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Impact of Irrigation Water Salinity and Some Soil Conditioners on Wheat Yield and Soil Productivity

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Abstract

This investigation aimed to evaluate the impact of varying irrigation water salinity levels and the application of soil conditioners on wheat productivity and some soil properties. A field experiment was conducted over 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) Using a split-plot design with three replications, six salinity levels of irrigation water were applied in the main plots, while three soil conditioners including (without conditioner, 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. From the fitted equations of the relationships between grain yield and salinity levels under some conditioners, the study also 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). However, at extreme salinity levels (more than10.71 dS/m), also it could be predicted that PG was not effective, resulting in a yield reduction. The findings suggest that irrigation water salinity levels of 20.6, 17.32, and 24.61 dS/m could be predicted to result in zero wheat grain yields in the case of without conditioner, PG and FA applications respectively, emphasizing the critical importance of managing salinity and soil conditioners for optimal wheat productivity.

Keywords: Irrigation water salinity, PG, FA, conditioners, wheat productivity.

Full-length article **Corresponding Author*, e-mail: *Drelsayed11154@gmail.com*

1. 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 conditioners on wheat yield components, as well as the accumulation and distribution of salts at different soil depths. 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[1]. Soil salinity stress negatively impacts plant growth and development, leading to significant losses in cereal crop production worldwide [2]. 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 [3]. Wheat (Triticum aestivum L.), being the most important grain crop globally [4], is directly impacted by these conditions. As the global population rises, the world's food supply must increase by 50% by 2050 [5]. In Egypt, where 1.39 million hectares are cultivated with wheat, producing 8.90 million tons annually [6], soil and water salinity pose a significant threat to wheat productivity. For instance, wheat productivity de creases by 7.1% for each 1 dS/m increase in salinity above 6 dS/m [7]. 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 [8]. Salinity induces oxidative stress, nutrient imbalances, and hormonal irregularities in plants, which drastically reduce wheat production [2-9]. Additionally, using low-quality water in agriculture can increase soil salinity and heavy metal content, both of which have detrimental effects on soil properties and crop yield [10]. 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 [11]. It has been shown to increase nutrient uptake and improve soil physic-chemical conditions when used in combination with fertilizers [12-13]. Phosphogypsum (PG), another soil conditioner, improves soil structure by reducing surface crust formation and increasing soil permeability, which enhances water infiltration and reduces erosion [14]. The application of PG has been shown to improve wheat yield and quality by enhancing soil physico-chemical properties [15-16]. The primary objectives of this study were to evaluate the effects of irrigation water salinity, FA and PG on wheat yield and yield components, as well as on certain soil chemical properties. Previous research has highlighted the adverse effects of low-quality water on soil and crop health, which significantly reduce crop productivity [10-17-19]. That is making it a critical issue for sustainable agriculture.

2. Materials and methods

A field experiment was conducted during the 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 conditioners, on wheat productivity, and various soil properties. 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, (0.58, 1.00, 2.00, 4.00, 6.00, 8.00 dS/m) or ranging from S1 (371 ppm) to S6 (6400 ppm). The sub-plots were designated for soil conditioner treatments, which include: control, A1 (without conditioners), A2 fulvic acid (FA) applied at a rate of 4kg / feddan (feddan = 4200 m2) and A3 phosphogypsum (PG) applied at a rate of 2 tons / feddan. The setup allowed for a comprehensive evaluation of how varying salinity levels and soil conditioners 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, Nitrogen (N), phosphorus (P) and potassium (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 first dose was applied before the second irrigation; the second dose was applied before the third irrigation. P fertilizer the recommended dose in the form of Ca-superphosphate (15.5% P_2O_5) was added with soil preparation at rate of 100 kg/ fed. K fertilizer (recommended dose) was added in the form of potassium sulphate (48% K_2O) at the rate of 5o Kg/ fed was added 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 m3) 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 [20] and [21]. Moisture parameters; Field capacity (FC) and permanent wilting point (PWP) were determined by pressure membrane method according to [22]. Organic matter content (OM) was determined according to Walkley and Black method [23]. 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/ m³ [24]. Soil samples (0-20, 20-40 and 40-60 cm depth from each lysimeter were taken before sowing and after harvesting in the two seasons 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

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 Co 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 et al [25] and analyzed as follows:

N in plant: was determined in the digested grain and straw by micro-Kjeldahl method as explained by [23].

P Content: was determined by using hydroquinine method

K Content: was determined by using flame photometer [21].

Protein content: Crude protein percentage in grains and straw of wheat was calculated by multiplying total nitrogen percentage by 6.25.

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 (ECw), 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 ECw is an assessment of all soluble salts in irrigation water, (7, 3.00 dS/m, classified to class 5 = unsuitable or severe) [7-26].

Potential salinity (PS): potential salinity (PS) was defined as the chloride plus half of the sulfate concentration. PS = cl- + 1/2 SO4

The PS classification in as follows: permissible 5-20, 3-15 and 3-7, for soils of good, medium. and low permeability, respectively [27].

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 [28]:

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

Water with SSP less than 60 is safe with little Sodium accumulations that will cause a breakdown of Soil's physical properties [29].

Sodium adsorption ratio (SAR): is a measure of the sodicity of the soil. The SAR was calculated according to [30], 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 [7].

Sodium to Calcium Activity Ratio (SCaR): SCaR can be calculated according to the relationships presented by [31] 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, So (< 5) ; normal water, S1 (5-10) ; Low sodicity water, S2 (10-20) ; medium sodicity water, S3 (20-30), high sodicity water, S4 (30-40) and very high sodicity water, S5 (>40).

permeability index (PI) : The (PI) given by the following formula [27-30]:

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

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

Sea water was diluted to ECw, 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).

Wheat was planted and received five irrigations were applied during the growing season. The total applied water was 2261 m3fed-1 and 2370 in the first season and the second season.

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

3. Results and discussion

Results emanating from the present investigation are to improve the salt tolerance of wheat by Soil application of FA and PG under different irrigation water salinity. Lysimeter experiment 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 under the following headings

3.1. Growth characters:

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).

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 first season the average of plant height amounted the highest value (104.8 cm) when irrigating with S1, (control) to 103.8, 101.3, 99, 96.7 and 94.4 cm at S2, S3, S4, S5 and S6 respectively,. So it was decreased by 0.95, 3.31, 5.53, 7.73 and 9.89% with the same salinity levels Compared to S1 in The first Season respectively. The 2nd season, plant height of wheat significantly decreased by 1.15, 2.82, 3.45, 8.11 and 10.02%. at EC 1,2, 4, 6 and 8 dS/m Compared to EC 0.58 dS/m Table (6). 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 for the plant, which negatively affected the average of plant height. 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 [32]. 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 season and 2nd Seasons, respectively, when irrigation water S1, (0.58 dS/m) and Lowest average spike length values (9.44 and 9.22 cm) when using irrigation water at the level of S6 (8 dS/m) in the 1st season 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 [33]. Data shows that the weight of 1000 grains of wheat plants was significant decrease with increasing salinity levels for the used irrigation water, where the average weight of 1000 grains amounted the highest values (47.37

and 48:06 g) at S1 and the lowest values (40.75 and 41.939) where obtained with S6 (8 dS/m) in the 1st season 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 seawater 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 waler should be held to avoid deleterious impact, but the soil studies in this field are still little in Egypt [34].

Effect of FA and 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 significant 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 that 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 spite length were 10.94 and 12.0 cm with both soil conditioners, 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 heaviest values (43.48 and 49.33) in the 1st season season and (44.65 and 46.04 g) in the 2nd seasons, respectively. These results are in agreement with those obtained by [11-13-35-36]. The positive effect of FA on plant growth may be attributed to its increase in fertilizer efficiency or enhancement of plant biomass [37], and FA may augment the plant growth characteristics, nutrient uptake and reduce the perception of harmful Components and improve plant metabolism [38].

Interaction effect of irrigation water salinity and soil conditioners (FA and PG) on plant height, Spike length and 1000- grain weight of wheat plant.

Regarding the interaction of irrigation water salinity and Soil conditioners (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 S1 and soil application of FA in the both seasons, respectively. Regarding the interaction of irrigation water salinity and PG on these parameters 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 S1 and PG in the both seasons, respectively. On the other hand, Soil application of FA and PG with fresh irrigation water S1 increased these yield Components (plant height, spike length and 1000-grain weight) as compared with the untreated plots irrigated with saline water in both seasons. These findings are in the same Line with those recorded by [38-39].

3.2. Wheat yield:

3.2.1. Grain yield as affected by irrigation water salinity

As shown in Table (8) and fig (2), there is a significant decrease in wheat grain yield with increasing of irrigation water salinity in both growing seasons. In the 1st season the highest grain yield (2946 Kg/ fed) was recorded with fresh water (S1) but it was decreased to 2861, 2786, 2768, 2607 and 2356 Kg/ fed with S2, S3, S4, S5 and S6 respectively, while the lowest grain yield (2356 kg /fed) was obtained with S6. Grain yield of wheat was decreased by 2.89, 5.43, 6.04, 11.51 and 20.03% with S2, S3, S4, S5 and S6 compared to S1 in the 1st 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 S2, S3, S4, S5 and S6 respectively compared to S1. 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. The results agree with those obtained by [34-40-42]. 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 [43]. Negative effects of salinity on shoot and root of wheat were stated to be observed with S6. Different responses of wheat genotypes to irrigation salinity levels may be resulted from the differences in their genetic structure [44]. 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 [45].

Grain yield as affected by Soil conditioners (FA and PG):

Data in Table (8) and fig (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 season and 2nd Seasons, respectively. FA as an organic fertilizer stimulates plant productivity and contributes towards cation exchange capacity of the soil [46] and [13], who demonstrate FA as the optimum choice for the improvement of P availability and soil physicochemical conditions. 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 [47]. 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 [48]. The data in table (9) and fig (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 2 853 kg /fed) were obtained in soil application PG in the 1st season and 2nd seasons, respectively. PG application resulted higher yield of rice and wheat over the equivalent dose of mineral gypsum [49].

Interaction effect of irrigation water salinity and Soil conditioners (FA and PG) on grain yield of wheat plant:

Fig (2) 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 S1 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 S1 (control) and soil application of PG in the both seasons.

On the other hand, soil application of FA and PG with fresh water (S1) increased grain yield compared to that in untreated plots (without soil conditioners) irrigated by saline water in both seasons. Data in Fig (2) presented the effect of interaction of irrigation water salinity and soil conditioners (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. According to the fitted polynomial equations of the 2nd degree for the response of wheat plant to the conditioner applications, the limit of the data to distinguish between PG and FA is at a salinity of 6.59 It is preferable to use PG in case of low salinity (ECw less than 6.59), It is preferable to use FA in the higher salinity level (EC greater than 6.59), If the irrigation water has a salinity of 10.07, it is not preferable to use these conditioners, as the yield will further decrease. it could be predicted that zero yields could be obtained whenever the irrigation water salinity of 20.6 dS/m, 17.32 dS/m and 24.61 dS/m in the case of irrigation with salty water only without adding conditioners, application of PG and application of FA, respectively.

3.2.2. Straw yield:

Effect of irrigation water salinity.

Data in Table (8) and Fig (3) 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 first season the highest straw yield (3629 Kg fed) was amounted with fresh water S1 (control), then it was decreased to 3431, 3228, 4646, 2856 and 2438 Kg/fed with S2, S3, S4, S5 and S6 respectively. Straw yield of wheat in the 1st season was decreased by 5.46, 11.03, 16.07, 21.3 and 32.82% with S2, S3, S4, S5 and S6, respectively compared to S1, while in the 2nd season, it was significantly decreased by 4.15, 11.29, 20.81, 25.22 and 30.102% with S2, S3, S4, S5 and S6, respectively compared to S1.

Effect of Soil conditioners (FA and PG):

The results in Table (8) and fig (3) 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 first and second seasons, respectively. 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, respectively. The application of FA substances increases root mass and volume, which are the main factor controlling the nutrient uptake [34]. 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 [47]. 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 [7]. 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, respectively), were observed by adding PG. The obtained results were agreed with those reported **[15-35-50]** in wheat plant.

Interaction effect of irrigation water salinity and soil conditioners on straw wheat yield:

Data in Table (8) and Fig (3) 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 S1 (control) and soil application of PG.

3.2.3. Biological yield:

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

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 (S1), while the lowest biological yields (4794 and 5038 Kg fed-1) were recorded with S6 (8 dSm-1) in the 1st season and 2nd seasons, respectively.

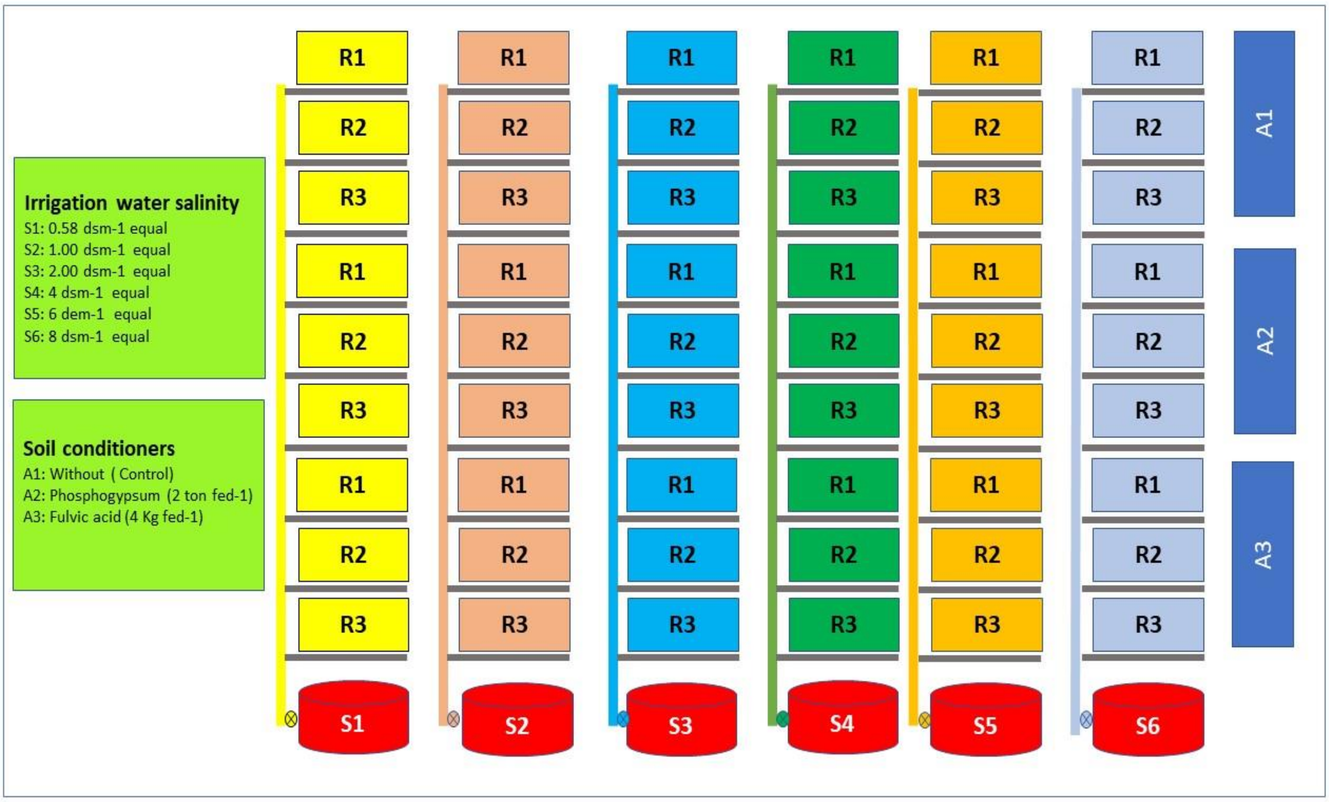

Figure 1: The experimental Layout

Table 1: Some physical properties of the experimental soil before 1st season 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	20.42	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	40.39	20.12	20.26	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 season 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	31.9	9.5	217

Table 3: The volume of sea water for specific irrigation volume and ECw 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	Required vol. L per irri.	Sea water required (L)
41.2	32.96	0.58	0.58	20	0
41.2	32.96	0.58	1.00	20	0.204
41.2	32.96	0.58	2.00	20	0.689
41.2	32.96	0.58	4.00	20	1.660
41.2	32.96	0.58	6.00	20	2.631
41.2	32.96	0.58	8.00	20	3.602

Table 4: Some criteria for diluted sea water which used in irrigation.

Irrigation diluted water sea water	PH	EC (dS/m)	PS	SSP	SAR	SCaR	SAR/SCaR	PI
S_1Fresh irrigation water	7.35	0.58	3.8	61.90	4.0	3.56	1.13	88.36
S_2 (1 dS/m)	7.61	1	7.05	62.96	5.29	4.69	1.13	81.33
S_3 (2 dS/m)	7.76	2	13.75	64.76	7.49	6.64	1.13	75.90
S_4 (4 dS/m)	7.85	4	29.15	65.86	10.59	9.38	1.13	71.96
S_5 (6 dS/m)	7.91	6	43.85	66.23	12.97	11.49	1.13	70.83
S_6 (8 dS/m)	7.98	8	57.30	66.34	14.96	13.27	1.13	70.48

*Concentration of sea water ** The different required volume (L) mixed with 20 L fresh water to obtain the required EC for irrigation.

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	0.58	4.00	3.9	0.5	1.2	0.7	--	1.5	2.8	2.0
S_2	7.61	1.00	5.29	6.8	0.7	2.1	1.2	--	2.0	2.8	3.5
S_3	7.76	2.00	7.49	13.6	0.8	4.2	2.4	--	3.0	5.3	8.5
S_4	7.58	4.00	10.59	27.2	0.9	8.4	4.8	--	3.5	9.5	17.3
S_5	7.91	6.00	12.97	40.8	1.0	12.6	7.2	--	4.5	20.5	26.5
S_6	7.98	8.00	14.97	54.4	1.2	16.8	9.6	--	6.5	30.6	36.4

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 season	2nd Season	1st season	2nd season	1st season	2nd season
Irrigation water salinity						
S_1	104.77a	106.44a	13.22a	12.33a	47.37a	48.06a
S_2	103.77a+	105.22b	12.88a	11.88b	45.23b	46.61b
S_3	101.33b	103.44c	12.11b	11.88b	44.32c	45.75c
S_4	99c	102.77c	11c	11.11c	42.17d	43.94d
S_5	96.66d	97.11d	10.33d	10.33d	41.15e	42.31e
S_6	94.44e	95.77e	9.44e	9.22e	40.75f	41.93f
F-test	**	**	**	**	**	**
LSD at 5%	1.067	0.96	0.55	0.344	0.23	0.286
Soil conditioners						
C	97.61c	99.83c	10.44c	10.44c	42.68c	43.81c
FA	100.33b	101.5b	11.72b	10.99b	43.48b	44.65b
PG	102.05 a	104.05 a	12.33 a	12.00 a	44.33 a	46.04 a
F-test	**	**	**	**	**	**
LSD at 5%	0.595	0.41	0.42	0.508	0.198	0.23

Values having the same alphabetical letter (s) in each column did not significantly at 0.05 level

Table 7: Interaction effect of irrigation water salinity and soil conditioners (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- grains weight	
irrigation water salinity	soil conditioner	1st season	2nd season	1st season	2nd season	1st season	2nd season
S_1	C	102.66de	104.66c	12.66abc	11.66ab	46.34c	46.25d
	FA	104.66.bc	106.44b	13.33ab	12.66a	47.23b	47.83b
	PG	107a	108.66a	13.66a	12.66a	48.46a	50.1a
S_2	C	101.66ef	103.33de	12.33bcd	11.33abc	44.53d	45.73d
	FA	104.cd	104.66c	12.66abc	11.66ab	45.23d	46.2d
	PG	105.66ab	107.66a	13.66a	12.66a	45.29c	47.9b
S_3	C	97.66ij	102.33ef	11.33de	11.33abc	43.43f	44.5e
	FA	102ef	102.66e	12.33bcd	11.66ab	44.5e	45.8bd
	PG	104.33bc	105.33bc	12.66abc	12.66a	45.03e	46.9c
S_4	C	97..00ij	101.33 fg	9.66fg	10.33bcde	41.67h	42.9g
	FA	99.33gh	102.66e	11.66cde	10.66bcd	42.07h	43.86f
	PG	100.66fg	104.33cd	11.66cde	12.33a	42.8g	45.06e
S_5	C	94.66i	93.66j	8.66gh	9.66de	41.13j	41.16j
	FA	97j	96i	10.66ef	10.00cde	41.43ij	42.16hi
	PG	98.33hi	97.66h	11.66cde	11.33abc	41.66hi	43.6f
S_6	C	92m	93.66j	8h	8.33f	39.9k	41.13j
	FA	95kl	97hi	9.66fg	9ef	40.16k	41.96i
	PG	96.33 ik	100.66g	10.66ef	10.33bcde	40.93j	42.79gh
F-test		NS	**	NS	NS	NS	**
LSD at 5%		1.45	1.01	1.038	1.26	0.485	0.579

Values having the same alphabetical letter (s) in each column did not significantly at 0.05 level

Table 8: Grain yield, straw yield, biological yield and harvest index as affected by irrigation water salinity and soil conditioners during 2020/21 and 2021/ 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	2946a	3013a	3629a	3711a	6575a	6724a
S_2	2861b	2929ab	3431b	3557b	6292b	6486b
S_3	2786c	2874bc	3228c	3292c	6014c	6166c
S_4	2768c	2799c	3046d	2955d	5814d	5754d
S_5	2607d	2477d	2856e	2775e	5463e	5252e
S_6	2356e	2441d	2438f	2597f	4794f	5038f
F-test	**	**	**	**	**	**
LSD at 5 %	29.61	91.22	59.07	36.28	62.77	53.12
Soil conditioners						
C	2562c	2666c	2960c	3006c	5522c	5662c
FA	2760b	2655b	3128b	3167b	5888b	5922b
PG	2839a	2853a	3227a	3269a	6066a	6122a
F-test	**	**	**	**	**	**
LSD at 5%	12.91	66.18	29.15	17.67	30.26	24.8

Values having the same alphabetical letter (s) in each column did not significantly at 0.05 level

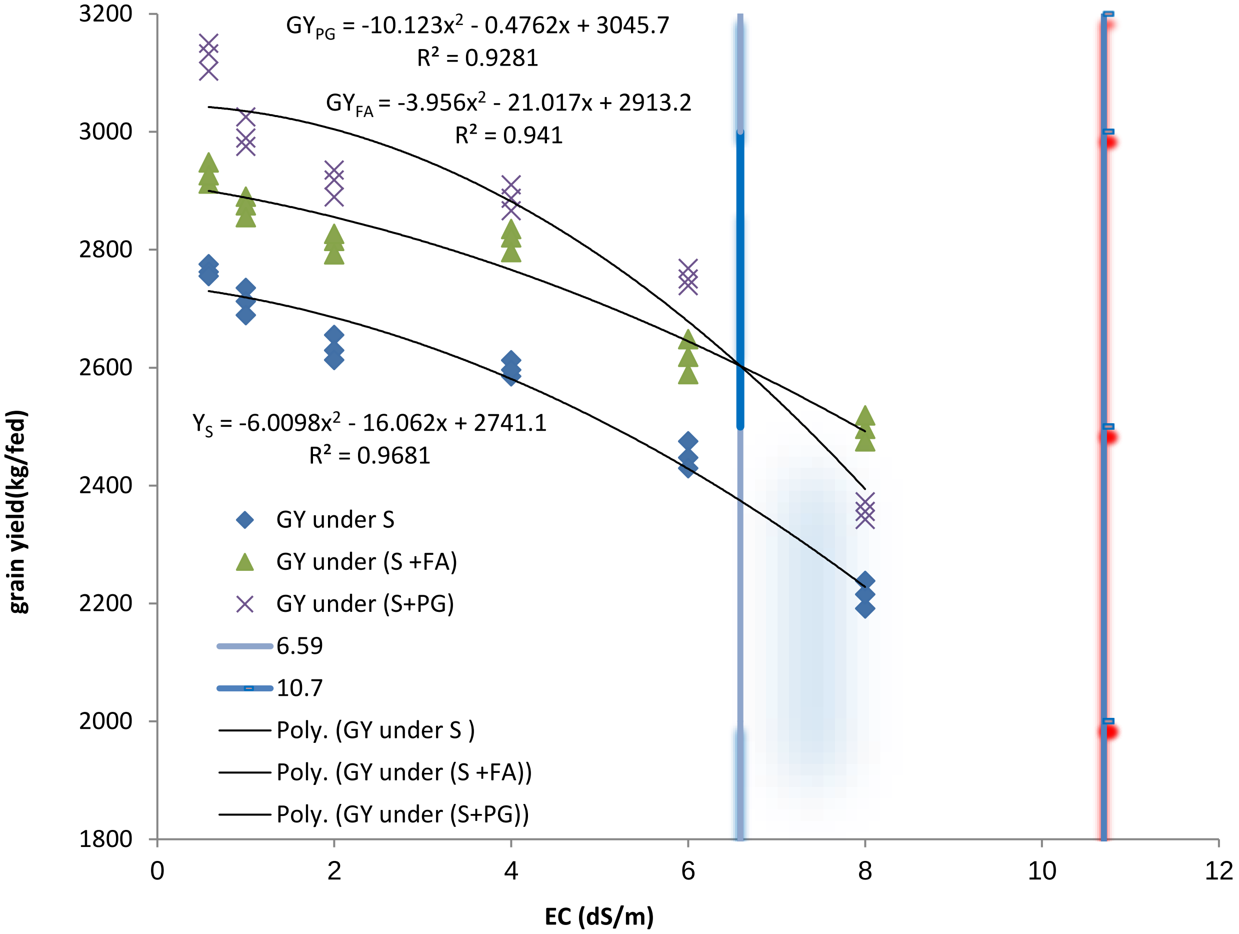

Figure 2: Effect of irrigation water salinity on wheat grainyield under some soil conditioners.

Table 9: Available N, P and K concentration in grain wheat affected by irrigation water salinity and soil conditioners (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	3.19a	4.54a	0.28a	0.31a	1.28a	1.30a
S2	2.95b	4.09b	0.27b	0.30b	1.15b	1.09b
S3	2.79c	4.07c	0.26c	0.283c	1.138c	1.05c
S4	2.75d	3.81d	0.24d	0.28d	1.133d	1.05c
S5	2.69e	3.57e	0.22e	0.263e	1.13e	1.02d
S6	2.43f	2.89f	0.16f	0.21f	1.125f	0.90e
F-test	**	**	*	*	**	**
LSD at 5%	0.0066	0.0091	5.63	6.29	0.0027	0.0025
Soil conditioners						
C	2.60c	3.32c	0.22c	0.25c	1.15c	1.001c
FA	2.83b	3.92b	0.24b	0.27b	1.15b	1.0468b
PG	2.96a	4.26a	0.26a	0.30a	1.17a	1.07a
F-test	**	**	*	*	**	**
LSD at 5%	0.0041	0.0058	3.56	3.95	0.0017	0.0015

Values having the same alphabetical letter (s) in each column did not significantly at 0.05 level

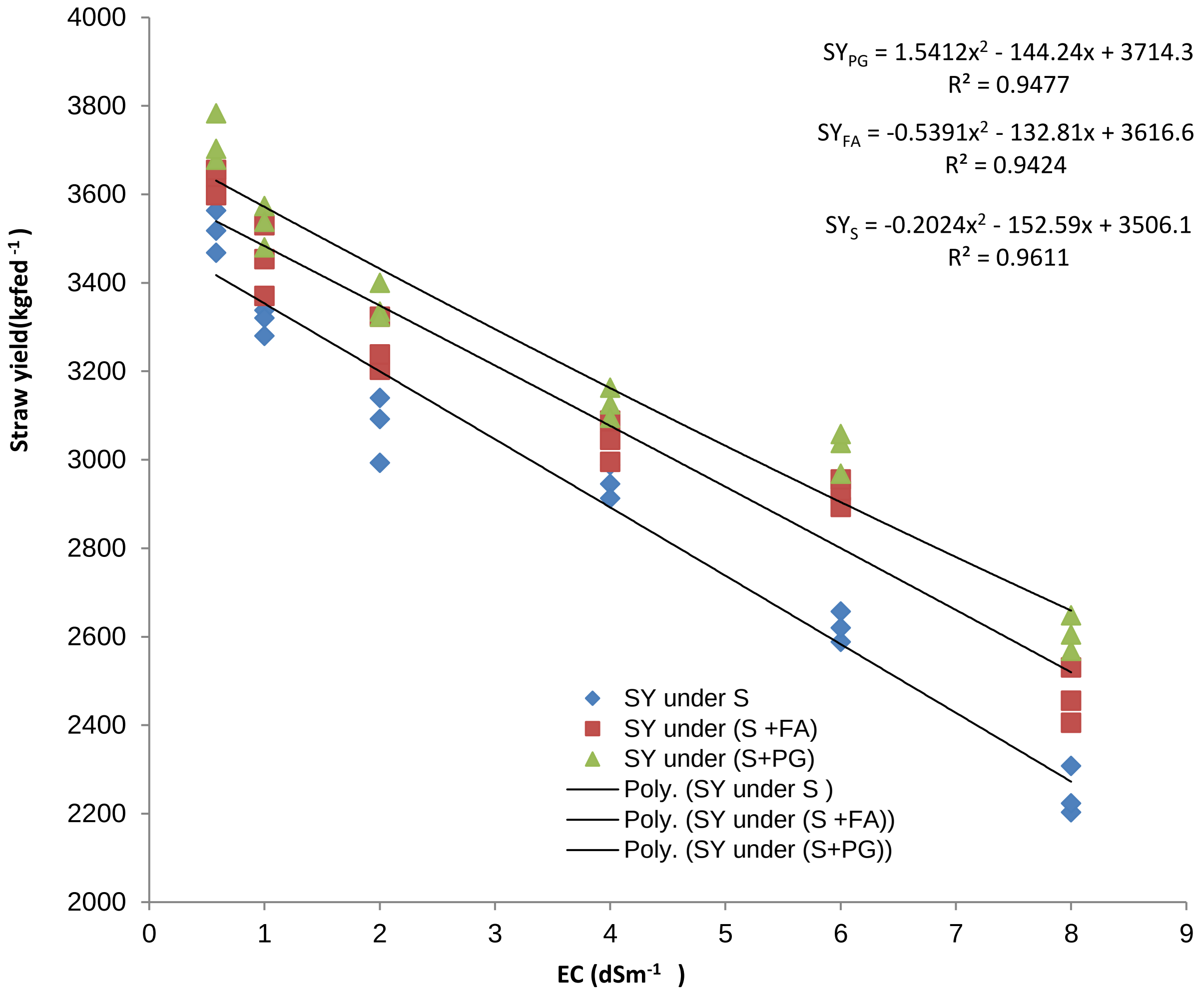

Figure 3: Effect of irrigation water salinity on wheat straw yield under some soil conditioners.

Effect of Soil conditioners (FA and PG):

A biological yield was significantly increased by the FA application in both seasons (Table 8) 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 previous studies [15-35-50].

Interaction effect of irrigation water salinity and Soil conditioners (FA and PG) on biological yield of wheat plant:

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 (S1) and FA, in both seasons, respectively. Organic acids are formed by decomposition of plants in Soil [51] 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 mater. FA has a lower molecular weight than HA, however, former has more oxygen and Carbon- poor functional groups [52]. 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 [53]. The application of FA to the leaves increased the seedling growth and the root weight of the wheat plants [18]. 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 (S1) treatment and Soil application of PG in the first and second seasons respectively [15].

3.3. N, P, and K contents in grain wheat plant.

Effect of Irrigation water Salinity on N, P and K in grain wheat plant.

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 first and Seacond Seasons, respectively, when using Ivrigatin water at the level at 56 (8 dS/m-1 equal 6400 ppa), respectively. The obtained results agree with those reported in wheat plant [15-32-40-54].

4. Conclusions

The findings suggest that irrigation water salinity levels of 20.6, 17.32, and 24.61 dS/m could be predicted to result in zero wheat grain yields in the case of without conditioner, PG and FA applications, respectively, emphasizing the critical importance of managing salinity and soil conditioners for optimal wheat productivity. From the fitted equations of the relationships between grain yield and salinity levels under some conditioners, the study indicated that PG is more effective at lower salinity levels.

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