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MUTUAL EFFECTS OF SULPHUR AND ORGANIC MANURE ON CALCAREOUS SOIL PROPERTIES AND BARLEY PRODUCTIONS USING SALINE IRRIGATION WATER

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ABSTRACT

Barley is one of the important crops tolerant to environmental stresses such as salinity and drought conditions. The shortage of water for irrigation and increasing salinity in the irrigation water are the two main factors affecting agriculture productivity under Saudi Arabian conditions. A green house experiment was conducted to study the effect of sludge manure and sulphur application rates on the growth and mineral composition of barley plants as well as the ionic balance in calcareous soil irrigated with different saline waters. Results indicated that, the EC, SAR and pH values of the studied soil as well as the concentrations of soluble Ca^{2+}+ Mg^{2+}, Na^{+}, Cl^{-}, HCO_3^{-}, and SO_4^{2-} were significantly increased with increasing salinity levels of the irrigation water without amendments application. Also increasing the application rate of sludge manure relatively decreased soil pH values while increased soil EC, concentration of soluble ions and the availability of N, P, Fe, Mn, Zn and Cu. The rate of increase was quite different from one element to another; however, the highest increase was obtained at the higher application rate of sludge manure whether the soil was irrigated with tap water or saline water. In spite of SO_4^{2-} and Ca^{2+}+ Mg^{2+} ions, opposite trends were found at elemental sulphur treatments. The EC, SAR, pH values and the concentrations of soluble Na^{+}, Cl^{-}, and HCO_3^{-} were significantly decreased, whereas available N, P, Fe, Mn, Zn and Cu values were increased depending on the rate of elemental sulphur applied and salinity levels of the irrigation water.

Irrigation using saline water alone led to a significant decrease in barley dry matter yield, while the application of elemental sulphur and/or sludge manure either alone or in combinations significantly increased the dry matter yield of grains, straw and their contents of N, P, Fe, Mn, Zn and Cu. Mixing the highest rate of manure with the highest rate of elemental sulphur show the best treatment. Therefore, mixing sludge manure with elemental sulphur was quit good management practices for the improvement of calcareous soil coditions to obtain relatively high barley yields under saline water irrigation.

Keywords: calcareous soil, sludge manure, elemental sulphur, saline water, availability of N, P, Fe, Mn, Zn, & Cu, barley crop.

INTRODUCTION

Saudi Arabia agriculture facing two main environmental constraints that affecting the management practices in the soil. These constraints are the shortage of irrigation water and the existence of high salinity in the water. However, the use of saline water for irrigation has deleterious impact on many soil properties such as pH, ion exchange equilibrium and soil salinity. To avoid the hazards of salinity a fair number of investigations were conducted using some natural soil amendments such as gypsum and elemental sulphur. The other common natural amendments are; organic manure, natural clay deposits (Tafla), town refuse and sludge were used to improve the physico-chemical properties of the soil and in turn, its nutrients supplying power, (Wassif *et al.*, 1988; El - Gala *et al.*, 1990; Wassif *et al.*, 1995; Beheiry *et al.* 1997; El – Maghraby *et al.*, 1997; and Dahdoh *et al.*, 2000). The application of organic manures may have a role on; (a) improving soil aggregation and increasing water stable aggregates; (b) increasing soil water retention due to its effect on pore size distribution, i.e., water holding pores; (c) decreasing soil pH values which lead to increase nutrient availability and supply (Dahdoh and El-Hassanin, 1994); (d) stimulating biodegradation of organic manures through increasing the population and activities of soil microorganisms (Cifuentes and Lindemann,1993). Although, such materials were efficient under the uses of fresh water, there is a shortage in the information among the role of organic manure and elemental sulphur under the uses of saline water for irrigating calcareous soils. Kaplan et al (2005) found that the use of sulphur containing industrial waste on the soil with high $CaCO_3$ and clay content did not create heavy metals (Ni, Cr, Co and Cd) build-up or toxicity. Even after the application of the high level of waste (60 ton ha^{-1}), it could not be seen any important toxic element accumulation in sorghum plant. They add that repeated waste application would result in different heavy metal accumulation rates. The aim of the present work was to study the effect of varied and combined rates of sludge manure and elemental sulphur on some chemical properties and nutrients availability of calcareous soil under fresh and saline irrigation water for barley plants.

MATERIALS AND METHODS

Surface soil sample was collected from 0-30 cm depth from Derab Experimental Station, College of Food Sciences and Agriculture, King Saud University. Table (1) indicated some chemical and physical characteristics of the soil. In brief, soil was highly calcareous, very low in CEC and quite low in organic matter and available nutrients. The collected soil sample was air dried ground and sieved through a 2mm sieve. Organic manure was brought from El-Bustan Company to be used in the experiment. Table (1) showed that manure was relatively low in salinity and quite rich in macro and micronutrients. A factorial pot experiment (6-kg capacity) was conducted in the green house using different rates of elemental sulfur or organic manure and different irrigation water qualities. The applied treatments are: 1) Three rates of manure (% on w/w bases) namely: OM_1 (0 % addition), OM_2 (1% addition; w/w bases); and OM_3 (2% addition). 2) Three rates of elemental sulfer namely S_1, (0.0% addition), S_2 (0.1% addition) and S_3 (0.2 % addition). 3) Three levels of water salinity namely; tap water W_1 (300 ppm); W_2 (3000 ppm) and W_3 (6000 ppm). Irrigation water was artificially prepared from NaCl, $CaCl_2$ and $MgCl_2$ salts and has constant SAR value of 5. The sulphur or manure treatments were firstly mixed into the soil and incubated for 28 days under green house conditions. The experiment included 27 treatments (3 water salinity levels, 3 rates of elemental sulphur and 3 rates of organic manure) were arranged in a completely randomized block design with three replicates.

Table (1): Some physical and chemical characteristics of soil sample and sewage sludge

Characteristics	Soil Sample	Sludge Manure Sample
Particle size analysis		
% clay	10.0	-
% Silt	18.0	-
% sand	72.0	-
Texture Class	Sandy Loam	-
$CaCO_3$ (%)	48.3	-
Organic Matter (%)	0.20	41.7
CEC (Cmole/kg)	3.85	-
C:N Ratio	-	11
pH	7.57	7.20
EC (dS/m)	6.90	2.35
Soluble cations (meq/l)		
$Ca^{+2} + Mg^{+2}$	25.5	15.97
Na^{+}	40.3	5.68
K^{+}	3.22	2.32
Soluble Anions (meq/l)		
HCO_3^-	1.89	2.94
Cl^-	44.90	9.14
SO_4^{-2}	20.43	11.47
Available N (ug/g)	28.5	-
NH_4HCO_3-DTPA Extractable (ug/g)		DTPA Extr. (ug/g)
P	2.70	-
K	78.0	-
Fe	2.30	266.5
Mn	1.50	114.8
Zn	0.52	113.4
Cu	0.21	42.8
Total Nutrients		
N %	-	2.20
P %	-	0.40
K %	-	0.34
Fe (mg/kg)	4860	9250
Mn (mg/kg)	152	476
Zn (mg/kg)	44	351
Cu (mg/kg)	21	236

Barley seeds (20 seeds/ pot) were planted and thinned to 10 plants / pot after two weeks from cultivation. Irrigation was commenced weekly up to the field capacity of the soil plus 30%. At maturity, barley plants were harvested and the dry matter yields of both straw & grains from each treatment were estimated. Statistical analysis was completed according to (Snedecor and Cochran, 1973). Thereafter, plant samples from straw or grains were wet ashed with ternary acid mixture following the method reported by Van Schowenburg (1968). In the prepared acid extracts, total potassium was measured using Flame Photometer and phosphorus was determined colorimetrically using ascorbic acid method. Fe, Mn, Zn and Cu were determined using atomic absorption spectrophotometer (AAS). N was estimated using Kjeldahl method. A representative soil samples were collected from each replicate at the end of harvesting for chemical analysis of pH, EC, and soluble ions in the soil paste extract according to Rainwater and Thatcher, (1979) and Page *et al.*, (1982). Available N was determined according to the modified Kjeldahl method after Chapman and Pratt (1961). Available P, Fe, Mn, Zn and Cu were extracted by NH_4HCO_3-DTPA according to Soltanpour and Schwab (1977) then P was measured using colorimetric method while Fe, Mn, Zn, and Cu were measured using AAS.

RESULTS AND DISCUSSION

1- Effect of the experimental treatments on soil chemical properties:

Soil reaction: Results in Table (2) showed that soil pH values were increased relatively with increasing salinity levels of the irrigation water at no amendment application treatments. This indicated that, irrigation with saline water for long period, without adding soil amendments, will change the soil to be more alkaline depending on the quality of the used water (El-Maghraby *et al.*, 1997). Opposite trends were obtained either by adding sulphur or organic manure in single and / or in combined applications. It appears that application of elemental sulphur alone or in combination with organic manure was more effective in lowering soil pH. The positive effect of sulphur on reducing soil pH values may be due to the oxidation of sulphur by soil microorganisms which were able to produce sulphuric acid in amount enough to lower the soil pH (Cifuentes and Lindemann, 1993; and Guang *et al.*, 2001). This is in harmony with the results found by Hilal and El-Bagouri (1986) and Hashem *et al.*, (1992). They reported that decreasing soil pH was attributed to the acidic nature of the oxidation reactions of the applied sulphur in the soil. Also, addition of organic manure alone led to significant decrease in soil pH compared with the control treatment. The highest decrease in soil pH was more pronounced at the highest manure and elemental sulpher application rates 2 % and 0.2% respectively. The favorable effects of organic manure on lowering soil pH values may be rendered to the organic and inorganic acids formations as a result of organic manure decompositions by microorganisms which also contribute to sulphur oxidation (Dahdoh and El-Hassanin, 1994). The reduction in soil pH values due to manure applications agrees well with the findings of Dahdoh and El-Hassanin, (1994) and El Kassas *et al.*,(1997). They reported that increasing the rate of application of manure decreased soil pH values after harvesting growning plants. They added that, the high CEC of the organic matter in addition to its decomposition reactions in the presence of soil $CaCO_3$ could be a contributing factor to reduction of soil pH. Data denote also that, elemental sulphur and/ or manure applications were also effective in lowering soil pH at the studied levels of salinity of irrigation water. This means that, such materials can be successfully used for controlling the overall changes in soil chemical properties and avoiding the hazardous effects of raising soil pH caused by increasing irrigation water salinity.

Table (2) Effect of sulphur and manure on some chemical properties of the treated soil at three level of saline irrigation water

treatments			pH	EC dS/m	Soluble Cations			Soluble anions			SAR
Salinity	Manure	Sulphur			Ca^{+2} + Mg^{+2}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	
W_1	OM_1	S_1	7.61	7.61	27. 3	40. 8	8. 0	2. 6	48. 9	23.0	11.1
		S_2	7.04	5.00	29. 2	16. 3	4. 5	1. 2	18. 3	30.1	4.27
		S_3	7.00	4.78	28. 3	14. 6	4. 9	0. 9	14. 7	31.9	3.89
	OM_2	S_1	7.4	6.94	25. 5	35. 3	8. 6	1. 6	42. 8	24.8	9.89
		S_2	7.25	5.75	27. 4	23. 6	6. 6	1. 4	19. 3	36.5	6.38
		S_3	6.83	4.13	20. 4	16. 4	4. 6	0. 9	8. 6	31.3	5.14
	OM_3	S_1	6.78	8.70	33. 8	43. 2	10. 0	1. 9	53. 7	30.9	10.5
		S_2	6.75	6.05	34. 5	18. 7	7. 4	2. 1	13. 2	44.8	4.50
		S_3	6.64	5.38	32. 0	16. 3	5. 5	1. 0	10. 2	43.0	4.07
W_2	OM_1	S_1	7.83	14.23	49. 0	82. 9	10. 4	1. 4	113. 3	27.1	16.7
		S_2	7.02	13.02	61. 5	60. 1	8. 6	1. 4	83. 4	45.0	10.8
		S_3	6.88	9.77	70. 5	21. 5	5. 7	1. 7	44. 7	50.8	3.63
	OM_2	S_1	7.25	14.86	53. 9	83. 0	11. 7	2. 4	118. 2	27.5	16. 1
		S_2	7.19	12.60	55. 0	59. 6	11. 5	1. 7	81. 2	42.6	11.3
		S_3	6.98	9.47	45. 4	42. 1	7. 2	1. 8	57. 4	35.0	8.85
	OM_3	S_1	6.74	13.55	63. 1	62. 0	10. 4	2. 2	97. 0	35.8	11.1
		S_2	7.00	13.18	76. 8	46. 0	9. 0	1. 7	84. 0	45.3	7.42
		S_3	6.78	10.60	66. 9	30. 0	9. 2	2. 1	57. 6	45.5	5.18
W_3	OM_1	S_1	8.03	19.27	82. 0	104. 1	6. 5	1. 1	166. 9	23.9	16.3
		S_2	7.12	15.11	101. 3	46. 0	3. 8	1. 1	107. 7	41.5	6.46
		S_3	6.85	12.25	83. 6	33. 6	5. 3	1. 4	74. 9	45.4	5.19
	OM_2	S_1	7.12	17.33	109. 4	53. 8	10. 2	1. 4	142. 3	28.9	7.28
		S_2	6.95	16.77	111. 0	46. 5	10. 2	1. 7	126. 9	38.2	6.25
		S_3	6.76	14.01	102. 9	31. 3	5. 9	1. 0	98. 5	39.8	4.36
	OM_3	S_1	7.02	18.61	83. 0	90. 7	12. 5	1. 9	145. 9	37.5	14.1
		S_2	6.69	15.68	97. 3	51. 5	7. 0	1. 7	104. 2	50.0	7.39
		S_3	6.62	15.67	103. 2	44. 8	8. 7	1. 2	104. 4	50.2	6.24
LSD at 0.05 % level											
Salinity (A)			0.092	1.094	8.690	4.340	0.917	0.212	12.84	2.336	0.60
Manure (B)			0.092	1.094	8.690	4.340	0.917	0.212	12.84	2.336	0.60
Sulpher (C)			0.092	1.094	8.690	4.340	0.917	0.212	12.84	2.336	0.60
A × B			0.159	1.895	15.04	7.520	1.588	0.366	22.24	4.047	1.04
A × C			0.159	1.895	15.04	7.520	1.588	0.366	22.24	4.047	1.04
B × C			0.159	1.895	15.04	7.520	1.588	0.366	22.24	4.047	1.04
A × B × C			0.276	3.283	26.06	13.02	2.750	0.634	38.52	7.009	1.80

Soil Salinity: Data in Table (2) showed that, the EC and SAR values of the studied soil, as well as the concentrations of soluble (Ca^{2+}+ Mg^{2+}), Na^{+}, Cl^{-}, HCO_3^{-}, and SO_4^{2-} were remarkably increased with increasing salinity levels of the applied water without amendment applications. This is mainly due to the continuous applications of saline water during plant growth. However, when soil amendments were applied opposite trends was obtained, for example the EC and SAR values of the (S_3) sulphur treatment alone were decreased by 11.5 and 48.5% as compared with the control treatment (S_1, OM_1, W_1). Also, the concentrations of soluble Na^{+}, Cl^{-}, and HCO_3^{-} were significantly decreased due to sulphur applications (except for SO_4^{2-} & Ca^{2+}+ Mg^{2+}),. The favorable effect of sulphur on reducing soil salinity may be due to its role on increasing the solubility of ions, along with increasing the infiltration rate of the soil (Alawi *et al.*, 1980). Consequently, more soluble salts can be moved downward at the following irrigation. The role of sulphur is also attributed to its effect on releasing Ca^{++} and $SO_{4=}$ ions due to sulphur transformation in the presence of $CaCO_3$. This leads to the exchange of Ca^{++} ions on the exchange complex and the increase of Na^+ and Cl^- ions in the leachates ((Khafagi and Abdel Hadi,1990). Concerning the effect of manure treatments, data clearly indicated that, increasing the application rate of sludge manure increased the EC values and the concentrations of soluble (Ca^{2+} + Mg^+), Na^+, Cl^-, HCO_3^-, and SO_4^{2-}. This is more pronounced under the highest application rate (2%) of sludge manure. The increase in EC values may be attributed to the release of some ions due to the decomposition of manure by microorganisms (Dahdoh and El- Hassanin, 1994). This was true under irrigation either with tap water or with saline water. Also, the relatively high salt content of the used organic manure (Table, 1) may contribute to increasing EC of the treated soil samples. Such results were confirmed by the interactions between the sulphur and sludge manure, as the application of manure emphasized the role of sulphur on decreasing soil salinity. This was true for the soil samples irrigated with tap or saline waters. The combined applications of the two amendments were also effective on reducing soil salinity at any salinity level of the applied water. This could be attributed to the effects of organic manure and / or sulphur on improving some physical properties of the soil, which in turn facilitate salt leaching. In addition, manure amendments have high cation exchange capacity, which leads to the preferential exchange of divalent ions over monovalent ones, which also improve salt leaching and consequently decrease soil salinity and soluble ions. Such effect was clearly shown as the concentration of Na ions significantly decreased with the increase of sulphur and manure applications.

Availability of nutrients: Data in Table (3) revealed that, irrigation with saline water alone reduced the availability of soil N, P, Fe, Mn, Zn and, Cu. This was more pronounced under high salinity levels. The reduction in available soil P may be explained by the competition between Cl and phosphate ions. Also the antagonistic relationships between (Fe &Mn), (Cu & Zn) may explain the reduction of Cu due to salinity treatments (Moussa *et al.*, 1996, Dahdoh & El Hassanin, 1994). On the other hand, soil amended with sludge manure alone, increased the availability of soil N, P, Fe, Mn, Zn and Cu. The rate of increase was quite different from one element to another, however the highest values were found with the higher application rate of sludge manure when the soil was irrigated either with tap water or saline water having total salinity up to (6000 ppm). For example, the highest rate of increment over the control (W_1, OM1, S1) due to 2% application rate of sludge manure reached 262.4, 239.5, 267,169,476.8 and 182.6% for N, P, Fe, Mn, Zn, and Cu respectively.

This may be rendered to the biodegradation of sludge manure by soil microorganisms, having higher initial content of such nutrients (Table, 1). These results are supported by the data obtained by Hashem *et al.*, (1992) and Beheiry *et al.*, (1997), who attributed total soil nitrogen increase to organic manure application or to the enhancement of soil organic matter through higher root mass. On the other hand, organic manure decomposition will result in reducing soil pH values by organic and inorganic acids which may chelate Ca ions and contribute to increasing availability of soil P. Singh and Dahiya, (1980); Hilal and El-Bagouri, (1986); and Dahiya and Singh, (1980), reported that increasing P concentration due to organic manure application could partly be due to the release of organic acids which enhance the solubility of native P in the soil. Furthermore, they reported that bicarbonate ions formed from organic matter decomposition might have increased P availability through ion exchange phenomenon.

Table (3) Effect of sulpher and manure on the availability of some nutrient in calcareous sansdy soil the treated soil under saline irrigation water

treatments								
Salinity	**Manure**	**Sulfur**	**N**	**P**	**Fe**	**Mn**	**Zn**	**Cu**
W_1	OM_1	S_1	33.8	2.38	2.15	2.79	0.82	0.23
		S_2	47.6	4.82	3.69	5.77	1.10	0.37
		S_3	58.8	4.87	4.23	6.96	1.08	0.46
	OM_2	S_1	66.4	4.53	7.41	4.09	2.53	0.56
		S_2	86.7	7.31	8.65	7.87	4.48	0.75
		S_3	97.1	8.41	8.09	9.19	5.14	1.09
	OM_3	S_1	122.5	8.08	7.89	7.99	4.73	0.65
		S_2	126.1	10.89	10.97	8.77	5.26	0.84
		S_3	148.7	13.70	11.57	9.42	7.79	1.09
W_2	OM_1	S_1	18.7	2.17	2.12	2.41	0.80	0.21
		S_2	49.9	5.63	3.73	6.11	1.24	0.42
		S_3	60.3	8.06	4.25	7.69	1.19	0.61
	OM_2	S_1	84.9	5.22	5.30	3.59	4.30	0.47
		S_2	92.4	7.24	7.25	4.90	6.53	0.91
		S_3	128.7	8.29	7.42	5.90	7.41	1.05
	OM_3	S_1	49.2	4.89	6.01	4.99	6.21	0.72
		S_2	81.9	8.97	7.42	6.27	7.26	0.89
		S_3	126.7	12.68	8.19	7.42	7.53	0.82
W_3	OM_1	S_1	18.2	2.09	2.04	2.26	0.53	0.21
		S_2	38.7	2.63	4.57	6.65	1.19	0.88
		S_3	53.5	5.28	5.34	7.11	1.33	0.91
	OM_2	S_1	52.6	4.39	4.93	4.79	5.89	0.76
		S_2	76.5	6.03	6.86	6.63	7.10	0.97
		S_3	136.3	8.84	9.29	6.98	9.04	0.91
	OM_3	S_1	76.1	4.61	5.95	5.32	6.05	0.78
		S_2	140.0	5.34	7.73	7.11	8.22	0.81
		S_3	154.5	987	9.22	7.71	6.64	1.13
LSD at 0.05% level								
Salinity (A)			7.008	1.02	0.342	0.470	0.268	0.045
Manure (B)			7.008	1.02	0.342	0.470	0.268	0.045
Sulpher (C)			7.008	1.02	0.342	0.470	0.268	0.045
A × B			12.139	1.766	0.593	0.814	0.465	0.079
A × C			12.139	1.766	0.593	0.814	0.465	0.079
B × C			12.139	1.766	0.593	0.814	0.465	0.079
A × B × C			21.025	3.059	1.027	1.411	0.805	0.136

Similar trends were obtained when the soil was amended with elemental sulphur alone; as the available soil N, P, Fe, Mn, Zn and, Cu was significantly increased with increasing sulphur application rate. This trend was true weather the soil was irrigated with fresh or saline water (6000 ppm). It may be due to the influence of sulphur on reducing soil pH (Table 2) or to the release of phosphate ions from soil collides by sulphate ions (El-Gala *et al.*, 1989). The results were confirmed by the interaction effects between (Sulphur & organic manure); (Sulphur & salinity levels); (Salinity & organic manure) (Sulphur & organic manure & salinity levels), which indicates that there was a wide variation among the lowest and highest values of the studied elements due to salinity of irrigation water along with the rate of applying sulphur and / or sludge manure. In most elements the highest values are found when the soil was treated with 2% manure and 0.2% elemental sulphur at any level of salinity of irrigation water. Therefore, mixing sludge manure with elemental sulphur when applied to calcareous soil creates conditions suitable for increasing the availability of plant nutrients even under saline water irrigation.

2- Effect of treatments on dry matter yield of barley plants:

Data in Table (4) show that irrigation with saline water alone led to a significant decrease in the grain and straw yields of barley plants. The rate of reduction below the control treatment (Tap water, W_1) reached 13.48&28.1% for grains and 9.41 & 24.31% for straw due to irrigation with W_2 &W_3 salinity levels, respectively. The reduction occurred in the dry matter yields were mainly attributed to the deleterious effects of salinity on growth, physiological processes and metabolic activities of growing plants. Also, it may be due to the harmful effect of salinity on soil moisture stress and nutrient balance disorder in the root medium (Dahdoh *et al.*, 2000). On the other hand, the application of organic manure alone significantly increased the dry matter yields of both grains and straw. The rate of increment over the control (W1 OM_1) reached 9.51 & 17.43 % for the yields of grains, while it reached 11.37 & 30.98 % for straw due to the application of 1 & 2% sludge manure respectively.

The positive effect of manure on increasing dry matter yields of barley plants under the experimental conditions could be due to the following : a) improving some physical properties of the soil such as aggregation and water stable aggregates (El- Maghraby *et al.*, 1997); (b) increasing soil water retention due to its effect on pore size distribution, i.e., water holding pores; (c) decreasing soil pH values (Table, 2) which lead to increasing nutrient availability (Table, 3), (d) stimulates biodegradation through increasing the population and activities of soil microorganisms (Cifuentes and Lindemann,1993). The application of elemental sulphur alone significantly increased both grains and straw yields of barley compared to the control treatment. The percentage increase over the control (W_1 OM_1 S_1) for 0.1 & 0.2 % elemental sulphur treatments was 10.3 & 25.9 % for barley grains and 41.6 & 66.1 % for barley straw. The favorable effect of sulphur on increasing dry matter yields of barley could be due to its effects on reducing soil pH and increasing the availability of certain plant nutrients. The above mentioned results were confirmed by the interaction among the studied treatments, as the yields of both straw and grains of barely plants were significantly increased depending on either the rate of applying sulphur and / or sludge manure. Generally mixing the highest rate (OM_3 , 0.2 %) of manure with the highest rate of elemental sulphur (S_3, 0.2 %) into calcareous soil could be a good management practices for reducing the hazard effects created by salinity of irrigation water.

Table (4):Yield of barley plants as affected by sulphur and sludge manure under saline irrigation

Treatments			Yield (gm)		
Salinity	**Manure**	**Sulfur**	**Grain**	**Straw**	**Total**
W_1	OM_1	S_1	5.05	5.10	10.14
		S_2	5.57	7.22	12.79
		S_3	6.36	8.47	14.82
	OM_2	S_1	5.53	5.68	11.21
		S_2	7.40	6.52	13.92
		S_3	7.79	5.79	13.59
	OM_3	S_1	5.93	6.68	12.61
		S_2	6.38	7.24	13.62
		S_3	6.72	7.50	14.22
W_2	OM_1	S_1	4.45	4.62	9.17
		S_2	5.39	6.14	11.53
		S_3	6.00	6.28	12.28
	OM_2	S_1	6.02	6.88	12.90
		S_2	6.88	6.80	13.68
		S_3	6.97	6.37	13.33
	OM_3	S_1	6.05	6.49	12.54
		S_2	7.83	6.61	14.44
		S_3	8.48	7.07	15.55
W_3	OM_1	S_1	3.63	3.86	7.49
		S_2	6.52	7.29	13.80
		S_3	6.89	7.58	14.47
	OM_2	S_1	4.59	7.06	11.65
		S_2	5.70	7.19	12.89
		S_3	6.93	7.24	14.17
	OM_3	S_1	5.52	5.11	10.63
		S_2	6.84	6.89	13.74
		S_3	7.11	7.11	14.22
Salinity (A)			0.419	0.394	0.807
Manure (B)			0.419	0.394	0.807
Sulphur (C)			0.419	0.394	0.807
A × B			1.043	0.683	1.398
A × C			1.043	0.683	1.398
B × C			1.043	0.683	1.398
A × B × C			1.680	1.830	2.421

3- Effect of treatments on nutrient contents of barley grains: The concentrations of N, P, K, Fe, Mn, Zn and, Cu in the grains of barley plants were affected negatively, with different magnitudes, by saline irrigation water

(Table, 5).However, the individual applications of either sludge manure or sulphur, resulted in significant increases in the concentration of N, P, K, Fe, Mn, Zn and, Cu in barley grains. Such increases were more pronounced with increasing the application rates of either manure or sulphur at any of the studied levels of irrigation water salinity. The combined applications of the two amendments under investigation gave higher concentrations of the nutrients in the grains of barley. The efficiency of the studied materials was varied in accordance to the type and rate of the applied amendments and/ or salinity level of irrigation water. The positive effect of sulfur and/or sludge manure on increasing the content of nutrients could be to the improvement of physical and chemical properties of the calcareous soil.

Table (5): Nutrient content of barley grains as affected by sulphur and sludge application under saline irrigation water.

treatments			%			(ug/g)			
Salinity	Manure	Sulfer	N	P	K	Fe	Mn	Zn	Cu
W_1	OM_1	S_1	2.02	0.34	1.17	194.0	24.67	25.33	14. 0
		S_2	2.10	0.38	1.29	218.0	32.67	36.00	14. 7
		S_3	2.20	0.37	1.35	224. 7	39.33	38.67	15. 3
	OM_2	S_1	2.16	0.36	0.92	133.3	26.00	40.00	17. 3
		S_2	2.21	0.40	1.25	151.3	27.33	54.67	20. 0
		S_3	2.17	0.39	1.27	170.0	36.00	54.67	22. 0
	OM_3	S_1	2.24	0.43	1.22	129.3	33.33	49.33	14. 7
		S_2	2.27	0.38	1.39	156. 7	40.00	57.33	31.3
		S_3	2.29	0.39	1.52	171. 3	42.00	60.67	30. 0
W_2	OM_1	S_1	1.52	0.31	1.13	175.3	28.67	23.57	12. 7
		S_2	2.25	0.41	1.29	193.3	40.67	34.2	13.3
		S_3	2.13	0.42	1.44	204.0	45.33	42.33	14. 7
	OM_2	S_1	1.97	0.34	1.31	110. 7	17.33	51.33	8.67
		S_2	2.13	0.35	1.43	141. 3	24.67	61.33	9.76
		S_3	2.30	0.42	1.71	176. 7	29.33	63.33	16. 0
	OM_3	S_1	1.86	0.38	1.40	128. 7	32.67	59.33	11. 3
		S_2	2.15	0.39	1.49	134. 7	36.67	54.00	12. 7
		S_3	2.20	0.39	1.77	168. 0	46.00	66.67	15. 3
W_3	OM_1	S_1	1.05	0.29	1.02	98.0	20.00	22.00	7.33
		S_2	2.17	0.33	1.15	112.0	21.33	30.00	13.3
		S_3	2.28	0.31	1.26	128. 7	30.00	51.33	14. 7
	OM_2	S_1	1.87	0.30	1.10	95.0	11.33	48.67	8.67
		S_2	1.95	0.40	1.34	100. 7	21.33	56.67	11.3
		S_3	2.06	0.38	1.20	158. 0	22.00	67.33	16. 7
	OM_3	S_1	2.21	0.37	1.21	166. 0	15.33	44.67	9.67
		S_2	2.27	0.39	1.37	176. 7	22.00	53.33	12. 7
		S_3	2.31	0.42	1.34	180.67	24.00	57.33	18. 0
LSD at 0.05% level									
Salinity (A)			0.146	0.016	0.026	7.145	2.437	2.501	3.553
Manure (B)			0.146	0.016	0.026	7.145	2.437	2.501	3.553
Sulpher (C)			0.146	0.016	0.026	7.145	2.437	2.501	3.553
A × B			0.253	0.028	0.044	8,961	4.221	4.332	6.153
A × C			0.253	0.028	0.044	8.961	4.221	4.332	6.153
B × C			0.253	0.028	0.044	8.961	4.221	4.332	6.153
A × B × C			0.439	0.049	0.077	21.461	7.312	7.503	10.657

The higher values of nutrient concentrations of N, P, K, Fe, Mn, Zn and Cu are associated with the highest rate of manure (2%) and elemental sulphur (0.2%) at the studied irrigation water salinity.

From the above-mentioned results, it can be concluded that, elemental sulphur and / or sludge manure can be successfully used for minimizing the hazard effects of saline irrigation water. It is good enough to mix such materials into calcareous soils to obtain high quantity and quality of the grown plants. Therefore, one can conclude the importance of using elemental sulphur with sludge manure in improving calcareous soil properties and enhancing its productivity even under high salinity level of irrigation water.

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التأثيرات المتبادلة للكبريت والسماد العضوى على خواص التربة الجيرية وانتاج الشعير تحت ظروف مياه الرى المالحة

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يعتبر الشعير من المحاصيل المقاومة للإجهادات البيئية مثل ظروف الملوحة والجفاف.

ويعتبر النقص فى مياه الرى وارتفاع ملوحة المياه من أهم العوامل المؤثره على انتاجية المحاصيل فى المملكة العربية السعودية. أقيمت تجربة أصص لدراسة تأثير معدلات السماد العضوى (سماد الحمأة) والكبريت على بعض خواص التربة الجيرية ونمو ومحتوى نباتات الشعير من العناصرالغذائية. أوضحت النتائج حدوث زيادة معنوية فى قيم EC ، وال p H ، SAR وفى تركيزات Ca^{2+}+ Mg^{2+} , Na^{+}, HCO_3^{-}, Cl^{-} ال SO_4^{2-} مع زيادة ملوحة مياه الرى المستخدمة. وأدت زيادة معدلات سماد الحمأة المستخدمة الى انخفاض نسبى فى p H التربة وزيادة فى ال EC وكذلك زيادة الصورة الميسرة من العناصر الغذائية التالية: Fe, Mn, Zn, Cu , P, N وتفاوتت معدلات الزيادة حبث كانت اعلى القيم فى معدلات الاضافة العالية من السماد العضوى سواء فى حالة مياه الرى منخفضة الملوحة أو مرتفعة الملوحة. لوحظ انخفاض معنوى فى تركيزات Ca^{2+}+ Mg^{2+} , SO_4^{2-} فى معاملات الكبريت وزادت الصورة الميسرة من العناصر الغذائية التالية: Fe, , P, N Mn, Zn, Cu وتفاوتت معدلات الزيادة مع زيادة معدلات إضافة الكبريت. أدى استخدام المياه مرتفعة الملوحة فقط الى انخفاض معنوى فى محصول المادة الجافة بينما أدت اضافة الكبريت وسماد الحمأة سواء فى صورة منفردة أو مع بعضها الى زيادة معنوية فى محصول المادة الجافة للحبوب والقش و كذلك محتوى الحبوب من العناصر الغذائية (N, P, Cu, Zn, Mn and Fe).

وكانت أعلى زيادة فى معاملة خليط أعلى تركيز للكبريت مع أعلى معدل للسماد العضوى. وعلى ذلك فإنه يستنتج من الدراسة أن خلط السماد العضوى مع الكبريت تعتبر من العمليات الاداريه الجيدة لتحسين خواص الأراضى الجيرية وللحصول على أعلى محصول لحبوب الشعير تحت ظروف ملوحة مياه الرى.