Paper No . 518

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ABBREVIATIONS USED IN THIS PAPER

Parts per million	(ppm)
Total dissolved salts	(TDS)
Sodium adsorption ratio	(SAR)
Electrical conductivity of saturation extract	(ECe)
Desi-siemens per meter	(dS/m)
Gypsum requirement	(GR)
Farm yard manure	(FYM)
Hectare	(ha)
Sesbainia aculeata	(S. aculeata)
Residual sodium carbonate	(RSC)
Milli-equivalent per litre	(me/1)
Exchangeable sodium percentage	(ESP)
Nitrogen	(N)
Phosphorus	(P)
Potassium	(K)
Sodium	(Na)
Calcium	(Ca)
Magnesium	(Mg)
Carbonates	(CO_3)
Bicarbonates	(HCO_3)
Chlorides	(Cl)
Sulphates	(SO_4)
Least significant differences	(LSD)
Coefficient of variation	(C.V)
Mean	(X)

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ABSTRACT

The effect of brackish water (2050 ppm, TDS and 11.3 SAR) was studied on saline-sodic soil having pH, ECe and SAR of upper 15cm depth in range of 8.3 - 9.0, 9.2 - 11.5 (dS/m) and 20.4 - 37.0 respectively. Treatments tried were: i. Simple leaching, ii. Gypsum @ 50% GR III. Gypsum @ 25% GR IV. FYM @ 50 tons/ha V. Pressmud @ 50 tons/ha and vi. Green manuring with jantar (S.Aculeata). Rice-berseem-rice-wheat crop rotation (rice 1984 to wheat 1986-87) was followed with 120:60:30 kg/ha NPK dose of fertilizers.

Sodium absorption ratio and Electrical conductivity of upper 15cm soil layer was significantly reduced in treated plots and brought within safe limits after Ist and IInd rice crops respectively. In the lower depths the ECe and SAR was also reduced considerably within the same time period although maximum reduction was observed after first rice crop. Paddy and wheat grain yields were also affected significantly by different treatments. Maximum yield of paddy, berseem fodder and wheat grain was observed with gypsum application @ 50% GR. Considering the reclamation effect and crop yields efficiency of different treatments was in the order of:- gypsum @ 50% GR> pressmud @ 50 tons/ha.>FYM @ 50 tons/ha> green manuring with jantar> gypsum @ 25% GR> simple leaching with saline water. It is clear from the results that water having 2050 ppm, TDS and SAR 11.3 can be safely used for reclamation of moderately affected saline sodic medium textured soil and production of rice, berseem and wheat crops. Application of chemical amendments at the initial stages is preferable.

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INTRODUCTION

Agriculture continues to be the mainstay of Pakistan economy but crop yields are much below the potential of the area. Soil salinity and sodicity and shortage of good quality irrigation water are some of the factors causing yield reductions. Due to shortage of good quality water, it is not possible to spare it for reclamation of salt affected soils which extensively occur all over the irrigated area. Poor quality ground water can however be made available for irrigation to bring salt affected soils under production.In order to study the effect of poor quality water on soil reclamation and crop production by using different amendments this piece of research has been conducted. Good land and good quality water being limited to meet the ever increasing requirements of agricultural products, this type of research is gaining importance with passage of time.

REVIEW OF LITERATURE

Gallatin et al. (1963) reported the use of brackish water (1000-6000, micromhos/cm) for five years without harmful effects on plant growth.

Kaddah and Ghowail (1964) revealed that grain yield of corn was greatly reduced by irrigation with water having 1500,3000, 6000 and 9000 ppm of salts.

Haider and Farooqi (1972) reported that potentially hazardous tubewell water with SAR ranging between 10-14 can be used successfully if application of gypsum is made to the soil to be irrigated by such waters.

Halim (1972) found no significant yield decrease of corn stover or grain and pinto beans by using irrigation water, having salinity upto 4000 micromhos/cm.

Qayuum (1973) observed that germination of maize was affected significantly by the saline/sodic water having TDS and SAR less than 1500 ppm and 20 respectively. He further observed that soil salinity was increased with the increase of water salinity.

Haider et al. (1975) reported that ground water having salinity upto 2600 ppm TDS can be used successfully for growing wheat crop provided the SAR is less than 4 and RSC zero me/l.

Chaudhry, et al. (1983) tried four water salinity levels of 736, 1056, 1408 and 2039 ppm TDS on fine and coarse textured soils and found that soil salinity was increased significantly with the use of 2039 ppm TDS water in fine textured soil. Wheat yield was also affected more seriously in fine textured soil by water salinity as compared with coarse textured soil.

Chaudhry et al. (1984) found no significant effects of salinity on the ECe, SAR and crop yeild. However there was 7,5,13 percent decrease in wheat and 8,11 and 17 percent decrease in paddy yield with the increase of water salinity levels from 736 to 1056, 1408 and 2000 ppm TDS respectively.

Chaudhry et al. (1985) used irrigation water having 1728 ppm, TDS 1803 SAR and 3.4 me/l RSC on wheat (1980-81 to 1983-84) and found considerable increase in the ECe and SAR of soil in control plots as compared with gypsum treated plots. Yield was increased with the application of gypsum but in general a decreasing trend in wheat and paddy yield was observed with the passage of time and,on an average, the highest and the lowest decrease was observed in control and 100% gypsum treated plots respectively.

Ahmad et al. (1986) reported promising growth of several plant species through saline water irrigation after chemical amendments. All the tested species exibited a reduction, both in vegetative growth and other biochemical constituents, yet these reductions were under permissible limits in terms of their use for forge, fodder and fuel purposes under arid and semi arid conditions. Khan et al. (1986) concluded that highly saline waters could be used to lower salinity of the saline sodic soils of even low permeability provided they are kept constantly moist (near field capacity) but the use of suitable soil amendment is essential to minimize sodium hazard.

Ghafoor et al. (1987) used saline sodic water for reclamation and crop production after passing it through 183 m long water course lined with gypsum stones and found a significant decrease in soluble salts and SAR of soil due to different treatments, the decrease being more for the 0-15cm as compared to the 15-30cm depths. The reclamation efficiency was in the order of subsoiling +

gypsum, subsoiling, control. Gypsum gave the highest net income which was however only slightly higher than that obtained with sub soiling alone or the control.

Akhtar et al. (1988) reported improvement in physico-chemical characteristics of saline sodic soil profile as a result of growing highly salt tolerant plant "kallargrass" using brackish water. Soil pH, EC,ESP and SAR decreased while hydraulic permeability, SP and water storage capacity increased after growing the grass.

MATERIAL AND METHODS

The study was carried out in 0.4 hectare saline sodic, silty clay loam soil having pH, ECe and SAR between 8.3 to 9.0, 9.2 to 11.5 (ds/m) and 20.4 to 37.0 respectively in the command of tubeweell MN-42 from Kharif, 1984 to Rabi 1986-87. Following treatments were tried:

T_1 Simple leaching (Kharif, 1984 to Kharif 1985) (Wheat-rice-wheat)

T_2 Gypsum @ 50% GR. (Rice-Berseem-rice-wheat-rice-wheat)

T_3 Gypsum @ 25% GR. -do-

T_4 FYM @ 50 tons/ha. -do-

T_5 Pressmud @ 50 tons/ha. -do-

T_6 Green manuring with Jantar -do-

The field was properly levelled and divided into 18 equal plots. The treatments were allocated randomly and all the amendments were applied at the start of the experiment. Amendments were mixed in the upper soil layer by ploughing and planking. Rice-berseem-rice-wheat crop rotation was followed and tubewell water having 2050 ppm TDS and 11.3 SAR was used for irrigation purposes throughout the experiment.Recommended dose of NPK fertilizers were applied to each crop. The crop yield was estimated on whole plot basis. The soil samples were collected before and after harvesting of each crop from 10 randomly selected points from each plot and analysed for ECe and SAR.

RESULTS AND DISCUSSION

Tubewell water having 2050 ppm TDS and 11.3 SAR was used for reclamation of moderately affected, saline sodic soil and production of rice-berseem, rice-wheat crops. The objective was to study the impact of this quality water or reclamation of silty clay loam soil and crop production as influenced by different treatments. The results concerning these para-meters are discussed as under:

1. Soil Reclamation

i) Electrical Conductivity (ECe) of Soil

a) 0-15cm depth:

The results depicted in Table-3 show that ECe was considerably reduced in all treatments including simple leaching after the first rice crop. There was slight increase after the next crop i.e. berseem probably because the upward movement of salts was intensified due to lesser delta of irrigation. After the 2nd rice crop ECe was brought within safe limits for all treatments except (i) simple leaching and (ii) gypsum application @ 50% gypsum requirement. After wheat which was the 4th crop in succession ECe was brought within safe limits for all treatments except simple leaching. Subsequently ECe was also brought within safe limits for this treatment. In the third year of experimentation the ECe fluctuated a little bit in all treatments but the differences remained statistically insignificant. In treated plots reduction in ECe was significant compared with control but the treatments among

themselves were non-significantly different.

b) 15-30 cm depth:

The reduction in ECe show the same trend (Table-4) as reported for O-15cm soil depth. Reclamation of this depth was quite fast as the water could pass through it without any hinderance while dissolving the excess soluble salts for leaching to lower depths. Press mud application @ 50 tons/ha. produced the best results but these were not significantly different from other treatments. Simple leaching was however observed as the poorest treatment which was significantly different from all other treatments.

c) 30-90cm depth

The soil being permeable, reclamation of this depth was also quite rapid and comparable with the surface layers (Table-5). The reduction in ECe after the first rice crop was drastic but later reductions were statistically insignificant. The treatment effect was also insignificant although simple leaching and green manuring treatments were observed to be inferior to rest of the treatments.

The results for 0-15, 15-30 and 30-90cm soil depths discussed above show that medium textured, moderately affected saline-sodic soil can be reclaimed by using water having 2050 ppm TDS and 11.3 SAR by following rice-berseem-rice-wheat rotation. When rice is planted as the first crop the speed of reclamation is very rapid and crop production can be done on regular basis without leaving the land fallow. Application of gypsum, farm yard manure and press mud are preferable to achieve better results. Similar results have been reported by Khan et al. (1986), Ghafoor et al (1987) and Akhtar et al. (1988).

ii) Sodium Adsorption Ratio (SAR) of Soil

a) 0-15cm depth:

The treatment effect is highly significant compared with simple leaching but treatments did not differ significantly among themselves (Table-6). SAR was lowered to safe limits after the first rice crop in all treatments except simple leaching which took another crop season. Rate of reduction in SAR upto the second rice crop was significant but later reductions were insignificant.

b) 15-30cm depth:

The reduction in SAR shows similar trend as for the upper layer and these reductions were significant upto 2nd rice crop (Table-7). Later reductions were insignificant. Simple leaching was significantly inferior to other treatments. Reclamation effect was rapid because of good permeability of the soil and better drainage conditions.

c) 30-90cm depth:

Like upper soil depths, SAR reduction for this soil layer was rapid due to good permeable conditions (Table-8). SAR was brought down within safe limits after the first rice crop. Further reductions continued with passage of time but those were observed to be insignificant. The treatmental differences were totally insignificant.

Moderately affected saline sodic medium textured soil can be fully reclaimed by using water having 2050 ppm TDS and 11.3 SAR by following rice-berseem-rice-wheat crop rotation. With the passage of time there is improvement in soil as SAR reduction continues and there is no risk of build up of sodicity. Results are in agreement with those reported by Khan et al. (1986), Ghafoor et al. (1987) and Akhtar et al. (1988).

2. Crop Yield

i) Paddy:

Results presented in Table-9 show that paddy yield was improved in the 2nd year for all the treatments except simple leaching which was kept fallow. Contrary to soil improvement the paddy yield for all treatments was recorded to be lower for the 3rd year but that was mainly because of the dry weather conditions prevailing during that year. It is added that rice production in the project area was affected by weather conditions hence the experimental plots were not different. The paddy yield for various treatments was however low due to the reason that water could not be kept standing due to highly permeable nature of the soil. The yields produced by gypsum application @ 50% gypsum requirement and presumed @ 50 tons per ha. were the highest and significantly better than the other treatments.

ii) Berseem:

The highest green fodder yield of berseem was produced by gypsum

application @ 50% gypsum requirement followed by application of FYM @ 50 tons/ha. yields were much lower for rest of the treatments (Table-10).

iii) Wheat:

Wheat yield for two crop seasons and the statistical analysis reported in Table-11 indicate non significant effect of treatments. On average basis, significant reduction occured during the second crop season mainly because of damage by hailstorm at maturity. However gypsum application @ 50% gypsum requirement produced the highest yield which was followed by pressmud application @ 50 tons/ha.

When the effect on yield of the three crops is compared, gypsum application @ 50 tons gypsum requirement appears to be more responsive. The results also show the advantages of application of lower dose of gypsum (25% gypsum requirement), green manuring, FYM and pressmud over simple leaching. The results are in consonance with those reported by Gallatin et al (1963), Haider and Farooqi (1972) and Haider et al. (1975).

CONCLUSIONS

Moderately affected saline sodic silty clay loam soil can be fully reclaimed by using irrigation water having 2050 ppm TDS, 11.3 SAR by following rice-berseem-rice-wheat crop rotation. Application of gypsum @ 50% GR is considered a better treatment although gypsum @ 25% GR., FYM @ 50 tons/ha, pressmud @ 50 tons/ha. and green manuring can also be tried.

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TABLE:1

PHYSICO-CHEMICAL PROPERTIES OF SOIL

A. PHYSICAL

Sand %	Silt %	Clay %	Textural Class
35	52	13	Silty clay loam

B. CHEMICAL

Depth (cm)	ECe (dS/m)	SAR	pH
0 - 15	9.22 - 11.5	20.35 - 37.04	8.3 - 9.0
15 - 30	9.00 - 13.67	18.87 - 28.82	8.4 - 9.2
30 - 90	12.00 - 36.00	24.25 - 80.10	8.35 - 9.30

TABLE:2

COMPOSITION OF TUBEWELL WATER (TUBEWELL MN-42)

TDS	SAR	RSC	Na	Ca+Ng	CO_3	HCO_3	C1	SO_4
ppm			me/1			me/1		
2050	11.3	0.0	23.4	8.6	0.0	16.0	14.0	2.0

TABLE:3

EFFECT OF BRACKISH WATER ON ECe (dS/m) OF SALINE SODIC SOIL

(0-15cm)

Treatments	Initial	Post Rice 1984 S_1	Post Berseem 1984-85 S_2	Post Rice 1985 S_3	Post Wheat 1985-86 S_4	Post Rice 1986 S_5	Post Wheat 1986-87 S_6	Average (S_1 to S_6)
T_1 Simple leaching with saline water	10.33	7.45	8.55	6.30	5.86	2.17	2.50	5.47 (a)
T_2 Gypsum @ 50% GR	11.50	4.00	5.28	4.83	2.10	1.93	1.50	3.32 (b)
T_3 Gypsum @ 25% GR.	9.22	4.81	5.37	3.30	2.47	2.37	2.00	3.39 (b)
T_4 FYM @ 50 tons/ha.	10.17	4.91	5.25	3.13	2.33	2.13	2.20	3.35 (b)
T_5 Pressmud @ 50 tons/ha.	11.33	5.21	5.40	3.83	2.60	2.47	3.00	3.75 (b)
T_6 Green manuring with Jantar	10.83	5.67	6.18	3.33	2.70	2.36	2.40	3.77 (b)
Average:	10.56	5.34 (a)	6.01 (a)	4.12 (b)	3.01 (bc)	2.24 (c)	2.32 (c)	

LSD (Treatments)1% = 1.178

LSD (Samplings) 1% = 1.178

TABLE:4

EFFECT OF BRACKISH WATER ON ECe (dS/m) of SALINE SODIC SOIL

(15-30cm)

Treatments	Initial	Post Rice 1984 S_1	Post Berseem 1984-85 S_2	Post Rice 1985 S_3	Post Wheat 1985-86 S_4	Post Rice 1986 S_5	Post Wheat 1986-87 S_6	Average (S1 to S6)
T1 Simple leaching with saline water	9.67	6.90	7.63	5.40	4.63	3.77	4.20	5.42 (a)
T2 Gypsum @ 50% GR.	9.83	3.95	5.13	4.86	3.83	3.70	2.50	3.99 (b)
T3 Gypsum @ 25 % GR.	9.00	4.07	5.37	3.77	5.50	3.20	3.20	4.19 (b)
T4 FYM @ 50 tons/ha.	13.67	4.03	5.60	3.60	4.07	3.60	3.50	4.07 (b)
T5 Pressmud @ 50 tons/ha.	12.67	3.93	5.80	3.97	3.10	3.05	3.10	3.83 (b)
T6 Green manuring with jantar	13.00	4.40	5.60	3.83	4.00	2.90	3.20	3.99 (b)
Average:	11.31	4.55 (b)	5.86 (a)	4.24 (bc)	4.19 (bc)	3.37 (c)	3.28 (c)	

LSD (Treatments) 1 % = 1.033

LSD (Samplings) 1 % = 1.033

TABLE:5

EFFECT OF BRACKISH WATER ON ECe (dS/m) OF SALINE SODIC SOIL

(30-90cm)

Treatments	Initial	Post Rice 1984 S_1	Post Berseem 1984-85 S_2	Post Rice 1985 S_3	Post Wheat 1985-86 S_4	Post Rice 1986 S_5	Post Wheat 1986-87 S_6	Average (S_1 to S_6)
T1 Simple leaching with saline water	12.25	4.06	4.64	4.83	4.08	3.93	4.30	4.31
T2 Gypsum @ 50 % GR.	12.08	3.75	4.71	4.10	3.81	3.85	3.40	3.94
T3 Gypsum @ 25 % GR.	12.08	3.96	4.85	3.61	4.25	3.53	3.65	3.98
T4 FYM @ 50 tons/ha.	18.65	3.96	4.73	3.00	4.21	3.09	3.85	3.81
T5 Pressmud @ 50 tons/ha.	28.33	3.64	5.24	3.69	4.20	3.43	3.75	3.99
T6 Green manuring with jantar	36.00	5.23	4.79	3.66	3.95	3.48	3.90	4.17
Average:	19.90	4.10 (b)	4.83 (a)	3.82 (b)	4.08 (b)	3.55 (b)	3.81 (b)	

LSD (Samplings) 1 % = 0.631

TABLE:6

EFFECT OF BRACKISH WATER ON SAR OF SALINE SODIC SOIL

(0-15 cm)

Treatments	Initial	Post Rice 1984 S_1	Post Berseem 1984-85 S_2	Post Rice 1985 S_3	Post Wheat 1985-86 S_4	Post Rice 1986 S_5	Post Wheat 1986-87 S_6	Average (S_1 to S_6)
T1 Simple leaching with saline water	26.32	16.66	12.08	10.73	9.79	9.00	8.41	11.11(a)
T2 Gypsum @ 50 % GR.	24.45	7.80	5.69	4.50	4.37	4.18	3.57	5.02 (b)
T3 Gypsum @ 25 % GR.	24.51	8.46	6.24	5.73	4.39	4.37	3.78	5.49 (b)
T4 FYM @ 50 tons/ha.	20.35	8.89	7.25	6.73	4.46	4.41	4.51	6.04 (b)
T5 Pressmud @ 50 tons/ha.	21.32	6.49	7.41	6.33	4.60	4.34	4.16	5.56 (b)
T6 Green manuring with jantar	37.04	9.10	6.63	6.50	4.04	3.79	3.90	5.66 (b)
Average:	25.67	9.57 (a)	7.55 (b)	6.75 (b)	5.28 (c)	5.02 (c)	4.72 (c)	

LSD (Treatments) 1 % = 1.318

LSD (Samplings) 1 % = 1.318

TABLE:7

EFFECT OF BRACKISH WATER ON SAR OF SALINE SODIC SOIL

(15-30cm)

Treatments	Initial	Post Rice 1984 S_1	Post Berseem 1984-85 S_2	Post Rice 1985 S_3	Post Wheat 1985-86 S_4	Post Rice 1986 S_5	Post Wheat 1986-87 S_6	Average (S_1 to S_6)
T1 Simple leaching with saline water.	21.10	16.30	10.95	7.07	6.80	6.65	7.03	9.13 (a)
T2 Gypsum @ 50 % GR.	21.34	6.63	5.64	4.17	4.10	4.00	3.26	4.63 (b)
T3 Gypsum @ 25 % GR.	18.87	5.39	5.05	4.80	5.36	5.20	4.41	5.04 (b)
T4 FYM @ 50 tons/ha.	28.82	7.67	7.63	4.37	4.96	4.92	4.91	5.74 (b)
T5 Pressmud @ 50 tons/ha.	25.80	7.02	7.07	4.93	4.07	3.83	3.60	5.09 (b)
T6 Green manuring with jantar	26.90	8.59	6.21	3.90	3.01	2.96	3.08	4.63 (b)
Average:	23.72	8.60 (a)	7.09 (a)	4.87 (b)	4.72 (b)	4.59 (b)	4.38 (b)	

LSD (Treatments) 1 % = 2.132

LSD (Samplings) 1 % = 2.132

TABLE:8

EFFECT OF BRACKISH WATER ON SAR OF SALINE SODIC SOIL

(30-90cm)

Treatments	Initial	Post Rice 1984 S_1	Post Berseem 1984-85 S_2	Post Rice 1985 S_3	Post Wheat 1985-86 S_4	Post Rice 1986 S_5	Post Wheat 1986-87 S_6	Average (S_1 to S_6)
T1 Simple leaching with saline water.	25.44	7.77	6.01	7.07	5.29	4.64	3.75	5.76
T2 Gypsum @ 50 % GR.	24.25	4.45	4.21	3.90	4.46	3.93	3.32	4.05
T3 Gypsum @ 25 % GR.	24.70	5.75	4.70	4.36	4.83	4.24	4.51	4.73
T4 FYM @ 50 tons/ha.	39.18	5.48	4.33	4.13	4.70	4.71	4.93	4.71
T5 Pressmud @ 50 tons/ha.	48.11	10.35	5.63	4.75	3.78	4.09	4.96	5.59
T6 Green manuring with jantar	80.10	4.61	4.86	3.55	4.51	3.65	3.96	4.19
Average:	40.30	5.76 (a)	4.05 (c)	4.73 (bc)	4.71 (bc)	5.59 (ab)	4.44 (bc)	

LSD (Samplings) 1 % = 1.280

TABLE:9

EFFECT OF BRACKISH WATER ON PADDY YIELD

(Kg/ha)

Treatments	Paddy			Average
	1984	1985	1986*	
T1 Simple leaching with saline water	Not planted	Not planted	964	964.0 (b)
T2 Gypsum @ 50 % GR.	1661	2072	1224	1652.3 (a)
T3 Gypsum @ 25 % GR.	1075	1548	1033	1218.7 (b)
T4 FYM @ 50 tons/ha.	1222	1584	1016	1274.0 (b)
T5 Pressmud @ 50 tons/ha.	1540	1951	1372	1621.0 (a)
T6 Green manuring with jantar	1195	1728	1120	1347.7 (b)
Average:	1338.6(b)	1776.6(a)	1121.50(c)	

LSD (Treatments) 1 % = 262.07

LSD (Yield) 1 % = 185.31

* Low yield during 1986 was due to dry weather conditions.

TABLE: 10

EFFECT OF BRACKISH WATER ON BERSEEM FODDER YIELD

(Kg/ha)

Treatments	Berseem 1984-85
T1 Simple leaching with saline water	Not sown
T2 Gypsum @ 50% GR.	58047
T3 Gypsum @ 25% GR.	32382
T4 FYM @ 50 tons/ha.	46599
T5 Pressmud @ 50 tons/ha.	32622
T6 Green manuring with jantar.	39783
Average:	41886.6

$\overline{X}$ = 41886.6
C.V. = 23 %

TABLE:11

EFFECT OF BRACKISH WATER ON WHEAT YIELD

(Kg/ha)

Treatments	Wheat 1985	Wheat* 1986-87	Average
T1 Simple leaching with saline water.	3349	2862	3105.50
T2 Gypsum @ 50% GR.	4600	3495	4047.50
T3 Gypsum @ 25 % GR.	3444	2922	3183.00
T4 FYM @ 50 tons/ha.	4120	2928	3524.00
T5 Pressmud @ 50 tons/ha	4473	2982	3727.50
T6 Green manuring with Santar	3851	2982	3416.50
Average:	3972.83 (a)	3028.50 (b)	

LSD (yields) 1 % = 649.80

* Crop damage by hailstorm at maturity caused yield reduction.