Plant Archives Vol. 20 Supplement 1, 2020 pp. 3535-3542 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

IMPACT OF SALINITY OF IRRIGATION WATER AND GYPSUM APPLICATION ON SOIL PROPERTIES AND YIELD OF WHEAT PLANT

Abdullah S. Aljughaiman

Department of Environmental and Natural Resources, College of Agriculture & Food Sciences, King Faisal University, Alahsa, Saudi Arabia.

Abstract

This study carried out in pot experiments at the Research and Training Station of King Faisal University (KFU), Al Hassa region, Saudi Arabia, during 2017 growing season of wheat (*Triticum aestivum* L.). The purpose of this research work is to study the effect of gypsum and groundwater quality on some soil chemical properties. Two types of soil samples namely sandy soil and calcareous soil were used in the investigation. Four levels of ground water with different qualities (1.46, 4.24, 6.44 and 8.37 dS/m) were used for the wheat irrigation. Gypsum was applied as a soil amendment at rates of (0, 20 and 40 t/ha). The data revealed that, soil pH, ECe, the cations (Sodium Na^+, Potassium K^+, Calcium Ca^{2+} and Magnesium Mg^{2+}), the anions (Colure Cl^-, Hydro-Carbonate HCO_3^+ and Sulphate SO_4^+) and Sodium Adsorption Ratio (SAR) of saturation paste extract in both soils increased as a result of increasing salinity levels of irrigation water. Moreover, Soil pH, ECe, cations (Na^+, K^+ and Mg^{2+}), anions (Cl^- and HCO_3^-) and a significant reduction in the absorption rate SAR of the soil saturation paste for both calcium Ca^{2+} and sulfate SO_4^+ resulted in the use of gypsum. The grain yield of wheat decreased significantly in sandy soil and calcareous soil with the increase in salinity of irrigation water. On the other hand, the grain yield of wheat enhanced gradually as the application rate of gypsum increased in both sandy and calcareous soils.

Key words: Sandy soil, calcareous soil, ground water, gypsum, soil properties, wheat.

Introduction

The world is facing challenges of water shortage, especially in arid and semi-arid areas, and good water resources management in any country is highly efficient. Water is one of the most important factors that help to increase agricultural development in developing countries and help to meet the needs of the population in those countries. Therefore, water from seawater treatment can be used for irrigation activities. The irrigation water in Eastern region of Saudi Arabia, particularly at Al-Hassa oasis, varies widely in term of salt concentration in water and in soil.

The important factors that control soil salinity are the irrigation system, method, soil texture and quantity of water added (Balba, 1995). Interaction between the deficit irrigation and water quality significantly affected crop yield (Arafat *et al.*, 2019). The highest salinity levels found were in deepest layers of the irrigated zone, due to salt leaching caused by irrigation (Dohouha *et al.*, 2018). The chemical properties of the soil are affected by the salinity of the irrigation water and the extent to which it contains salts, the pH of the soil is inversely proportional to the salinity of the irrigation water, which may exceed 4000 ppm (Alawi *et al.*, 1980). On the other hand, concentration of soluble Ca^{2+}, Mg^{2+}, K^+; Na^+ highly increase as the salinity level of the irrigation water increased up to 4000 ppm (Abd El-Nour, 1989). Concentration of soil available of cations such as Na^+, K^+, Ca^{2+} and Mg^{2+} increased with increases of irrigation water salinity (IWS) and P and Zn were decreased (Dina A. Ghazi 2018). Clark *et al.*, (1999) reported that soil salinity, extract soil Ca^{2+}, Mg^{2+}, K^+, Na^+, while soil pH and sulphur (S) decreased, with increasing salinity levels in irrigation water.

Some chemical properties of water used for irrigation were studied and it was observed that in case of increasing salinity of irrigation water, this results in gradual increase in soil salinity, (Ragab, 2001). Ragab *et al.*, (2008) reported that soil salinity and soluble cations and anions in sandy and the calcareous soil increase as result with the increasing of salinity levels in the irrigation water.

***Author for correspondence :** E-mail: aaljughaiman@kfu.edu.sa

Kalavrouziotis *et al.,* (2008) found that the effects of the treated municipal reclaimed wastewater (TMRW) on macro- and the micro-elements status of the soil. The results showed that applied TMRW has significant increasing, in the comparison by control, the content of some the macro and the microelements in the same soil type, whereas, concentrations of the most of them in general were accepted of the critical levels.

Kadam and Mahatma (2006) noticed that soil pH, EC, Na^+, Mg^{2+} and SAR of saturation soil paste extracted has been increased with the saline water irrigation treatments, in the other hand Ca^{2+} contents has been decreased. Fatih *et al.,* (2007) reported that, the applied wastewater has been increased of the soil salinity, exchangeable of Ca^{2+}, Mg^{2+}, K^+; Na^+ and has been decreased of the soil pH.

Bajwa *et al.,* (1993) reported that application of gypsum decreased sodium adsorption ratio of the soil. Niazy *et al.,* (2000) reported that various gypsum treatments resulted in improved soil chemical properties by lowering its pHs, ECe and SAR.

C.M. *et al.,* 2012 mentioned that Gypsum that was not treated with sulfur was significantly increased at the occurrence of ground clusters less than 0.25 mm, the rate of water leaching in the soil and the rate of salinity of sodic Ks of the soil. However, it was confirmed by a prolonged experiment where no significant changes in soil acidity were observed using gypsum and irrigation using saline water (Rashid *et al.,* 1994). It was observed that pH, ECe, Na +, Mg2 + and SAR in the saturated soil sample extract were reduced at the same time, an increase in Ca2 content was observed with the addition of gypsum (Kadam and Mahatma, 2006).

Wheat is considered a crop that is classified as semi-resistant to the salinity of water and soil. It was noted (Padole 1991) that in the case of irrigation with high salinity water about (EC = 4.2 dSm^{-1}) or severe water in the salinity (EC = 14 dSm^{-1}) Sodium absorption ratio (SAR = 8.6) resulted in a very significant decrease in the value of wheat production. Chauhan and Singh (1993) studied wheat production in clay sandy soils under the influence of salinity levels of irrigation water with a value between 2-16 dSm^{-1}. It was found that seed germination of wheat decreased in relation to salinity levels greater than 6 dSm^{-1}. Also, the dry matter (DM) and wheat grain production decreased at salinity levels of 12 dSm^{-1}.

Soliman *et al.,* (1994) found that when irrigated with salinity levels 4, 8.2, and 12.5 dSm^{-1} helped reduce hay and wheat grains, (Samiha 2006) found that when using saline irrigation water, the value of wheat yield was reduced by 4.14, 4.38% for each of Sakha 93 varieties, brief 168 respectively, Wheat yield increased by 132% using gypsum soil treatment by 100% (Niazi 2000). The addition of gypsum to soil during deep tillage improved the physical and chemical properties of saline soils with sodium ion and increased wheat yield (Kheir *et al.,* 2018).

The aims of current research work are to clarify the impact of irrigation by saline water and application of gypsum as a soil amendment on soil chemical properties of the calcareous and sandy soils and yield of wheat plant that irrigated with saline water.

Materials and methods

The experiments of the study conducted in pots under greenhouse conditions at the Research and Training Station of KFU, Al Hassa area. Two types of soil samples namely sandy soil and calcareous soil were used, taken from surface layer (0-30 Cm), were collected from the Station and Al Hassa area. Some physical and chemical properties of these soils are shown in Table 1. Four levels of ground water with different qualities (1.46, 4.24, 6.44 and 8.37 dS m^{-1}) were used for irrigation. Chemical analysis of ground water was determined according to the recommended methods (Richard, 1972, Wilcox, 1958 and FAO, 1973 & 1976) (Table, 2). Gypsum was applied as a soil amendment at rates of (0, 20 and 40 t/ha).

Plastic pots of 30 cm in diameter and 35 cm deep with small holes in the bottom for drainage were filled with 20kg soil samples mixed with gypsum, leaving about 7 cm of free upper space for applying irrigation water. The experiment was conducted in a Split Plot Design with 3 replicates. The main plots contain Gypsum (G) treatments, while the subplot was devoted to the groundwater (W) treatments. The pots were seeded with wheat, Twenty five seeds of wheat *Triticum aestivum* L., were planted in each pot on Oct.,15, 2016 When seedlings were established, and then thinned to ten uniform plants per pot. Nitrogen, Phosphorus and potassium fertilizer was added as per recommendation of Ministry of Agriculture. Throughout the harvest period (Feb., 25, 2017) grains yield per pot was measured.

At the end of season, representative soil samples were taken by soil tube from each pot to a depth of 28 cm. All collected soil samples were air dried, grounded and sieved through a 2mm sieve and kept for chemical analysis. The pH and total soluble salts were measured in the soil paste extract (Rhoades, 1982). Sodium and potassium was determined by flame photometery according to Jackson (1973). Calcium and magnesium were determined by atomic absorption spectrophotometer according to Carter (1993). Soluble carbonates and bicarbonates were determined volumetrically in the soil paste extract by titration against 0.01 N Hydrochloric acid using phenolphthaline and methyl orange as an indicator according to Jackson (1967). Soluble chlorides were determined by titration with 0.01 N silver nitrate solution and potassium chromate as indicator according to Richards (1954).

All collected data were subjected to statistical analysis of variance according to SAS Software (SAS Institute Inc., 1996).

Results and Discussion

Quality of irrigation water

The water quality parameters for all selected ground water sources (1.46 to 8.37 dS/m), were evaluated and presented in Table 3. (FAO, 1976), recognized that the salinity level of EC-iw = 3 dSm^{-1} is acute and causes soil and plant problems. Therefore, the appropriate value for the treatment of a salinity problem is EC-iw = 1 dSm^{-1}, which is below the limit that causes salinity problems. Any problem in its use in agricultural activities.

Other treatments of irrigation water have ECiw values more than the critical level ranging from moderate to high saline. High salinity irrigation water (8.37 dS/m) may cause severe salinity problems for soil and plant. Consequently, continuous irrigation without good water management (washing needs) will lead to large and significant salinity problems in the soil and thus adversely affect plants.

Table 3 show that Sodium Adsorption Ratio, (SAR) of the values of all sources of ground water has the lowest in the comparing with the value of the critical sodium hazard level (less than 10), has been reported by (Richards, 1972).

Sodium gravity index in groundwater is expressed as soluble sodium (SSP) where SSP ranges from 45.51 to 45.98%. The data revealed that all values of SSP were in the range of safety limit (< 60%) as reported by Wilcox (1958).

Magnesium hazard (SMgP) considered one of an important suitable irrigation water. In this respect, the SMgP values tabulated within Table 3 indicated that all sources of ground water have a value ranged from 36.76 to 44.08%. Therefore, all obtained values of magnesium hazard for treatments irrigation water are less than the 50%, harmful level. Salts of magnesium have some toxic effects on the higher toxicity of Mg ions and plants than the toxicity of the Na ions which it has the same concentration.

The remaining sodium RSP helps in the formation of carbonates and the dissolution and deposition of calcium as well as the degree of being less than magnesium carbonate. Thus, the rate of insoluble carbonate increases and increases the severity of the sodium in irrigation water more and worsens the condition of the irrigated soil with this water containing sodium carbonate.

The obtained values of the RSP are negative values, which means that Ca^{2+} + Mg^{2+} is more than the CO_3^{2-} + HCO_3^- resulted in no problem of sodium hazard. Potential salinity (PS) for all sources of groundwater used ranged from 8.24 to 60.14 meq/L. The high values of PS over the critical level (5 meq/L) as reported by Richards (1972) may be due to high chloride and sulphate content in the irrigation water. Chloride ion (Cl^-) is extremely high and ranged from 5.80 to 45.5 meq/L as shown in Table 2. According to the guidelines for interpreting water quality (FAO, 1976) this may also cause severe problems concerning Cl^- toxicity to plants. The nitrate contents (NO_3^-) of groundwater used in this study varied from treatment to another, but did not exceed the critical limit (45 mg/L) that cause nitrate poisoning (Wilcox, 1958). Generally, from the data previously presented, it appears

Table 1: Physical and chemical properties of soils.

Property Particle size distribution,%	Sandy soil	Calcareous soil
sand	92.32	59.12
silt	2	24
clay	5.68	16.68
Texture	sand	sandy loam
EC, dS/m	0.92	1.26
pH	7.11	7.99
Cations, meq/L	Paste	Paste
Na^+	1.51	1.71
K^+	0.75	0.71
Ca^{++}	4.51	6.47
Mg^{++}	2.47	3.67
Anions, meq/L	Paste	Paste
$CO_3^=$+HCO_3^-	1.15	1.3
Cl^-	5.72	6.21
$SO_4^=$	2.37	4.79
NO_3^-, mg/L	17.36	21.7
CaCO3,%	2.6	27.9

Table 2: Water quality characteristics of irrigation water.

Treatm-ent NO.	PH	EC (dS/m)	Soluble cations, meq/L				Soluble anions, meq/L		
			Na^+	K^+	Ca^{2+}	Mg^{2+}	CL^-	HCO_3^-	SO_4^{2-}
1	7.06	1.46	7.64	0.31	4.15	2.41	5.80	3.83	4.88
2	6.89	4.24	19.18	0.99	12.05	9.50	22.00	5.10	14.63
3	7.55	6.44	28.97	1.29	19.26	14.13	36.10	3.83	23.72
4	7.04	8.37	40.26	1.90	24.07	14.93	45.50	6.38	29.29

Table 3: Quality parameters of ground water used in the irrigation.

Treatment NO.	EC (dS/m)	SAR	SSP	RSP	SMgP	PS	NO_3^- (mg/L)
1	1.46	4.22	52.67	-2.73	36.76	8.24	8.00
2	4.24	5.84	45.98	-16.45	44.08	29.31	30.40
3	6.44	7.09	45.51	-29.57	42.32	47.96	40.20
4	8.37	9.12	49.60	-32.63	38.29	60.14	24.50

that, ground water has been used in the current study may cause some problems.

The effect of saline irrigation water and gypsum on the soil chemical properties

The data in Tables no. (4 and 5) show the electrical conductivity of soil paste extract (ECe) significantly increased because of the increasing the irrigation water salinity levels, which less pronounced in the sandy soil than calcareous soils. This attributed to great surface area of fine particles, which adsorb the more soluble and the exchangeable cations of the saline solution. The highest values were 1.70 and 6.93 dS/m for the treatment (4) and lowest one for the control (treatment, 1) (1.04; 1.40 dS/m) in the sandy and the calcareous soil, in the same sequence. There are a significant correlation between the salinity of irrigation water (ECiw) and soil salinity (ECe), it reached a values of 0.99** and 0.99** for sandy soil and calcareous soil, respectively. Dahdoh and Hassan (1997) confirmed this result. They mentioned the increasing in soil ECe attributed to accumulation of the salts in the soil as result of the application of the saline water. Soil pH increased from 7.37 to 7.56 and from 7.95 to 8.31 for sandy soil and calcareous soil, respectively under saline water irrigation treatment.

The data also, indicated that all soluble cations and anions of soil solution were significantly increased as the salinity of irrigation water increased. Soluble calcium content in sandy soil increased by 21, 45 and 63%, respectively over the control (treatment, 1). The corresponding values for calcareous soil were 162, 279 and 395 %, respectively over the control (treatment, 1). Also, soluble magnesium content in sandy soil increased by 32, 50 and 94%, respectively over the control (treatment, 1). The corresponding values for calcareous soil 131, 246 and 421 %, respectively over the control (treatment, 1). Soluble chloride increased by 124, 141 and 147% in sandy soil and 216, 369 and 472% in

Table 4: Effect of of irrigation water salinity and gypsum on chemical properties of sandy soil.

Treatments		pH	EC	The soluble cations, (meq/L)				The soluble anions, (meq/L)			SAR
Gypsum (t/ha)	Water, dS/m		(dS/m)	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO_3^-	SO_4^{2-}	
0	1.34	7.49	1.09	1.22	0.68	8.18	0.29	9.06	0.20	1.11	8.39
	4.24	7.58	1.39	1.34	1.26	10.92	0.33	11.68	0.23	1.94	9.58
	6.44	7.61	1.65	1.52	1.44	12.57	0.38	13.01	0.26	2.63	10.34
	0	7.64	1.89	1.68	1.57	13.44	0.42	13.19	0.33	3.59	10.54
20	1.34	7.35	1.05	1.25	0.88	7.88	0.28	7.21	0.17	2.91	7.64
	4.24	7.48	1.26	1.39	1.01	8.60	0.35	8.72	0.22	2.41	7.85
	6.44	7.56	1.52	1.55	1.16	11.48	0.37	9.97	0.28	4.30	9.87
	8.37	7.55	1.63	1.73	1.69	11.99	0.41	10.85	0.30	4.66	9.17
40	1.34	7.27	0.99	1.27	0.87	6.51	0.29	6.21	0.16	2.56	6.30
	4.24	7.39	1.12	1.52	0.93	8.23	0.31	7.50	0.19	3.30	7.43
	6.44	7.44	1.36	1.65	1.05	9.88	0.33	8.82	0.23	3.86	8.49
	8.37	7.48	1.59	1.85	1.45	11.74	0.34	9.10	0.27	6.01	9.14
main effect of gypsum (t/ha)											
0		7.58	1.51	1.44	1.24	11.28	0.36	11.74	0.26	2.32	9.71
20		7.49	1.37	1.48	1.18	9.99	0.35	9.19	0.24	3.57	8.63
40		7.40	1.27	1.57	1.07	9.09	0.32	7.91	0.21	3.93	7.84
LSD (0.05)		0.01**	0.02**	0.04**	0.18**	0.23**	0.01**	0.05**	0.02**	0.06**	0.15**
main effect of water (dS/m)											
1.34		7.37	1.04	1.25	0.81	7.52	0.29	7.49	0.18	2.19	7.44
4.24		7.48	1.26	1.42	1.07	9.25	0.33	9.30	0.21	2.55	8.29
6.44		7.54	1.51	1.57	1.22	11.31	0.36	10.60	0.26	3.60	9.57
8.37		7.56	1.70	1.75	1.57	12.39	0.39	11.05	0.30	4.75	9.62
LSD (0.05)		0.02**	0.02**	0.02**	0.16**	0.45**	0.01**	0.06**	0.02**	0.04**	0.13**
Interaction W × G LSD (0.05)		**	**	**	**	**	**	**	NS	**	**

calcareous, respectively over the control treatment.

Sulphate content of sandy and calcareous soil increased by increasing the salinity of irrigation water. Clark *et al.*, (1999) noticed that the soil salinity, extracted soil calcium: Ca, magnesium: Mg, sodium: Na and potassium: K, has been increased with increasing the salinity in the irrigation water. Ragab *et al.*, (2008) reported that, the soil salinity and soluble cations and anions in sandy and the calcareous soil has been increased as result of the increasing of the salinity levels of the water of irrigation. Kadam and Mahatma (2006) noticed that the soil pH; EC; Na^{+}; Mg^{2+} and SAR of the saturation of paste extract has been increased under the saline of the irrigation water treatments. The irrigation with saline water significantly increased SAR values in sandy soil and calcareous soil. The highest of the values is found for the treatments no. (4), while lowest values have been found for the control (treatment, no. 1). In sandy soil the percent of increases were 93, 124 and 126%, respectively over control treatment. With regard the effect of gypsum on soil chemical properties. The results indicated that soil pH, EC, Na^{+}, K^{+}, Mg^{2+}, HCO_3^{-}, Cl^{-}; SAR of the saturation of soil paste extract in both sandy and calcareous soil significantly has decreased while the Ca^{2+} and SO_4^{2-}, the content of significant increased with the application of the gypsum (Table, 4). Soil ECe, Na^{+}, K^{+}, Mg^{2+}, HCO_3^{-}, Cl^{-} and SAR of sandy soil decreased by about 5.95, 13.10, 19.42, 10.56, 32.62, 16.67 and 19.25%, respectively over the control treatment. The corresponding values for calcareous soil were 16.42, 18.35, 18.21, 11.73, 48.71, 16.91 and 19.50%, respectively over the control treatment. Ca^{2+} and SO_4^{2-} content of sandy soil increased by about 40.86 and 69.60% %, respectively over the control treatment. The corresponding values for calcareous soil were 36.63 and 261%, respectively over the control treatment. These results agree with those obtained by Kadam and Mahatma (2006).

Gypsum applied within treatment 100% GR in two splits decreased sodium adsorption ratio of the soil, (Niazi *et al.*, 2000). Similar results has been published where the gypsum has reported to be most successful chemical reclamation agent used in Pakistan (Qureshi, 1998).

The effect of the saline irrigation water and gypsum application on the wheat yield

Table 6 show the effect of the saline irrigation water

Table 5: The effect of saline irrigation water and the gypsum application on the chemical properties of the calcareous soil.

Treatments		pH	EC	The soluble cations, (meq/L)				The soluble anions, (meq/L)			SAR
Gypsum (t/ha)	Water, dS/m		(dS/m)	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{2-}	
0	1.34	8.05	1.54	1.79	1.24	11.13	0.99	12.80	0.38	1.97	9.04
	4.24	8.13	3.91	4.28	3.76	30.72	1.05	35.66	0.48	3.67	15.32
	6.44	8.28	5.63	5.63	4.90	42.88	1.16	48.42	0.66	5.49	18.69
	8.37	8.39	7.37	7.22	6.12	52.40	1.32	56.88	0.73	9.45	20.29
20	1.34	7.92	1.46	1.70	1.40	8.60	0.93	7.24	0.36	5.03	6.91
	4.24	8.09	3.85	4.25	2.09	26.28	1.01	23.91	0.48	9.25	14.76
	6.44	8.19	5.44	5.54	4.14	37.50	1.12	35.69	0.64	11.97	17.05
	8.37	8.3	7.27	9.16	7.52	50.60	1.25	48.40	0.72	19.41	17.52
40	1.34	7.88	1.20	1.51	1.05	7.89	0.84	3.84	0.30	7.15	6.97
	4.24	8.03	3.24	2.89	2.69	23.80	0.94	15.90	0.40	14.02	14.25
	6.44	8.11	4.84	6.26	3.75	35.14	1.03	27.84	0.57	17.78	15.71
	8.37	8.23	6.14	15.19	5.59	45.32	1.18	31.28	0.61	35.39	14.06
main effect of gypsum (t/ha)											
0		8.21	4.61	4.73	4.01	34.28	1.13	38.44	0.56	5.14	15.84
20		8.13	4.51	5.16	3.79	30.75	1.08	28.81	0.55	11.42	14.06
40		8.06	3.86	6.46	3.27	28.04	1.00	19.72	0.47	18.58	12.75
LSD (0.05)		0.03**	0.03**	0.04**	0.02**	0.62**	0.04**	1.95**	0.02**	0.35**	0.71**
main effect of water (dS/m)											
1.34		7.95	1.40	1.67	1.23	9.21	0.92	7.96	0.35	4.72	7.64
4.24		8.08	3.67	3.81	2.85	26.93	1.00	25.16	0.45	8.98	14.78
6.44		8.19	5.30	5.81	4.26	38.51	1.10	37.31	0.62	11.75	17.15
8.37		8.31	6.93	10.52	6.41	49.44	1.25	45.52	0.69	21.42	17.29
LSD (0.05)		0.01**	0.03**	0.04**	0.03**	1.42**	0.02**	1.33**	0.02**	0.26**	0.40**
Interaction W × G LSD (0.05)		NS	**	**	**	NS	NS	**	NS	**	**

and gypsum treatments on wheat grain yield. The result show, the increased of saline irrigation water has been significant decreased grain yield in pots. Wheat yield has been increased by increasing the saline of irrigation water and reach to highest at 8.37 dS/m saline level. Increasing water salinity in sandy soil reduced the grain yield of wheat by about 30, 36 and 42 %, for salinity levels 4.24, 6.44 and 8.37 dS m^{-1}, respectively, relative to the control treatment. The corresponding values for calcareous soil were 18, 24 and 49%, respectively, relative to the control treatment. Zein *et al*., (2003) found that wheat grain significantly affected by increasing irrigation water salinity.

With respect the effect of gypsum application on grain yield of wheat. Data in Table 6 revealed that grain yield of weight increased gradually as the application rate of gypsum increased in both soils. Grain yield in sandy soil increased by 9.0 and 15.0%, for rates of 20 and 40 ton/ha, respectively, relative to the control treatment. The corresponding values for calcareous soil were 7.0 and 13.0%, respectively, relative to the control (treatment, 1). These results agree with those obtained by (Niazi *et al*., 2000), they found that, the application of gypsum within treatment of 100% GR in the split doses has improved the yield of wheat with significant. The highest increase of wheat yield was (132%) has been observed in the gypsum in plots treated within the treatment of 100% GR in the one shot.

Table 6: The effect of saline water and the gypsum treatments on the wheat grain yield.

Treatments		The sandy	The calcareous
Gypsum (t/ha)	Water, EC,dS/m	soil Grain /pot (g)	soil Grain /pot (g)
0	1.34	58.41	71.92
	4.24	37.27	58.78
	6.44	36.86	55.11
	8.37	31.89	37.44
20	1.34	59.52	77.12
	4.24	45.12	63.66
	6.44	37.88	58.19
	8.37	37.52	40.19
40	1.34	61.38	81.16
	4.24	46.43	67.19
	6.44	43.28	62.47
	8.37	38.32	41.56
main effect of gypsum (t/ha)			
0		41.11	55.81
20		45.01	59.79
40		47.35	63.10
LSD (0.05)		2.69**	1.92**
main effect of water (dS/m)			
1.34		61.38	77.12
4.24		42.93	63.21
6.44		39.34	58.59
8.37		35.91	39.73
LSD (0.05)		2.36**	1.44**
Interaction W × G LSD (0.05)		NS	NS

Conclusion

Soil pH, EC, soluble cations, anions and Sodium Adsorption Ratio (SAR) of saturation paste extract of sandy and calcareous soils significantly increased with increasing salinity of irrigation water. Moreover, various of the gypsum treatments has resulted in the better wheat yield and the improved of the soil chemical properties by the lowering its pH, EC and SAR. Therefore, the application of gypsum could be recommended as the effective and the useful for the water and irrigation management tool for the salts-affected soil.

References

Abdel-Nour, A.S. (1989). The interaction effects of salty water and fertilization on soil physical and chemical properties, yield and water consumption use of plant grown in different Egyptian soils. Ph.D. Thesis, Fac. Agric., Ain Shams., Univ., Egypt.

Abo EL-Defan, T.A. (1990). Effect of organic manures on plant growth and nutrients uptake under saline condition. Ph.D. Thesis, pp. 56-181. Fac. Agric. Ain Shams Univ., Egypt.

Alawi, B.J., I.L., E.A. Strochlein, Hanlon and F. Turner (1980). Quality of irrigation water and effect of sulphuric acid and gypsum on soil properties and Sudan grass yields. *Soil Sci.,* **129:** 315-319.

Arafat A. and A. Abdulrasoul (2019). Simulated tomato yield, soil moisture, and salinity using fresh and saline water: experimental and modeling study using SALTMED model. *Irrigation Science,* **37:** 637-655.

Bajwa, M.S., A.S. Josan and O.P. Choudhary (1993). Effect of frequency of sodic and saline-sodic irrigations and gypsum on the buildup of sodium in soil and crop yields. *Irrigation Science,* **14(1):** 21-26; 18 ref.

Balba, A.M. (1995). Management of Problem Soils In Arid Ecosystems. CRC Press. 250 p.

Bhatti, H.M. (1986). Management of irrigation water qualities for crop production. Final Technical Report of PL-480 Project. AARI, Faisalabad.

Carter, M.R. (ed.). (1993). Soil Sampling and Methods of Analysis. Canadian society of Soil Science, Lewis Publishers. London, Tokyo.

Chauhan, C.P.S. and S.P. Singh (1993). Wheat cultivation under saline irrigation. *Wheat Information Service,* **77:** 33-38.

Clark, D.R., C.J. Green, V.G. Alle and C.P. Brown (1999). Influence of salinity in irrigation water on forage sorghum and soil chemical properties. *Journal of plant nutrition*, **22(12):** 1905-1920 (2 p.).

Chi, C.M., C.W. Zhao, X.J. Sun and Z.C. Wang (2012). Reclamation of Saline-Sodic soil properties and improvement of rice (*Oriza sativa* L.) growth and yield using desulfurized gypsum in the west of Songnen Plain, northeast China.

Dina A.G. (2018). Effect of irrigation with diluted seawater on coriander growth and soil properties of sandy soil amended by chicken manure and biochar. *J. Soil Sci and Agric. Eng. Mansoura Univ.,* **9(11):** 647-656.

Dahdoh, M.S.A. and F.A. Hassan (1997). Combined effect of sewage sludge and saline water irrigation on growth and elemental composition of Broad Bean. *Egypt. J. Soil Sci.,* **37(2):** 189-204.

Dohouha, L., M. Rajouene, R. Hafedh and A. Habiba (2018). Effects of irrigating with saline water on soil salinization (Eastern Tunisia). *Arabian Journal for Science and Engineering,* **43:** 3793-3805.

Dosoky, A.K.R. (1999). Effect of saline water on some physical and chemical soil properties. M.Sc. Thesis, Fac. Agric., Moshtohor. Zagazig University, Egypt.

El-Boraie, F.M. (1997). A study on the water management under arid conditions. M.Sc. Thesis, Fac. Agric., Ain Shams University, Egypt.

FAO. (1973). Salinity, irrigation and drainage, pp. 177-204.

FAO. (1976). Water quality for Agriculture. Irrigation and Drainage paper 29, R.S. Ayers and D.W. Westcot

Fatih, M. Kiziloglu, Metin Turan, Ustun Sahin, Ilker Angin, Omer Anapali and Mustafa Okuroglu (2007). Effects of wastewater irrigation on soil and cabbage-plant (*Brassica olerecea var.* capitate *cv.* yalova-1) chemical properties. *J. Plant Nutr. Soil Sci.,* **170:** 166–172.

llyas, M.R.H. Qureshi and M.A. Qadir (1997). Chemical changes in a saline-sodic soil after *gypsum application and cropping soil technology,* **10:** 247-260.

Hussain, M.A. and M. Asghar (1984). Gypsum as an amendment for the reclamation of saline-sodic lands. *Pakistan Engg. Cong. Proc.,* **60:** 193–9.

Hussain, T., G. Jilani, A. Haq and R. Ahmad (1993). Management of brackish irrigation water with chemical amendment in conjunction with rice culture. *Pakistan J. Soil Sci.,* **8:** 42–7.

Hassanein, S.A., N.F. Kandil, M.A. Abu-Sinna and M.I. Selem (1993). Effect of irrigation with Bahr El-Baqar drain water on some soil chemical properties and yield. *Com. In. Sci. and Dev. Res.,* **41:**.

Jackson, M.L. (1967). Soil Chemical Analysis. Prentic Hall, Inc., Engle Wood Cliff., USA.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall, Inc. India.

Kadam, R. and Mahatma Phule Krishi Vidyapeeth (2006). Chemical Properties of Soil and Yield of Sunflower as Influenced by Application of Saline Water and Gypsum.18th World Congress of Soil Science. July 9-15, 2006 - Philadelphia, Pennsylvania, USA.

Kalavrouziotis, I.K., P. Robolas, P.H. Koukoulakis and A.H. Papadopoulos (2008). Effects of municipal reclaimed wastewater on the macro- and micro-elements status of soil and of *Brassica oleracea var.* Italica, and *B. oleracea var.* Gemmifera. *Agricultural water management,* **95:** 419-426.

Kheir, A.M.S., M.M.A. Shabana and M.F. Seleiman (2018). Effects of gypsum, sulfuric acid and Nano Zeolite application on saline-sodic properties and wheat productivity under different tillage types. *J. soil Sci. Agric. Eng. Mansoura Univ.,* **9(12):** 829-838.

Mostafa, M.A., M.O. Elsharawy and F.M. Elboraei (2004). Use of Sea Water for Wheat Irrigation. II. Effect on Soil Chemical Properties, Actual Evapotranspiration and Water Use Efficiency. International Conf. on Water Resources & Arid Environment.

Niazi, B.H., N. Hussain, M. Salim, G. Hassan and A. Ali (2000). Effect of split application of gypsum on wheat yield and properties of a saline-sodic soil irrigated with brackish water. *International J. Agr. and Biology,* **3:** 234-236.

Oster, J.D. (1982). Gypsum usage in irrigated agriculture: *a review fertilizer research,* **3:** 73-89.

Padole, V.R. (1991). Effect of irrigation of saline and sodic water on uptake of nutrients and yield of wheat grown under salt affected condition. *PKV, Research, Journal,* **15(2):** 120-124.

Qureshi, R.H. (1998). Management of salt affected soils of Pakistan. *Pakistan J. Soil Sci.,* **14:** 90–5.

Ragab, A.A.M. (2001). Physical properties of some Egyptian soils. Ph.D. Thesis, Fac. of Agric. Cairo Univ., Egypt.

Ragab, A.A.M., F.A. Hellal and M. Abd El-Hady (2008). Water Salinity Impacts on Some Soil Properties and Nutrients Uptake by Wheat Plants in Sandy and Calcareous Soil. *Australian Journal of Basic and Applied Sciences,* **2(2):** 225-233.

Rao, D.L.N., N.T. Singh, R.K. Gupta and N.K. Tyagi (1994). Salinity Management for Sustainable Agriculture. Central Soil Salinity Research Institute, Karnal, India, p. 314.

Rashid, M., M.Y. Shakir and M. Jamil (1994). Effect of brackish water on crop yields and properties of a soil treated with amendments. *Pakistan J. Soil Sci.,* **9:** 86–90.

Rhoades, J.D. (1982). Soluble salts P. 167-185. In A.L. Page *et al.,* (ed.) Methods of soil analysis Part 2. Chemical and microbial methods. . 2nd ed. Agron. Monogr 9. ASA and SSA. Madison, WI.

Richard, L.A. (1954). Diagnosis and Improvement of Saline and Alkali Soils. United States Department of Agriculture, Washington, D.C. USA, Hand book 60, p. 160.

Richards, L.A. (ed.). (1972). Diagnosis and Improvement of

Saline and Alkaline Soils. U.S. Dept. of Agric., Agric. Handbook No. 60.

Samiha, A.H. Ouda (2006). Predicting the Effect of Water and Salinity Stresses on Wheat Yield and Water Needs. *Journal of Applied Sciences Research,* **2(10):** 746-750, 2006. INSInet Publication.

SAS Institute Inc. (1996). The SAS System for Windows. Release 6.12, SAS Institute Inc., Cary, NC, USA.

Shainberg, I., M.E. Summer, W.P. Miller, M.P.W. Farina, M.A. Paven and M.V. Fey (1989). Use of Gypsum on soils: a review. *Advances in Soils Sciences,* **9:** 1-111.

Soliman, M.S, H.G. Shalabi and W.F. Campbell (1994). Interaction of salinity, nitrogen, and phosphorus fertilization on wheat. *Journal of Plant Nutrition,* **17(7):** 1163-1173.

Wilcox, L.V. (1958). Determining quality of irrigation water. *Agr. Inf. Bull.,* **147:** USDA, Washington.

Zein El-Abedine, I.A., S.B. El Amir, A.E. Abd Allah and A.A.M. Ragab (2004). Influence of irrigation with saline drainage waters on some soil physico-chemical properties of the northern west area of Nile delta. *Fayom J. Agric. Res. and Dev.,* **18(1):** 133-142.

Zein, F.I., S.A. Abd El-Wahab, M.A. El-Abaseri and A.T.A Moustafa (2003). Evaluation of some wheat varieties to salt tolerance. *Egypt. J. Soil Sci.,* **43(3):** 319-327.