The interaction between the mineral and nano zinc with Mycorrhiza on the concentration of some nutrients, the ratio of K/Na and the proportion of protein in grains of wheat (Triticum aestivum L.) irrigated with saline water.

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ABSTRACT:

A factorial pots experiment was carried out according to a Randomized Completely Block Design (RCBD) to study the effect of the addition of mycorrhizal fungi and the two type of zinc fertilizers and their interactions on the concentration of some nutrients, the ratio of K/Na and the proportion of protein in grains of wheat crop irrigated with different saline water levels . The results showed a significant effect of adding mycorrhizal to the concentration of phosphorous and potassium with an increase of (5.88 and 18.14)%, respectively, compared with the treatment of no addition of mycorrhizal, while there was no significant effect of adding mycorrhizal to nitrogen concentration, potassium to sodium ratio and protein content in the grains.The addition of zinc with its two types, metallic and nano, significantly affected (the concentration of N, P, K, the percentage of K/Na and the percentage of protein) in the grains, with an increase of (18.43 and 17.24)% for nitrogen and (10.66 and 1.82)% for phosphorous and (5.11, 4.23)% for potassium, (9.48 and 13.35)% for K/Na, and (19.32 and 14.91)% for protein, compared with the treatment without zinc addition. The results showed that the concentration of N, P, K, K/Na ratio and protein content in the grains decreased with the increase in the salinity levels of the irrigation water.

Key words : Mycorrhiza , Nano-zinc , wheat , Nutrients , Salt stress ,protein .

DOI Number: 10.14704/nq.2022.20.12.NQ77099 **NeuroQuantology 2022; 20(12): 1183-1205**

INTRODUCTION:

Wheat (*Triticum aestivum* L.) is extensively used crop globally. About 50% of the world's population takes wheat as a staple diet (Curtis and Halford , 2014), because wheat contains protein and dietary fibers which are compulsory for human nutrition, so the wheat crop ranks first in terms of production and the cultivated area in Iraq. The quantity of production and the total cultivated area were estimated (4234tons, 9464dunums), respectively. It is ahead of the rest of the grain crops (Central Statistical Organization, 2021). The scarcity of the waters of the Tigris and Euphrates rivers is one of the main problems facing Iraq at the present time, due to the lack of rain for the past few years, as well as the policies of Iraq's neighboring countries, which began to introduce the so-called redistribution of water in the region and facing this great challenge, many efforts have focused on using saline water sources such as springs and wells and exploiting them in a scientific and thoughtful manner to reduce the negative effects of salinity .For the purpose of optimal use of saline water, it must be used in a way that ensures good productivity of the crops used, maintains the physical and chemical properties of the soil and reduces their deterioration.

Salinity stress affects grain yield adversely (Sorour et al., 2019). Abbas et al. (2013) confirmed a significant decrease in grain yield and content phosphorous, potassium, K:Na ratio and protein ratio in wheat grains grown under salt stress conditions. Hasan et al. (2015) observed that saline stress (15 dsm^{-1}) significantly decreases seed yield in tolerant and sensitive wheat cultivars. Al-Sharifi (2018) found that the increase in the salinity levels of the irrigation water led to a decrease in the potassium to sodium ratio of (7.50, 5.85, and 4.44) when irrigated with salinity levels of (2, 4, and 6)dsm^{-1} sequentially. the results are consistent with [Al-Khafaji and Al-Burki , 2021], which indicates decreased on the yield trait under the influence of salt.

Zinc is an important mineral and is known as micronutrients for plants , and it is an essential element for all types of plants (Sturikova et al., 2018). Zinc has important roles in plants, as it is responsible for nitrogen metabolism, the amount of protein and nitrogen absorbed, photosynthesis and chlorophyll synthesis, resistance to biotic and abiotic stresses, protection from oxidative processes, and it has an effect in the formation of the amino acid tryptophen, which enters the manufacture of indole acetic acid (IAA) has an important effect on auxin production in plants (Al-Amidi, 2014), therefore its deficiency leads to a decline in both the yield and nutritional quality of cereal grains (Liu et al., 2018).

Abbas (2005) conducted a study on the effect of spraying wheat with three levels of zinc, namely (0, 0.4 and 0.8) kg Zn H^{-1}. He noticed a significant increase in the percentage of protein, as the concentration exceeded (0.8) kg H^{-1} Zn and gave the highest average In the aforementioned trait, with an increase of 9.35% compared to the comparison treatment. Abu Dahi et al. (2009) observed when studying the effect of spraying wheat with three different levels of zinc, which are (0, 15 and 30) mg Zn L^{-1}, and a significant increase in the protein percentage in wheat grains.

Al-Tamimi and Al-Watifi (2015) in a study for them on the effect of spraying zinc at three levels (0, 50 and 100) mg Zn L^{-1} in the wheat plant Dor 29, showed a significant increase in grain yield with an increase in zinc levels. Sultan and others (2016) confirmed that spraying with zinc has a significant positive role in the yield and yield components of wheat plants in the late stages of growth. In a study conducted by Liu et al. (2019) on winter wheat, it was found that the grain yield was significantly increased when zinc was added, with an increase of (8.74)%. The results reached by Hafez et al. (2020) in their study on the effect of spraying wheat with zinc by (300) ppm Zn showed a significant effect on the nitrogen, phosphorous, potassium and protein content in the grains.

Nanoparticles (NPs) are the particles having at least one dimension between (1 and 100) nm in size and these particles have unique characteristics and special features as compared to their bulk counterparts (Irshad et al., 2020 ; Seadh et al,2020). Nano-fertilizers (NFs), have the potential to mitigate various stress conditions and increase crop yield by enhancing nitrogen metabolism, seedling growth, carbohydrate and protein synthesis, photosynthesis, and transfer of nutrients from roots to leaves (Zulfiqar et al., 2019; Al-Juthery et al. , 2021).

Adrees *et al.* (2021) suggested that foliar use of zinc oxide nanoparticles (ZnO NPs) might be an efficient way for increasing g wheat growing and yields. The results reached by Al-Masoudi (2021) showed in her study of the effect of adding nano-zinc with three concentrations (0, 1, and 2) g L^{-1} in wheat plant Ibaa 99, the concentration (1) gm Zn L^{-1} achieved the highest value in yield grains with an increase of (16.71) % compared to the comparison treatment.

Sheoran et al. (2021) observed that when foliar spraying of nano zinc oxide fertilizer instead of standard zinc fertilizer, the grain protein content increased by more than (20)%.

Mycorrhizae establish symbiotic relationships with plants and play an essential role in plant growth, disease protection, and overall soil quality, there are two main categories of Mycorrhizae relationships: Endomycorrhizal fungi (Arbuscular Mycorrhizal Fungi) (AMF) form relationships with over 90% of plants (including turf grasses) , Ectomycorrhizae fungi form relationships with only about 2% of plants, but some of them are quite common(Khrieba ,2019). AMF are soil-borne fungi that can significantly improve plant nutrient uptake and resistance to several abiotic stress factors (Sun et al., 2018). Mycorrhizal symbiosis protected wheat against the detrimental effect of salinity and significantly improved the concentrations of N, K^+ and protein the content(Talaat and Shawky,2014)

Materials and Methods:

A factorial experiment was carried out according to the Compeletely Randomized Block Design (RCBD) during the agricultural season 2020-2021 in the greenhouses of the Department of Field Crops of the College of Agriculture at Karbala University, located in the Husseiniya area of Karbala governorate.

The experiment included three factors with three replications. The first factor (S) represents irrigation with salty well water diluted with tap water to four levels, namely (2, 4, 6 and 8) dsm^{-1}. And the second factor Z) represents the addition of zinc and it is in three levels (without adding zinc), (adding mineral zinc 15 mg L^{-1}) , (adding nano-zinc 15 mg L^{-1}). And the third factor (M) is the addition of Mycorrhizae Glomus spp and it is at two levels(Without adding mycorrhiza), (adding mycorrhiza).

Wheat (*Triticum aestivium* L.)), cultivar (Iba 99), was obtained from the College of Agriculture - University of Karbala. Also, the Mycorrhizal fungus (Glomus Spp (VAM) vaccine was used in this study, which consisted of (spores loaded with Ptmus), which was obtained from the Agricultural Research Department / Ministry of Science and Technology in Zafaraniyah. Wheat seeds of Iba 99 were sown on 11/11/2020 in Plastic pots at a depth of 2 cm from the surface of the soil at a rate of 20 tablets per pot contains 30 kg of sandy soil with physical and chemical specifications specified in Table No. (2) taken from the Husseiniya River after sterilizing the soil with formalin (Hassan et al. (2013) and leaving it

for several days before Put them in pots, and then the mycorrhizal vaccine was distributed with a width of 5 cm and a thickness of 5 cm, where the addition amounted to 20 g of the vaccine per pot. It was irrigated with tap water for 20 days until germination was completed, and after the plants reached the two-leaf stage, the plants were thinned to 10 plants in each pot. After that, they were irrigated with well water in the Fariha area located in the Karbala governorate after reducing it to four levels (2,4,6 and 8) dsm^{-1} according to Table No. (2) and according to the needs of the plant, the fertilization process was carried out with urea fertilizer at a rate of 80 kg of urea 1 dunum, divided into three equal batches (when preparing the soil for planting, when three full leaves appeared on the plant and when flowering) and 55 kg. 1 dunum of calcium superphosphate fertilizer at once when preparing the land for planting, potassium sulfate fertilizer was added at a rate of 30 kg 1 dunum in two batches, the first when three leaves appear and the second when flowering and according to the guidance leaflet (2) issued by the Ministry of Agriculture The National Program for the Development of Wheat in Iraq 2013) (Jadoua, et al. 2013). Commodore was used to control the black aphid once. The chelated nano and mineral zinc was sprayed with an amount of (15 mgL^{-1}) in two batches, the first at the branching stage and the second at the endothelial stage. It was sprayed in the early morning after mixing it with a small amount of bubblegum as a diffuser to reduce the surface tension water and to ensure complete wetness of the plants and then increase the efficiency of absorption of the spray solution) and the spraying process was carried out until reaching the stage of complete wetness using a 2-liter hand-sprayer).

Estimation of the concentration of some elements and ratio of protein and K/Na in grains : (0.5) g of the harvested seeds from all treatments were taken, crushed well and digested by wet digestion method using sulfuric acid and concentrated pyrrochloric acid from each experimental unit as follows:

1- Nitrogen (%):It was determined by using a Micro-Kijeldahl apparatus according to the method of Bremner described in Page et al. (1982).

2- Phosphorous (%):It was estimated by ammonium molybdate and ascorbic acid and by using a spectrophotometer according to the method of Ollabsen and Watsen described in Page et al. (1982).

3- Potassium (%):It was measured in plants by means of a flame-photometer, as mentioned in Haynes (1980).

4- Sodium (%): It was estimated by using a solution of HNO_3 - $HClO_4$) using a flame spectrophotometer ,this value was used to extract the ratio of potassium to sodium .

5- The ratio of potassium to sodium: This ratio was estimated by dividing potassium to sodium in the grains.

6- Determination of protein (%): The protein in grains at maturity was estimated by multiplying the percentage of nitrogen by a factor of 6.25 according to the method of Tkachuk (1977).

Percentage of protein = nitrogen concentration in seeds x6.25 .

7- Grain yield (g. $plant^{-1}$): Hand-treated ears were studied, isolating the grains from the straw, then weighing the total grain yield for each pot, and then dividing it by the number of plants in the pot.

statistical analysis:

The results were statistically analyzed for the studied traits according to the experimental design, which is the randomized complete block design RCBD (Randomized Complete Block Design) as a factorial experiment 4 * 3 * 2 and with three replications using the Genistat program, and the comparison between the means was done using the least significant difference Least. With a probability of 0.05.

Table (1): Some physical and chemical properties of the experimental soil before planting:

Property		Value	Unit
PH		7.09	-
Electrical conductivity EC		1.52	ds m^{-1}
Soil Organic matter		5.4	gm. Kg^{-1}Soil
$CaCO_3$		304.01	
Dissolved cations	Ca^{2+}	16.02	C mol.Kg^{-1}
	Mg^{2+}	9.03	
	Na^{1+}	5.60	
	K^+	0.35	
Dissolved anions	HCO_3^{1-}	4.05	
	Cl^-	0.51	
Available Nitrogen		10.02	gm. Kg^{-1} Soil
Available Potassium		61.2	
Available Phosphorus		42.5	
Soil separates	Sand	892	
	Silt	22	
	Clay	86	
Soil texture		Loamy Sand	

Table No. (2) Chemical analysis of the water used in the experiment.

properties	2 ds m^{-1}	4 ds m^{-1}	6 ds m^{-1}	8 ds m^{-1}
pH	7.82	7.81	7.91	7.83
EC (ds m^{-1})	1.9	4.1	6.2	9.0
Ca^{++} (mg L^{-1})	57.11	95.19	131.26	195.40
Mg^{++} (mg L^{-1})	5.86	14.54	22.96	40.99
Na^+ (mg L^{-1})	197.00	586.80	824.70	1182.00
K^+ (mg L^{-1})	14.10	22.90	34.50	53.50
Cl^- (mg L^{-1})	221.10	781.5 0	1986.00	3403.00
CO_3 (mg L^{-1})	0.00	0.00	0.00	0.00
HCO_3 (mg L^{-1})	108.80	163.70	261.30	275.50
SO_4 (mg L^{-1})	387.27	942.62	1543.30	2672.45

Results

1- Nitrogen concentration in grains (%):

The results presented in Table No. (3) indicate the effect of adding mycorrhizae and the type of zinc added and their interactions on nitrogen concentration in wheat grains irrigated with different salt levels. Through this table, it was found that there was no significant effect of the addition of mycorrhizate on the nitrogen concentration in the grains, while the results showed a significant effect of the type of zinc added in this trait, as the treatment of adding metallic zinc (Zn1)) achieved the highest value of nitrogen concentration in the grains (1.807%).), which did not differ significantly from the treatment of adding nano-zinc (Zn2), while the lowest value for this concentration was (1.474%) found when the treatment was not sprayed with zinc (Zn0).

The results presented in the mentioned table showed a significant effect on nitrogen concentration in grain when irrigated at different levels of salinity. The concentration of nitrogen decreased from (2.040%) when irrigating the first level (S1) to (1.717, 1.515 and 1.478)% when irrigating at levels (S2, S3, and S4) sequentially, with a decrease of (27.55, 13.92 and 2.44)% in the same sequence. Compared to irrigation at the first level (S1).

The bilateral interaction between the addition of mycorrhizae and the type of zinc added had a significant effect on the nitrogen concentration in the grains. The treatment (Zn1M1) achieved the highest value of nitrogen concentration (1.874%), while the treatment (Zn0M1) recorded the lowest value for this trait (1.451%). The binary interaction between the addition of mycorrhizae and irrigation at different levels of salinity gave a significant difference in the nitrogen concentration in the grains, and the highest value of it was (2.042%) observed in the treatment (S1M1), which did not differ significantly from the treatment (S1M0), while the lowest value of the nitrogen concentration was In cereals, its amount (1.450%) was found at treatment (S4M0).

The results showed a significant effect of the binary interaction between the type of zinc added and irrigation with different salt levels on the nitrogen concentration in the grains. The treatment (S1Zn1) achieved the highest value of it (2.208%), which did not differ significantly from treatment (S1Zn2), while the lowest value for this trait was (1.241%) observed with treatment (S4Zn0).

The results in the mentioned table showed a significant effect of the triple interaction of the factors under study on the nitrogen concentration in the grains. The highest value of it reached at the treatment (S1Zn2M0) and its amount (2.440%), which did not differ significantly from the treatment (S1Zn1M1), while the lowest value of nitrogen concentration in the grain was (1.158%) observed with the treatment (S4Zn0M1).

Table (3) Effect of different levels of salinity and zinc, with its two types, metallic, nano, and mycorrhizal, and the interaction between them on nitrogen concentration in the grains of the wheat crop of Ibaa variety (99):

Mycorrhizal fungus (M) *Glumus spp*	type of zinc added Zn(mg L^{-1})	Salinity levels of irrigation water S ds m^{-1}				Average Fungus effect
		S1 2	S2 4	S3 6	S4 8	
Without adding fungus M0	Without adding	1.570	1.730	1.360	1.323	1.677
	Zn 15mg L^{-1}(mineral)	2.105	1.728	1.645	1.486	
	Zn 15mg L^{-1}(nano)	2.440	1.662	1.540	1.540	
Add fungus M1	Without adding	2.030	1.330	1.278	1.158	1.698
	Zn 15mg L^{-1}(mineral)	2.310	2.135	1.475	1.575	
	Zn 15mg L^{-1}(nano)	1.785	1.715	1.785	1.785	
Irrigation water salinity rate		2.040	1.717	1.515	1.478	

Zinc rate	Zn0	Zn1	Zn2
	1.474	1.807	1.781
Zinc * Fungus	Zn0	Zn1	Zn2
M0	1.469	1.471	1.795
M1	1.451	1.874	1.768

Irrigation water salinity * Fungus	S1	S2	S3	S4
M0	2.038	1.707	1.515	1.450
M1	2.042	1.727	1.516	1.506
Irrigation water salinity *Zinc	S1	S2	S3	S4
Zn0	1.800	1.530	1.323	1.241
Zn1	2.208	1.932	1.560	1.530
Zn2	2.113	1.688	1.663	1.663

L.S.D 0.05	M	Zn	S	Zn *M	S*M	S* Zn	S* Zn *M
	n.s	0.1516	0.1751	0.2144	0.2476	0.3033	0.4289

2- The concentration of phosphorous in grains %:

The results presented in Table No. (4) indicate the effect of adding mycorrhizae and the type of zinc added and their interactions on nitrogen concentration in the irrigated wheat grains at different levels of salinity.) The highest value of phosphorous concentration in grains was (0.4231%), while the treatment of not adding mycorrhizal (M0) recorded the lowest value for this trait and its amount (0.3996%) and an increase of (5.88%).

The results in the mentioned table showed a significant effect of the type of zinc added on the phosphorous concentration in the grains. The treatment of adding metallic zinc (Zn1) achieved the highest value of it (0.4400%), while the lowest value of this concentration was (0.3931%) found in the treatment of no Zinc (Zn0) was added with an increase of (11.93%). The results also showed a significant effect of irrigation with different levels of salinity in the concentration of phosphorous in grain, as its concentration decreased from (0.4662%) when irrigating the first level (S1) to (0.4384, 0.3876 and 0.3512)% when irrigating with levels (S2, S3 and S4).) sequentially with a decrease of (32.74, 24.83 and 10.36)%, in the same sequence, compared to irrigation at the first level (S1).

The results showed a significant effect of the bilateral interaction between the addition of mycorrhizae and the type of zinc added phosphorous concentration in the grains. The treatment (Zn1M1) achieved the highest value of it (0.4554%), while the lowest value of the phosphorus concentration in the grain (0.378%) was observed during the treatment. (Zn0M0). The dual interaction between the addition of mycorrhizae and irrigation with different salt levels had a significant effect on the phosphorous concentration in the grains. The transaction (S1M1) recorded the highest value of it (0.4964%). While it was less for the concentration of phosphorus in the grains and its amount (0.3304 %) was observed when treatment (S4M1). The bilateral interaction between the type of zinc added and irrigation with different saline levels had a significant effect on the phosphorous concentration in the grains. The treatment (S1Zn1) achieved the highest value of this concentration (0.913%), which did not differ significantly from the treatment (S1Zn2), while it was the lowest value of the concentration An amount of phosphorous (0.3126%) was found at the treatment (S4Zn0).

The results indicated in the table showed a significant effect of the triple interaction of the factors under study on the phosphorous concentration in the grains. The highest value of it was (0.5247%) observed with the treatment (S1Zn2M1), which did not differ significantly from the treatment (S1Zn1M1), while the lowest value was The amount of phosphorous in the grains was (0.2982%) found when treated (S4Zn4M4).

Table (4) Effect of different levels of salinity and zinc, with its two types, metallic, nano and mycorrhizal, and the interaction between them on the concentration of phosphorus in the grains of the wheat crop of Ibaa variety (99):

Mycorrhizal fungus (M) *Glumus spp*	type of zinc added Zn(mg L^{-1})	Salinity levels of irrigation water S ds m^{-1}				Average Fungus effect
		S1 2	S2 4	S3 6	S4 8	
Without adding fungus M0	Without adding	0.3890	0.4370	0.3653	0.2982	0.3996
	Zn 15mg L^{-1}(mineral)	0.4750	0.4400	0.4335	0.3500	
	Zn 15mg L^{-1}(nano)	0.4560	0.4495	0.3578	0.3440	
Add fungus M1	Without adding	0.4570	0.4740	0.3975	0.3270	0.4231
	Zn 15mg L^{-1}(mineral)	0.5077	0.4565	0.4305	0.4270	
	Zn 15mg L^{-1}(nano)	0.5247	0.3737	0.3408	0.3610	
Irrigation water salinity rate		0.4662	0.4384	0.3876	0.3512	
Zinc rate		Zn0	Zn1	Zn2		
		0.3931	0.4400	0.4009		
Zinc * Fungus		Zn0	Zn1	Zn2		
M0		0.3724	0.4246	0.4018		
M1		0.4139	0.4554	0.4000		
Irrigation water salinity * Fungus		S1	S2	S3	S4	
M0		0.4400	0.4422	0.3856	0.3307	
M2		0.4964	0.4347	0.3896	0.3717	
Irrigation water salinity *Zinc		S1	S2	S3	S4	
Zn0		0.4230	0.4555	0.3814	0.3126	
Zn1		0.4913	0.4483	0.4320	0.3885	
Zn2		0.4903	0.4116	0.3493	0.3525	

L.S.D 0.05	M	Zn	S	Zn *M	S*M	S* Zn	S* Zn *M
	0.02242	0.02746	0.03170	0.03883	0.04484	0.05491	0.07766

3- Potassium concentration in cereals %:

The results presented in Table (5) indicate the effect of adding mycorrhizae and the type of zinc added and their interactions on potassium concentration in wheat grain irrigated with different salt levels. Through this table, it was found that there was a significant effect of adding mycorrhizae on the potassium concentration in the grains, as the treatment of adding mycorrhizae (M1) achieved the highest value for this trait and its amount (0.4477%), while the treatment of not adding mycorrhizae (M0) recorded the lowest value of potassium concentration in the grains. Its amount is (0.4140%), with an increase of (8.14%). The addition of zinc had a significant effect on the potassium concentration, as the highest value of potassium concentration in the grains was (0.4411%) found when the addition of metallic zinc (Zn1), while the lowest value of the potassium concentration in the grains was observed when the amount of (Zn0) was not added. 0.4165%), with an increase of (5.91%).

The results presented in the mentioned table showed a significant effect of irrigation with different salt levels on potassium concentration in grain. Irrigation treatment at the first level (S1) achieved the highest value of (0.4549%), while the lowest value of potassium concentration in cereals was (0.3945%) recorded at the fourth level (S4), with a decrease of (13.28%).

The bilateral interaction between the addition of mycorrhizae and the type of zinc added had a significant effect on potassium concentration. The highest value of (0.4703%) was observed with the (Zn1M1) treatment, while the lowest value of potassium concentration in the grains was (0.3956%) recorded with the (Zn0M0) treatment.) . The bilateral interaction between the addition of mycorrhizal and irrigation with different salt levels gave the potassium concentration in the grains. The transaction (S1M0) achieved its highest value (0.46585%). Whereas, the lowest value of potassium concentration in the grains was (0.3203%) observed when treatment (S4M0). Also, the bilateral interaction between the type of zinc added and irrigation with different saline levels showed a significant effect on the potassium concentration in the grains, as it reached the highest value of (0.4987%) recorded with the treatment (S1Zn1).

The triple interaction of the factors under study showed a significant effect on potassium concentration in grains. Treatment (S1Zn1M1) achieved the highest value of it (0.4963%), while treatment (S4Zn0M0) recorded the lowest value of potassium concentration in grains (0.2230%).

Table (5) Effect of different levels of salinity and zinc, with its two types, mineral, nano, and mycorrhizal, and the interaction between them on potassium concentration in the grains of the wheat crop of Ibaa variety (99):

<table>
<tr><th rowspan="2">Mycorrhizal fungus (M) Glumus spp</th><th rowspan="2">type of zinc added Zn(mg L^{-1})</th><th colspan="4">Salinity levels of irrigation water S dS m^{-1}</th><th rowspan="2">Average Fungus effect</th></tr>
<tr><th>S1 2</th><th>S2 4</th><th>S3 6</th><th>S4 8</th></tr>
<tr><td rowspan="3">Without adding fungus M0</td><td>Without adding</td><td>0.4403</td><td>0.4340</td><td>0.4850</td><td>0.2230</td><td rowspan="3">0.4140</td></tr>
<tr><td>Zn 15mg L^{-1}(mineral)</td><td>0.5010</td><td>0.3920</td><td>0.3307</td><td>0.4240</td></tr>
<tr><td>Zn 15mg L^{-1}(nano)</td><td>0.4560</td><td>0.3885</td><td>0.4873</td><td>0.4060</td></tr>
<tr><td rowspan="3">Adding fungus M1</td><td>Without adding</td><td>0.4350</td><td>0.4705</td><td>0.4270</td><td>0.4175</td><td rowspan="3">0.4477</td></tr>
<tr><td>Zn 15mg L^{-1}(mineral)</td><td>0.4963</td><td>0.4500</td><td>0.4947</td><td>0.4400</td></tr>
<tr><td>Zn 15mg L^{-1}(nano)</td><td>0.4005</td><td>0.4260</td><td>0.4580</td><td>0.4567</td></tr>
<tr><td colspan="2">Irrigation water salinity rate</td><td>0.4549</td><td>0.4268</td><td>0.4471</td><td>0.3945</td><td></td></tr>
<tr><td colspan="2" rowspan="2">Zinc rate</td><td>Zn0</td><td>Zn1</td><td colspan="2">Zn2</td><td></td></tr>
<tr><td>0.4165</td><td>0.4411</td><td colspan="2">0.4349</td><td></td></tr>
<tr><td colspan="2">Zinc * Fungus</td><td>Zn0</td><td>Zn1</td><td colspan="2">Zn2</td><td></td></tr>
<tr><td colspan="2">M0</td><td>0.3956</td><td>0.4119</td><td colspan="2">0.4345</td><td></td></tr>
<tr><td colspan="2">M1</td><td>0.4375</td><td>0.4703</td><td colspan="2">0.4353</td><td></td></tr>
<tr><td colspan="2">Irrigation water salinity * Fungus</td><td>S1</td><td>S2</td><td>S3</td><td>S4</td><td></td></tr>
<tr><td colspan="2">M0</td><td>0.4658</td><td>0.4048</td><td>0.4343</td><td>0.3510</td><td></td></tr>
<tr><td colspan="2">M2</td><td>0.4439</td><td>0.4488</td><td>0.4599</td><td>0.4381</td><td></td></tr>
<tr><td colspan="2">Irrigation water salinity *Zinc</td><td>S1</td><td>S2</td><td>S3</td><td>S4</td><td></td></tr>
<tr><td colspan="2">Zn0</td><td>0.4377</td><td>0.4523</td><td>0.4560</td><td>0.3203</td><td></td></tr>
<tr><td colspan="2">Zn1</td><td>0.4987</td><td>0.4210</td><td>0.4127</td><td>0.4320</td><td></td></tr>
<tr><td colspan="2">Zn2</td><td>0.4283</td><td>0.4073</td><td>0.4727</td><td>0.4313</td><td></td></tr>
</table>

L.S.D 0.05	M	Zn	S	Zn *M	S*M	S* Zn	S* Zn *M
	0.02015	0.0246	0.02850	0.03490	0.04030	0.4936	0.06980

4- The ratio of potassium to sodium in cereals %:

The results presented in Table No. (6) indicate the effect of different levels of salinity, zinc, of its two types, mineral, nano, and mycorrhizal, and the interaction between them on the ratio of potassium to sodium in the grains of the wheat crop of Ibaa variety (99), and through this table it was found that there was no significant effect of adding mycorrhizae in these character, while the results showed a significant effect of the type of zinc added in the ratio of K:Na, as the treatment of adding nano-zinc (Zn2) achieved the highest value of it (11.72), which did not differ significantly from the treatment of adding metallic zinc (Zn1) compared to the treatment of no addition Zinc (Zn0), which recorded the lowest value for this trait (10.34). The different levels of salinity of irrigation water significantly affected the ratio of K:Na, as this percentage decreased with the increase in salinity levels, and its highest value was (14.04) when irrigating at the first level. S1), which decreased to (12.10, 9.29 and 8.27) when irrigated with levels (S2, S3 and S4) sequentially with a decrease of (13.82, 33.83 and 41.10)%, in the same sequence compared with the treatment of irrigation at the first level (S1).

The binary interference between the addition of mycorrhizae and the two types of zinc added showed a significant effect on the ratio of K:Na, as the interaction treatment (M1Zn2) gave the highest percentage and reached (12.83) which did not differ significantly from the treatment (M1Zn1), while the two treatments recorded (M0Zn0) and (M1Zn0), The lowest value of the ratio of potassium to sodium (10.34). The bilateral interaction between the addition of mycorrhizal and irrigation with different levels of salinity gave a significant effect for this trait, as the interaction treatment (M1S1) achieved the highest value of (14.86), which did not differ significantly from the treatment (M1S2), while the interaction treatment (M0S4) recorded the lowest value The ratio of K:Na and its amount (7.91), which did not differ significantly from the treatment (M1S4). The binary interaction between the two types of zinc added and different salt levels showed a significant effect on the ratio of potassium to sodium, the highest value of which was (15.07) was observed with (S1Zn2) treatment, which did not differ significantly from (S1Zn1) and (S2Zn2) treatments, while Its lowest value was (6.56) found at the transaction (S4Zn0).

The triple interaction between the study factors had a significant effect on the K:Na ratio, as the interaction treatment (S1Zn2M1) achieved the highest value for this ratio (16.58), while the treatment (S4Zn0M0) gave the lowest value (6.66), which did not differ significantly from Transaction (S4Zn0M1).

Table (6) Effect of different levels of salinity and zinc, with its two types, metallic, nano, and mycorrhizal, and the interaction between them on K/Na ratio in the grains of the wheat crop of Ibaa variety (99):

Mycorrhizal fungus *Glumus spp* (M)	Type of zinc added Zn(mg L^{-1})	Salinity levels of irrigation water S ds m^{-1}				Average Fungus effect
		S1 2	S2 4	S3 6	S4 8	
Without adding fungus M0	Without adding	13.17	11.39	10.34	6.66	11.07
	Zn 15mg L^{-1}(mineral)	13.97	12.32	11.27	9.26	
	Zn 15mg L^{-1}(nano)	14.56	13.53	10.53	7.82	
Adding fungus M1	Without adding	12.07	11.07	8.86	7.47	11.18
	Zn 15mg L^{-1}(mineral)	13.94	11.63	9.42	8.39	
	Zn 15mg L^{-1}(nano)	16.58	11.64	11.34	9.76	
Irrigation water salinity rate		14.04	12.10	10.29	8.27	
Zinc rate		Zn0	Zn1	Zn2		
		10.34	11.32	11.72		
Zinc * fungus		Zn0	Zn1	Zn2		
M0		10.34	10.38	10.61		
M1		10.34	12.26	12.83		
Irrigation water salinity * Fungus		S1	S2	S3	S4	
M0		12.91	13.40	10.06	7.91	
M2		14.86	11.45	9.87	8.54	
Irrigation water salinity rate *Zinc		S1	S2	S3	S4	
Zn0		12.63	10.71	10.13	6.56	
Zn1		13.96	12.47	10.35	9.82	
Zn2		15.07	14.09	9.43	8.29	

L.S.D 0.05	M	Zn	S	Zn *M	S*M	S* Zn	S* Zn *M
	n.s	0.994	1.148	1.406	1.623	1.988	2.812

5- The percentage of protein in cereals:

The results presented in Table No. (7) indicate the effect of adding mycorrhizae and the type of zinc added and their interactions on the protein percentage in the grain of the wheat plant irrigated with different levels of salt. Through this table, it was found that there was no significant effect of the addition of mycorrhizae on the proportion of protein in the grains, while the results showed a significant effect of the type of zinc added on the proportion of protein in the grains. The treatment of spraying metallic zinc (Zn1) achieved the highest percentage (11.30%), which did not differ significantly from the treatment of spraying with nano-zinc (Zn2), while the lowest value of the percentage of protein in the grains was (9.47%) observed when the treatment did not spray with zinc (Zn0), with an increase of (19.32%).

The results presented in the table showed a significant effect of irrigation with different levels of salt on the percentage of protein in the grains. This percentage decreased with the increase in the salinity levels of the irrigation water. The first level irrigation treatment (S1) recorded the highest protein content (13.10%), which decreased to (10.73, 9.47 and 9.24)% when irrigated at the levels (S2, S3 and S4) sequentially and with lower rates of (29.47, 13.89 and 2.43)% in the same sequence compared to irrigation at the first level (S1).

The bilateral interaction between the addition of mycorrhiza and the type of zinc added had a significant effect on the percentage of protein in the grains. The treatment (Zn1M1) achieved the highest percentage and amount (11.71%), which did not differ significantly from the two treatments (Zn2M0) and (Zn2M1), while the lowest value for this The ratio of (9.07%) was found in the treatment (Zn0M1), and the bilateral interaction between the addition of mycorrhizae and irrigation at different levels of salt had a significant effect on the protein percentage in the grains. It was noted that the highest percentage of (13.43%) was found in the treatment (S1M0), in Whereas, the lowest percentage of protein in cereals was (9.06%) recorded at treatment (S4M0).

The bilateral interaction between the type of zinc added and irrigation with different salt levels had a significant effect on the protein content in the grains. It was noted that the highest percentage of (13.80%) was found in treatment (S1Zn1), which did not differ significantly from treatment (S1Zn2), while the lowest value of protein percentage in cereals was (7.76%) observed with treatment (S4Zn0).

The results showed a significant effect of the triple interaction of the factors under study on the percentage of protein in cereals, as the treatment (S1Zn2M0) gave the highest percentage of it (15.25%), which did not differ significantly from the treatment (S1Zn1M1), while the treatment (S4Zn0M1) recorded the lowest value for the percentage of protein In grains and its amount (7.24%).

Table (7) Effect of different levels of salinity and zinc, with its two types, metallic, nano, and mycorrhizal, and the interaction between them on the percentage of protein in the grains of the wheat crop of Ibaa variety (99):

Mycorrhizal fungus (M) *Glumus spp*	type of zinc added Zn(mg L^{-1})	Salinity levels of irrigation water S dS m^{-1}				Average Fungus effect
		S1 2	S2 4	S3 6	S4 8	
Without adding fungus M0	Without adding	11.90	10.81	8.50	8.27	10.66
	Zn 15mg L^{-1}(mineral)	13.16	10.80	10.28	9.29	
	Zn 15mg L^{-1}(nano)	15.25	10.39	9.62	9.62	
Add fungus M1	Without adding	12.69	8.31	8.04	7.24	10.61
	Zn 15mg L^{-1}(mineral)	14.44	13.34	9.2	9.84	
	Zn 15mg L^{-1}(nano)	11.16	11.16	11.14	10.72	
Irrigation water salinity rate		13.10	10.73	9.47	9.24	

Zinc rate	Zn0	Zn1	Zn2
	9.47	11.30	11.13
Zinc * Fungus	Zn0	Zn1	Zn2
M0	9.87	10.88	11.22
M1	9.07	11.71	11.05

Irrigation water salinity * Fungus	S1	S2	S3	S4
M0	13.43	10.67	9.47	9.06
M1	12.76	10.79	9.47	9.41
Irrigation water salinity *Zinc	S1	S2	S3	S4
Zn0	12.29	9.56	8.27	7.76
Zn1	13.80	12.07	9.75	9.56
Zn2	13.20	10.55	10.39	10.39

L.S.D 0.05	M	Zn	S	Zn *M	S*M	S* Zn	S* Zn *M
	n.s	0.924	1.067	1.307	1.509	1.848	2.614

6- Grain yield (g plant^{-1}):

The results presented in Table No. (8) refer to the effect of adding mycorrhizae and the type of zinc added and their interactions on the trait of grain yield in the irrigated wheat plant at different levels of salinity. M1) and its amount is (8.417) g plant^{-1}, while the lowest value of the grain yield was recorded when the treatment did not add mycorrhizae (M0) and its amount was (7.911) g plant^{-1}, with an increase of (6.40%). The addition of mineral zinc (Zn1) had the highest value for grain yield of (8.483) g plant^{-1}, while the lowest value for this trait was (7.908) g plant^{-1}, which was found when the comparison treatment (Zn0) with an increase rate of (7.27%).

The results of the mentioned table showed a significant effect of irrigation with different levels of salinity on the character of the grain yield, as the grain yield decreased with the increase in the salinity levels of the irrigation water. And 8.061 and 7.461) g of plant^{-1} when irrigated at levels (S2,S3 and S4) sequentially, with a decrease of (13.86, 11.93, and 7.44)%, respectively, compared to irrigation at the first level (S1).

The results in the above-mentioned table showed a significant effect of the bilateral interaction between the addition of mycorrhizae and the type of zinc added. The treatment (Zn1M1) achieved the highest value for the grain yield trait of (8.633) g plant^{-1}, while the lowest value for this trait was (7.558) g plant $^{-1}$ was observed upon treatment (Zn0M0). The bilateral interaction between the addition of mycorrhizae and irrigation with different levels of salinity had a significant effect on the grain yield, as the highest value of this trait was (9.050) g plant^{-1}, which was observed with treatment (S1Zn2), which did not differ significantly from treatment (S1Zn1), while it was less A value for grain yield of (7.233) g plant^{-1} was observed when treatment (S4Zn2).

The triple interaction of the factors under study showed a significant effect on grain yield, the treatment (S1Zn2M1) recorded the highest value for this trait and its amount is (9.100) g plant^{-1}, which did not differ significantly from the two treatments (S1Zn2M0) and (S2Zn1M1), while the treatment (S4Zn0M0) achieved) The lowest values of grain yield and its amount is (6.867) g plant^{-1}.

Table (8) The effect of different levels of salinity and zinc with its two types of metallic, nano and mycorrhizae and the interaction between them on the grain yield (g plant^{-1}) of the wheat crop of Ibaa variety (99):

Mycorrhizal fungus (M) *Glumus sp*	type of zinc added Zn(mg L^{-1})	Salinity levels of irrigation water S ds m^{-1}				Average Fungus effect
		S1 2	S2 4	S3 6	S4 8	
Without adding fungus M0	Without adding	7.633	7.800	7.933	6.867	7.911
	Zn 15mgL^{-1}(mineral)	8.933	8.667	8.067	7.667	
	Zn 15mg L^{-1}(nano)	9.000	8.067	7.100	7.200	
Add fungus	Without adding	8.433	8.233	8.733	7.633	8.417

M1	**Zn 15mgL^{-1}(mineral)**	**8.967**	**8.967**	**8.467**	**8.133**
	Zn 15mg L^{-1}(nano)	**9.100**	**9.000**	**8.067**	**7.267**
Irrigation water salinity rate		**8.661**	**8.472**	**8.061**	**7.461**
Zinc rate		**Zn0**		**Zn1**	**Zn2**
		7.908		**8.483**	**8.100**
Zinc * Fungus		**Zn0**		**Zn1**	**Zn2**
M0		**7.558**		**8.333**	**7.842**
M1		**8.258**		**8.633**	**8.358**
Irrigation water salinity * Fungus		**S1**	**S2**	**S3**	**S4**
M0		**8.522**	**8.178**	**7.700**	**7.244**
M1		**8.800**	**8.767**	**8.422**	**7.678**
Irrigation water salinity *Zinc		**S1**	**S2**	**S3**	**S4**
Zn0		**8.033**	**8.017**	**8.333**	**7.250**
Zn1		**8.900**	**8.867**	**8.267**	**7.900**
Zn2		**9.050**	**8.533**	**7.583**	**7.233**

	M	Zn	S	Zn *M	S*M	S* Zn	S* Zn *M
L.S.D 0.05	**0.4020**	**0.4923**	**0.5685**	**0.6963**	**0.8040**	**0.9847**	**1.3925**

DISCUSSION:

The results shown in Tables (3, 6 and 7) indicated that there was no significant effect of adding mycorrhizal to nitrogen concentration, potassium to sodium and protein ratios in the grains of wheat crop.

The results shown in Tables (4 and 5) showed a significant effect of adding mycorrhizal to the concentration of both phosphorous and potassium in the grains. The reason may be due to mycorrizha fungi greatly enhanced the ability of plants to take up phosphorus and other nutrients those are relatively immobile and exist in low concentration in the soil solution. mycorrhizal fungi are capable of absorbing and transporting almost all the 15 essential macro- and micronutrients vital for growth of the plant, and AMF produce fungal structures like arbuscules, which assist in exchange of inorganic minerals and the compounds of carbon and phosphorus, ultimately imparting a considerable vigor to host plants (Li et al., 2016 ; Prasad et al., 2017).

The results shown in Table (8) showed a significant effect of adding mycorrhiza on grain yield . These results suggest that AMF inoculation mitigates the negative effects of salinity stress by influencing carbon use efficiency and maintaining higher grain yield under stress, and the reason may be attributed to the mycorrhizal plants increases the seed yield and nutrition nutritional level in many cereal crop species, such as wheat (Komala et al.,2017) .The increase in grain yield was identical with Balliu et al. (2015) , Farahbaksh and Sirjani(2019) and Eroglu et al.(2020) was conducted AM wheat plants subjected to salinity stress at both pre-anthesis and post-anthesis maintained higher grain yield than non-AM salinity-stressed plants.

The results shown in Tables (3, 4, 5, 6 and 7) confirmed that there is a significant effect of adding zinc on the concentration of nitrogen, phosphorous and potassium in the grains, the ratio of potassium to sodium and the percentage of protein in the grains. The reason may be due to zinc takes part in various biochemical procedures in plants, including synthesis of protein (Kambe et al., 2015), and zinc is involved in tryptophan synthesis, cell division and photosynthesis and is involved as a regulatory cofactor in protein synthesis (Lacerda et al., 2018). These results are in agreement with what was found by Hafez et al. (2020) in their study on the effect of sprinkling wheat with zinc and a significant increase in grain yield, protein content in grains and NPK grain content.

The results shown in Table (8) showed a significant effect of adding the two types of zinc on the grain yield of wheat. Zinc has a central effect on biomass production and grain yield. The positive effect of zinc in the yield characteristics can be attributed to what it does in activating growth enzymes that lead to a higher level of physiological processes and this in turn increases the components of the yield, as it has an important biological effect in raising the rate of photosynthesis, the manufacture of carbohydrates and the transfer of metabolic materials to the seeds (Al- Doori, 2014). This result is similar to what was confirmed by Abbas (2005), Farohki et al. (2014), Ali and Salman (2017) , Liu et al. (2019) and Al-Masoudi (2021) .

It was shown from Table (3, 4, 5, 6, 7 and 8) that the salinity levels of irrigation water had a significant effect on the concentration of nitrogen, phosphorous and potassium in the grains, the ratio of potassium to sodium and the proportion of protein in the grains, respectively, for the wheat crop. It was observed that the lowest values of nitrogen and phosphorous concentrations And potassium in cereals when irrigated at the fourth level (8 ds m^{-1}). This was confirmed by Abboud and Abbas (2013) and Al-Masoudi (2015), as they noticed that the increase in the salinity of the irrigation water significantly reduced the concentrations of nitrogen, phosphorous and potassium in the grains of the wheat crop.

It was noted from (table 6) that the ratio of potassium to sodium decreased with the increase in the salinity levels of the irrigation water. This result is similar to what was confirmed by Asgari (2011), Abbas(2013) in wheat and Al-Sherifi(2018) , Al-Saadi (2019) and Al-Zuwaini (2021) in maize who observed decreased K/Na ratio with increasing salinity levels of irrigation water.

The protein content of grains(Table7) decreased with the increase in salinity levels of the irrigation water, the reason for this was attributed to the fact that salinity led to an increase in the activity of the protease enzyme responsible for degrading protein, causing a reduction in the percentage of protein in the plant. This result is identical to what was found by Abbas et al. (2013) , Rashid and Alwan (2014), to find out the effect of salinity on the percentage of protein in the wheat plant indicated a significant decrease in the percentage of protein with an increase in salinity levels,

The results shown in Tables (8) showed a significant effect when irrigating with different salt levels on grain yield. The reason may be salinity has inhibitory effects on physiological aspects of wheat which impair the growth and yield of the crop, and the reason for the decrease may be due mainly to the fact that the ears were carrying a small percentage of the full seeds due to the lack of filling the grain with nutrients and a reduction in the percentage of knots and the atrophy of the seeds and their low number, which leads to a decrease in the grain yield when exposed to salt stress. This result is similar to what was confirmed by Abbas et al.(2013), Shamsi and Kobrae (2013), Al-Jafar (2014), Al-Raqabi (2016), Ali and Ahmed (2017) , Al-Zuwaini (2017), AL-Burki et al. (2019) observed a significant decrease in the grain yield of wheat with an increase in the salinity levels of irrigation water.

The interaction of salinity stress and AMF significantly affects the concentrations of P ,N in plant shoots (Wang et al., 2018). AMF can increase the osmolytes, carbohydrates, and antioxidant systems (Evelin et al. , 20013). AMF can also influence carbon use efficiency, maintaining a higher grain yield, a higher rate of net photosynthesis and stomatal conductance, and lower intrinsic water use efficiency under salt stress (Evelin et al. ,2009)]. zinc application reduces the negative effect of salinity on crop growth and yield. From the literature, it is evident that combination of salinity and Zn caused a broad range of physiological response in wheat plants, which alleviate the detrimental effects of stress.

Grain protein was decreased by salinity, while the utilization of grain protein enhanced and finally improved the growth and yield of wheat by decreasing the effects of salinity, therefore the addition of Zn helped in reducing the unfavourable effects of increased salinity tolerance of wheat to salinity(Kamrani et al. 2013).

Conclusion

Salinity has inhibitory effects on physiological aspects of wheat which impair the growth and yield of the crop. Zinc application can increase both quantitative and qualitative traits of wheat when applied properly. Also, zinc application reduces the negative effect of salinity on crop growth and yield. From the literature, it is evident that combination of salinity and Zn caused a broad range of physiological response in wheat plants, which alleviate the detrimental effects of stress and these outcomes might be regarded as a nutrient management tool, particularly for plants under salinity stress..

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