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Effects of Binary Irrigation and Humic Acid on Maize Yield in Saline Conditions

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ABSTRACT

In the fall of 2022, a study was conducted on clay soil in western Iraq to determine the effect of binary irrigation and humic acid (HA & BI) on the growth of maize (*Zea mays* L.). The aim was to reduce the negative effects of irrigation water salinity on the growth of maize plant and to indicate the extent to which saline water can be used for irrigation using the method of mixing with binary irrigation and adding humic acids to the soil. water. The study was conducted using a randomized completely block design (RCBD) with three repetitions. The three factors examined were: varying electrical conductivity of salty water the corn seeds were planted and subjected to varying levels of salinity at 1.34, 4.0, 7.0, and 10.0 dS m^{-1}, as well as two different levels of humic acid application at 0 and 30 kg ha^{-1}. Additionally, two distinct irrigation procedures were employed: constant irrigation (CI) and dual irrigation (BI). All irrigation was conducted using the American evaporative pot method. The maximum plant height (PHI) was recorded at 213.33 cm when the irrigation water had an electrical conductivity 1.34 dS m^{-1} with HA level of 30 kg ha^{-1} using BI. Compared to 142.0 cm when irrigating with salinity water of 10.0 dS m^{-1} for HA level of 0 kg.ha^{-1} and for continuous irrigation (CI). The highest total grain yield (TY) value was 12.721 Mg ha^{-1} when irrigating with salinity water of 1.34 dS m^{-1} and for the HA level of 30 kg ha^{-1} and for BI compared to 4.950 Mg ha^{-1} when irrigating with salinity water 10 dS m^{-1} and for the HA 0 kg ha^{-1} with CI irrigation style.

1. INTRODUCTION

Many countries around the world are experiencing severe water scarcity as a result of environmental changes associated with the expansion of industrialization and agriculture, causing researchers and experts to put in place water management technologies that allow the use of salty water for agriculture by linking or disconnecting it from pure water [1, 2]. Saline water (from 2.25 to 20 dS m^{-1}) has been used in irrigation for crops and orchards in many countries around the world in a variety of soils and climates around the world. Use of saline water lowers total yield and dry matter in a level that depends on the type of plant, the characteristics of the soil and the degree of salinization of the used water [3, 4]. The use of saltine water in irrigation can create an adverse environment for crops, which inevitably affects their growth. This can result in a decrease. The extent of this damage may vary depending on the type of plant in question [5]. To mitigate the negative effects of saline water, binary irrigation is one of the methods used as the Binary irrigation is divided into two stages; the first stage contains half of the salty water required. Then second stage contains the other half of fresh water to reduce the impact of saline water on soil and plants [6]. Various methods and techniques have been introduced the dangerous special, includes the application of organic acids such as Humic Acids, applying it into the surface soil in fluid and hard compounds, or by spraying it over plants through the liquid foliar application, because HA acts as an adsorbent on a variety of surfaces, such as the surface of plant's cell walls, as HA has 2 dissimilar classes of substances, hydrophobic and hydrophilic compounds [7]. To improve growth, a lot of scientists have used fulvic and Humic acids to reduce the damage caused by salt stress, two organic acids found in humus that are produced that increase nutrient availability, especially when it is exposed to salt stress [8], it also enhances the soil's physical, chemical, and biological qualities, as well as reducing the difficulties and damage caused by salt and excess alkali, resulting in increased root strength [9]. One of the most effective strategies for mitigating the adverse effects of saline water is the inclusion of organic acids. Additionally, utilizing software and online resources can enhance understanding of soil potential (pH) and help reduce the harmful effects of salt and soil erosion [10]. Organic acids can change the nutrient balance of the soil, destroying other important nutrients, through the increase of certain ions [11, 12]. Adding HA to irrigation water increases grain yield, green and green areas, improves air conditions and oxygen flow, researchers can utilize software and products to ensure that the root system receives the necessary nutrients. The incorporation of organic acids, along with chemicals and physical bioactivity, enhances the release of minerals added to the soil. Additionally, organic acids promote plant development as carbon compounds that contribute to building plant tissue while also improving soil properties [13]. The current study tries to answer the following question, is it possible to use saline water in irrigation?

This current study aims to:

1. The possibility of using saline water to irrigate the maize crop using the method of mixing and binary irrigation with the addition of humic acid to the soil.

2. Monitoring the effect of mixing method, binary irrigation and adding humic lion in the growth properties and yield of maize crop.

2. MATERIALS AND METHODS

2.1 Site location

The research was conducted in the west of Heet town/Anbar Province located 42°42’57’’ east and latitude 33°42’06’’ north in the autumn of 2022 to study the function of Binary Irrigation and Humic Acid (HA and BI) in order to reduce the saline impact of different salty irrigations water on the development and production of corn (*Zea mays* L). Before planting, representative samples of the soil are taken from 0 to 30 cm deep, then they are dried, and finally, they are covered with a sieve of 2 mm in diameter. Common soil characteristics are estimated (Table 1). The soil is defined by its topography and is classified by the American classification as Torrifluvents Type [14].

2.2 Experiment treatments

The current study contained the following factors:

1. Irrigation water salinity (IWS); with levels of (1.2± 0.2, 4.0± 0.2, 7.0 ±0.2, and 10.0 ± 0.2 dS m^{-1}).
2. Humic acid (HA); with levels of (0 and 30 kg ha^{-1}).
3. Binary irrigation (BI).

Humic acid levels and irrigation water types were selected based on pre-applied research. As the net irrigation depth is added to any water quality used in irrigation completely and called continuous irrigation (CI), and the second method is by adding 50% of the net irrigation depth for different water types of salinity, followed by adding 50% of the net irrigation depth from the water of the Euphrates River and called binary irrigation (BI) [15].

The salinity of irrigation water is created by combining four levels of draining saline water (with a salinity of 5.2 dS m^{-1}) transported from a nearby drain to the field in the Shaksaliyah region, which is mixed with specific quantities of Euphrates River water which has EC of 1.20 dS m^{-1}, to gain electrical conductivity (EC) of (1.2± 0.2, 4.0± 0.2, 7.0 ±0.2, and 10.0 ± 0.2 dS m^{-1}), For each Irrigation water salinity(IWS) level, the mixing ratios determined by the equation provided by Ayres and Westcot [16] are as follows:

$$EC=[ECa\times a]+[ECb\ (1-a)] \quad (1)$$

where, EC=hydraulic conductivity (dS m^{-1}); ECa=electrical conductivity of river water (dS m^{-1}); a=percentage of river water in the mixture; ECb is the average volume of drainage or saline consumed per day (dS m^{-1}).

To ensure that the desired salinity is achieved, the estimated salinity is verified by measuring the electrical conductivity (EC) of the combined water. The mixing process takes place in a 1 m^3 galvanized steel tank. The USDA Salinity Laboratory Classification was used to estimate some chemical properties of water and classify the quality of irrigation water [17] (Table 2). Humic acid (HA) was added to the soil in two amounts: 0 and 30 kg ha^{-1}. HA made in China (CO. LTD. Chin Leili Agrochemicals). The characteristics of the HA used in the experiments are shown in Table 3.

2.3 Irrigation method

The first method is the continuous or constant irrigation (CI). The second method is the binary irrigation (BI). Within this environment, the soil possesses certain chemical and physical properties that distinguish it from others. Table 1 shows these routine properties.

Table 1. The physical and chemical properties of soil

(a) Physical Properties

Size Distribution of Particles (g kg^{-1})			Soil Texture	Bulk Density Mg m^{-3}	Saturated Hydraulic Conductivity (cmhour^{-1})	Gravimetric Moisture				
						Tensions %				
Sand	Clay	Silt				0	33	50	500	1500
390	252	358	Clay loam	1.35	9.70	36.44	24.04	19.25	10.50	9.65

(b) Chemical Properties

EC* dS m^{-1}	pH*	OM g kg^{-1}	Soluble Ions (Mmol L^{-1})								Adjusted Sodium Adsorption Ratioadj.SAR
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-2}	HCO_3^{-}	$CO_3^{=}$	
2.5	8.10	23	9.5	7.1	3.3	1.1	7.5	9.4	3.0	0.0	5.16

Table 2. Some chemical properties of irrigation water

Water Quality	EC* dS.m^{-1}	pH*	Soluble Ions (MmolL^{-1})								SAR	Class*
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	SO_4^{-2}	HCO_3^{-}	$CO_3^{=}$		
Euphrates river	1.34	6.5	4	2	2.5	1.35	4.30	5.0	1.9	0.0	1.45	C_3 S_1
Drainage	5.2	8.1	20.1	18.30	23.42	3.41	45.75	19.75	16.60	0.0	5.36	C_4 S_1

*according to FAO 1985.

2.4 Cultivation and fertilization

The land is plowed in any way by using the trumpet. Then there's ground, and the land is divided into three halves, with a 2-meter gap between each block. Where each point is divided into four holes separated by a distance of two meters. The soil is divided into two parts and the HA level is randomly distributed between them at a distance of 1.5 m between them, dividing each part into two parts. Therefore, each treatment area is 1 m^2, the distance between plots is 1 m, and the water treatment system is randomly distributed. The phosphate fertilizer is added as granular DAP (diammonium phosphate) fertilizer with a nitrogen content of 18% and P_2O_5 45%. For application, an average of 150 kg P_2O_5 ha^{-1} is used. And on 18 July, 2022, soil and corn fruit (Zea mays L.) (Fajr Variety) were mixed, the hole spacing was 0.20 m, three seeds were placed in each planting hole, and one plant was cut fourteen days later. Fertilizer 46% N-urea nitrogen, add an average of 320 kg N ha^{-1} in three batches. The first batch is added by calculating the amount of nitrogen to add before mixing the diammonium phosphate fertilizer with the soil, and the second batch is added for the first time. Add after pruning, forty days after adding the first batch in the third quarter. Potassium fertilizer containing an average of 150 kg of K_2O ha^{-1} is added to the soil in the form of potassium sulfate (50% K_2O). And the second added three weeks of planting [18].

Weeding is done regularly for all treatments; corn borer is also managed by hand using Super Athwaite pesticide water at a rate of 100 ml per 100 liters of water and using Diazinon granulated pesticide at 10% as a preventative control of work with 6 kg. ha^{-1} by feeding on the heart of the plant.

Table 3. Some properties of humic acid (HA)

EC ($dS\ m^{-1}$)	pH	($g\ kg^{-1}$) N	Organic carbon	P	K	C:N Ratio	HA
3.2	6.7	38	346	20	4.1	9.1	14.4

T-Tape drippers and a discharge rate of 2 liter h^{-1} were employed in the drip irrigation system. Germination irrigation was performed on July 18, 2022, and soil moisture was given to the field to a restricted capacity. Irrigation was set at a 50% reduction in available water for all treatments. The corn plant development and planting pattern shown in Allen et al. [19] was used.

A great deal of attention is devoted to the measurement of the volume of water in the container, which is 1.2 meters in diameter and has a depth of 0.25 meters. This is used to determine the time of day when the water is dispensed [20].

The volume of water needed is added to the bottom's volume (D) using the following equation [21]:

$$d=\theta_{f.c}-\theta_{pwp}/100\times dp\times D \quad (2)$$

where, d=the added depth of water in the soil. This is equal to the amount of water actually consumed (Eight); $\theta_{f.c}$=The volume of water in the soil at the maximum capacity of water in the field ($cm^3\ cm^{-3}$); θ_{pwp}=The volume of water in the soil at the permanent drought ($cm^3\ cm^{-3}$). The percentage of time spent removing the water is called the dp; D: The size of the active region of the nucleus (cm). If the volume of water consumed is 0, the equation is simple:

$$ETa=(P+Ir)-\Delta s \quad (3)$$

where, Eta: The volume of water consumed; P: The depth of the water's rain; Ir: The volume of water necessary for irrigation; Δs: difference in soil humidity.

Discover the amount of time required to plant using the following equation [22]:

$$q\times t=a\times d \quad (4)$$

where, q: Discharge is given to field lines, m^3 $hour^{-1}$; t: Irrigation time, an hour; a: Area of the wetting circle of dripper, m^2; d: Depth of added water, m.

The volume of water required for each irrigation turn has also been calculated [23]:

$$V=q\times n\times t \quad (5)$$

where, V: The required volume of water addition, liters; t: irrigation time, an hour; q: discharge of dripper, liter $hour^{-1}$; n: the number of drippers in the field line.

Table 4 shows the additional depths of water according to growth stages of maize crop.

Samples incorporated an average of five tall plants per experimental unit, after which plants were cut from the plant-ground meeting point, washed with distilled water, dried, and dry weight (DW) was calculated. Total Grain Yield (TY) (Mg ha^{-1}) was calculated from the plant density of (66,000 plants ha^{-1}) according to [24]. Statistical analysis of soil and crop results was performed using GenStatGenwin 3.2 to calculate the least significant difference of L.S.D. and 0.05 significance level.

Table 4. Depth of added water during the growing season

No.	Growth Stages	Period	Roots Depth (cm)	Irrigation Number	Additional Water Depth (mm)	Water Requirements (m^3ha^{-1})
1	Germination	2022/7/30 -7/18	10	2	40	**212.8**
2	Vegetative growth	2022/9/1 -7/31	25	6	120	**638.4**
3	Flowering	2022/9/13 -9/2	40	2	100	**532**
4	Milky phase	2022/10/7 -9/14	50	5	150	**798**
5	Repining phase	2022/10/25 -10/8	50	3	90	**478.8**
6	Maturity	2022/11/10 -10/26	50	1	55	**292.6**
	Total			19	555	**2.952.6**

3. RESULTS AND DISCUSSION

The least significant difference of L.S.D. with significance level of 0.05 was used as statistical method to indicate the significance or insignificance of differences among treatments.

3.1 Plant height (PHI)

Table 5 shows the effect of treatments on corn PHI. These values vary significantly according to the salinity of the irrigation water, the maximum value for each degree of humic acid added is 1.34 dS m^{-1}, while the minimum values are 4.0, 7.0 and 10.0 dS m^{-1}, the PHI was decreased with increasing water salinity at the value is 10 dS m^{-1} to reach 142.00, 150.00, 161.00 and 171.00 cm for treatment 0 and 30 kg ha^{-1} HA and BI respectively.

Table 5. The effect of treatments on PHI (cm)

IWS Rate	Levels of HA $kg.ha^{-1}$				IWS Levels ($dS\ m^{-1}$)
	30		0		
	BI	CI	BI	CI	
201.17	213.33	205.00	196.67	189.67	1.34
192.33	201.00	196.00	190.00	182.33	4.0
167.50	181.67	172.33	161.00	155.00	7.0
156.33	171.67	161.67	150.00	142.00	10.0
	187.83		170.83		Rates of HA
	BI		CI		Rate of irrigation system
	183.17		175.5		
salinity S: 1.9	humic H: 5.7		irrigation I: 5.4		L.S.D. 0.05
	5.7: S*H*I				

The decrease in plant height with increased salinity of irrigation water may be attributed to several factors that negatively affect the plant's ability to absorb water and nutrients necessary for its growth, as the salinity of the soil may increase as a result of the high salinity of the water used in irrigation, which leads to raising the osmotic pressure around the roots, thus hindering the absorption of water by the roots of the plant, as well as the toxic effect of some ions and the effect on the phenomenon of selectivity absorption of elements, so the plant absorbs an element in large quantities that it does not need and this affect on the absorption of another element (increasing the effect of the phenomenon of antagonism and activation). This is consistent with Atta et al. [25].

The reason may also be due to the fact that the use of salt water in irrigation creates an unsuitable environment for the growth of crops through the effect of the concentration and quality of accumulated salts in the absorption of water and nutrients by the plant and thus affects the growth of the plant, and thus affects the reduction of plant height, dry weight, leaf area and the number of leaves, and this varies according to the plant, this result is consisted with the study by Blanco et al. [5]. The results in Table 5 show significant differences between PHI values as a function of HA level, for each applied system of irrigation. It reaches its highest value at 30 kg ha^{-1} which was 187.83 cm. In fact, HA changes the nutrient balance of the soil, in which the increase of some harmful ions destroys the essential elements, these results consistent with the findings of studies [11, 26]. The reason for this could be due to the hormonal impact of HA on both the cell protoplasm and cell wall. This impact results in an acceleration of cell division and growth, leading to an overall increase in the height of the plant [27], these results are consistent with Al-Gartani et al. [28] who found that maize plants treated with humic acid significantly superior in traits (plant height, dry weight of vegetative total, grain yield and associated traits) compared to untreated plants, and this is consistent with the findings of Kadhim et al. [29].

Table 5 shows that BI considerably raised PHI values compared to CA at any level of HA, with rates of 175.5 and 183.17 cm for CI and BI, respectively, presumably because to BI's ability to minimize the detrimental effects of saline water [30].

It may be attributed to the fact that binary irrigation reduced the negative impact of saline water, as adding half of the net depth of irrigation with saline water and followed by adding the other half of the net depth of irrigation with fresh water will reduce the salt concentration in the root area and thus reduce the negative impact of salt accumulation and reduce the osmotic pressure in the root area, as well as improving the physical properties of the soil, where the dispersion or slaking of soil aggregates decreases and the mean weight diameter increases, so the soil structure improves and the bulk density decreases. The porosity of the soil increases, which facilitates the process of gas exchange, the spread of air and roots, increasing the effectiveness and activity of microorganisms, and improving soil temperature, and all this will be positively reflected in increasing the availability of nutrients and improving the efficiency of their absorption by the plant, which leads to increased plant growth and increase its height, and this is consistent with the findings of Li et al. [31].

3.2 The plants' dry weight (DW)

Table 6 shows the treatment effect on grain dry weight (DW). The values corresponding to IWS levels are variable, with the highest value being obtained at 1.34 dS m^{-1}. This is in contrast to the values at 4.0, 7.0, and 10.0 dS m^{-1} for any HA added level. The values of DW were decreased at salinity level of 10 dS m^{-1} of irrigation water. Additionally, the minimum values of 74.67, 86.00, 87.67, and 95.00 gm $plant^{-1}$ are observed for each level of HA that is added for CI and BI respectively. The high percentage of dissolved salts in the soil solution due to irrigation with saline water, which has a high percentage of sodium chloride and some harmful salts, works to raise the osmotic pressure of the soil solution and thus leads to the difficulty of the plant's ability to absorb nutrients from the soil solution. The percentage of salinity gradually decreased productivity until the plant reaches a stage where it cannot produce and may eventually reach the death of the plant This is consistent with the study by Shrivastava and Kumar [32]. Availability and uptake of nutrients by the plant affected by IWS, because the increase in IWS leads to a decrease in nutrients and corrupt the balance of them in the soil. This is due to competition between nutrients on the absorption points in soil colloids because of dissolved salts in irrigation water and this is consisted with studies [26, 33].

The results in Table 6 show significant differences between plant DW values as a function of the HA value applied to each irrigation system. The highest peak value is reached at 30 kg ha^{-1} or 136.42 gm $plant^{-1}$. Compared to the non-addition treatment of humic in which the DW of the plant was 117.42 gm $plant^{-1}$. The reason may be due to the high ability of humic acid to exchange ions (CEC) as well as its content of oxygen and nutrients and also its high ability to retain water and thus improve soil fertility, nutrition and plant growth and the most important feature of humic fertilizers lies in their high ability to bind (cohesion) undissolved metal ions, oxides and hydroxides and release them slowly and continuously to plants when needed and this is consistent with the findings of Al-Falahi et al. [34]. In addition, the humic acid works to improve soil structure and improves soil aeration, especially in cohesive clay soils, facilitates tillage procedures and all agricultural operations, helps increase salt leaching operations from the soil and increases its ability to retain water, which leads to savings in irrigation water and drought resistance In fact, HA regulates the nutrient balance of the soil, with the increase of some harmful ions destroying other important elements [11, 35].

Table 6. Effect of study treatments on the values of DW of the plant (gm plant^{-1})

IWS Rate	Levels of HA kg ha^{-1}				IWS Levels dS m^{-1}
	30		0		
	BI	CI	BI	CI	
182.5	210.00	193.33	184.00	151.67	1.34
134.67	149.33	142.67	128.33	118.33	4.0
102.42	115.00	98.33	109.67	86.67	7.0
85.83	95.00	87.67	86.00	74.67	10.0
	136.42		117.42		HA rate
	BI		CI		
	134.67		119.17		Rate of irrigation system
salinity S : 5.1	Humic H:9.3		irrigation I:5.4		L.S.D. 0.05
	7.5: S*H*I				

The results in Table 6 show that BI increased plant DW values significantly more than CA at each HA level, with the averages of 119.17 and 134.67 gm plant^{-1} for CI and BI being, respectively. The reason may be due to the fact that binary irrigation (irrigation with saline water and followed by fresh water) has an important role in reducing the negative impact of saline water on the physical properties of the soil, especially the effect of the sodium element (highly hydrated), which works on the dispersion of soil particles where water shells gather around the sodium ion, leading to an increase in the ionic diameter of sodium, as well as that biary irrigation reduces the problem of corruption in the balance of nutrients in the soil solution and the problem of antagonism or competition between nutrients on absorption sites where fresh water helps in diluting the concentration of salts allowing the plant to absorb nutrients more efficiently, and therefore binary irrigation can be an effective strategy for dealing with saline water in areas with limited fresh water with saving the physical properties of the soil and improve plant productivity, and this corresponds the finding of Zhao et al. [36]. This may be because BI reduces the negative effects of saline water [37].

3.3 Grain total yield (TY) (Mg ha^{-1})

Table 7 shows the treatment effect on the TY. It should be noticed that the values differ depending on the level of IWS. Their highest value was 1.34 dS m^{-1} compared to 4.0, 7.0 and 10.0 dS m^{-1} for each level of HA added and reached the lowest value for the treatment without HA of 4,950 and 6,150 Mg ha^{-1} for CI and BI, respectively. Although they reached 6,600 and 7,480 Mg ha^{-1} for the HA treatment of 30 kg ha^{-1} for CI and BI respectively, the reason for the decrease in yield when using saline water is due to the effect of the quality of salts in irrigation water and thus affects plant growth, respiration rate and carbon metabolism. The inhibition of the absorption of certain nutrients by plants as well as toxic effects on plants by interfering with the physiological process so that it leads to stopping its growth and thus its dying. This is consistent with the study by Blanco et al. [5].

Table 7. Effect of study treatments on the TY of grains (Mg ha^{-1})

IWS Rate	Levels of HA kg ha^{-1}				WIS Levels DS m^{-1}
	30		0		
	BI	CI	BI	CI	
11.633	12.721	12.210	11.330	10.230	1.34
10.615	11.923	11.220	10.080	9.240	4.0
7.645	9.240	8.250	6.820	6.270	7.0
6.298	7.480	6.600	6.150	4.950	10.0
	9.960		8.135		HA rate
	BI		CI		Rate of irrigation system
	9.474		8.621		
salinity S: 0.178	Humic: H:0.268		irrigation :I:0.274		L.S.D. 0.05
	0.588: S*H*I				

In addition, irrigation with saline water exposes the plant to metabolic stress, as it needs more energy to reduce the concentration of salts inside its cells, which leads to the depletion of resources that may be directed to growth or production. Moreover, high salinity of the soil as a result of irrigation with high salinity water will affect the availability of nutrients for the plant, as excess salts may prevent the absorption of some necessary nutrients such as potassium, calcium and magnesium, which leads to a lack of nutrition and a deterioration in plant growth and productivity. Increased salinity of water affects several physiological processes such as photosynthesis, regulation of opening and closing stomata, and developing tissues, which leads to reduced biomass production and final crop production [38].

The reason for reduced yields due to increased IWS levels may be the negative impact of water salinity on soil properties and damage that prevents plants from obtaining appropriate conditions. Growth or water stress can affect plants. Since IWS plays an important role in increasing osmotic pressure pressure. As a result, the amount of water that the plant consumes is reduced, reducing the activity of biological processes that are important for plant growth [39, 40].

The results in Table 7 show significant differences between the grain TY values, depending on the HA level for each irrigation system. It reached its highest level at 30 kg ha^{-1} of 9,960 Mg ha^{-1}. Compared to the non-addition treatment of humic in which the grain yield was 8.135 Mg ha^{-1}. It can be said that this high productivity is the positive effect of HA, which stimulates plants to perform their physiological operations optimally. Moreover, the important role of HA and its ability to provide nutrients as required forms [41]. The addition of humic acid improves soil structure by increasing cohesion among microparticles of soil which in turn increases soil airation and permeability of water hence improving soil capability to drain extra saltsand thus decreasing salinity concentration in rhizosphere. Humic also works to increase the ability of the soil to retain water, which helps the plant to obtain a sufficient amount of water even in conditions where the soil is saline and thus improve the plant's ability to resist stress resulting from salinity, as well as increase the plant's ability to absorb nutrients such as potassium, calcium and magnesium, which are negatively affected by high soil salinity and this contributes to improving plant growth and increasing its productivity even in salinity conditions. Humic acid stimulates the growth of beneficial soil microorganisms that play an important role in the decomposition of organic matter and improve soil fertility. These microorganisms can help reduce salt concentration and improve soil health in general. This result was consistent with studies [42, 43].

The results shown in Table 7 show that binary irrigation increased the values of grain yield significantly compared to CI and for any HA level. Their averages were 8.621 and 9.474 Mg ha^{-1} for CI and BI, respectively. The reason for the increase in yield may be attributed to the fact that the binary irrigation method reduced the negative impact of saline water added by rotation method [44]. As the application of the BI method has economic feasibility because it reduces the negative effects of the use of saline water for irrigation [45].

4. CONCLUSIONS

The results demonstrated that the purposeful treatments had a substantial effect on plant height values, dry weight and total yield. The highest value of the height of the plant when watering with water of salinity 1.34 dS m^{-1} for the humic acid level of 30 kg.ha^{-1} and the second rate of irrigation in terms of irrigation with water salinity 10 dS m^{-1} for an acidic humic acid level of 0 kg.ha^{-1} and for continuous irrigation. Dry weight of plants was reduced after irrigation with water salinity 10 dS.m^{-1} and humic acid level of 0 kg ha^{-1} in continuous water compared to irrigation with water salinity 1.34 dS m^{-1} and humic acid level 30 kg ha^{-1} and for binary. The highest yield in irrigation with saline water is 1.34 dS m^{-1} and the level of humic acid is 30 kg ha^{-1} and for two fractions compared to l irrigation with saline water 10dS m^{-1} and for the level of humic acid 0 kg ha^{-1} in continuous water.

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