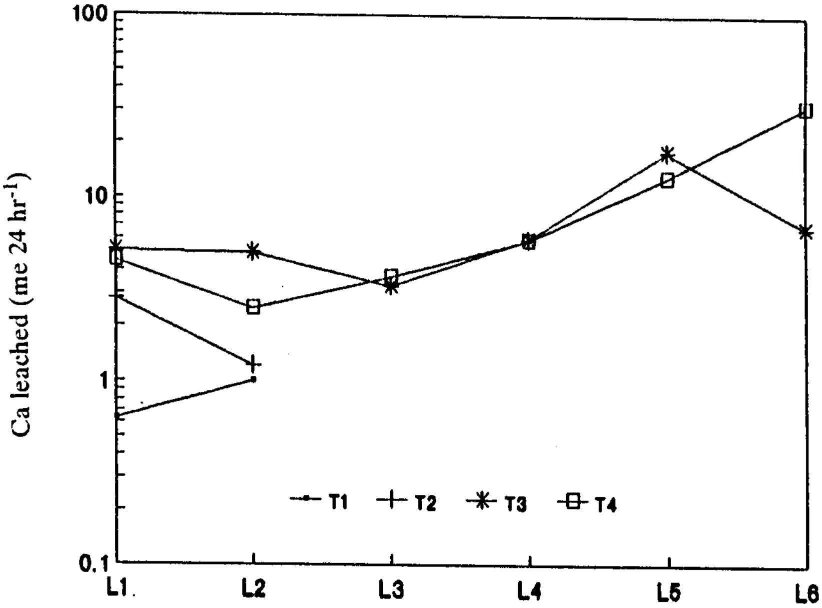

Fig. 2. Removal of Ca in leachate (me 24 hr^{-1}) during soil reclamation using water with different Ca concentrations.

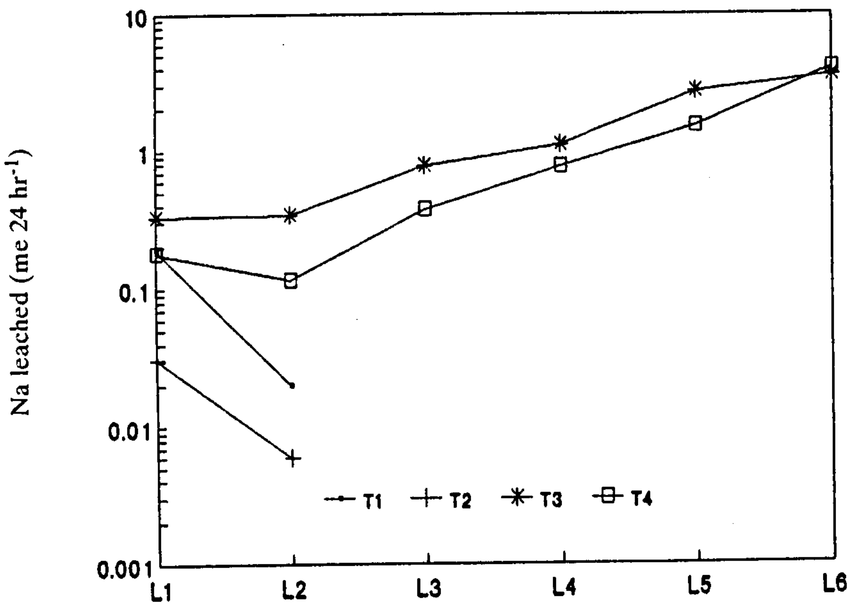

Fig. 3. Removal of Na in leachate (me 24 hr^{-1}) during soil reclamation using water with different Ca concentrations.

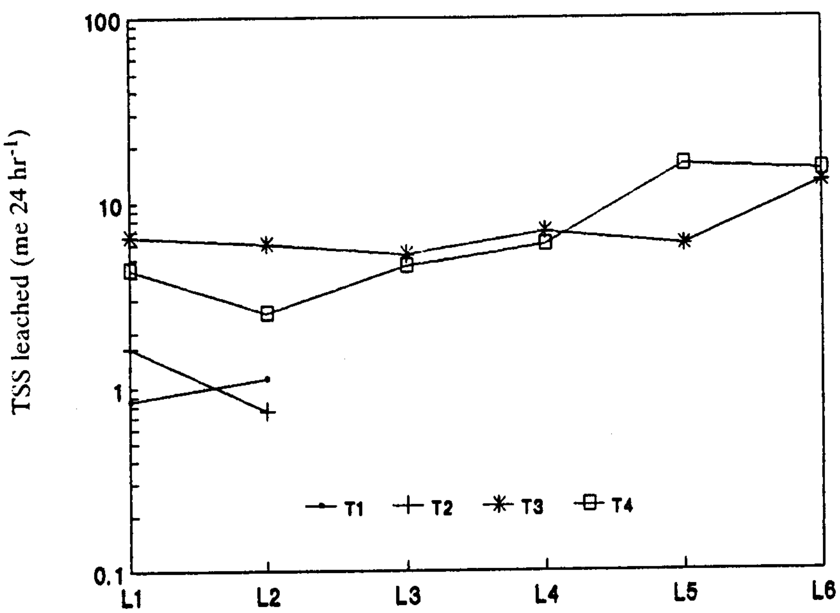

Fig. 4. Removal of TSS in leachate (me 24 hr^{-1}) during soil reclamation using water with different Ca concentrations.

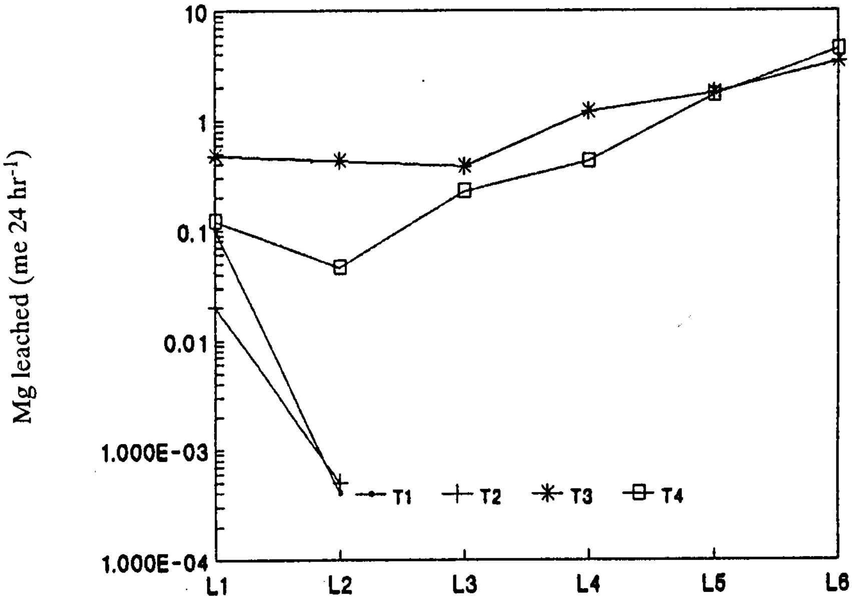

Fig. 5. Removal of Mg in leachate (me 24 hr^{-1}) during soil reclamation using water with different Ca concentrations.

effect of Ca on soil permeability (Oster *et al.*, 1980). In general, the rate of water passage through the soil columns was low for which compaction method could be held responsible, i.e. it could be expected that during taping of the columns to achieve uniform bulk density, the bottom portion of soil was compacted more than the upper part. This aspect needs further studies.

Up to the second leachate, most of the Ca in the irrigation water was consumed in Na-Ca exchange (Fig. 2). Later on, there was slight increase in Ca leached with T_3 and T_4 perhaps due to partial decrease in exchangeable Na and also due to potentially low rate of Na-Ca exchange (Bear, 1964). However, the rate of leaching of Na perpetually increased as the Ca concentration increased (Fig. 3). Although with T_1 and T_2 treatments, the leaching stopped after collecting the second leachate, yet the Na removal decreased by that time. The removal of total soluble salts (TSS) was almost similar up to the collection time of the fourth leachate with T_3 and T_4 (Fig. 4) but there was a slight increase afterwards. The rate of Mg leaching decreased with T_1 and T_2 treatments (Fig. 5). For T_3 and T_4 treatments, it first decreased up to the time of the third leachate collection and then increased. This could be attributed to higher adsorption affinity of Ca than that of Mg by the soil exchange complex (Bohn *et al.*, 1985).

The EC_e of the post-experiment soil decreased to safe levels with all the treatments and the treatment differences remained statistically similar (Table 1) which is in accordance to the leaching rate of TSS (Fig. 4). However, pHs decreased significantly as the Ca concentration in irrigation water increased from 1.25 to 14.0 me L^{-1}. Similarly, SAR also decreased below the critical limit, treatment differences being significant. The decrease in SAR of the control and partially in T_2 treatment pots could be attributed to valence dilution (Eaton and Sokoloff, 1935). Almost similar was the pattern in soil improvement at lower depth of the soil columns.

From the results, it could be inferred that Ca concentration of about 10 me L^{-1} is optimum for reclaiming medium textured sodic soils. This much concentration of Ca can be achieved from coarse grades of gypsum (Ghafoor *et al.*, 1988) for cost-effective soil reclamation of native sodic soils.

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