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Effect of Levels Water Salinity and Inoculation With Azospirillum and Bacillus on Some Growth and Yield Characters of Wheat (*Triticum aestivum* L.)

Salama Tahseen Ali¹, Shaimaa Ibrahim Al-rifae² and Turki meften Saad³

^{1,2,3}Collage of Agriculture, Field Crops Department, Al-Muthanna University, Iraq.

¹Email: salamatahseen@mu.edu.iq

Abstract

A field experiment has been conducted at the College of Agriculture - University of Al-Muthanna (Al Bandar station 2 km from the center of Al-Muthanna Governorate), during seasons 2019-2020 and 2020-2021, to study the effect of four salinity levels of irrigation water (S1, S2, S3, S4) and four treatments of Bio Fertilization (A, B, AB, C), and knowing its effect on some characteristics of growth and yield of wheat, result showed that levels of water salinity was significant effect on growth characters, the level S1 was superior in high plant, No. tellers, leaf flag area was reached 76.03 and 82.08 cm, 358.5 and 357.2 tellers m², 40.08 cm² for both season on sequences. The treat of salinity S3 was superior in seed of spikes and total yields and give high means 32 and 34.42 seed spike⁻¹, 3.850 and 4.13 ton h⁻¹ in both season. The inoculation treatment was high significant in growth characters and the treat A was superior in plant high reached 77.78 and 77.76 cm, in tellers treat A was superior in No. tellers reached 352.4 tellers m², the treatment AB was superior in flag leaf area and reached 40.17 cm². The result showed superior treat AB in seeds spikes⁻¹ reached 32.58 and 34.67 seeds spike⁻¹ for both season, in 1000 seed weight was treat B was superior and give 33.83 and 35.08 gm in both season, the treat AB was superior in total yield its reached 3.52 and 3.82 ton h⁻¹.

Keyword: Wheat, Salinity, Inoculation, Yield.

1. Introduction

The increase in the population will lead to an increase in the demand for food, and in order to obtain this level with the continued increase of the population, about 9 billion in the year 2030 [1] it becomes necessary to make scientific efforts to reach production It meets the population's need for these nutritional requirements from the wheat crop, which is one of the most important and most productive cereal crops in the world and comes at the for front of basic food crops (rice, maize) in terms of human consumption, due to the high nutritional value of carbohydrates and protein compounds for its grains, and here we can point out that Efficient management of adequate nutrition for plants, especially in the provision of basic elements, including nitrogen, will be the basis for obtaining high production and advanced agriculture [2]. Salinity is one of the main factors in agricultural production, as salts directly or indirectly affect production, and the direct effect is through the toxicity of some ions when their concentration increases in irrigation water, such as sodium ions, chloride, boron and nitrate, and the indirect effect is through the effect of the components of irrigation water. In some of the soil's physical, chemical and biological properties, Iraq is currently suffering from a decrease in the water levels of the Tigris and Euphrates rivers, as well as the drying up of most of the subsidiary rivers, which caused the salinity of irrigation water as well as the high degree of soil salinity in some areas. Therefore, irrigation with water with salinity of up to 5 ds m⁻¹ has caused many problems, as well as its rise in other areas to 12 ds m⁻¹, which caused thousands of hectares to leave agriculture, and therefore many recent research and studies have resorted to finding ways and ways to reduce the impact of high salinity of irrigation water such as drip irrigation Sprinkler irrigation, construction of drainage systems and cultivation of salinity-tolerant crops, as well as the use of salinity-resistant bio-fertilizers [3].

Bio-Fertilization works to change the microbial content in the area surrounding the roots by inoculating the soil or seeds or both with microorganisms capable of bringing about beneficial changes to the plant [4]. Azospirillum is one of the most efficient types of free-living nitrogen-fixing bacteria, as research indicated that about (100) nitrogen-fixing bacterial strains can be isolated from the rhizosphere, but Azospirillum are not considered the most efficient in fixing [5]. It works to improve



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plant growth through the secretion of some hormones, enzymes, vitamins and growth regulators, which positively reflects on the state of plant growth and increases its productivity when using different salt concentrations [5].

2. Materials and Working Methods

A field experiment has been conducted at the College of Agriculture - University of Al-Muthanna (Al Bandar station 2 km from the center of Al-Muthanna Governorate), during seasons 2019-2020 and 2020-2021, to study the effect of four salinity levels of irrigation water (S1, S2, S3, S4) and four treatments. of Bio Fertilization (A, B, AB, C), and knowing its effect on some characteristics of growth and yield of wheat, the experiment was applied according to the strip block design with three replication, where the salinity levels of irrigation water were placed in the main plots and the Bio Fertilization was in secondary plots.

Experience factors:

The first factor: It includes the levels of salinity of irrigation water :

- S1 : 1ds m⁻¹
- S2: 3ds m⁻¹
- S3: 6ds m⁻¹
- S4: 9ds m⁻¹

The second factor: Bio Fertilization treatments, which included:

- A: Azospirillum brasilense.
- B: Bacillus sibiricus.
- AB: a mixture of Azospirillum brasilense and Bacillus sibiricus.
- C : (control Without adding).

2.1 Soil service operations

The field was plowed with the inverted plow twice, orthogonally, to a depth of approximately 30 cm. After that, the area was smoothed and leveled. Then was divided into experimental units with dimensions of 2 x 1 m². Each experimental unit included five lines with a length of 2 meters and the distance between the lines was 20 cm, and by (48 experimental units), the units were distributed. The experimental group was divided into three blocks, with 16 experimental units for each block, at a seeding rate of (120 kg H⁻¹), separated by a distance of 1 meter between each block, so that each experimental unit was irrigated separately, and urea fertilizer was added 200 kg N ha⁻¹ in two doses (seedling - tillers). 100 kg P₂O₅ hectare⁻¹ was added in the form of triple super phosphate fertilizer (20%P) in one dose when planting and 60 kg K ha⁻¹ [6] to the soil before planting, and irrigation water was prepared using a tank of 2000 liters. The draining water was used and the salinity level was adjusted using a ready-made Ec-meter. Seven irrigations were given during the growing season, and depending on the moisture content of the soil using gypsum cubes and measuring its water conductivity, wheat seeds (Ibaa 99 variety) were planted on 11/19/2019 and 11/16/2020 for the two seasons in succession, and at the end of the season the harvest was done. The plants of the experimental units were dated 04/22/2018 and 04/21/2019 for the two seasons, respectively, and hoeing and weeding were carried out whenever needed.

2.2 Studied traits

2.2.1 plant height (cm)

It was calculated as an Means of ten plants randomly selected in the flowering stage and the height was measured from the base of the plant to the tip of the terminal spikelet of the main stem.

2.2.2 number of tillers (m²)

It was calculated on the basis of the area harvested for each experimental unit and converted into number of tillers square meters.

2.2.3 Leaf flag area (cm^2)

It was calculated as an Means of ten plants taken randomly for each experimental unit in the two study seasons in the flowering stage, according to the equation:

$$\text{Area of the flag leaf} = \text{length of the flag leaf} \times \text{width of the widest area} \times \text{correction factor (0.95)} [7].$$

2.2.4 Number of spikes (m^2)

The number of spikes of the harvested plant group was calculated from the median lines.

2.2.5 Weight of 1000 grains (gm)

A random sample of grains was taken for each experimental unit and 1000 grains were counted and their weight was extracted.

2.2.6 Grain yield (tons h^{-1})

After conducting the threshing process of the sample harvested from an area of 0.8 square meters, the straw was separated and the grains were weighed, and the weight of the harvested area was converted to 1 ton ha^{-1} .

2.3 Statistical analysis

After collecting the samples, they were arranged, tabulated and analyzed statistically by means of the statistical program Gen.12, and the means were compared using the least significant difference (L.S.D) test at a probabilistic level of (0.05) [8].

3. Results and Discussion

3.1 Plant height (cm)

The data in Table (1) indicated that there were high significant differences in the plant height characteristic between the levels of salinity of irrigation water and Bio Fertilization and the interaction between them. The treatment (1 ds m^{-1}) excelled in this trait and gave the highest Means of 77.78 cm and 82.08 cm in both seasons, respectively, in comparison with treatment S4 (9 ds m^{-1}), which gave the lowest Means plant height of 62.17 cm and 58.25 cm and in both The two seasons respectively, and results agreed with the findings of [9] the irrigation of wheat plants with water of high saline levels reduced the amount of absorbed elements and decreased the growth rates of wheat, thus negatively affecting the plant height.

Bio Fertilization treatments had a significant effect on plant height, as the treatment Azospirillum (A) was superior and gave the highest Means of 76.03 cm and 77.76 cm in both seasons, respectively, compared to the control treatment (c) which gave the lowest mean of 60.17 cm and 59.00 cm in both seasons respectively, as these results agreed with [10] he found that the addition of Azospirillum bacteria led to a noticeable increase in plant height. The interaction between the two factors of the study in this trait had a significant effect on the plant height trait, as the interaction (A + S1) outperformed the plant height trait and gave two Means of 86.80 cm and 94.76 cm in both seasons, respectively, while the interaction (C + S4) gave The lowest Means plant heights were 55.33 cm and 51.67 cm in both seasons, respectively.

3.2 Number of tillers (tiller m^2)

The data in Table (2) indicated that there were high significant differences between the levels of salinity of irrigation water and Bio Fertilization and the interaction between them in the number of tillers m^2 . The effect of the salinity levels of the irrigation water was evident in the number of tillers in Table (2) as the levels differed significantly, and level S1 gave the highest Means number of tillers, reaching 358.5 m^2 tillers and 357.2 m^2 in both seasons, respectively, while level S4 gave the lowest two Means tillers m^2 . 264.6 m^2 and 223.1 m^2 in both seasons, respectively. These results also agreed with the findings [11] if it was mentioned that irrigation of wheat plants with saline water led to a decrease in the number of tillers formed in wheat plants.

The results of Table (2) indicated that there was a significant effect of the Bio Fertilization on the number of tillers per square meter, as the treatment of the Bio Fertilization B (Bacillus) was superior in the first season and gave the highest Means of 356.4 tiller per square meter, which did not differ significantly with the treatment of AB vaccine, which gave 350.1 While the

treatment without vaccine (C) gave the lowest Means of 239.2 tillers m^2 , while in the second season, the treatment of Bio Fertilization A excelled and gave the highest Means of 352.4 tillers m^2 compared with the control treatment C, which gave the lowest Means of 267.1 m^2 tiller. These results are with what was indicated by [12] if they mentioned that the addition of the Bio Fertilization to the wheat plant led to an increase in the number of tillers formed. (B+S1) in the first season and it gave the highest Means of 386.7 m^2 tiller, which did not differ significantly from the interaction (B+S3), which gave 378 m^2 tiller, while the interaction (C+S4) gave the lowest Means of 195.7 m^2 tiller, while in the second season it was The interaction (A + S1) outperformed and gave the highest mean of 3 . 90.7 m^2 tiller, while the interaction (C+S4) gave the lowest Means of 184.7 m^2 tiller.

Table 1. Effect of irrigation water levels and Bio Fertilization on plant height (cm) for the two seasons (2019-2020 and 2020-2021).

salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	86.80	73.33	75.00	69.00	76.03
S2	82.00	73.33	72.67	64.00	73.00
S3	78.33	73.67	71.33	60.33	70.92
S4	64.00	62.00	62.33	55.33	60.92
Means	77.78	70.58	70.33	62.17	
l.s.d _(0.05)	Bio Fertilization	3.36	Salinity 2.61	Bio Fertilization* Salinity 4.32	

salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	94.67	72.67	80.33	63.00	82.08
S2	88.00	77.00	75.33	60.33	70.50
S3	81.33	73.00	71.00	58.00	71.83
S4	64.33	59.33	60.67	51.67	58.25
Means	77.67	75.17	70.83	59.00	
l.s.d _(0.05)	Bio Fertilization	3.27	Salinity 2.01	Bio Fertilization* Salinity 5.35	

Table 2. The effect of irrigation water levels and Bio Fertilization on the character of the number of tillers in the two seasons (2019-2020 and 2020-2021).

salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	379.0	386.7	368.7	299.7	358.5
S2	349.7	353.7	357.0	229.0	322.3
S3	364.7	378.0	371.0	232.7	336.6
S4	251.7	307.3	303.7	195.7	264.6
Means	336.2	356.4	350.1	239.2	
l.s.d _(0.05)	Bio Fertilization	7.37	Salinity	Bio Fertilization*	Salinity
			8.20		12.41
salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	390.7	380.7	369.0	269.3	357.2
S2	360.3	345.3	345.0	215.3	347.8
S3	374.7	369.0	363.7	223.0	340.5
S4	303.3	296.0	284.3	184.7	223.1
Means	352.4	316.5	332.6	267.1	
l.s.d _(0.05)	Bio Fertilization	8.79	Salinity	Bio Fertilization*	Salinity
			7.68		26.71

3.3 Area of the flag leaf (cm^2)

The results indicated in Table (3) that there was a significant effect of the levels of salinity of irrigation water and Bio Fertilization and the interaction between them in the flag leaf area, it was found that treatment S1 was superior in the first season, as it gave the highest mean of 40.08 cm^2 , which did not differ significantly from treatment S3, which gave 39.25 cm^2 while treatment S4 recorded the lowest Means of 30.83 cm^2 in the first season. In the second season, treatment S3 excelled and gave the highest Means of 41.67 cm^2 while treatment S4 recorded the lowest Means of 30.92 cm^2 . Treatment B excelled in the first season and gave the highest mean of 41.75 cm^2 , which did not differ significantly from treatment AB, which gave 40.33 cm^2 , while treatment C4 recorded the lowest Means of 26.50 cm^2 , while in the second season, treatment AB excelled and gave the highest mean of 40.17 cm^2 compared to treatment C4. Which gave the lowest Means of 29 cm^2 . These results also agreed with [13] as they mentioned that the addition of the bacterial vaccine led to an increase in the area of the flag leaf.

As for the interaction in this trait between irrigation water salinity levels and Bio fertilization, the interaction (B + S3) was superior in the first season and gave the highest Means of 47.33 cm^2 , while the interaction (C + S4) recorded the lowest Means of 20.67 cm^2 , while in the second season the interaction outperformed (AB+S3) had the highest Means of 54 cm^2 , while the interaction (C+S4) recorded the lowest Means in the second season, which amounted to 26.67 cm^2 .

Table 3. The effect of irrigation water levels and Bio Fertilization on the character of the area of the flag leaf (cm^2) for the two seasons (2019-2020 and 2020-2021).

salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	40.33	47.33	41.33	31.33	40.08
S2	40	40.67	40	28.67	37.33
S3	41.33	47.33	43	25.33	39.25
S4	34	31.67	37	20.67	30.83
Means	38.92	41.75	40.33	26.50	
l.s.d _(0.05)	Bio Fertilization 1.15	Salinity 1.53		Bio Fertilization* Salinity 3.08	
salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	39	43	38.67	30.67	37.83
S2	37	38.67	33.67	27.67	34.25
S3	42.67	39	54	31	41.67
S4	31.67	31	34.33	26.67	30.92
Means	37.58	37.92	40.17	29.00	
l.s.d _(0.05)	Bio Fertilization 1.78	Salinity 2.74		Bio Fertilization* Salinity 4.48	

3.4 Number of grains per spike

The results of the statistical analysis in Table (4) indicated the significant effect of the levels of salinity of irrigation water and Bio Fertilization and the interaction between them in both seasons on the number of grains spike⁻¹. The results in Table (4) showed the superiority of treatment S3 and gave the highest Means of 32 and 34.42 grains of spike⁻¹ for the two seasons, respectively, while treatment S4 recorded the lowest Means, which were 22.92 and 22.75 grain spike⁻¹, in both seasons, respectively. Whereas, treatment C recorded the lowest Means of 24.50 and 23.92 grains of spike⁻¹ in both seasons, respectively. These results also agreed with the findings of [14] they mentioned that the wheat plant treated with Bio Fertilization has outperformed in the trait of the number of grains in the spike compared with no addition of Bio Fertilization. As for the interaction between salinity levels of irrigation water and Bio Fertilization in this trait, the interaction (AB+S3) was superior in this trait and gave the highest Means of 39 and 47 grains of spike⁻¹ in both seasons, respectively, while the interaction (C+S4) recorded the lowest Medium, 20 and 20 grains Spike⁻¹ and In both seasons in succession.

Table 4. Effect of irrigation water levels and Bio Fertilization on the number of seeds spike⁻¹ for the two seasons (2019-2020 and 2020-2021).

and 2020-2021):					
salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	30	31.33	31.67	30	30.75
S2	26.33	34.33	35.33	25.67	30.42
S3	32.67	34	39	22.33	32.00
S4	24	23.33	24.33	20	22.92
Means	28.25	30.75	32.58	24.50	
l.s.d _(0.05)	Bio Fertilization	Salinity		Bio Fertilization* Salinity	
	1.81	1.60		2.82	
salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	28	29.33	29.33	28.33	28.75
S2	25.33	30.33	35	24	28.67
S3	32.33	35	47	23.33	34.42
S4	22.33	21.33	27.33	20	22.75
Means	27.00	29.00	34.67	23.92	
l.s.d _(0.05)	Bio Fertilization	Salinity		Bio Fertilization* Salinity	
	3.09	2.37		4.10	

3.5 Weight of 1000 grains (g)

The results of the statistical analysis in Table (5) indicated that there were significant differences between the levels of salinity of irrigation water and the Bio Fertilization and the interaction between them in both seasons. respectively, while the level S4 recorded the lowest Meanss in this trait, reaching 21.17 and 22.17 g. Also, these results differed with the findings of [9] as they indicated that irrigating wheat with saline water led to a decrease in the area of the flag leaf. It was noticed when adding the Bio Fertilization a noticeable increase in the weight of 1000 grains, thus treatment B excelled in the first season and gave the highest Means of 33.83 g, while treatment C gave the lowest Means of 18.17 g. In the second season, treatment AB excelled and gave the highest Means of 24.67 g, while it recorded Treatment C had the lowest Means of 18.58 g. Also, these results were in agreement with the findings of [15] as they stated that the addition of the bacterial vaccine led to an increase in the weight of 1000 grains. As for the interaction between the levels of salinity of irrigation water and the Bio Fertilization, the interaction (B+S3) outperformed It gave the highest Meanss of 40 and 41.67 g in both seasons, respectively, while the interaction (C+S4) recorded the lowest Meanss of 15 and 14.67 g in both seasons respectively.

Table 5. Effect of irrigation water levels and Bio Fertilization on the weight of 1000 grains for the two seasons (2019-2020 and 2020-2021).

salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	32	35	27.33	21.33	28.92
S2	29.67	32.33	23.67	18.67	26.08
S3	21.67	40	22	17.67	25.33
S4	21.67	28	20	15	21.17
Means	26.25	33.83	23.25	18.17	
l.s.d(0.05)	Bio Fertilization 0.79	Salinity 1.20	Bio Fertilization* Salinity 1.73		
salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	30.67	36.67	28	21.67	29.25
S2	29.33	32.33	25.33	19.33	26.58
S3	23.67	41.67	23	18.67	26.75
S4	22	29.67	22.33	14.67	22.17
Means	26.42	35.08	24.67	18.58	

3.6 Grain yield (ton ha⁻¹)

The results indicated a significant effect of the levels of salinity of irrigation water and Bio Fertilization and the interaction between them on the biological yield in the first and second seasons (Table (6)). It was found from the data in Table (6) to the superiority of irrigation water level S3 in the total yield and gave the highest Meanss, which were 3.85 and 4.13 tons ha⁻¹ in both seasons respectively, which did not differ significantly from treatment S1 which gave 3.24 and 3.79 tons ha⁻¹ in both seasons respectively, compared to treatment S4, which gave the lowest Meanss of 1.73 and 1.89 tons ha⁻¹. These results also differed with what was indicated by [10] as they indicated that irrigating wheat with saline water led to a decrease in the yield. It was noted from the data of Table (6) to The presence of a significant effect of the Bio Fertilization, as treatment AB excelled and gave the highest Meanss, which amounted to 3.53 and 3.82 tons ha⁻¹ in both seasons, respectively, while treatment C gave the lowest Meanss, which amounted to 1.79 and 1.94 tons ha⁻¹ in both seasons, respectively.[7] As they indicated that the addition of the Bio Fertilization led to an increase in the wheat yield. As for the interaction in this trait, the interaction (AB+S3) outperformed and gave the highest Meanss of 4.76 and 5.3 tons ha⁻¹ in both seasons, respectively, which did not differ significantly from the interaction (B+S3) which gave 4.63 and 4.9 tons ha⁻¹ in both. The two seasons respectively, while the interaction (C+S4) gave the lowest Meanss of 1.33 and 1.46 tons ha⁻¹ in both seasons respectively.

Table 6. The effect of irrigation water levels and Bio Fertilization on the characteristics of the total yield of the two seasons (2019-2020 and 2020-2021).

salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	3.667	4.067	3.967	2	3.425
S2	3.3	3	3.367	2	2.917
S3	4.167	4.633	4.767	1.833	3.850
S4	1.633	1.967	2	1.333	1.733
Means	3.192	3.417	3.525	1.792	
l.s.d _(0.05)	Bio Fertilization 0.28	Salinity 0.32		Bio Fertilization* Salinity 0.52	

salinity concentrations (ds m ⁻¹)	2019-2020 season				Means
	Bio Fertilization				
	A	B	AB	C	
S1	4.333	4.2	4.267	2.367	3.792
S2	3.667	3.233	3.6	2	3.125
S3	4.4	4.9	5.3	1.933	4.133
S4	1.933	2.033	2.133	1.467	1.892
Means	3.583	3.592	3.825	1.942	
l.s.d _(0.05)	Bio Fertilization 0.40	Salinity 0.26		Bio Fertilization* Salinity 0.76	

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