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USING SEAWATER IN AGRICULTURAL AND RESISTANT IT'S POSSIBLE HAZARDS ON SOIL AND PLANT

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ABSTRACT: Water is certainly one of the most critical inputs in crop production in many parts of the world particularly in the arid and semi-arid regions, *i.e.* Egypt, in the near future the required development of irrigated agriculture is necessary to cope with the increasing food demands from increasing population and water scarcity in Egypt. It has thus become necessary to explore new water sources that can meet current or future demand for irrigation supply. The main objective of this study was to determine the maximum amount of seawater irrigation needed to produce a good yield and study the combined effect of diluted seawater (I_1, I_2, I_3, I_4, I_5, and I_6) and rates of compost addition (0.0, 4.0, 8.0 ton fad.$^{-1}$) on plant growth, crop production and soil properties. Sandy soil Lysimeters were planted by salt-tolerant plants (barley) followed by sunflower crop under the same treatments. Results concluded that all diluted seawater prepared was suitable for irrigation crops according to the calculated criteria of water quality. The values of soil pH, Ec (ds/m) and ESP at the end of the two seasons were taken the same trend, which increased significantly with increasing the salinity of irrigation water or increasing the rate of compost addition as individual factors but in combination among them appeared insignificant variation in most studied properties. Also, available macronutrients residual in experimental soil were affected by the antagonism relationship between the studied factors, positively by addition of compost and negatively with salinity water supply. It was noticed that the interaction between treatments has positive role in reducing the hazards of the salinity irrigation water, which the biological yield of barley was decreased to maximum percentage (28.95%) at using the highest salinity irrigation water (I_6). But, it was obtained the minimum reduction percentage (5.9%) if combined with the highest rates of compost addition compared with the control (I_1). The residual effect of highest compost addition was more clearly on the parameters studied of sunflower cultivated in the second season which hadn't reduce the hazards of high salinity irrigation water (I_6) alone but optimized with the values parameters studied particularly seed yield by 16.3% at the treatments ($I_6 \times C_3$) compared with the control (I_1).

Key words: Seawater, irrigation, barley and sunflower production, sandy soil.

INTRODUCTION

One of the most urgent global problems is finding enough water and land to support the world's food needs. Agriculture will continue to be the most important user of water in many countries, evapotranspiration from irrigated agricultural land is the largest consumptive use of water withdrawn for human use. Also, steadily increasing demand for agricultural products to satisfy the needs of a growing population continues to be the main driver behind agricultural water use. The net result is that agricultural water use is increasing the severity of water scarcity in some areas, and causing water scarcity even in areas that are relatively well endowed with water resources (FAO, 2012). Increasing water scarcity in arid and semiarid regions, where rainfall is scanty and evaporation rates are high. Surface water is limited. The increase in population and socio-economic development has led to an imbalance between supply and demand. So, it has been to search for non-conventional water resources in

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irrigated agriculture to meet the growing water needs (Nair and Kumar, 2013). Since the water resources in Egypt are limited and depend on the Nile river. Egypt water allocation is 55.5 × 10^9 m^3 a year and with tremendous increase in the population, production has to be increased and irrigation water has to be well managed and how to find the way for saving more irrigation water becomes essential (Moursi and Abdelkhalek, 2015). Seawater is already being considered in a significant number of water stressed developed countries as a major source of water (Gleick *et al.,* 2006 ; Lattermann and Hopner, 2008), also it's being reported as an alternative water source in some Mediterranean countries for sustaining agricultural production. It represents an abundant and steady water source which effectively removes the climatological and hydrological constraints, (Martínez-Alvarez *et al.,* 2016).

There are multiple strategies to augment water resource availability for irrigated agriculture, including water conservation, modernization of irrigation schemes, treatment of low-quality water, *etc.* However, most of these strategies can only improve the use of conventional water resources. Nonconventional water resources (desalination and recycling) are the only methods to increase water supply beyond that available from the hydrological cycle (Shannon *et al.,* 2008). As Sea-water desalination remained more expensive, it had rarely been considered for agricultural purposes, but nowadays it is emerging as a feasible option for crop irrigation in Spain (Zarzo *et al.,* 2013). Diluted seawater (DSW) is a simple yet vital input used in natural farming as a source of mineral nutrition for the production of a variety of fruit and vegetable crops, as well as for lawns, pastures, and flowers (Sgherri *et al.,* 2008). Increased percentages of seawater in the irrigation solution had the following effects on ion concentrations in the shoots: no change in Ca^{2+} and Mg^{2+}, a slight increase in K^+, and marked elevations in Na^+ and Cl^-. Importantly, total polyphenol, β-carotene and ureides, all known for their antioxidant capacities, rose with increasing seawater percentage, findings that indicated improved nutritional values for *Salicornia* irrigated with high concentrations of seawater (Ventura *et al.,* 2011) as well as, total yield declined with increasing percentage of seawater above 50% in the irrigation water.

Both the quality and quantity of water are critical to the successful production of plants. While the most critical chemical water quality parameters are the water salinity hazard (as measured by electrical conductivity (EC_w)), sodium and chloride concentration, sodium adsorption ratio (SAR) and soluble sodium percent (SSP), (Mass, 1990; Ayers and Westcot, 1994). On the basis of the foregoing, we proposed using seawater dilution in irrigation as strategy to augment water resource availability for irrigated agriculture, particularity with sowing resistant plants to salinity (*i.e.* barley). Lysimeter experiments were conducted to evaluate the effect of irrigation by diluted seawater with or without application of compost at different rats on plant production and soil properties.

MATERIALS AND METHODS

Experimental Layout

Lysimeter experiment was conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during two seasons (winter of 2014/2015 and summer season of 2015) to examine the irrigation by nonconventional water resources (diluted seawater) combined with different rates of compost on yield and yield components of barley (Giza 123) and sunflower (Sakha 53) and its effects on soil chemical properties in the end of each season. The experiment was laid out in a split-plot design with three replicates. The main plots were the compost rates (0.0, 4.0 and 8.0 ton $fad.^{-1}$), while, the different diluted seawater (I_1, I_2, I_3, I_4, I_5 and I_6) were the subplots, they were obtained by diluting seawater with the canal irrigation water to obtain the desired salinity levels non-hazardous for irrigation as follows; I_1 (canal irrigation water as control), I_2 (dilution 1: 60), I_3 (dilution 1: 50), I_4 (dilution 1:40), I_5 (dilution 1 : 30) and I_6 (dilution 1 : 20). Irrigation with diluted seawater in different concentration was started after 21 days from sowing. The experimental unit consists of one lysimeter (0.50 m^2) in a square shape and a height of 60 cm with filter (gravel) of 10 cm in dawn, each lysimeter was filled by sandy soil. Total number of used lysimeters were 54 units (3 rates of compost × 6 levels of water × 3 replicates). Before addition the treatments and cultivation, soil samples were taken at three depths and prepared for chemical analysis according to the standard methods. Soil samples were dried, sieved through a 2 mm and analyzed for texture, soluble cations and anions, soil pH, EC and OM (%) as well as available N, P and K according to Page (1982) and Klute (1986), soil ESP was estimated as a function of soil SAR by equation (ESP = 1.95 + 1.03 SAR) according to Rashidi and Seilsepour (2008) (Table 1). The chemical analyses of compost and irrigation water characteristics were presented in Tables 2 and 3.

Barley grains (Giza, 123) were sown on 24/11/2014 and harvested on 15/4/2015 followed by planting of sunflower (Sakha 53) on 15/5/2015 and harvested on 7/9/2015. Other recommendations for barley and sunflower growing were followed according to the Ministry of Agriculture, Egypt. Each treatment (lysimeter unit) was received equal amount of irrigation water every irrigation time (20 l/lysimeter at once). This quantity realized the FC+20% as LF. The irrigation intervals were depending on the status of plant and soil (from 10- 15 days), within the limits of 10 irrigations to barley and 9 irrigations to sunflower through growing seasons.

The irrigation water samples (diluted seawater) were taken to determine the validity of some criteria *i.e.* water salinity hazard (as measured by electrical conductivity (EC_w), potential salinity (PS), soluble sodium percentage (SSP), sodium adsorption ratio (SAR), sodium to calcium activity ratio (SCAR), permeability index (PI). where concentrations of all ions have been expressed in mmol/l. and these criteria were calculated as the following:

Water salinity hazard

While EC_w is an assessment of all soluble salts in irrigation water, ($\geq$3.00 ds.m^{-1} classified to Class 5= unsuitable or severe). (Mass, 1990; Ayers and Westcot, 1994).

Potential salinity (PS)

Potential salinity (PS) was defined as the chloride plus half of the sulfate concentration.

$$PS = Cl^- + \frac{1}{2} SO_4$$

The PS classification is as follows: permissible 5-20, 3-15 and 3-7, for soils of good, medium and low permeability, respectively (Doneen, 1964 and Gupta, 1990).

Soluble sodium percentage (SSP)

High sodium ion concentration in soil can take a toll on internal drainage patterns in soil as release of calcium and magnesium ions are facilitated due to absorption of sodium by clay particles. SSP was calculated using the following equation (Todd, 1980):

$$SSP = \frac{Na^+}{Na^+ + K^+ + Ca^{++} + Mg^{++}} \times 100$$

Water with SSP less than 60 is safe with little sodium accumulations that will cause a breakdown of the soil's physical properties (Fipps, 1998).

Sodium adsorption ratio (SAR)

Sodium adsorption ratio is a measure of the sodicity of the soil. The SAR was calculated according to (USDA, 1954) using the following equation:

$$SAR = \frac{Na^+}{(\{Ca^{++} + Mg^{++}\}/2)^{1/2}}$$

The SAR classes include, low, S1 (<10); medium, S2 (10–18); high, S3 (18–26); and very high, S4 (>26). Which general classifications of irrigation water based upon SAR values (Above 18 is unsuitable for continuous use), Ayers and Westcot (1994).

Sodium to calcium activity ratio (SCAR)

SCAR can be calculated according to the relationships presented by Gupta (1990) in the following equation:

$$SCAR = Na^+ / (Ca^{2+})^{1/2}$$

On the basis of SAR/SCAR, the irrigation waters may be classified in six classes of sodicity, Non-sodic water, S0 (<5); normal water, S1 (5-10); low sodicity water, S2 (10-20); medium sodicity water, S3 (20-30), high sodicity water, S4 (30-40) and very high sodicity water, S5 (>40).

Table 1. Some chemical properties of the initial experimental soil

Depth (Cm)	Soluble Ions (meq/l)							EC (dS/m)	ESP	OM (%)	pH (1:2.5)	Available macro-nutrients (mg.kg^{-1} Soil)			Texture
	Cations				Anions										
	Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	$SO_4^=$					N	P	K	
0-15	7.5	0.1	1.8	2.4	1.5	5.3	5.0	1.10	7.3	0.19	7.78	25.0	6.1	175.0	Sandy soil
15-30	8.6	0.1	2.0	2.8	1.5	6.0	6.0	1.26	7.7	0.18	7.92	23.0	5.5	168.0	Sandy soil
30-45	9.9	0.2	2.3	3.2	2.0	6.9	6.7	1.45	8.1	0.16	8.05	19.0	5.2	155.0	Sandy soil
Mean	8.7	0.1	2.0	2.8	1.7	6.1	5.9	1.27	7.7	0.18	7.92	22.3	5.6	166.0	Sandy soil

Table 2. Some characteristics of the compost added to soil experiment

OM (%)	OC (%)	C:N ratio	SP (%)	$CaCO_3$ (%)	Available macro-nutrients (mg.kg^{-1})			CEC meq.100g^{-1}
					N	P	K	
33.1	19.0	19.0	80.0	3.3	2180	22.23	6450	79
pH (1:2.5)	**EC (dS/m)**	**Soluble Ions (meq. 100 g compost^{-1})**						
		Cations				**Anions**		
		Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	$SO4^=$
7.2	2.4	9.7	8.0	9.9	2.8	2.8	20.0	14.5

Table 3. Chemical analysis of different irrigation water salinity

Irrigation water variety (diluted seawater)	pH	EC (dS/m)	Soluble Ions (meq. l^{-1})						
			Cations				Anions		
			Na^+	K^+	Ca^{++}	Mg^{++}	HCO_3^-	Cl^-	$SO_4^=$
I_1 (Canal irrigation water)	7.65	1.10	7.3	0.2	1.7	2.6	1.5	6.0	4.3
I_2 (1:60)	7.19	1.80	11.8	0.2	2.8	3.8	2.0	8.3	8.3
I_3 (1:50)	7.82	2.04	13.2	0.3	3.1	4.3	2.5	9.2	9.2
I_4 (1:40)	8.01	2.62	17.0	0.4	4.0	5.5	3.0	11.9	12.0
I_5 (1:30)	8.13	3.30	21.0	0.5	4.9	6.8	3.5	14.7	15.0
I_6 (1:20)	8.27	4.11	26.7	0.5	6.3	8.6	4.0	18.7	19.5

Permeability index (PI)

The PI given by the following formula (USDA, 1954; Doneen, 1964):

$$PI = \frac{Na^{+} + (HCO_3)^{1/2}}{Na^{+} + Ca^{++} + Mg^{++}} \times 100$$

The PI classification is as follows: Excellent (>75%), Good (25-75%) and Unsuitable (<25%) (Al-Amry, 2008).

At the end of each season, plants were harvested from each lysimeter and some of growth parameters, biological and economical yield and yield components were recorded. Plant samples were taken from each treatment and separated to grains and straw, dried and digested for chemical determinations according to Ryan *et al.* (1996). Also, soil samples were collected from each treatment at three different depths 0-15, 15-30, and 30-45 cm, respectively it were dried and chemically analyzed. Also, SAR and ESP were calculated.

Statistical Analysis

The data were subjected to analysis of variance using MINITAB Statistical Software Program for Windows Release 16, according to Barbara and Brain (1994). The ANOVA test was used to determine significance of ($p \leq 0.05$) treatment effect and the Least Significant Difference (LSD) test was used to determine significance of the difference between individual means.

RESULTS AND DISCUSSION

Irrigation Water Quality

Plant growth is primarily limited by the salinity (EC_w) level of the irrigation water, the application of water with a sodium imbalance can further reduce the yield. Generally, seawater is unsuitable for use in irrigation crops without treated by fresh water because it's highest salinity (EC_w = 55.8 dS/m) and sodium hazards (SAR > 90) which harmful on plant growth and damage the soil properties. For this, diluted seawater is the proposal solution to meet the growing water needs. It was prepared by mixing the seawater with fresh water at a different quantity whose presented in Table 4 in which all of dilutions is suitable for irrigation crops. Results in Table 4 show the most of criteria calculated for different diluted seawater which used as irrigation treatments, it was noticed that the highest values calculated of these criteria were at the minimum diluted seawater (I_6 = 1:20), it was still suitable to use for irrigation.

The Effect of Treatments on Soil Chemical Properties

Results in Table 5 show that increasing the salinity of irrigation water (diluted seawater) or rates of compost addition to soil as individual factor increases significantly each parameter studied, *i.e.* EC and ESP whether after the first or second season which the mean values of these parameters were gradually increased with increasing the salinity levels of irrigation water up to the minimum dilution of seawater (1:20), and compost addition up to the maximum rates (8.0 ton fad.$^{-1}$). Although, Soil electrical conductivity and exchanged sodium percentage increased as a result of increasing water salinity and rates of compost, the effect of interaction among them on theses parameters of soil were insignificant through the two seasons except the pH parameter at the end of second season which appeared significant effect, these may be due to degradation of organic compost. Also, the interaction treatments appeared significant effect on the values of ESP at the end of first season, which it is more pronounced in treatments combined with compost addition. This may be due to the great surface area of the fine particles of compost, which adsorb more soluble and exchangeable cations of saline solution. With continuous irrigation with the same quality in the other season, the values of chemical parameters of irrigated soil were increased compared to the control (canal irrigation water) but this increasing were decrement if compared with the first season. Finely, salts accumulation in root zone was highly affected by the quality of irrigation water (*i.e.* its EC and SAR) and *vice versa*. This result was in agreement with Al-Busaidi *et al.* (2009), they reported that saline water remarkably affected the salt accumulation in soil.

Table 4. Some criteria for diluted seawater which used in irrigation

Irrigation water variety (diluted seawater)	pH	EC (dS/m)	PS	SSP	SAR	SCAR	SAR/ SCAR	PI
I_1 (Canal irrigation water)	7.65	1.10	8.15	61.86	4.98	5.60	0.89	73.49
I_2 (1:60)	7.19	1.80	12.45	63.44	6.50	7.05	0.92	71.82
I_3 (1:50)	7.82	2.04	13.75	63.16	6.86	7.50	0.92	71.75
I_4 (1:40)	8.01	2.62	17.90	63.20	7.80	8.50	0.92	70.69
I_5 (1:30)	8.13	3.30	22.20	63.25	8.68	9.49	0.92	69.94
I_6 (1:20)	8.27	4.11	28.45	63.42	9.78	10.64	0.92	68.99

Table 5. Effect of studied treatments on the soil chemical properties at harvest for two seasons

Parameter studied	After the first season				After the second season			
	pH			Mean	pH			Mean
Treatments (I×C)	Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$		Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$	
I_1 (canal water)	7.86	7.86	7.86	7.86 c	7.96	7.97	7.96	7.96 e
I_2 (1:60)	7.98	7.91	7.98	7.96 b	7.96	8.05	8.10	8.04 d
I_3 (1:50)	7.95	7.95	7.95	7.95 b	8.06	8.10	8.12	8.09 bc
I_4 (1:40)	8.10	8.06	8.11	8.09 a	8.05	8.15	8.14	8.11 b
I_5 (1:30)	8.12	8.10	8.16	8.13 a	8.18	8.13	8.24	8.18 a
I_6 (1:20)	8.11	8.11	8.15	8.12 a	8.08	8.23	8.28	8.20 a
Mean	8.02 a	8.00 a	8.03 a	……	8.05 b	8.11 a	8.14 a	……
LSD at 0.05 level	(I : 0.06) (C: ns) (I×C : ns)				(I : 0.05) (C: 0.03) (I×C : 0.09)			
Parameter studied	**EC (dS/m)**			**Mean**	**EC (dS/m)**			**Mean**
Treatments (I×C)	**Without compost**	**With 4.0 ton. fad.$^{-1}$**	**With 8.0 ton. fad.$^{-1}$**		**Without compost**	**With 4.0 ton. fad.$^{-1}$**	**With 8.0 ton. fad.$^{-1}$**	
I_1 (canal water)	1.29	1.40	1.57	1.42 e	1.35	1.41	1.76	1.51 d
I_2 (1:60)	1.39	1.50	1.79	1.56 d	1.56	1.52	2.00	1.69 bc
I_3 (1:50)	1.45	1.58	1.93	1.65 c	1.60	1.62	2.14	1.79 bc
I_4 (1:40)	1.52	1.68	1.95	1.72 c	1.67	1.73	2.17	1.86 b
I_5 (1:30)	1.64	1.79	2.19	1.87 b	1.80	1.92	2.43	2.05 a
I_6 (1:20)	1.78	1.95	2.30	2.01 a	1.87	2.06	2.54	2.16 a
Mean	1.51 c	1.65 b	1.96 a	……	1.64 b	1.71 b	2.17 a	……
LSD at 0.05 level	(I : 0.06) (C: 0.05) (I×C : NS)				(I : 0.11) (C: 0.08) (I×C : NS)			
Parameter studied	**ESP**			**Mean**	**ESP**			**Mean**
Treatments (I×C)	**Without compost**	**With 4.0 ton. fad.$^{-1}$**	**With 8.0 ton. fad.$^{-1}$**		**Without compost**	**With 4.0 ton. fad.$^{-1}$**	**With 8.0 ton. fad.$^{-1}$**	
I_1 (canal water)	7.89	8.27	8.51	8.22 d	8.20	8.47	8.89	8.52 e
I_2 (1:60)	7.92	8.30	8.75	8.32 d	8.30	8.37	9.13	8.60 d
I_3 (1:50)	8.10	8.40	9.02	8.51 bc	8.34	8.37	9.37	8.69 d
I_4 (1:40)	8.20	8.65	9.06	8.63 b	8.51	8.68	9.44	8.87 c
I_5 (1:30)	8.44	8.95	9.47	8.82 b	8.82	9.13	9.88	9.27 b
I_6 (1:20)	8.75	9.06	9.68	9.16 a	8.89	9.26	10.05	9.40 a
Mean	8.15 c	8.60 b	9.08 a	……	8.51 c	8.71 b	9.46 a	……
LSD at 0.05 level	(I : 0.17) (C: 0.12) (I×C :0.30)				(I : 0.14) (C: 0.10) (I×C : NS)			

Values are means (N = 3). Values followed by different letters are significantly different, $p < 0.05$.

The Effect of Treatments on Availability of Macronutrients (NPK) in Soil After Harvesting of Each Season

As a general trend results in Table 6 show antagonism effect between the studied treatments whether, after the first or second seasons, which the soil fertility (NPK content) was negatively significant affected by increasing the irrigation water salinity, in contrast, the availability of macronutrients were increased significantly with increasing the rates of compost. The beneficial effect of compost on increasing available nutrient contents in the soil may be attributed to it is not only considered as a chelating agent through enhancing the released active organic acids and as a storehouse for plant essential nutrients but also to be a strategy to preserve these nutrients from loss versus their easily uptake by plants. In addition, the slow nutrients released during the decomposition and mineralization processes of these organic substances resulted in minimizing their possible loss by leaching throughout the studied relatively coarse textured soil. It is noteworthy to mention that the diluted seawater applications had lowest effect on the available macronutrient contents of the soil compared to the effect of the compost addition as individual factors. Thus, the interactions among them were significant which, the values were increased as a general trend with increasing the applied rates of compost, and decreased with increasing the irrigation water salinity at the same rate of compost. Although, the treatment ($I_6 \times C_3$) gave the minimum values obtained for NPK in the soil compared with different irrigation water salinity combined with the highest rates of compost addition, this value was better than the values obtained at the treatment (I_6) without compost and the control (I_1; canal irrigation water). This may be attributed to the beneficial role of compost (Mohammed, 2004). In addition, the percentage increases of these above availability values were by 20.7, 6.6 and 22.5% for N, P and K respectively compared to the control (canal irrigation water without compost) at the harvesting of barley (first season), while the percentage of these macronutrients at the same treatment ($I_6 \times C_3$) after harvesting of sunflower (second season) were increased to 32.5, 13.6 and 26.9% for NPK compared to the control at the first season, respectively. This may be due to degradation the compost with the time. However, these percentages were gradually increased with increasing the dilution of seawater up to the maximum percentage of NPK with fresh irrigation water.

Effect of Applied Treatments on Biological Yield and Grain Quality of Barley

The beneficial effects of the applied treatments were greatly supported by the values of biological yield and grains quality, as shown in Table 7, which can be explained on the basis that the irrigation with the highest salinity water (I_6) without compost addition reduced each of the grains and straw yield of barley by 26.9% and 27.3%, respectively compared to the control (I_1 = canal water without compost addition). As well as, wt 1000 grains and crude protein were reduced by 7.7% and 13.7% respectively, at using the same treatment (I_6) compared to the control (I_1). These may be due to inability of the plant to compete with ions in the soil solution for water (physiological drought), negative effect on the ability of plant to absorb more water, also the rate of evapotranspiration will decrease. These results were in agreement with Al-Busaidi *et al.* (2009). On the other hand, compost addition as individual factor up to 8.0 ton fad.$^{-1}$ increased the percentage of grains, straw, wt 1000 grains and crude protein up to 35.5, 35.1, 3.8 and 32.9%, respectively compared to without compost addition. These results attributed to the compost addition thus became enriched in the released nutrient contents, which are involved directly, or indirectly information of protein and other biological components through their roles in the respiratory and photosynthesis mechanisms as well as in the activity of various enzymes.

Also, it was noticed that the interaction between treatments has positive role in reducing the hazardous of irrigation water salinity, which all above studied parameters were decreased to maximum percentage at using the highest salinity irrigation water but it was obtained the minimum reduction percentage with increasing the rates of compost addition, *i.e.* the decreasing in grains yield at using (I_6) were changed from 26.9%, without compost to 12.1% and 5.9% if combined with 4.0 and 8.0 ton compost fad.$^{-1}$,

Table 6. Effect of studied treatments on the residual macronutrients in soil after the harvest for two seasons

Parameter studied	After the first season				After the second season			
	N (mg. kg^{-1})			Mean	N (mg. kg^{-1})			Mean
Treatments (I×C)	Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$		Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$	
I_1 (canal water)	27.0	40.1	46.8	38.0 a	21.7	45.3	60.6	42.5 a
I_2 (1:60)	27.9	40.7	49.1	39.2 a	22.3	44.8	57.7	41.6 a
I_3 (1:50)	26.7	37.1	44.6	36.1 a	21.4	41.1	52.7	38.4 b
I_4 (1:40)	28.5	29.7	36.7	31.6 b	22.5	35.1	43.8	33.8 c
I_5 (1:30)	18.7	26.8	34.9	26.8 c	15.9	31.1	40.1	29.0 d
I_6 (1:20)	17.9	25.1	32.6	25.2 c	15.0	28.7	35.8	26.5 e
Mean	24.5 c	33.3 b	40.8 a	……	19.8 c	37.7 b	48.5 a	……
LSD at 0.05 level	(I : 4.35) (C: 3.07) (I×C : NS)				(I :1.97) (C: 1.40) (I×C : 3.42)			
parameter studied	P (mg. kg^{-1})			Mean	P (mg. kg^{-1})			Mean
Treatments (I×C)	Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton.fad.$^{-1}$		Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$	
I_1 (canal water)	7.6	8.2	8.9	8.2 bc	7.6	8.3	9.5	8.5 b
I_2 (1:60)	9.1	9.1	9.3	9.2 a	7.9	9.4	10.4	9.2 a
I_3 (1:50)	8.5	8.7	8.9	8.7 b	7.8	9.0	9.3	8.7 b
I_4 (1:40)	8.1	8.5	8.5	8.4 bc	7.4	8.8	9.1	8.4 b
I_5 (1:30)	7.9	8.3	8.3	8.2 bc	7.2	8.5	8.8	8.2 bc
I_6 (1:20)	7.4	7.9	8.1	7.8 d	6.8	8.1	8.6	7.8 d
Mean	8.1 b	8.5 a	8.7 a	……	7.4 c	8.7 b	9.3 a	……
LSD at 0.05 level	(I : 0.34) (C: 0.24) (I×C : ns)				(I : 0.30) (C: 0.23) (I×C : ns)			
Parameter studied	K (mg. kg^{-1})			Mean	K (mg. kg^{-1})			Mean
Treatments (I×C)	Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$		Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$	
I_1 (canal water)	181.7	224.5	246.0	217.4 a	173.8	251.3	268.2	231.1 a
I_2 (1:60)	176.1	228.4	242.8	215.7 b	171.8	256.4	260.3	229.5 a
I_3 (1:50)	172.0	219.1	234.9	208.7 c	169.2	247.2	253.8	223.4 b
I_4 (1:40)	166.1	215.7	208.2	196.7 d	161.2	236.0	247.3	214.8 c
I_5 (1:30)	160.0	207.7	214.7	194.1 d	151.3	232.3	242.0	208.6 d
I_6 (1:20)	156.1	203.8	222.6	194.2 d	151.3	220.4	230.6	200.7 e
Mean	168.6 c	216.5 b	228.2 a	……	163.1 c	240.6 b	250.3 a	……
LSD at 0.05 level	(I : 2.93) (C: 2.08) (I×C : 5.08)				(I : 4.41) (C: 3.12) (I×C : ns)			

Values are means (N = 3). Values followed by different letters are significantly different, $p < 0.05$.

Table 7. Effect of studied treatments on the biological and quality yield of barley at harvest

Item studied	Treatments (I×C)	I_1 (canal water)	I_2 (1:60)	I_3 (1:50)	I_4 (1:40)	I_5 (1:30)	I_6 (1:20)	Mean
Grains Y. (kg fad.$^{-1}$)	Without compost	1145.6	1072.4	989.6	940.4	882.0	837.2	977.9d
	With 4.0 ton. fad.$^{-1}$	1453.0	1354.0	1275.6	1136.4	1079.2	1006.5	1217.5b
	With 8.0 ton. fad.$^{-1}$	1566.4	1529.6	1384.4	1284.0	1106.0	1077.6	1324.7a
Mean		1388.3a	1318.7b	1216.5c	1120.3d	1022.4e	973.8f	....
LSD at 0.05 level		(Irr. : (I), compost : (c), (I :14.9) (C: 10.5) (I×C :25.8)						
Straw Y. (kg fad.$^{-1}$)	Without compost	1613.7	1505.1	1414.1	1317.6	1234.2	1173.7	1376.4d
	With 4.0 ton. fad.$^{-1}$	2043.5	1898.6	1789.4	1594.6	1519.7	1413.8	1709.9b
	With 8.0 ton. fad.$^{-1}$	2204.0	2141.4	1940.0	1797.8	1551.5	1515.6	1858.4a
Mean		1953.7a	1848.4b	1714.5c	1570.0 d	1435.1e	1367.7f	....
LSD at 0.05 level		Irr. : (I), compost : (c), (I : 25.8) (c: 18.2) (I×C : 44.7)						
Wt. 1000 grains (g)	Without compost	53.5	53.3	51.7	51.6	50.5	49.4	51.7b
	With 4.0 ton. fad.$^{-1}$	54.7	54.5	54.1	53.8	52.2	51.0	53.4a
	With 8.0 ton. fad.$^{-1}$	56.7	55.1	54.1	53.5	51.8	51.1	53.7a
Mean		55.0 a	54.3b	53.3c	53.0 c	51.5d	50.5e	………
LSD at 0.05 level		Irr. : (I), compost : (c), (I : 0.63) (c: 0. 45) (I×C :ns)						
Crude protein (%)	Without compost	11.27	11.24	11.05	10.13	9.89	9.64	10.54b
	With 4.0 ton. fad.$^{-1}$	11.50	11.32	10.84	10.50	10.11	9.83	10.68b
	With 8.0 ton. fad.$^{-1}$	12.95	12.60	12.28	12.08	11.57	11.50	12.16a
Mean		11.91 a	11.72 a	11.39b	10.90c	10.52d	10.33e	…….
LSD at 0.05 level		Irr. : (I), compost : (c), (I : 0.24) (c: 0. 17) (I×C : ns)						

Values are means (n = 3). Values followed by different letters are significantly different, $p < 0.05$.

respectively, compared to the control (I_1= canal irrigation water) and 6.1%. This trend was recorded for the other barley studied parameters. Which the reduction percentage for straw yield and, wt 1000 grains were decreased from 27.3%, without compost to 6.1% and from 7.7% without compost to 4.5% at addition the highest rate of compost (8.0 ton fad.$^{-1}$), respectively. On the other hand, this rate of compost (8.0 ton fad.$^{-1}$) wasn't reduce the hazards of salinity irrigation water alone but it was enhanced to increases the crude protein in barley by 8.8%. Generally, we can be compensated the scarcity of fresh water by mixed 2.5% from seawater (I_4) with fresh irrigation water combined with treated sandy soil by 4.0 ton fad.$^{-1}$ of compost, which gave the same production particularly compared with the control (I_1= canal irrigation water without compost). The treatment ($I_4 \times C_2$) appeared this conclusion, which the grains and straw yield of barley had insignificant differences with its production at control (I_1).

Results presented in Table 8 show the individual significant effect of the two studied factors whether negative effect due to the salinity irrigation water or positive effect to compost addition on the concentration and uptake of macronutrients in grains barley at harvest. On the other hand, the interactions between treatments recorded insignificant difference among them on macronutrients concentration in grains, but they appeared highly significant effect on the remove of macronutrients to grains which followed the same trend thus above discussed with the grains yield and cause the availability of macronutrients in soil.

Table 8. Effect of studied treatments on the concentration and removal of macronutrients to grains barley at harvest

Parameter studied	Macronutrients content in grains				Macronutrients uptake in grains			
	N (%)			Mean	Grains N-uptake (kg fad.$^{-1}$)			Mean
Treatments (I×C)	Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$		Without compost	With 4.0 ton. fed^{-1}	With 8.0 ton. fad.$^{-1}$	
I_1 (canal water)	1.80	1.84	2.07	1.91 a	20.66	26.76	32.45	26.62 a
I_2 (1:60)	1.80	1.81	2.02	1.88 a	19.29	24.53	30.85	24.89 b
I_3 (1:50)	1.77	1.73	1.97	1.82 b	17.50	22.12	27.21	22.28 c
I_4 (1:40)	1.62	1.68	1.93	1.74 c	15.24	19.09	24.82	19.72 d
I_5 (1:30)	1.58	1.62	1.85	1.68 d	13.95	17.45	20.48	17.29 e
I_6 (1:20)	1.54	1.57	1.84	1.65 d	12.92	15.83	19.84	16.20 f
Mean	1.69 b	1.71 b	1.95 a	…….	16.59 c	20.96 b	25.94 a	…….
LSD at 0.05 level	(I : 0.038) (C: 0.027) (I×C : ns)				(I : 0.66) (C: 0.47) (I×C : 1.15)			
Parameter studied	P (%)			Mean	Grains P-uptake (kg fad.$^{-1}$)			Mean
Treatments (I×C)	Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$		Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$	
I_1 (canal water)	0.28	0.44	0.49	0.41 a	3.25	6.45	7.67	5.79 a
I_2 (1:60)	0.26	0.44	0.47	0.39 a	2.76	5.95	7.14	5.28 b
I_3 (1:50)	0.23	0.40	0.44	0.36 ab	2.31	5.10	6.09	4.50 c
I_4 (1:40)	0.22	0.37	0.40	0.33 ab	2.04	4.25	5.18	3.82 d
I_5 (1:30)	0.18	0.36	0.41	0.32 ab	1.62	3.85	4.53	3.33 e
I_6 (1:20)	0.18	0.33	0.39	0.30 abc	1.48	3.29	4.24	3.00 e
Mean	0.23 c	0.39 b	0.43 a	…….	2.24 c	4.81 b	5.81 a	…….
LSD at 0.05 level	(I : 0.04) (C: 0.03) (I×C : ns)				(I : 0.42) (C: 0.30) (I×C : 0.73)			
Parameter studied	K (%)			Mean	K (mg. kg^{-1})			Mean
Treatments (I×C)	Without compost	With 4.0 ton. fad.$^{-1}$	With 8.0 ton. fad.$^{-1}$		Without compost	With 4.0 ton. fed-1	With 8.0 ton. fad.$^{-1}$	
I_1 (canal water)	0.33	0.49	0.56	0.46 a	3.74	7.18	8.77	6.56 a
I_2 (1:60)	0.31	0.47	0.54	0.44 a	3.36	6.36	8.21	5.98 b
I_3 (1:50)	0.30	0.44	0.50	0.41 ab	2.93	5.61	6.97	5.17 c
I_4 (1:40)	0.27	0.41	0.49	0.39 ab	2.57	4.66	6.25	4.50 d
I_5 (1:30)	0.25	0.39	0.48	0.38 ab	2.23	4.24	5.35	3.94 e
I_6 (1:20)	0.23	0.36	0.44	0.34 c	1.96	3.59	4.74	3.43 f
Mean	0.28 c	0.43 b	0.50 a	…….	2.80 c	5.28 b	6.71 a	…….
LSD at 0.05 level	(I : 0.03) (C: 0.02) (I×C : ns)				(I : 0.39) (C: 0.27) (I×C : 0.67)			

Values are means (N = 3). Values followed by different letters are significantly different, $p < 0.05$.

The Residual Effect of Applied Treatments on Growth Parameter and Biological Yield of Sunflower Which Cultivated in the Second Season

With continuous irrigation with the same quality in the second seasons, soil salinity was increased with the time, but this increasing was reduced if compared with the first season (Table 5). As well as the prediction degradation of compost and releases the nutrients which followed by improving the soil fertility and physical properties. This cause may be create balance in treated soil had positive effect on the cultivated sunflower in this season. Results in Table 9 indicate this proposal which showed.

Table 9. Effect of studied treatments on growth parameters and biological yield of sunflower cultivated in the second season

Item studied	Treatments (I×C)	I_1 (canal water)	I2 (1:60)	I3 (1:50)	I4 (1:40)	I5 (1:30)	I6 (1:20)	Mean
Plant height (cm)	**Without compost**	118.7	116.2	113.9	110.9	105.6	103.9	111.5 c
	With 4.0 ton. fad.$^{-1}$	128.9	124.9	122.6	121.9	119.9	115.9	122.3b
	With 8.0 ton. fad.$^{-1}$	132.2	128.0	124.6	125.7	123.4	121.8	125.9a
mean		126.6 a	123.0 b	120.3 c	119.5c	116.3d	113.9e	……..
LSD at 0.05 level		Irr. : (I), compost : (c), (I : 0.90) (c: 0.64) (I×C : 1.56)						
Stem diameter (cm)	**Without compost**	1.53	1.43	1.39	1.34	1.32	1.30	1.39 c
	With 4.0 ton. fad.$^{-1}$	1.65	1.59	1.55	1.52	1.49	1.46	1.54b
	With 8.0 ton. fad.$^{-1}$	2.27	1.87	1.70	1.63	1.59	1.51	1.76a
Mean		1.82a	1.63 b	1.55 c	1.50cd	1.47d	1.42d	……
LSD at 0.05 level		Irr. : (I), compost : (c), (I :0.05) (c: 0.03) (I×C : 0.08)						
Head diameter (cm)	**Without compost**	16.0	15.6	15.3	14.9	14.5	13.5	15.0c
	With 4.0 ton. fad.$^{-1}$	18.9	18.4	18.2	17.6	17.1	16.0	17.7b
	With 8.0 ton. fad.$^{-1}$	21.6	20.1	19.7	18.9	18.2	17.5	19.3a
Mean		18.8 a	18.0 b	17.7c	17.1d	16.6e	15.66f	
LSD at 0.05 level		Irr. : (I), compost : (c), (I : 0.18) (c: 0.13) (I×C : 0.32)						
Seed yield (kg fad.$^{-1}$)	**Without compost**	774.6	769.8	759.0	738.5	734.5	729.3	750.9c
	With 4.0 ton. fad.$^{-1}$	855.1	846.1	839.7	834.7	825.9	812.2	835.6b
	With 8.0 ton. fad.$^{-1}$	984.2	967.8	952.7	937.8	933.6	926.1	950.4a
Mean		871.3 a	861.2b	850.5c	837.0d	831.3e	822.5f	….
LSD at 0.05 level		Irr. : (I), compost : (c), (I :4.3) (c: 3.0) (I×C : 7.4)						
Seed oil content (%)	**Without compost**	19.15	18.85	18.47	18.39	17.90	17.73	18.42c
	With 4.0 ton. fad.$^{-1}$	23.07	22.64	21.26	20.93	20.48	20.24	21.44b
	With 8.0 ton. fad.$^{-1}$	23.67	23.29	21.74	21.24	20.68	20.03	21.77a
Mean		21.97 a	21.59b	20.49c	20.18d	19.69e	19.34f	…..
LSD at 0.05 level		Irr. : (I), compost : (c), (I : 014) (c: 0. 10) (I×C : 0.25)						
Wt. 100 seeds (g)	**Without compost**	6.74	6.71	6.57	6.53	6.40	5.94	6.47 c
	With 4.0 ton. fad.$^{-1}$	7.60	7.54	7.45	7.41	7.10	6.97	7.34 b
	With 8.0 ton. fad.$^{-1}$	7.98	7.90	7.68	7.42	7.26	6.96	7.53a
Mean		7.44 a	7.38b	7.23c	7.12c	6.92d	6.62e	……
LSD at 0.05 level		Irr. : (I), compost : (c), (I : 0.14) (c: 0. 10) (I×C :ns)						

Values are means (N = 3). Values followed by different letters are significantly different, $p < 0.05$.

the beneficial role of compost in minimizing the hazards of salinity irrigation water. Although, the negative effect of salinity water and the positive effect of compost addition as individual factors on the parameter studied of cultivated sunflower. The residual effect of compost addition was more pronounced with interactions treatments compared the first season. Which it wasn't reduce the hazards of salinity irrigation water alone but it was enhanced to increases the values of parameter studied, *i.e.,* the values of growth parameter (plant height, stem diameter, and head diameter) were decreased to maximum percentage with highly salinity irrigation water (I_6), they were decreased by 12.4, 15.3 and 15.6% compared to the canal irrigation water respectively. Whilst, theses percentage were decreased to the minimum percentage (2.3, 4.5 and 0.1% pour the same parameter, respectively) in the treatment ($I_6 \times C_2$) which received 4.0 ton fad.$^{-1}$ in the first season. In contrast, the residual effect of the rate (8.0 ton fad.$^{-1}$ compost addition) dissolved the hazards of highest salinity irrigation water, which appeared significantly increasing in values of sunflower growth studied parameters particularly plant height, and head diameter by 2.5 and 8.5%, respectively.

On the other hand, this phenomenon was more clearly for the seed yield, which it was noticed highly increasing to the role of compost at the two rates supplied in dissolved the hazardous of highest salinity irrigation water, at these treatments ($I_6 \times C_2$) and ($I_6 \times C_3$) the grain yield was significantly increase by 4.6 and 16.3%, respectively.

Conclusion

Freshwater is the best option for optimum plant growth but the scarcity or shortage of freshwater is compelling researchers to investigate the use of saline irrigation water. Using diluted seawater for agricultural deserves attention nowadays or future production to satisfy the needs of growing population continuous and water scarcity in Egypt. However, caution in the practice of over-irrigation with salty water should be held to avoid deleterious impact on the soil. Studies in this field are still little in Egypt. Under our experimental condition, we obtained a positive effect of organic compost addition to sandy soil to alleviate salinity irrigation water problem.

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استخدام مياه البحر في الزراعة ومقاومة مخاطرها المحتملة على الأرض والنبات

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من المؤكد أن المياه هي واحدة من أكثر المدخلات الهامة لإنتاج المحاصيل في أجزاء كثيرة من العالم، ولاسيما في المناطق الجافة وشبه الجافة كما بمصر، يلزم في المستقبل القريب تنميه الزراعة المروية لمواجهة زيادة الطلب على الغذاء نتيجة للزيادة السكانية وندرة المياه في مصر، وهكذا أصبح من الضرورى استكشاف مصدر مياه زراعية غير تقليدية يمكن أن تلبى الطلب الحالى أو المقبل للإمداد بالري، الهدف الرئيسى من هذه الدراسة هو تحديد الحد الأقصى من مياه البحر التى يمكن إستخدامها في الرى لإنتاج محصول جيد، أيضاً دراسة التأثير المشترك لتخفيفات مياه البحر المستخدمة (I_1, I_2, I_3, I_4, I_5, I_6) ومعدلات الكمبوست المضاف (صفر ، ٤,٠ و٨,٠ طن/فدان) على نمو وإنتاج محصول الشعير ودوار الشمس، وخواص التربة، زرعت صناديق التربة الرملية بواسطة النباتات التي تتحمل الملوحة (الشعير) فى الموسم الأول ثم تبعه زراعه محصول (دوار الشمس) فى الموسم التالى على نفس معاملات التجربة، خلصت النتائج إلى أن كل مياه البحر المخففة والمعدة للرى كانت مناسبة للري وفقا لمعايير جودة المياه المحسوبة، قيم التوصيل الهيدروليكى ونسبه الصوديوم المتبادل لتربة التجربة فى نهاية الموسمين أعطت نفس الإتجاة الذى زاد معنويا بزيادة ملوحة مياه الرى أو زيادة معدل الكمبوست المضاف كعوامل فردية ولكن فى حاله الإقتران بينهما أظهرت اختلاف ضئيل على معظم الصفات المدروسة، أيضا المغذيات الكبرى المتبقية بأرض التجربة تأثرت بعلاقة التضاد بين عوامل الدراسة إجابيا بإضافة الكمبوست وسلبيا بإضافة الماء المالح، كما لوحظ أن التداخل بين المعاملات له دور إيجابى فى التقليل من مخاطر ملوحة مياه الرى، حيث انخفض محصول الشعير إلى أكبر نسبه (٢٩,٩%) لكل من الحبوب والقش عند استخدام التركيز الأعلى من ملوحة مياه الرى (I_6) لكن مع اضافة الكمبوست بالمعدل الأعلى (٨ طن/فدان) انخفضت هذه النسبة لتصل إلى (٥,٩%) باستخدام المعاملة (I_6 x C_3) مقارنه بالكنترول (I_1) (الرى بمياه غير مالحة بدون إضافة الكمبوست إلى التربة)، التأثير المتبقى للتركيزات العالية من الكمبوست كان أكثر وضوحا على الخواص المدروسة لدوار الشمس النامى فى الموسم الثانى حيث لم يتوقف دور الكمبوست على التقليل من مخاطر التركيز العالى من مياه الرى بل تعدى الى تعظيم قيم الصفات المدروسة خاصة محصول البذور الذى ذاد ب ١٦,٣% عند استخدام المعاملة (I_6 xC_3) مقارنه بالكنترول (I_1).

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