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Optimization of the Efficiency of Saline Irrigation Water by Addition of Hydrophilic Soil Conditioners to Enhance The Barely (*Hordeum valgare* L.) Productivity in Sandy Soil

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ABSTRACT

This study aims to assess the efficiency of the low quality irrigation water mixed with Nile fresh water accompanied by the application of some hydrophilic soil conditioners to improve the barely crop productivity in sandy soil. The irrigation water used was five grades of salinity that are Nile water (NW) as the control, underground water (GW), agricultural drainage water (DW), mixed NW with GW (0.5:1 v/v ratio), and mixed NW with DW (0.5:1 v/v ratio). A greenhouse pots and two field experiments were carried out using the hydrophilic poly-acrylamide (PAC) and gelatin (G) polymers. The PAC was applied as received while the G was dissolved to prepare an aqueous solution mixed with either the K-silicate S powder (GKS mixture 1:10 g/g ratio) or with the air-dried water hyacinth powder WH (GWH mixture 1:10 g/g ratio) then left to dry. All treatments were arranged in a split-plot design with three replicates for each treatment. The main factor was the irrigation treatments (I) while the sub-factor was the applied hydrophilic conditioners (H). Barely grains (*Hordeum valgare* L.) were sown (winter seasons 2022/2023 and 2023/2024). In field experiment, the PAC and GKS have increased the grains yield by 76.8% and 60.2%, respectively (by NW) and 72.4% and 60.8%, respectively (by NW+DW). The NW+DW with or without the PAC treatment have significantly increased the N, P, and K uptake by the grains and straw. The studied treatments can be recommended to improve the barely plant yield under sandy soil conditions using saline irrigation water.

Keywords: Agricutural Drainage water; Ground water; Hydrogel polymers; Water salinity.

INTRODUCTION

The continuous climate changes are resulting in a deficiency of the good quality irrigation water and making one of the most significant problems hinder the agricultural sustainability under the arid and semi-arid conditions. The source and quality of the irrigation water are significantly controlling the plant growth, crop production and salt balance in soil. Saline water negatively affects both the soil chemical/physical features and plants growth. Field studies regarding different levels of the irrigation water quality and soil salinity over time are important in the cropping system management (Pandya, 2018). The salinity of irrigation water impedes the agricultural development in areas that do not implement rain-fed irrigation as a main method of agriculture (Basheer, 2023). One of the sustainable uses of water of different salinities for irrigation is the dilution of the water salinity by mixing with better quality fresh water like the non-saline river water that can partially solve such problem by producing a medium quality irrigation water (Wahba, 2017; Mohamed *et al*., 2018).

The ground water and agricultural drainage water are commonly lower quality irrigation water. They are sometimes used for growing crops of high salt tolerance (Fayrap and Koc, 2012; GabAllah and Ghaly, 2020). Low quality water strategies are often depending on using a medium saline irrigation (EC 1 - 4 dS m^{-1}) like agricultural drainage water and ground water. Use mixed river water with agricultural drainage water or groundwater in sandy soil was recommended to wash soil salts (Gabr, 2018). For example, water of the agricultural drainage water in Egypt is one of the important untraditional irrigation resources. Mixing the river fresh water with agricultural drainage water such as EL-Salam river project is re-charting irrigation water province (EL-Komy, 2012). Irrigation by the mixed agricultural drainage water can contribute in minimizing the gap in water resources and is beneficial as it decreases the amount required from fresh water and consumes the saline water instead of its wastage by discharge to the environment (Sharma and Tyagi, 2004; Flowers *et al*., 2005; Ragab *et al*., 2005).

Sandy soil is suffering from the insufficient irrigation water problem. Lower quality water reduces the crop yields >25 to 50% when EC of irrigation water is >6 dS m^{-1}. The use of hydrophilic materials such as polymeric hydrogels as soil conditioners and as fertilizers' carrier can enhance the water and nutrient use efficiency in sandy soils as they decrease the deep percolation and reduce the evaporation and infiltration rates. This effect is due to their chemical structures containing the hydrophilic groups like $–NH_2$, $–SO_3H$ and $–OH^-$ groups (Omer *et al*., 2023). A commonly used water-retention polymer, the poly acrylamide (PAM) $[(H_2\text{-}CH\text{-}CO\text{-}NH_2)_n]$ applied at rates 0.2–0.8 g/kg that resulted in the inhibition of the soil water infiltration. Success of the hydrophilic polymeric hydrogels depend on numerous factors such as the soil texture and mineralogy, soil management, application rate, and method, water quality, etc. they can be spread on soil surface or mixed with topsoil (Ning *et al*. 2019). Hydrogels are hydrophilic super-absorbents, which are usually acrylamide-based polymers with a three-dimensional structure and a water (H_2O) storing capacity from 400 to 1500

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g H_2O/g polymer (Cannazza *et al*., 2014). Hydrophilic polymers have high molecular weight, low application rates, and environmental, soil conservation, and irrigation efficiency benefits for general agriculture. In agriculture, they are used as soil conditioners to reduce irrigation, water consumption runoff, and soil erosion (Ozturk *et al.*, 2005; Rokhade *et al.*, 2007).

Natural polymers are mostly come from plant like cellulose, starch and gum or from an animal like gelatine and chitosan. Chemical, physical, surface, and biological modifications improve their physical and chemical properties. Gelatine is a water-soluble, biodegradable polymer consists of 19 amino acids joined by peptide linkages produced from the partial de-naturation of collagen, a by-product of meat processing. Biodegradation depended on the type of cross-linking reagent and density (Martucci and Ruseckaite, 2009; Ghobashy *et al*., 2018). Gelatin is a mixture of proteins and peptides derived from the partial hydrolysis of collagen extracted from the connective tissues of animals and it was considered a soil conditioner that enhances the growth of plants, leaves, chlorophyll, and soil moisture (Wilson *et al.*, 2018).

Cellulose-containing derivatives have been utilized for developing superabsorbent hydrogels because they are abundant in nature, non-toxic, biodegradable, and hydrophilic with low-cost production (Omer *et al*., 2023). Water hyacinth is a floating aquatic plant that can live on the surface of fresh water and the fresh stalks comprises of 90-95% of water (Center *et al*., 2005) while dried stalk has good amount of cellulose, hemicellulose and lignin (Villamagna and Murphy 2010; Wei *et al*., 2020). It has been reported that the treatment of water hyacinth with saline water is an effective control method that can be used to significantly reduce hyacinth carpets on water surfaces. Minimum salinity that can be used to remove water hyacinth plants about 24 g/L (Nadege *et al*., 2017).

Addition of the dried and chipped water hyacinth to the sandy soil may improve it physically and chemically because it is rich of biologically active chemicals such as flavonoids, alkaloids, tannins, phenols, oxidative enzymes and non-enzymatic antioxidant useful for plants against plant pathogens. It contains sugars, carbohydrates, Na, K, Mg and Ca as well as lower content of Cu, Fe, Zn and Mn. The dried water-hyacinth plant ~10% crude protein, 11% ash and 79% organic matter OM in addition tofats, crude fibers, and ash (Abdel Shafy *et al*., 2016).

Silicon (Si) application alleviates the detrimental effect of salinity stress on plant growth (Richmond and Sassman, 2003; Hamayun, 2010). It is present in the soil mostly as insoluble oxides or silicates, as well as soluble silicic acid 0.1-0.6 mM concentration and exists in plant tissues and shoots ≈ 10% dry weight. Potassium silicate is a source of highly soluble K and Si used in agriculture production systems primarily as silica amendment (El-Zeiny *et al.* 2007; Abo-Baker *et al.*, 2011; Alsadon *et al*., 2013). Adding Si may improve salt tolerance by improving the soil hydrophilic properties by *in-situ* formation of silica gel and significantly decreasing salt content in soil. It can improve the solubility and mobility of nutrients such as N, P and K in the sandy soil solution to be readily absorbed for plant growth and decrease their loss by leaching (Matthew and Akinyele, 2014; Matichenkov *et al*., 2020; Xu *et al*., 2020; Al-Saeedi, 2021).

Barely (*Hordeum vulgar* L.) is an important crop used to feed animals, malt, and human food. It's a highly adaptable cereal grain and ranks fifth among all crops for dry matter production in the world (Thalooth *et al*., 2012). Its importance derives from the ability to grow the produce in marginal environments, which are often characterized by drought, low temperature, and salinity (Baum *et al.*, 2003). The total cultivated of barely in the world is 47 million hectares with an annual production of 147.4 million tons, with an average productivity of 3136 kg ha^{-1}(FAO, 2018).

The present work aims to assess the efficiency of the low quality irrigation water mixed with Nile fresh water accompanied by the application of some hydrophilic soil conditioners to improve the barely crop productivity in sandy soil. The conditioners used in the study were the Poly-acrylamide (PAC) and gelatin (G) polymers mixed with either the K-silicate powder or with the air-dried water hyacinth powder. The irrigation water used was including five grades of salinity obtained by mixing the Nile fresh water from the Ismailia canal with the underground water and/or the agricultural drainage water from El-Solley agricultural drainage branch.

MATERIALS AND METHODS

A greenhouse experiment and two field experiments were carried out in sandy soil conditions and were arranged in a randomize complete block (RCB) design with three replicates used in a spilt plot design arrangement. The first factor was the irrigation water (1) NW: EC = 313.6 ppm, (2) GW: EC = 1715.2 ppm, (3) DW: EC = 1824.0 ppm, (4) NW+ GW: EC = 1350.4 ppm and (5) NW+DW: EC = 1427.2 ppm, while the second factor was the hydrophilic polymer material (1) control zero-polymer, (2) PAC, (3) GKS and (4) GWH.

Materials

The hydrophilic polymeric conditioners used in the study were the Poly-acrylamide (PAC) single and gelatine (G) polymers mixed with either the K-silicate powder and/or mixed air-dried water hyacinth powder. The PAC was applied as received while the G was dissolved in hot water at 80 °C to prepare an aqueous solution. This solution was mixed with either the K-silicate S powder (GKS mixture 1:10 g/g ratio) or with the air-dried water hyacinth powder WH (GWH mixture 1:10 g/g ratio) then left to dry. The water hyacinth was collected from the 16 km-Ismailia-Port Said Road and air-dried for 20 days then crushed into 1-2 mm specimens before mixing with the G polymer.

The irrigation water used was including five grades of salinity that are Nile water (NW) from the Ismailia canal as the control, underground water (GW) from the El-Solley village, agricultural drainage water (DW) from El-Solley agricultural drainage branch, mixed NW with GW (0.5:1 v/v ratio), and mixed NW with DW (0.5:1 v/v ratio). Their chemical analysis results were indicated in Table 1. They were used in the study location by a sprinkle irrigation system. The main factor of the study was the irrigation treatments (I) while the sub-factor was the applied hydrophilic conditioners (H). All treatments of the irrigation and conditioners were arranged in a split-plot design with three replicates for each treatment.

Greenhouse pots and field experiments

The pots experiment was constructed in the green house at the experimental Farm of the Ismailia Agricultural Research Station (Lat. 30° 35' 30" E elevation 3 m above surface sea level). About 20 kg of sandy soil (Soil 1) were packed in plastic pots that were PVC columns 60 cm height and 15.2 cm diameter. Each of the PAC, GKS, and GWH, additives were mixed individually with the upper 15 cm surface of soil at rate 0.03% w/w equivalent 714.29 kg ha^{-1}, i.e. 6.0 g applied to the soil column. The columns were irrigated by the different irrigation treatments nearly up to the soil FC.

All columns were fertilized by the recommended doses (RD) of the ammonium sulphate at the rate 0.4 g N per column (≈ 47.9 kg N ha^{-1}) was added in five times (20, 35, 50, 65 and 80 days after sowing), calcium mono super-phosphate at the rate 0.14 g P per column (≈ 16.10 kg P ha^{-1}) was added before sowing and potassium sulphate at the rate 0.96 g K per column (≈ 48.4 kg K ha^{-1}) was added in two splits; before sowing and flowering.

The pots experiment was carried out under sandy soil (Soil 1) conditions was accompanied by two field experiments under sandy soil (Soil 2) conditions during the two successive winter seasons 2022/2023 and 2023/2024. The field experiments were constructed at El-Solley village (Lat. 30° 46' 47" E elevation 3 m above surface river level) in Ismailia – Abo-Suare Road at a location falling in the Ismailia government district, Egypt.

The N-P-K mineral fertilization of soil was applied by the RD using the ammonium sulphate (200 g N kg^{-1}) at the rate 238.0 kg N ha^{-1} added during the plant growth in five addition times, the calcium mono super-phosphate (67.39 g P kg^{-1}) at a rate 16.10 kg P ha^{-1} added before sowing and the potassium sulfate (400 g K kg^{-1}) at the rate 96.01 kg K ha^{-1} added before and at flowering.

Barely grains (*Hordeum valgare* L. Giza 123) cultivar was recommended by the ARC-Egypt being suitable for the sandy soil stress. For the pots experiment, five barley grains were sown in each column during the successive winter seasons 2022/2023 and 2023/2024 after two week from the November beginning. For the field experiment, sowing was on the 3rd. of November (2022 and 2023) by the mechanical planting in 5 cm depth hills in plots (plot area = 4 m × 5 m = 20 m^2), with 0.6 m space surrounding the plot. Irrigation water requirements for barley were scheduled to be 4760 m^3 ha^{-1} at the FC of the experiment soil.

Barely plants harvested at full maturity 125 days after sowing for the greenhouse experiment and the dry weight of grains, straw yield and plant height were recorded. Harvesting the field experiments was 132 days after sowing by collection of samples from each plot area to be air-dried. Some characteristics of the soils 1 and 2 and irrigation water mixtures used in this study are shown in Tables 1 and 2, respectively.

Soil and plant sampling analysis

After harvesting representative barley samples from plots were picked up for analysis and testing according to the recommended methods (Black, 1982). Grain samples were picked up after air-drying, yield components such as 1000-grain weight (g), grain yield (Mg ha^{-1}), straw yield (Mg ha^{-1}), plant height (cm), Spike weight (g), Spike length (cm), N-P-K uptake, available N-P-K in soil, some characteristics of the soil and water were estimated and the mean values of two seasons were recorded.

The soil available N-P-K nutrients were extracted by KCl extract (1: 10 w/v) soil: water, $NaHCO_3$ 0.5 N, and NH_4OAc 1 N, respectively (Jackson, 1973). Barley grain and straw were dried at 70 ºC for 50 h and ground. A 0.5 grams of the grains and/or straw ground were wet digested by acid mixture ($HClO_4/H_2SO_4$, 1:1) (Chapman and Pratt, 1961). The N-P-K content in soil and plant extracts were measured by distillation using Kjeldahl apparatus, colorimetric using the UV-V Spectrophotometer, and using the flame photometer, respectively (Page, 1982).

Table 1. Some properties of the soils used in this study before cultivation, Soil (1) Ismailia Research Station soil and Soil (2) El Solley location soil.

Property	Soil (1)	Soil (2)
Particle size distribution (%)		
Coarse Sand	64.45	52.18
Fine Sand	25.38	37.10
Silt	6.42	6.49
Clay	3.75	4.23
	Sandy Texture	
pH (1:2.5) soil : water suspension	8.01	8.05
EC (dS m^{-1}) soil paste extract	0.72	0.75
$CaCO_3$ (g kg^{-1})	0.45	0 .42
Organic Matter (OM, g kg^{-1})	0.31	0.37
Soluble cations (meq L^{-1})		
Na^+	1.54	1.50
K^+	0.60	0.58
Ca^{2+}	1.79	2.07
Mg^{2+}	1.18	1.94
Soluble anions (meq L^{-1})		
CO_3^{2-}	0.00	0.00
HCO_3^-	1.30	1.51
Cl^-	1.60	2.70
SO_4^{2-}	4.35	4.10
Moisture characteristic		
Field capacity (FC, %)	9.36	10.10
Available water (AW, %)	6.49	7.04
Salt characteristic		
SAR	1.26	1.06
SSP (%)*	26.3	23.1
Available nutrients (mg/kg)		
N	19.75	21.04
P	7.13	7.25
K	68.9	71.6

***Soluble Sodium Percentage** $= \frac{Na}{(Ca+Mg+Na)-(CO3+HCO3)} \times 100$

Table 2. Some characteristics of the irrigation water types used in this experiments: Nile water (NW) from the Ismailia canal, Ground water (GW), Agricultural Drainage water (DW), 0.5:1 v/v (NW+GW) mixed water, and 0.5:1 v/v (NW+DW) mixed water.

Properties		NW	GW	DW	NW+ GW	NW+ DW
pH		7.79	7.86	8.14	7.83	7.81
EC (dS m^{-1})		0.49	2.68	2.85	2.11	2.23
EC (ppm)		313.0	1715.2	1824.0	1350.4	1427.2
Soluble cations (meq L^{-1})						
Na^+		1.57	8.53	8.34	5.34	5.06
K^+		0.38	2.06	3.11	2.10	3.24
Ca^{2+}		2.20	11.95	12.19	9.20	10.25
Mg^{2+}		0.92	4.99	5.00	4.00	4.71
Soluble anions (meq L^{-1})						
CO_3^{2-}		0.00	0.00	0.00	0.00	0.00
HCO_3^-		1.15	5.24	6.32	4.32	5.38
Cl^-		1.76	8.46	9.27	6.27	6.14
SO_4^{2-}		2.14	12.62	12.78	10.78	11.00
SAR		1.01	2.85	2.85	2.08	3.04
Total	N	11.24	16.50	62.01	19.21	47.32
(mg L^{-1})	P	2.81	3.46	11.20	4.33	13.97

Statistical Analysis

At a significance level $p<0.05$ the statistical significance (LSD) of the mean factors irrigation, sub mean factors hydrophilic materials and barley production and barley characteristics were estimated by the 2-way tested of variance (ANOVA) using the software Package of Co-State (Ver. 6.311), a products of Cohort software Inc.; Berkley, California (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Results

Salinity Levels of Irrigation Water After Mixing With The Non-Saline Nile Water

The 0.5:1.0 v/v ratio of mixing the NW with saline water types used in this study was somewhat suitable as it consumed less fresh water for irrigation and decreased the salinity degree of the saline water from different sources; GW and DW as indicated in Table 2. Since the soil properties of the pots and field experiments are comparable (Table 1), the variations in the estimated parameters are almost depending on the factors under study, which are the types of irrigation water and types of the hydrophilic conditioners applied to the soil. The salinity of the mixed NW+GW and NW+DW was decreased by 21.27% and 21.75%, respectively, compared to the original GW and DW.

Effect of the irrigation water salinity and hydrophilic materials on the soil available N-P-K nutrients (mg kg^{-1})

Application of the hydrophilic polymers to the sandy soil has significantly increased the soil available N-P-K nutrients (mg kg^{-1}) for both the pots and field experiments compared with the control at $p<0.05$ according to the LSD values in Table 3 and Figure 1 under the effect of the irrigation by different types of water. The non-saline NW has resulted in the most significant increase in the available N-P-K because it is almost ideal for irrigation. The mixed NW+DW and NW+GW have significantly increased the mean values of the available N, P, and K by 18.3, 25.8, 20.1% and 11.5, 25.7, 8.9%, respectively, for the pots experiment relative to the mean values of single application of the more saline DW and GW.

Also, the PAC with different types of water has exhibited the almost significant increase in the available N.

The pots available N was increased by 15.3%, 15.6%, and 13.9% compared with the control with the NW, NW+GW, and NW+DW, respectively. This may be due to an additional N content present in the PAC chemical structure that may be released in the soil during the cultivation season. However, the GKS was almost the most efficient conditioner significantly increased the soil P and K in the pots experiment and the soil N-P-K in the field experiment.

Table 3. Effect of levels of irrigation water salinity and addition of hydrophilic materials on soil available N-P-K (mg kg^{-1}), Greenhouse experiment, average of two seasons.

Irrigation (I)	Hydrophilic (H)	Available (mg kg^{-1}) N	P	K
NW	Control	25.79	11.89	76.94
	PAC	29.74	13.14	88.40
	GKS	28.42	14.25	93.04
	GWH	27.75	12.00	84.11
Mean		27.93	12.81	85.54
GW	Control	20.84	6.54	64.10
	PAC	23.33	10.00	67.57
	GKS	22.54	10.51	68.14
	GWH	21.65	7.82	67.21
Mean		22.10	8.71	66.76
DW	Control	21.25	7.45	65.17
	PAC	23.43	10.72	69.55
	GKS	26.22	10.87	70.01
	GWH	22.24	8.94	68.22
Mean		22.69	9.50	68.03
NW+GW	Control	22.92	8.70	66.95
	PAC	26.50	11.74	72.85
	GKS	23.85	11.82	76.04
	GWH	22.37	11.32	72.29
Mean		24.64	10.95	72.75
NW+DW	Control	25.00	10.66	73.87
	PAC	28.47	12.16	84.62
	GKS	26.75	13.57	88.82
	GWH	27.08	11.47	79.46
Mean		26.84	11.95	81.70
$LSD_{0.05}$	I	0.09	0.21	0.33
	H	0.10	0.22	0.30
	IxH	15.01	0.50	0.71

NW: Nile water, GW: Ground water, DW: Agricultural Drainage water, Control: without application, PAC: polyacrylamide,GKS: gelatin/K-silicate mixture, GWH: gelatin/water hyacinth mixture

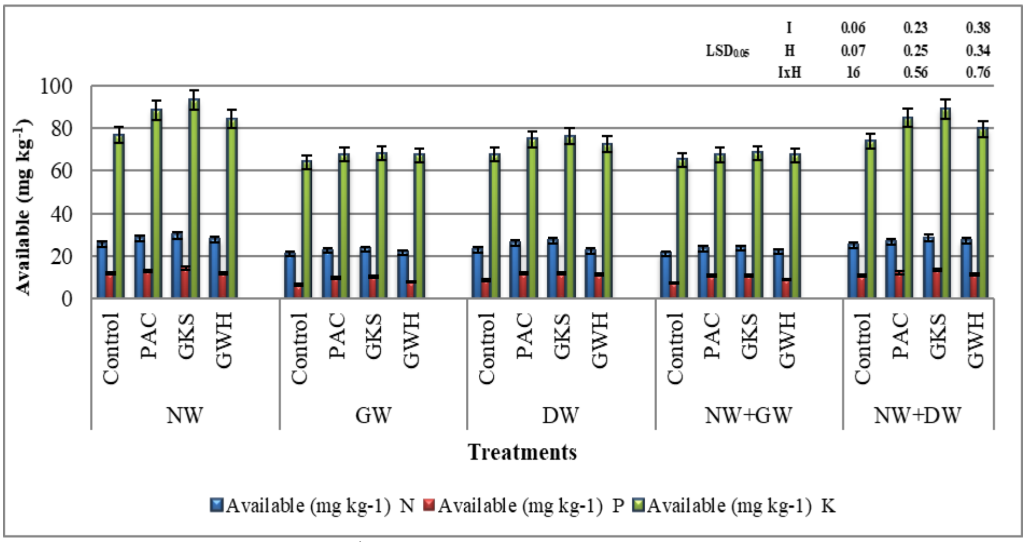

Fig. 1. Soil available N-P-K (mg kg^{-1}) under the effect of different treatments for the field experiment

For instance, the GKS treatment in the field has increased the available N, P, and K by 15.37%, 19.87%, and 21.37%, respectively in case of the NW and by 13.98%, 26.93%, and 20.25%, respectively in the case of the mixed NW+DW. This can be attributed to the nutritional and fertilization role of the K-silicate containing K and Si in addition to the more available water provided by the hydrophilic gel in the form of gelatin and silica gel. Perhaps, it is more effective than the PAC and GWH to support the sandy soil by water and N-P-K nutrients. These results agree with those obtained previously (Alsadon *et al*., 2013; Matthew and Akinyele, 2014; Matichenkov *et al*., 2020; Xu *et al*., 2020; Wei *et al*., 2020; Al-Saeedi, 2021; Basheer, 2023).

Effect of the irrigation water salinity and hydrophilic materials on the yield (Mg ha^{-1}) of barely grains and straw

The irrigation by the NW has produced the maximum yield of barely grains (3.93 and 3.89 Mg ha^{-1}), straw (5.39 and 5.33 Mg ha^{-1}) and plant weight (4.46 and 4.40 g), followed by the irrigation by NW+DW that produced 3.89 and 3.85 Mg ha^{-1} grains, 5.24 and 5.19 Mg ha^{-1} straw, and 4.4 and 4.35 g plant weight, for the pots and field experiments, respectively.

Furthermore, the PAC has increased the grains yield significantly by 75.6%, 74.0%, and 70.9% for the NW, NW+GW and NW+DW, respectively, relative to the corresponding control in the pots experiment (Table 4). Also, in the field experiment (Figure 2) the PAC and GKS have increased the grains yield by 76.8% and 60.2%, respectively (by NW) and by 72.4% and 60.8%, respectively (by NW+DW). Similarly, the straw yield and plant weight were increased by 33.6% and 8.9% by PAC (NW). They were also increased by 47.8% and 16.0% by PAC (NW+GW). Similar trend was obtained in previous studies (EL-Komy, 2012; Fayrap and Koc, 2012; Gabr, 2018; Mohamed, *et al*., 2018; GabAllah and Ghaly, 2020).

Table 4. Effect of levels of irrigation water salinity and addition of hydrophilic materials on yield (Mg ha^{-1}) of the barley plant. (Greenhouse experiment, average of two seasons).

Irrigation (I)	Hydrophilic (H)	Grain yield (Mg ha^{-1})	Straw yield (Mg ha^{-1})	Plant weight (g)
NW	Control	2.75	4.62	4.20
	PAC	4.83	6.16	4.58
	GKS	4.38	5.65	4.74
	GWH	3.77	5.15	4.28
Mean		3.93	5.39	4.46
GW	Control	2.28	3.35	3.47
	PAC	3.76	4.45	3.91
	GKS	3.45	5.07	4.07
	GWH	3.44	4.29	3.80
Mean		3.52	4.51	3.83
DW	Control	2.33	3.63	3.68
	PAC	3.93	5.22	4.25
	GKS	3.47	5.13	4.28
	GWH	3. 55	4.43	3.89
Mean		3.52	4.51	3.83
NW+GW	Control	2.50	4.34	3.81
	PAC	4.35	5.52	4.50
	GKS	3.94	5.71	4.49
	GWH	3.57	4.82	4.24
Mean		3.32	4.54	4.02
NW+DW	Control	2.72	4.64	4.16
	PAC	4.65	5.65	4.52
	GKS	4.36	5.92	4.68
	GWH	3.86	5.35	4.28
Mean		3.89	5.24	4.40
LSD$_{0.05}$	I	0.31	0.59	0.12
	H	0.24	0.40	0.09
	IxH	0.49	0.14	0.14

NW: Nile water, GW: Ground water, DW: Agricultural Drainage water, Control: without application, PAC: polyacrylamide, GKS: gelatin/K-silicate mixture, GWH: gelatin/water hyacinth mixture

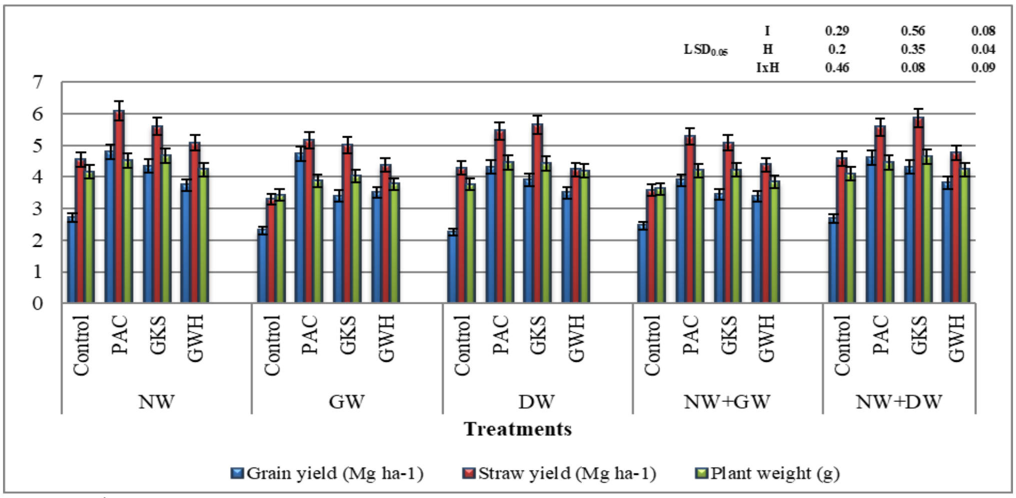

Fig. 2. Yield (Mg ha^{-1}) of the grains and straw and plant weight (g) under the effect of different treatments for the field experiment

Effect of the irrigation water salinity and hydrophilic materials on some of the yield attributes

Irrigation in the field experiment by the NW has produced the highest significant mean values of the barely spike weight (g) and length (cm) as well as the 1000-grains weight (g) in comparison with the corresponding lowest mean values obtained by the GW. Their relative increases were by 20.33%, 6%, and 31.59% for the spike weight and length, and 1000-grains weight, respectively at $p<0.05$(Table 5). Also, the mixed NW+DW and NW+GW showed relative increases in the mean values by 2.35 and 3.28% for the spike weight, by 1.22 and 1.06% for the spike length, respectively. The PAC and GKS hydrophilic additives were more efficient than the GWH resulted in the highest significant relatives in the mentioned yield components under the irrigation by different types of saline water types. For example, the PAC has increased the spike weight, length, and the 1000-grains weight significantly and respectively by 67.21%, 7.07%, and 9.49% in case of the NW+DW and by 67.4%, 13.55%, and 32.1% in case of the NW+GW relative to the corresponding control at $p<0.05$.

Table 5. Effect of levels of irrigation water salinity and addition of hydrophilic materials on some yield components of the barley plant, field experiment average of two seasons.

Irrigation (I)	Hydrophilic (H)	Spike wt. (g)	Spike length (cm)	1000-grain wt. (g)
NW	Control	2.53	14.29	40.00
	PAC	4.32	15.27	40.38
	GKS	4.35	15.75	40.44
	GWH	3.49	14.74	39.96
Mean		3.67	15.01	40.20
GW	Control	2.12	12.97	30.32
	PAC	3.61	14.85	30.67
	GKS	3.34	14.72	30.83
	GWH	3.11	14.09	30.36
Mean		3.05	14.16	30.55
DW	Control	2.43	13.96	30.52
	PAC	4.05	15.22	40.22
	GKS	3.88	15.35	40.30
	GWH	3.25	14.35	39.76
Mean		3.40	14.72	37.70
NW+GW	Control	2.27	13.28	30.44
	PAC	3.80	15.08	40.21
	GKS	3.37	14.77	40.30
	GWH	3.15	14.11	30.65
Mean		3.15	14.31	35.40
NW+DW	Control	2.47	14.28	36.76
	PAC	4.13	15.29	40.25
	GKS	3.94	15.54	28.33
	GWH	3.36	14.50	39.62
Mean		3.48	14.90	36.24
$LSD_{0.05}$	I	0.08	0.08	0.12
	H	0.12	0.12	0.08
	IxH	0.26	0.25	0.27

NW: Nile water, GW: Ground water, DW: Agricultural Drainage water, Control: without application, PAC: polyacrylamide,GKS: gelatin/K-silicate mixture, GWH: gelatin/water hyacinth mixture

Effect of the irrigation water salinity and hydrophilic materials on the uptake (kg ha^{-1}) of N-P-K nutrients by barely grains and straw

As a result of the improved nutrients' availability obtained by the studied treatments, the N-P-K uptake (kg ha^{-1}) by the barely grains and straw was significantly increased at $p<0.05$ according to the LSD values in Table 6. Considering the NW as an ideal irrigation in the field experiment, it showed the maximum mean values in the macronutrients uptake by grains and straw by 25.6%, 43.3%, 28.1% and 27.7%, 45.7%, 23.2%, respectively, relative to the minimum mean values obtained by the GW. Following it, the NW+DW treatment has significantly increased the N, P, and K uptake by 20.3%, 28.0%, 21.1% and by 21.8%, 22.2%, 12.9% by the grains and straw, respectively.

Also, the PAC has significantly increased the grains' uptake by 49.8, 68.1, 41.8% and by 44.5%, 48.3%, 35.8% relative to the corresponding control affected by the irrigation using the NW and NW+DW, respectively. The second most efficient hydrophilic material was the GKS increased the grains' N-P-K uptake respectively by 42.7%, 76.5%, and 46.4% for NW+GW irrigation treatment and by 41.1%, 44.4%, and 35.5% affected by the NW+DW irrigation treatment relative to the corresponding control.

Table 6. Effect of levels of irrigation water salinity and addition of hydrophilic materials on total N-P-K uptake (kg ha^{-1}) by grains and straw of the barley plant (field experiment average of two seasons).

Irrigation (I)	Hydrophilic (H)	Uptake (kg ha^{-1})					
		Grains			Straw		
		N	P	K	N	P	K
NW	Control	36.47	22.31	41.13	33.87	20.60	38.43
	PAC	54.65	37.50	58.33	52.53	34.63	39.10
	GKS	53.27	36.57	57.53	50.27	33.47	40.90
	GWH	47.69	32.67	52.50	45.50	30.63	38.10
Mean		48.02	32.26	52.38	45.54	29.83	39.13
GW	Control	28.74	16.40	33.41	26.33	14.50	29.73
	PAC	39.52	24.63	42.45	36.97	22.47	30.13
	GKS	46.21	25.38	46.18	43.67	23.47	30.90
	GWH	38.50	23.67	41.57	35.63	21.50	36.27
Mean		38.24	22.52	40.90	35.65	20.48	31.76
DW	Control	34.89	20.41	39.87	32.43	16.67	29.87
	PAC	47.69	31.50	53.87	45.50	28.33	38.77
	GKS	47.35	31.54	53.40	44.87	26.73	36.23
	GWH	43.60	27.97	44.67	40.80	25.20	34.80
Mean		43.38	27.85	47.95	40.90	24.23	34.92
NW+GW	Control	31.20	16.67	34.44	28.53	14.87	25.80
	PAC	45.54	29.80	50.11	43.14	27.20	35.10
	GKS	44.52	29.43	50.43	42.30	26.57	32.77
	GWH	41.38	23.83	43.40	38.90	23.00	29.97
Mean		40.66	24.93	44.60	38.22	22.91	30.91
NW+DW	Control	35.71	21.67	40.78	33.27	17.77	30.17
	PAC	51.60	32.14	55.38	48.50	27.80	43.17
	GKS	50.38	31.30	55.27	48.10	26.67	39.23
	GWH	46.30	30.20	46.70	43.80	27.90	30.97
Mean		46.00	28.83	49.53	43.42	25.03	35.88
$LSD_{0.05}$	I	0.17	1.17	0.71	0.25	0.99	0.97
	H	0.23	0.67	0.66	0.28	0.45	0.75
	IxH	0.50	1.50	1.47	0.63	1.00	1.68

NW: Nile water, GW: Ground water, DW: Agricultural Drainage water, Control: without application, PAC: polyacrylamide,GKS: gelatin/K-silicate mixture, GWH: gelatin/water hyacinth mixture

Discussion

Mixing the NW with the saline DW and GW has led to a dilution of the ionic salts and different organic/inorganic species dissolved in water, which in turn decreased the EC of the mixed irrigation water NW+DW and NW+GW. The salt stress on the barely plant growth was decreased that has improved the estimated macronutrients' availability and uptake as well as the yield and its components for both the pots and field experiments. The treatment NW (control) in the pots and field experiments gave the highest mean values in grain yield, straw and plan height of barley plants. The mean values for the pots experiment followed the order NW (EC = 313.0 ppm) > NW+GW (EC = 1350.4 ppm) > NW+DW (EC = 1427.2 ppm) > GW (EC = 1715.2 ppm) > DW (EC = 1824.0 ppm) but the mean values for the field experiment followed the order NW (EC = 313.0 ppm) > NW+DW (EC = 1427.2 ppm) > NW+GW (EC = 1350.4 ppm) > DW (EC = 1824.0 ppm) > GW (EC = 1715.2 ppm). This practice can be recommended to economically save fresh water by reducing its consumption for irrigation and to present a beneficial utilization of the saline ground water and the agricultural drainage water. Additionally, the drainage water includes residual soluble fertilizers and pesticides that can play a useful role during the plant growth stages. Another useful practice is the soil application of the hydrophilic polymeric conditioners in combination with the irrigation by the slightly saline mixed water or even the saline water. The results attributed to the effectiveness of a polymer were affected when saline water was used for irrigation and similar observations were made by other authors who demonstrated that polymers can absorb up to 500 times their own weight in distilled water but water absorption decreases with increasing the salinity of water. The results are in accordance with those obtained by (Haghighi and Mohamed, 2013; Hanaa *et al.*, 2017; Ning *et al.*, 2019; Xu *et al.*, 2020; Daniela *et al.,* 2022), who reported that a significant increase in growth and yield in tomato plants by using K-Si under saline conditions.

Regarding the main effect of levels of irrigation water salinity, the obtained results showed that in most cases, the treatment NW (control) gave the highest mean values in all yield and yield components of barley plants.

Concerning the effect of hydrophilic materials applications in the pots and field experiments on yield and yield components of barley plants, the results indicated that, all yield characters were affected significantly by the addition of hydrophilic materials (GWH, PAC, and GKS). It may be indicated when the soil was treated with PAC resulted in the highest mean values compared with the other treatments.

Concerning the interaction effect between levels of irrigation water salinity and hydrophilic materials on yield characters of barley plants, the obtained results show that when the soil treated with PAC and GKS and plants irrigated with NW+DW and DW gave a positive increase in all yield characters in the field experiment while in the pots experiment; the DW gave the low in all yield characters. The treatment of NW+DW*PAC, NW+DW*GKS, DW*PAC, and DW*GKS resulted in the highest significant increase in all cases of yield compared with the other mixture treatments in the all experiments. Moreover, the treatments of NW+DW*PAC and NW+DW*GKS in most cases recorded values nearly by to the treatment of NW*PAC and NW*GKS and there were non-significant differences between them and the relative increases between these treatments in the field experiment were 96.4 and 99.3 % for grain yield and 91.6 and 104.0 % for straw yield respectively.

The salinity of irrigation water in the field experiment significantly increases NPK uptake by grain and straw except for the treatments GW and NW+GW which resulted in the lowest mean values in all studied cases. The highest N-P-K uptake was noticed using treatments of NW+DW and DW (salinity water from soil agricultural drainage) while the best results were recorded using the treatment of NW (standard treatment). Also, the treatment NW+DW recorded values higher than DW and there was a significant increase between them. The relative increases by using agriculture drainage water (NW+DW) to the control treatment (NW) were 95.7, 89.3, and 94.5 % for N, P, and K uptake by grain respectively while for straw were 94.8, 83.9, and 91.6 respectively. These results can be attributed to the osmotic pressure of the developing cell, by osmotic adjustment of salt accumulation to meet the increasing osmotic pressure of rooting media which is reflected in increasing the nutrient uptake by plants. These results are compatible with those mentioned by Gao *et al*., 2013, Matthew and Akinyele, 2014, Matichenkov *et al*., 2020, and Al-Saeedi, 2021).

With respect to the main effect of the different hydrophilic materials applications, the total N, P, and K uptake by both grain and straw were affected significantly by application of hydrophilic materials compared with control. Almost in all cases application of PAC and GKS produced the highest N-P-K uptake and using PAC was higher than GKS while the lowest values of N-P-K-uptake were obtained from the treatment of GWH.

About the interaction effect we can observe N-P-K-uptake by grain and straw were influenced by di-interaction between water irrigation salinity and application of hydrophilic materials. Generally the treatments of GW and NW+GW with all hydrophilic materials registered the lowest values of NPK-uptake by grain and straw. In addition, the treatments of NW+DW*PAC and NW+DW*GKS in some cases resulted in mean values nearby which were received by NW*PAC and NW*GKS. These results may be due to polyacrylamide significantly potassium silicate can improve the performance of salinity water irrigation. These results are in harmony with those obtained by (Tesfy *et al*., 2011; Abd El-Megeed *et al*., 2016; Hanaa *et al*., 2017; Daniela *et al*., 2022).

The obtained results show that the main effect of salinity water irrigation in pots and field experiment significantly decreased soil content of available NPK particularly in treatments of GW and NW+GW compared with the standard irrigation NW while, in all cases the treatment of NW+DW is the closest to the control treatment (NW). In pots and field experiments recorded the mean values in available N, P and K for NW+DW (EC = 1427.2 ppm) to NW highest for NW+GW (EC = 1350.4 ppm) to NW and the mean values in available N, P and K for DW (EC = 1824.0 ppm) highest for GW (EC = 1715.2 ppm) where the relative increases in NW+DW to NW were 96.06, 93.04, and 95.4 for available N, P, and K respectively in field experiment.

Also, the effect of different hydrophilic materials applications on soil available NP, the results clear the same trend which received in yield characters and NPK-uptake where available K due to GKS gave values in cases higher than by using other hydrophilic materials treatment. Using treatments of PAC and GKS gave values in all cases higher than by using GWH treatment in pots and field experiment.

Concerning the interaction effect between salinity water levels and applications of hydrophilic materials on the soil content of available NPK after harvest data show that among all combined treatments, the treatments of NW*PAC and NW*GKS recorded the highest mean values in available N and P especially available K when the soil was treated with gelatin and potassium silicate (GKS). Moreover, the treatments of NW+DW*PAC and NW+DW*GKS in all cases resulted in mean values nearly or similar to those treated with NW*PAC and NW*GKS and there were non-significant differences between them. In field experiment, the relative increases in NW+DW*PAC to NW*PAC were 94.1, 99.6, and 96.0 % for N, P, and K respectively while for NW+DW*GKS to NW*GKS were 95.7, 95.2 and 95.4 % respectively. These results are in harmony with those obtained by (Munn and Tester, 2008; Hussien and Nesreen, 2014; Abd El-Megeed *et al*., 2016; Wei *et al*., 2020; Basheer 2023)

CONCLUSION

The salt stress on the barely plant growth was decreased that has improved the estimated macronutrients' availability and uptake as well as the yield and its components. Irrigation of the seedlings of barley plants by agricultural drainage water mixed with Ismailia river water (1:0.5 v/v) where EC equivalent 1427.2 ppm is recommended along with the use polyacrylamide (PAC) and gelatin mixed with K-Silicate powder (GKS) at a rate of 0.3% w/w (equivalent 714.0 kg ha^{-1}) to soil surface. They have improved the growth, yield of barley plants and productivity of sandy soil which gave results similar to by using Ismailia river water individually. Additionally, we can conclude that using PAC and GKS reduces the harmful effect of the water salinity to get the highest rate of vegetative growth increases the affordability of salinity, and improves the growth and yield of barely plants grown in sandy soil.

Declaration

Ethics approval and consent to participate

Consent for publication: The article contains no such material that may be unlawful, defamatory, or which would, if published, in any way whatsoever, violate the terms and conditions as laid down in the agreement.

Availability of data and material: Not applicable.

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REFERENCES

Abdel Shafy, H.I., Farid, M.R., Shams El-Din, A.M. 2016. Water-hyacinth from Nile river: chemical contents, nutrient elements and heavy metals. Egypt. J. Chem. 59 (2), 131- 143.

Abd El-Megeed, S.A., Abd El-Fattah, Y.M., Zaghlol, A.A., Abd El-Kader, M.M. 2016. Effect of irrigation water salinity potassium silicate levels and their interaction treatments on Eucalyptus CamaldulensisDehn. Hort. Sci. J. of Suez River Univ. (2): 23 – 35.

Abo-Baker, N.H., Abd-Eladl, M., Abas, M.M. 2011. Use of silicate and different cultivation practices in alleviating salt stress effect on bean plants. Aust. J. Basic Appl. Sci., 5(9): 671 – 781.

Alsadon, A., Monther, S., Wahb-Allah, M. 2013. Responsive gene screening and exploration of genotypes responses to salinity tolerance in tomato. AJCS., 7(9): 1383-1395.

Al-Saeedi, A.H. 2021. Contribution of Nano-Silica in Affecting Some Physico-Chemical Properties of Cultivated Soil with the Common Bean (*Phaseolus vulgaris*). J. Adv. Agric. Res., 25 (4): 389-400.

Fayrap, A., Koc, C. 2012. Comparison of Drainage Water Quality and Soil Salinityin Irrigated Areas with Surface and Subsurface Drainage Systems. Agric. Res., (July–September 2012) 1(3):280–284.

Basheer, H.M. 2023. The effect of potassium silicate on the chemical parameters of prunusarmeniaca C.V. Qaisi seedlings irrigated with salty water. J. Survey Fisheries Sci. 10(35): 5164 – 5173.

Baum, M., Grando, S., Backes, G., Jahoor, A., Sabbayh, A., Ceccarelli, C. 2003. GTL for organic traits in the Mediterranean environment identified in recombinant inbred lines of the cross. Arta. Spontaneom, 41.1. Theoret. Appl. Genetics 107(7): 1215- 25. doi 10.1007 -122-003-1357-2.

Black, C.A. 1982. Methods of Soil Analysis. Soil Sci. Soc. Amer., Inc. Pub., Madison, Wisconsin, USA.

Center, P.P., Rayamajhi, M., Van, T., Franks, S., Dray, F., Rebelo, M. 2005. Herbivory alters competitive interactions between two aquatic plants. Biol. Control. 33: 173-185.

Cannazza, G.; Cataldo, A.; De Benedetto, E.; Demitri, C.; Madaghiele, M. and Sannino, A. (2014). Experimental assessment of the use of a novel superabsorbent polymer (SAP) for the optimization of water consumption in agricultural irrigation process. Water. 6, 2056–2069.

Chapman, H. D. and Pratt, P. F. 1961. Methods of Analysis for Soil, Plant and Water. DIV. Agric. Sci., Univ. of Calif.

GabAllah, D.F., Ghaly, H.W. 2020. Efficiency use resources of the most important salt tolerant crops productivity in Sahl EL-Tina. Sci. J. Agric. Sci. 2 (1): 55-61.

Daniela, C., Claudia, B., Johanna, M., Pilar, M. 2022. Response of potted citrus trees subjected to water deficit irrigation with the application of super absorbent polyacrylamide polymers. Agron. J. 12: 1546 – 1555.

EL-Komy, M.N. 2012. Assessing the quality of irrigation water resources in north Kafer-EL-Sheikh Governorate. M. Sci. Thesis, Fac. Sci., Mansoura Univ.

El-Zeiny, H.A., Abou Gaballah, M.S., Khalil, S. 2007. Anti transpirant application to sesame plant for salinity stress Augmentation Res. J. Agric. Biologic. Sci. (3): 950 – 959.

FAO, 2018. Food and Agriculture Organization of the United Nations. http//www.fao.org/giews/english/cpfs/index.htm#2018.

Flowers, T.J., Ragab, R., Malash, N., Abdel Gwad, G., Cuartero, J., Arslan, A. 2005. Sustainable strategies for irrigation in salt-prone Mediterranean: SALTMED. Agric. Water Manag., (78): 3 – 14.

Gabr, M. 2018. Evaluation of Irrigation Water, Drainage Water, Soil Salinity, and Ground water for Sustainable Cultivation. Irrig. Drain. Sys. Eng., 3:7.

Gao, S., Liu, K.T., Chung, W., Chen, F. 2013. The effect of NaCl stress in jatropgacotyled on growth and nitrogen metabolism. J. Soil Sci. Plant Nutri. 13(1): 99 – 113.

Gomez, K.A., Gomez, A.A. 1984. Statistical Procedures of Agricultural Research. Second Ed. Willy Inter Science Publ. John Wiley and Sons. New York, Pp. 357-423.

Ghobashy, M. M., El-Damhougy, B. Kh., Abd El-Wahab, N. N. H., Naser, A. M. and Abdelhai, F. 2018. Radiation Crosslinking of Modifying Super Absorbent (Polyacrylamide/Gelatin) Hydrogel as Fertilizers Carrier and Soil Conditioner Journal of Polymers and the Environment 26: 3981–3994.

Haghighi, M., Mohamed, P. 2013. Influence of silicon and non-silicon on salinity tolerance of cherry tomatoes (*Solanumlycopersicum* L.) at early growth stage. Scient. Hort., 161: 111 – 117.

Hamayun, M. 2010. Effect of silicon on growth and salinity stress of soybean plant grown under hydroponic system. Agroforestry Systems Impact Factor., 80 (3): 333 – 340.

Hanaa, M., Yossria, A., Alad, M.A., Hedat.Allah, A., Hossien, M., El-Awady, R.A. 2017. Effect of potassium humate and potassium silicate on growth and productivity of wheat plants grown under saline conditions J. Soil Sci. Agric. Eng. Mansoura Univ. 8(11): 577 – 582.

Hussien, M.M., Nesreen, A.B. 2014. Growth and mineral status of moringa plants as affected by silicate and salicylic acid under salt stress. J. Appl. Sci. Res. 3(2): 163 – 177.

Jackson, M.L. 1973. Soil chemical analysis. Prentice-Hall, Inc., Englewood Cliffs. NJ, USA.

Martucci, J. F., Ruseckaite, R. A. 2009. Tensile Properties, Barrier Properties, and Biodegradation in Soil of Compression—Molded Gelatin-Dialdehyde Starch Films. J. Appl. Polym. Sci., 112: 2166–2178.

Matichenkov, V., Bocharnikova, E., Campbell, J. 2020. Reduction in nutrient leaching from sandy soils by Si-rich materials: Laboratory, greenhouse and field studies. Soil Tillage. Res., 196: 104450.

Matthew, A., Akinyele, A. 2014. Sodium and Calcium Salts Impact on Soil Permeability. J. Earth Sci., 4(3): 37– 45.

Mohamed, M.M., Mashhour, A.M.A., Abd El-Fattah, A.M.M., Abo-Ziud, M.H. 2018. Effect of Water Irrigation from Different Sources on Soil and Plant Properties in Qalyubiya Governorate, Egypt. J. Soil Sci. Agric. Eng., Mansoura Univ., 9 (8): 353 – 358.

Munn, R., Tester, M. 2008. Mechanisms of salinity tolerance. Ann. Rev. Plant Biol., 59: 651 – 681.

Nadege, C.G., Emile, D.F., Mhuman, T.S., Paul, E.K., Allassane, O. 2017. Evaluation of sodium chloride (NaCl) effects on water hyacinth Eichhorniacrassipes development: preliminary results. Environ. And Water Sci., Pub. Health. Terri. Intel. (1): 34 – 40.

Ning, S., Jumai, H., Wang, Q., Zhou, B., Su, L., Shan, Y. and Zhang, J. 2019. Comparison of the Effects of Polyacrylamide and Sodium Carboxy methyl cellulose Application on Soil Water Infiltration in Sandy Loam Soils. Advances in Polymer Technology, Volume 2019, 7.

Omer, A.M., Tamer, T.M., Hassan, M.E., Khalifa, R.E., Abd El-Monaem, E.M., Eltaweil, A.S., MohyEldin, M.S. 2023. Fabrication of Grafted Carboxymethyl Cellulose Superabsorbent Hydrogel for Water Retention and Sustained Release of Ethephon in Sandy Soil. Arab. J. Sci. Engin., 48:561–572.

Ozturk, H.S.; Turkmen, C.; Erdogan, E.; Baskan, O.; Dengiz, O. and Parlak, M. (2005). Effect of a soil conditioner on some physical and biological features of soil: results of greenhouse study. Bioresour. Technol. 96: 1950-1954.

Page, A.L., Miller, R.H., Keeney, D.R., 1982. Methods of soil analysis. Part 2.Chemical and microbiological properties, Agronomy, No. 9. Soil Sci. Soc. Amer., Madison, WI, Pp. 1159.

Pandya, A.B. 2018. Modernizing irrigation and drainage for a new green revolution: outcome of 23rd. ICID Congress. Irrig. Drain. 67: 148-149.

Ragab, R., Malash, N., Abdel Gwad, G., Arslan, A., ghaibeh, A. 2005. A holistic generic integrated approach for irrigation, crop and field management 1. The SALTMED model and its calibration using field data from Egypt and Syria. Agric. Water Manage. 78: 67 – 88.

Richmond, K.E., Sussman, M. 2003. Got silicon? The non-essential beneficial plant nutrient. Current Opinion Plant Biol., 6: 368 – 272.

Rokhade, A.P.; Potil, S.A. and Aminabhavi, T.M. (2007). Synthesis and characterization of semi-inter penetrating polymer network microspheres of acrylamide grafted dextran and chitosan for controlled release of acyclovir. Carbohydr. Polym. 67: 605-613.

Sharma, D.P., Tyagi, N.K. 2004. On-farm management of saline drainage water in arid and semiarid regions. Irri. Drain., 53: 87 – 103.

Tesfy, S.Z., Bertlingt, I., Bower, J.P. 2011. Effects of postharvest potassium silicate application on phenolic and other anti-oxidant systems aligned to avocado fruit quality postharvest. Biol. Tech., 60: 92 – 96.

Thalooth, A.T., Bahr Amany, A., Tawfik, M.M. (2012) Productivity of Some Barley Cultivars as Affected by Inoculation under Water Stress Conditions. Elixir Applied Botany, 51, 10743-10749.

Villamagna, A., Murphy, B. 2010. Ecological and socio-economic impacts of invasive water hyacinth (*Eichhornia Crassipes*): a review. Fresh water Biology (55): 282 – 298.

Wahba, M.A. 2017. Assessment of option for the sustainable use of the agricultural drainage water for irrigation in Egypt by simulation modeling. Irrig. Drain. (66): 118 – 128.

Wei, K., Zhang, J., Wang, Y., Chen, M., Diny, Q. 2020. Effect of ionized brackish water and polyacrylamide application on infiltration characteristics and improving water retention and reducing soil salinity. Can. J. Soil Sci. 101: 324 – 334.

Wilson, H.T., Amirkhani, M., Taylor, A.G. 2018. Evaluation of gelatin as a bio stimulant seed treatment to improve plant performance. Front. Plan. Sci. (9): 10006 – doi.10.3389/fpls.2018.01006.

Xu, D., Gao, T., Fang, X., Bu, H., Li, Q., Wang, X., Zhang, R. 2020. Silicon addition improves plant productivity and soil nutrient availability without changing the grass:legume ratio response to N fertilization. Sci. Rep., 10 (1): 1–9.

تحسين كفاءة مياه الرى الملحية بإضافة محسنات التربة الجاذبة للماء لتحسين إنتاجية نبات الشعير في الأرض الرملية

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الملخص

تهدف هذه الدراسة إلى تقييم كفاءة مياه الرى منخفضة الجودة المخلوطة مع مياه النيل العذبة والمستخدمة مع إضافة محسنات التربة الجاذبة للماء لتحسين إنتاجية محصول الشعير فى التربة الرملية , حيث مثلت مياه الرى المستخدمة خمس مستويات من الملوحة هى مياه النيل العذبة NW (كنترول) , مياه جوفية GW , مياه صرف زراعى DW , خليط من NW مع GW بنسبة ٠,٥ : ١ حجم/حجم , وخليط من NW مع DW بنسبة ٠,٥ : ١ حجم/حجم . أجريت تجربة أصص بالصوبة وتجربتان حقليتان بإستخدام بوليمرات البولى أكريلاميد PAC والجيلاتين G حيث إستخدم ال PAC بحالته بينما تمت إذابة الجيلاتين لتحضير محلول مائى منه تم خلطه مع مسحوق سيليكات البوتاسيوم S بنسبة ١:١٠ جرام/جرام ليكون خليط GKS أو خلطه مع مسحوق ورد النيل WH الجاف هوائياً بنسبة ١:١٠ جرام/جرام ليكون خليط GWH ثم ترك الخليط ليجف . رُتبت جميع معاملات الرى ومحسنات التربة فى تصميم قطع منشقة بثلاث مكررات لكل معاملة , وكان العامل الرئيسى هو معاملات الرى (I) والعامل تحت الرئيسى هو محسنات التربة (H) الجاذبة للماء . تمت زراعة بذور الشعير (*Hordeum valgare* L.) خلال موسمى الشتاء المتتاليين لعامى٢٠٢٢/٢٠٢٣ و٢٠٢٣/٢٠٢٤ . أدى خليط NW+DW و NW+DW إلى زيادة معنوية فى القيم المتوسطة للعناصر المُيسَرة من N وP وK بنسبة ١٨,٣ و٢٥,٨ و٢٠,١٪ وبنسبة ١١,٥ و ٢٥,٧ و٨,٩٪ على التوالى لتجربة الأصص نسبة إلى القيم المتوسطة للإستخدام المنفرد ل DW وGW الأكثر ملوحة . فى التجربة الحقلية أدى PAC وGKS الى زيادة فى إنتاجية الحبوب بنسبة ٧٦,٨٪ و٦٠,٢٪ على التوالى (ب NW) وبنسبة ٧٢,٤٪ و٦٠,٨٪ على التوالى (ب NW+DW). أدت معاملة NW+DW مع وبدون PAC إلى زيادة معنوية فى إمتصاص عناصر N وP وK بواسطة الحبوب والقش. إن المعاملات التى تمت دراستها يمكن أن يُوصى بها لتحسين إنتاجية نبات الشعير تحت ظروف التربة الرملية وإستخدام مياه رى مِلحية .

الكلمات الدالة : مياه الصرف الزراعى , المياه الجوفية , بوليمرات الهيدروجيل , ملوحة المياه