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USE OF HIGH-Mg BRACKISH WATER ON PHOSPHOGYPSUM AND FYM TREATED SALINE-SODIC SOIL. II. GROWTH OF WHEAT AND RICE

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

A pot experiment was carried out to monitor the growth characteristics of wheat Blue Silver and rice KS 282 during reclamation of a saline-sodic soil (pHs 8.6, EC_e 21 dS m^{-1}, SAR 183.7, GR 5.6 me 100 g^{-1}) using brackish waser (EC 2 dS m^{-1} SAR 12, RSC 3 meL^{-1}) having Ca:Mg ratios of 1:4 and 1:6. The soil received phosphogypsum @ 50 and 100% of soil GR or FYM @ 10 and 20 tons per acre. Canal water alone served as the control. The results showed that high Mg in irrigation water tended to adversely affect the growth components of wheat and rice. Application of phosphogypsum at both the rates and with both the Ca:Mg ratio waters counteracted the ill-effects of Mg in water better than the FYM. Concentration of Na, Mg and Cl increased but that of Ca decreased with irrigation water having Ca:Mg ratio of 1:6 in both grain and straw of wheat and rice. The application of phosphogypsum antagonized the assimilation of the ions by plants in a better way than the FYM. These ions were in much higher concentration in the straw than that in grain or paddy but remained lower than their critical levels in both the plant organs.

INTRODUCTION

About 75% of the pumped groundwater in the Punjab is reported to be hazardous (Malik *et al.*, 1984) according to the U.S. Salinity Lab. Staff (1954) criteria. Besides having higher concentration of total soluble salts, EC and SAR, these waters often have more Mg than Ca. The proportion of Mg, in general, increases with increasing the EC and/or SAR of the groundwater (Ahmad and Chaudhry, 1988).

The continuous irrigation with such a poor quality water, those having high Mg, influences the properties of normal soils adversely (Khan, 1975) and plant growth (Chaudhry *et al.*, 1986). However, using high-Mg brackish water has been found promising for reclaiming a saline-sodic soil (Ghafoor *et al.*, 1990) and for the crops during reclamation (Ghafoor *et al.*, 1991). However, the rate of soil reclamation and crop growth was inferior to that with canal water without application of any soil amendment. Hence this study was planned to monitor the crop growth on a phosphogypsum or FYM treated saline-sodic soil. The phosphogypsum is a by-product from NFC owned Hazara Fertilizer Complex which contains 54% water soluble material. The water soluble fraction contains Ca = 18, Mg = 0.84, P_2O_5 = 2, HCO_3 = 7 and Cl = 1%.

MATERIALS AND METHODS

A bulk sample of a 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} soil) was collected from a field. After passing it through a 2 mm sieve, 10 kg soil was placed in each of the 33 pots having a leaching provision. For proper packing of the soil as well, as a presowing irrigation canal water @ 3 times the soil saturation percentage was applied. The wheat Blue Silver was sown on December 24, 1988 when soil was at "wattar" condition. Recommended dose of NPK @ 75, 25 and 25 mg kg^{-1} soil as urea, TSP and K_2SO_4, respectively was applied. One third of N and all the P and K were basal applied, one third N one month after sowing and one third N after 2 months of sowing were applied. In each pot plants were thinned to 5 after 10 days of germination and the uprooted plants were crushed and added back to the same pot.

After wheat harvest, one month old, two rice KS 282 seedlings per hill and 5 hills per pot were transplanted. The rate of NPK was 100, 50, 25 mg kg^{-1} soil as ammonium sulphate, SSP and potassium sulphate, respectively. One half of N along with all the P and K were basal applied while the remaining N was added one month after the first application.

The synthetic irrigation water (EC 2 dS m^{-1}, SAR 12, RSC 3 me L^{-1}) having Ca:Mg ratios of 1:4 and 1:6 were prepared using mixture of salts ($NaHCO_3$, NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$). Canal water served as the control. Phosphogypsum @ 50 and 100% of the soil GR and FYM @ 10 and 20 tons $acre^{-1}$ were applied once before sowing the first wheat crop. During growing period and at harvest of each crop, data on yield and its components were recorded. Then the data were subjected to ANOVA technique (Steel & Torrie, 1980) for statistical analysis.

RESULTS AND DISCUSSION

Crop growth: Plant height, dry matter and grain yield and 100-grain weight of wheat were statistically lower with application of

Table 1. Yield and yield components of wheat and rice grown during reclamation of a saline-sodic soil with amendments using high-Mg brackish water

Treatment	Wheat Blue Silver				Rice KS 282			
Ca:Mg + Amednment	Plant height (cm)	TDM ....($g\ pot^{-1}$)........	Grain	100-grain weight (g)	Plant height (cm)	Straw	Paddy ....($g\ pot^{-1}$)........	Sterility (%)
1:4 + PG @ 50% soil GR	58.9 ab	20.6 b	6.7 b	4.4 a	76.3 bc	39.1 bcd	38.4 b	29.0 de
1:4 + PG @ 100% soil GR	66.5 a	33.8 a	14.7 a	5.0 a	80.6 ab	42.4 bc	42.3 b	30.6 cde
1:4 + FYM @ 10 t $acre^{-1}$	46.3 bc	3.6 c	1.0 c	2.8 bc	78.3 abc	33.0 de	25.5 c	43.8 abcde
1:4 + FYM @ 20 t $acre^{-1}$	44.5 bc	8.1 c	3.1 c	2.9 b	76.5 bc	38.4 bcd	20.8 c	50.3 abc
1:6 + PG @ 50% soil GR	59.3 ab	21.1 b	8.0 b	4.9 a	76.2 bc	39.9 bcd	36.9 b	36.6 abcde
1:6 + PG @ 100% soil GR	66.1 a	35.0 a	16.0 a	5.1 a	80.1 abc	39.5 bcd	41.56 b	25.4 e
1:6 + FYM @ 10 t $acre^{-1}$	33.6 bc	1.9 c	0.4 c	2.5 bc	75.2 bc	29.4 e	24.5 c	40.2 abcde
1:6 + FYM @ 20 t $acre^{-1}$	36.6 c	5.0 c	1.4 c	2.6 bc	74.3 c	34.8 cde	17.1 c	51.7 ab
1:4	33.3 c	5.7 c	1.1 c	2.0 cd	80.3 abc	45.5 ab	23.6 c	48.3 abcd
1:6	39.8 c	2.6 c	0.4 c	1.6 d	75.3 bc	41.9 bcd	19.1 c	58.1 a
Canal water	83.3 c	5.6 c	0.9 c	2.0 cd	84.4 a	52.4 a	54.6 a	27.1 d

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

Table 2. Per cent Na, Ca, Mg and Cl ions in wheat grown during reclamation using high-Mg brackish water on a saline-sodic soil receiving amendments

Treatment	Grain				Straw			
	Na	Ca	Mg	Cl	Na	Ca	Mg	Cl
1:4 + PG @ 50% soil GR	0.04 e	0.09 b	0.32 c	0.47 b	0.28 h	1.60 b	0.61 fg	0.59 e
1:4 + PG @ 100% soil GR	0.02 f	0.11 a	0.24 e	0.40 bc	0.26 h	1.72 a	0.59 g	0.52 f
1:4 + FYM @ 10 t acre^{-1}	0.05 d	0.06 cd	0.35 b	0.60 a	0.43 e	1.47 c	0.71 e	0.71 b
1:4 + FYM @ 20 t acre^{-1}	0.05 d	0.07 c	0.34 bc	0.64 a	0.35 f	1.47 c	0.69 e	0.74 ab
1:6 + PG @ 50% soil GR	0.04 e	0.09 b	0.30 c	0.38 bc	0.32 fg	1.50 bc	0.64 f	0.48 fg
1:6 + PG @ 100% soil GR	0.04 e	0.10 ab	0.26 de	0.35 c	0.28 gh	1.62 ab	0.68 e	0.46 g
1:6 + FYM @ 10 t acre^{-1}	0.06 c	0.06 cd	0.37 a	0.56 ab	0.64 c	1.45 c	0.81 d	0.67 c
1:6 + FYM @ 20 t acre^{-1}	0.06 c	0.07 e	0.38 a	0.64 a	0.52 c	1.47 c	0.85 c	0.73 b
1:4 -	0.07 b	0.05 d	0.35 b	0.59 ab	1.08 b	1.42 cd	0.89 b	0.73 b
1:6 -	0.06 c	0.04 de	0.37 a	0.60 a	1.12 b	1.42 cd	0.92 a	0.68 c
Canal water -	0.09 a	0.04 de	0.28 d	0.66 a	1.41 a	1.32 d	0.78 d	0.77 a

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

Table 3. Per cent Na, Ca, Mg and Cl ions in rice KS 282 grown during reclamation on using high-Mg brackish water on a saline-sodic soil receiving amendments

Treatment	Grain				Straw			
	Na	Ca	Mg	Cl	Na	Ca	Mg	Cl
1:4 + PG @ 50% soil GR	0.16 abc	0.24 ab	0.18 c	0.41 d	0.67 cde	0.57 a	0.69 bc	0.50 b
1:4 + PG @ 100% soil GR	0.13 cd	0.28 a	0.20 c	0.36 d	0.63 cde	0.58 a	0.79 abc	0.48 b
1:4 + FYM @ 10 t acre^{-1}	0.20 abc	0.13 d	0.29 abc	0.71 a	1.34 b	0.36 bc	0.73 abc	0.68 a
1:4 + FYM @ 20 t acre^{-1}	0.20 abc	0.15 cd	0.39 a	0.70 ab	0.99 bcde	0.41 b	0.74 abc	0.70 a
1:6 + PG @ 50% soil GR	0.14 bcd	0.20 abcd	0.27 ab	0.42 d	0.43 e	0.55 a	0.76 abc	0.51 b
1:6 + PG @ 100% soil GR	0.17 abc	0.22 abc	0.23 bc	0.34 d	0.51 de	0.59 a	0.75 abc	0.46 b
1:6 + FYM @ 10 t acre^{-1}	0.21 ab	0.12 d	0.39 a	0.54 c	1.23 bc	0.36 bc	0.85 a	0.70 a
1:6 + FYM @ 20 t acre^{-1}	0.20 abc	0.13 cd	0.40 a	0.65 ab	1.13 bcd	0.33 bc	0.72 abc	0.70 a
1:4 -	0.20 abc	0.18 bcd	0.30 abc	0.70 ab	4.37 a	0.30 c	0.81 c	0.69 a
1:6 -	0.22 a	0.18 bcd	0.33 abc	0.72 a	4.57 a	0.30 c	0.82 ab	0.69 a
Canal water -	0.07 d	0.20 abcd	0.27 abc	0.60 bc	4.97 a	0.35 bc	0.67 c	0.64 a

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

synthetic waters alone (Table 1). These parameters were improved more with phosphogypsum application than that with FYM. With brackish irrigation water having Ca:Mg ratio of 1:4, both the amendments behaved alike but with Ca:Mg ratio of 1:6, the values of these components were considerably lower. This could be due to Ca supplied by applied phosphogypsum which might be sufficient to counteract the Mg in water having Ca:Mg ratio of 1:4 but fell short at 1:6 ratio of Ca:Mg. Moreover, the toxic products from decomposition of FYM (Inoue *et al.,* 1953) might be held responsible for these lower values of growth components for treatments receiving FYM. However, the response of productive tillers was inconsistent (data not given). Similar results were reported by Ahmad *et al.* (1984) and Chaudhry *et al.* (1986).

The growth components of rice were significantly affected by the treatments (Table 1). The values of growth components were lower with FYM compared to those with phosphogypsum for both the Ca:Mg ratios in brackish irrigation water. Again the values of yield components were slightly lower for Ca:Mg ratio of 1:6 compared to those with Ca:Mg ratio of 1:4. However, the treatment differences were smaller than those of the wheat crop. This could be due to partial soil reclamation during the first wheat crop of this experiment (Ghafoor *et al.,* 1992) and because of higher sodicity tolerance of rice (Verma and Abrol, 1980) who reported no paddy yield loss at ESP of 55. Again the poor effect of FYM on rice growth could be due to its anaerobic decomposition by-products (Inou, 1953 and Kitamura, 1955).

Chemical composition: The concentration of Na, Mg and Cl was higher in wheat grain with FYM than with phosphogypsum application (Table 2). These ions were in higher concentration where Ca:Mg ratio of 1:6 water was applied compared to that with Ca:Mg ratio of 1:4. The Ca behaviour was opposite to these ions in response to the amendments or Mg concentration in irrigation water. This reflects antagonism of Mg for Ca assimilation but stimulation for Na, Mg and Cl assimilation (Davidescu and Davidescu, 1982). However, the concentration of these ions remained lower than the critical levels reported by Soper (1985).

These ions were present in wheat straw at much higher concentration than that in grain (Table 2) suggesting that most of the absorbed ions were retained in straw perhaps due to decreased translocation within plant by higher Mg (Ohno and Grunes, 1985). In general, the response of Na, Ca, Mg and Cl concentration to the tested treatments was almost similar to that in wheat grain.

The concentration of Na, Ca, Mg and Cl in rice grain and straw are shown in Table 3. The perusal of the data reveals ionic distribution similar to that in the case of wheat (Table 2). There was higher Na, Mg and Cl but lower Ca percentage in paddy and straw with FYM than that with phosphogypsum with Ca:Mg ratio of 1:6 than those with Ca:Mg ratio of 1:4 in brackish water. Similar to wheat, all these ions were present at higher concentration in straw than paddy. Similar results were reported by Chaudhry *et al.* (1986) and Ghafoor *et al.* (1990 and 1991).

On the basis of these results, the use of brackish water having Ca:Mg ratio up to 1:6 to grow wheat and rice during reclamation of saline-sodic soils with chemical or organic amendments could be considered safe. Since most of the native groundwaters have Ca:Mg ratio of less than 1:6, their use for soil reclamation may help save canal water for good soils.

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