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RESPONSE OF WHEAT YIELD TO SOME SOIL AMENDMENTS UNDER IRRIGATION WITH SALINE WATER

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ABSTRACT

Field experiments were conducted in two winter successive seasons (2020-2021 and 2021-2022) at the Soil Improvement and Conservation Research Department, Sakha Agricultural Research Station, Kafr Elsheikh Governorate. Egypt (located 6 meters above sea level, with latitude of 31° 05' 38" N and longitude of 30° 56' 53" E) The experiments aimed to evaluate the response of wheat yield and its components as well as some soil properties to some soil amendments i. e. fulvic acid (FA) and phosphogypsum (PG) under irrigation conditions that using irrigation saline water. A split-plot design with three replications was applied; six salinity levels of irrigation water were applied in the main plots, while three soil amendments including (without amendment, FA and PG) were tested in the sub-plots.

The results revealed that increasing irrigation water salinity led to significant reductions in wheat plant height, spike length, and 1000-grain weight, while the application of FA and PG mitigated these effects, enhancing these growth parameters. Similarly, grain yield, straw yield, and biological yield significantly decreased with higher salinity levels but were improved with the application of FA and PG The nutrient content (N, P, and K) in wheat plant grain also decreased with increased salinity but improved with the use of FA and PG. The relationships between grain yield as well as straw yield and salinity levels under some amendments were expressed in six equations namely:

Grain yield:

Linear: $GY_L = 2800 - 66.207x \qquad R2 = 0.9385$

Quadratic: $GY_Q = 2741.1 \ -16.062x \ -6.0098x2 \qquad R2 = 09681$

Straw yield:

Linear : $SY_L = 3508.1 - 154.28x \qquad R2 = 0.9611$

Quadratic: $SY_Q = 3506.1 \ - 152.59\,x \ -0.2024\,x^2 \qquad R^2 = 0.9611$

Where: GY_L , GY_Q, SY_L *and* SY_S, *are the grain and straw yield (kgfed^{-1})for linear and quadratic relationship under irrigation water salinity,* x *is irrigation water salinity level (dSm^{-1}).*

These fitted equations indicated that with respect to grain yield PG is more effective at lower salinity levels (below 6.59 dS/m), while FA is preferable at higher salinity levels (above 6.59 dS/m), however, resulting in a yield reduction Moreover, the results revealed that increasing irrigation water salinity led to significant reductions in wheat plant height, spike length, and 1000-grain weight, while the application of FA and PG mitigated these effects, enhancing these growth parameters. The nutrient content (N, P, and K) in wheat plant grain also decreased with increased salinity but improved with the use of FA and PG. emphasizing the critical importance of managing salinity and soil amendments for optimal wheat productivity.

Conclusively, *from the fitted equations of the relationships between grain yield and salinity levels under some amendments the study indicated that PG is more effective at lower salinity levels (below 6.59 dS/m), while FA is preferable at higher salinity levels (above 6.59 dS/m)*..

Keywords: Irrigation water salinity, PG, FA, amendments and wheat productivity.

INTRODUCTION

Water management at the field level for soils affected by salinity is crucial, especially in the presence of limited and low-quality irrigation water, to maximize resource use and improve crop productivity. This study aims to clarify the effects of varying irrigation water salinity and the application of some soil amendments on wheat yield components. Globally, salinity affects over 800 million hectares of land, accounting for 6% of the earth's total land area and 20% of the cultivated land area **(Munns and Tester, 2008)**. Soil salinity stress negatively impacts plant growth and development, leading to significant losses in cereal crop production worldwide (**Kumar *et al.*, 2022**). The expansion of saline regions is expected to increase due to the excessive use of saline water for irrigation, particularly in arid and semi-arid regions where evapotranspiration exceeds precipitation **(Jha *et al.*, 2019).** Wheat (***Triticum aestivum L.***), being the most important grain crop globally **(Igrejas and Branlard, 2020),** is directly impacted by these conditions. As the global population rises, the world's food supply must increase by 50% by 2050 **(Mora *et al.*, 2020).** In Egypt, where 1.39 million hectares are cultivated with wheat, producing 8.90 million tons annually **(Foreign Agricultural Service USDA, 2021),** soil and water salinity pose a significant threat to wheat productivity. For instance, wheat productivity decreases by 7.1% for each 1 dS/m increase in salinity above 6 dS/m **(Ayers and Westcot, 1985).** While using saline water for irrigation can reduce the demand for fresh water in salt-tolerant crops, it also affects crop yield depending on the degree of salinity, particularly during critical growth stages. Therefore, the use of saline water must be carefully managed to ensure safe and effective irrigation **(Rhoades *et al.*, 1991).** Salinity induces oxidative stress, nutrient imbalances, and hormonal irregularities in plants, which drastically reduce wheat production **(Kumar *et al.*, 2019 and Abdrabou *et al.*, 2022).** Additionally, using low-quality water in agriculture can increase soil salinity, both of which have detrimental effects on soil properties and crop yield **(Mostafa, 2001).** Organic matters, such as fulvic acid (FA), significantly improve soil properties by enhancing the availability of essential nutrients for plant growth. FA as a key component of organic matter is effective in enhancing root initiation and growth **(Pettit, 2004).** It has been shown to increase nutrient uptake when used in combination with fertilizers **(Yang *et al.*, 2013).** Phosphogypsum (PG), another soil amendment, improves soil structure by reducing surface crust formation and increasing soil permeability, which enhances water infiltration and reduces erosion **(Toma and Saigusa, 1997 and Amezkata *et al.*, 2005)**. The application of PG has been shown to improve wheat yield and quality by enhancing soil physico-chemical properties **(Meena *et al.*, 2019 and Al-Naser, 2018).** Previous researches has highlighted the adverse effects of low-quality water on soil and crop yield, which significantly reduce crop productivity **(Mostafa, 2001a, Zein *et al.*, 2012, Atwa *et al.*, 2013 and Seema Sahay *et al.*, 2013).** The primary objectives of this study were to evaluate the effects of irrigation water salinity.

Additionally it aimed to evaluate the response of wheat yield and its components to some soil amendments i. e. FA and PG irrigation saline water. That is making it a critical issue for sustainable agriculture.

MATERIALS AND METHODS

A field experiments were conducted during the two winter seasons of 2020-2021 and 2021-2022 at the Soil Improvement and Conservation Research Department, Sakha Agricultural Research Station, Kafr El Sheikh Governorate, Egypt (located 6 meters above sea level, with latitude of 31° 05' 38" N and longitude of 30° 56' 53" E) to investigate the effect of irrigation water salinity and some soil amendments, on wheat productivity, and various soil properties. Also the experiments aimed to evaluate the response of wheat yield and its components as well as some soil properties to some soil amendments i. e. fulvic acid (FA) and phosphogypsum (PG) under irrigation conditions that using irrigation saline water.

The experimental field 54 m², was divided into six plots, (1 m² for each), as an individual lyzimeter unit to accommodate the different irrigation water salinity treatments. The experiment followed a split-plot design, where the main plots were assigned to six levels of irrigation water salinity, (1.0, 2.5, 4.0, 5.5, 7.00, 8.5 dS/m) or ranging from S_1 (640 ppm) to S_6 (5440 ppm). The sub-plots were designated for soil amendment treatments, which include: control, A_1 (without amendments), A_2 fulvic acid (FA) applied at a rate of 4 kg / feddan (feddan = 4200 m^2) and A_3 phosphogypsum (PG) applied at a rate of 2 tons / feddan. The setup allowed for a comprehensive evaluation of how varying salinity levels and soil amendments influenced wheat growth and soil health under the experimental conditions.

Wheat seed of variety Misr 3 was planted on November 20th, 2020 and November 15th, 2021 seasons, N, P and K fertilizers were added according to the recommended doses at North Delta, EGYPT. N fertilizer was applied in the form of urea (46%.N) at the rate of 75 N Kg/ fed. in two equal doses. The 1st dose was applied before the 2nd irrigation; the 2nd dose was applied before the 3rd irrigation. P fertilizer the recommended dose was added in the form of Ca-superphosphate (15.5% P_2O_5) with soil preparation at rate of 100 kg/ fed. K fertilizer (recommended dose) was added in the form of potassium sulfate (48% K_2O) at the rate of 5o Kg/ fed in two equal doses at the same time of adding N fertilizer. PG and FA were added at rates of 2 ton/ fed. (Fed. =4200 m^2) and 4 Kg /fed., respectively in one dose before planting.

Plant height (cm) was measured at harvest time from the base plant to tip of the main spike of ten plants in each plot.

Soil analysis

Soil samples were collected from different layers and subjected to the following hydrophysico- chemical analysis according to **Richards (1954)** and **Jackson (1967).** Moisture parameters; Field capacity (FC) and permanent wilting point (PWP) were determined by pressure membrane method according to **Klute (1986).** Organic matter content (OM) was determined according to Walkley and Black method **(Hesse, 1971).** Soil bulk density (BD) was determined using cylindrical sharp edged samples. Each cylinder was pressed gently into the soil to the desired depth to obtain a known volume of the undisturbed soil. Samples were dried in oven at lost and the BD was calculated as g/ m^3 **(Vomocil, 1957).** Soil samples (0-20, 20-40 and 40-60 cm depth from each lyzimeter were taken before sowing to determine some chemical and physical properties of the experimental soil as shown in Tables (1and 2).

Wheat yield:

Grain yield (ton/ fed), determined by threshing the harvested area in each subplot and weighting the resulted grains. The straw yield (ton/ fed), was determined by the difference between biological yield and grains yield of the harvested area in each sub plot.

Table (1): Some physical properties of the experimental soil before the 1st growing season.

Soil depth (cm)	Particles size distribution %			Texture grade	OM %	Soil moisture characteristics			BD* g/cm^3
	Sand	Silt	Clay			FC*	PWP*	AW*	
0-20	18.65	29.53	51.82	clayey	1.65	42.12	21.10	21.02	1.15
20-40	17.91	29.46	52.63	clayey	1.53	41.85	19.91	21.94	1.24
40-60	17.35	28.53	54.12	clayey	1.18	37.17	18.75	18.42	1.31
Mean	17.97	29.17	52.86	clayey	1.45	40.38	19.92	2046	1.23

*FC = Field capacity, PWP = permanent welting point, AW = available water. And BD = bulk density**.**

Table (2): Some chemical properties of the experimental soil before 1st growing season.

Soil depth (cm)	pH*	EC** (dS/m)	ESP	SAR	Soluble cations (meq/ L)				Soluble anions (meq/ L)				Available nutrients (ppm)		
					Na^+	K^+	Ca^{++}	Mg^{++}	CO^-	HCO^{-3}	Cl^-	$SO4^{--}$	N	P	K
0-20	7.95	3.35	9.24	9.98	23.1	0.6	6.8	3.9	0	1.5	17.5	15.4	49.3	9.4	231
20-40	8.15	3.75	10.16	11.04	27.5	0.8	7.9	4.5	0	2.0	20.9	17.8	43.2	9.9	233
40-60	8.32	4.22	10.64	11.60	30.7	0.9	8.9	5.1	0	3.5	22.1	20.0	42.6	9.6	223
Mean		3.64	10.01	10.87	27.1	0.77	7.87	4.5	0	2.33	20.17	17.73	45.03	9.5	217

* pH was determined in soil water suspension (1:2.5).

** EC was determined in saturated soil paste extract.

Yield attributes :

Spike length (cm): ten main spikes were randomly selected, measured and their average was calculated to express spike length 1000- Grain weight: A random sample of 1000-grain was taken from each sub- plot hand counted and weighted.

Chemical components :

Grain and straw samples were taken at harvest time and washed by distilled water and dried in an oven at 70 C^o for 48 hrs. Ground, mixed and wet digested using hot sulfuric acid with repeated additions of 30% hydrogen peroxide (H_2O_2) as described by **Wolf (1982)** and analyzed as follows:

N in plant: was determined in the digested grain and straw by micro-Kjeldahl method as explained by **Hesse (1971).**

P Content: was determined by using hydroquinine method **(Snell and Snell,1967)**

K Content: was determined by using flame photometer **(Jackson 1967)**.

Irrigation water salinity

The irrigation water samples (diluted sea water) were taken to determine the validity of some criteria i.e. water salinity hazard (as measured by Electrical

Conductivity (EC_w), Potential salinity (PS), Soluble Sodium percentage (SSP), Sodium Adsorption Ratio (SAR), Sodium to Calcium Activity Ratio (SCaR),

Permeability Index (PI). Where concentrations of all ions have been expressed in mmolil. And these criteria were calculated as the following:

water Salinity hazard : while EC_w is an assessment of all soluble salts in irrigation water, (7,3.00 dS/m, classified to class 5 = unsuitable or severe). **(Mass, 1990, and Ayers and westcob, 1985).**

Potential salinity (PS): potential salinity (PS) was defined as the chloride plus half of the sulfate concentration. PS = $cl^- + 1/2\ SO_4$

The PS classification is as follows: permissible 5-20, 3-15 and 3-7, for soils of good, medium and low permeability, respectively (**Doneen 1964 and Gupta, 1990**). Soluble Sodium percentage (SSP): High sodium ion concentration in soil can take a tell on internal drainage patterns in soil as release of calcium and magnesium ions are facilitated due to absorption of sodium by clay particles. SSP was calculated using the following equation **(Todd, 1980):**

$$SSP = \frac{Na^+}{Na^+ + K^+ + Ca^{++} + Mg^{++}} \times 100$$

Water with SSP less than 60 is safe with little Sodium accumulations that will cause a breakdown of Soil's physical properties **(Fipps, 1998).**

Sodium adsorption ratio (SAR): is a measure of the sodicity of the soil. The SAR was calculated according to **USDA, (1954)** using the following equation:

$$SAR = \frac{Na^+}{((Ca^{++} + Mg^{++})/2)^{1/2}}$$

The SAR classes include, Low, S1 (3-10); medium, S2 (10-18), high, S3 (18-26); and very high, S4 (>26), which general classifications of irrigation water based upon SAR values.

Above 18 is unsuitable for continuous use, **(Ayers and Westcot, 1985).** Sodium to Calcium Activity Ratio (SCaR): SCaR can be calculated according to the relationships presented by **Gupta (1990)** in the following equation:.

$$SCaR = Na^+ / (Ca^{++})\ ½$$

On the basis of SAR/ SCaR, the irrigation waters may be classified in six classes of sodicity; non- sodic water, S_o (< 5); normal water, S_1 (5-10); Low sodicity water, S_2 (10-20); medium sodicity water, S_3 (20-30), high sodicity water, S_4 (30-40) and very high sodicity water, S_5 (>40).

permeability index (PI) : The (PI) given by the following formula **(USDA, 1954)** ; **Doneen, 1964):**

$$PI = \frac{Na^+ + (HCO_3)^{1/2}}{Na^+ + Ca^{++} + Mg^{++}} \times 100$$

The PI classification is as follows; Excellent (>75%), Good (25-75%) and Unsuitable (< 25%) (**AL- Amry, 2008**).

Sea water was diluted to EC_w, 1, 2, 4, 6 and 8 dS/m and fresh water as a control was used for irrigation are shown in Tables (3, 4 and 5).

Table (3): The volume of sea water for specific irrigation volume and EC_w according to its salt content in growing season 2020/2021.

EC dS/m	Sea water salinity gL^{-1}	Fresh water EC dS/m	Required EC of irrigation water (dS/m)	Required vol. per irri.(L)	Sea water required (L)
41.2	32.96	1.0	1.0	20	0
41.2	32.96	1.0	2.5	20	0.728
41.2	32.96	1.0	4.0	20	1.456
41.2	32.96	1.0	5.5	20	2.184
41.2	32.96	1.0	7.0	20	2.913
41.2	32.96	1.0	8.5	20	3.641

Wheat was planted and received five irrigations were applied during the growing season. The total applied water was 2261 m^3/fed and 2370 in the both seasons.

Table (4): Some criteria for the diluted sea water that used in irrigation.

Irrigation diluted water sea water	pH	EC (dS/m)	PS	SSP	SAR	SCaR	SAR/ SCaR	PI
S_1Fresh water	7.35	1.0	3.8	61.90	4.0	3.56	1.13	88.36
S_2 (1 dS/m)	7.61	2.5	7.05	62.96	5.29	4.69	1.13	81.33
S_3 (2 dS/m)	7.76	4.0	13.75	64.76	7.49	6.64	1.13	75.90
S_4 (4 dS/m)	7.85	5.5	29.15	65.86	10.59	9.38	1.13	71.96
S_5 (6 dS/m)	7.91	7.0	43.85	66.23	12.97	11.49	1.13	70.83
S_6 (8 dS/m)	7.98	8.5	57.30	66.34	14.96	13.27	1.13	70.48

PS=Potential salinity, SSP= Soluble Sodium percentage, SAR= Sodium Adsorption Ratio ,SCaR=Sodium to Calcium activity Ratio and PI= Permeability Index.

Table (5): Chemical analysis of different irrigation water salinity

Treat.	pH	ECw dS/m	SAR	Cations (meq/L)				Anions (meq/L)			
				Na^+	K^+	Ca^+	Mg^{+2}	CO_3^-	HC_{O3}	Cl^-	SO_4^-
S_1	7.35	1.0	4.00	3.9	0.5	1.2	0.7	--	1.5	2.8	2.0
S_2	7.61	2.5	5.29	6.8	0.7	2.1	1.2	--	2.0	2.8	3.5
S_3	7.76	4.0	7.49	13.6	0.8	4.2	2.4	--	3.0	5.3	8.5
S_4	7.58	5.5	10.59	27.2	0.9	8.4	4.8	--	3.5	9.5	17.3
S_5	7.91	7.0	12.97	40.8	1.0	12.6	7.2	--	4.5	20.5	26.5
S_6	7.98	8.5	14.97	54.4	1.2	16.8	9.6	--	6.5	30.6	36.4

Statistical analysis

Data were statistically analyzed using analysis of variance (ANOVA). Treatments means and significance of differences were calculated and presented using (LSD) according to **Duncan (1955).**

All statistical analyses were performed using analysis of variance technique by mean of CoHort Computer software.

RESULTS AND DISCUSSION

The aim of the present investigation is to promote and enhance the salt tolerance of wheat plant by some soil applications e. g. FA and PG under different levels of irrigation water salinity. Lyzimeter experiments in soil Improvement and Conservation Res. Dept. Sakha Agric. Res. station, Kafr- El-Sheikh Gov. Egypt during two successive winter Seasons (2020/2021, 2021/2022). The results of the study have been presented as follows:

1- Growth traits:

Plant height, spike length and 1000-grain weight of wheat plant at harvest as affected by irrigation water salinity, FA and PG in both Seasons are presented in Table (6).

1.1 - Effect of irrigation water Salinity:

The results in Table (6) show a significant decrease in the plant height values with increasing salinity levels of the used irrigation water in the both growing seasons. In The 1st season the average of plant height amounted the highest value (104.8 cm) when irrigating with S_1 (control), to 103.8, 101.3, 99, 96.7 and 94.4 cm at S_2, S_3, S_4, S_5 and S_6 respectively,. So it was decreased by 0.95, 3.31, 5.53, 7.73 and 9.89% with the same salinity levels Compared to S_1 in the 1st Season, respectively.

In the 2nd season, plant height of wheat significantly decreased by 1.15, 2.82, 3.45, 8.11 and 10.02%. at S_2, S_3, S_4, S_5 and S_6 dS/m Compared to S_1. The reason for the decrease in the average of plants height is due to the effect of salinity of irrigation water, where salty water causes harmful effects, including the osmotic pressure, the toxic effect, or the effect on the nutrition balance, as well as the effect on the enzymatic activity that plays an important role in bioactivities of the wheat plant, which negatively affected the average of plant height **(Al- Zubaidi, 1989).** The excessive salt appears to affect the growth and wheat yield by restricting nutrients uptake to extent that a deficiency take place. This may be due to a possibility that plants grown under saline condition utilize energy for osmotic adjustment process at expense of growth and the most important factor which is the high soil water potential, hence the water flow from soil to plant is very much limited under saline conditions **(Ragab *et al.*, 2008).**

Table (6) shows a significant decrease in the spike length with increasing irrigation water salinity, where the average spike length values (13.22 and 12. 33 cm) in the 1st and 2nd Seasons, respectively, when irrigation water S_1, (1.0 dS/m) and Lowest average spike length values (9.44 and 9.22 cm) when

Table (6): Plant height, spike length and 1000- grain weight as affected by irrigation water salinity, FA and PG during (2020/21 and 2021/22) seasons.

Treatments	Plant height (cm)		Spike length (cm)		1000- grain weight (g)	
	1st	2nd	1st	2nd	1st	2nd
Irrigation water salinity						
S_1	104.77 a	106.44 a	13.22 a	12.33 a	47.37 a	48.06 a
S_2	103.77 a	105.22 b	12.88 a	11.88 b	45.23 b	46.61 b
S_3	101.33 b	103.44 c	12.11 b	11.88 b	44.32 c	45.75 c
S_4	99 c	102.77 c	11 c	11.11 c	42.17 d	43.94 d
S_5	96.66 d	97.11 d	10.33 d	10.33 d	41.15 e	42.31 e
S_6	94.44 e	95.77 e	9.44 e	9.22 e	40.75 f	41.93 f
F-test	**	**	**	**	**	**
LSD 0.05	**1.067**	**0.96**	**0.55**	**0.344**	**0.23**	**0.286**
LSD 0.01	**1.55**	**1.37**	**0.79**	**0.49**	**0.33**	**0.41**
Soil amendments						
C	97.61 c	99.83 c	10.44 c	10.44 c	42.68c	43.81 c
FA	100.33 b	101.5 b	11.72 b	10.99 b	43.48b	44.65 b
PG	102.05 a	104.05 a	12.33 a	12.00 a	44.33 a	46.04 a
F-test	**	**	**	**	**	**
LSD 0.05	**0.595**	**0.41**	**0.42**	**0.508**	**0.198**	**0.23**
LSD 0.01	**0.81**	**0.56**	**0.57**	**0.69**	**0.27**	**0.31**

Note: Means of each factor designated by the same letter in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT).

using irrigation water at the level of S_6 (8.5 dS/m) in the 1st and 2nd Seasons respectively. High salt concentration in the soil solution reduces the ability of plants to uptake water, known as the osmotic or drought effects of salinity. The damage occurs when the concentration of salts is high enough to reduce plant growth **(Machado and Serralheiro, 2017).**

Data shows that the weight of 1000 grains of wheat plants was significantly decreased with increasing the irrigation water salinity levels, where the average weight of 1000-grain amounted the highest values (47.37 and 48:06 g) at S_1 and the lowest values (40.75 and 41.939) where obtained with S_6 (8.5 dS/m) in the 1st and 2nd seasons, respectively . Fresh water is the best option for optimum plant growth but the scarcity or shortage of fresh water is compelling researchers to investigate the use of low-quality water using diluted sea water for agricultural deserves attention nowadays or future production to satisfy the needs of continuous growing population and water scarcity in Egypt. However caution in the practice of over- irrigation with salty water should be held to avoid deleterious impact, but the soil studies in this field are still little in Egypt. **(Amer, *et al.*, 2017).**

1.2 - Effect of fulvic acid (FA) and phosphogypsum (PG):

Data presented in Table (6), indicated that the plant height, spike length and weight 1000-grain of wheat were significantly increased by the application of FA and PG in both seasons. The data indicated that the plant height was highly significantly increased by addition of FA and PG in the 1st season (100.33 and 102.05 cm) and in the 2nd season (101.5 and 104.05 cm) respectively, compared with the control, (97.61 and 99.83 cm in both seasons, respectively)

Data also, revealed that the application of FA and PG had significant effect on increasing of spike Length of wheat plants. Where spike length recorded the highest values (11.72 and 12.33 cm) with application of FA and PG in the 1st season, respectively. In The 2nd season, the highest values of spike length were 10.94 and 12.0 cm with both soil amendments, respectively.

The data shows that the weight of 1000-grain of wheat plants significantly affected by the application of FA and PG in the two study seasons that gave the highest values (43.48 and 49.33) in the 1st season and (44.65 and 46.04 g) in the 2nd seasons, respectively. These results are in agreement with those obtained by **yang *et al.*, (2013), Gomaa, *et al.*, (2019), Muhanbet *et al.*, (2016), and Bossolani *et al.*, (2012).**

The positive effect of FA on plant growth may be attributed to its increase in fertilizer efficiency or enhancement of plant biomass **(Ahmad *et al.*, 2018),** and FA may augment the plant growth characteristics, nutrient uptake and reduce the perception of harmful components and improve plant metabolism **(Sootahar *et al.*, 2019),**

1.3 - ***Interaction effect of irrigation water salinity and FA and PG.***

Regarding the interaction of irrigation water salinity and soil amendments; FA and PG, there was a significant effect on those traits in the 2nd season. The results in Table (7) showed that the highest mean values of plant height (104.66 and l06.44 cm), spike length (13.33 and 12.66 cm) and 1000-grain weight (47.27and 47.83) were obtained with S_1 and soil application of FA in the both seasons, respectively.

Regarding the interaction of irrigation water salinity and PG on these traits; mean values of plant height (107 and 108.66 cm), spike length (13.66 and 12.66 cm) and 1000-grain weight (48.46 and 50.1g) were obtained by S_1 and PG in the both seasons, respectively.

On the other hand, soil application of FA and PG with fresh irrigation water S_1 increased these yield components (plant height, spike length and 1000-grain weight) as compared with the untreated plots irrigated with saline water only in the both seasons. These results are in the same Line with those recorded by **Gomaa, *et al*, (2019), Sary *et al*, (2011) and Sootahar *et al.*, (2022).**

Table (7): Interaction effect of irrigation water salinity and FA and PG on plant height, Spike length and 1000-grain weight of wheat in 2020/2021 and 2021/ 2022 seasons.

Treatments		**Plant height (cm)**		**Spike length (cm)**		**1000- grain weight (g)**	
Irrig. water salinity	**Soil amend.**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
S_1	Cont.	102.66d e	104.66 c	12.66 abc	11.66 ab	46.34 c	46.25 d
	FA	104.7 bc	106.44 b	13.33 ab	12.66 a	47.23 b	47.83 b
	PG	107 a	108.66 a	13.66 a	12.66 a	48.46 a	50.1 a
S_2	Cont.	101.66 ef	103.33 de	12.33 bcd	11.33 abc	44.53 d	45.73 d
	FA	104.c d	104.66 c	12.66 abc	11.66 ab	45.23 d	46.2 d
	PG	105.66 ab	107.66 a	13.66 a	12.66 a	45.29 c	47.9 b
S_3	Cont.	97.66 ij	102.33 ef	11.33 de	11.33 abc	43.43 f	44.5 e
	FA	102 ef	102.66 e	12.33 bcd	11.66 ab	44.5 e	45.8 bd
	PG	104.33 bc	105.33 bc	12.66 abc	12.66 a	45.03 e	46.9 c
S_4	Cont.	97.00 ij	101.33 fg	9.66 fg	10.33 bcde	41.67 h	42.9 g
	FA	99.33 gh	102.66 e	11.66 cde	10.66 bcd	42.07 h	43.86 f
	PG	100.66 fg	104.33 cd	11.66 cde	12.33 a	42.8 g	45.06 e
S_5	Cont.	94.66 i	93.66 j	8.66 gh	9.66 de	41.13 j	41.16 j
	FA	97.0 j	96 i	10.66 ef	10.00 cde	41.43 ij	42.16 hi
	PG	98.33 hi	97.66 h	11.66 cde	11.33 abc	41.66 hi	43.6 f
S_6	Cont.	92 m	93.66 j	8 h	8.33 f	39.9 k	41.13 j
	FA	95 kl	97 hi	9.66 fg	9 ef	40.16 k	41.96 i
	PG	96.33 ik	100.66 g	10.66 ef	10.33 bcde	40.93 j	42.79 gh
F-test		**ns**	**	**ns**	**ns**	**ns**	**
LSD 0.05		**1.45**	**1.01**	**1.038**	**1.26**	**0.485**	**0.579**
LSD 0.01		**1.98**	**1.37**	**1.41**	**1.69**	**0.66**	**0.77**

Note: Means of each factor designated by the same letter in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT)

2. Wheat yield:
2.1 - Grain yield:
2.1.1- Grain yield as affected by irrigation water salinity.

As shown in Table (8) and Figure (2), it is clear that there is a significant decrease in wheat grain yield with increasing of irrigation water salinity in both growing seasons. In the 1^{st} season the highest grain yield (2946 Kg/ fed) was recorded with fresh water (S_1) but it was decreased to 2861, 2786, 2768, 2607 and 2356 Kg/ fed with S_2, S_3, S_4, S_5 and S_6 respectively. Wheat grain yield was decreased by 2.89, 5.43, 6.04, 11.51 and 20.03% with S_2, S_3, S_4, S_5 and S_6 compared to S_1 in the 1^{st} season, respectively. In the second season, grain yield of wheat significantly decreased by 2.79, 4.45, 7.10, 17.79 and 18.99% at S_2, S_3, S_4, S_5 and S_6 respectively compared to S_1.

Table (8): Grain yield, straw yield and biological yield as affected by irrigation water salinity and soil amendments during 2020/21 and 2021/20 22 seasons.

Treatments	Grain yield (kg/ fed)		Straw yield (kg/ fed)		biological yield (kg/ fed)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation water salinity						
S_1	2946 a	3013 a	3629 a	3711 a	6575 a	6724 a
S_2	2861 b	2929 ab	3431 b	3557 b	6292 b	6486 b
S_3	2786 c	2874 bc	3228 c	3292 c	6014 c	6166 c
S_4	2768 c	2799 c	3046 d	2955 d	5814 d	5754 d
S_5	2607 d	2477 d	2856 e	2775 e	5463 e	5252 e
S_6	2356 e	2441 d	2438 f	2597 f	4794 f	5038 f
F-test	**	**	**	**	**	**
LSD 0.05	**29.61**	**91.22**	**59.07**	**36.28**	**62.77**	**53.12**
LSD 0.01	**42.126**	**129.76**	**84.027**	**89.68**	**89.3**	**76.55**
Soil amendments						
Cont.	2562 c	2666 c	2960 c	3006 c	5522 c	5662 c
FA	2760 b	2655 b	3128 b	3167 b	5888 b	5922 b
PG	2839 a	2853 a	3227 a	3269 a	6066 a	6122 a
F-test	**	**	**	**	**	**
LSD 0.05	**12.91**	**66.18**	**29.15**	**17.67**	**30.26**	**24.8**
LSD 0.01	**17.49**	**89.68**	**39.51**	**23.95**	**41.01**	**33.61**

Notes: S_1, S_2, S_3, S_4, S_5, S_6 are salinity levels with ECw = 0.58, 1, 2, 4, 6 and 8 dS/m, respectively. Means of each factor designated by the same letter in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT**).**

The reason for the yield decreases may be attributed to the role of irrigation water salinity in increasing soil salinity and which negatively affects plant growth through the osmotic effect of soil solution, leading to the inability of the plant roots to photosynthesis, thus leads to decrease grains yield. These results were agreed with those obtained by **Hussein *et al*., (2019), Amer *et al*., (2017), Aiad. *et al*., (2017) and Nassar *et al*., (2014).**

The accumulation of salt in the root zone causes the development of osmotic stress and alters the homeostasis of cell ions by inducing both the inhibition of uptake of the essential elements such as k^+, Ca^{++} and Mg^{++} and the accumulation of Na and Cl **(Ahanger and Agarwal, 2017).** Negative effects of salinity on shoot and root of wheat were stated to be observed with S_6. The salts in irrigation water and the soil solution have many effects on plant growth and grain yield, including direct and indirect effects. Direct effects appear in the absorption of water by the plant, sense increasing the salt concentration increases the osmotic pressure in the soil solution. This leads to a lack of water absorption by the plant, in addition to that the salts in the soil solution lead to an imbalance in the absorption of nutrients needed by the plant, where. The salts and their components of different ions have a direct impact on the plant through the competition of those ions with some of the necessary nutrients that lead to reduce the absorption of important ions needed by the plant. As for the indirect effects, they are mainly related to the changes in the soil physical and chemical traits, and then on the growth and productivity of plants **(Saleh and Hassan 1998) .**

2.1.2 - Grain yield as affected by FA and PG:

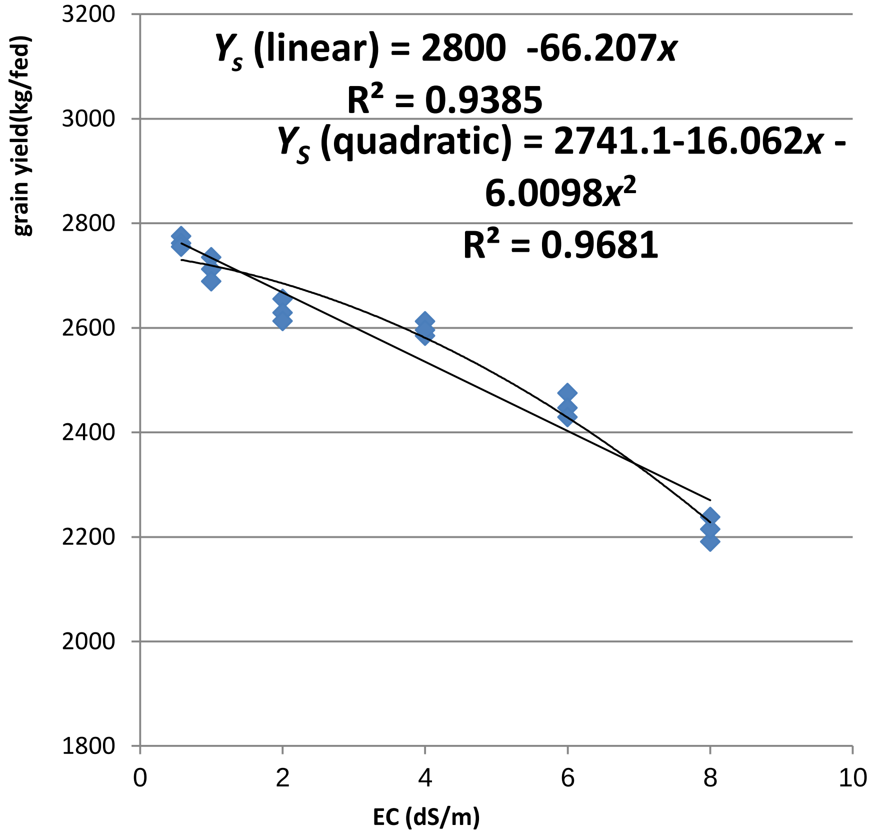
Data in Table (8) and Figure (2) indicated that a significant improvement in the grain yield of wheat with application of FA in the both Seasons was obtained. Consequently, the highest grain yield (2760 and 2655 kg/fed), were observed in the 1st and 2nd Seasons, respectively. FA as an organic fertilizer stimulates plant productivity and contributes towards cation exchange capacity of the soil **(Malan, 2015) and (Yang *et al.,* 2013)**, who demonstrate FA as the optimum choice for the improvement of P availability and soil physicochemical conditions.

Rasool *et al.,* (2015) recommended that the application of humic acid and FA increased wheat yield and yield components. The foliar application of liquid form of FA is more effective for plant growth and metabolic sites in plant cells because they contain many small microbes, which polarized the soil and available nutrients to plants **(Robert, 2014).** Humic substances enter as supplement source for polyphenols in the early stages of plant growth, which acts a respiratory chemical mediator and that leads to an increase in the biological activity of the plant as a result of the increase in the effectiveness of the enzymatic system that increase in cell division. The development of the root system and the production of dry matter is increased **(Arjumend *et al.,* 2015).**

The data in Table (8) and Figure (2) indicated that the soil application PG had positive and significant effects on the wheat grain yield in both seasons. The highest grain yields (2839 and 2853 kg /fed) were obtained in soil application PG in the 1st and 2nd seasons, respectively . PG application resulted higher yield of rice and wheat over the equivalent dose of mineral gypsum **(Nayak *et al.,* 2009).**

2.1.3 - Interaction effect of irrigation water salinity and FA and PG on grain yield:

Figure (1) showed that the interaction of irrigation water salinity and FA had a significant impact on wheat grain yield in the 1st season. The highest mean values of grain yield (2945 and 2992 kg/ fed) were obtained by irrigating S_1 with FA in the both seasons. The grain yield of wheat was significantly impacted by the interaction between irrigation water salinity and PG, where the highest mean values of grain yield (3128 and 3196 kg/ fed) were obtained by irrigation water S_1 (control) and soil application of PG in the both seasons. On the other hand, soil application of FA and PG with fresh water (S_1) increased grain yield compared to that the untreated plots (without soil amendments) .



Fig(1): Effect of irrigation water salinity on wheat grain yield

Data in Fig (2) presented the effect of interaction of irrigation water salinity and soil amendments (FA and PG) on grain yield and showed that Increased salinity of irrigation water has a detrimental effect on wheat grain yield, but adding FA and PG have a positive effect on grain yield.

The relationships between grain yield and salinity levels was expressed in two equations and fitted in linar and quadratic formula as follows:

Linear: $GY_L = 2800 - 66.207x$ $\quad$ $R2 = 0.9385$

Quadratic: $GY_Q = 2741.1 \ -16.062x \ -6.0098x2$ $\quad$ $R2 = 09681$

Where: GY_L and GY_Q are the grain yield (kgfed^{-1}), under irrigation water salinity, x is irrigation water salinity level (dSm^{-1}).

These fitted equations indicated that, with respect to grain yield, it is predicted that PG is more effective at lower salinity levels (below 6.59 dS/m), while FA is preferable at higher salinity levels (above 6.59 dS/m).

*2.2- **Straw yield:***

*2.2.1 - **Effect of irrigation water salinity.***

Data in Table (8) and Fig (2) show that there is a significant decrease in wheat straw yield with increasing salinity levels of irrigation water in the both growing seasons. In the 1st season the highest straw yield (3629 Kg fed) was amounted with fresh water S_1 (control), then it was decreased to 3431, 3228, 4646, 2856 and 2438 Kg/fed with S_2, S_3, S_4, S_5 and S_6 respectively. Straw yield of wheat in the 1st season was decreased by 5.46, 11.03, 16.07, 21.3 and 32.82% with S_2, S_3, S_4, S_5 and S_6, respectively compared to S_1, while in the 2nd season, it was significantly decreased by 4.15, 11.29, 20.81, 25.22 and 30.102% with S_2, S_3, S_4, S_5 and S_6, respectively compared to S_1.

3.2.2.2 - *Effect of Soil amendments (*FA *and* PG*):*

The results in Table (8) and Fig (2) show a significant increase in the straw yield of wheat plants with soil application of FA. Where, the highest straw yield (3128 and 3167 kg/fed), were observed when applying FA in the both seasons, respectively.

Also, the data indicated that soil application of PG had positive significant effect on wheat straw yield in both seasons. The highest straw yield (3221 and 3269 kg/ fed) in both seasons were obtained with soil application of FG in the 1st and 2nd seasons, respectively.

3.2.2.3 - Interaction effect of irrigation water salinity and FA and PG on straw yield:

Data in Table (8) and Figure (2) showed that the interaction of irrigation water salinity and FA had a significant effect on wheat straw yield in both seasons. The highest mean values of straw yield in the both seasons (3630 and 3704 kg/fed, respectively) were obtained with fresh water and soil application of FA. The straw yield of wheat was significantly impacted by the interaction between irrigation water salinity and PG in both seasons where the highest mean values in the both seasons (7221 and 3814 kg/fed, respectively) were obtained with S_1 (control) and soil application of PG.

The relationships between straw yield and salinity levels were expressed in two equations namely; linear and quadratic formula as follows:

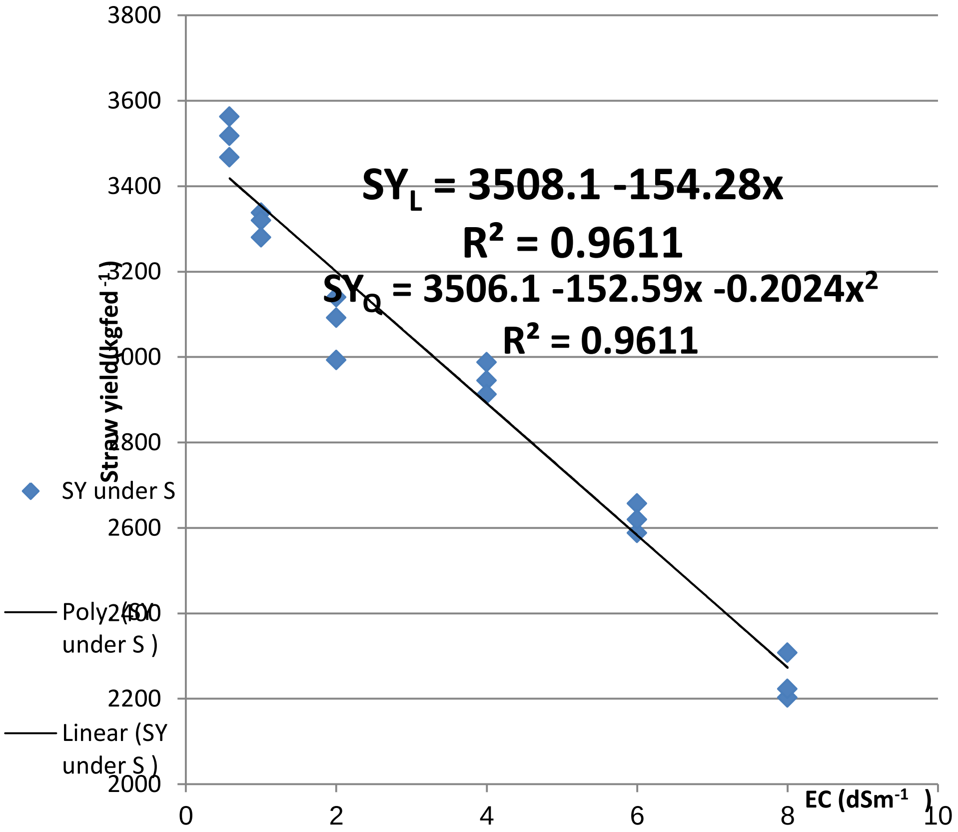
$$\textit{Linear}: SY_L = 3508.1 - 154.28x \qquad R2 = 0.9611$$

$$\textit{Quadratic}: SY_Q = 3506.1 - 152.59x - 0.2024x^2 \qquad R^2 = 0.9611$$

Where: SY_L and SY_Q, are the straw yield (kgfed^{-1}) for linear and quadratic relationships, respectively, x is irrigation water salinity level (dSm-1).

2.3 .Biological yield:

Biological yield as affected by irrigation water salinity and soil amendments in the two seasons is presented in Table (8).



Fig(2): Effect of irrigation water salinity on wheat straw yield for linear and quadratic relationships

2.3.1 - Effect of irrigation water Salinity:

Wheat biological yield was affected with increasing salinity levels, where the average biological yield amounted its highest value (6513 and 6124 kg/fed) with fresh water (S_1), while the lowest biological yields (4794 and 5038 Kg fed^{-1}) were recorded with S_6 (8 dSm^{-1}) in the 1st and 2nd seasons, respectively.

2.3.2 - Effect of FA and PG:

A biological yield was significantly increased by the FA application in both seasons (Table 9) Also, data indicated that the highest biological yield in both seasons (5888 and 5922 Kg/ fed, respectively), were observed with FA. The results indicated also that the soil application of PG had positive significant effect on wheat biological yield in the both seasons. The highest biological yields in both seasons (6066 and 6122 Kg /fed, respectively), were obtained with FG. These results are agreed with that of **Al- Naser *et al*., (2018), AL-Juboori *et al*., (2019)** and **Bossolani *et al*.,(*2022*).**

2.3.3-Interaction effect of irrigation water salinity and soil amendments on wheat biological yield.

Data in Table (8) and Fig (3) show that the effect of interaction of irrigation water salinity and FA had a significant impact on biological yield of wheat plant in both seasons. The highest mean values of biological yield (6515 and 6696 kg /fed) were obtained with the fresh water (S_1) and FA, in both seasons, respectively. Organic acids are formed by decomposition of plants in soil **(Morales *et al.*, 2012)** which In generate from FA (FA) and humic acid (HA). These organic acids are called as humic substances and constitutes 60 to 70% of total organic matter. FA has a lower molecular weight than HA, however, former has more oxygen and carbon- poor functional groups **(weng *et al.*, 2006).** It is known that FA increases nutrient uptake from soil and resistance to drought in plants. It shows significant effects in reducing fertilizer usage and stabilizing soil pH **(Aiken *et al.*, 1985).** The application of FA to the leaves increased the seedling growth and the root weight of the wheat plants, **(Katkat *et al.*, 2009) .** The biological yield of wheat was Impacted by the Interaction between soil application of water salinity and PG In the both seasons .The highest mean values of biological yield (6849 and 7010 kg fed) were obtained by irrigation fresh water (S_1) treatment and soil application of PG in the first and second seasons respectively**. (AL- Naser *et al.*, 2018).**

4 - N, P, and K contents in wheat grain:

***4.1 - Effect of Irrigation water Salinity on N, P and K in wheat grain:** .*

Results presented in Table (9) show that N, P, and K contents in grain wheat was significantly decrease with increasing salinity levels of the irrigation water in the first and second seasons. The highest N, P and K content (3.19, 4.54%), (0.28 and 0.312) and (1.28 and 1. 30 %.) in both seasons, respectively when using S1 (control), while The lowest N, P, and K (2.43, 2.89%), (0.16 and 0.21%), (1.125 and 0.90%) In the 1st and 2nd Seasons, respectively, when using Irrigation water at the level at 56 (8 dS/m-1 equal 6400 ppm), respectively. The obtained results agree with those reported in wheat plant by **Ragab *et al.*, (2008), Mojid *et al.* (2013), Nasser,(2014), and Aiad, *et al.*. (2017).**

*4.2 - **Effect of FA and PG on N, P and K.**:*

Data in Table (9) show that the application of FA significantly increased N, P and K. contents. The highest contents of N (2.83, 3.92%), P (0.24 and 27%) and K (1.15, 1.047) were obtained by adding FA in both seasons,

Table (9): Available N, P and K concentration in wheat grain as affected by irrigation water salinity and soil amendments (FA and PG) during 2020/21 and 2021/22 seasons.

Treatments	N %		P %		K %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Irrigation water salinity (s)						
S1	1.8182 a	1.9987 a	0.28 a	0.31 a	1.28 a	1.30 a
S2	1.6743 b	1.8045 b	0.27 b	0.30 b	1.15 b	1.09 b
S3	1.5900 c	1.7929 c	0.26 c	0.283 c	1.138 c	1.05 c
S4	1.5664 d	1.6802 d	0.24 d	0.28 d	1.133 d	1.05 c
S5	1.5313 e	1.5727 e	0.22 e	0.263 e	1.13 e	1.02 d
S6	1.3798 f	1.2747 f	0.16 f	0.21 f	1.125 f	0.90 e
F-test	**	**	*	*	**	**
LSD 0.05	**0.0066**	**0.004007**	**0.000563**	**0.000629**	**0.0027**	**0.0025**
LSD 0.01	**0.0536**	**0.005699**	**0.000802**	**0.000896**	**0.004**	**0.0037**
Soil amendments						
C	1.4804 c	1.4604 c	0.22 c	0.25 c	1.15 c	1.001 c
FA	1.6112 b	1.7247 b	0.24 b	0.27 b	1.15 b	1.0468 b
PG	1.6884 a	1.8767 a	0.26 a	0.30 a	1.17 a	1.07 a
F-test	**	**	*	*	**	**
LSD 0.05	**0.002577**	**0.0058**	**0.000356**	**0.000395**	**0.0017**	**0.0015**
LSD 0.01	**0.003493**	**0.0349**	**0.000483**	**0.000536**	**0.0024**	**0.0022**

Note: Means of each factor designated by the same letter in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT)

respectively. The application of FA substances increases root mass and volume, which are the main factor controlling the nutrient uptake **(Eyheraguibel *et al.*, 2008).** The FA substances have hydrophobic and hydrophilic surface, which interact with the phospholipid structures of cell membranes and a nutrient carrier Therefore, this characteristic of FA substances is closely related to the uptake of macro elements N, P, and S **(pettit, 2004).** Also, **Mansoor *et al.*, (2014)** suggested that the application of humic acid and FA improved soil nutrients availability. The obtained results agreed with those reported by **Manal *et al.*, (2016), Kenawy (2017),** and **Dinesoy and Sonmez (2019).** Humic substances increase the conversion of nutrients (N, P, K, Ca, Mg, Fe, Zn, Mn, and Cu) into the available forms to plants.

Humic fertilizers are known for their effectiveness because of their effects on the physical, chemical and biological properties of soil **(Sary and hamed 2011).** According to the results In Table (10), the soil application of PG had positive and significant effects on nutrient contents, including N, P, and K% in wheat grains. The highest N, P, and K contents in the 1st season (2.96, 0.26 and 1.17%, respectively) and in the 2nd season (4.26, 0.30 and 1.07,

Table (10): Interaction effects of irrigation water salinity and soil amendments (FA and PG) on available N, P, and K(%) in wheat grains in 2020/21 and 2021/22 seasons.

Treatments		**N%**		**P%**		**K%**	
Irri. water salinity	**soil conditi oners**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
S_1	Cont.	3.086 c	4.28 e	0.28 b	0.29 e	1.28 c	1.08 e
	FA	3.25 b	4.60 b	0.29 a	0.32 c	1.29 b	1.10 c
	PG	3.26 a	4.74 a	0.29 a	0.34 a	1.39 a	1.11 b
S_2	Cont.	2.66 j	3.97 g	0.26 d	0.28 f	1.14 g	1.07 g
	FA	2.92 e	3.83 i	0.27 c	0.29 e	1.13 gh	0.97 j
	PG	3.25 b	4.40 d	0.29 a	0.33 b	1.18 d	1.02 h
S_3	Cont.	2.61 k	3.32 j	0.24 f	0.26 h	1.12 k	1.08 e
	FA	2.827g	4.23 f	0.25 e	0.27 g	1.13 hi	1.13 a
	PG	2.95 d	4.74 a	0.29 a	0.32 c	1.16 e	1.13 a
S_4	Cont.	2.57 i	2.91 m	0.21 h	0.25 i	1.12 k	0.98 i
	FA	2.27 h	3.98 g	0.24 f	0.28 f	1.13 ij	1.06 g
	PG	2.91 e	4.56 c	0.28 b	0.31 d	1.15 f	1.11 b
S_5	Cont.	2.51 n	2.86 n	0.19 i	0.24 j	1.12 k	0.95 k
	FA	2.68 i	3.88 h	0.23 g	0.26 h	1.13 hi	1.11 b
	PG	2.87 f	3.97 g	0.25 e	0.29 e	1.14 g	1.09 d
S_6	Cont.	2.18 o	2.55 o	0.15 i	0.19 m	1.12 k	0.85 n
	FA	2.53 m	2.97 i	0.16 k	0.21 i	1.12 jk	0.91 m
	PG	2.56 i	3.17 k	0.18 j	0.23 k	1.13 hi	0.94 i
F-test		**	**	**	**	**	**
LSD 0.05		**0.00584**	**0.00631**	**0.00087**	**0.00097**	**0.00430**	**0.03946**
LSD 0.01		**0.00791**	**0.00856**	**0.00118**	**0.00131**	**0.00583**	**0.00530**

Notes: S_1, S_2, S_3, S_4, S_5, S_6 are salinity levels with ECw = 0.58, 1, 2, 4, 6 and 8 dS/m, respectively Means of each factor designated by the same letter in a column are not significantly different at 0.05 level using Duncan's Multiple Range Test (DMRT

respectively), were observed by adding PG. The obtained results were agreed with those reported by **Al- Naser, (2018), Al- Jubeori, *et al,* (2019)** and **Bossolani *et al*., (2022)** in wheat plant.

*4.4.3 - **Interaction effects of Irrigation water salinity and FA and PG on N, P, and K contents of wheat grain**:*

Results in Table (10) indicated that the Interaction between of irrigation water salinity, and FA significantly affected the nutrient Content including N, P, and K in grains wheat plants . The highest N, P, and K Contents in the first season were (3.25, 0.29 and 1.29%), respectively, while in The Second Season were (4. respectively), were recorded in 4 kg/ fed-1 under irrigating. water fresh (control S_1 = 0.58dS/m equal 371ppm.

The nitrogen, phosphorus, and potassium in grains of wheat were significantly impacted by the interaction between soil application of irrigation water salinity and phosphogysum in both seasons, where the highest mean values of N, P, and K Contents in first season were (3.26, 0.29, and 1.30%) respectively, while in the second season were (4.74, 0.34 and 1.11% respectively) were obtained by irrigation water (Fresh water) and Soil application of PG at the rate 2 ton fed-1, respectively, on the other hand, soil application of FA at the rate 4Kg fed-1 and phosphogypsum at rate of 2 ten had with irrigation fresh water increased N, P, and K content of grains of wheat plants as compared with other irrigation water salinity treatments and untreated plots (without FA and PG) in both seasons.

Conclusively, from the fitted equations of the relationships between grain yield and salinity levels under some amendments the study indicated that PG is more effective at lower salinity levels (below 6.59 dS/m), while FA is preferable at higher salinity levels (above 6.59 dS/m)**..**

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استجابة محصول القمح لبعض المحسنات الارضية تحت ظروف الري بمياه مالحة

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. تم إجراء تجربة حقلية على مدار موسمي الشتاء ٢٠٢٠-٢٠٢١ و٢٠٢١-٢٠٢٢ في قسم بحوث تحسين وصيانة الاراضي بمحطة البحوث الزراعة بسخا، مركز البحوث الزراعية. مصر ، تهدف هذه الدراسة إلى تقييم تأثير مستويات ملوحة مياه الري المختلفة بالإضافة الي دراسة استجابة محصول القمح وبعض خواص التربة الي بعض محسنات التربة (مثل : حامض الفولفيك والجبس الفوسفاتي) على إنتاجية القمح وخصائص التربة ، تم استخدام تصميم القطاعات المنشقة مع ثلاث مكررات، حيث تم تطبيق ست مستويات من الملوحة في القطع الرئيسية، بينما تم اختبار محسنين بالاضافة الي الكنترول (بدون إضافة) محسنات للتربة (بدون اضافة محسنات وإضافة حمض الفولفيك والفوسفوجيبسوم) في القطع الفرعية.

أظهرت النتائج أن زيادة ملوحة مياه الري أدت إلى انخفاض كبير في ارتفاع نبات القمح وطول السنبلة ووزن ألف حبة، بينما ساعدت إضافة حمض الفولفيك والفوسفوجيبسوم في التخفيف من هذه التأثيرات، مما عزز هذه الصفات الزراعية. وبالمثل، انخفض محصول الحبوب ومحصول القش والمحصول البيولوجي بشكل كبير مع ارتفاع مستويات الملوحة، لكن تحسنت مع إضافة حمض الفولفيك والفوسفوجيبسوم. كما انخفضت محتويات العناصر الغذائية (النيتروجين، الفوسفور، والبوتاسيوم) في حبوب القمح مع زيادة الملوحة، لكن تحسنت مع استخدام حمض الفولفيك والفوسفوجيبسوم. وقد امكن اشتقاق اربع معادلات لتعبر عن العلاقة بين محصول القمح (حبوب وقش) في ظل ظروف الري بمياه مالحة وهذه المعادلات هي كما يلي :

<u>محصول الحبوب:</u>

Linear: $GY_L = 2800 - 66.207x$ $R2 = 0.9385$

Quadratic: $GY_Q = 2741.1 - 16.062x - 6.0098x2$ $R2 = 09681$

<u>محصول القش:</u>

Linear : $SY_L = 3508.1 - 154.28x$ $R2 = 0.9611$

Quadratic: $SY_Q = 3506.1 - 152.59x - 0.2024x^2$ $R^2 = 0.9611$

حيث: SY_Q, SY_L, GY_Q, GY_L هو محصول الحبوب والقش للصورة الخطية والتربيعية x , مستوي ملوحة مباه الري (ديسي سيمينز/م).

التوصية: المعادلات الملائمة للعلاقات بين محصول الحبوب ومستويات الملوحة تحت بعض التعديلات أشارت الدراسة إلى أن PG أكثر فعالية عند مستويات الملوحة المنخفضة (أقل من ٦.٥٩ ديسي سيمنز/م)، في حين أن FA هو الأفضل عند مستويات الملوحة الأعلى (أعلى من ٦.٥٩ ديسي سيمنز/م)