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The effect of irrigation water quality on the growth of maize plants, electric conductivity and pH of the soil

ABSTRAC

The research aims to determine the response of the Maize crop to irrigation with salt water during the growth stages, and to study the accumulation of salts in the soil, the degree of their interaction, and the efficiency of water use.
Three types of irrigation water with salt concentrations (1.5, 4.5, 6.5) dSm^{-1} with three replicates for every kind water. The Randomized Complete Blocks Design was used in the experiment, and it was statistically analyzed using SPSS. Statistically significant differences were found at the 5% level according to Duncan's method. Statistical analysis showed that there were significant differences attributed to the salinity of irrigation water at the level of 4.5 dsm^{-1} (T2), which caused about 50% damage in plant height, root growth, leaf area per cob length, weight of 500 seeds, grain yield, and soil. Compared to salinity if irrigated with 1.5 dsm^{-1} (T1) salinity of river water. Using water with a salinity of 6.5 dsm^{-1} (T3) as wastewater resulted in a reduction of all apparent plant characteristics by 75%. An increase in soil salinity was also observed at the end of the experiment compared to its salinity at the beginning of the experiment, and this damage increases with an increase in the electrical conductivity of the water used in irrigation operations. It has been observed that soil PH decreases with increasing soil salinity.

KEYWORDS:
Maize, Salt water, Phenotypic characteristics, Water use efficiency, Duncan

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Влияние качества поливной воды на рост растений кукурузы, электропроводность и pH почвы

РЕЗЮМЕ

Целью исследований является определение реакции кукурузы на орошение соленой водой на этапах роста, изучение накопления солей в почве, степени их взаимодействия и эффективности использования воды.
Использовали три типа поливной воды с содержанием солей 1,5, 4,5, и 6,5 dSm^{-1} в трех повторностях для каждого вида воды. В эксперименте применяли рандомизированный дизайн полных блоков, который был статистически проанализирован с использованием SPSS. Статистически значимые различия были обнаружены на уровне 5% по методу Дункана. Статистический анализ показал, что существуют значительные различия, связанные с соленостью поливной воды на уровне 4,5 dSm^{-1} (T2), что приводит к примерно 50% снижению высоты растений, уменьшению роста корней, площади листьев, длины початка, массы 500 семян, урожайности зерна и ухудшению почвы по сравнению с минерализацией при орошении соленостью речной воды 1,5 dSm^{-1} (T1). Использование в качестве поливной воды с минерализацией 6,5 dSm^{-1} (T3) привело к снижению всех видимых характеристик растений на 75%. В конце эксперимента также наблюдалось увеличение засоления почвы по сравнению с ее засолением в начале эксперимента, причем этот ущерб увеличивается с увеличением электропроводности воды, используемой в оросительных системах. Было замечено, что pH почвы снижается с увеличением засоления почвы.

КЛЮЧЕВЫЕ СЛОВА:
кукуруза, поливная вода, соленость воды, фенотипические характеристики, эффективность использования воды

Introduction

Year after year, the need for irrigation water increases until it has become a restriction for agriculture, at a time when there is waste in water use.

The priority was to think about investing in limited water and even using salt water in agriculture, even though Ayers and Westcott [1] classified wastewater as salty. 3.5 dSm^{-1}, considering that it is highly salty water, but it is used in agriculture, which causes the soil salinity to rise up to 4.9 dSm^{-1}.

Fahd et al. [2] indicated the possibility of irrigating yellow maize crops with salt water depending on the stages of growth and its effect on the plant and the accumulation of salts, while Al-Saadawi, and Dahash [3] showed the response of irrigating different types of barley with salt water during different growth stages and the importance of adding salt irrigation water. During growth stages that are not sensitive to salinity, as the germination and emergence stage is the most sensitive stage to salinity for most crops.

Shaaban, et al. [4] studied the effect of different quantities and types of irrigation water on the growth and composition of maize and the distribution of some ions in the soil and found a significant decrease in the absorption of iron, zinc and manganese in plants irrigated with salt water.

Douri [5] indicated that high salinity of irrigation water led to an increase in salt accumulation in the soil, an increase in the concentration of sodium, calcium and magnesium ions in the soil solution and a significant decrease in growth and development plants.

As for Al-Helou et al [6] it was shown that the accumulation of salts in the soil leads to an increase in total dissolved salts (TDS) during irrigation, which lead to a negative impact on plant growth and had a negative impact on agricultural production, and this is as shown by Al-Rubaie et al. [7] therefore, the soil must be washed after harvesting.

The research aims to determine the response of the Maize crop to irrigation with salt water during the growth stages, and to study the accumulation of salts in the soil, the degree of their interaction, and the efficiency of water use.

Materials and Methods

The experiment was carried out at Al-Dabouni Research Station located in the Al-Aziziya district at longitude: 45°.063 and latitude 32°.9107

It is bordered to the south by Wasit Governorate, 90 km away, to the north by Baghdad Governorate, 120 km away. It is bordered to the east by Diyala Governorate, 30 km away, and to the west, by Babylon Governorate, 90 km away.

Soil samples were taken to depths of 0-25 cm to determine some chemical and physical soil properties, to grow a plant (Zea mays) in the fall season of 2023 in soil woven with Silt Loam.

The average soil electrical conductivity was 2.4 dSm^{-1} and its pH reaction was 7.4. Maize was grown in conditions of the first three three water treatments (salt water mixed with irrigation water to have an electrical conductivity of 4.5) dSm^{-1}

The second treatment: (water, salinity more than 6.5 dSm^{-1}), the third treatment (river water, salinity 1.5 dSm^{-1}).Each irrigation treatment was repeated three times.

The land was prepared by plowing, leveling and fertilizing according to the recommendations of specialists. Local corn seeds planted in plank method (m x m) with 50cm lines between line and line.

A seed bed dug 5cm deep and the distance between one bed and another was 20 cm.

That is 15 plants per square meter, every seed that was planted, and after growth, one of them was removed.

The first irrigation for all treatments was done with river water only.

Subsequent irrigations were performed with water with an electrical conductivity of 4.5 dSm^{-1} and 6.5 dSm^{-1}..The control sample was irrigated with water of 1.5 dSm^{-1} conductivity

It gave 8 irrigations within 115 days (corn life) starting from planting on 8/27/2023.

Eight irrigations were carried out within 115 days of the corn life, starting from planting on August 27, 2023, at a rate of three plantings per square meter for each type of irrigation water.

Statistical analysis:

The research was designed according to randomized complete blocks (RCBD) of three water treatments with three replicates for each treatment.

Table 1. Some physical and chemical characteristics of the soil used in the study

Adjective		Value
pH		7.40
EC Dsm^{-1}		2.40
The dissolved ions Mmol L^{-1}	Ca++	3.67
	Mg++	0.89
	Na+	2.41
	K+	0.35
	Cl-	1.24
	SO_4--	5.26
	HCO_3-	2.23
Soil separators g kg^{-1}	Sand	302
	silt	460
	clay	233

Table 2. Mineral composition, pH and electrical conductivity (EC) of irrigation water before planting

Irrigation water	HCO_3 mmol L^{-1}	SO4- mmol L^{-1}	Cl- mmol L^{-1}	Na+ mmol L^{-1}	Mg++ mmol L^{-1}	Ca++ mmol L^{-1}	pH	EC dSm^{-1}
Drainage water	8.5	8.7	15.8	13.1	8.2	6.2	7.6	6.5
River water	2.9	4.6	4.7	6.3	2.7	5.1	7.8	1.5

Table 3. ANOVA explained sun of squares ,mean square and significance'

		Sum of Squares	df	Mean Square	F	Sig.
Plant height	Between Groups	21650.000	2	10825.000	30.929	.001
	Within Groups	2100.000	6	350.000		
	Total	23750.000	8			
Root length	Between Groups	302.000	2	151.000	37.750	.000
	Within Groups	24.000	6	4.000		
	Total	326.000	8			
Ear lenth	Between Groups	122.000	2	61.000	36.600	.000
	Within Groups	10.000	6	1.667		
	Total	132.000	8			
Leaf area	Between Groups	39920000.000	2	19960000.000	124.750	.000
	Within Groups	960000.000	6	160000.000		
	Total	40880000.000	8			
500 grain weight	Between Groups	10338.000	2	4.694	18.695	.003
	Within Groups	1234.000	6	.251		
	Total	11572.000	8			
Grain yield	Between Groups	9.389	2	12.250	59.274	.000
	Within Groups	1.507	6	.207		
	Total	10.896	8			
EC	Between Groups	24.500	2	.370	22.200	.002
	Within Groups	1.240	6	.017		
	Total	25.740	8			
PH	Between Groups	.740	2			
	Within Groups	.100	6			
	Total	.840	8			

SPSS statistical analysis was conducted and significant differences were found at the probability level of 0.05, using Duncan's method.

Results and Discussion

Plant growth and salt accumulation were monitored after harvest. The results showed significant differences at the 5% level in plant height, root length, Ear length, leaf area, 500 grains weight, yield, and soil salinity.

Plant height (cm)

Mean height of plants supplied with low conductivity water measured after harvesting reached 190 cm. Appropriate decrease in plant height was registered with the increase of water salinity, mean value reaching 135 cm at 4.5 dSm^{-1} water conductivity (T2).

The reason for this decrease is a negative effect of continued irrigation with salt water during the growing season.

High salinity water (EC 6.5 dSm^{-1}) reduced plant height of the plants up to 70 cm with T1 treatment.

The phenomenon was consistent with the results of Monowara and Khatun [8] on the effect of salt water on plant height. Fernandez-Ballester [9] also indicated the growth inhibition effect of salt water.

Salt stress also leads to a decrease in the production of DNA that participates in leaves production.

According to Abboud, Hadi Yasser and Riad Abdel Zaid [10] maize plant irrigation with different water electrical conductivity from 1.8 to 3, 4.5, and 6 dSm^{-1} resulted in a decrease of maize height from 87 cm to 73.96, 68, 51, 59.72 cm, respectively.

Root length (cm)

The results showed that roots were significantly affected by high salty irrigation water (T3) characterized by root length of 14 cm, while river water sample (T1) produced root length of 32 cm, and in T2 case the root length was 23 cm.

Thus, percentage decrease of root length in T2 and T3 conditions reached 28.1 % and 56.25 % for T2 and T3 conditions compared to T1.

Table 4. The effect of irrigation water quality on the phenotypic characteristics of Maize and soil salinity and pH

Irrigation treatments	Plant height (cm)	Root length (cm)	Ear height (cm)	Leaf area (cm^2)	500 grain weight (g)	Yield (t.ha^{-1})	EC (dSm^{-1})	pH
River water 1.5 dSm^{-1} (T1)	190*	28*	20*	8000*	153*	6.0*	4.5	7.8*
River water 4.5 dSm^{-1} (T2)	135	23	16	4400	110	4.8	6.0	7.4
River water 6.5 dSm^{-1} (T3)	70	14	11	3000	70	3.5	8.5*	7.1

* *significant differences at a probability P<0.05*

Water salinity is known to cause a decrease in water absorption and seed imbibition and slow seed transformation during germination, in addition to inhibiting division and elongation processes due to salts [11].

Ear height (cm)

Accordingly Ear length decreased due to water salinity reaching 20% in T2 treatment and 45% in T3 treatment compared to river water application (T1).

The reason may be that salinity inhibits the process of photosynthesis and the manufacture of carbohydrates, which negatively affects cell division and plant growth [12].

Leaf Area (cm^2)

The leaf area was measured before the harvesting stage according to the following equation:

Leaf area (cm^2) = leaf length x maximum width x 0.75 Correction factor: 0.75 [13]. Plants under T3 treatment demonstrated a 62.5% decrease of leaf area compared to T1 conditions which was in accordance with the observation of leaf chlorophyll content decrease with increasing levels of salinity due to osmotic pressure and the toxic effect of salinity.

This is consistent with the opinion of Bouchareb [14] that the decrease in the total leaf area may be due to the decrease in the number of leaves and their lack of expansion with increasing salinity and lack of irrigation.

The expansion of leaf area depends on leaf swelling, temperature, and drought which lead to a reduction in leaf area as a result of the inhibition of leaf expansion during a decline in the photosynthesis process .

leaf during a decline in the photosynthesis process, and this is consistent with the results of Al-Azzawi [15]. The RNA content of leaves decreases when salinity levels rise from (1.9-17.9 dSm^{-1}[16].

500 grain weight (g)

Statistical analysis indicates that there is a significant difference when treated with irrigation with river water (T1) with a value of 153 grams, while the treatment with irrigation with drainage water (T3) was 70 grams, meaning that the weight of 500 seeds decreased by an estimated rate of 54.2%, while the treatment with river water mixed with drainage water (T2) gave a value of 110 grams (28.1%)..

This decrease is caused by the salinity of irrigation water, which affected the growth of the dry matter of the grains.

It can be noted that the convergence between the decrease in yield and the decrease of approximately 500 grains is less than 50%.

Grain yield (t.ha^{-1})

The highest grain yield reached 6 t.ha^{-1} for T1 treatment which is significantly higher than for T2 (4.8 t.ha^{-1}) and T3 treatments (3.5 t.ha^{-1}) and this indicates the importance of providing fresh water in agriculture or performing soil washing operations after the planting season. Accordingly grain yield decrease reached 20% and 41.7% for T2 and T3 conditions.

The results were consistent with the data of Malash, et al. [17] and Bouchareb [14] who demonstrated a 20% decrease in corn grain yield by using different salinity levels of water between 3-4.5 dSm^{-1}.

Soil analysis after the experiment

Salt accumulation in soil

The average soil salinity before planting was 4.2 dSm^{-1} for depth 0–25 cm increasing up to 4.50 dSm^{-1} in T1, 6.00 dSm^{-1} at T2 and 8.50 dSm^{-1} at T3 salinity levels which corresponds to a 50% increase of soil salinity at the end of the season and indicates significant salt accumulation at the end of the agricultural season and the necessity of soil washing process application.

There is a strong positive moral correlation between the salinity of the soil after irrigation with salty water and the ions of sodium and magnesium in comparison to calcium, because these ions are the basis for raising the salinity of the soil.

This result was proven by Hadithi et al. [12] when they said that increasing the salinity of irrigation water from 1.2 to 4 and 8 dSm^{-1} led to an increase in soil salinity after harvest from 4.77 to 8.20 and 13.96 dSm^{-1}, respectively.

Furthermore, a negative relationship between pH and the salinity level was recorded by Al-Azzawi [15].

In a whole, it seems obvious that the soil characteristics are most affected by the quality of irrigation water and the most rapid changes are the chemical characteristics of the soil such as electrical conductivity (EC) and the degree of soil interaction (pH).

Irrigation with salty water led to an increase in the concentration of sodium and magnesium after the experiment (3.33),(1.58) (mmolL^{-1}) compared tp the initial concentrations of sodium (2.41 mmolL^{-1}) and magnesium (0.89, mmolL^{-1}).In our trial calcium concentration increased from 3.67 mmol L^{-1} to 5.48 mmol L^{-1} which was in agreement with Abdal Majeed, et al. [18] who demonstrated that salty water utilization led to a reduction in the saturated water conductivity of the surface soil layer by 15.2% compared to river water application which maintained the level of water conductivity ,the phenomenon is connected with the increased concentration of sodium and magnesium compared to calcium, and the dispersion of soil particles and decreased permeability.

Soil pH

The results of the analysis after harvest showed a decrease of pH in soil which was irrigated with T3 drainage water, so it was 7.1, while the degree of soil interaction in the soil that was irrigated with T1 river water was 7.8.

As for the soil that was irrigated with the T2 treatment, its pH was 7.4.

PH decrease with increasing water salinity concentration is known as a dilution effect. The reason is that cations of high concentration of salts exchange with hydrogen bound to the surface of soil particles [19].

The concentration of ions increased with increasing mixing with drainage water, especially for the first depth, 0-30 cm.

It is also noted that the concentration of calcium, sodium, and sulfate ions increases with the increase of the drainage water application

Conclusion

The greater salinity of the irrigation water, the lower the plant production of the corn plant and the greater the accumulation of salts in the soil. Increasing the salinity of the irrigation water from 1.5 to 4.5 dSm^{-1} will decrease production to 50%. If they use water with a salinity of more than 6.5 dSm^{-1}, the production will decrease to 75%. Production is 100% at the water salinity level of 1.5 dSm^{-1}.

This result applies to the soil, as the salinity of the irrigation water increases, the salinity of the soil will increase.

Recommendations

The use of salt water, although important in reducing the use of fresh water, effectively causes an increase in soil salinity, so we advise against expanding the use of irrigation water if its conductivity is 6 dsm^{-1}.

Drainage water may have a small effect on corn plants, but its effect on soil properties is significant.

Therefore, we recommend using organic fertilization because of its importance in reducing soil salinity.

Adding organic waste reduces the damage caused by the salinity of irrigation water and improves the distribution of soil pores, which increases its ability to retain water and aeration, increases root secretions, and reduces the harmful effect of salts in the soil. Soil solution.

Finally, we recommend using sprinkler and drip irrigation methods for growing yellow corn due to its impact on the amount of production and reducing water consumption.

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