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USE OF HIGH MAGNESIUM BRACKISH WATER FOR RECLAMATION OF SALINE-SODIC SOIL. II. YIELD AND CHEMICAL COMPOSITION OF WHEAT AND RICE

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In a pot experiment brackish water (EC 2 dS m^{-1}, SAR 12, RSC 3 me L^{-1}) with different Ca:Mg ratios (4:1, 2:1, 1:1, 1:4, 1:6) was applied to wheat and rice crops grown on a calcareous sandy loam saline-sodic soil. The results indicated that all the yield components of wheat LU 26S remained statistically similar. In rice, productive tillers and paddy yield decreased while sterility percentage increased significantly with a decrease in Ca:Mg ratios in the applied water.

Percentage of Na and Mg increased while that of K and Ca decreased in wheat straw but Na increased in grain as the Ca:Mg ratio in irrigation water decreased. There was little effect of the tested treatments on K, Ca and Mg concentrations in wheat grains. Concentration of Na in rice straw and paddy increased while that of K decreased statistically as the Ca:Mg ratio decreased. All the cations were present at much higher concentrations in straw of both the wheat and rice than those in their economic produces.

INTRODUCTION

Groundwater is amongst the important sources of irrigation in Pakistan, i.e. 40 MAF water is pumped and used for irrigation (NCA, 1987). Out of the pumped groundwater about 75% is hazardous. Besides having a higher concentration of dissolved salts and SAR, these waters often have more Mg than Ca. The proportion of Mg generally increases with an increase in the EC and/or SAR of most of the groundwaters (Ahmad and Chaudhry, 1988).

The continuous use of such poor quality waters, those have higher proportion of Mg, influences adversely the properties of normal productive soils (Khan, 1975) and plant growth (Chaudhry *et al.*, 1986). It is still controversial whether Mg should be grouped with Ca or Na for calculating the SAR and also for judging the quality of irrigation waters. Some scientists (U.S. Salinity Lab. Staff, 1954; Ahmad *et al.*, 1969) concluded that Mg acts like Ca in influencing the properties of soils only because of its divalent nature. Others (Bohn *et al.*, 1985; Kanwar and Chaudhry, 1968) believe that Mg should not be combined with Ca due to varying affinity for adsorption by the soil exchange complex.

Little work has been done regarding the effects of poor quality water with Mg higher than Ca on the soil and plant health particularly when soil is saline-sodic. Keeping these diverse opinions in view, the present studies were planned to observe the effects of low quality water with different Ca:Mg ratios on the growth characteristics of wheat and rice on a saline-sodic soil.

MATERIALS AND METHODS

A bulk sample of a moderately calcareous sandy loam saline-sodic soil (pHs 8.9, EC_e 21 dS m^{-1}, SAR 183, GR 5.16 me $100g^{-1}$) was collected from a field near Kurrianwala town. After passing through 2 mm sieve, 10 kg soil was placed in glazed pots. Canal water @ 3 times of the soil saturation as presowing soaking irrigation was applied. Then wheat LU 26S was planted on December 12, 1988 when the soil was at *"wattar"* condition. Nitrogen, phosphorus and potassium @ 75, 25 and 25 mg kg^{-1} soil were applied as urea, triple superphosphate and potassium sulphate. Nitrogen was applied in three equal splits while P and K were basal applied.

Later in these pots, rice variety KS 282 was transplanted and was grown under submerged conditions. The rate of application of NPK was 100, 75 and 25 mg kg^{-1} soil, respectively. One half N and all the P and K quantities were applied basally. The remaining N was applied in two equal splits, i.e. the first one month after transplanting and the second at earing. During the growth and at the harvest of wheat and rice, the tillers per hill (productive and non-productive), plant height, straw and grain yields were recorded and subjected to statistical analyses (Steel and Torrie, 1980). Plant samples were analysed for Na, Ca and Mg (Page *et al.*, 1982).

Synthetic irrigation water (EC 2 dS m^{-1} SAR 12, RSC 3 me L^{-1}, Cl:SO = 1:1) were prepared using $NaHCO_3$, NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. Ratios of Ca:Mg were maintained as 4:1, 2:1, 1:1, 1:4, 1:6 and canal water served as the control.

RESULTS AND DISCUSSION

Crop growth: The growth components of wheat LU 26S remained statistically similar (Table 1). However, the proportion of non-productive tillers increased while straw and grain yields decreased as the Ca:Mg ratio in brackish irrigation water decreased. The similar treatment effects appear to be due to high EC_e and SAR of the soil.

Table 1. Effect of brackish water with different Ca:Mg ratios on growth characteristics of wheat LU 26S

Ca:Mg in water	Germination (%)	Height (cm)	Tiller $plant^{-1}$		Straw	Grain
			productive	Non-productive	g pot^{-1}	
4:1	55	36	3.3	2.3	6.8	2.6
2:1	44	44	3.3	3.0	7.0	2.2
1:1	60	31	1.3	3.3	3.3	1.0
1:4	53	33	1.7	4.0	3.9	1.4
1:6	53	40	2.3	4.3	3.4	2.0
Canal water	62	38	2.7	2.3	6.1	2.0
SE	6.7^{NS}	8.2^{NS}	1.1^{NS}	0.6^{NS}	2.3^{NS}	1.1^{NS}

The productive tillers and grain yield of rice (Table 2) were lower for the plants irrigated with all the Ca:Mg ratio waters than those irrigated with canal water but were statistically similar with all the Ca:Mg ratios

Table 2. Effect of brackish water with different Ca:Mg ratios on the growth characteristics of rice KS 282

Ca:Mg in water	Tiller hill^{-1}		Straw	Paddy	Sterility (%)
	Productive	Non-productive	g pot^{-1}		
4:1	6.6 b	1.5	37.3	28.9 b	28.8 b
2:1	6.6 b	2.1	44.7	36.9 b	31.2 b
1:1	6.3 b	1.7	40.0	22.6 b	47.9 ab
1:4	5.5 b	2.9	45.5	23.6 b	49.6 ab
1:6	5.1 b	2.6	41.9	19.1 b	58.1 a
Canal water	8.8 a	1.9	52.4	54.6 a	27.1 b
SE	0.6*	0.4^{NS}	3.6^{NS}	5.5*	7.0*

Table 3. The percentage of Na, K, Ca and Mg in straw and grain of wheat as affected by Ca:Mg ratios in brackish irrigation water

Ca:Mg in water	Na	K	Ca	Mg
		a. Straw		
4:1	0.82 c	0.90 a	0.26 b	0.10 f
2:1	0.91 bc	0.83 ab	0.38 a	0.18 d
1:1	1.05 a	0.79 bc	0.31 ab	0.21 c
1:4	1.13 a	0.72 cd	0.16 c	0.40 b
1:6	1.43 a	0.67 d	0.16 c	0.43 a
Canal water	0.41 d	0.89 a	0.16 c	0.12 e
		b. Paddy		
4:1	0.03 c	0.34	0.22	0.18
2:1	0.04 bc	0.33	0.21	0.17
1:1	0.05 ab	0.32	0.14	0.12
1:4	0.06 ab	0.32	0.16	0.18
1:6	0.06 ab	0.31	0.14	0.19
Canal water	0.05 ab	0.35	0.13	0.10
SE	0.005*	0.05^{NS}	0.03^{NS}	0.03^{NS}

in water. The sterility percentage was the highest for water having Ca:Mg ratio of 1:6 and was the lowest for the canal water. There was a consistent increase in the sterility percentage with an increase of Mg in brackish irrigation water. Similar results have been reported by Chaudhry *et al.* (1986) and Kanwar and Chaudhry (1968). In our study, treatment differences regarding the non-productive tillers and straw yield were non-significant.

Chemical composition of wheat LU 26S: In straw, the concentrations of Na and Mg increased but those of K and Ca decreased as the Ca:Mg ratio in irrigation water decreased (Table 3). These effects may partly be due to poor crop growth with higher Mg waters. Low K and Ca may also be due to the antagonistic effect of Na and/or Mg upon their absorption. Higher Mg even might have decreased the translocation of Ca from root to shoot (Ohno and Grunes, 1985). Similar results have been reported by Girdhar and Yadav (1982).

Chemical composition of rice KS 282: The concentration of Na increased significantly while that of K decreased in rice straw as Ca:Mg ratio in irrigation water decreased. However, Ca and Mg concentrations differed non-significantly. In paddy, Na increased with a decrease in Ca:Mg ratio but K, Ca and Mg concentrations remained almost similar. The concentration of these cations remained much higher in straw

Table 4. The percentage of Na, K, Ca and Mg in straw and grain of rice as affected by Ca:Mg ratios in brackish irrigation water

Ca:Mg in water	Na	K	Ca	Mg
		a. straw		
4:1	4.07 ab	0.83 b	0.59	0.45
2:1	2.71 b	1.10 b	0.63	0.49
1:1	4.86 a	0.80 b	0.41	0.46
1:4	4.25 ab	0.91 b	0.42	0.42
1:6	4.58 a	0.77 b	0.41	0.55
Canal water	0.98 c	1.59 a	0.53	0.48
SE	0.52*	0.13*	0.07^{NS}	0.06^{NS}
		b. Paddy		
4:1	0.17 ab	0.29	0.29	0.35
2:1	0.11 b	0.23	0.28	0.31
1:1	0.27 a	0.32	0.21	0.18
1:4	0.29 a	0.35	0.23	0.29
1:6	0.22 ab	0.30	0.21	0.32
Canal water	0.07 b	0.22	0.26	0.24
SE	0.05*	0.03^{NS}	0.05^{NS}	0.06^{NS}

In grain, concentration of Na increased significantly with a decrease in Ca:Mg ratio. However, K, Ca and Mg concentrations differed non-significantly. Concentrations of the cations were much higher in the straw of the plants irrigated with brackish water compared to those of the control plants. compared to those in the paddy. Kanwar and Chaudhry (1968) and Chaudhry *et al.* (1986) have reported similar results.

On the basis of present investigations, it is concluded that waters having EC and SAR similar to the one used with a wider range of Ca:Mg ratios can successfully be

applied to wheat and rice crops during reclamation of saline-sodic soils. This way canal water can be saved and used on normal soils.

REFERENCES

Ahmad, N. and G.R. Chaudhry. 1988. Irrigated agriculture of Pakistan. Shazad Nazir, 61-B/2, Gulberg III, Lahore. pp. 5. 128-5. 166.

Ahmad, S., L.D. Swindale and S.A. Swaify. 1969. effect of adsorbed cations on physical properties of tropical red earth and tropical black earths. J. Soil Sci. 20: 255-268.

Bohn, H.L., B.L. McNeal and G.A.O'Conner. 1985. Soil chemistry. (IInd Ed.). John Wiley and Sons, NY, USA. PP. 221-224.

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. 1982. Effect of magnesium rich waters on soil properties, yield and chemical composition of wheat. Soil Sci. 134: 348-353.

Kanwar, J.S. and M.L. Chaudhry. 1968. Effects of Mg on the uptake of nutrients from the soil. J. Res. Pb. Agric. Univ. 5: 309-319.

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

National Commission on Agriculture (NCA). 1987. Report of Commission on Agriculture. Ministry of Food and Agriculture, Islamabad, Pakistan. pp. 63-68.

Page, A.L., R.H. Miller and P.R. Keeney. 1982. Methods of soil analysis. Part 2. ASA Monogr. No. 9, Madison, WI, USA.

Ohno, T. and D.L. Grunes. 1985. Potassium-magnesium interactions affecting nutrient uptake by wheat forage. Soil Sci. Soc. Am. J. 49: 685-690.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. (2nd Ed.). McGraw Hill Book Co., NY, USA.

U.S. Salinity Lab. Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA Handb. No. 60, Washington, D.C.