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Abstract

The Field experiment was conducted at private land in Grdarasha southern Erbil-Iraq to study the effect of 7 water qualities having electrical conductivity of (0.42, 0.50, 1.43, 2.20, 2.60, 5.40 and 5.70) dS m-1 on chemical characteristics and growth of plant and protein percent in wheat grains in winter season of 2015-2016. The crop was cultivated on 11.12.2015 and continued growing to 30.5.2016. The experiment land was equally divided into three plots spaced 75 cm between them. The results showed that weights and lengths of straw and spike were reduced by W.q5 (67.49, 100.01) g and (51.87, 6.30) cm increased with W.q3 treatment (96.58, 139.17) g and (91.08, 10.57) cm respectively; and wheat grains protein percentage was also increased by W.q6 (13.70) treatment comparing with minimum percent of protein by W.q5 (7.26). The data of Irrigation by saline water of W.q7 resulted concentration increasing of Ca2+, Mg2+ and Na+ (7.39, 2.22 and 4.52) mg g-1; while the concentrations of the same elements were 1.54, 0.61 and 1.81 mg g-1 by W.q2 watering respectively. Potassium concentration was the highest (0.16) mg g-1 by W.q2 water compared to minimum level (0.06) mg g-1 with W.q5 irrigation. The watering by W.q5 (0.29) mg g-1 resulted was lower concentration of phosphorus in the plant compared to minimal saline water W.q3 and W.q4 (0.34) mg g-1.

Keywords

Groundwater, Saline wat, Wheat, Yield index

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RESEARCH ARTICLE

Effect of Groundwater Quality on Yield Index and Nutrient Concentration in Stem Plant Tissue of Winter Wheat (*Triticum turgidum* L.)

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ABSTRACT

The field experiment was conducted at private land in Grdarasha southern Erbil, Iraq, to study the effect of seven water qualities having electrical conductivity of 0.42, 0.50, 1.43, 2.20, 2.60, 5.40, and 5.70 dS/m on chemical characteristics and growth of plant and protein percent in wheat grains in winter season of 2015–2016. The crop was cultivated on December 11, 2015, and continued growing to May 30, 2016. The experiment land was equally divided into three plots spaced 75 cm between them. The results showed that weights and lengths of straw and spike were reduced by W.q5 67.49 and 100.01 g and 51.87 and 6.30 cm increased with W.q3 treatment 96.58 and 139.17 g and 91.08 and 10.57 cm, respectively, and wheat grains protein percentage was also increased by W.q6 (13.70) treatment comparing with minimum percentage of protein by W.q5 (7.26). The data of irrigation by saline water of W.q7 resulted concentration increasing of Ca^{2+}, Mg^{2+}, and Na^{+} (7.39, 2.22, and 4.52 mg/g); while the concentrations of the same elements were 1.54, 0.61, and 1.81 mg/g by W.q2 watering, respectively. Potassium concentration was the highest (0.16 mg/g) by W.q2 water compared to minimum level (0.06 mg/g) with W.q5 irrigation. The watering by W.q5 (0.29 mg/g) resulted was lower concentration of phosphorus in the plant compared to minimal saline water W.q3 and W.q4 (0.34 mg/g).

Keywords: Groundwater; Saline water; Wheat; Yield index

INTRODUCTION

The use of saline water for irrigation has been commonplace for 50 years, as it is obtainable in many developing countries. In the last water requirements with available resources data of the Iraqi Ministry of Water Resources in 2002 showed that the water resource predictions for 2015 would be 43.93 billion m^3, and the actual need for multiple purposes will be 65.35 billion m^3, which indicates the necessity of exploitation of groundwater, and the initial studies were done actually in the fifties on the quality of groundwater in the Altun Kopre basin (Persons and Ralph, 1955). On the other hand, numerous studies were conducted in Kurdistan region by Esmail, 1992; Dohuki, 1997; Esmail et al., 2007; Salih, 2008; Dohuki et al., 2013; Rajab, 2015; Alani, 2015; and Salih, 2018.

Most of the water resources suffer from inconsistencies in their quantity and paucity in quality due to the environmental changes associated with the continuous industrial and agricultural expansion. However, the large expansion of the use intermediate level of saline water in both irrigation and studies in the field has been reported; the field management of using this water for agricultural purposes still requires further researches to diminish soil salinity risk that costs extremely human life. Most plants tolerate to a certain level of salinity, and then, the effect of salinity on productivity will be observed. When the salinity level influences yield negatively, it is called threshold (TH) point. Furthermore, the variation of crops in tolerating salinity was observed. It is the minimum relative production to be accepted economically by irrigation of saline water reaching 50% of the maximum production under the same conditions (FAO, 1985).

Many researchers have pointed out that irrigation with different saline water causes direct or indirect harmful effects on plant growth. The direct harmful effect is shown in the inability of the plant to absorb water due to increase osmotic pressure of the soil solution or to cause the imbalance in plant absorption of nutrients and finally reflects on growth and plant yield (Dohuki, 1997 and Sharma et al., 2005). Oscarson (2000) described that wheat (*Triticum aestivum* L.) as one of the most economically important cultivated plants. Furthermore, it is the dominant crop in temperate countries being used for human food and livestock feed; however, wheat is counted among the "big three" cereal crops, with over 600 million tones being harvested annually as described by Shewry (2009).

Both irrigation water quality and proper irrigation management are critical to successful crop production. Low-quality water for irrigation can impose a major environmental constraint to crop productivity and type of amendment on the yield and quality of plants (Al-Omran et al., 2010). In plants, salinity can induce damages in proteins, lipids, and nucleic acids, and alterations in photosynthesis and respiration which affect plant growth and development (Manai et al., 2014 and Hussain et al., 2016).

Growth is suppressed when salinity exceeds beyond a TH value (Tanji, 1990). The higher electrical conductivity (EC) results the less water available to plants, even though a field may appear wet.

The use of saline drainage waters in such environments shows promise for growing agricultural crops (Rhoades, 1987). Salinity is a severe problem which not only reduces the agricultural potential but also creates serious effects on livelihood of farmers (Haider and Hossain, 2013).

Several crops are sensitive to salinity and the negative effect on growth leads to the decrease in yield and quality. For this reason, salinity has been considered as one of the most important factors which affect irrigation water suitability (Beltran, 1999). Irrigating saline water can also result in salt accumulation in soil, leading to the decrease in yield and deterioration in soil resource (Ould et al., 2007, Feizi et al., 2010).

Table 1: The GPS reading for the studied groundwater

Water quality	Coordinates		Elevation (m)
	Latitude	Longitude	
W.q1	44°00'28"	36°03'06"	412.3
W.q2	44°00'41"	36°06'48"	421.6
W.q3	43°53'57"	35°57'02"	338.6
W.q4	43°53'22"	35°57'48"	341.2
W.q5	43°36'05"	35°46'54"	298.4
W.q6	43°46'32"	35°46'59"	300.2
W.q7	43°43'09"	35°52'23"	341.2

Numerous studies were conducted in Kurdistan region about the effect of water quality on soil chemical properties and plant growth by Esmail, 1986, 1992; Dohuki, 1997; Mam Rasul, 2000; Esmail, 2001; Salih, 2008; Baba, 2010; Kareem, 2010; and Alani, 2015.

Most of the mentioned investigations either depended on pot experiment or on corn plant, it means none of them included the effect of saline water under field condition on growth and yield index of wheat, for this reason, the aim of this study was the effect of saline water on yield index of wheat in Erbil plain under field condition.

MATERIALS AND METHODS

This study was conducted from December 11, 2015, to May 30, 2016, at Grdarasha field, where is located southwest of Erbil about 6 km from the city center; and the field situated between latitudes of northern 35.253942°–36.348443° and longitudes of eastern 43.264947°–44.353321°. The experiment land was equally divided into three plots spaced 75 cm between the blocks and divided every block to seven experimental units. The dimension of each experimental unit was 150 cm×75 cm and the distance between them was 50 cm. Each plot was split to seven experimental units. Seven of EC were used (0.42, 0.50, 1.43, 2.20, 2.60, 5.40, and 5.70 dS/m). The randomized complete block design with three replicates was applied.

Wheat seeds (*Triticum turgidum* L. variety Acsad 65) were planted at a depth of 4 cm on December 11, 2015, considering 100 kg/ha. Each experimental unit was seeded with three lines at a distance of 15 cm from the east to the west. Diammonium phosphate fertilizer was used for all experimental units at a rate of 20 g (200 kg/ha). Collected data of the experiment were plant morphology measurement, cation, and anion in hay and grains protein. The experiment was conducted under natural rainfall conditions; supplemental irrigation was carried out whenever needed (Walker, 1989). Totally, each experimental unit was irrigated by 140.44 mm. The geographical position of the studied wells is presented in Table 1 and their

Table 2: Mean of some chemical properties of irrigation water during the growing season*

Water quality	Concentration mmol$_c$/L								pH	EC dS m^{-1}	SAR	Mg^{2+}/Ca^{2+}	Mg^{2+}/Na^{+}	RSC	S.P**=(Cl^-+1/2SO_4^{2-}) mmol$_c$/L
	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	NO_3	SO_4^{2-}	HCO_3^-							
W.q1	2.42	2.12	0.57	0.01	0.35	0.15	0.50	3.10	7.64	0.42	0.38	0.88	3.72	-1.44	0.60
W.q2	2.64	2.07	0.42	0.01	0.30	0.15	0.82	3.15	7.63	0.50	0.27	0.78	4.93	-1.56	0.71
W.q3	4.53	4.90	2.80	0.15	1.30	0.60	4.14	5.12	7.57	1.43	1.29	1.08	1.75	-4.31	3.37
W.q4	5.94	7.25	2.82	0.05	2.50	0.60	4.50	6.80	7.32	2.20	1.10	1.22	2.57	-6.39	4.75
W.q5	11.55	8.65	3.22	0.15	2.82	0.08	5.35	5.40	7.22	2.60	1.01	0.75	2.69	-14.80	5.50
W.q6	17.12	14.63	9.52	0.15	8.50	0.90	25.42	5.00	7.24	5.40	2.39	0.85	1.54	-26.75	21.21
W.q7	16.75	14.82	15.25	0.15	7.45	0.80	35.12	4.45	7.58	5.70	3.84	0.88	0.97	-27.12	25.01

* The waters were analyzed 4 times during the field experiment. **S.P: Salinity potential

chemical analysis results are given in Table 2. Furthermore, the common physical and chemical parameters of soil were determined as referenced in Table 3 mention the amount of rainfall during the grown season.

RESULTS AND DISCUSSION

The summary of ANOVA showed that EC of irrigation waters significantly ($P \leq 0.05$) affected the weight and length of hay and wheat spike [Table 4] (Mohammed and Yassen, 2009) and (Al-Jobouri and AL-Dawdi, 2014). The highest values of hay and spike weight are 96.58 and 139.17 g and length of hay and spike are 91.08 and 10.57 cm, respectively, recorded from treatment W.q3, while the lowest values 67.49 and 100.01 g) and 51.87 and 6.30 cm, respectively, were recorded from treatment W.q5. This was due to the difference in chemical properties of the irrigation water. These results were similar to those recorded by Esmail (1986; 1992), Salih (2008), and Alani (2015). Plant height average at W.q5 was decreased due to inhibition of cell plants elongation and saline stress diminishes amino acid synthesis, as well as some plant hormones that contribute in cell division, which influences negatively plant height (Heron, 2003 and Mohamed et al., 2007).

Table 5 shows the significant effect of water quality ($P \leq 0.05$) on protein content and weight of 1000 seeds. The increase in water EC caused an increase in protein content and weight of 1000 seeds except treatment W.q5 which recorded the lowest value. This due to the difference in chemical composition of the applied water qualities in irrigation, especially NO_3^- concentration since the concentration of NO_3^- in W.q5 is very low (0.08 $mmol_c/L$) in comparing with other water qualities [Table 2]. These results were similar to those recorded by Esmail (1986; 1992) Salih (2008), and Alani (2015).

The water qualities affected significantly ($P \leq 0.05$) on concentration of cations in hay [Figure 1], the highest concentration value 7.39, 2.22, and 4.52 mg/g of Ca^{2+}, Mg^{2+}, and Na^+ was recorded from treatment W.q7, respectively, and the highest mean concentration (0.16) of K^+ was recorded from treatment W.q2, while the minimum concentration (1.54 and 1.81 mg/g) of Ca^{2+} and Na^+ was obtained from treatment W.q2 and the lowest mean concentration (0.19 mg/g) of Mg^{2+} was obtained from treatment W.q3, the minimum concentration (0.06 $mmol_c/L$) of K^+ was obtained from treatment W.q5. Similar results were obtained by Mostafa et al. (2004). The difference in elements proportions might be due to increasing of Na^+, which is absorbed by plant roots faster than K^+ (Smith, 1966; Julain, 2004; and Mohamed et al., 2007).

Table 3: Some physical and chemical properties of the soil before experiment

Parameter of average soil	pH	EC ds/m	Organic matter g/Kg	Total $CaCO_3$ g/Kg	CEC Cmol/Kg	Bulk density Mg m^{-3}	Texture name	PSD%			Total rainfall mm	Amount of irrigation waters per experimental unit
								Clay	Silt	Sand		
soil	7.55	0.65	7.9	340	23.20	1.25	SiCL	38	46	16	330	158 L=140.44 mm

Soil	Concentration mmolc/L												
	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO_3^-	NO_3^-	SO_4^{2-}	Mg^{2+}/Ca^{2+}	Na^+/Ca^{2+}	RSC	SAR	Adj. SAR	Adj. RNa
SiCL	1.43	1.21	1.20	0.10	0.73	1.33	0.40	0.95	0.85	0.84	−1.31	1.04	1.64	0.95

The statistical methods were used to analyze the results of the research. In all cases, Tukey's H.S.D multiple range tests were applied at $P \leq 0.05$ for comparing between the means of treatments using SPSS 22.0 program (IBM Corp., 2013)

Table 4: Effect of water quality on some growth characters (g) and (cm) of wheat

Water quality	Hay weight (g)	Spike weight (g)	Plant height (cm)	Spike length (cm)
W.q1	87.25	135.13	85.47	8.87
W.q2	89.11	113.17	85.77	8.80
W.q3	96.58	139.17	91.08	10.57
W.q4	91.39	131.16	87.77	9.27
W.q5	67.49	100.01	51.87	6.30
W.q6	88.26	114.03	83.53	8.83
W.q7	86.07	121.32	79.73	8.00
Tukey's HSD values	6.68	4.70	6.67	0.62

Table 5: Effect of water quality on concentration of protein percentage in seed and weight of 1000 seeds

Water quality	Protein in seed (%)	Weight 1000 seed (g)
W.q1	9.81	33.45
W.q2	8.52	33.44
W.q3	12.07	33.53
W.q4	12.50	34.36
W.q5	7.26	30.02
W.q6	13.70	34.70
W.q7	12.13	33.83
Tukey's HSD values	1.04	0.63

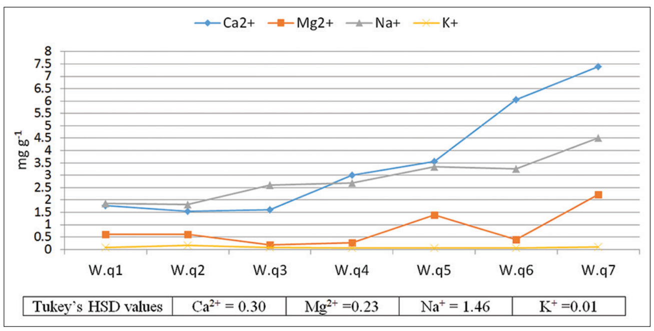

Figure 1: Effect of water quality on cations concentration in hay (mg/g) after irrigation water

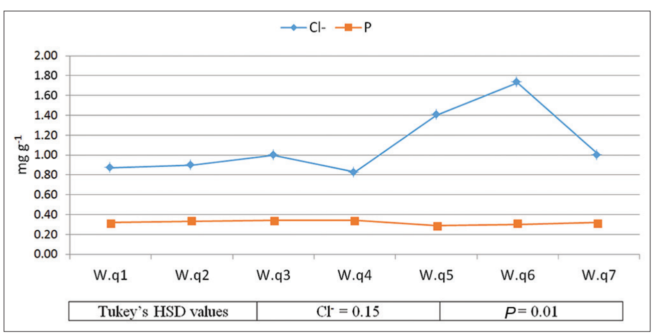

Figure 2: Effect of water quality on chlorine and phosphorus concentration in hay (mg/g) after irrigation water

In Figure 2, the statistical analysis shows the significant difference between concentration of Cl^- and P in hay wheat. The highest concentration (1.73 mg/g) of Cl^- was recorded from treatment W.q6, the highest concentration (0.34 mg/g) of P was recorded from treatment W.q3. On the other hand, the lowest concentration (0.83 mg/g) of Cl^- was recorded from treatment W.q4 and the lowest concentration (0.29 mg/g) of P was recorded from treatment W.q5. This may be due to chemical composition of irrigation water, especially Mg^{2+}/Ca^{2+} ratio [Table 2]. These results agree with those recorded by Esmail (1986), Al-Azawi (1986), and Esmail et al. (2000), Salih (2008), Alani (2015), and Esmail and Rajab (2018). Low significant variations were due to the ability of wheat plant to tolerate such levels of saline stress and the leaching of Cl^- by rain (Al-Azawi, 1986; Yasseen et al., 1989; and Salih, 2008).

RECOMMENDATIONS

Groundwater of the study area is main source of irrigation to field crops. Hence, it is required to conduct more experiments in future on different field crops, particularly wells that suffer more from saline stress to choose best tolerant crop to cultivate in such areas. It is also recommended that these regions can be monitored or supervised by experts of the ministry of agriculture continuously to avoid the risk of saline stress.

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