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Influence of Salinity Water Levels on Wheat Growth Components under Salt Stress Conditions

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Abstract

The research was conducted in the Field Crops Department, College of Agriculture, Al-Qasim Green University during the 2025-2026 season. The study was carried out to examine the impact of immersed wheat seeds and irrigation with saline water on growth components of wheat under saline stress conditions. The experiment was composed of two elements, the first one was immersed by saline water and the second was saline water with three distinct qualities (1.45, 5.58 and 10.28 dS m⁻¹). The results showed that soaking or immersed the seeds and irrigating with level 1.45 and 5.58 dS m⁻¹ was significantly increased the wheat growth components. Specifically, the average tillers was 13.33 tillers plant⁻¹, height of wheat plant was 113.48 cm, the flag leaf area was 56.35 cm² and dry matter was 16.07 g.

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1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most important strategic cereal crops of the world, providing vital food, energy and protein for human consumption. It is a staple crop in certain arid and semi-arid regions. Today, wheat production faces many environmental problems especially soil and irrigation water salinity. These factors have become major determinants of crop productivity and sustainability of agricultural production, especially in areas with scarce water resources that depend on low quality irrigation water. Salinity is a major abiotic stress that limits wheat growth and yield because of its effects on physiological and biochemical processes in the plant and mineral uptake ^[1, 2, 3]. The effect of salt stress on wheat has been confirmed from germination and early growth stages to reproductive and grain formation stages in recent studies, and the severity of the effect depends on the level of salinity, genetic composition, growth stage, and environmental conditions ^[4, 5]. Salinity problems arise from the accumulation of dissolved salts in the soil or root zone from saline irrigation water, poor drainage or high evaporation rates. This leads to a higher concentration of salt in the soil solution. The higher salt concentration lowers the water potential of the soil, and so lowers the ability of the roots to absorb water, This causes osmotic stress and is part of the early plant response to saline conditions. With continued exposure to salinity, sodium (Na⁺) and chloride (Cl⁻) ions start to accumulate in plant tissues leading to ion toxicity and disruption of nutrient balance and cellular functions ^[1, 2, 5]. Osmotic stress and ion toxicity together cause extensive changes in the physiological processes of plants, which directly affect the growth and yield of wheat. Recent studies on irrigation with saline water directly confirm that the high salinity leads to a significant reduction in growth and yield. ^[6] studied the response of ten durum wheat genotypes to different salinity levels (2.6, 10 and 15 dS m⁻¹) under hot and dry conditions. The results revealed that high salinity caused reduction in plant height, chlorophyll content and grain yield with differential response of genotypes. Moreover, the lower yield was correlated with a higher sodium concentration in the grains, underlining the importance of the variety's ability to limit sodium accumulation in maintaining production under saline irrigation conditions ^[6].

In contrast, the salinity level of irrigation water is relatively controllable thru the selection of appropriate water sources and irrigation and drainage management. The study of response of wheat under varying levels of salinity is thus of great practical importance especially in arid and semi-arid regions. The determination of the level of salinity at which the growth and yield characters start to decline, helps in fixing the practical limits for use of limited quality irrigation water. This information can be very useful in selecting the most appropriate varieties for cultivation in environments affected by salinity and in reducing the losses in productivity due to salt stress ^[1, 2, 6].

Therefore, the aim of the study is to evaluate the effect of treatment with varying levels of salinity water on the growth components of wheat under salt stress.

2. Materials and Methods

2.1. Soil

The fields of Al-Qasim Green University's College of Agriculture were used to select soil, Table (1) shows the results of the soil tests that were done before planting, which included physical and chemical studies. In the fall of 2025 and 2026, the agricultural experiment took place. Before planting wheat of the 'IPA99' variety in an experimental unit measuring 9 m² (dimensions 3 m*3 m), the land was prepared by plowing, leveling, and modifying it. In each unit, a seeding rate of 130 kg per hectare was executed in level rows with 20 cm between rows. The fertilizers were applied during planting at rates of 220 kg of nitrogen, 150 kg of phosphorus, and 160 kg of potassium sulfate per acre, respectively, following the fertilizer recommendations provided by ^[7].

Table 1: Physical and Chemical Properties of Soil Before Planting.

Properties	Unit	Value
pH _e	----	7.60
Ec _e	dSm ⁻¹	3.78
Ca ⁺²	mmol kg ⁻¹	11.84
Mg ⁺²		6.39
Na ⁺		2.95
K ⁺		0.69
Cl ⁻		13.18
HCO ₃ ⁻		9.45
SO ₄ ⁼		5.86
Sand	g kg ⁻¹	308
Silt		325
Clay		367
Texture of soil		Clay Loam
Bulk Density	Mg m ⁻³	1.28
Organic Matter	g kg ⁻¹	4.76
CaCO ₃	g kg ⁻¹	265.40
Cation Exchange Capacity (CEC)	Cmol+kg ⁻¹	25.73

2.2. Treatments

This study included the following treatments:

Three levels of saline water were utilized: Q1 = 1.45 dSm⁻¹ (river water), Q2 = 5.58 dSm⁻¹, and Q3 = 10.28 dSm⁻¹, derived from high salinity water (drainage water Ec = 19.25 dSm⁻¹). Following the preparation of the three levels of saline

water, wheat seeds were immersed in same saline water for 12 hours prior to planting. It is represented by the symbols that follow: S₁, S₂ and S₃. Table 2 presents the chemical analyses of the water quality employed in the study. Water quality was utilized for irrigating wheat based on the usage of 50% of the available water.

Table 2: Chemical Analysis of Saltwater Quality.

Properties	Q ₁	Q ₂	Q ₃	Drainage water	Unit
pH	7.39	7.46	7.23	7.49	----
Ec	1.45	5.58	10.28	19.25	dS m ⁻¹
Ca ⁺²	4.63	14.85	23.05	29.03	mmol L ⁻¹
Mg ⁺²	2.19	8.49	15.33	22.67	
Na ⁺	3.28	15.33	24.63	49.69	
K ⁺	0.18	0.24	0.34	0.59	
Cl ⁻	29.89	39.88	79.54	98.87	
HCO ₃ ⁻	2.32	4.65	10.88	13.25	
SO ₄ ⁼	2.88	5.98	14.58	18.63	

2.3. Study Indicators

The study's indicators included the growth components of wheat, which are:

1. **Tillers (Tiller plant⁻¹):** random samples of wheat were selected for each experimental unit, the number of tillers for each wheat plant present in 1m⁻² was calculated, with the flowering stage was in 100%.
2. **Height of the wheat plant (cm):** Plant height was measured at 100 % flowering stage using a metre ruler.
3. **Flag Leaf Area (cm⁻²):** The flag leaf area at the 100% flowering stage was determined as the mean flag leaf area of the main stems.
4. **Dry matter (g):** The plant samples were oven-dried at 65 °C to constant weight.

The data for the studied parameters were collected and statistically analyzed using a randomized complete block design with a derivational arrangement for each experiment, and using the Genstat program, the value of the least significant difference (L.S.D) was extracted for each parameter to compare the means of the coefficients at a significance level of 0.05.

3. Results and Discussion

3.1. Tillers (Tiller plant⁻¹)

Table (3) illustrates the significant differences in saltwater quality levels and their effect on the tillers under salt stress, demonstrating a negative impact. A level of 10.28 dS m⁻¹ (S₃)

resulted in the lowest mean weight of tillers, at 7.22 tillers plant⁻¹, while the control (a river water) recorded the highest mean tillers in plants, at 12.00 tillers plant⁻¹. The data indicate a significant effect of using saline water quality, River water recorded the highest mean of tillers, at 11.00 tillers plant⁻¹, while saline water recorded the lowest mean of tillers, at 8.44 tillers plant⁻¹. The interaction treatment, which included immersed and saline water quality, recorded the highest mean of tillers, totaling 12.67 tillers plant⁻¹, while the interaction treatment recorded the lowest mean of tillers, at 5.67 tillers plant⁻¹.

Table 3: Effect of immersed and irrigation water salinity on the tillers (Tiller plant⁻¹).

Immersion (S)	Q1 = 1.45 (dS m ⁻¹)	Q2 = 5.58 (dS m ⁻¹)	Q3 = 10.28 (dS m ⁻¹)	Effect of immersion
S1	12.67	13.33	10.00	12.00
S2	11.00	10.40	9.67	10.33
S3	9.33	6.67	5.67	7.22
Effect of water quality	11.00	10.11	8.44	—

LSD (0.05): S = 0.040; Q = 0.053; S × Q = 0.083.

Note: S = immersion treatment; Q = water quality; dS m⁻¹ = decisiemens per meter. The measured trait was not specified in the provided data.

3.2. Height of the Wheat Plant (cm)

The results shown in Table (4) indicate significant differences in height of the wheat plant (cm) under saline stress conditions. The immersed by (10.28 dS m⁻¹) had the worst effect on height of the wheat plant, reaching 83.43 cm, while the control (a river water 1.45 dS m⁻¹) recorded the highest mean height of the wheat plant, at 99.56 cm. The same table also indicates a significant effect of irrigation with

saline water quality, where the Q₂ achieved a 92.41 cm, compared to the Q₃ that recorded least mean height of the wheat plant reached to 84.43 cm. The interaction effect between immersed and saline irrigation water quality is also significant, the highest mean height of the wheat plant, occurring with the interaction 113.48 and the lowest mean with the interaction 73.36 cm.

Table 4: Effect of immersed and irrigation water salinity on the Height of the wheat plant (cm).

Immersion (S)	Q1 = 1.45 (dS m ⁻¹)	Q2 = 5.58 (dS m ⁻¹)	Q3 = 10.28 (dS m ⁻¹)	Effect of immersion
S1	113.48	93.75	91.44	99.56
S2	103.99	98.98	88.49	97.15
S3	92.41	84.51	73.36	83.43
Effect of water quality	103.30	92.41	84.43	—

LSD (0.05): S = 0.056; Q = 0.035; S × Q = 0.073.

Note: S = immersion treatment; Q = water quality; dS m⁻¹ = decisiemens per meter.

3.3. Flag Leaf Area (cm²)

The results shown in Table (5) revealed significant differences between immersed quality water, indicating a negative impact on the flag leaf area (cm²) of wheat grown under saline stress conditions. The 10.28 dS m⁻¹ level recorded the lowest flag leaf area at 36.80 cm², while the second level quality water 5.58 dS m⁻¹ recorded the highest at 46.71 cm², this value differ significantly from the control

(a river water), which recorded 52.86 cm². The same table also indicates a significant effect of using saline water quality on wheat flag leaf area, the highest flag leaf area was recorded at 49.55 cm² by using river water, compared to the lowest at 41.43 cm² with saline water Q₃. Furthermore, the interaction between treatments showed a significant effect between immersed and saline water quality, with the highest flag leaf area reaching 56.35 cm² and the lowest at 34.16 cm².

Table 5: Effect of immersed and irrigation water salinity on the Flag Leaf Area (cm²).

Immersion (S)	Q1 = 1.45 (dS m ⁻¹)	Q2 = 5.58 (dS m ⁻¹)	Q3 = 10.28 (dS m ⁻¹)	Effect of immersion
S1	56.35	51.97	50.26	52.86
S2	52.36	47.90	39.88	46.71
S3	39.94	23.80	34.16	36.80
Effect of water quality	49.55	36.30	41.43	—

LSD (0.05): S = 0.020; Q = 0.053; S × Q = 0.077.

Note: S = immersion treatment; Q = water quality; dS m⁻¹ = decisiemens per meter.

3.4. Dry Matter (g)

The results shown in Table (6) indicate significant differences in dry matter under saline stress conditions. The level 10.28 dS m⁻¹ had the highest effect on dry matter, reaching to 15.49 g, while 5.58 and 1.45 dS m⁻¹ recorded the

least mean dry matter, at 13.80 and 13.30 g sequentially. The same table also indicates a significant effect of irrigation with saline water quality, where the Q₃ achieved a 14.95 g, compared to the Q₁ and Q₂ that recorded least mean dry matter reached to 13.14 and 14.50 g sequentially. The

interaction effect between immersed and saline irrigation water quality is also significant, the highest mean dry matter

occurring with the interaction 16.07 g and the lowest mean with the interaction 11.81 g.

Table 6: Effect of immersed and irrigation water salinity on the Dry matter (g).

Immersion (S)	Q1 = 1.45 (dS m ⁻¹)	Q2 = 5.58 (dS m ⁻¹)	Q3 = 10.28 (dS m ⁻¹)	Effect of immersion
S1	11.81	13.27	14.82	13.30
S2	12.84	14.17	14.39	13.80
S3	14.76	16.07	15.63	15.49
Effect of water quality	13.14	14.50	14.95	—

LSD (0.05): S = 0.022; Q = 0.042; S × Q = 0.063.

Note: S = immersion treatment; Q = water quality; dS m⁻¹ = decisiemens per meter.

It is shown (see tables above) that pre-treatment of wheat seeds in saline solutions increases the physiological readiness of seeds to germination under conditions of salt stress. Pre-planting seed soaking has a positive effect on wheat growth parameters under salt stress and this stimulation begins with the imbibition which reduces the time for the osmotic potential to reach equilibrium inside the seed. This, in turn, activates metabolic enzymes such as alpha-amylase and protease, thereby improving the rate at which nutrients are trans-located to the embryo [8]. Soaking also promotes faster and synchronized seedling emergence and the final germination percentage of grains in saline soil. Providing the appropriate plant density per unit area is a vital factor in determining growth and productivity [10]. Moreover, soaking encourages the early development of roots and enables the plant to better absorb water and nutrients (such as potassium, instead of toxic sodium), which in turn positively affects the number of spike-bearing tillers [11]. It also increases the formation of antioxidants within the cells of plants, thus reducing the damaging oxidative effects of salinity during the initial stages of growth. Soaking helps also in the preservation of chlorophyll pigments of leaves for longer period (thereby postponing salinity induced senescence) [12]. This ensures the continuation of photosynthesis and the supply of nutrients needed to increase dry matter – and, therefore, to resist the negative effects of salinity. Moreover, the use of water of different quality and electrical conductivity can help to meet the plant's nutritional requirements. Dissolved ions in saline water, such as calcium, potassium and sulfates (Table 2), can help the plant to resist salt stress [9, 10].

4. Conclusions

Soaking of seeds in solutions; nutrient solution or saline solution does not completely eliminate the damage due to saline irrigation, but it greatly reduces the failure of growth and its adverse effects on the components of growth and consequently yield and its constituents. The study suggests that soaking wheat seeds in specific concentrations according to the plant tolerance to different environmental stresses including salinity could improve seedling growth and crop yield under salinity conditions with saline water.

Conflict of Interest

The authors declare no conflict of interest.

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