Impact of the Saline Irrigation Water on Crop Production

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Abstract. An experimental study was carried out on the experimental field in Baghdad during the spring season of 2018 to investigate the effects of water quality and irrigation method on yield of maize crop. To this end, two types of water quality were investigated i.e. fresh water, and highly saline water (6.46 dS/m). Besides, the alternating irrigation method were adopted to analyze the possible enhancements of Maize crop production through two irrigate of fresh water followed by one irrigate of highly saline water. These different types of water quality were irrigated by using two irrigation system (drip and furrow). The gross area of the field is 1000 m² divided into 24 plots, with an area of 9 m² for each plot and distant of 2 m between each adjacent plots. The fresh water and highly saline water with alternating irrigation method were applied during planting season of 2018. Maize yield measurements were taken for each replicate. Results indicated that, the plots which were irrigated with fresh water gave the highest yield compared with the plots irrigated by the saline water. Statistical analysis and the linear equations showed a significant correlation between yield reduction and increasing water salinity levels. Also, the results show significant differences in yield reduction between the different irrigated water under the two irrigation systems, where furrow irrigation system gave maize yield reduction more than drip irrigation system.

1. Introduction
The decreasing of fresh water availability has become a worldwide problem, which prompts the initialize of alternative water resources with low quality for agricultural use. Several studies have indicated that when saline water is used for irrigation, more attention should be given to minimize root-zone salinity, where cause saline water increase of soil salinity and reducing agricultural production. [1] studied at India the effect of continuous use of irrigation water with high levels of Na and bicarbonate on soil profiles and yields of maize and wheat. They observed that average yields of maize fodder significantly decreased with increasing levels of EC and SAR in waters, where, maize yields reduced to 50% at an average ESP of 30.5, while wheat yields were unaffected. At Egypt studied [2] the influence of irrigation water salinity ((0.43 (control), 4.85, 6.60 and 8.86 dS/m) on chemical composition of soil water and wheat yield grown in this soil. Results showed that soil salinity increased as a result of increasing salinity levels of irrigation water. Also, the yield reduction increases by 23 % when reaches salinity value of irrigation water at its maximum value (8.86 dS/m).

At Iraqi, Al-Musawi [3] showed that the use of different water qualities by furrow irrigation system (river water EC=1.4 dS/m, saline water EC=4.9 dS/m, and mixed water (prepared by mixing 1:1 saline water and river water to obtain EC=3.2 dS/m)) were caused increase in soil salinity (ECe) and Sodium adsorption ratio (SAR) compared with river water and caused obvious difference in corn grain yield, where, the use of mixed water caused significant reduction of 12% as compared with river water, while, the reduction increased to 28 % with use of saline water. [4] observed that there was significant decreased in onion yields (5, and 32%) with increased water salinity to (3, 7 dS/m), respectively when he used saline irrigation water (0.98, 3, 5, 7 dS/m) for the cultivation of onion crop. [5] studied the effect of irrigation
water quality by using furrow irrigation system on some of soil characteristics and Cauliflower yield. The study included the effect of three levels of saline water (1.4, 3.0 and 4.5 dS/m) on soil. The results showed that increased irrigation water salinity caused significant increase in some of Soil chemical characteristics, such as, EC\text{e}, SAR. Also, it caused a significant decrease in Cauliflower yield. [6] investigated through field experiment during the autumn season the effect of irrigation water salinity on some soil chemical properties and cabbage growth. The factor of irrigation water salinity included four levels are river water, two mixing water, and drainage water. The results indicated a decrease significantly in the total production of the cabbage plant with increasing irrigation water salinity levels. The treatment of drainage water gave lower values of production compared with mixing water and river water. This decline in plant production has been attributed to the negative impact of rising soil salinity and its effects direct and indirect on plant growth

Many studies have reported substantial decreases in crop yield as a result of unsuitable water irrigation contains toxic ions under saline conditions. [7] noted that, saline irrigation water can have a direct toxic effect on plants, because of its contained specific ions, such as chlorine, sodium, or boron, which have a toxic effect on plant roots and leaf tissues and may stunt or stop their growth through accumulation these ions in leaf tissues and its desiccation. This dehydration leads to cell death. Also, [8] noted that saline irrigation water was accumulated high amounts of salts in the root zone, particularly during periods of high evapotranspiration (ET) demand. These soluble salts restrict plant roots from withdrawing water from the surrounding soil (osmotic effects), thus, it reduced the plant available water, increased plant stress, and caused a decrease in plant growth, and its death.

Most the previous studies were conducted using surface irrigation systems. Others studies have indicated the need to select the appropriate irrigation systems that may supply a sufficient quantity of water to the root zone to meet the evaporative demand without maximize salt accumulation inside the root zone, such as, drip irrigation system which did not allow the accumulation of salts around the root zone and increase the yield. Clarified [9] that the use of saline water through drip irrigation system led to the removal of salts away from the emitter and their accumulation at the soil surface, and increase of production. Some of studies reached that the production was high when using drip irrigation system compared with irrigation by furrows irrigation system, such as [9]. They reached that the production of tomato was (130, and 114 Ton/ha) when using drip irrigation method and furrows irrigation method, respectively. [10] were used two types of irrigation methods (drip and surface) and different levels of irrigation water salinity (0.5, 2.0, 3.0, and 4.5 dS/m). The results indicated that that drip irrigation has increased the growth and production of tomato compared with surface irrigation at all salinity levels, also the drip irrigation method did not allow the accumulation of salts around the root zone, while, the salts accumulated in the root zone to a depth 30 cm with surface irrigation.

Other studies concluded that the alternating between good quality and saline waters could be a better way to alleviate the negative effects of saline water on soil properties and reeducation production. [11] were conducted long-term field experiment at India to study the effect of alternating sodic water (SW) having (RSC =10 mmol\text{c}/L) and good quality canal water (CW) on soil properties and sunflower yield. They observed that, sustained use of sodic water increased pH and ESP of the soil and decreased achene yield of sunflower, also they noticed that the sunflower yield did not improve significantly over SW alone treatment, whereas, alternating sodic water with canal water could be considered as success way to grow sunflower in areas having sodic ground water. At South Asia, [12] were observed increase in soil salinity (3.8 ds/m) and sodicity (ESP 27.3) as a consequence of irrigation with alkali water markedly affected the yields of both the crops (paddy and wheat. They concluded also that the alternating of a good quality water supplies through canal networks (EC_w=0.5, RSC=nil) and that having residual alkalinity (AW, EC_w=2.3 dS/m, RSC =11.3 mequiv/L, SAR_w=15 mmol/L^{0.5}) could be success method to alleviate sodicity problems caused with the use of alkali water alone. [13] was carried study included three types of water: river water (0.98 dS/m), salty well water (1.89 dS/m) and alternating between the above two. This study summarized that, the two types of water (river water, and alternating irrigation) had positive effects on soil properties, while, well
water had a negative effect on it. As well, it was showed that the yield decreased by %30, and %10 in the case of constant use of well water, and alternative irrigation, respectively in comparison with treatments that were irrigated with river water.

Other researches have shown crops and varieties should be selected beforehand so that can tolerate a degree of water and salinity stress. [14] were identified that some crops are very sensitive to salts in the soil solution, while others can tolerate much higher concentrations, such as, onions which are sensitive crop of salinity. This crop yield can be reduced by 10 percent when soil EC is 1.8 dS/m and by 50 percent when EC is 4.3. [15] were cropped two subplots (A and B) with cotton and sugar beet during 1997 and 1998 in south west Spain. Irrigation was applied by furrows. Subplot A was irrigated with fresh water (0.9, 1.7 dS/m) during the whole season of 1997 and 1998, respectively, while, subplot B was irrigated with high and moderately saline water (22.7, 5.9–7.0 dS/m) for two irrigations during 1997 and 1998, respectively. They noted that the irrigation with high saline water affected crop development, where, cotton yield was reduced in comparison with that in the (subplot A) irrigated only with fresh water, whereas, sugar beet yield did not show differences between subplots.

Abu Ghraib region is suffers from soil deteriorating and the production reduction due to the irrigation water salinity used because discontinuity of Euphrates river water completely from the Abu Ghraib during the past years because of the terrorist destruction and trend the farmers to rely on groundwater wells of the irrigation, in addition to, the low rate of precipitation, and the rule of old irrigation methods in planting (surface irrigation). This reasons called for to choose Abu Ghraib region as case study to implement this experiment. Therefore, the objective of this research is to study the negative effects of irrigation water (water wells) on maize crop in this region, addition to, the successful using of these salinity waters through the sound management ways (alternative irrigation) and irrigation systems (furrow and drip) to avoid problems on crop production. Two levels of saline water ($W_2$, and $W_3$) with fresh water ($W_1$)as a reference were used. These water types were employed with two irrigation systems (furrow and drip) and the impacts of irrigation systems on maize production were evaluated.

2. Materials and Methods

2.1 The Preparation of Field

The field experiment was conducted in the west of Baghdad province between latitude 33° 19′ 30.61″ north and longitudes 44° 12′ 45.75″ east, with an area of 1000 m². The field is divided into two major sectors. Each sector is sub-divided into (12) experimental plots with an area of each plot 9m². The field is flooded with water for leaching purpose then the land is plowed in main furrows through the use of furrows machine, figure 1.b

2.2 Experimental Replicates

The implementation of the experimental work included the following replicates:

1- Using fresh (tap) water ($W_1$) (0.73ds/m),
2- Using high saline water ($W_2$) (6.46 ds/m) (wells water),
3- Using alternating irrigation method ($W_3$), through using two irrigate of tap water followed by one irrigate of highly saline water. Each of the above three types was applied by using drip and furrow irrigation systems.

2.3 Irrigation Systems

The water supplying system for both drip and furrow included reservoirs to store water with network of pipes for conveying water from these reservoirs to the sub-pipes (sub main lines) in the experiment field. A fertilized machine was used to fertitize agricultural land. For removing the suspended sediments from water, disk water filter was used. Furrow irrigation system was designed with distance between each two furrows 0.7 m and the width and depth of each furrow are 0.4, and 0.2 m, respectively. Whereas, drip irrigation system was contained field lines (drip pipes) with 3 m length for each plot, the distance between the lines is 0.75 m. The Field pipes consists of 10 emitters, the distance between emitters is 25 cm. Designed discharge of each emitter is 3.8 L/hr.
2.4 Water Requirements of the Crop and Irrigation Scheduling

The following equations (1, 2, and 3), were used to find the values for each of actual evapotranspiration for furrow irrigation system \(ET_a\), drip irrigation system\(ET_{crop \ localized}\), and gross irrigation requirement \(IR_g\), respectively, [16], and [17].

\[
ET_a = ET_o \times K_c \tag{1}
\]

\[
ET_{crop \ localized} = ET_a \times K_r \tag{2}
\]

\[
IR_g = \frac{ET_a}{E_a} - (P_e + LR) \tag{3}
\]

where \(ET_a\) is actual evapotranspiration of the crop (L/T) for the furrow irrigation system; \(ET_o\) is reference evapotranspiration (L/T); \(K_c\) is crop coefficient; \(ET_{crop \ localized}\) is actual evapotranspiration of the crop for drip irrigation system (L/T); \(K_r\) is reduction coefficient; \(IR_g\) is gross irrigation requirement (L/T); \(P_e\) is effective rainfall (L/T); \(LR\) is leaching requirement (L/T); and \(E_a\) is field application efficiency (irrigation efficiency) (%).

Irrigation processes of the field are carrying by the gravimetric method when the moisture depletion reaches 50% of available water (initial moisture) in the plants roots depth and through follow-up development of these roots depth based on three stages: beginning of agriculture, vegetative growth stage, and flowering stage until the end of the physiological maturity stage. The following equations were used to find the added water depth to compensation moisture depletion from the field capacity, [18]:

\[
d_{furrow} = (\theta_{F,c} - \theta_{bi}) \times D \tag{4}
\]

\[
d_{drip} = (\theta_{F,c} - \theta_{bi}) \times D \times A_w \tag{5}
\]

where \(d\) is added water depth (L); \(\theta_{F,c}\) is volumetric moisture content at field capacity; \(\theta_{bi}\) is volumetric moisture content before the irrigation; \(A_w\) is wetted area ratio (%); and \(D\) is soil depth required at the effective root system (L).

Also, the following equations were used to find the irrigation time for both irrigation systems (furrow and drip), respectively:

\[
t_{furrow} = \frac{A \times d}{Q_{pump}} \tag{6}
\]

\[
t_{drip} = \frac{A \times d}{Q_{drip} \times n} \tag{7}
\]

where \(t\) is irrigation time (T.); \(Q_{pump}\) is pump discharge \(\left(\frac{L^3}{T}\right)\); \(A\) is the cultivated area \(\left(\frac{L^2}{T}\right)\); \(Q_{drip}\) is the discharge of emitters (drip lines) \(\left(\frac{L}{T}\right)\); and \(n\) is number of emitters on the field.

2.5 The Yield Production

The cultivation of maize crop was performed as reference plant, Figure 1.a. The calculation of maize yield production was carried out depending on calculating of the grains weight per replicate (plot). Relative yield of maize was calculated from the following equation, [19]:

\[
Y = 100 - B (EC_e - A) \tag{8}
\]

where \(Y\) is relative yield; \(A\) is the salinity threshold (dS/m); \(B\) is the percent yield decrease per unit salinity increase; and \(EC_e\) is the soil salinity (dS/m).
2.6 The Statistical analysis
The Statistical evaluation of the results was done by finding the linear regression equations and the regression coefficient \((R^2)\), which link each of soil salinity \((EC_s)\), and the sodicity (exchangeable sodium percentage) (ESP) of soil with the maize production. Also, Pearson correlation coefficient \((r)\) with a significant level of 0.01 was employed to determine the correlation between the salinity and sodium concentration (explanatory variables) with the production (response variables).

2.7 Laboratory Work
It is included the collection and laboratory analysis of the water samples used in the irrigation process, (Table 1). Soil samples were investigated before planting and at the end of the agricultural season to recognize the changes in salinity \((EC_s)\) and sodicity (ESP) of the field soil as a result of irrigation with the different salinity water, (Table 2).

| Water Properties | Water source | Water source |
|------------------|-------------|-------------|
| \((EC_{iw})\) (dS/m) | 0.73        | 6.46       |
| pH               | 7.25        | 7.9        |
| Ca\(^{2+}\)      | 6.9         | 9.22       |
| Mg\(^{2+}\)      | 3.27        | 19.6       |
| Na\(^+\)         | 1.4         | 33.59      |
| SO\(_4^{2-}\)    | 3.8         | 26.5       |
| Cl\(^-\)         | 2.1         | 22.7       |
| CO\(_3^{2-}\)    | 0.6         | 2.19       |
| HCO\(_3^-\)      | 1.3         | 3.7        |
| NO\(_3^-\)       | 2.93        | 7.59       |
| SAR              | 0.68        | 6.34       |

\((\text{mmol/L})^{1/2}\)

| Water Properties | Water Properties |
|------------------|------------------|
| \((EC_{iw})\) (dS/m) | 2.75        |
| pH               | 7.6          |
| Ca\(^{2+}\)      | 11.4         |
| Mg\(^{2+}\)      | 11.83        |
| Na\(^+\)         | 9.69         |
| SO\(_4^{2-}\)    | 7.52         |
| Cl\(^-\)         | 88.16        |
| CO\(_3^{2-}\)    | Nill         |
| HCO\(_3^-\)      | 3.55         |

\((\text{CEC}) \text{ (Meq/100gm soil)}\) \quad 74.18

\((\text{OM}) \%) \quad 4.28

\((\text{CaSO}_4)\%) \quad 1.03

\((\text{CaCO}_3) \%) \quad 22.59

\((\text{P}) \text{ ppm}\) \quad 40.11

\((\text{K}) \text{ ppm}\) \quad 285.06

\((\text{NO}_3^-) \text{ ppm}\) \quad 21.11

\((\text{NH}_4) \text{ ppm}\) \quad 51.19

\((\text{SAR})\) \quad 3.47

\((\text{mmol/L})^{1/2}\)
3. RESULTS AND DISCUSSION

3.1 Change of Irrigated Soil Properties
In terms of the effect of using saline irrigation water on the chemical properties of the soil (Tables 1, 2, and 3). It is observed that, the soil salinity (ECs) and soil sodicity (SAR) decreased to the lowest values at the end of the agriculture season when the use of tap water (W1) compared with the values of ECS and SAR of soil before the agriculture. The reason for this is due to low salinity water, which causes increasing of calcium ion ratios and decreasing sodium ion ratios in soil, as, it contains a small percentage of sodium ion versus a high percentage of calcium ion, and this causes the declination of ESP in the soil, addition to improving the hydraulic properties of the soil.

When the use of water (W2), the values of (ECs) were larger than the values when the use of water (W1, and W3), as it characterized by high salts concentrations compared with other water types.

The values of ESP at the soil depths when using water (W2) were more than the values when the use of water (W1, and W3) due to this water contains high proportions of sodium ion compared with the calcium and magnesium ions, this helped to increased its concentration in the soil more than other ions, thus the sodic index of soil (ESP) is increasing, while, it has observed that, the irrigation water (W1) contains on proportions calcium ion higher somewhat than proportions ion sodium, as well the alternately irrigation method (W3) contains also on high levels of calcium and magnesium ions through the irrigation by tap water and high salinity water (W2), this caused an increase concentrations calcium and magnesium ions in soil compared sodium ion and increase their impact in competing with sodium ion on exchange surface of soil particles, thereby, reducing the effect of the sodium ion and declining the values of ESP.

Figure 1. Site preparation, and Farming.
3.2 Yield Production of Maize

The results of this study showed that, the plots irrigated with fresh water (control) gave the highest yield compared to the treatments irrigated with different saline water levels. Table (4) show that the average yield of per square meter increased to about 0.924 Kg/m$^2$ when using fresh water (W1) with drip irrigation system compared with the production rate when using furrow irrigation system (0.861 Kg/m$^2$). It has been observed that tap water contains a small percentage of sodium versus a high percentage of calcium, thereby, this causes declination of ESP in the soil, and improving the hydraulic properties of the soil and increase the maize yield. In contrast, the average yield decreased to 0.291, and 0.365 Kg/m$^2$ when using high saline water (W2) for furrow and drip irrigation systems, respectively due to the fact that the water used for irrigation purposes (wells water) contains high levels of salinity, which causes increase of the salinity in cultivated soil. Thus, increasing the salinity stress (the osmotic, and toxic stresses), which in turn causes the yield reduction.

Figure 2 show significant correlation between the soil salinity and maize yield with a value of $r = -0.9982$, and -0.9999, for drip and furrow irrigation systems, respectively, therefore, it has been observed through the linear equation that the rate of maize yield declined to be 12-13 % with each increase in ECs of cultivated soil.

Moreover, highly saline water (W2) contains high proportions of sodium ion compared with the calcium and magnesium ions caused an increase in its concentration in water (SAR) and the sodic index of soil (ESP) is increased also. This caused reduction of the maize yield, where, it has shown a significant correlation between the soil sodicity and maize yield with a value of $r = -0.9995$, and 0.9910 for drip and furrow irrigation systems, respectively. Therefore, the linear equations show that the rate of maize yield declined to be 7 - 9 % with each increase in ESP of cultivated soil (Figure 3). Through using of two irrigate of fresh water followed by one irrigate of highly saline water in alternating irrigation method (W3), the average yield was higher compared with using highly saline water (W2) only. Where an increased was recorded in the yield rate to be 0.548 and 0.4615 Kg/m$^2$ for drip and furrow irrigation systems compared with using highly saline water (W2). The reason for that is attributed to the fact that water used of the irrigation by tap water (W1) contains high levels of calcium ion. In addition to the amount found in high salinity water (W2). This caused an increase in concentrations in soil compared with sodium ion, thereby, reducing the values of sodic indicators (SAR and ESP) and improving the maize yield somewhat compared with highly saline water (W2).

3.3 The Yield Reduction

The salt tolerance of a crop can best be described by the linear equations which plotting its relative yield as a continuous function of soil salinity. Through the linear equation can be find the relative yield then calculate of the yield reduction. The linear equation proposed by Maas and Hoffman was used to calculate the yield reduction and results were compared with the yield reduction of the linear equations in Figure (2). In Table 5, it was observed that there were no significant differences in yield reduction when using Maas and Hoffman equation (equation 8) with that calculated by using linear equations in Figure 2. Maize yield decreased with increasing salinity level, particularly in high saline water compared to fresh water. Moreover, there were differences in yield reduction under irrigation systems. The maize yield reduced to 71%, under the saline water W2 when plants irrigated by furrow irrigation, whereas, the yield reduction was less when using drip irrigation system by about 58% under the same salinity level. In contrast, under alternating irrigation method (W3) the maize production increased compared with the irrigation of high saline water (W2). So that the yield reduced to 54% when plants irrigated by furrow irrigation, while the results indicated that, the yield reduction was 47% when using drip irrigation system compared with furrow irrigation system.
**Table 3.** The Changes of Salinity (EC<sub>s</sub>) and Sodicity (ESP) of the Field Soil at the End of the Agricultural Season

| Water quality | Drip | Furrow |
|---------------|------|--------|
|               | EC<sub>s</sub> (dS/m) | ESP (%) | EC<sub>s</sub> (dS/m) | ESP (%) |
| W<sub>1</sub> | 2.11 | 0.92   | 2.43   | 1.28   |
| W<sub>2</sub> | 6.38 | 7.11   | 7.19   | 9.58   |
| W<sub>3</sub> | 5.21 | 5.26   | 5.82   | 6.11   |

**Table 4.** Effect of Water Types on Total Maize Yield Through Using two Irrigation Systems

| Replicate No. | Irrigation Systems |
|---------------|--------------------|
|               | Drip Irrigation System | Furrow Irrigation System |
|               | W<sub>1</sub> | W<sub>2</sub> | W<sub>3</sub> | W<sub>1</sub> | W<sub>2</sub> | W<sub>3</sub> |
| 1             | 0.861 | 0.428 | 0.564 | 0.916 | 0.276 | 0.369 |
| 2             | 0.976 | 0.375 | 0.493 | 0.925 | 0.224 | 0.482 |
| 3             | 0.863 | 0.362 | 0.609 | 0.791 | 0.315 | 0.415 |
| 4             | 0.996 | 0.295 | 0.526 | 0.812 | 0.349 | 0.506 |
| Average (Kg/m²) | 0.924 | 0.365 | 0.548 | 0.861 | 0.291 | 0.4615 |
| The Total Yield (Kg/ha) | 9240 | 3650 | 5480 | 8610 | 2910 | 4615 |
**Figure (2).** Impact of soil salinity (ECs) through four water types on maize yield.

**Figure (3).** Impact of soil sodicity (ESP) through four water types on maize yield.

| Water quality | Drip irrigation system (Maas and Hoffman model) | Furrow irrigation system (Maas and Hoffman model) |
|---------------|-----------------------------------------------|--------------------------------------------------|
| W<sub>1</sub>  | 5                                             | 9                                                |
| W<sub>2</sub>  | 56                                            | 66                                               |
| W<sub>3</sub>  | 42                                            | 49                                               |
3.4 Effect of the irrigation systems

The method of irrigation can affect the crop's response to salinity. With pressurized systems, such as drip, small applications of water can be applied to fields uniformly, unlike surface irrigation methods such as furrow, (Maas and Hoffman, 1977). Thus, these irrigation methods that maintain a higher soil-water potential reduce the salt concentration in the soil-water and support the optimal plant performance. Therefore, it has been noted in Figure (4) that the total yield irrigated by drip irrigation system was higher than that from furrow irrigation system. Especially, when using water of low salinity ($W_1$) or using alternating irrigation method ($W_3$) which contains on high levels of calcium ion versus small percentage of sodium ion, thereby, improving the maize yield. The total yield was 9240 kg/ha and 5480 kg/ha of $W_1$ and $W_3$, respectively when using drip irrigation system compared with the total yield when using furrow irrigation system which was 8610 kg/ha and 4615 kg/ha of $W_1$ and $W_3$, respectively. The reason for that is slow wetting pattern of the emitters with the horizontal movement of water (radial movement) in the soil surface and decrease vertical movement with depth. Therefore, the efficiency of leaching the salts is decreased with the soil depth, in addition, the effect of the aggregates stability of soil and regularity of the capillary tubes has helped to get movement adverse to soil moisture in the intervals between irrigations to carry salts of sub-surface depth (near the root zoon of maize plant) to the soil surface. Therefore, the salts are collected significantly in the soil surface. In contrast, the reduction of the total yield of $W_2$ was higher when the irrigation by furrow irrigation system (2910 kg/ha) compared with drip irrigation system (3650 kg/ha). This could be explained by the fact that the furrow irrigation system is characterized by rapid moisturizing through large amounts of irrigation water, also the field soil type (silt clay loam), which contains high percentage of silt helped on increase the vertical movement of irrigation water with the salts from surface depth to the deep depths. For this reason salts accumulated in larger quantities near the root zoon of maize plant, especially, when using high saline water, which caused the degradation of chemical and physical properties of soil because of increasing sodium concentration in soil, thus, maize yield reduction.

4. CONCLUSIONS

The results of this study indicated that there were significant effects of the studied factors (water quality, and irrigation systems) on maize production. The results showed that the maize yield was higher when using fresh water ($W_1$), but decreased significantly when using salinity water in both two irrigation systems. The results also showed that drip irrigation system improved maize yield compared with furrow irrigation system when using salinity water. Also, the plots irrigated by alternating irrigation method ($W_3$), gave maize yield
reduction less compared to the treatments irrigated with highly saline water levels ($W_2$), particularly for plants irrigated by drip irrigation system.

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