IRRIGATION MANAGEMENT OF SALINE GROUND WATER FOR BARLEY GROWN ON A SANDY CALCAREOUS SOIL

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ABSTRACT

A field experiment was carried out in the experimental farm of Faculty of Agriculture at Qena, South Valley University, Egypt, in winter 2003/2004, to study the effect of some irrigation management treatments of saline ground water on barley grown on a sandy calcareous soil. Five irrigation management treatments of saline ground water were used. They included: 1) twelve continuous irrigations of the fresh water, the control (T_1), 2) four continuous irrigations of the fresh water + four continuous irrigations of saline ground water + four continuous irrigations of fresh water (T_2), 3) an exchangeable irrigation of fresh water and saline ground water of total 12 irrigations (T_3), 4) four continuous irrigations of saline ground water + four continuous irrigations of fresh water + four continuous irrigations of saline ground water (T_4), and 5) twelve continuous irrigations of the saline ground water (T_5). The plant growth, yield, yield components and nutrient uptake by barley as well as soil properties at harvest were examined.

Relative reductions values of 19.1, 7.6, 12.2 and 34.4% in the grain yield and relative reductions values of 20.1, 7.1, 20.6 and 38.0% in the straw yield for T2, T3, T4 and T5, respectively, compared with T1 were recorded. Continuous irrigation with the fresh water (T1) gave the highest values of grain and straw yields (13.1 ardab/fed and 3.89 ton/fed, respectively) as well as yield components of barley. However, the continuous irrigation with saline ground water (T5) produced the lowest values of both grain and straw yields (8.6 ardab/fed and 2.41 ton/fed, respectively).

Both concentration and uptake of N, P, K, Ca and Na by both barley straw and grains decreased with using these treatments compared with T1. The lowest values of concentration and uptake of the nutrients by straw and grains were recorded for those plants continuously irrigated by the saline ground water (T5). The plants irrigated by one irrigation of the fresh water in an exchange with another irrigation of the saline ground water (T3) took up higher amounts of most nutrients by straw and grains than other treatments except the control (T1). It was noticed that higher amounts of nutrients are taken up by straw than by grains although N, P and Ca concentrations in the grains are higher than in the straw.

Irrigation management treatments of saline the ground water (T2, T3, T4 and T5) caused decreases in the uptake of Cu and Zn by barley grains. However, concentrations and uptake of Fe and Mn in grains of the plants irrigated by management treatments of T2 and T3 increased compared with the control.

Soil salinity and saturation percentage increased, but soil pH slightly decreased at the end of the experiment due to the treatments compared with the control. Generally, it may be concluded that the best irrigation management treatment of saline ground water to be recommended in such soils is to use it in an exchange with the fresh water (T3). The irrigation management treatment of T2 could also be used in these soils to grow these crops.

Keywords: Saline ground water, Irrigation management, Barley, Nutrient uptake.

INTRODUCTION

In arid and semi-arid regions, irrigation is the only mean of supplying the necessary water for agricultural production. Most of the problems that face the agriculture in these regions are the salinity of soils and irrigation water as well as water shortage. Most of the Egyptian lands for which the Nile water is not available lie in the western and eastern desert. Therefore, other water resources for irrigation demands such as ground water must be used or looked for. Such water resources vary widely in their concentration and composition of the dissolved salts.

Saline water can affect plants in three ways. Initially, a salt makes them more difficult to withdraw water from the soil, even if the soil appears quite moist. Under this effect, the plant suffers from the drought, which can result in retarding plant growth and consequently reducing the yield. Secondly, the salts contain several ions such as Na+ and Cl- that can be directly toxic to plants (Greenway and Munns, 1980; Mostafa, 2001). Plants take up salts with the water, and often these salts can damage the plants internally and affect the plant physiological processes resulting in reducing growth, leaf burn, nutritional disorders and even plant death. Therefore, this effect is the most serious one for plants. Thirdly, high amounts of ions such as Na+ and Cl- may affect the availability of other ions like N, P, K and Mg which are extremely important for plant growth. Additionally, the harmful effect of high salinity could be attributed to the increase in the osmotic pressure of the soil solution and the reduction in available water, resulting in an accumulation of certain ions in toxic concentrations (Figin, 1985; Mass et al., 1996).

Barley is a cereal crop which is grown for green forage, feeding animals and Arabian tribes and malt in the brewing industry. Recently, it is grown on the new reclaimed soils of Egypt. Most of these soils are suffering from water shortage, high salinity as well as nutrient deficiency. Egyptian agronomists are facing several problems during cultivating the newly reclaimed soils, such as water deficit and water salinity as well as soils of high content of soluble salts. Consequently, it would be promising if these soils could be cultivated by glucophytes, especially the suitable cultivars of barley which have good performance with less damage and high productivity under these conditions (Munns et al., 2002).

The grain yield of barley was reported to decrease with increasing the salinity of irrigation water (Wagenet et al., 1980; Saleh et al., 2002). The total dry matter yield of barley plants was also found to reduce by salinity (Mchenzie et al., 1983; Haggag et al., 1999; Saleh et al., 2002). Moreover, El-Sodany (2004) showed that using irrigation with saline water significantly decreased plant height, spike length, number of grains per spike, grain weight per spike, straw and grain yields of barley plants.

Salinity has been shown to influence the nutrient contents of plants. Hassan and Mostafa (2002) reported that increasing salinity level of irrigation water significantly decreased the uptake of N, P, K. Fe, Zn, Cu, and Mn by barley plants. However, Saleh et al. (2002) found that concentrations of N, P, K, Na, Zn and Fe in barley grains increased with increasing the salinity of irrigation water up to 4000 ppm. Conversely, N, Ca, Mn, and Zn contents in grains decreased with increasing salinity levels.

This study aims to evaluate some irrigation management treatments of saline ground water in a sandy calcareous soil for yield, yield components and nutrient contents of barley.

MATERIALS AND METHODS

A field experiment was carried out at the Experimental Farm of Faculty of Agriculture at Qena, South Valley University, Egypt, during the winter season of 2003/2004 to evaluate some irrigation management treatments of saline ground water for the growth, yield, yield components and nutrient uptake by a genotype of barley grown on a sandy calcareous soil and finally to select the proper irrigation management of this saline ground water for barley growth on this soil. Soil properties after harvest were also examined as a result of these treatments. Some physical and chemical properties of this soil are present in Table 1.

A barley genotype no. 508552 was brought from Arizona, USA to test it under Egyptian conditions. The ground water that is used in the farm for irrigation is saline. The analysis of the ground water as well as the fresh water that is used for drinking is shown in Table 2.

The experimental design was completely randomized one including five irrigation management treatments of ground water and four replications. The treatments were twelve continuous irrigations of fresh water (T1), four continuous irrigations of fresh water + four continuous irrigations of saline ground water + four continuous irrigations of fresh water (T2), alterative irrigations of fresh water and saline ground water of total 12 irrigations (T3), four continuous irrigations of saline ground water + four continuous irrigations of fresh water + four continuous irrigations of saline ground water (T4), and twelve continuous irrigations of saline ground water (T5).

The experiment included 20 plots. Each plot had an area of 3 m x 3.5m = (10.5 m^2). On November 15, 2003, 125 g barley seeds were sown in each plot (50 kg/fed.) by broadcasting. The fresh water was applied to each plot using water tanks of 4 m3 size.

Nitrogen was applied at a level of 300 kg/fed. as ammonium nitrate (33.5 % N) in two equal doses (at 30 and 85 days from sowing). Phosphorus and potassium were added as superphosphate (15.5 % P2O5) and potassium sulfate (48 % K2O), respectively, to each plot at a level of 100 kg /fed for each one during the soil preparation. Surface irrigation was applied as needed (10-15 days) in both saline and fresh water treatments.

After 150 days from germination, plants were harvested and the following parameters were recorded for each plot:

1. Plant height (cm).
2. Fresh weight /10 plants (g).
3. Dry weight /10 plants (g).
4. Spike length (cm)
5. Number of spikelets/spike.
6. Number of tillers/plant
7. Grain weight/spike (g)
8. Straw yield ton/fed.
9. Grain yield ardab/fed.

Table 1 Some physical and chemical properties of the soil used in the experiments.

Property		Value
Particle-size distribution:		
	Sand (%)	86.2
	Silt (%)	8.6
	Clay (%)	5.2
Texture class		Sandy
Classification		Typic Torripsamments
Field capacity (%)		14.5
Saturation percentage (%)		22.1
pH (1:1) in water		7.88
EC_e (dS/m)		2.62
Calcium carbonate (%)		12
Organic matter (%)		0.12
Soluble cations in saturated soil paste extract (cmol/kg).		
	Ca^{2+}	0.35
	Mg^{2+}	0.10
	Na^{+}	0.13
	K^{+}	0.07
Soluble anions in saturated soil paste extract (cmol/kg).		
	CO_3^{2-}+HCO_3	0.23
	SO_4^{-}	0.22
	Cl^{-}	0.35
	Total N (%)	0.02
Available P (ppm)		6.4
DTPA-extractable Fe (ppm)		6.5
DTPA-extractable Mn(ppm)		4.2
DTPA-extractable Cu (ppm)		0.76
DTPA-extractable Zn (ppm)		1.7

Table 2: Analysis of fresh water and ground water used in the study.

Irrigation Water Type	EC (dS/m)	pH	Soluble cations (mmol/l)				Soluble anions (mmol/l)				SAR
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	
Fresh water	0.61	7.20	1.55	0.65	1.5	0.22	nil	1.4	2.8	1.0	1.0
Ground water	5.36	7.56	2.3	3.5	41.0	1.4	nil	6.5	36.0	5.5	17.1

The fresh weight, dry weight and plant height were estimated on samples of 10 plants that were randomly selected from each plot. Also, soil and plant samples from each plot were collected after harvest for plant and soil analysis.

At harvest, Plant samples for each plot were washed with distilled water, oven-dried at 70^{o}C, and kept for chemical analysis. The dried plant material was digested using the sulfuric-perchloric acids mixture and then analyzed for Na, K and Ca using the flame photometry method according to Jackson (1967). Phosphorous in plant digests was determined using the chlorostannous-phosphomolybdic acid, Jackson (1967). Total N in the plants was determined using the microkjeldahl method as described by Jackson (1967). Iron, manganese, zinc and copper in the plant digests were determined using the buck scientific 410 atomic absorption spectrometry.

Soil pH, electrical conductivity (EC_e), saturation percentage, soluble cations (Na, K, Ca and Mg) and anions (Cl, SO_4, and HCO_3) were determined in the post-harvest soil samples according Jackson (1967).

Statistical analyses of data were performed using procedures described in Steel and Torrie (1960). Means were compared using the least significant difference (LSD) test at the 0.05 level of confidence

RESULTS AND DISCUSSION

1- Growth, Yield and Yield Components of Barley

Table 3 shows the effects of irrigation management treatments of the saline ground water on growth, yield and yield components of barley.

a. Plant growth

The fresh weight, dry weight and plant height of barley plants affected by irrigation management treatments of the saline ground water are present in Table 3. The continuous irrigation with the fresh water (T_1) gave highest values of 111.7 g, 84.3 g and 88.5 cm of the fresh and dry weights as well as plant height, respectively.

However, lowest values of the fresh weight, dry weight and plant height of 63.2 g, 54.3 g and 61.3 cm, respectively, were recorded for the plants continuously irrigated by the saline ground water (T_5). The relative reductions values of the fresh weight of barley plants using irrigation management treatments of the saline ground water of T_2, T_3, T_4, and T_5 compared with T_1 were 20.7, 24.3, 33.3 and 43.4%, while the relatively respective values for the dry weight were 11.2, 10.0, 30.5 and 36.0%. Moreover, the respective reduction values of the plant height were 12.0, 11.2, 14.0 and 31.0%. The reduction was relatively higher in the fresh weight than in the dry weight. It is shown from the results that there are no fresh weight, dry weight and plant height differences between the plants irrigated by T_2 treatment and those irrigated by T_3.

These results are in an agreement with those obtained by Hussain et al. (1997) and El-Garhy et al. (2003). Hassan and Mostafa (2002) indicated that the dry matter yield of barley significantly decreased with increasing the salinity level of irrigation water. Haggag et al. (1999) also reported that the dry matter yield of barley at various growth stages decreased with raising the salinity level. Under salinity stress, the fresh and dry weights of shoots decrease due to maintenance of turgor in plants (Shazia, 2001).

Table 3: Effects of irrigation management treatments of saline ground water on growth, yield and yield components of barley.

Irrigation management treatment	Fresh weight of 10 plants (g)	Dry weight of 10 plants (g)	Plant height (cm/plant)	Spike length (cm)	No. spikelets/spike	Grain weight/spike (g)	No. tillers/plant	Straw yield (ton/fed)	Grain yield (ardab/fed)
T_1	111.7*	84.3	88.5	7.2	16.7	1.95	3.5	3.89	13.1
T_2	88.6	74.9	78.3	6.3	15.2	1.77	3.4	3.11	10.6
T_3	84.6	75.9	78.6	6.4	15.2	1.84	3.1	3.61	12.1
T_4	74.5	58.6	76.2	6.2	14.1	1.73	2.5	3.09	11.5
T_5	63.2	54.3	61.3	5.0	11.8	1.56	1.8	2.41	8.6
$LSD_{0.05}$	5.0	4.8	2.3	1.3	1.1	0.10	0.3	0.28	0.6

T_1 = twelve continuous irrigation of fresh water (control), T_2 = four continuous irrigations of fresh water + four continuous irrigations of saline ground water + four continuous irrigations of fresh water, T_3 = twelve alternative irrigation of fresh water and saline ground water, T_4 = four continuous irrigations of saline ground water + four continuous irrigations of fresh water + four continuous irrigations of saline ground water and T_5 = twelve continuous irrigation of saline ground water.

* Each value represents the mean of 4 replications. SP= saturation percentage.

b. Yield and yield components

Grain and straw yields as well as the studied yield components of barley were significantly reduced by using the irrigation management treatments of the saline ground water compared with the control treatment (Table 3).

The results in Table 3 clearly show that irrigating barley plants with the saline water management treatments significantly decreased the spike length, no. of spikelets per main spike, no of tillers per plant, the grain weight of the main spike, the straw yield and the grain yield as compared with the continuous irrigation with the fresh water (the control treatment). Highest values of the main spike length, no. of spikelets per main spike, weight of grains per spike and no of tillers per plant of 7.2 cm, 16.7, 1.95 g and 3.5, respectively, were using the continuous irrigation of fresh water (T_1), but lowest respective values of 5.0 cm, 11.8, 1.56 g and 1.8 were recorded for the continuous irrigation with the saline ground water.

The respective reduction values in the spike length under irrigation management of saline ground water treatments of T_2, T_3, T_4 and T_5 were 12.5, 11.1, 13.9 and 30.6%, respectively, compared with the control (T_1). Meanwhile, the respective reduction values in no of spikelets / spike were 9.0, 9.0, 15.6 and 29.3% compared with the control. Moreover, the respective reduction values in of weight grains/spike were 9.2, 6.0, 11.3 and 20.0%, and in no. of tillers/plant were 2.9, 11.4, 28.6 and 48.6%. The reduction in no. spikelets per spike and weight of grains per spike for the irrigation management using T_5 could be due to the decrease in the spike length and number of fertile flowers/spike. The reduction in the grain weight/ spike of the plants irrigated with the saline ground water might be also attributed to the reducing effect of the salinity on the amount of dry assimilates translocated and stored in the grains as well as on the number of grains / spike. These results are in harmony with those of Francois et al. (1986) and El-Beially (2001). Mass et al. (1996) and Javed et al. (2003) reported that salinity stress significantly decreased the number of spikelets per spike of barley.

The continuous irrigation with the fresh water (T_1) gave highest values of grain and straw yields of 13.1 ardab/fed and 3.89 ton/fed, respectively, while the continuous irrigation with the saline ground water (T_5) produced lowest values of 8.6 ardab/fed and 2.41 ton/fed, respectively. Irrigation management of the saline ground water treatments caused relative reduction values of 19.1, 7.6, 12.2 and 34.4% in the grain yield and relative reduction values of 20.1, 7.2, 20.6 and 38.0% in the straw yield for T_2, T_3, T_4 and T_5, respectively, compared with the continuous irrigation with the fresh water (T_1) (Figure 1). These results concur with those of Francois et al. (1994), El-Beially (2001), Shazia (2001), Saleh et al. (2002) and El-Sodany (2004). In general, the use of the fresh water in an alternate with the saline ground water whereas one irrigation of the fresh water is followed by another one of the saline ground water (T_3) gave higher values of the grain and straw yields than other treatments that used saline ground water. It is considered the best irrigation management treatment of the saline ground water to be used for barley.

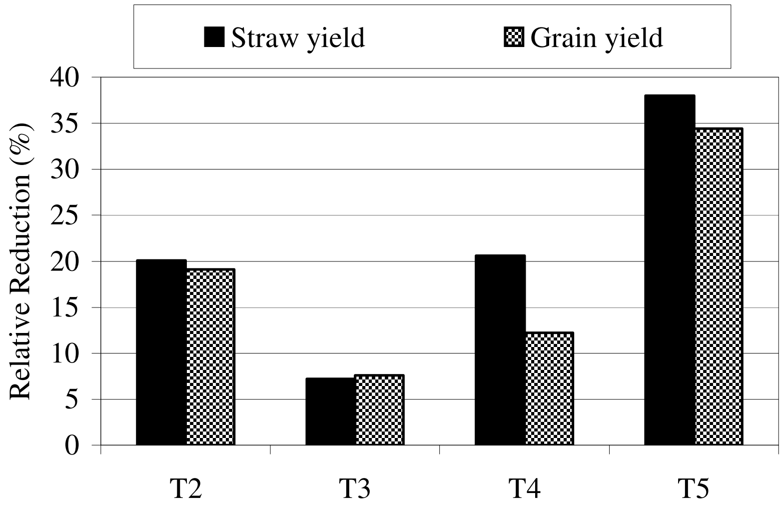

Figure 1: Effect of studied irrigation management treatments of saline ground water on grains and straw yields of barley.

The salt-induced grain yield reduction could be attributed to the reduction in the number of spikelets per spike, the reduction in the number of grains per spike, the reduction of spike length, the reduction in the number of spikes per plant, or/and the reduction in the number of tillers bearing fertile spikes. However, the reduction in the straw yield might be attributed to the reduction effect of the salinity on the plant height and number of tillers per plant (El-Beially, 2001; Hussian et al., 2002)

Salinity is harmful to plant growth and decreases yield and yield characters of crops. The injurious effect of the high salinity could be attributed to the increase in the osmotic pressure of the soil solution causing a reduction in the water availability to plants and accumulation of certain ions in plants in toxic concentrations leading to nutritional disorders in plants (Mostafa, 2001).

2. Nutrient Contents of Barley

a. Barley straw

Data in Table 4 show that both concentrations and uptake of N, P, K, Ca and Na by the barley straw decreased with using irrigation management treatments of the saline ground water of T_2, T_3, T_4 and T_5 compared with T_1 (control). The lowest values of nutrient concentration and uptake by the straw were recorded for the plants continuously irrigated by the saline ground water (T_5). The uptake of these macronutrients by the straw as affected by the studied irrigation management treatments of the saline ground water had a similar trend to that obtained for the dry matter yield.

Table 4: Effects of irrigation management treatments of saline ground water on N, P, K, Ca and Na contents of barley straw.

Irrigation management treatment	N		P		K		Ca		Na	
	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)
T1	1.68*	65.28	0.227	8.82	3.75	145.7	1.65	64.12	1.75	68.01
T2	1.57	48.83	0.221	6.87	3.47	107.9	1.61	50.07	1.75	54.43
T3	1.41	50.92	0.218	7.87	3.30	119.2	1.54	55.61	1.59	57.41
T4	1.38	42.60	0.199	6.14	3.25	100.3	1.23	37.97	1.31	40.44
T5	1.12	27.00	0.195	4.70	3.13	75.5	1.24	29.90	1.19	28.69
$LSD_{0.05}$	0.14	8.90	N.S.	1.10	0.08	9.31	0.18	1.18	0.10	6.80

The highest concentration and uptake values by barley straw obtained by the continuous irrigation with the fresh water (T_1) were 1.68% and 65.28 kg/fed, respectively, for N, 0.227% and 8.82 kg/fed, respectively, for P, 3.75 % and 145.7 kg/fed, respectively, for K, 1.65% and 64.12 kg/fed, respectively, for Ca, and 1.75% and 68.01 kg/fed, respectively, for Na. On the other hand, the lowest concentration and uptake values by the barley straw due to the continuous irrigation with the saline water (T_5) were 1.12% and 27.00 kg/fed, for N, 0.195% and 4.70 kg/fed, respectively, for P, 3.13 % and 75.5 kg/fed, respectively, for K, 1.24% and 29.90 kg/fed, respectively, for Ca, and 1.19% and 28.69 kg/fed, respectively, for Na. The relative reduction values in concentration and uptake of N, P, K, Ca and Na by the barley straw are shown in (Figures 2 and 3). Irrigation management through the alternating between the fresh and saline ground waters (T_3) gave higher uptake values of the studied nutrients than other management treatments except the control. Sometimes, there is no significant difference in nutrient uptakes between the plants irrigated by T_3 and those irrigated by T_2.

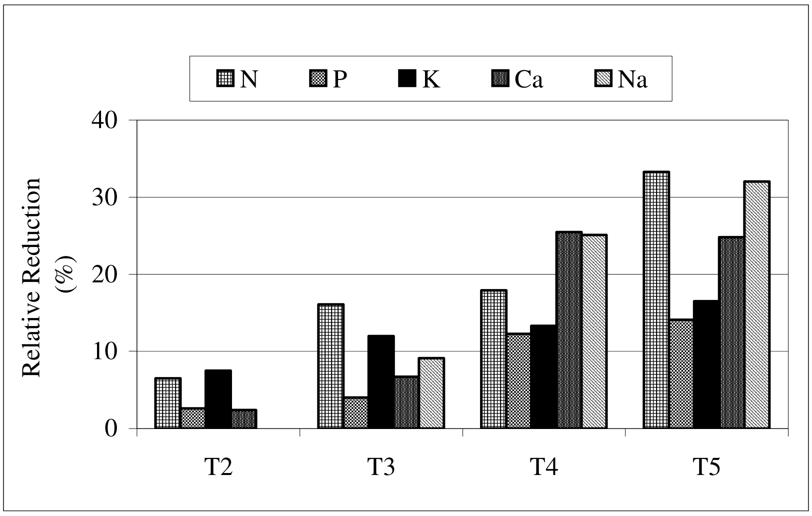

Figure 2: The relative reduction values in concentrations of N, P, K, Ca and Na of barley straw due to studied irrigation management treatments of saline ground water.

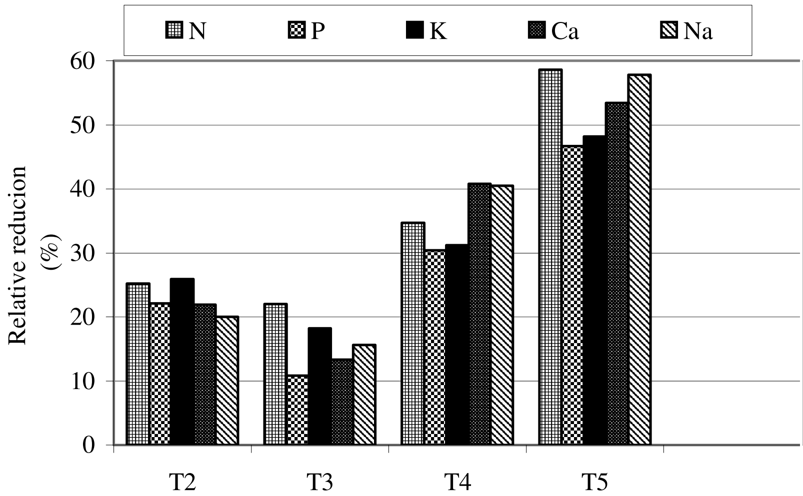

Figure 3: The relative reduction values in the uptake of N, P, K, Ca and Na of barley straw due to studied irrigation management treatments of saline ground water.

This result agrees with that has been previously discussed for the straw and grain yields. So, the best irrigation management treatment of the saline ground water is to use it in an alternate with the fresh water, whereas an irrigation of fresh water is followed by another one of the saline water (T_3). Soil salinity may increase the osmotic pressure of the soil solution that decreases the absorption of both water and nutrients by plants (Mass et al., 1996).

The effect of irrigation management treatments with the saline ground water on concentrations and uptake of Fe, Mn, Zn, and Cu by the barley straw is shown in

Table 5. The concentration and uptake of these micronutrients by the straw decreased in most cases with using irrigation management treatments of the saline ground water of T_2, T_3, T_4 and T_5 compared with the control (T_1). The lowest concentration and uptake values of these micronutrients in the straw were for the barley plants that were continuously irrigated by the saline water (T_5). The concentration and uptake values by the barley straw using the continuous irrigation of fresh water (T_1) were 800 ppm and 3109 g/fed, respectively, for Fe, 84 ppm and 328 g/fed, respectively, for Mn, 103 ppm and 398 g/fed, respectively, for Zn and 28 ppm and 107 g/fed, respectively for Cu. On the other hand, the lowest respective values of the concentration and uptake by barley straw that were obtained by the continuous irrigation of the saline ground water (T_5) were 469 ppm and 1131g/fed, for Fe, 57 ppm and 137 g/fed for Mn, 101 ppm and 244 g/fed, for Zn and 16 ppm and 39 g/fed, for Cu. The relative reduction values of Fe, Mn, Zn and Cu uptakes by the barley straw are illustrated in Figure 4. It is clear that there are insignificant differences in amounts Fe, Mn and Zn taken up by the barley straw among irrigation management treatments of T_2, T_3, and T_4.

Table 5: Effects of irrigation management treatments of saline ground water on Fe, Mn, Zn and Cu contents of barley straw.

Irrigation management treatment	Fe		Mn		Zn		Cu	
	Conc. (ppm)	Uptake (g/fed)	Conc. (ppm)	Uptake (g/fed)	Conc. (ppm)	Uptake (g/fed)	Conc. (ppm)	Uptake (g/fed)
T_1	800*	3109	84	328	103	398	28	107
T_2	450	1400	66	204	108	334	23	70
T_3	394	1423	64	233	88	316	29	104
T_4	506	1562	64	199	98	303	29	91
T_5	469	1131	57	137	101	244	16	39
$LSD_{0.05}$	59	85	3	26	11	31	8	29

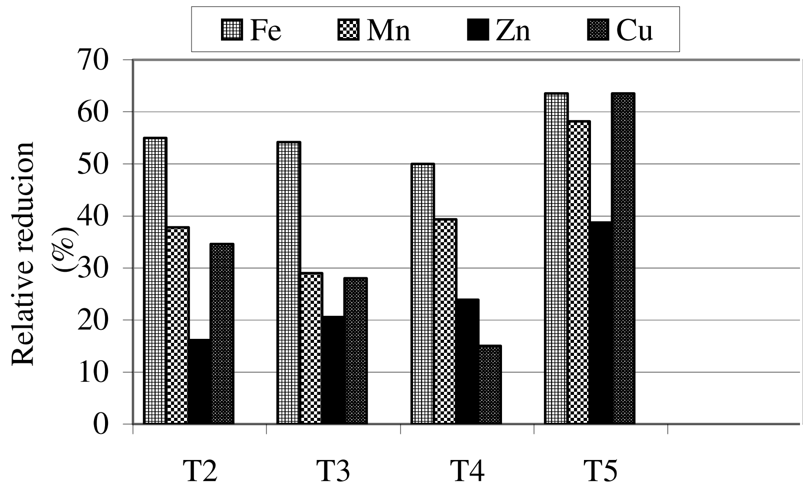

Figure 4: The relative reduction values in the uptakes of Fe, Mn, Zn and Cu by barley straw due to studied irrigation management treatments of saline ground water.

b. Barley grains

Table 6 shows that the concentration and uptake of N, P, K, Ca and Na by barley grains decreased using irrigation management treatments of the saline ground water of T_2, T_3, T_4 and T_5 compared with the control treatment (T_1). The lowest concentration and uptake values of these nutrients were recorded for the plants that were continuously irrigated by the saline ground water (T_5) because the salinity may affect the various metabolic processes in the plants. These respective values were 1.37% and 14.19 kg/fed for N, 0.378 ppm and 3.92 kg/fed, for P, 1.15% and 11.91 kg/fed for K, 1.99% and 20.62 kg/fed for Ca, and 0.88% and 9.12 kg/fed, for Na. In contrast, the highest respective values of nutrient concentration and uptake in the plants that were continuously irrigated by fresh water (T_1) were 2.18% and 34.10 kg/fed for N, 0.579% and 9.06 kg/fed for P, 1.60% and 25.18 kg/fed for K, 2.45% and 38.32 kg/fed for Ca, and 1.25% and 19.55 kg/fed for Na. Similar effects of salinity on N content of wheat have been reported by Hassan and Mostafa (2002) and Saleh et al. (2002). Figures 5 and 6 illustrate the relative reduction values in concentration and uptake, respectively, of N, P, K, Ca and Na by barley grains. As shown previously with straw, the plants irrigated by an irrigation of the fresh water in an alternate with another irrigation of the saline ground water (T_3) took up higher amounts of N, P, K, Ca and Na by grains than other treatments except the control (T_1). Although there are nonsignificant differences, sometimes, among T_2, T_3 and T_4, applying the saline ground water in an alternate with the fresh water (T_3) could be the best irrigation management for the saline water. It was noticed that higher amounts of nutrients were taken up by the straw than by the grains although N, P and Ca contents in grains are higher than straw. Also the straw yield of barley is greater than the grain yield leading to higher amounts of nutrient taken up by the straw. The concentrations of K and Na in the barley straw tissue were found much higher than in the grains. These elements remain in the straw tissue as elements and do not assimilate inside the plants. So, they do not enter the metabolic processes inside the grains. These results are in a harmony with those obtained by Zein et al. (2002).

Table 6: Effects of irrigation management treatments of saline ground water on N, P, K, Ca and Na contents of barley grains.

Irrigation management treatment	N		P		K		Ca		Na	
	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)	Conc. (%)	uptake (kg/fed)
T_1	2.18*	34.10	0.579	9.06	1.60	25.18	2.45	38.32	1.25	19.55
T_2	2.10	26.67	0.489	6.21	1.55	19.69	2.31	29.34	1.25	15.88
T_3	2.14	31.05	0.477	6.92	1.49	21.62	2.21	32.07	1.06	15.38
T_4	2.09	28.80	0.421	5.80	1.48	20.39	2.10	28.94	1.00	13.38
T_5	1.37	14.19	0.378	3.92	1.15	11.91	1.99	20.62	0.88	9.12
$LSD_{0.05}$	0.31	4.80	0.109	2.02	N.S.	3.20	0.14	2.78	N.S.	1.30

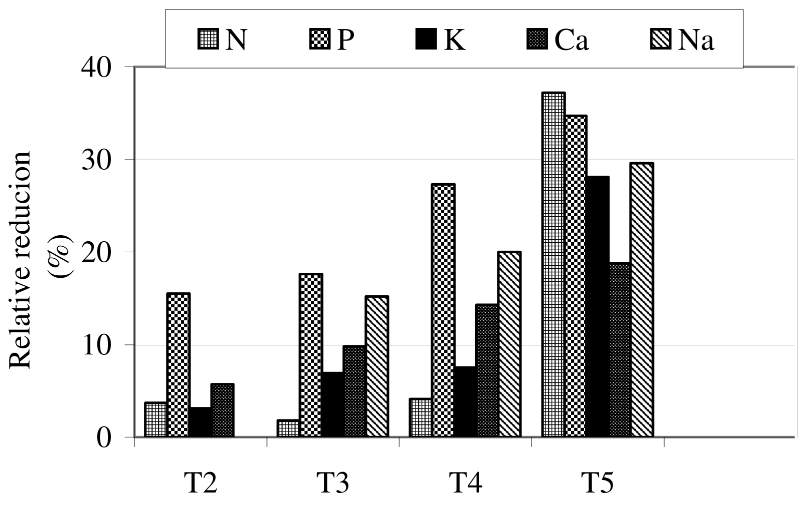

Figure 5: The relative reduction values in concentrations of N, P, K, Ca and Na by barley grains due to studied irrigation management treatments of saline ground water.

Nitrogen, P, K, Ca, and Na contents of the grains and straw of barley were significantly affected by water salinity levels (Tables 4 and 6). This may be attributable to decreasing the plant ability to absorb nutrients under the high water salinity level and because the salinity may affect different metabolic processes (Hassan and Mostafa, 2002).

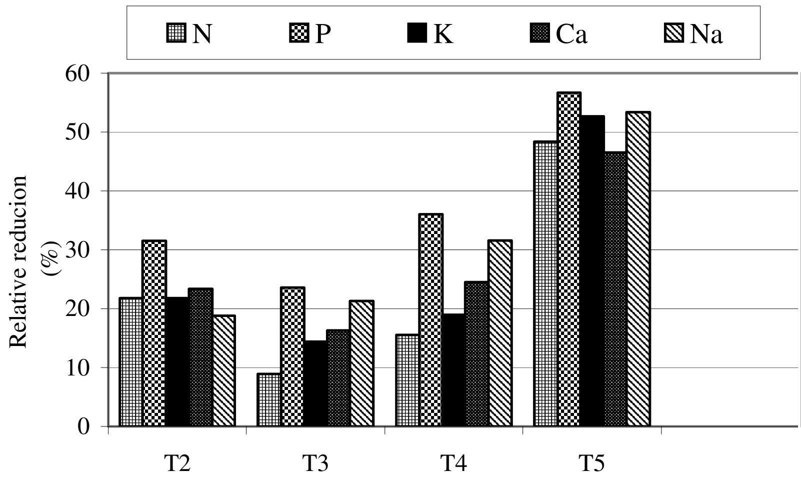

Figure 6: The relative reduction values in the uptakes of N, P, K, Ca and Na by barley grains due to studied irrigation management treatments of saline ground water.

Irrigation management treatments of the saline ground water (T_2, T_3, T_4 and T_5) caused decreases in the uptake of Cu and Zn by barley grains (Table 7). However, the concentration and the uptake of Fe and Mn in the grains of the plants irrigated by T_2 and T_3 treatments increased compared with those of the control (T_1).

Table 7: Effects of irrigation management treatments of saline ground water on Fe, Mn, Zn and Cu contents of barley grains.

Irrigation management treatment	Fe		Mn		Zn		Cu	
	Conc. (ppm)	Uptake (g/fed)	Conc. (ppm)	Uptake (g/fed)	Conc. (ppm)	Uptake (g/fed)	Conc. (ppm)	Uptake (g/fed)
T_1	378*	591	53	83	129	202	29	45
T_2	488	620	74	94	126	160	25	32
T_3	469	681	58	84	132	192	24	35
T_4	375	517	57	79	122	168	30	41
T_5	500	518	61	63	133	138	24	25
$LSD_{0.05}$	N.S.	25	11	10	7	36	4	2

The increases in the concentrations of these micronutrients in the plants induced by the saline water irrigation could be from the release of these nutrients from exchange sites by the ions of the saline irrigation water. These released micronutrients become available in the soil solution for plants to absorb them. El-Desoky (1997) pointed out that Mn and Zn extracted by DTPA from the soil and the uptake of these nutrients by sugar beet increased with increasing the salinity of irrigation water due to their displacement from soil exchange sites by Na^+ and Ca^{+2} of saline water and partly to the salt-induced soil pH drop. However, Mostafa (2001), Hassan and Mostafa (2002) and Saleh et al. (2002) showed that increasing salinity levels of irrigation water caused significant decreases in concentration and uptake of Fe, Mn, Cu, and Zn by wheat, barley and Triticale cultivars. Other studies indicated that the relationship between salinity and trace elements nutrition is complex. The interaction is dependent upon the level and type of salt used, crop species tested and the concentration of micronutrients in the soil solution (Mass et al., 1972).

3. Post-Harvest Soil Properties

Effects of irrigation management treatments of the saline ground water on some soil properties after harvesting the barley plants are present in Table 8. The irrigation management treatments of the saline ground water increased the soil salinity (EC_e) compared with the control (T_1). The lowest level of soil salinity (4.93 dS/m) concerning these irrigation management treatments of the saline ground water was in the soil that was irrigated by T_2 treatment where number of irrigations of the saline ground water was the least. On the other hand, the continuous irrigation with the saline water (T_5) caused the soil to keep the highest level of salinity (8.28 dS/m). The relative increases in the EC_e of the soil were 0.82, 38.24, 10.02 and 69.33% for T_2, T_3, T_4 and T_5, respectively. The soil salinity is likely increased as a result of the soluble salts added with the irrigation treatments (Clark et al., 1999; El-Sodany, 2004).

The soil pH slightly decreased and the saturation percentage (SP) increased at the end of the experiment using all irrigation management treatments of the saline ground water compared with the control. The decreases in the Soil pH due to saline irrigation water are probably due to the release of H and Al from the exchange sites due to the mass replacement by cations of irrigation water (El-Desoky, 1997; Clark et al. 1999; El-Sallami and Makary, 2001). Increasing amounts of salts in the soil due to the irrigation with the saline water causes the soil to keep more moisture at saturation compared with that irrigated by the fresh water (Hassan et al. 1970).

Using the irrigation management treatment of T_5, soluble Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-}, and HCO_3^- in the soil increased from 0.236, 0.358, 0.249, 0.104, 0.482, 0.240 and 0.217 cmol/kg, respectively (for T_1 treatment) to 0.475, 0.782, 0.499, 0.340, 1.047, 0.429 and 0.575 cmol/kg, respectively (Table 8). The increases in soil Ca, Na and Cl levels were probably attributed to the saline irrigation water that contains these ions, while those of Mg, K, HCO_3^- and SO_4^- were due to their release from soil exchange sites by the added Ca, Na and Cl (Clark et al., 1999). The decreases in the soil pH could be due to the displacement of protons by Na^+ and Ca^{2+} of the saline irrigation water (El-Desoky, 1997).

The chemical composition of the soil treated with T_5 showed that the soluble cations decreased in the order of Ca > Na > Mg > K, while the soluble anions were in the order of Cl > HCO_3 > SO_4. However, for the soil treated with T_1 the soluble cations had the order of Ca > Mg > Na > K but its soluble anions followed the order of Cl> SO_4 > HCO_3.

Table 8: Effects of irrigation management treatments of saline ground water on some post-harvest soil properties

Irrigation management treatment	EC_e (dS/m)	pH	SP (%)	Soluble ions cmol/kg						
				Ca	Mg	Na	K	Cl	SO_4	HCO_3
T_1	4.89*	7.77	22.0	0.358	0.249	0.236	0.104	0.482	0.240	0.217
T_2	4.93	7.75	22.9	0.368	0.258	0.386	0.222	0.634	0.178	0.325
T_3	6.76	7.79	23.7	0.550	0.418	0.397	0.256	0.861	0.289	0.452
T_4	5.38	7.78	23.5	0.432	0.259	0.318	0.242	0.656	0.242	0.415
T_5	8.28	7.68	24.2	0.782	0.499	0.475	0.340	1.047	0.429	0.575
$LSD_{0.05}$	0.44	0.05	0.9	0.080	0.060	0.070	0.11	0.039	0.10	0.12

Generally, it may be concluded that this genotype barley genotype has a great ability to build up more dry matter in its tissues under such unfavorable conditions. This may ensure that it is relatively tolerant to saline conditions and could be recommended to be grown on the sandy calcareous soil. Moreover, the best irrigation management treatment of saline ground water to be recommended in such soils is to use it in an alternate with the fresh water (T_3), whereas one irrigation of fresh water is followed by one irrigation of saline water. The irrigation management treatment of T_2 (four continuous irrigations of the fresh water + four continuous irrigations of the ground water + four continuous irrigations of the fresh water) could also be used in these soils to grow this crop.

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