Pak. J. Agri. Sci., Vol. 29, No. 2, 1992

USE OF HIGH-Mg BRACKISH WATER ON PHOSPHOGYPSUM AND FYM TREATED SALINE-SODIC SOIL. I. SOIL IMPROVEMENT

Abdul Ghafoor, M. Iqbal Shahid, M. Soghir & G. Murtaza
Department of Soil Science,
University of Agriculture,. Faisalabad

A pot experiment was conducted where a sandy clay loam saline-sodic soil (pHs 8.6, EC_e 21 dS m^{-1}, SAR 183.7 and GR 5.6 me 100 g^{-1}) was treated with phosphogypsum @ 50 and 100% GR and FYM @ 10 and 20 tons $acre^{-1}$. A synthetic irrigation water (EC 2 dS m^{-1}, SAR 12, RSC 3 me L^{-1}) was applied to wheat and rice crops. The soil improvement was more with phosphogypsum followed by FYM. There was some adverse effects of high Mg in irrigation water but because of soil salinity/sodicity, overall tendency remained towards improvement.

INTRODUCTION

In Pakistan, 5.7 mha of soils are salt-affected, out of which 80% in the Punjab are saline-sodic and require calcium application. To augment the canal irrigation water about 40 MAF groundwater is pumped annually (NCA, 1987), of which 70% is hazardous (Ahmad and Chaudhry, 1988) according to the criteria of U.S. Salinity Laboratory Staff (1954).

The hazardous groundwaters along with higher EC and SAR, also contain Mg higher than Ca which progressively increases further as EC and SAR increases. High Mg irrigation water has shown increased dispersion and hence a decrease in hydraulic conductivity (Khan, 1975; Keren, 1989). However, EC of irrigation waters will tend to decrease the dispersion as a result of which hydraulic conductivity will increase (Reeve and Doering, 1966; Girdhar and Yadav, 1980).

In this paper, soil properties as affected by brackish water having Ca:Mg ratios of 1:4 and 1:6 applied to grow wheat and rice on a phosphogypsum and FYM treated saline-sodic soil sample are reported.

MATERIALS AND METHODS

A bulk sample of moderately calcareous sandy clay loam soil (pHs 8.6, EC_e 21 dS m^{-1}, SAR 183.7, GR 5.6 me 100 g^{-1}) was collected from a field. After passing it through a 2 mm sieve, 10 kg soil was placed in each of 33 pots having a leaching provision. Canal water @ three times the soil saturation was applied as a presowing irrigation. The wheat Blue Silver was sown on December 24, 1988 when soil was at 'watter' condition. Recommended dose of NPK as urea, TSP and K_2SO_4 was 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 1:4 and 1:6. The synthetic water and canal water to control were applied to grow wheat and rice crops up to maturity. Before sowing wheat, the soil received FYM @ 10 and 20 tons $acre^{-1}$ and phosphogypsum @ 50 and 100% soil GR for both the ratios of Ca:Mg in water (Table 1). After wheat harvest, soil samples were drawn for analysis.

In these pots rice KS 282 was transplanted during summer of 1989 and was grown under submerged conditions. A recommended rate of NPK was applied. The crop was harvested at maturity and soil samples were drawn for analysis. During the growing period of both the crops, leachates were collected, measured and analysed for EC_e, CO_3, HCO_3, Cl, Na, K, Ca and Mg (Page *et al.*, 1982). The data collected were analysed by the ANOVA technique following completely randomised design (Steel and Torrie, 1980).

Table 1. Amount of leachate and removal of solutes during growth of wheat and rice on a saline-sodic soil

Treatment Ca:Mg	Amendment	Vol. Leachate (L)	LF	Na	Ca (me treatment^{-1})	Mg
1:4	PG @ 50% GR	24.6	0.28	1619	215	265
1:4	PG @ 100% GR	26.9	0.29	1652	321	294
1:4	FYM @ 10 T/A	17.0	0.24	1665	55	105
1:4	FYM @ 20 T/A	15.7	0.22	1569	48	98
1:6	PG @ 50% GR	24.0	0.27	1577	201	278
1:6	PG @ 100% GR	27.9	0.31	1632	309	323
1:6	FYM @ 10 T/A	14.3	0.22	1587	46	98
1:6	FYMM @ 20 T/A	13.7	0.21	1578	48	94
1:4	-	12.0	0.19	1566	37	80
1:6	-	12.0	0.19	1602	78	79
Canal water	-	14.5	0.18	1054	41	64

PG = Phosphogypsum.

RESULTS AND DISCUSSION

The volume of leachate (Table 1) was lower from pots receiving synthetic water alone compared to the other treatments. Phosphogypsum application resulted in more leachate followed by FYM treatments. In general, Ca:Mg ratio of 1:4 in water caused more leachate than that with 1:6 ratio water which may be attributed to swelling of clay by Mg because of more hydration of Mg (Keren, 1989; Yousaf *et al.*, 1988). Similar pattern was achieved in case of LF.

The synthetic water, with and without amendments, caused more Na removal than that of with canal water. Phosphogypsum supplied soluble Ca and hence there was higher amount of Na replaced and leached compared to that with FYM. The leaching of Ca was about 4-fold that of with FYM or synthetic water alone. This indicates perhaps the rate of Na-Ca exchange was lower because of lower CEC of the soil (Bear, 1964) containing illite type clay minerals (Ranjha, 1988). Hence soluble Ca get leached. Similar was the pattern of Mg removal.

phosphogypsum followed by FYM and simple irrigation waters. All the above proper-

Table 2. Soil properties after wheat harvest grown with brackish water on a saline-sodic soil

Treatment Ca:Mg	Amendment	pHs	EC_e (dS m^{-1})	Na	Ca	Mg	SAR
				....................(me L^{-1})			....
1:4	PG @ 50% GR	8.1 c	9.9 b	103.2 b	8.8 b	4.4 c	40.2 de
1:4	PG @ 100% GR	8.0 c	9.9 b	90.1 b	10.2 a	5.2 bc	32.6 e
1:4	FYM @ 10 T/A	8.5 a	14.6 a	161.4 a	10.4 a	8.2 a	53.0 c
1:4	FYM @ 20 T/A	8.5 a	13.4 a	147.1 a	10.6 a	6.3 b	51.1 c
1:6	PG @ 50% GR	8.1 c	10.9 a	115.1 b	8.1 b	7.4 ab	41.5 d
1:6	PG @ 100% GR	8.1 c	9.0 b	86.8 b	8.8 b	7.7 ab	30.3 e
1:6	FYM @ 10 T/A	8.4 a	14.7 a	163.5 a	9.8 a	8.4 a	54.3 c
1:6	FYM @ 20 T/A	8.5 a	13.6 a	146.5 a	10.1 a	8.3 a	48.1 cd
1:4	-	8.2 b	13.9 a	157.8 a	4.2 d	7.8 ab	64.9 b
1:6	-	8.3 b	14.3 a	166.0 a	3.4 d	8.6 a	67.4 b
Canal water		8.3 b	13.0 ab	150.8 a	5.5 c	1.9 d	78.5 a

PG = Phosphogypsum.
Figures sharing the same letter(s) in a column do not differ statistically at P = 0.05.

The pHs of soil after wheat harvest was statistically the lowest with phosphogypsum followed by irrigation water alone and FYM treatment (Table 2). Almost similar was the case regarding the EC_e. The concentration of Na was the lowest for the phosphogypsum, FYM and simple water application. The concentrations of Ca and Mg were higher for the FYM treatments than that with phosphogypsum as well as irrigation water alone. This may be attributed to the likely increase in soil CEC with FYM, because of which the equilibrium concentrations of Ca and Mg has to be higher. There was a significant decrease in SAR of the soil saturation extract. The decrease being more with ties were improved more with water having Ca:Mg of 1:4 than those with 1:6 ratio water. Similar results were reported by Girdhar and Yadav (1980), Chaudhry *et al.* (1986). These workers reported that Mg has lower binding energy than that of Ca resulting less removal of Na by Mg than Na by Ca. This fact will cause lower rate of soil reclamation.

After rice harvest (Table 3), the pHs was again the lowest for the phosphogypsum followed by FYM and irrigation water alone. The EC_e was statistically similar but higher for all the synthetic waters with and without amendments compared to the canal water. The Na in soil solution behaved similarly to the imposed treatments. The concentration

Table 3. Soil properties after rice harvest grown with brackish water on a saline-sodic soil

Treatment Ca:Mg	Amendment	pHs	EC_e ($dS\ m^{-1}$)	Na	Ca	Mg	SAR
				....	($me\ L^{-1}$)	....	
1:4	PG @ 50% GR	7.8 c	8.1 a	46.0 a	23.0 ab	14.3 abc	10.7 de
1:4	PG @ 100% GR	7.8 c	8.7 a	54.3 a	27.0 a	15.3 abc	11.7 cde
1:4	FYM @ 10 T/A	8.1 abc	7.6 a	51.3 a	8.7 c	11.3 abc	16.3 ab
1:4	FYM @ 20 T/A	8.1 abc	7.0 a	48.3 a	8.7 c	9.0 c	16.4 ab
1:6	PG @ 50% GR	7.9 c	8.1 a	52.7 a	20.3 b	17.3 ab	12.3 bcde
1:6	PG @ 100% GR	7.8 c	7.1 a	38.3 a	20.3 b	18.7 a	8.8 ef
1:6	FYM @ 10 T/A	8.1 abc	6.9 a	47.3 a	7.7 c	10.3 bc	15.8 abc
1:6	FYM @ 20 T/A	8.0 bc	7.7 a	54.3 a	7.3 c	13.7 abc	16.9 a
1:4	-	8.3 ab	7.1 a	46.7 a	12.0 c	13.7 abc	13.0 bcde
1:6	-	8.3 a	7.5 a	51.0 a	10.0 a	15.7 abc	14.5 abcd
Canal water		8.1 abc	3.7 b	16.7 b	11.0 c	8.3 c	5.5 f

Figures sharing the same letter(s) in a column do not differ statistically at P = 0.05.

of Ca and Mg in saturation extract was higher for the phosphogypsum treated pots followed by simple water and FYM applications. The soil solution SAR was decreased to about 12 by the phosphogypsum application whereas its values remained above 15 with FYM treatments receiving water of both the Ca:Mg ratios. The lowest SAR was recorded for the control treatments. This could be attributed to valence dilution through which Ca in applied canal water, from native lime as well as the originally present Ca replaced the exchangeable Na, followed by leaching of the desorbed Na. The results are similar to those reported by Chaudhry *et al.* (1986).

On the basis of these studies, it is concluded that brackish water containing Mg more than Ca can be used for reclaiming saline-sodic soils treated with an amendment (@ of soil GR) capable of releasing soluble calcium.

REFERENCES

Ahmad, N. and G.R. Chaudhry. 1988. Irrigated Agriculture of Pakistan. Shahzad Nazir, 61-B/2, Gulberg III, Lahore. P. 5.128-5.166.

Bear, F.E. 1964. Chemistry of the Soil. 2nd Ed., Reinhold Pub. Co., NY, USA. p. 380-384.

Chaudhry, M.R., A. Hamid and B. Ahmad. 1986. Effect of different Ca/Mg ratio waters on soil properties and crop yield. Mona Recl. Expt. Project Pub. No. 154. 24 p.

Girdhar, I.K. and J.S.P. Yadav. 1980. Effect of different Mg/Ca ratios, SAR values and electrolyte concentrations in leaching water on the dispersion and hydraulic conductivity of soils. p. 210-217. In: Proc. Int. Symp. Salt-affected Soils. Feb. 18-21, 1980, Karnal, India.

Keren, R. 1989. Water-drop kinetic energy effect on water infiltration in calcium and magnesium soils. Soil Sci. Soc. Am. J. 53: 1624-1628.

Khan, M. 1975. The effect of Mg on soil classification and alkali soils. P. 390-395. In: Proc. Int. Conf. Waterlogging and Salinity. Oct. 13-17, 1975, Lahore.

National Commission on Agriculture (NCA). 1987. Report of the Natl. Comm. on Agri. Ministry of Food and Agri., GOP, Islamabad. p. 370-395.

Page, A.L., R.H. Miller and D.R. Keeney. 1982. Methods of Soil Analysis. Part 2. ASA-CSSA-SSSA Monogr. No. 9, WI, USA.

Ranjha, A.M. 1988. Morphological, mineralogical and chemical properties of some soils of Pakistan. Ph.D. Thesis, Dept. Soil Sci., Univ. of Agri., Faisalabad.

Reeve, R.C. and E.J. Doering. 1966. The high-salt water dilution method for reclaiming sodic soils. Soil Sci. Soc. Am. Proc. 30: 498-504.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and Procedures of Statistics. 2nd Ed., McGraw Hill Book Co. Inc., NY, USA.

U.S. Salinity Lab. Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA Handb. 60. Washington, D.C., USA.

Yousaf, M., O.M. Ali and J.D. Rhoades. 1987. Dispersion of clay from salt-affected arid land soil aggregates. Soil Sci. Soc. Am. J. 51: 920-924.