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Effect of irrigation water quality, bacterial inoculum and humic acids on wheat growth and yield

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A FIELD experiment was conducted in the private farms in Babylon province for the winter season of year(2024-2023),to study the role of bacterial inoculum(*Azotobacter chroococcum* bacteria loaded on peatmoss and the symbol for the treatments(without adding inoculum A0) and (adding bacterial inoculum A1) and adding humic acids at three levels(0,25,50kg ha^{-1})symbols(H0,H1,H2) in reducing salt stress and the types of water used are:(river water W0 with a salt concentration of 1.4$dSm^{-1}$and mixing water W1 with a salt concentration of 3.6dSm^{-1}W1and well water W2with a concentration of 7.0dSm^{-1}) and wheat growth and yield.The factorial experiment was conducted according to Split-Split Plot arrangement and (RCBD) design with three replicates.The averages were compared according to the Least Significant Difference (LSD) test at the 0.05 level.The results were as follows:River water(W0)was significantly excelled and gave highest values for plant height 95.14 cm,flag leaf area 43.29cm^2,spike length 12.39cm,grain yield 5.43ton.ha^{-1},biological yield 18.34ton.ha-^{1}. Azotobacter bacteria(A1)treatment recorded the highest rate for the traits of plant height 74.08 cm,flag leaf area 33.34 cm^2,spike length 9.12 cm,grain yield 5.02 tons.ha^{-1},biological yield 14.62tons.ha^{-1},harvest index 35.24%,while humic acids 50 kg.ha^{-1}treatment excelled and gave the highest rate for the traits of plant height 73.32 cm,flag leaf area 32.92 cm^2,spike length 9.48 cm,grain yield 5.10 tons.ha^{-1},biological yield 14.90 tons. ha^{-1},harvest index 35.42%.The triple interaction treatment W0A1H2 gave the highest rate for traits of plant height 104.26 cm,flag leaf area 47.55 cm^2,spike length 16.27 cm,grain yield 6.20 tons.ha^{-1},biological yield 19.11 tons. ha^{-1},while the harvest index was the highest value in the triple interaction treatment W2A1H2, reaching 42.51%.

Keyword: Irrigation water quality,Azotobacter chroococcum ,humic acids ,wheat ,river water.

Introduction

It is known that the amount of fresh water needed to meet the water needs for growing crops at the country level is small, which requires the use of saline water as additional or supplementary sources for irrigation water (such as well and drain water). As confirmed by some research and studies, these resources can be used by mixing them with fresh water in limited proportions to obtain a salinity that suits the nature of the cultivated crop (Fahd et al., 2000). Salinity in soil or water is one of the most important environmental stresses determining the growth, development and production of crops in most regions of the world, especially in arid and semi-arid areas. High salinity affects plants in several ways, including osmotic stress, ion toxicity, ionic imbalance, oxidative stress and stress resulting from hormonal imbalance, accompanied by a disruption in the function of the plasma membrane and a change in metabolic processes, in addition to a reduction in cell division and cell expansion, as well as the occurrence of genetic toxicity (Zhu, 2007).

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These factors, combined or individually, lead to a reduction in growth and development and limit its ability to survive at the onset of the effect and during the stages of exposure to salt stress (Parida and Das, 2005). To reduce the negative impact of salinity, bacterial inoculums are used, which are ready-made structures of microorganisms that, if treated with the soil, colonize the areas surrounding the roots and stimulate plant growth by increasing the availability of nutrients or producing hormones, forming a thin layer directly surrounding the roots in which all vital activities occur. The most important of these organisms used are Azotobacter bacteria (Saleh, 2015). Humic acids have also been used since ancient times as fertilizer to improve soil properties and increase the growth and health of crops by providing essential nutrients by containing organic acids, improving soil texture, and increasing the ability to retain water. Studies have shown that it has an effect in encouraging vegetative growth, increasing yield, and improving its quality, as its use causes an increase in vital activities in the plant without causing any toxicity or distortion to the treated plant (Al-Falahi et al. 2022). Wheat (Triticum aestivum L.) is the first cereal crop in the world in terms of global consumption, as it is the main food for most peoples of the world. In Iraq, wheat comes first in terms of cultivated area, reaching about (4,215,906) dunums in 2017, with a total production of (2,974,136) tons. It is a source of carbohydrates due to its high starch content. The grain consists of 63-71% starch, 8-17% protein, 2-2.5% cellulose, 2-3% sugar, 1.5-2% fat, and 1.5-2% mineral elements. The efficiency, production, cultivation and storage of the crop depend on the stability and food security of any country (EL-Fouly et al., 2011). In view of the above, this study aims to identify the role of bacterial inoculum and humic acids in reducing salt stress and increasing growth indicators and yield of wheat crop.

Materials and Methods

A field experiment was conducted in one of the private farms in Babylon Province / for the winter season of the year (2023-2024), to study the role of bacterial inoculum and humic acids in treating salt stress and improving some chemical properties of the soil. Random samples were taken from different places of the soil of the experimental field and from a depth of (0-30) cm, then air-dried and crushed with a polyethylene hammer and sieved through a sieve with a hole diameter of 2 mm)) then mixed well and samples were taken from it to conduct chemical and physical analyses as in (Table 1).

Water samples were taken from the river and from a well located near the field to a depth of 0.3 m (Amadi et al., 1996) to conduct chemical analysis of water parameters and the water type was determined according to Rhoades et al. (1992). Table (2) shows the chemical properties of irrigation water.

TABLE 1. Some chemical and physical properties of the study soil before planting.

traits		Values	units
pH		7.87	------
Electrical conductivity		5.67	dsm^{-1}
Cation exchange capacity		22.67	centimole.charge.kg-1
Organic matter		9	g.kg-1
Carbonate minerals		361	
Dissolved ions in saturated soil paste extract ($mmol.L^{-1}$)			
Dissolved positive ions	Calcium	14.27	($mmol.L^{-1}$)
	Magnesium	10.45	
	Potassium	0.93	
	Sodium	20.27	
Dissolved negative ions	Carbonates	Nill	
	Bicarbonates	4.67	
	Sulfates	9.37	
	Chlorine	32.05	
available elements	Nitrogen	15	$mg.kg^{-1}$
	Phosphorus	6.12	
	Potassium	124.02	
Sandy loam particle size analysis	sand	572	$g.kg^{-1}$
	Silt	380	
	clay	48	
Bulk density		1.31	$Mg.m^{-3}$
Particle density		2.63	$Mg.m^{-3}$

TABLE 2. Chemical properties of irrigation water types.

Irrigation water types	traits										
	EC dsm^{-1}	PH	Positive ions (mmol L^{-1})				Negative ions (mmol L^{-1})				SAR
			^{+}Na	K^{+}	Ca^{+2}	Mg^{+2}	$HCO3^{-}$	$CO_3^{=}$	CL^{-}	SO_4^{-2}	
River water	1.4	7.71	4.85	0.07	2.24	1.82	1.00	Nill	4.52	3.73	2.41
Mixed water	3.6	7.59	16.14	0.12	2.82	3.93	1.41	Nill	16.53	5.88	6.21
Well water	7	7.48	26.14	0.21	6.33	10.33	1.84	Nill	39.01	9.61	6.40

The field was prepared before planting by plowing, and the field was divided according to the design used according to the experimental units with dimensions (3m X 2) for each experimental unit. Each main plot was isolated from the other by a distance of 2m, each subplot was isolated from the other by a distance of 1.5m, and each sub-subplot was isolated from the other by a distance of 0.50m to facilitate crop service and prevent the movement of water and salts and interference between the different treatments. Wheat seeds were planted, variety IPA99, with a seed quantity of 140 $kg.ha^{-1}$, according to the recommendations of the Iraqi Ministry of Agriculture. The field was fertilized with nitrogenous, phosphate and potassium fertilizers, according to the fertilizer recommendations, where phosphate fertilizer was added 15 days before planting at an amount of 100 kg $ha^{-1}P_2O_5$ (20%P) in one batch at planting (Jadoo, 1995). Potassium fertilizer was added at an amount of 120 kg ha^{-1} (K_2SO_4 51%) to the soil and for all treatments in two equal batches, the first at planting and the other at the lining stage. The nitrogen fertilization process was carried out at an amount of 200 kg ha^{-1} in the form of urea fertilizer ((N%46) in three batches at the stages (beginning of planting, branches and lining) as in (Al-Taher, 2005). At planting, the field was irrigated with fresh water (germination irrigation), after which Irrigation according to the water parameters used in the study, which is the first factor, water types, including river water with a salt concentration of 1.4 dSm^{-1}, symbolized by the symbol W0, and mixing water with a salt concentration of 3.6 dSm^{-1} alternately, symbolized by the symbol W1, and well water with a salt concentration of 7.0 dSm^{-1}, symbolized by the symbol W2. The second factor included biofertilization by adding bacterial inoculum (A). The Azotobacter chroococcum bacteria inoculum was used, loaded on peat moss and produced in the laboratories of the Agricultural Research Department of the Ministry of Science and Technology / Zaafaraniya. The inoculum was added according to the experimental parameters in the lines prepared for planting seeds at a depth of 5 cm, so that the biofertilizer is in direct contact with the roots of the plants when they emerge, and the symbol for the parameters is (without adding the inoculum, symbolized by A0) and (adding the Azotobacter bacteria inoculum, symbolized by A1). The third factor included organic fertilization, where humic acids were used, as they were The soil addition was done at three levels (without addition and symbolized by the symbol (H0), adding humic acids at a level of 25 kg ha^{-1} and symbolized by the symbol (H1), and adding humic acids at a level of 50 kg h^{-1} and symbolized by the symbol (H2). Weeding and weeding were carried out whenever necessary during the plant growth season.

Experimental design of field experiment treatments

A factorial experiment was carried out according to the split-split plot arrangement and the RCBD design with three replicates, where each replicate contains 18 treatments, so that the number of experimental units becomes 54) experimental units). The irrigation water quality factor occupies the main plot, while the bacterial inoculum factor occupies the secondary plots (sub plot), and the addition of humic acids occupies the sub-sub plot.

Studied traits

1- Plant height (cm)

The average plant height in cm was calculated for ten plants using a measuring tape from the soil surface to the end of the spike of the main stem when the plant was fully grown (Al-Sahouki, 1990).

2- Flag leaf area (cm)

The average of ten readings was taken from each experimental unit below the secondary of the main stem and calculated from the following equation:

Leaf length × leaf width at the middle × 0.95.. .... (Robertson and Giunta, 1994)

3- Spike length (cm)

The average spike length was determined by measuring from the base of the spike to the end of the terminal spikelet using a measuring tape. The average length was calculated for fifteen spikes from each secondary experimental unit.

4- Grain yield (Mg ha^{-1})

The grains of the previously harvested square meter were weighed and the weight was converted to tons. ha^{-1}.

5- Biological yield (Mg ha^{-1})

Obtained from the dry matter yield (grains + straw) from the area of the harvested square meter from each sub-secondary experimental unit and the weight was converted to tons. ha^{-1} (Donaldson, (1996.

6- Harvest index (%)

Calculated from the following equation (Gonzalez et al., 2007)

$$\textbf{Harvest index\%} = \frac{\textit{Total grain yield}}{\textit{Dry matter yield}} \times 100$$

Results and Discussion

Plant height (cm)

It is noted from the results of Table (3) that the type of irrigation water has a significant effect on the height of the wheat plant cm, as river water (W0) was significantly excelled to the other treatments and gave the highest rate of plant height of 95.14 cm, while the mixing water (W1) gave a rate of plant height of 65.65 cm, while the well water treatment (W2) recorded the lowest rate of plant height of 49.87 cm .It is also noted that the bacterial inoculum had a significant effect on the trait of wheat plant height, as the inoculum for treatment (A1) achieved the highest height of 74.08 cm compared to treatment (A0) which reached 66.36 cm.It is also noted from the same table that adding humic acids had a significant effect on increasing plant height (cm). The treatment of adding humic acids at a concentration of 50 kg. ha^{-1} (H2) was significantly excelled and gave the highest rate of 73.32 cm, followed by the treatment of adding at a concentration of 25 kg. ha^{-1} (H1) and gave an average plant height of 70.03 cm, while control treatment (H0) gave the lowest average plant height of 67.30 cm with an increase rate of ( ) ( ) respectively. The results also showed that bi-interaction between bacterial inoculum and irrigation water quality (W*A) had a significant effect on plant height. Treatment W0A1 recorded the highest plant height rate of 98.60 cm, while treatment W2A0 gave the lowest plant height of 44.99 cm. The interaction between irrigation water quality and humic acids W0H2 recorded the highest plant height rate of 98.66 cm, while treatment W2H0 recorded the lowest plant height rate of 46.51 cm. The interaction between bacterial inoculum and humic acids A1H2 was significantly excelled and recorded the highest plant height rate of 77.64 cm, while the interaction treatment A0H0 recorded the lowest plant height rate of 64.28 cm. The data in Table (3) showed that the triple interaction between the experimental factors of irrigation water quality, bacterial inoculum and humic acids had a significant effect on the height of wheat plants (cm). The interaction treatment W0A1H2 significantly excelled on other interaction treatments and recorded the highest rate of plant height of 104.26 cm, while the treatment W2A0H0 gave the lowest rate of plant height of 41.94 cm,

Flag leaf area (cm^2)

It is noted from the results of Table (4) that all the experimental factors had a significant effect on the flag leaf area (cm2), as the effect of the irrigation water quality had a significant effect on this characteristic and its highest value reached 43.29 cm2 compared to the well water treatment W2, which reached a value of 18.63 cm^2 .Adding the bacterial inoculum also had a significant effect on the flag leaf area, as the treatment of adding Azotobacter bacteria (A1) recorded the highest average flag leaf area of 33.34 cm^2, significantly excelled to the treatment without addition (A0), which recorded the lowest average flag leaf area of 28.41 cm^2. It is also noted that the addition of humic acids had a significant effect in increasing the flag leaf area. The treatment of adding humic acids at a concentration of 50 kg. ha^{-1} (H2) was significantly excelled and gave the highest rate of 32.92 cm^2, followed by the treatment of adding at a concentration of 25 kg. ha^{-1} (H1) and gave an average flag leaf area of 31.07 cm^2, while control treatment (H0) gave the lowest average flag leaf area of 28.62 cm2. The bi-interaction also led to a significant effect in increasing the average flag leaf area of 45.15 cm^2, while the W2H0 treatment gave the lowest average flag leaf area of 16.56 cm2. The interaction treatment between irrigation water quality and humic acids W0H2 recorded the highest average flag leaf area of 44.98 cm2, while the W2H0 treatment recorded the lowest average flag leaf area of 17.15 cm2, and the interaction treatment between bacterial inoculum and humic acids A1H2 was significantly excelled and recorded the highest average flag leaf area of 35.92 cm^2, while the interaction treatment A0H0 recorded the lowest average flag leaf area of 26.97 cm^2.Table (4) also showed that the triple interaction between the experimental factors of irrigation water quality, bacterial inoculum and humic acids had a significant effect on the flag leaf area (cm2), as the interaction treatment W0A1H2 was significantly excelled to the rest of the other interaction treatments and recorded the highest average flag leaf area of 39.57 cm2, while the treatment W2A0H0 gave the lowest average flag leaf area of 10.50 cm2.

Spike length (cm)

It is noted from the results of the statistical analysis in Table (5) that the effect of the study factors had a significant effect on the spike length trait and that the effect of the bacterial inoculum was significant on this trait, as it reached its highest value in treatment (A1), which reached 9.12 cm, significantly excelled to the treatment without addition (A0), which recorded the lowest average spike length of 6.76 cm.As noted from the same table, the addition of humic acids had a significant effect on increasing spike length (cm), as the treatment of adding humic acids at a concentration of 50 kg. h-1 (H2) was significantly excelled and gave the highest rate of 9.48 cm, followed by the treatment of adding at a concentration of 25 kg. ha^{-1} (H1) and gave an average spike length of 7.94 cm, while control treatment (H0) gave the lowest average spike length of 6.39 cm. As noted from the same table, the bi-interactions between the bacterial inoculum and the quality of irrigation water (W*A) had a significant effect on spike length, as treatment W0A1 recorded the highest average spike length of 13.99 cm, while treatment W2A0 gave the lowest spike length of 2.78 cm. The treatment of the interaction between the quality of irrigation water and humic acids W0H2 also recorded The highest spike length rate was 14.88 cm, while the W2H0 treatment recorded the lowest spike length rate of 2.70 cm. The interaction treatment between bacterial inoculum and humic acids A1H2 was significantly excelled and recorded the highest spike length rate of 10.80 cm, while the interaction treatment A0H0 recorded the lowest spike length rate of 5.37 cm. Table (5) also showed that the triple interaction between the experimental factors of irrigation water quality, bacterial inoculum and humic acids had a significant effect on spike length (cm). The interaction treatment W0A1H2 was significantly excelled to the other interaction treatments and recorded the highest spike length rate of 16.27 cm, while the W2A0H0 treatment gave the lowest spike length rate of 2.10 cm.

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

The results of the statistical analysis in Table (6) indicated that the type of irrigation water had a significant effect on the grain yield rate $Mg.ha^{-1}$, as irrigation water (W0) significantly excelled the other treatments and gave the highest grain yield rate of 5.43 $Mg.ha^{-1}$, while mixing water (W1) gave a grain yield rate of 5.01 $Mg.ha^{-1}$, while the well water treatment (W2) recorded the lowest grain yield rate of 3.46 $Mg.ha^{-1}$. The addition of bacterial inoculum also had a significant effect on grain yield. The treatment of adding Azotobacter bacteria (A1) recorded the highest rate of grain yield, reaching 5.02 $Mg.ha^{-1}$, significantly excelled to the treatment without addition (A0), which recorded the lowest rate of grain yield, reaching 4.24 $Mg.ha^{-1}$. The addition of humic acids had a significant effect on increasing the grain yield. The treatment of adding humic acids at a concentration of 50 kg. ha^{-1} (H2) was significantly excelled and gave the highest rate of 5.10 Mg.ha-1, followed by the treatment of adding at a concentration of 25 kg. ha^{-1} (H1) and gave a grain yield rate of 4.60 $Mg.ha^{-1}$, while the control treatment (H0) gave the lowest grain yield rate of 4.19 Mg.ha-1. The bi-interactions between the bacterial inoculum and the quality of irrigation water (W*A) also had a significant effect on the grain yield. The treatment W0A1 recorded the highest grain yield rate of 5.83 $Mg.ha^{-1}$, while the treatment W2A0 gave the lowest grain yield rate for wheat plants of 3.24 $Mg.ha^{-1}$. and the interaction treatment between irrigation water quality and humic acids W0H2 recorded the highest rate of grain yield, which amounted to 5.90 Mg.ha-1, while the treatment W2H0 recorded the lowest rate of grain yield, which amounted to 3.06 Mg.ha-1, and the interaction treatment between bacterial inoculum and humic acids A1H2 was significantly excelled and recorded the highest rate of grain yield, which amounted to 5.43 Mg.ha-1, while the interaction treatment A0H0 recorded the lowest rate of grain yield, which amounted to 3.84 Mg.ha-1. The data in Table (6) also showed that the triple interaction between the experimental factors of irrigation water quality, bacterial inoculum and humic acids had a significant effect on the rate of grain yield (tons.ha-1), as the interaction treatment W0A1H2 significantly excelled the rest of the other interaction treatments and recorded the highest rate of grain yield It reached 6.20 Mg.ha-1, while the W2A0H0 treatment gave the lowest rate of grain yield, which reached 2.84 Mg.ha-1.

Biological yield Mg.ha^{-1}

The results of Table (7) showed that the type of irrigation water had a significant effect on the rate of biological yield Mg.ha^{-1}. River water (W0) significantly excelled the other treatments and gave the highest rate of biological yield, reaching 18.34 tons. ha^{-1}, while the mixing water (W1) gave a rate of biological yield, reaching 15.74 Mg.ha^{-1}, while the well water treatment (W2) recorded the lowest rate of biological yield, reaching 8.98 Mg.ha^{-1}. The bacterial inoculum also had a significant effect on the biological yield. The treatment of adding Azotobacter bacteria (A1) recorded the highest rate of biological yield, reaching 14.62 Mg.ha-1, significantly excelled to the treatment without addition (A0), which recorded the lowest rate of biological yield, reaching 14.08 Mg.ha-1. As for humic acids, the results showed that adding humic acids had a significant effect on increasing the biological yield. The treatment of adding humic acids at a concentration of 50 kg. h-1 (H2) was significantly excelled and gave the highest rate of 14.90 Mg.ha-1, followed by the treatment of adding at a concentration of 25 kg. h-1 (H1) and gave a biological yield rate of 14.37 Mg.ha-1, while control treatment (H0) gave the lowest biological yield rate of 13.78 Mg.ha-1. The results also showed that bi-interaction between the bacterial inoculum and the quality of irrigation water (W*A) had a significant effect on the biological yield. Treatment W0A1 recorded the highest biological yield rate of 18.71 Mg.ha-1, while The W2A0 treatment gave the lowest rate of biological yield of wheat plant, which amounted to 8.75 Mg.ha-1, and the interaction treatment between irrigation water quality and humic acids W0H2 recorded the highest rate of biological yield, which amounted to 18.98 Mg.ha-1, while the W2H0 treatment recorded the lowest rate of biological yield, which amounted to 8.35 Mg.ha-1. The interaction treatment between bacterial inoculum and humic acids A1H2 was also significantly excelled and recorded the highest rate of biological yield, which amounted to 15.09 Mg.ha-1, while the interaction treatment A0H0 recorded the lowest rate of biological yield, which amounted to 13.78 Mg.ha-1. Table (7) also showed that the triple interaction between the experimental factors of irrigation water quality, bacterial inoculum and humic acids had a significant effect on the biological yield rate (tons.ha-1). The interaction treatment W0A1H2 significantly excelled the other interaction treatments and recorded the highest biological yield rate of 19.11 tons.ha-1, while the treatment W2A0H0 gave the lowest biological yield rate of 8.17 tons.ha-1.

Harvest index (%)

The results of Table (8) showed that the type of irrigation water had a significant effect on the rate of harvest index (%), as well water (W2) significantly excelled the other treatments and gave the highest percentage of harvest index, reaching 38.40%, while the mixing water (W1) gave a percentage of harvest index, reaching 31.76%, while the river water treatment (W0) recorded the lowest percentage of harvest index, reaching 29.51%. The results also showed that the bio-inoculum had a significant effect on the harvest index, as the treatment of adding Azotobacter bacteria (A1) recorded the highest percentage of harvest index, reaching 35.24%, significantly outperforming the treatment without adding (A0), which recorded the lowest percentage of harvest index, reaching 31.20%.

The results showed that the addition of humic acids had a significant effect on increasing the harvest index. The treatment of adding humic acids at a concentration of 50 kg. h-1 (H2) was significantly excelled and gave the highest rate of harvest index of 35.42%, followed by the treatment of adding at a concentration of 25 kg. h-1 (H1) and gave a percentage of harvest index of 32.78%, while control treatment (H0) gave the lowest percentage of harvest index of 31.46%. The results also showed that the bi-interactions between the bacterial inoculum and the quality of irrigation water (W*A) had a significant effect on the harvest index. The treatment W2A1 recorded the highest percentage of harvest index of 39.85%, while the treatment W0A0 gave the lowest percentage of harvest index for wheat plants of 27.87%. The treatment of the interaction between the quality of irrigation water and humic acids W2H2 also recorded the highest percentage of harvest index of 41.75% while the treatment W0H0 recorded the lowest percentage of harvest index, which amounted to 27.72%, and the interaction treatment between bacterial inoculum and humic acids A1H2 was significantly excelled and recorded the highest percentage of harvest index, which amounted to 37.03%, while the interaction treatment A0H0 recorded the lowest percentage of harvest index, which amounted to 29.49%.

The data in Table (8) also showed that the triple interaction between the experimental factors of irrigation water quality, bacterial inoculum and humic acids had a significant effect on the rate of harvest index (%), as the interaction treatment W2A1H2 significantly excelled the rest of the other interaction treatments and recorded the highest percentage of harvest index, which amounted to 42.51%, while the treatment W0A0H0 gave the lowest percentage of harvest index, which amounted to 26.27%.

Through tables (3, 4 and 5) that indicated the effect of different types of irrigation water on the growth of wheat plants, we notice a decrease in vegetative growth indicators, including (plant height, flag leaf area, spike length) in plants irrigated with well water compared to plants irrigated with river water and mixed water, which the results showed - continuous irrigation with salt water during the growing season led to a significant decrease in growth in general and components of the crop. This may be due to the fact that the salinity of the irrigation water used in irrigation caused an increase in the osmotic potential of the soil solution around the root zone, which reduced water absorption and increased salt absorption, which in turn led to inhibition of cell growth, expansion and elongation. The osmotic effect and nutritional imbalance caused by salinity is what affected the low absorption of water and nutrients, and then led to weak plant growth. The reason for this decrease may be due to weak root growth when soil salinity increases, which leads to low absorption of water and nutrients that contribute to plant growth and elongation.) Shukri, (2002. These results also agreed with what was found by Kobrae and Shamsi 2013 and also agreed with what was found by Al-Jaafar 2014, about wheat plant exposure to salt stress has reduced plant height. The study of Foulkes et al. (2002) also showed a reduction in the area of the flag leaf, as the area of the flag leaf decreased with increasing salinity for w h eat plants. The emergence and duration of the e xpansion of the flag leaf from stem elongation to flowering) is a critical period affected by s a lt stress, and this is negatively reflected on the area and effectiveness of the flag leaf. This confirms what Ali (2005) and Al-Rahbawi (2012) reached, that the reason for the decrease in the average area of the flag leaf is due to exposing plants to high levels of salt, which led to changes in the biochemi c al cha r acteristics in favor of avoiding water dehydration by reducing the size of the cells. I a g reed w i th them. The results of Al-Rubaie (2002) and Al-Hassan (2007) indicate that the flag leaf plays an important role in providing grains with nutrients in the late stages of crop growth, as it contributes more than 80% of the materials transferred to the grains. The beginning of the decrease in spike length was not significant, but it increased with the increa s e in electrical conductivity above 7 dSm-1. The reason is due to the lack of nutrients reaching the spike holder due to the obstruction of the photos y nthesis process and the increase in competition for nutrients (Faraj 2002). Ali (2005) indicated that the reason for this is the lack of available p hotosy n thesis products, and the increase in competition between the area of the flag leaf and the length of the spike for the limited sources of dry matter, since the elongation of t h e flag leaf occurs s imulta n eously with the elon g ation of the last i nterno d es (spike holder) and t he formation of fl o wers i n the spike. It is also attributed to To the water stress that the root is exposed to as a result of the increase in sodium and chloride ions (Mohammed, 2000), the negative effect of salts affects the availability of nutrients and water in the soil as well as the plant's absorption of nutrients and their effect on the photosynthesis proc e ss, which negativ e ly aff e cts the plant's growth and production. These results are consistent with Naseer et al. 2001 and Akram et al. 2002. The effect of different types of irrigation water on the components of the wheat crop includes each of: - (Grain yield, biological yield, harvest index)

The increase in the salinity of irrigation water led to negative effects on the components of the whea t crop. Through th e resul t s obtained that indicated the effect of different types of irrigation water, it was noted that the decrease in grain yield in the irrigated treatments with different types of irri gation water may b e due t o the salt stress to which the plants were exposed, especially in the stag e from elongation t o physi ological maturity. The inhibitory effect of salinity is caused by many fact o rs such as water r eadine s s, osmotic effect, the q ualitative effect of ion s and their toxicity, nutritional disturbance, or accumulation of some toxic compounds, in addition to the effect of salinity on the effectiveness of enzymes, membranes and cell organelles Azubaidi Saba, 2022

TABLE 4. Effect of irrigation water quality, bacterial inoculum, humic acids and their interaction on the flag leaf area cm^2.

Irrigation water quality	Bacterial inoculum	Adding of humic acids			x Bacterial inoculum Irrigation water quality
		Without adding	kg.ha- 25	kg.ha- 50	
River water	Without adding	40.50	41.37	42.40	41.42
	Azotobacter bacteria	42.13	45.77	47.55	45.15
Mixed water	Without adding	25.10	27.50	29.10	27.23
	Azotobacter bacteria	29.70	35.23	37.57	34.17
Well water	Without adding	15.30	16.17	18.20	16.56
	Azotobacter bacteria	12.13	12.77	14.55	13.15
L.S.D 0.05		2.12			1.22
Interaction between Irrigation water quality and humic acids					Average Irrigation water quality
River water		41.315	43.57	44.98	43.29
Mixed water		27.40	31.365	33.34	30.70
Well water		17.15	18.29	20.44	18.63
L.S.D 0.05		1.50			0.87
Interaction between bacterial inoculum and humic acids					Average Bacterial inoculum
Without adding		26.97	28.35	29.90	28.41
Azotobacter bacteria		30.28	33.80	35.93	33.34
L.S.D 0.05		1.22			0.71
Average humic acids		15.46	19.91	22.08	
L.S.D 0.05		0.87			

TABLE 5. Effect of irrigation water quality, bacterial inoculum , humic acids and their interaction on spike length (cm).

Irrigation water quality	Bacterial inoculum	Adding of humic acids			x Bacterial inoculum Irrigation water quality
		Without adding	kg.ha- 25	kg.ha- 50	
River water	Without adding	8.40	10.47	13.50	10.79
	Azotobacter bacteria	11.37	14.33	16.27	13.99
Mixing water	Without adding	5.60	6.93	7.57	6.70
	Azotobacter bacteria	7.60	9.07	10.67	9.11
Well water	Without adding	2.10	2.83	3.40	2.78
	Azotobacter bacteria	3.30	4.00	5.47	4.26
L.S.D 0.05		0.54			0.34
Interaction between Irrigation water quality and humic acids					Average Irrigation water quality
River water		9.88	12.40	14.88	12.39
Mixing water		6.60	8.00	9.12	7.91
Well water		2.70	3.42	4.43	3.52
L.S.D 0.05		0.41			0.34
Interaction between bacterial inoculum and humic acids					Average Bacterial inoculum
Without adding		5.37	6.74	8.16	6.76
Azotobacter bacteria		7.42	9.13	10.80	9.12
L.S.D 0.05		0.30			0.17
Average humic acids		6.39	7.94	9.48	
L.S.D 0.05		0.23			

TABLE 6. Effect of irrigation water quality, bacterial inoculum , humic acids and their interaction on grain yield Mg.ha-1.

Irrigation water quality	Bacterial inoculum	Adding of humic acids			x Bacterial inoculum Irrigation water quality
		Without adding	kg.ha- 25	kg.ha- 50	
River water	Without adding	4.50	4.95	5.60	5.02
	Azotobacter bacteria	5.31	5.98	6.20	5.83
Mixing water	Without adding	4.18	4.32	4.92	4.47
	Azotobacter bacteria	5.05	5.70	5.89	5.55
Well water	Without adding	2.84	3.09	3.80	3.24
	Azotobacter bacteria	3.27	3.56	4.20	3.68
L.S.D 0.05		0.22			0.013
Interaction between Irrigation water quality and humic acids					Average Irrigation water quality
River water		4.91	5.47	5.90	5.43
Mixing water		4.62	5.01	5.41	5.01
Well water		3.06	3.33	4.00	3.46
L.S.D 0.05		0.016			0.009
Interaction between bacterial inoculum and humic acids					Average Bacterial inoculum
Without adding		3.84	4.12	4.77	4.24
Azotobacter bacteria		4.54	5.08	5.43	5.02
L.S.D 0.05		0.013			0.007
Average humic acids		4.196	4.60	5.10	
L.S.D 0.05		0.009			

TABLE 7. Effect of irrigation water quality, addition of biological inoculum, humic acids and their interaction on the biological yield (tons.ha-1).

Irrigation water quality	Bacterial inoculum	Adding of humic acids			x Bacterial inoculum Irrigation water quality
		Without adding	25 kg.ha-	kg.ha- 50	
River water	Without adding	17.13	17.91	18.85	17.96
	Azotobacter bacteria	18.21	18.81	19.11	18.71
Mixing water	Without adding	15.22	15.37	15.99	15.53
	Azotobacter bacteria	15.43	16.13	16.30	15.95
Well water	Without adding	8.17	8.80	9.27	8.75
	Azotobacter bacteria	8.53	9.20	9.88	9.20
L.S.D 0.05		0.158			0.091
Interaction between Irrigation water quality and humic acids					Average Irrigation water quality
River water		17.67	18.36	18.98	18.34
Mixing water		15.33	15.75	16.15	15.74
Well water		8.35	9.00	9.58	8.98
L.S.D 0.05		0.112			0.065
Interaction between bacterial inoculum and humic acids					Average Bacterial inoculum
Without adding		13.51	14.03	14.70	14.08
Azotobacter bacteria		14.06	14.71	15.096	14.62
L.S.D 0.05		0.091			0.053
Average humic acids		13.78	14.37	14.90	
L.S.D 0.05		0.065			

TABLE 8. Effect of irrigation water quality, adding bio-inoculum and humic acids and their interaction on harvest index (%).

Irrigation water quality	Bacterial inoculum	Adding of humic acids: Without adding	25 kg.ha-	kg.ha- 50	x Bacterial inoculum Irrigation water quality
River water	Without adding	26.27	27.64	29.71	27.87
	Azotobacter bacteri	29.16	31.79	32.44	31.13
Mixing water	Without adding	27.46	28.11	30.76	28.78
	Azotobacter bacteria	32.73	35.34	36.13	34.73
Well water	Without adding	34.76	35.11	40.99	36.95
	Azotobacter bacteria	38.34	38.69	42.51	39.85
L.S.D 0.05		1.17			0.67
Interaction between Irrigation water quality and humic acids					Average Irrigation water quality
River water		27.72	29.72	31.08	29.51
Mixing water		30.095	31.73	33.45	31.76
Well water		36.55	36.90	41.75	38.40
L.S.D 0.05		0.82			0.48
Interaction between bacterial inoculum and humic acids					Average Bacterial inoculum
Without adding		29.49	30.29	33.82	31.20
Azotobacter bacteria		33.41	35.27	37.03	35.24
L.S.D 0.05		0.67			0.39
Average humic acids		31.46	32.78	35.42	
L.S.D 0.05		0.48			

The decrease in biological yield is due to the use of saline water in irrigation, which negatively affected growth and production, which is mainly linked to the accumulation of salts in the soil core, the decrease in water availability for the plant, and the decrease in the growth rate due to the energy expended by the plant to obtain water from the root zone to carry out biochemical processes. This expended energy is taken from the energy used for growth and production processes. Salinity also affects through the toxic effect on some elements or through the effect on the surface membrane of plant roots or on plant membranes or through the effect on the absorption of essential nutrients (Jangir and Yadav, 2011). However, the use of alternating irrigation reduces salt stresses during growth stages sensitive to salinity and maintains the salinity of the root zone, especially in the upper part of the soil core (Wallender and Tanji, 2012). Irrigation with saline water negatively affects plant growth through the saline effect that reduces water availability for the plant, the osmotic effect, and the toxic effect of some elements such as sodium, chloride, and others (Choudhary et al., 2011). While alternating irrigation with saline and fresh water keeps the soil salinity relatively low and thus reduces the negative effect on plant growth (Phogat et al., 2011). These results confirm the possibility of increasing the biological yield with the addition of biofertilizer and the addition of humic and fulvic acid. These results are consistent with the findings of a number of researchers and other crops, such as Al-Khalaf (2009) and Al-Khalil (2011). The effect of irrigation water salinity on the harvest index was significantly affected by increasing irrigation salinity levels. Increasing irrigation levels with saline water throughout the growing season leads to negative effects on plant growth and productivity, but the decrease in straw weight was greater than the decrease in grain yield, which was reflected in increasing the harvest index. These results were consistent with Al-Jaafar (2014), who concluded during her study on wheat that irrigation with saline water of 4 and 8 dSm-1 recorded an increase in the harvest index. Abbosdokht (2008) also mentioned that grain yield, biological yield, harvest index and plant height increased when inoculated with A. chroococcum bacteria. These results are consistent with what Zaidi (2007) found, regarding an increase in the yield of wheat inoculated with Azotobacter. This increase may be attributed to the effect of the effectiveness of these organisms in their secretions of organic materials and enzymes to activate the work of nitrogen-fixing organisms already present in the soil, which increases the protein ratios in the grains and thus increases the grain yield (Mittal et al. 2008). Treating seeds with bacterial inoculants helps stimulate growth and increase grain yield as a result of the secretion of growth regulators by these organisms (AL-Samerrai, 2004). The significant increase in the harvest index is due to the importance of humic acids and their effect on the growth and productivity of wheat through their effect on increasing soil fertility and providing favorable conditions that helped plant growth and increased productivity Karčauskienė et al., (2019) and Marenych et al., (2019) (2019 Mohammed et al., They also found that adding humic acids had a significant effect on wheat growth and productivity indicators as it improved plant height, number of plants, branches, spike length, number of grains per spike, biological yield, straw, and grain yield.

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