DOI: https://doi.org/10.47847/fagropec.v17n2a1

ARTÍCULO DE INVESTIGACIÓN CIENTÍFICA

REVISTA FAGROPEC
FACULTAD DE CIENCIAS AGROPECUARIAS
ISSN-Revista en línea: 2539-178X

EL EFECTO DE DIFERENTES NIVELES DE SALINIDAD DEL AGUA DE RIEGO SOBRE LAS CARACTERÍSTICAS FENOTÍPICAS DE LA VARIEDAD DE TRIGO (*Triticum aestivum L*)

The Effect Of Different Level Of Irrigation Water Salinity On The Phenotypic Characteristics Of (Triticum Aestivum L) Wheat Variety

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RESUMEN

El objetivo de este estudio fue investigar el efecto de los niveles de salinidad del agua de riego sobre las características fenotípicas del crecimiento y la producción de la variedad de trigo “Triticum aestivum L.”, así como determinar los efectos perjudiciales sobre la germinación de las semillas y el crecimiento de las plantas de trigo al utilizar agua de riego con diferentes concentraciones de cloruro de sodio. Este estudio se llevó a cabo en la cuenca experimental de la Estación Dubouni, perteneciente al Departamento de Investigación Agrícola del Ministerio de Agricultura de Irak, durante la temporada agrícola 2021-2022. El agua de riego utilizada en el experimento tenía cinco niveles de salinidad: 0,000, 1000, 3000, 6000 y 9000 ppm de sales de sodio. El experimento se diseñó según un diseño de bloques completos al azar (DBA) con siete tratamientos y tres réplicas. Los resultados del experimento mostraron diferencias estadísticamente significativas, inferiores al 5%, para todos los parámetros experimentales estudiados (tasa de germinación, altura de la planta, longitud de la raíz, longitud de la espiga, área foliar, peso seco de la hoja y peso seco de la raíz).El estudio concluyó que a mayor concentración de sales de cloruro de sodio en el agua de riego, menor tasa de germinación, crecimiento y características fenotípicas de la planta en estudio. Esto demuestra de forma concluyente que el efecto nocivo del cloruro de sodio sobre la germinación y el crecimiento de las plántulas se debió al efecto osmótico tóxico. Los resultados del experimento actual revelaron que diferentes niveles de agua de riego salina pueden afectar

Fecha recepción: 27 de Junio de 2025 / Fecha Aprobación: 7 de Agosto 2025 / Fecha Publicación: 27 de Noviembre 2025

Cómo citar:

Alawadi, R. A., Nasir Al-Sadun, J. & Jabbar Almaliki, R.(2025). *The effect of different level of irrigation water salinity on the phenotypic characteristics of (Triticum aestivum L) wheat variety.* Revista. FAGROPEC. Vol. 17(2), ppt 7-23. https://doi.org/10.47847/fagropec.v17n2a1

significativamente el crecimiento, la productividad, la calidad, la concentración y la absorción de nutrientes en los cultivos de trigo. Las tasas de crecimiento más bajas en todos los fenotipos de plantas estudiados se obtuvieron cuando se utilizó agua con una salinidad de 900 ppm. Esto indica claramente que una mayor salinidad en el agua de riego reduce la productividad del cultivo debido a un aumento significativo del potencial osmótico en la superficie del suelo, lo que puede reducir la absorción de agua y nutrientes en la interfaz suelo - agua.

PALABRAS CLAVE:
(R.C.B.D), Triticum aestivum L, Salinidad, Duncan.

ABSTRACT

The aim of this study was to investigate the effect of saline irrigation water levels on the phenotypic characteristics of growth and production of wheat variety "Triticum aestivum L." as well as to determine the harmful effects on seed germination and growth of wheat plants when using irrigation water containing different concentrations of sodium chloride. This study was conducted in the experimental basin at the Dubouni Station, affiliated with the Agricultural Research Department, Iraqi Ministry of Agriculture, during the 2021-2022 agricultural season. The irrigation water used in the experiment was at five salinity levels: 0.000, 1000, 3000, 6000, and 9000 ppm of sodium salts. The experiment was designed according to a randomized complete block design (R.C.B.D.) with seven treatments and three replicates. The results of the experiment showed statistically significant differences, at a level of less than 5%, for all experimental parameters studied (germination rate, plant height, root length, spike length, leaf area, leaf dry weight, and root dry weight). The study concluded that the higher the concentration of sodium chloride salts in the irrigation water, the lower the germination rate, growth, and phenotypic characteristics of the plant under study. This conclusively proves that the harmful effect of sodium chloride on germination and seedling growth was due to the toxic osmotic effect. The results of the current experiment revealed that different levels of saline irrigation water can significantly affect the growth, productivity, quality, concentration, and uptake of nutrient content in wheat crops. The lowest growth rates across all studied plant phenotypes were achieved when water with a salinity of 900 ppm was used. This clearly indicates that increased salinity in irrigation water reduces crop productivity due to a significant increase in the osmotic potential at the soil surface, which may reduce water and nutrient uptake at the soil-water interface.

KEYWORDS:
(R.C.B.D),Triticum aestivum L, Salinity, Duncan

INTRODUCTION

Wheat is the dominant crop in temperate countries being used for human food and livestock feed. Success in its growth depends partly on its adaptability and high yield potential (Raji Al-Awadi , Ali Irfan ILBAS ,2024). Wheat is the most important staple food grain in Iraq and main source of population while wheat straw is a valuable livestock feed (Satish Kumar Sharma ,et al.,2018). Today, wheat is planted on an area of 220.4 million hectares around the world, and the average grain yield is 34.0 quintals per hectare (Malikov E.N,2020).

According to the Food and Agriculture Organization of the United Nations (FAO) more than 833 million hectares of agricultural land in the world are saline, which is 8.7% of the global area) Mambetnazarov, A. et al., 2022 (the year 2020 is forecast at around 950 million tonnes per year. This target will be achieved only, if global wheat production is increased by 2.5% per annum (Anon., 2016).

It is estimated that more than 60 million hectares of irrigated land, representing some 25% of the total irrigated land, have been damaged by the salt stress the salt stress causes a great reduction in the plant growth and biomass production of cereal plants such as barley, wheat and rice , human activities like poor management of water and soil, and over irrigation of poorly drained soils are also responsible for the soil salinity, high soil salinity is among the most widespread abiotic stress factor limiting the plant distribution and productivity and the salinity stress plays a major role in decreasing the global crop productivity (Ayah Awad ,.et al.,2021).

Wheat growth is affected by sequence of physiological and biochemical changes negative impact on water and nutrient uptake because of osmotic and ionicim balance. (Zahra N, et al.,2015). Wheat development, growth, and yield are affected by various environmental factors (especially drought and salinity). Salinity is one of the major obstacles to increasing the production of agricultural land throughout the world, and can severely limit crop production, especially in arid and semi-arid regions, Salinity impairs seed germination, reduces nodule formation, delays plant development, and reduces crop yield. Some studies have indicated that under high salt concentrations in irrigation water and soil, many plants are affected by osmotic stress, nutritional imbalance, oxidative stress, and water deficiency (Do Manh Cuong et al.,2020).

Soil salinity is a primarily harms plants through inhibition of leaf expansion, plant height, leaf area index, seed germination (Sidra GillM,et al., 2024). Most irrigation water has set limits for the amount of salts and the percentage of sodium in it, so if these limits are exceeded, the use of water in agriculture becomes dangerous. Therefore, the Salinity Laboratory in the United States of America has set the maximum limit for the use of water in agriculture as 300 mg/L, while the International Organization for Agriculture set the permissible limits at 4700 mg/L.therefore, this topic is considered special.

Land irrigation with saline water is a key factor that lead to salt accumulation in soil thus has a profound effect on agriculture (Shrivastava and Kumar,2015). Irrigating saline water can result in salt accumulation in soil,leading to the deterioration in soil resource. Most of the salt stresses in nature are due to Na+ salts.

Crop cultivation is facing many challenges due to induced by factors like faulty agronomic practices or the use of recycled water in irrigation that may contain large amounts of salts (Kumar and Sharma, 2020). The salt stress has become an important problem regarding the agricultural production in many regions of the world (Ayah Awad et al .,2021). The salts accumulation in soil was closely related to the salts concentration of irrigation water, there was a progressive and significant increase in soil salinity values as the increases of salinity in irrigation water .

The effect of the quality of irrigation water on soil properties has been discussed by many researchers found that soil electrical conductivity (ECs) values increased with increasing salinity of irrigation water and decreased soil moisture depletion , Soil electrical conductivity increased as a result of increasing salinity levels of irrigation water, this may be due to the great surface area of the fine particles, which adsorb more soluble and exchangeable cations of saline solution, the increases in soil EC is proportional to the salts concentration inthe irrigation water (Bethelhem Awoke Sheferia et al.,2021)

MATERIALS AND METHODS

The experiment was carried out in 2021-2022 at Al-Dabouni Research Station located in the Al-Aziziya district at longitude: 45o.063 and latitude 32o.9107 It is bordered to the south by Wasit Governorate, 90 km away, to the north by Baghdad Governorate, 120 km away. It is bordered to the east by Diyala Governorate, 30 km away, and to the west, by Babylon Governorate, 90 km away.

Irrigation water was prepared in the laboratory (the four treatments) with salt concentrations of NaCl 1%, 3%, 6%, 9% in addition to a comparison sample of river water only S0 Soil samples were taken for analysis to a depth of 30 cm, and laboratory analysis of river water was also conducted, as in Tables (1 & 2) attached at the end of the research.

The experimental land was plowed with a disc, then adjusted at both rates, and plowed with a disc again, and compound fertilizer and urea were added according to the dose (the prescribed fertilizer dose), then the seeds were planted and the first irrigation was given from the laboratory-prepared solution then whenever the plant needs water, give it the same solution. After 40 days, the second fertilizer dose was given, and the field was controlled with Ventor pesticide for thin leaves and Crane Star for broad leaves

The experiment was designed according to a completely randomized design with seven treatments and three repetitions for each. External characteristics to be studied.

Germination rate:
We specified 100 wheat seeds within the experiment for each salt level, and after the first irrigation we waited 7-10 days, then we counted the plants growing at each salt level as in Table No (3)

Vegetative growth rate cm:
Two weeks before the harvest stage, and in a random manner, the vegetative growth was measured for each salt level from the top of the plant to the root zone using a ruler. The results are shown in Table No (4)

Root growth rate cm:
After the wheat plant matures, the root depth is measured for each salt level also using a ruler. See Table No (5).

Spike length cm:
The same procedure is done to measure the length of the spike using a ruler, one week before harvest. The results are in Table No (6)

Leaf area cm2
The leaf area of wheat plants was measured using a graduated ruler by calculating the maximum length multiplied by the maximum width and multiplying the result by the correction factor. Leaf area cm2 = maximum leaf length × maximum width × 0.79

Dry weight of the vegetative group :
The vegetative group is taken and dried in an electric oven at 60 degrees Celsius for 48 hours, then weighed.

Weight of the root group
The root group is taken, washed from the clay, dried for a week, then weighed with a sensitive balance. A ruler graduated in cm was used to measure the green and root mass and the length of the spike. See Tables No (7 , 8 & 9).

STATISTTICAL ANALYSIS
After collecting and tabulating the data for the studied phenotypic traits according to the Randomized Complete Block Design (R.C.B.D) by computer using the SPSS statistical program, the significant differences between the averages were compared using the least significant difference L.S.D at a probability level of 0.05 by using Duncan’s method.

RESULT AND DISCUSSION

Germination rate
A decrease in salinity in irrigation water (S1) by 97.6% resulted in early emergence of wheat seedlings, while higher levels delayed seedling emergence significantly, as in S4 (41%).

The percentage of daughter seedlings decreased with increasing sodium chloride concentration, as shown in Table (3), due to the toxic effect of chlorine and sodium. Only germination was delayed. The decrease in final germination at 16 and 20 dS/m may be due to osmotic or toxic effects, or a combination of both (Cüneyt Uçarlı, 2020). The germination percentage decreased with increasing sodium chloride concentration, and seedlings grew better at lower salinity levels. Treatment S0 and S1 gave the same level of significance.

Increasing salinity levels had a highly significant negative effect ($P < 0.01$). Germination decreased with increasing salt accumulation, which led to increased osmotic pressure and increased concentration of toxic ions in the medium, requiring greater effort to absorb water and nutrients. This is consistent with the findings of (Mahmood, K et al.,2009) and In their study of the effect of salinity on the growth of Acacia ampliceps seedlings. (Abbas, G et al., 2013)

Plant length cm

Table No (4) it is clear that the length of the stem decreases as the salinity concentrations increase, the decrease was recorded as follows: 50, 42, 36.6, 30.6, 24.6 at the salinity levels used in the experiment, (S0 , S1, S2, S3, S4) respectively. High concentration of sodium chloride leads to a decrease in stem length due to the plant’s inability to absorb water (Soleman m Al-Otayk ,2020). A study confirmed a significant decrease in the height of wheat plants with increased water stress during the different growth stages(khakwani, A. A. et al.,2011)

Plant root cm

Statistical analyses showed a significant difference ($P \geq 0.05$) in the effect of salt concentrations of NaCl solution on root length.

Table No (5) indicated a decrease in the average root length as the salt concentration in irrigation water increased, root length is one the most important features for salt stress because of contacting with soil directly increasing salinity doses, so that rate of root length decreased extremely. on control conditions we had the tallest root length with (9.8) cm At salt level S0 and the minimum root length when treated with salt is S4 (2) cm.

This is what previous studies have concluded, When the roots experience a water deficit due to salinity stress, growth and differentiation of root cells are inhibited which reduces root length and root diameter (DRachmawati.et al.,2021). Results indicated a decrease in root length under different levels of water stress when studying wheat plants(Hamoudi, Malik Abdullah.2011).

Salt stress negatively affects root growth, such as length and weight, because roots are in direct contact with salt ions in the soil. High salt levels in the root zone contribute to cell desiccation. Salinity also reduces root cell water absorption, inhibiting root division and expansion, resulting in reduced length and weight

Spike length cm

The results of the statistical analysis, as shown in Table No (10) indicated the presence of a significant difference in the spike length. The highest spike length of 6.7 cm was achieved in the salt-free comparison sample, and it decreased with increasing salt concentration in the irrigation water, as the lowest spike length was 3.8 cm at a salinity level of S4. This is what previous studies have proven, that salinity affects plant growth (Niaz Ahmed Kalhoro,et al,.2016). Research results indicated that the decrease in spike length is due to whe.at plants being exposed to water stress (Aldesuquy,2012). (Johari-Pirevatlou, M et al.,2010) proved that spike length is affected by water stress.

Leaf area cm^2

Low salinity led to a slight increase (s1) in average leaf area 48.3 cm2 but higher levels of salinity (s2, s3 and s4) caused a decrease in leaf area 40 cm2 , 37.1 cm2 and 24 cm2 because salts raise the osmotic potential and the seeds cannot obtain a sufficient amount of water, germination fails or is delayed (Gülcan, et al.,2020). (Kazmi, R. H et al., 2003) leaf area decreased by 14% when wheat plants were exposed to water stress 60 days after planting.

Dry weight of leaves and roots g

Decrease in the average dry weight of leaves, which reached 20.2, 15.1, 12.1, 10.6, 7.7 gram as well as the decrease in the dry weight of the root, which reached 2.2, 3, 2 , 1.7 , 1.2 ,1 gram at salinity levels s0 ,s1, s2, s3, s4, respectively, see Tables (8 & 9) at the end of the research. }

Salinity stress causes metabolic and physiological disruptions in plants, altering their development, yield, growth, and quality. Salinity inhibits plant growth by lowering the water potential of the leaf (Kritika Pandit et al., 2024))Eltayeb, M. A. and Ahmed, N. L. 2010 (Water stress causes a decrease in the dry color of the vegetative and root systems of wheat plants.Despite the difference in the weight of the dry root system in treatments S1 and S2, they gave the same significant difference.

CONCLUSION

Wheat germination decreased with increased salt concentration in irrigation water. Plant vegetative and root growth also decreased with increased salt concentration, due to increased osmotic pressure and sodium chloride toxicity. We recommend studying other wheat varieties to determine their tolerance to salinity and adopting those that are salt-tolerant.

APPENDIX TABLES

Table 1.

Some physical and chemical characteristics of the soil used in the study

Table 2.

Mineral composition, pH and electrical (EC) conductivity of irrigation water before planting

Irrigation water	HCO_3 Mmol L^{-1}	SO_{4-} Mmol $^{L-1}$	Cl^- Mmol $^{L-1}$	Na^+ Mmol $^{L-1}$	Mg++ Mmol L-1	Ca^{++} Mmol $^{L-1}$	pH	EC DSm^{-1}
	2.9	3.5	3.7	4.2	2.2	3.3	7.7	1.3

Table 3.

ANOVA explained sun of squares mean square and significance

ANOVA

Adjective										Value
pH										7.4
EC Dsm^{-1}										5.7
									Ca^{++}	16.5
									Mg^{++}	21.7
									Na^+	9.6
	HCO_3 Mmol L^{-1}	SO_{4-} Mmol $^{L-1}$	Cl^- Mmol $^{L-1}$	Na^+ Mmol $^{L-1}$	Mg^{++} Mmol $^{L-1}$	Ca^{++} Mmol $^{L-1}$	pH	EC DSm-1		
									K^+	1.0
Irrigation water									Cl^-	18.0
	6.5	3.6	4.7	5.3	3.7	4.2	7.6	1.9	SO_{4--}	20.0
				The dissolved ions Mmol L-1					HCO3-	2.0
									Clay	340

	Sum of Squares	df	Mean Square	F	Sig.

Germination rate%	Between Groups	7194.267	4	1798.567	148.234	.000
	Within Groups	121.333	10	12.133		
	Total	7315.600	14			
Plant height cm	Between Groups	1158.400	4	289.600	85.176	.000
	Within Groups	34.000	10	3.400		
	Total	1192.400	14			
Root height cm	Between Groups	51.504	4	12.876	536.500	.000
	Within Groups	.240	10	.024		
	Total	51.744	14			
spike length cm	Between Groups	15.103	4	3.776	102.973	.000
	Within Groups	.367	10	.037		
	Total	15.469	14			
Leaf area cm2	Between Groups	1413.823	4	353.456	1204.962	.000
	Within Groups	2.933	10	.293		
	Total	1416.756	14			
leaf dry weight g	Between Groups	272.353	4	68.088	327.348	.000
	Within Groups	2.080	10	.208		
	Total	274.433	14			
root dry weight g	Between Groups	7.243	4	1.811	679.000	.000
	Within Groups	.027	10	.003		
	Total	7.269	14			

Table 4.

Effects of different levels of irrigation water salinity on wheat germination rate

Germination rate%					
Duncan[a]		Subset for alpha = 0.05			
salinity	N				
		1	2	3	4
s4	3	41.000			
s3	3		58.000		
s2	3			81.333	
s0	3				95.000
s1	3				97.667
Sig.		1.000	1.000	1.000	.371

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table 5.

Effects of different levels of irrigation water salinity on wheat rate Plant height (cm) Duncan[a]

Plant height cm

Duncan[a]						
		Subset for alpha = 0.05				
salinity	N	1	2	3	4	5
s4	3	24.667				
s3	3		30.667			
s2	3			36.667		
s1	3				42.000	
s0	3					50.000
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table 6.
Effects of different levels of irrigation water salinity on the length of wheat roots (cm)

Root height cm						
Duncan[a]						
		Subset for alpha = 0.05				
salinity	N	1	2	3	4	5
s4	3	2.000				
s3	3		3.200			
s2	3			5.000		
s1	3				6.200	
s0	3					7.000
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table 7.
Effects of different levels of irrigation water salinity on the length of the wheat spike(cm)

spike length cm						
Duncan[a]						
		Subset for alpha = 0.05				
salinity	N	1	2	3	4	5
s4	3	3.800				
s3	3		4.200			
s2	3			4.667		
s1	3				5.100	
s0	3					6.700

Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table 8.

Effects of different levels of irrigation water salinity on the area of wheat plant leaves (cm²)

Leaf area cm2						
Duncan[a]						
		Subset for alpha = 0.05				
salinity	N	1	2	3	4	5
s4	3	24.000				
s3	3		37.133			
s2	3			40.000		
s1	3				48.300	
s0	3					51.767
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table 9.

Effects of different levels of irrigation water salinity on the dry weight of wheat plant lea-ves(g)

leaf dry weight g						
Duncana						
		Subset for alpha = 0.05				
salinity	N	1	2	3	4	5
s4	3	7.7333				
s3	3		10.6000			
s2	3			12.1667		
s1	3				15.1000	
s0	3					20.2333
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

Table 10.

Effects of different levels of irrigation water salinity on the root dry weight (g)

root dry weight g						
Duncan[a]						
		Subset for alpha = 0.05				
salinity	N	1	2	3	4	5

s4	3	1.0000				
s3	3		1.2667			
s2	3			1.7000		
s1	3				2.0000	
s0	3					3.0000
Sig.		1.000	1.000	1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

Uses Harmonic Mean Sample Size = 3.000.

Table11.

Shows the significant differences in the germination percentage and the plant's phenotypic characteristics using different levels of salt concentrate

* significant differences at a probability $P < 0.05$

Water Salinity sample	%	Germination percentage %	Average plant height (cm)	Average plant root depth (cm)	Average leaf area (cm2)	Average spike length (cm)	leaf dry weight (g)	root dry weight (g)
S0	0	95.0 *	50.0 *	7.0 *	51.7 *	6.7 *	20.2 *	3.0 *
S1	1	97.6*	42.0	6.2	48.3	5.1	15.1	2.0
S2	3	81.3	36.6	5.0	40.0	4.6	12.1	1.7
S3	6	85.0	30.6	3.2	37.1	4.2	10.6	1.2
S4	9	41.0	24.6	2.0	24	3.8	7.7	1.0

Figure 1.

The effect of saline irrigation water on wheat germination rate

Figure 2.

The effect of saline irrigation water on wheat germination length

Figure 3.

The effect of saline irrigation water on the length of wheat roots

Figure 4.

The effect of saline irrigation water on the length of wheat spikes

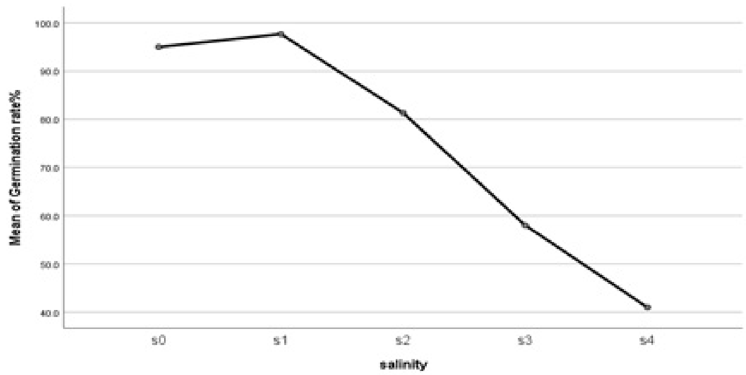


Figure 5.
The effect of saline irrigation water on the leaf area of wheat plants

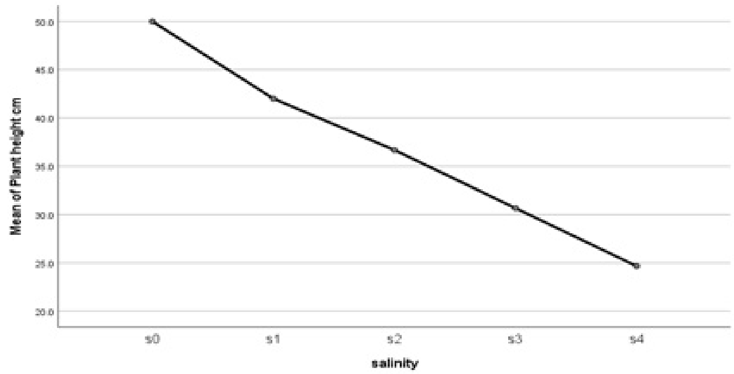


Figure 6.
The effect of saline irrigation water on the dry vegetative weight of wheat plants

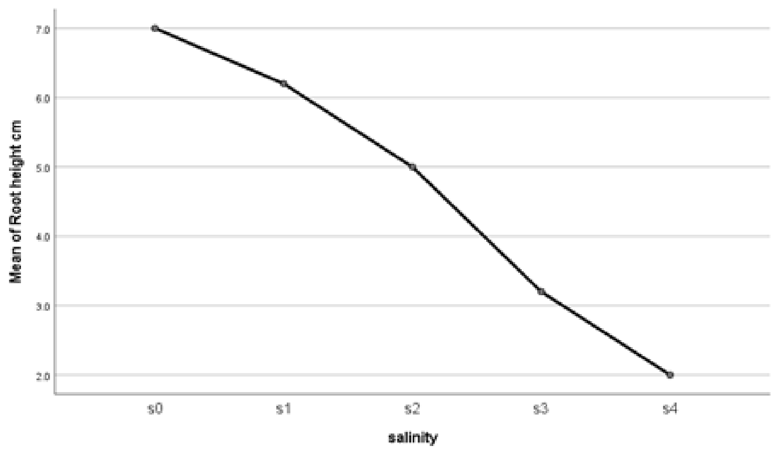
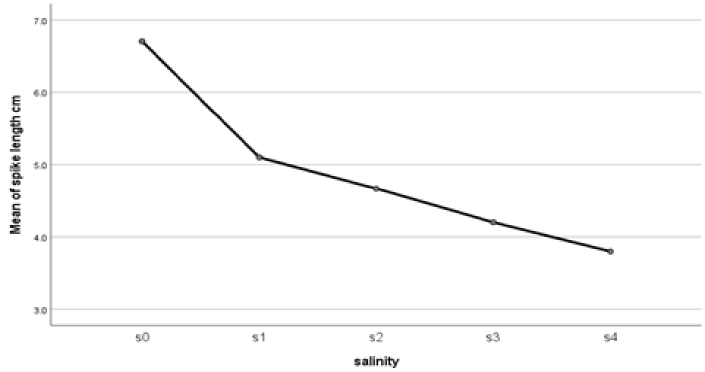
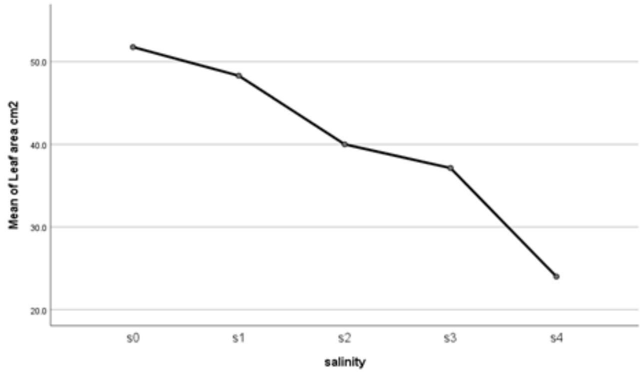


Figure 7.



The effect of saline irrigation water on the dry root weight of wheat plants



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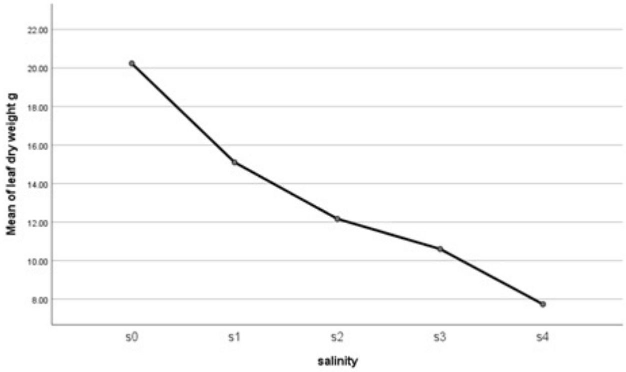

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