

EFFECT OF SALINE WATER WITH VARYING LEVELS OF SAR AND Ca : Mg RATIOS ON GROWTH AND YIELD OF WHEAT AND SOIL PROPERTIES

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ABSTRACT

Effect of different Ca : Mg ratios, SAR levels and two salinity levels of irrigation water were studied on growth and yield of HD 1593 wheat (*Triticum aestivum* L.) and properties of soil. Plant height, number of spikelets and grains/spike and grain yield/barrel were markedly affected with poor quality waters. Depression in grain yield was maximum (56.9%) with EC of 10 m mhos/cm and least (40.0%) with Ca : Mg ratio of 1:8 over control. Although main effects of SAR and Ca : Mg ratios were non-significant for all the traits yet additional yield losses occurred with the higher levels of salinity. Higher values of SAR and Mg/Ca ratios also drastically affected grain yield. There was more salt build-up with saline water than with SAR values and Ca : Mg ratios. Na content increased dramatically in all the treatments, whereas Ca and Mg were maximum at EC 10 m mhos/cm but their high contents were associated to the lower levels of SAR and Ca : Mg ratios. Mg was twice to that of Ca at SAR 10 having Ca : Mg ratio of 1 : 8 and EC 10 m mhos/cm whereas the same was 1 : 1 in other treatments. Contents of Cl and SO₄ rose considerably with salinity levels, however remained unchanged with other treatments.

INTRODUCTION

Salinity is a common problem for agriculture throughout the world and is a matter of serious concern to many countries. However, in arid, semi-arid and coastal zones of India, this menace is mainly characterized with the poor quality underground water. In considerable pockets of these areas, poor quality underground waters contain high Mg : Ca ratio and sodium hazard due to high SAR. Due to non-availability of alternate good quality waters from the secondary sources, these waters are very often used for irrigation purpose. Application of the same is likely to result in higher concentration of Mg and Na at the exchange site of irrigated lands (Girdhar and Yadav, 1980). High Mg content of these sites results in the deterioration of physio-chemical properties of the soil (Klages, 1966; Khan, 1975) and affects the growth and yield of plants (Girdhar and Yadav, 1982). There is therefore, a need to ascertain the role of

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Mg-rich water on crop growth and soil properties. However, compared to the importance, information on these aspects particularly, impact on growth and yield of crop plants is quite meagre. Hence, it was desired to initiate a study to assess the effects of different Mg : Ca ratios and SAR values of synthetic saline waters on growth and yield of wheat and soil properties.

MATERIAL AND METHODS

Present study was conducted in bottomless RCC barrels (1 m long and 1.4 m diameter). These barrels were embedded in the soil upto a depth of 90 cm without disturbing the soil profile. A heavy initial irrigation with good quality water was applied to stabilize the soil. A factorial randomized block design with 3 replications was adopted. Thirteen different qualities of irrigation waters having two salinity levels (5 and 10 m mhos/cm), two SAR levels (10 and 50) and three Ca : Mg ratios (1:1, 1:4 and 1 : 8) and control (de-ionised water with EC 0.05 to 0.09 m mhos/cm) were used in this study. Canal water (EC 0.6 m mhos/cm) was used to prepare these waters. In preparing these waters, Cl, SO₄ and HCO₃ anions were used in the ratio of 2 : 1 : 1, respectively. Requisite quantity of certain salts, viz. CaCl₂, MgCl₂, Na₂SO₄, NaHCO₃ and NaCl were dissolved in pre-determined quantity of water for each barrel. Experimental soil, was in general, characterized by pH (1.2 soil-water ratio) 9.1, ECe 3.6 m mhos/cm, organic matter 0.60%, CEC 10.4 meq/100 g, hydraulic conductivity 1.06 cm/hr, SAR 7.0 and sandy loam texture (Table 1).

Table 1. Initial properties of the experimental soil

Property	0-10	Soil depth (cm)	
		20-30	30-60
Mechanical			
Sand (%)	70	60	54
Silt (%)	14	20	22
Clay (%)	16	20	24
Free CaCO ₃	0.75	1.00	0.75
Hydraulic conductivity (cm/hr)	1.13	1.13	0.92
PH (1:2.5)	9.0	9.3	9.1
CEc (meq/100 g)	9.4	10.0	11.9
ECe (m mhos/cm)	2.9	3.6	4.5
Cations (meq/l)			
Ca ⁺⁺	2.2	2.4	2.4
Mg ⁺⁺	2.5	0.5	0.6
Na ⁺	30.2	30.5	40.2
K ⁺	0.24	0.20	0.21
Anions (meg/l)			
CO ₃ ⁻	1.2	0.7	1.6
HCO ₃ ⁻	4.7	5.0	5.5
Cl ⁻	17.0	17.2	25.0
SO ₄ ⁻	12.5	10.7	11.3

Seven seeds of HD 1593 wheat (*Triticum aestivum* L.) were sown in each barrel and the plants were maintained as such. In all 5 irrigations, of 6 cm each, were given during the cropping period. Observations were recorded on per cent emergence, number of tillers/barrel, grain and dry matter yield/barrel (g); all surviving plants were included to record observations on plant height (cm), number of spikelets/spike, number of grains/spike and 1,000-grain weight (g). Usual agronomic practices with N, P and K at 120, 60 and 60 kg/ha, respectively, were used. The crop was sown on November 26, 1980 and harvested on April 9, 1981. Recommended methods were used for soil and water analysis (Richards, 1954).

RESULTS AND DISCUSSION

Compared to control, the means for plant height, number of spikelets and grains/spike and grain yield/barrel decreased significantly with the application of poor quality water (Table 2). Plant height was adversely affected with a significant margin at SAR 50, Ca:Mg ratio of 1:8 and EC 10 m mhos/cm of the irrigation water vis-a-vis control. Moreover, a reduction by 11.3, 13.4 and 15.9% at SAR 50, Ca:Mg ratio of 1:8 and EC 10 m mhos/cm over control lime lights that the latter type of quality water proved more hazardous than the formers for this trait.

Number of spikelets/spite appeared to be more prone to the brackish water since marked reductions were noted at SAR 10, Ca:Mg ratio of 1:1 and EC above 5 cm mhos/cm. Contrary to it, however, grains/spike were affected with a significant margin at SAR 50, Ca:Mg ratio of 1:4 and EC of 10 m mhos/cm. Of the three qualities of irrigation water compared to control, reduction was maximum at EC 10 m mhos/cm (13.1 %) and minimum with SAR 50 (10.7%). More adverse effects of salinity than those of SAR are on records on plant traits (Paliwal and Mehta, 1973; Tripathi and Pal, 1979). It may be pointed out that decreased number of spikelets seemed to be compensated by increased fertility at the initial levels of the poor quality water types.

Marked depression in grain yield was noted at SAR 50, Ca:Mg ratio of 1:4 and EC 10 m mhos/cm; the same was maximum (56.9%) for EC 10 m mhos/cm and least (40.0%) for Ca:Mg ratio of 1:8. Results of Girdhar and Yadav (1982) on wheat fall in line with these results that yield decreased markedly with rising SAR, Mg/Ca ratios and salinity levels. Depression in yield of highest magnitude at EC 10 m mhos/cm could be postulated to manifold increase in the content of Na and Cl and decrease in K in the root zone soil (Table 5) which might have led to more osmotic pressure and thereby resulting in the inhibition of water intake. Yield reduction due to higher Mg/Ca ratio might have been due to soil deteriorating effect of Mg and its excessive absorption resulting in deficiency of Ca and K in the plants (Paliwal, 1972). Mention of Strogonov (1964) May also be made in this context that inhibitory effects of salts and SAR on plant growth resulted in the lack of poor utilization of

Table 2. Effect of different Ca : Mg ratios, SAR levels and the salinity of irrigation waters on growth and yield of HD 1593 wheat

Treatment	Emergence (%)	Plant height (cm)	No. of tillers/barrel	No. of spikelets/spike	No. of grains/spike	1000-grain weight (g)	Drymatter /barrel (g)	Grain yield/barrel (g)
Control	76.0	75.9	33.3	21.3	67.6	37.0	178.3	81.6
SAR levels								
10	64.8	67.9	24.9	19.2	60.2	35.1	134.1	58.7
50	52.5	67.3	27.1	19.0	58.3	34.1	123.6	47.8
Ca : Mg ratios								
1 : 1	57.0	68.5	27.5	19.3	16.3	35.3	140.0	55.4
1 : 4	53.8	68.7	27.6	19.7	58.8	34.0	117.9	48.0
1 : 8	65.2	65.7	22.8	18.5	57.7	34.5	128.7	48.9
Salinity (m mhos/cm)								
5	66.5	71.5	30.2	19.8	61.5	36.5	159.1	66.5
10	50.8	63.8	21.8	18.5	57.0	32.2	98.6	35.1
SEm ± (control vs treatments)	13.8	3.14	5.96	0.77	3.77	1.56	9.90	10.4
CD 5%	NS	9.16	NS	2.24	10.97	NS	NS	32.02
SEm ± (SAR)	5.7	1.28	2.44	0.31	1.54	0.64	10.78	4.48
CD 5% "	NS	NS	NS	NS	NS	NS	NS	NS
SEm ± (Ca : Mg)	6.8	1.57	2.98	0.38	1.88	0.78	13.20	5.49
CD 5% "	NS	NS	NS	NS	NS	NS	NS	NS
SEm ± (Salinity)	5.7	1.28	2.44	0.31	1.54	0.64	10.78	4.48
CD 5% "	NS	3.73	7.09	0.91	4.48	1.85	30.77	13.07

carbohydrates and nitrogenous substances, their accumulation in the plants caused stunted growth and reduced yields.

Non-significant impacts of three types of poor quality waters on emergence and number of tillers confirm moderate salt tolerance nature of wheat (Mass and Hoffman, 1977). Moreover, waters of EC¹⁰ m mhos/cm, Ca:Mg, ratio of 1:8 and SAR 50 yielded very poor salt build-up (4.2, 3.4 and 3.0 m mhos/cm, respectively) in 0-15 cm soil depth (Table 5). The same was due the first year of this experiment and secondly, due to rainfall (41 mm) during November and December. This is quite obvious that emergence and the tiller number, the chief traits of wheat under salinity (Bernstein, 1964) would not be reduced at EC of 3.0 to 4.2 m mhos/cm of soil extract.

Interactions : All the interactions for the traits studied, including grain yield, were non-significant. Paliwal and Mehta (1973) also found that interaction between SAR and salinity levels were non-significant for germination and growth of paddy. Interaction for yield, however, gives useful information. Grain yield decreased considerably with a rise in salinity level on the one hand and the levels of SAR and Mg/Ca ratios on the other (Table 3). For instance, compared to control, decline in yield at EC 10m mhos/cm was observed 52.4 and 61.6% at SAR 10 and 50, respectively. Similarly, yield reduced by 47.9, 56.1 and 66.9% with Ca:Mg ratio of 1:1, 1:4 and 1:8, respectively at EC 10 m mhos/cm over control. Higher level of salinity, therefore, proved very hazardous when encountered with higher levels of SAR and the higher ratios of Mg:Ca. Adverse effects of salinity on grain yield appear to be greatly magnified with higher ratios of Mg to Ca because of soil deteriorating properties of Mg and deficiency of Ca and K in the grains (Girdhar and Yadav, 1982).

Table 3. Effect of different levels of SAR, Ca: Mg ratios and salinity of irrigation water on grain yield of HD 1593 wheat

SAR/Ca:Mg ratios	Grain yield (g/barrel)		Per cent decrease over control	
	Ec 5	Ec 10	Ec 5	Ec 10
SAR levels				
10	68.5	38.8	16.0	52.4
50	64.4	31.3	21.0	61.6
SEm±	6.34			
CD 5%	NS			
Ca:Mg ratio				
1:1	68.3	42.5	16.2	47.9
1:4	60.3	35.8	26.1	56.1
1:8	70.8	27.0	13.2	66.9
SEm±	7.76			
CD 5%	NS			

Interesting observation on the interaction between the levels of SAR and the ratios of Ca:Mg was that yield was maximum at the initial levels of these types of water (Table 4) and yield reduction was only 17% at these levels over control. Lower level of SAR (10) and Ca:Mg (1:4) were, therefore, very critical for grain yield in wheat.

Table 4. Effect of different levels of Ca:Mg ratio and SAR on grain yield of HD 1593 wheat

Ca:Mg ratio	Grain yield (g/barrel)		Per cent decrease over control	
	SAR 10	SAR 50	SAR 10	SAR 50
1:1	67.50	43.3	17.2	46.9
1:4	46.1	50.0	43.5	38.7
1:8	47.5	50.3	41.7	38.3
SEm±	7.71			
CD 5%	NS			

Soil properties : Data pertaining to pH, EC, cations and anions of soil after the crop harvest are presented in Table 5. It is evident from the data that salt build up increased with the salinity of irrigation water where it rose from 0.5 EC in control to EC 4.2 in the application of 5 irrigations of water possessing EC 10 m mhos/cm. Salt content with SAR slightly increased in comparison to control yet magnitude at 50 SAR over 10 SAR could not be recorded. Similarly, salt content considerably increased in Ca : Mg ratio of 1:1 over control, it however remained unchanged thereafter.

Among the cations, the contents of Na increased with rising levels of different quality of irrigation water. For instance, increases of 353.8, 705.7, 542.8, 554.2, 631.4, 311.4 and 842.8% were recorded at SAR 10 and 50; Ca:Mg ratios of 1:1, 1:4 and 1:8; and EC 5 and 10 m mhos/cm, respectively over control. On the contrary, contents of Ca and Mg were maximum at the higher level of salinity and at lower levels of SAR and Ca: Mg ratio. Mg was twice to that of Ca at SAR 10, Ca: Mg ratio of 1:8 and EC 10 m mhos/cm whereas at other levels Ca:Mg remained almost 1:1.

The contents of Cl and SO₄ increased with the salinity of irrigation water, they remained unaffected with rising levels of SAR and Mg/Ca ratios. Thus, higher salinity of the soil extract of EC 5 and 10 m mhos/cm water could be ascribed mainly to the establishment of Na and Cl type of ions. Moreover, very high Na and Cl ions would not be unexpected in view of their higher level in the irrigation water. Such higher Na content may be of great harm to the plants because of direct toxicity and nutritional imbalance due to Na under saline conditions are well documented.

Table 5. Effect of Mg rich waters of different salinity on pH (1: 2), EC, cationic and anionic composition of soil extract after the harvest of crop

Treatment	Soil depth (cm)	pH (1:2)	EC (m mhos/cm)	Cations (meq/l)				Anions (meq/l)						
				Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	Co ₃ ⁼	Hco ₃ ⁻	Cl ⁻	So ₄ ⁼			
SAR														
10	0-15	8.3	2.8	4.7	8.8	17.3	0.18	0.40	1.6	20.4	7.2			
	15-30	8.1	2.3	3.0	6.4	15.6	0.12	0.40	1.2	15.3	6.2			
50	0-15	8.3	3.0	2.5	2.4	28.2	0.11	0.40	1.0	20.7	9.8			
	15-30	8.3	2.3	2.0	2.5	18.4	0.08	0.30	1.6	14.6	6.8			
Ca : Mg ratio														
1 : 1	0-15	8.5	3.0	4.7	5.4	22.5	0.18	0.41	1.5	21.7	7.9			
	15-30	8.2	2.4	3.1	4.8	14.2	0.14	0.05	1.1	15.8	6.9			
1 : 4	0-15	8.3	3.4	3.4	5.2	22.9	0.12	0.45	1.4	20.6	8.2			
	15-30	8.3	2.2	2.3	2.6	17.2	0.08	0.55	1.3	14.0	6.9			
1 : 8	0-15	8.4	3.8	2.9	6.7	25.6	0.14	0.35	1.8	22.2	9.5			
	15-30	8.3	2.4	2.3	5.9	16.5	0.08	0.45	1.7	15.1	6.3			
Salinity (m mhos/cm)														
5	0-15	8.4	1.9	1.9	2.4	14.4	0.15	0.53	1.9	10.3	7.1			
	15-30	8.4	1.5	1.6	1.7	12.7	0.10	1.00	1.3	8.3	5.5			
10	0-15	8.3	4.2	5.2	8.4	33.0	0.14	0.40	1.8	32.7	10.0			
	15-30	8.1	3.2	3.5	7.0	21.4	0.10	0.33	1.4	21.6	7.5			
Control	0-15	8.7	0.5	1.0	0.0	3.5	0.51	0.4	2.3	1.8	3.9			
	15-30	8.6	0.4	1.4	0.4	3.2	0.30	0.4	2.0	1.7	3.8			

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