USE OF SEA WATER FOR WHEAT IRRIGATION

2-Effect on Soil Chemical Properties, Actual Evapotranspiration and Water Use Efficiency.

Journal

J Biol Chem Environ Sci, 2006, Vol. 1(3): 447-464
www.AcepsAg.org

M.A. Mostafa*, M.O. Elsharawy*, and F.M. Elboraei **

**Soil Dept. Fac. Agric. Am Shams Univ., Cairo, Egypt.*
***Desert Res. Center, Mataria, Cairo, Egypt.*

ABSTRACT

A greenhouse pot experiment was conducted to evaluate the influence of water management using diluted sea water and organic manure application on salinity build up in a calcareous soil (*Typic Calciorthents*) from the area west of the Nile Delta, Southern Tahreer, El-Beheira Governorate, cultivated with wheat plant (*Triticum aesitivum L.V.* Sakha 92). The modes of saline water application included irrigation with water having 6720 mgl^{-1} (1:5 diluted sea water), 8768 mgl^{-1} (1:3 diluted sea water) and a tap water as a control having 256 mgl^{-1}. Chicken manure application was done as a soil amendment (1.5% w/w), while water management practices were done as the following irrigation frequencies, namely, (a) irrigation with diluted sea water along the growth period, (b) irrigation with diluted sea water until pre-flowering stage then with tap water and (c) irrigation with saline water for three times and once with tap water along the growth season. Certain chemical properties of the studied soil were evaluated during different growth periods and after harvesting of wheat plant. Actual evapotranspiration (ETa) ratio and water use efficiency (WUE) were calculated. The obtained results indicated that increasing water salinity increased soluble cations and anions with different rates. For instance, $S0_4^{-}$ concentration in soil extract showed considerable increases as the time increases, reaching 6 folds of those found for the soils irrigated with tap water. Also, SAR increases to about 288, 325 and 57% for the vegetative, yield formation and harvesting stages, respectively. On the other hand, increasing salinity level of irrigation water decreased the actual evapotranspiration (ETa) and water use efficiency (WUE) values of wheat plant as compared to plants irrigated with tap water. Regarding the effect of irrigation frequencies on soil salinity, the lowest values of EC and SAR as well as soluble ions were associated with (c) frequency while the highest ones were associated with (a) frequency. In addition, irrigation frequency (c) gave the highest values of Eta and WUE as compared to the other two irrigation frequencies request alternation of saline and fresh water at a sequence of 3 to 1 caused considerable attenuation of salinity build-up as indicated by increasing its levels in the soil. Such increases reached about 5 folds comparing to those irrigated with tap water. Chicken manure application increased soil EC values as well as ETa and WUE, but lowered SAR values. It can be concluded that addition of organic manure and water management as (c) water irrigation frequency had promotive effect on reducing the salt stress in the plant root zone and providing the growing plants with adequate amounts of water and available nutrients as with as avoiding loss caused by extended periods of water stress under saline conditions.

Key words: Diluted sea water, Calcareous soil, Chicken manure, and irrigation frequencies, EC, SAR, ETa and WUE.

INTRODUCTION

A rapid increase in the population of Egypt during the past two decades has significantly increased the country's need for food and has put its land and water resources under severe stress. Freshwater resources of the country, both surface and ground water, has been over-exploited, often at the expense at deteriorating water and land quality. With limited room for expanding irrigation agriculture due to the lack of extra capacity in the country's freshwater resources, the possible use of sea water, whose salinity is well below that of the open seas and oceans, has some appeal (Dordipour, 2000). Saline water was used to be considered unusable for irrigation but research efforts during the past two decades have brought into practice some large irrigation schemes which depend on saline water (Hamdy *et al.*, 1993). The sustainability of irrigated agriculture in arid and semi-arid areas depends on maintenance of salt balance within the soil profile and disposal of shallow groundwater is a necessity. Rhoades *et al.* (1989) further demonstrated a strategy for using saline and non- saline water in rotation, which caused no reduction in yield providing there was a good stand. Salinity generally affects the growth of plants by either ion excess or by water deficits in the expanded leaves (Greenway and Munns, 1980). Water uptake is restricted by salinity due to the high osmotic potential in the soil and high concentrations of specific ions that may cause physiological disorders in the plant tissues (Feigin, 1985) and reduce yields (Verma and Neue, 1984). However ‹some crops such as wheat and barley can be tolerant of saline irrigation water and selection and breeding are likely to improve the performance of these crops under highly saline regimes (Yazdani, 1991).

The irrigation regime, the amount of applied water, the method of irrigation and soil texture are some of the most important factors governing soil stalinization (Balba, 1995). The presence of salts in irrigation water influences most of the chemical soil characteristics such as soil pH, soil EC, soluble ions and SAR as well as actual evapotranspiration and water use efficiency. Soil pH values were inversely proportional to salinity level of irrigation water of more than 4000 mgl^{-1} (Alawi *et al.*, 1980 and Mostafa *et al.*, 1992). On the other hand, concentration of soluble Ca^{2+}, Mg^{2+}, K^{+} and Na^{+} were sharply increased as salinity level of irrigation water increased up to 4000 mgl^{-1} (Abd El-Nour, 1989). With respect to soluble anions, Abo El-Defan (1990) found that increasing salinity of irrigation water up to 15.8 dS/m significantly increased the soluble ions in different soils as compared to the tap water treatment. However, Mostafa *et al.* (1992) stated that the use of saline water (4000 mgl^{-1}) for irrigation led to slightly and negatively effect on $HC0_3^-$ concentration in calcareous soils, while the concentration of Cl^- and $S0_4^{--}$significantly increased. The U.S. Salinity Laboratory used the ratio SAR as an index of sodicity hazard of irrigation water therefore; it is also extremely used for characterization of soil solution. Some authors suggested the adjusted SAR but recently Ayers and Westcott (1985) reported that this adjusted SAR is not longer recommended because it over predicts the sodium hazard. On the other hand, water use efficiency of wheat grown on high salty conditions was decreased due to salinity effect (Holloway and Aiston, 1992).The aim of this work was to study the effect of water management, salinity stress (irrigation with diluted sea water) and organic manure application on some chemical properties of a calcareous soil cultivated with wheat plant, actual evapotranspiration and water use efficiency were taken into consideration.

MATERIALS AND METHODS

Cultivation: A greenhouse pot experiment was carried out at faculty of agriculture, Ain Shams University, Cairo, Egypt, using plastic pots with a hole in the bottom (24 cm diameter and 30 cm height) filled with 10 kg calcareous soil *(Typic Calciorthents*, loamy mixed, Thermic) collected from Maryout, West Delta, Southern Tahreer, El-Beheira Governorate. Some physical and chemical properties of the used soil are shown in Table (la). Half of these pots were treated, 15 days before cultivation, with 1.5% (w/w) chicken manure as a dry basis (Table, lb), while the other ones received no chicken manure. All pots received the recommended doses of mineral fertilization as follows: single super phosphate fertilizer (15% P_2O_5) was added at a rate of 20 kg P/fed. (200 mg P) mixed thoroughly with the soil sample, three days before cultivation, urea (45%N) was added at a rate of 60 kg N/fed. (600 mg N/pot), 10 days after sowing and potassium sulphate (48%K_2O) was added at a rate of 48 K_2O/fed. (480mg K), 10 days after sowing.

Pre-experiment was conducted using three wheat varieties i.e. Giza 157, Sakha 8 and Sakha 92 to select the most salt tolerant one for cultivation. Sakha 92 variety was selected as the best one. Fifteen seeds of wheat (*Triticum aesitivum L.V.* Sakha 92) were sown in each pot and thinned to ten seedlings after 10 days from cultivation. The seedlings were irrigated with tap water equal to soil field capacity for 14 days, then irrigated with different saline waters (1:3, 1:5 diluted sea water and tap water) having electrical conductivities of 13.7, 10.5 and 0.4 dS/m, respectively).The irrigation water included excess water of 50% added as leaching requirement. Some chemical properties of the used water are shown in Table (1c). All pots were irrigated with different diluted sea waters as the following irrigation management (a) irrigation with diluted sea water along the period of the experiment (165 days), (b) irrigation with diluted sea water until pre-flowering (75 days from sowing), then tap water was added to the end of the experiment (90 days), and (c) irrigation with diluted sea water as three times and once with tap water. The control treatments were irrigated

Table (1a): Some physical and chemical characteristics of the investigated soil.

Location	Practical size distribution %			Texture class	Field capacity %	O.M. %	EC Ds/m	pH 1:2.5	$CaCO_3$ %	Soluble ions $me.L^{-1}$							
										Cations				Anions			
	Sand	Silt	Clay							Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3	Cl^{-}	SO_4^{-}
Maryout	69	21	10	Sandy clay loam	26	0.69	3.05	7.4	29	10.5	6.20	13.2	0.12	-	1.20	20.4	8.4

Table (1b): Some chemical characteristics of the used organic manure.

Organic manure	pH 1:2.5	EC Ds/m	Moisture content %	M.O. %	C:N ratio	Total elements											
						%						mg/kg					
						N	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	Cd	Pb
Chicken manure	6.8	5.1	17.1	31.3	19:1	1.16	0.10	0.14	0.09	0.05	0.25	223	480	529	228	13	46

Table (1c): Chemical analysis of the used irrigation water.

Water quality	pH 1:2.5	EC Ds/m	SAR	Adj-SAR	Soluble ions/L															
					Cations				Anions				Microelements							
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3	Cl^{-}	SO_4	Fe	Mn	Zn	Cu	Cd	Pb		
Fresh water	7.12	0.4	1.97	5.5	1.7	0.7	1.4	0.2	-	2.1	1.5	0.4	<0.01	<0.01	0.01	<0.01	<0.01	<0.01		
Conc. Sea water	8.9	45	27.1	13.6	29.9	148	256	15.2	0.48	9.0	340	100	1.9	0.13	0.07	0.50	<0.01	<0.01		
D.S.W. 1:5	7.9	10.5	14.6	7.3	7.1	30.9	63.6	3.3	-	1.9	75.7	27.4	0.1	0.10	0.30	0.30	<0.01	<0.01		
1:3	8.5	13.7	14.2	14.6	11.7	44.8	75.6	4.8	0.3	2.8	102	32.1	1.3	0.11	0.01	0.03	<0.01	<0.01		

with tap water along the period of the experiment. Treatments were arranged on greenhouse benches in a randomized design with five replicates for each.

Soil, organic manure and water analysis:

The surface soil sample (0-30 cm depth) was air dried, ground in wooden mortar, sieved and chemically analyzed as follows: Calcium carbonate equivalent (Richards, 1954); the mechanical analysis (Gee and Bouder, 1986), organic matter, soluble ions, and chemically available elements (Jackson, 1967). Organic matter, water analysis as well as determination of elements were done according to Jackson (1967).

Sampling:

Representative soil samples were taken from each treatment after 75, 135 and 165 days from planting to determine the chemical properties. PH values were determined in 1:2.5 soil: water suspension using a glass electrode pH meter, then EC values were determined in the extract, soluble ions and SAR values were determined according to Jackson (1967). Actual evapotranspiration (mm) were calculated for the various plant growth stages using the estimated average soil moisture contents. Water use efficiency (g.cm) was calculated by dividing the crop yield by the amount of seasonal evapotranspiration for wheat plant according to Giriappa (1982)

RESULTS AND DISCUSSION

Soil pH:

Soil pH may be one of the most important parameters which pinpoint the over all changes in soil chemical properties. Data presented in Table (2) indicate that soil pH values, during the different growth stages, decreased as a salinity level of irrigation water increased, the rate of this decrease was getting smaller with increasing period of plant growth. This may be due to that H^+ ions are released from the exchanger complex by the influence of other soluble cations in the applied saline waters (Mahrous *et al.*, 1983) or due to increasing the solubility of $CaSO_4$ and sulfate transformation which led to decrease in the soil pH values (El Sawaby, 1965).

Regarding the effect of irrigation frequencies on soil pH values, data show that the highest values were associated with "c" frequency

Table (2): The main effects of diluted sea water, irrigation frequency and chicken manure on pH, EC, soluble ions and SAR in soil at different wheat growth stages.

Treatments	pH 1:2.5	EC (dS/m)	SAR	Soluble Ions me. L^{-1}							
				Cations				Anions			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3	HCO_3	Cl^{-}	SO_4
At 75 days from planting											
Fresh water	7.90	1.34	7.60	1.70	1.51	9.6	1.25	-	0.36	8.4	5.1
Diluted sea water											
1:5	7.59	2.88	16.08	1.89	1.76	21.8	3.41	-	0.40	21.4	6.6
1:3	7.34	6.71	29.50	3.22	2.59	47.4	9.30	-	0.73	49.7	12.4
Irrigation frequency											
a	7.20	5.63	23.12	2.81	2.28	37.6	6.46	-	.0.62	39.1	8.7
b	7.46	4.78	26.94	2.36	2.14	37.5	6.47	-	0.64	35.8	11.4
c	7.63	3.96	18.26	2.80	2.11	28.5	6.14	-	0.54	25.8	8.4
Chicken manure											
0.0	7.70	4.11	22.22	2.35	1.89	19.0	2.45	-	0.48	18.3	6.9
1.5	7.66	5.47	13.22	2.19	1.80	25.1	5.15	-	0.45	25.7	7.7
At 135 days from planting											
Fresh water	7.62	1.45	6.71	1.80	2.31	9.6	0.81	-	0.26	9.9	2.9
Diluted sea water											
1:5	7.39	4.44	19.10	3.45	3.78	34.8	2.33	-	0.40	29.2	13.9
1:3	7.33	7.22	28.55	5.12	4.84	60.0	2.27	-	0.52	35.9	17.8
Irrigation frequency											
a	7.20	7.62	27.00	4.44	4.66	54.6	2.36	-	0.47	48.9	16.8
b	7.41	5.74	23.70	3.84	4.15	47.2	2.25	-	0.50	57.6	1.80
c	7.46	5.13	20.77	4.57	4.13	40.3	2.30	-	0.40	73.2	13.6
Chicken manure											
0.0	7.55	6.42	19.84	2.28	2.68	27.4	1.95	-	0.42	23.6	9.3
1.5	7.44	5.24	16.84	4.63	3.95	29.7	1.52	-	0.30	27.8	9.5
At 165 days from planting											
Fresh water	7.42	1.20	12.38	0.76	0.56	9.9	0.96	-	0.48	9.2	2.2
Diluted sea water											
1:5	7.35	3.85	19.21	3.23	2.34	32.2	0.68	-	0.43	25.9	12.3
1:3	7.30	6.14	19.48	6.45	4.80	44.1	0.70	-	0.36	29.9	12.4
Irrigation frequency											
a	7.22	5.51	19.05	5.50	4.14	47.3	0.71	-	0.41	39.9	12.8
b	7.37	4.84	20.52	5.16	3.71	28.7	0.70	-	0.40	34.7	3.4
c	7.38	3.57	18.46	3.86	2.86	28.5	0.67	-	0.40	24.5	10.7
Chicken manure											
0.0	7.43	3.91	18.04	2.84	1.70	20.7	0.56	-	0.42	18.2	6.6
1.5	7.32	6.08	16.00	4.12	2.43	27.4	0.82	-	0.46	24.0	7.9

and the lowest ones were obtained for "a" frequency. This means that irrigation with saline water during the whole growth period led to slight decrease in the soil pH values compared to the other two irrigation frequencies, i.e. "b" and "c"ones. This effect was more pronounced at the first growth period compared to the late ones. In other words, the magnitude of increases relative to "a" frequency treatment reached 5.9, 3.6 and 2.2% at the three growth stages, respectively.

Addition of 1.5% chicken manure slightly decreased soil pH value by about 0.1 units. This effect was expected and held true at different wheat growth periods due to the formation of CO_2 and other organic acids through decomposition of the added organic manure.

In addition data in Table (3) reveal that the soil pH values were clearly affected by the combined effect between diluted sea water and irrigation frequency as compared with the corresponding values obtained by irrigation with tap water, where the highest values were associated with the treatment of 1:5 diluted sea water + "c" frequency, while the lowest ones were achieved with the treatment of 1:3 diluted sea water +"a" frequency.

In this respect, the combined effect between 1:3 diluted sea water treatment +1.5% chicken manure gave the highest values , while the opposite trend was found for the treatment of those irrigated with fresh water + chicken manure application. Further more the tri-interaction effect among 1:5 or 1:3 diluted sea water +"a" frequency +1.5% chicken manure gave the the lowest values , indicating the role of water management under both saline conditions and organic manure application.

Soil Electrical conductivity (ECe):

Due to the diversity of water type used for irrigation, it was necessary to set up particular criteria for evaluating the quality of irrigation water. In this respect, the most important characteristics that may be considered here in determining water quality are salinity (expressed as electrical conductivity values ECw, and sodium adsorption ratio (SAR). Based on salinity of irrigation water, the following classification for water quality introduced by the U.S. Salinity lab. and published by FAO (1985) it could be mentioned that EC <0.7 dS/m, no restriction from its use, such as the used tap water in this experiment (ECw = 0.4 dS/m), 0.7 to 3.0 dS/m is considered slight to moderate but more than 3.0 dS/m is restricted in its use.

Table (3): Tri-interaction effect among the studied treatments on pH, EC, Soluble ions and SAR in soil at different wheat growth stages

Treatments	Irrigation frequency	pH 1:2.5	EC (dS/m)	SAR	Soluble ions me. L^{-1}							
					Cations				Anions			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}
At 75 days from planting (without chicken manure addition)												
Fresh water		7.93	1.22	6.08	1.80	1.60	6.60	2.2	-	0.36	7.69	4.88
Diluted sea water:												
	A	7.20	2.50	14.06	1.88	1.68	18.70	2.8	-	0.78	15.40	8.8
1: 5	b	7.70	2.15	12.42	1.60	1.70	15.90	2.6	-	0.66	12.90	7.8
	c	7.77	1.59	7.81	1.90	1.40	10.00	2.6	-	0.68	9.84	5.3
	a	7.20	7.27	17.43	3.60	3.40	32.60	5.2	-	0.43	38.60	7.5
1: 3	b	7.24	6.45	33.15	2.80	2.08	51.70	8.1	-	0.81	51.20	12.90
	c	7.35	4.70	15.83	4.62	3.88	32.20	6.3	-	0.63	38.50	8.0
At 75 days from planting (with chicken manure addition)												
Fresh water		7.86	1.54	9.11	1.60	1.42	11.20	0.3	-	0.35	8.89	5.3
Diluted sea water:												
	a	7.20	3.99	23.25	2.05	3.32.	31.60	3.9	-	0.44	28.40	5.6
1: 5	b	7.61	3.57	17.27	2.04	2.46	26.40	4.8	-	0.51	28.40	6.7
	c	7.70	3.45	21.37	1.88	1.02	27.90	3.7	-	0.63	30.60	5.5
	a	7.20	8.77	37.70	3.70	2.70	67.50	13.9	-	0.53	74.10	12.9
1: 3	b	7.27	6.95	44.88	1.80	1.32	56.10	10.4	-	0.43	50.70	18.3
	c	7.35	6.08	28.01	2.80	2.41	43.90	11.9	-	0.63	45.40	14.6
At 135 days from planting (without chicken manure addition)												
Fresh water		7.70	1.40	6.07	1.98	2.22	8.80	1.00	-	0.20	9.50	1.5
Diluted sea water:												
	a	7.20	4.70	28.00	1.64	2.38	39.70	3.30	-	0.48	34.30	12.13
1: 5	b	7.50	4.50	20.20	2.54	3.94	36.20	2.31	-	0.44	29.80	14.70
	c	7.55	3.20	15.10	2.64	2.52	24.30	2.60	-	0.42	23.10	8.40
	a	7.20	7.06	33.40	3.05	3.74	61.50	2.30	-	0.72	54.50	15.30
1: 3	b	7.83	6.51	30.60	3.20	3.50	55.90	2.60	-	0.68	44.10	20.50
	c	7.44	5.46	33.20	2.60	1.62	48.20	2.30	-	0.38	36.10	18.00
At 135 days from planting (with chicken manure addition)												
Fresh water		7.54	1.50	7.34	1.62	2.40	10.40	0.61	-	0.31	10.70	4.35
Diluted sea water												
	a	7.80	5.36	21.50	4.02	4.28	43.80	1.50	-	0.38	36.40	16.70
1: 5	b	7.41	4.45	16.90	. 4.00	4.18	34.20	2.10	-	0.32	22.90	21.10
	c	7.40	4.40	13.00	5.80	5.38	30.70	2.15	-	0.32	28.90	14.70
	a	7.72	6.36	25.20	9.04	8.24	73.90	2.33	-	0.36	70.40	23.00
1: 3	b	7.31	7.50	27.20	5.60	4.96	62.50	1.95	-	0.50	57.80	16.60
	c	7.59	7.45	21.80	7.22	6.99	58.20	2.12	-	0.46	60.80	13.10
At 165 days from planting (without chicken manure addition)												
Fresh water		7. 51	1.12	13.16	0.53	0.54	9.61	0.52	-	0.41	9.38	1.44
Diluted sea water:												
	a	7.23	4.12	19.21	3.70	2.64	34.20	0.67	-	0.46	26.80	13.80
1: 5	b	7. 43	3.11	28.78	1.00	0.95	28.50	0.73	-	0.49	20.80	10.10
	c	7.44	2.97	23.25	1.60	1.02	26.50	0.57	-	0.47	20.80	8.38
	a	7.20	6.14	20.04	6.98	4.96	48.90	0.58	-	0.39	50.10	10.80
1: 3	b	7.40	5.02	15.54	6.96	4.92	37.90	0.42	-	0.36	31.80	18.00
	c	7.40	2.11	16.07	3.72	2.62	14.50	0.59	-	0.37	11.20	9.50
At 165 days from planting (with chicken manure addition)												
Fresh water		7.33	1.27	11.59	0.98	0.58	10.20	0.86	-	0.55	9.10	2.93
Diluted sea water												
	a	7.23	4.70	10.71	4.22	3.06	39.00	0.68	-	0.38	34.00	14.00
1: 5	b	7.35	4.22	16.50	4.86	3.16	33.00	0.76	-	0.41	27.50	14.30
	c	7.37	3.97	16.79	4.10	3.90	31.90	0.63	-	0.38	25.50	13.40
	a	7.20	7.06	26.24	7.10	5.88	50.90	0.87	-	0.34	47.80	12.70
1: 3	b	7.30	7.00	21.26	7.82	5.77	55.50	0.85	-	0.31	58.60	11.10
	c	7.32	5.22	17.71	6.10	4.60	40.90	0.86	-	0.40	40.40	11.50

Consequently 10.5 dS/m of 1:5 diluted sea water or 13.7 dS/m of 1:3 diluted sea water are very high saline water for irrigation. So, as expected irrigation with high water salinity increased ECe values over the control treatment, where irrigation with 1:3 diluted sea water gave the highest values (Table, 2). It is obvious that the obtained values were highly significant at all plant growth stages and reached about 5 folds of those irrigated with tap water. Similar results were obtained by Abd El Nour (1989). It is worth to mention that soil ECe value at the beginning of the experiment was 3.05 dS/m, then at all growth stages, ECe of the soils irrigated with tap water decreased to values less than 1.5 dS/m due to the uptake of wheat plants the minerals occurred in the root zone. However, wheat plants can tolerate salinity of soil reaching 6.0 dS/m and salinity water having ECe 4.0 dS/m for irrigation produce 100% yield potential but soils of ECe 7.4 dS/m and irrigation water of ECe 4.0 dS/m produce only 75% yield of wheat compared to those irrigated with non-saline water (Maas,1984).

Concerning the effect of irrigation frequencies, the obtained data show that the highest values of soil electrical conductivity were associated with “a” frequency due to the irrigation with saline water along the plant growth periods and this is expected, while the lowest values were associated with “c” frequency treatment due to the alternative irrigation with saline or non-saline water.

Addition of 1.5% chicken manure gave higher soil EC values compared to those received no organic manure. This effect of chicken manure rendered to the nature of these materials that already contain high saline substances as indicated by its EC, 5.1 dS/m. Similar results were obtained by Valdares *et al.* (1983).

With respect to the combined effect between diluted sea water and irrigation frequency, data in Table (3) show that the lowest EC values were attained for the treatment of 1:5 diluted sea water + “c” frequency compared to the other irrigation treatments, indicating the role of irrigation frequency particularly “c” one in decreasing soil EC values compared to the corresponding ones attained for the individual effect of saline irrigation water. Regarding the irrigation with different saline irrigation waters combined with chicken manure, the obtained data showed an increase in soil EC values compared to the other combined treatments. On the other hand, the combined effect of chicken manure +“c” frequency had a positive effect on decreasing EC values under saline conditions. At the same time, the tri-interaction effect among the investigated treatments confirmed the aforementioned results.

Soluble ions:

To substantiate the influence of salt level in irrigation water on the soluble cations and anions in the soil under cultivation, the obtained results reveal that increasing salinity level of irrigation water increased all the studied cations and anions in soil with different rates, exception being the concentration of $HC0_3^-$ ions in soil. These increases are proportional to the increase in salts introduced through irrigation water. Irrigation with 1:3 diluted sea water resulted differences values reached 89, 184 and 749% for Ca^{2+} at the three growth stages, respectively, while being 72, 110 and 757% for Mg^{2+}, 396, 525 and 345% for Na^+ and 644, 180 and 1% for K^+ comparing with those irrigated with tap water. The complementary additions of salts through irrigation water, beside those of the soil extract under the practiced irrigation frequencies resulted different levels of soluble ions and SAR values. For monovalent ions, Na^+ as well as K^+ concentrations in soil irrigated with saline water were more affected by the salinity level of irrigation water rather than the divalent cations, Ca^{+2} and Mg^{+2} . However, data reveal that Ca^{+2} and Mg^{+2} were decreased to the lowest levels and this may be due to the selective uptake of these ions by wheat plants rather than Na^+. The increase in Cl^- concentration due to irrigation with 1:5 or 1:3 diluted sea water was 3 times or 5 times higher than those irrigated with tap water. The concentration of SO_4^{2-} in soil extract showed considerable increases as the time increase due to its accumulation in the soil and reached 6 folds of that of soil irrigated with tap water.

Regarding the effect of irrigation frequencies on reducing salinity effect due to irrigation with very high saline water, data reveal that "c" frequencies resulted lower salt concentrations in the soil compared to "a" frequencies. Differences reached 42% at the 3rd growth stage for Ca^{2+}, 45% for Mg^{2+}, 66% for Na^+, 6% for K^+, 1% for $HC0_3^-$, 62% for Cl^- and 8% for $S0_4^{2-}$ ions, respectively.

Although chicken manure application improved some physical, chemical and biological characteristics, it caused some increases in salt content of the soil amended with 1.5% chicken manure. These increases reached 45% at the 3rd stage for Ca^{2+}, 43% for Mg^{2+}, 32% for Na^+, 46% for K^+, 10% for $HC0_3^-$, 32%for Cl^- and 20% for $S0_4^{2-}$ compared to untreated soil, respectively. These findings may be due to the high content of these ions in irrigation water or in the used chicken manure. Similar results were obtained by Abd El Nour (1989).

Sodium adsorption ratio (SAR):

Sodium hazard, expressed as sodium adsorption ratio (SAR) is considered one of the major factors governing water quality. If the proportion of sodium in irrigation water is high, the alkali hazard is high, too. In the classification of water according to SAR values and the electrical conductivity Ew_e, thereby salt concentrations, were also taken in account. Accordingly as suggested here, tap water of EC 0.4 dS/m and SAR <10 is considered low, 1:5 diluted sea water of ECe 10.5 dS/m and SAR 14.6 is medium and 1:3 diluted sea water of EC 13.7 dS/m and SAR 14.2 is high to very high (Ayers and Westcott ,1985). Data show that the highest SAR values were associated with irrigation with 1:3 diluted sea water. The magnitude of increases reached 288, 325 and 57% relative to the control treatment (tap water) at all the studied growth stages, respectively. This may be due to the high sodium values existed at the first growth stage and so alkali hazard is high but it decreased with increasing the plant age. Similar results were obtained by Kenneth (1990).

Concerning the EC_e values of soil extract, changing SAR values are attributed to the effect of diluted sea water on the activity of Na^+, Ca^{2+} and Mg^{2+} ions. In other words, the increase in SAR values led to decrease in the activity of the monovalent ions particularly (Na^+) with a relative increase in the activities of both Ca^{2+} and Mg^{2+}, this may be due to the nature of SAR equation. The numerator (Na^+) is reduced as a result of dilution at a greater rate than the dominator (Ca^{2+}+Mg^{2+}) because the denominator is reduced the squire root of the dilution as discussed by Ayers and Westcott (1985).

"C" frequencies resulted the lowest SAR values in the soils irrigated with saline water compared to "b" frequencies with differences reached 48, 30 and 11%, respectively. This may be due to the high level of Na^+ ions associated with "b" irrigation frequency treatment which added more salts to soils through irrigation along the growth period until the flowering stage. In this respect, addition of chicken manure to soil decreased SAR values compared to the untreated soil. This finding held true at the three growth stages. This may be due to the release of organic acids and CO_2 through decomposition of organic manure that reduces the Na concentration in soil and consequently SAR values.

It is worth to mention that the combined effect between diluted sea water and irrigation frequency, data in Table (3) showed a discrepancy between positive and negative depending on the stage of growth where no definite trends were obtained. On the other hand, the combined effect between diluted sea water (1:3) and chicken manure (1.5%) gave a positive effect on increasing SAR values. Also the tri-interaction effect among the investigated treatments confirmed the role of irrigation frequencies in reducing soil SAR values than that of chicken manure application.

Actual evapotranspiration (ETa):

Data in Table (4) show that increasing salinity level of irrigation water decreased the actual evapotranspiration by wheat plant to about 6 and 10%due to irrigation with diluted sea water 1:5 and 1:3, respectively compared to irrigation with tap water at the vegetative stage (75 days after planting). While these decreases reached 6 and 18% at the yield formation stage (135 days after planting) and 8 and 10% at the harvest stage (after 165 days from planting), at the same order. This may be interpreted that increasing salinity of irrigation water increased tensions which water is held by soil and a relative slow rate of water conductivity through the soil compared to the great evaporative power of the atmosphere. Similar findings were obtained by Kanemasu *et al.* (1976).

The lowest ETa values were obtained as a result of using "a" frequency treatment and this could be explained that continuous irrigation with high saline water along the growth period induced ETa depression compared to "c" frequency, besides decreasing the vegetative growth and subsequently the evapotranspiration and water consumptive use during the growing season of plant. Similar results were obtained by Bhatnager and Kunder (1990).

In this respect, chicken manure addition increased ETa values compared to the untreated soil and this may be attributed to the high capacity of organic manure which keep a lot of water and provide high moisture content for a long time subsequently allow to increase actual evapotranspiration and water consumptive use. Similar results were obtained by Ahmed *et al.* (1990).

In addition, the combined effect between irrigation with tap water under 1.5% chicken manure addition achieved the highest actual evapotranspiration values, whereas the lowest ones were associated with no organic manure addition under irrigation with 1:3 diluted sea

Table (4): The main effect of the studied treatments on the actual evapotranspiration (mm.) for wheat plant.

Treatments	Date from planting, days		
	75	135	165
Fresh water(control)	146.4	201.40	199.10
Diluted sea water :			
1:5	137.35	190.04	109.43
1:3	131.14	165.99	106.00
Irrigation frequency			
a	109.15	168.95	100.20
b	132.65	180.13	110.51
c	139.92	184.95	112.43
Chicken manure application rate (%):			
0.0	117.29	177.87	101.24
1.5	159.30	193.75	121.78

Table (5a): The main effect of the studied treatments on the water use efficiency ($Kg.m^{-3}$) for wheat plant.

Treatments	Date from planting, days		
	75	135	165
Fresh water(control)	40	100	170
Diluted sea water :			
1:5	30	90	120
1:3	30	70	110
Irrigation frequency			
a	30	80	110
b	30	80	110
c	40	90	120
Chicken manure application rate (%):			
0.0	20	60	100
1.5	40	110	170

Table (5b): The tri-interaction effect among the studied treatments on the water use efficiency ($Kg.m^{-3}$) for wheat plant.

Treatments	Irrigation frequency	Date from wheat planting, days		
		75	135	165
Without chicken manure				
Fresh water		30	60	130
Diluted sea water:	a	20	60	90
1:5	b	20	50	90
	c	30	60	100
1:3	a	20	50	60
	b	20	50	60
	c	30	50	70
With chicken manure				
Fresh water		40	130	200
Diluted sea water:	a	30	90	140
1:5	b	40	110	140
	c	40	130	160
1:3	a	20	90	150
	b	30	80	130
	c	30	110	140

water. Differences reached 51, 34 and 36% at three growth stages, respectively, relative to irrigation with 1:3 diluted sea water only. In addition, the treatment of "c" frequency combined with 1:5 diluted sea water gave the highest ETa values, relative to "a" frequency and 1:3 diluted sea water.

It is important to mention that under all the studied treatments, data in Table (4) show that the highest values of calculated actual evapotranspiration were obtained at the yield formation stage (2^{nd} growth stage) followed by the vegetative stage (1^{st} growth stage) while at the harvest stage (3^{rd} growth stage), resulted the lowest ones, indicating the metabolic process reached its maximum value at the yield formation, while at harvest stage the growing plants didn't need more water. Therefore the late growth stage shows the lowest value of actual evapotranspiration.

Water Use Efficiency (WUE):

Data presented in Table (5a) show that increasing salinity level of irrigation water progressively decreased water use efficiency. The percentages of decrease reached 25, 25%; 10, 30% and 29, 35% for 1:5 and 1:3 diluted sea water at the three growth stages, respectively compared to irrigation with tap water. This may be due to the decrease of dry matter yield with increasing salinity level of irrigation water which increases the energy that plant must expend to acquire water from the soil and make the biochemical adjustments necessary to survive as reported by Kenneth (1990).

Use of (c) frequency treatment for irrigation as well as chicken manure application increased WUE by wheat plants due to improving soil characteristics which gave suitable conditions for giving higher yields and growth.

As shown in Table (5b) the highest water use efficiency was associated with the combined treatment of 1:5 diluted sea water + "c" frequency, while the lowest one was associated with 1:3 diluted sea water + "a" frequency.

At the same time, irrigation with fresh water during the whole growth period + 1.5% organic manure achieved the highest water use efficiency. The opposite trend was true when irrigation with 1:3 diluted sea water was only used. It is worth to mention that irrigation with tap water + 1.5% organic manure + "c" frequency gave the highest value of water use efficiency, Whereas the lowest one was attained with 1:3 diluted sea water + "a" frequency + no organic manure addition.

Conclusion

irrigation with diluted sea water as three times and once with tap water (c) accompanied with organic manure addition under saline conditions have a positive role in reducing the hazardous effect of salinity in plant root zone and subsequently the investigated soil chemical properties as well as the water use efficiency of wheat plants were improved.

REFERENCES

Abd El-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, pp. 144-159. 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.

Ahmed, M.; Akhtar, M.E.; Nizami, M.I.; Yasin, M.; Ahmed, S. and Hussein, Z. (1990). Seasonal crop evapotranspiration moisture stress. Functions for major climatic zones in Pakistan soil physics-application under stress environments. Proceedings to the International Symposium on' Applied Soil Physics in Stress Environments, (22-26 January, 1989). Islamabad Pakistan: 276-285.

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

Ayers, R.S. and Westcott, D.W. (1985). Water quality for irrigation. Irrigate. and Drainage Paper, FAO, Rome.

Bhatnagar, V.K. and Kundu, S. (1990). Evapotranspiration demand and pattern of soil moisture extraction of four rain fed winter crops in mid hills of Uttar Pradesh. Ind. J. Agric. Sci., 60(11):767-769.

El-Dosouky, M.H. and El-Hassanin, A.S. (1987). Water requirements of sugar beet in the calcareous soils of Maryout. Desert Inst. Bull., A.R.E., 37(1): 143-152.

El-Dosouky, M.H. and El-Hassanin, A.S. (1988). Water use efficiency of sugar beet grown in calcareous soils, applying different formula for calculating the water requirements. Desert Inst. Bull., A.R.E., 38(2): 187-197.

Giriappa, S. (1982). Water use efficiency in agriculture. Agricultural Development and Rural Transformation Unit. Int. for Social and Economic change Bangalore. Oxford & IBH Pub. Co.

Kenemasu, E.T., Stone, L.R. and Powers, W.L. (1976). Evapotranspiration model tested for soybean and sorghum. Agro. J. 68: 509-572.

Keller, P. and Deuel, H. (1969). Cation exchange equilibrium with dead root. Trans. Comm. II and IV. Int. Soc. Vol. II, p. 164-168, Hamburg 1958, Verlag Chem., Weingeim/Bergst. (C.F. Principles of plant nutrition. Handbook, ed. By K. Mengel, 1978).

Mahrous, F.N.; Mikkelson, D.S. and Haffaz, A.A. (1983). Effect of soil salinity on the electro chemical and chemical kinetics of some plant nutrients in submerged soils. Plant and Soil. 75: 45 5-472.

Mostafa, M.A., Khaled, E.M., El-Sweedy, A.M. and Abd El-Nour, A. Sh., (1992). The effect of irrigation water quality on some chemical properties of certain soils of Egypt. Egypt. J. Soil Sci., 32(3):391-406.

Val dares, J.M.A.; Gal, M.; Minge grin, U. and Page, A.L. (1983). Some heavy metals in soil treated with sewage sludge, their effects on yield, and their uptake by plants {C.F. Soil & Fert. 47(10406)}.

استخدام مياه البحر لرى القمح
٢- التأثير على الصفات الكيميائية للتربة والبخر- نتح الفعلى وكفاءة استخدام المياه

محمد أحمد مصطفى* - محمد عثمان الشعراوى* - فكرى محمد البرعى**
* قسم الأراضى - كلية الزراعة - جامعة عين شمس
** مركز بحوث الصحراء. القاهرة- مصر.

أجريت تجربة أصص تحت ظروف الصوبة بهدف تقييم أثر استخدام مياه البحر المخففة (بمستويات ١:٣ & ١:٥) تحت نظام فترات رى مختلفة مع اضافة مخلفات الدواجن (١,٥%) على بعض الصفات الكيميائية للتربة والبخر- نتح الفعلى وكفاءة استخدام المياه لنبات القمح (سخا ٩٢)المزروع فى تربة جيرية مأخوذة من منطقة مريوط جنوب التحرير محافظة البحيرة. وتتمثل الادارة المائية فى فترات رى كالأتى :

(أ) الرى بمياه البحر المخففة طول فترة النمو (١٦٥يوم) ، (ب) الرى بمياه البحر المخففة حتى ما قبل الأزهار(٧٥ يوم) ثم الرى بمياه الصنبور حتى نهاية التجربة(٩٠ يوم) ، و (ج) الرى بمياه البحر المخففة ثلاث مرات ومرة واحدة بمياه الصنبور. بالاضافة الى معاملة الكنترول (الرى بمياه الصنبور طول فترة نمو نبات القمح). وتشير أهم النتائج الى ما يلى :

* زيادة تركيز الأملاح فى مياه الرى أدى الى زيادة الكاتيونات والأنيونات الذائبة بمعدلات مختلفة فمثلا ازداد تركيز انيون الكبريتات الذائبة مع مرور الوقت حتى وصل الى ستة أضعاف مقارنة بمعاملة الكنترول ، زادت ايضا قيم نسبة الصوديوم المتبادل حتى بلغت ٢٨٨،٣٢٥،٥٧% فى المرحلة الخضرية ومرحلة تكوين السنابل على الترتيب. ومن ناحية أخرى انخفضت قيم كل من البخر - نتح الفعلى وكفاءة استخدام ا لمياه عند رى نبات القمح بالمياه الملحية مقارنة بالتى تروى بالمياه العذبة.
* بخصوص تأثير ادارة المياه فان أقل القيم للتوصيل الكهربى و نسبة الصوديوم المتبادل كانت مصاحبة بالادارة المائبة (ج)، وأعلى مصاحبة للأ دارة المائية (أ)، أوضحت النتائج ايضا ان أعلى قيم لكل من البخر - نتح الفعلى وكفاءة استخدام ا لمياه مصاحبة للادارة المائبة (ج) مقارنة بالمعاملات الأخرى تحت الدراسة.
* أدت اضافة مخلفات الدواجن الى زيادة قيم كل من ا لتوصيل الكهربى والبخر - نتح الفعلى وكفاءة استخدام ا لمياه بينما انخفضت قيم نسبة الصوديوم المتبادل.
* تأثير تداخل التفاعلات بين المعاملات المختلفة اكدت النتائج السابقة بدرجات متباينة معتمدة على مراحل النمو ومستوى ملوحة مياه الرى واضافة مخلفات الدواجن وادارة المائبة (ج) حيث كان لهم أثر مشجع فى خفض وتقليل أثر الزيادة فى مستوى الأملاح فى منطقة الجذور وامداد النبات بكميات المياه الكافية وتقليل فقدها أثناء مراحل نمو نبات القمح.

قام بتحكيم هذا البحث: أ.د/ حسن حمزة عباس ، أ.د/رمضان محمد عبدالمقصود