IMPROVING SODIC WATER WITH GYMPSUM FOR CROP PRODUCTION I.

by

**Muhammad Ramzan Chaudhry,*
Abdul Hamid and Muhammad Afzal Javed****

ABSTRACT

A field study was carried out on a non-saline non-sodic silt loam soil, Marginal quality tubewell water was used for irrigation with and without gypsum treatments. Gypsum application in both the forms increased the infiltration rate significantly whereas it decreased by the use of pure tubewell water of marginal quality. No siginificant effect was observed on ECe of soil. The SAR of soil considerably increased over a period of three years where pure tubewell water was used but it decreased in gypsum treated plots. More salts were accumulated in the upper 15cm soil layer as compared with lower layers. On an average 2.13 and 9.52% in wheat yield and 15.54 and 4.31% increase in paddy yield was observed when water was applied through gypsum bed and powdered gypsum applied in the field as compared with control. The highest benefit cost ratio of 1.95 was obtained when water was applied through gypsum bed laid down in the watercourse.

INTRODUCTION

In Pakistan good quality water is not sufficient to meet the crop requirements. To augment this an appreciable quantity of poor quality ground water is pumped. Sodic waters with low salinity can be amended and used successfully if Na:Ca +Mg ratio is lowered down. Gypsum is the reasonably priced source of Ca to lower this ratio. Powdered gypsum is costly but if gypsum stones are used the price can be reduced by two third. The present study was undertaken to evaluate the improvement in sodic tubewell water by gypsum application and its effects on soil properties and crop yield and to work out benefit cost ratio.

Change (1961) reported that the ratio of sodium to calcium is more important than the total amount of sodium and calcium in irrigation waters affecting sodium adsorption on exchange complex. Dutt (1964) found that presence of gypsum in the soil delays the accumulation of exchangeable sodium. Muhammad (1967) reported that higher salinity and SAR affected severely the yield of maize and sorghum crops. Haider and Farooqi (1972) reported that potentially hazardous tubewell water with SAR ranging between 10 to 14 can be used successfully if application of gypsum is made to the soil to be irrigated by such waters. They further added that application of gypsum increases infiltration rates and reduces SAR and pH of soil. Haider et al. (1974) found that gypsum stones (4–7 kg) on the beds of the watercourse lost from 0.10 to 0.15% of their weight per hour of exposure to the running water. Haider and Farooqi (1974) observed that the crop yield was adversely affected by the use of potentially

1,2 Senior Research Officer and Junior Research Officers, Soil and Reclamation Section MONA, BHALWAL.

hazardous irrigation water and the major changes in ECe and SAR of soil were observed in the upper 0–6 and 6–18 inches depths whereas these changes were non-significiant at lower depths. Kemper et al. (1975) showed that gypsum fragments 4cm in diameter could provide all the gypsum desired in water flowing through beds of these fragments. Qureshi et al. (1975) and Ahmad et al. (1979) found that high sodium waters flowing through gypsum beds would dissolve appreciable amount of gypsum to neutralize the harmful effect of high sodium tubewell waters on soils and crops. Haider et al. (1976) observed considerable reduction in crop yield and increase in SAR of soil with the use of high SAR water. Chaudhry et al. (1983) reported that wheat yield was reduced considerably in fine textured soil by water salinity as compared with coarse textured soil.

MATERIALS AND METHODS

The study was carried out in 0.4 hectare field of non-saline non-sodic silt loam soil under the command of tubewell MN-72 in the project area from 1979-80 to 1982-83. The physico chemical properties are reported in Table-1. The water of the subject tubewell was used for irrigation purposes. The chemical composition of pure tubewell water and after passing through the gypsum bed is reported in Table-2. Wheat varieties planted were Indus 79 and Sandal during 1979–80 and 1980–1982 respectively and B-370 was rice variety for this experiment. NPK was applied @ 134, 56 and 30 kg/ha to wheat and 112, 56 and 30 kg/ha to rice crop respectively.

Lining of watercourse bed with gympsum stones:

According to the formula developed by Ahmad et al. (1979) 56 meter length of watercourse was lined with 28 tons of 10-20 kg gypsum stones in order to lower down the SAR of water. The supply of tubewell was 1.62 cusecs. The treatments tested were:

Treatments	Description
T–1	Pure tubewell water without water or soil amendments.
T–2	Tubewell water after passing through gypsum stones placed in the watercourse on calculated basis.
T–3	Pure tubewell water with gypsum (100 mesh) application to soil on 100% requirement of water.

The field was properly levelled and divided into 9 equal plots. Different treatments were randomized. The gypsum requirements on water quality were determined and gypsum was applied by broadcast method, and mixed in the soil thoroughly by repeated ploughings and plankings before planting of each crop.

Soil samples were collected from 0-15, 15-30, 30-60 and 60-90 cm depth before initiation of the experiment. Subsequent soil sampling was done after completion of the experiment. The soil samples were dried, sieved and analysed for pH, ECe and SAR (U.S. Salinity Laboratory Staff 1954).

The infiltration rate was measured by "Standard Ring" method (Aronovici, 1955).

RESULTS AND DISCUSSION

1. Infiltration rate:

Effect of different treatments on the soil infiltration rate is reported in Table-3. On an average the infiltration of soil was significantly affected by use of pure sodic tubewell water. There was 25% increase in the infiltration rate of soil from 1979-80 to 1982-83 where 100% gypsum, on water quality basis, was applied and mixed thoroughly with the soil by ploughings and plankings (T-3). Slight increase of 3.85% in the infiltration rate was also observed when sodic tubewell water was applied through gypsum

TABLE – 1

PHYSICO-CHEMICAL CHARACTERISTICS OF THE SOIL (0-30 cm) USED FOR EXPERIMENTATION

pH	ECe x 10^3 at 25^oC	SAR	Sand%	Silt %	Clay%	Taxtural Class
8.19	0.89	2.53	31.2	55.8	13.0	Silt loam

TABLE – 2

CHEMICAL COMPOSITION OF IRRIGATION WATERS USED IN THE EXPERIMENT

T/Well No.	Milliequivalents per litre					TDS	EC x 10^6	pH	RSC	SAR
	Ca+Mg	Na	HCO_3	C1	SO_4	(ppm)	at 25^oC		me/1	
MN-72 (Pure T/Well water)	1.35	11.65	6.37	3.35	2.82	797	1245	7.92	5.02	14.37
MN-72 (T/Well water after passing through gypsum bed).	6.36	10.68	6.20	4.20	5.80	1037	1620	7.96	0.00	6.78

TABLE – 3

EFFECT OF SODIC TUBEWELL WATER AND GYPSUM TREATMENTS ON THE INFILTRATION RATE OF SOIL. cm/hr (Average values)

Treatments		1979-80	1980-81	1981-82	1982-83	Average	% decrease/ increase in 1982-83 over the initial* infiltration rate.
T-1	Pure T/well water.	0.40	0.34	0.35	0.35	0.36(c)	–32.69
T-2	T/Well water through gypsum bed.	0.51	0.50	0.53	0.54	0.52(b)	3.85
T-3	Pure T/Well water + 100% gypsum in the soil on water quality basis.	0.56	0.63	0.68	0.65	0.63(a)	25.00

Infiltration rate before initiating the experiment = 0.52*

LSD 1% = 0.998

bed, whereas the infiltration rate was decreased when pure sodic tubewell water was applied for irrigation for the same time period. It can be said that the soil structure might have deteriorated to some extent due to addition of sodium, through sodic water, on the soil exchange complex. The data further revealed that gypsum application, in both the forms nullified the effect of sodic water by replacing the sodium with calcium from the soil exchange complex. The sodium thus replaced was possibly leached down beyond the root zone. The three treatments differ significantly with each other. Similar results were reported by Dutt (1954), Haider and Farooqi (1972).

2. Soil pH:

The effect of different treatments on the pH of soil is reported in Table-4. No significant effect of different treatments on the pH of soil was observed within a period of four years. Contrary to this Haider and Farooqi (1972) found reduction in pH with the application of gypsum. No significant difference was noticed between pH of different soil depths varying from 0 to 90cm.

3. Electrical Conductivity (Ece x 10^3) of soil:

There was no significant effect of treatments on the ECe of soil (Table-5). However, significant effect on the ECe of upper 0-15cm depth was observed as compared to lower depths. No significant difference in ECe of lower layers of soil was observed indicating that less salts were accumulated in the lower layers during 4 years' period. It can be concluded that water has not affected the ECe of soil significantly under the prevailing set of soil and climatic conditions. In general, there was small increase in ECe when there was less rain during the crop period indicating that during heavy rains more salts were leached down. Overall the Ece of soil remained within safe limits (less than 4 dS/m) even in the control plots, but soil productivity may be affected if water is applied for longer period without any amendment especially in the dry regions. Haider and Farooqi (1974) observed that major changes in ECe were observed in upper 0-6 and 6-18 inches as compared to lower layers. The new findings are almost in conformity with the past results.

4. Sodium Adsorption Ratio (SAR) of soil:

There were non significant differences among different treatments (Table-5). However, there was small increase in treatment-1 but decrease in treatment-2 and 3. The effect on SAR was more pronounced where pure tubewell water was used (T-1) as compared to where 100% gypsum on water quality basis was applied and mixed with soil (T-3) and the water applied through gypsum bed (T-2). On an average, the highest SAR was observed in the control plots followed by plots where water was applied through gypsum bed and gypsum applied in the field respectively from 1979-80 to 1982-83. However, it remained within safe limits hence the crop yield was not considerably affected. As there is increasing trend in the SAR of soil especially in the control plots so if this type of water is used for longer period, the soil may be deteriorated due to addition of sodium on the exchange complex, resulting in reduction of crop yield. Similar findings were observed by Haider and Farooqi (1974), Qureshi et al. (1975), Ahmed et al. (1979) and Haider et al. (1976).

5. Yield of crops:

i. Wheat

There was no significant effect on the yield (Table-6). On an average, there was 9.52% increase over control when gypsum was applied in the field (T-3) and followed by 2.13% increase when field was irrigated with sodic tubewell water through gypsum bed laid down in the watercourse (T-2). However, the wheat yield obtained during 1979-80 was significantly higher compared with the later years showing that in general the water had affected the yield to some extent in all the cases. However, the effect was less in gypsum treated plots as compared to control

TABLE – 4

EFFECT OF SODIC TUBEWELL WATER AND GYPSUM TREATMENTS ON THE pH OF SOIL

Treatments	Depth (cm)	Pre Rabi 1979-80	Post Rabi 1982-83
T-1 Pure Tubewell water	0-15	8.10	8.23
	15-30	8.36	8.27
	30-60	8.33	8.33
	60-90	8.23	8.37
T-2 Tubewell water through gypsum bed.	0-15	8.00	8.17
	15-30	8.07	8.23
	30-60	8.07	8.27
	60-90	8.10	8.27
T-3 Pure tubewell water + 100% gypsum in the soil on water quality basis.	0-15	8.23	8.37
	15-30	8.40	8.20
	30-60	8.37	8.20
	60-90	8.43	8.33
Average	0-90	8.22	8.27

TABLE – 5

EFFECT OF SODIC TUBEWELL WATER AND GYPSUM TREATMENTS ON THE ECe AND SAR OF SOIL

Treatments	Depth (cm)	ECe x 10^3		SAR	
		Pre Rabi 1979-80	Post Rabi 1982-83	Pre Rabi 1979-80	Post Rabi 1982-83
T-1 Pure T/Well water	0-15	0.96	1.17	1.97	3.85
	15-30	0.70	0.76	1.70	3.53
	30-60	0.63	1.18	1.41	3.94
	60-90	0.64	0.80	1.43	3.16
T-2 Tubewell water through gypsum bed.	0-15	1.16	0.72	1.83	1.66
	15-30	0.68	0.65	2.27	2.21
	30-60	0.88	0.53	2.70	2.09
	60-90	0.85	0.99	3.47	1.77
T-3 Pure T/well water + 100% gypsum in the soil on water quality basis.	0-15	1.12	1.12	4.07	1.05
	15-30	0.72	0.82	3.33	1.16
	30-60	0.82	0.83	1.27	1.45
	60-90	0.74	0.55	1.97	2.22

TABLE – 6

EFFECT OF DIFFERENT METHODS OF GYPSUM APPLICATION ON WHEAT YIELD (Kg/ha)

Treatments		Rabi				Average	% increase
		*1979-80	1980-81	1981-82	1982-83	1979-80 to 1982-83	over control (on average).
T-1	Pure T/well water.	4358.10	2601.71	2888.31	2887.97	3184.02	–
T-2	T/well water through gypsum bed.	3970.68	2810.57	3166.38	3059.31	3251.74	2.13
T-3	Pure T/well water + 100% gypsum in the soil on water quality basis.	4332.82	2750.77	3770.35	3093.97	3486.98	9.52
	Average:	4220.55 (a)	2721.02 (b)	3275.01 (b)	3013.75 (b)	–	–

LSD (Years) 1% = 726.68

*Initial year of experimentation.

TABLE – 7

EFFECT OF DIFFERENT METHODS OF GYPSUM APPLICATION ON PADDY YIELD (Kg/ha)

Treatments		Kharif			Average	% increase
		1980	1981	1982	(1980-82)	over control (on average)
T-1	Pure T/well water.	21 05.19	2229.48	2850.91	2395.19(b)	–
T-2	T/well water through gypsum bed.	2650.98	2644.65	3006.90	2767.51(a)	15.54
T-3	Pure T/well water + 100% gypsum in the soil on water quality basis.	2200.48	2296.65	2998.05	2498.39(ab)	4.31
	Average (Years)	2318.88(b)	2390.26(b)	2951.96(a)		

LSD (Years) 1% = 471.62

LSD (T) 5% = 284.37

plots. It can be further concluded that during the first year the highest yield (4358 kg/ha) of wheat was obtained from the plots where pure tubewell water was used but later on the lowest yield was recorded from these plots, indicating some bad effects of pure tubewell water.

ii. Rice

There was 15.54% increase over control where water was applied through gypsum bed which was significantly higher than the yield of other treatments (Table-7). No significant differences were observed between the yield of control plots and that of gypsum treated plots. However, 4.31% more paddy yield was observed in plots when gypsum was applied in the field before planting the crop as compared to control plots. The yearly differences in yield were highly significant. Highest yield of 2952 kg/ha was recorded during 1982 followed by 1981 and 1980 respectively. This increase in yield may be possibly due to the prevailing climatic conditions during the later period of experiment. Almost similar results were reported by Muhammad (1967), Haider and Farooqi (1974) and Haider et al. (1976).

ECONOMIC ANALYSIS

There was increase in revenue from 1979-80 to 1982-83 in all the three treatments (Table-8). Using present worth formulae benefits for three different treatments i.e. T-1, T-2 and T-3 came to be as Rs. 20986, 22461 and 25302 and cost Rs. 11205, 11544 and 13571 respectively. Benefit cost ratio for T-1, T-2 and T-3 treatments is 1.87, 1.95 and 1.86 respectively. This indicates that treatment No. 2 (T-2) is more profitable and is followed by T-1 and T-3. It can be concluded that lower benefit cost ratio in case of T-3 as compared with T-1 is due to additional cost of powdered gypsum. However if the soil characteristics are taken into consideration T-3 may be more beneficial in the long run. The highest revenue was received in T-3 followed by T-2 and T-1 respectively. Application of all above treatments is economically feasible but treatment No.2 is more profitable and recommended to be adopted.

LITERATURE CITED

1. Ahmed, B., W.D. Kemper, G. Haider and M.A. Niazi. 1979. Use of gypsum stones to lower the sodium adsorption ratio of irrigation water. Soil Sci. Soc. Amer. J. 43: 698 - 702.

2. Aronovici, V.S. 1955. Model study of ring infiltrometer performance under low initial soil moisture Soil Sci. Soc. Amer. Proc. 18: 1-6.

3. Change, E.W. 1961. Effect of saline irrigation water and exch. sodium on soil properties and growth of alfalfa. Soil Sci. 91: 29-37.

4. Chaudhry, M.R., M. Sadiq, A. Hamid and Ihsan Ullah. 1983. Effects of moisture and water salinity levels on soil properties and crops yield. Mona Recl: Expl. Project, Wapda, Bhalwal Pub. No. 128. pp 26.

5. Dutt, G.R. 1964. Effect of small amount of gypsum in soils on the solutes in effluents. Soil Sci. Soc. Amer. Proc. 28: 754-757.

6. Haider, G., and M.A.R. Farooqi. 1972. Effect of gypsum on soils being irrigated with high SAR tubewell water. Mona Recl: Expl: Project, Wapda, Bhalwal, Publication No. 15, pp 59.

7. Haider, G., M.A.R. Farooqi and W.D. Kemper. 1974. Observation on gypsum solubility of gypsum stone in flowing water. Colorado State Univ. Water Management Res. Ann. Report (Mona Pub. No. 60, 1976 pp 3).

8. Haider, G., and M.A.R. Farooqi. 1974. Management of potentially hazardous tubewell water by the cultivators. Mona Recl: Expl: Project, Wapda, Bhalwal, Publication No.34, pp 66.

9. Haider, G., G. Hussain, and M.S. Tabassam. 1976. Effect of high SAR tubewell waters on soil conditions and plant growth. Mons Recl: Expl: Project, Wapda, Bhalwal, Publication No. 57, pp 20-21.

10. Kemper W.D., J. Olson and C.J. de Mooy. 1975. Dissolution rate of gypsum in flowing water. Soil Sci. Soc. Amer. Proc. 39: 458-463.

11. Muhammad, I. 1967. Effect of salts on the quality of maize and sorghum. M.Sc. Thesis, Deptt. Soil Science, W.P.A.U. Lyallpur.

12. Qureshi, R.H., M. Hanif, M.I. Rajoka and G.R. Sandhu. 1975. Use of saline sodic water for crop production. Cento Scientific Programme. The optimum use of water for Agriculture pp 63-69.

13. U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. U.S.D.A. Hand book 60, p. 160.

TABLE – 8

BENEFIT COST RATIO OF DIFFERENT METHODS OF GYPSUM APPLICATION

Treatments	Year	Revenue received in respective years (Rs.)	Present worth-benefit (PWB) in Rs. (1982-83)	Cost measured in respective years	Present worth cost(PWC) in Rs. (1982-83)
T-1	1979-80	2968.42	4670.8	1278.50	2011.7
Pure Tubewell	1980-81	3752.81	5272.3	2432.00	3416.7
water.	1981-82	4269.11	5355.2	2432.00	3053.2
	1982-83	5077.92	5687.3	2432.00	2723.8
	Total:		20985.6		11205.4
	B.C. Ratio 1.87				
T-2	1979-80	2567.01	4039.2	1302.62	2049.7
Tubewell water	1980-81	4576.71	6429.8	2515.30	3533.7
through gypsum	1981-82	4788.97	6007.3	2514.71	3154.5
bed.	1982-83	5343.61	5984.8	2505.79	2806.5
	Total:		22461.1		11544.3
	B.C. Ratio 1.95				
T-3	1979-80	2720.03	7279.6	1438.50	2263.5
Tubewell water	1980-81	4117.19	5784.2	2992.00	4303.4
+ 100% gypsum in the	1981-82	4850.26	6084.2	2992.00	3753.2
soil on water quality basis	1982-83	5494.34	6153.7	2992.00	3351.0
	Total:		25301.7		13571.1
	B.C. Ratio 1.86				

Solubility of gypsum stones was taken as 0.15% per hour (Haider et al. 1974).