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Physiological and Phenotypic Response of Wheat Cultivars with the Influence of Salt Water Irrigation

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Abstract

An experiment was conducted at the second agricultural experiment station of the College of Agriculture - Al-Muthanna University, during the winter agricultural season (2021-2022) in order to study some physiological and phenotypic indicators of bread wheat varieties (Babil, Buhooth, Rasheed) with the effect of irrigation with salt water (2.5, 5, 10 ds m^{-1}). The experiment was applied with RBCD design with three replications. The results of the statistical analysis showed that there were significant differences for the effect of salinity in most of the traits which recorded a noticeable decrease, such as plant height, tillers number, flag leaf area, spike length, and yield traits such as number of grains per spike and weight of 1000 grains, with regard to cultivars, the Babil variety excelled in height and weight of 1000 grains, Rasheed variety excelled in the length of the spike and the number of grains per spike, as for the anatomical traits, the density and length of the stoma decreased under saline stress, while the width of the stoma increased at the second and third saline levels.
Keywords. Wheat, Salinity, Variety, Stomata, Anatomical.

Introduction

Wheat is one of the most important cereal crops grown in different environments due to its adaptive nature worldwide [1]. and moderate tolerance to salt stress, and this tolerance varies according to the level of this stress and the degree and period of exposure, as well as the cultivar grown [2]. Salinity is one of the most important problems facing the agricultural sector, especially in arid and semi-arid regions, and its negative effects appear on agricultural productivity and food security, as well as the properties of soil and water [3]. Salinity also affects the growth and development of plants, including the wheat crop, through its impact on the various physiological processes of the plant, which is negatively reflected on the phenotypic traits [4]. which affects the ability of the plant to absorb water from the soil solution when irrigating the plants with salty water, which works to raise the water potential in the soil solution, which reduces the ability of the roots to absorb and thus increase the osmotic pressure and the toxic effect of the accumulation of salts, which led to the inhibition of growth, elongation and expansion of cells and thus is reflected on the shoot system in general [5]. Wheat genotypes show great variation in field and physiological responses when exposed to salinity, salinity-tolerant genotypes usually perform better [6]. and the responses of wheat plants to salinity are complex and dependent on several factors, including growth stage, concentration and type salt [7]. Salin stress negatively affects plant growth and causes significant losses in grain yield, as it represents a complex phenomenon resulting in the interaction of compounds involved in various biochemical and physiological processes [8]. The salt-tolerant varieties have higher water content, lower stomatal density and osmosis of leaf latex, and a significant negative relationship was observed between salt tolerance and stomata density, This indicates that changes in stomata density may represent an essential mechanism by which plants can improve water balance and maintain growth under combined saline conditions, and stomata density can be adopted as accurate screening indicators for salt tolerance in wheat at the seedling stage [9]. as the sudden increase in soil salinity leads to a change in the dimensions of the leaf cells, with a further decrease in the leaf area, making the leaves smaller and thicker, leading to an increase in the number of stomata and chloroplasts per unit of leaf area [10].

Materials and Methods

A pot experiment was carried out at the second agricultural research station, during the winter season (2021-2022). Soil samples were collected from each pot before planting, mixed well, representative samples were taken from them, and physical and chemical analyzes were performed on them, which are shown in the table (1).

Table 1. Chemical and physical properties of soil

Parameter	**Value**	**Unit**
)pH(	8.07	——
)(ECe	16.13	ds^{-1}
N	48.02	Mg/kg
P	20.67	Mg/kg
K	186.33	Mg/kg
Sand	50.47	**%**
Silt	40.21	**%**
Clay	9.32	**%**
Soil texture	MEDIUM LOAM	
organic matter	**%1.12**	

Experience Factors

The first factor: the salinity of the irrigation water, using three levels of the salinity of the irrigation water, which are: (10, 5, 2.5) ds m-1, by calculating the treatment of 2.5 ds m-1, which is irrigation with river water.

The second factor: three varieties of bread wheat are: (Babil, Buhooth, Rasheed).

The RBCD design was used with three replications, as the experiment contained 27 pots, wheat seeds were sown On the first of December 2021. Fertilization operations were carried out by adding P2O5 fertilizer at the rate of 100 kg ha-1, all at once before planting [11], and nitrogen fertilization was added using urea fertilizer (N 46%) at a rate of 200 kg ha-1, in two batches in the tillering and boating stages [12], Irrigation and weeding were also carried out as needed.

Studied Traits

- Plant height (cm): was measured at physiological maturity using a metric ruler
- Tillering number plant-1: The total tillering number of the plant at harvest was calculated.
- Leaf Area: It was measured using a ruler at the end of the flowering stage, according to the following equation: (Length of the flag leaf x Maximum width x .95). [13].
- Spike length (cm): It was measured from the base of the spike to the top of the upper end of the spike, without an awn.
- The number of grains per spike (spike-1 grain): calculated after separating the spikes manually and calculating the number of grains.
- The weight of a 1000 grains (gm): calculated for 100 grains taken at random, then each sample was weighed using the sensitive balance, then adjusted to the weight of 1000 grains-1.
- Grain yield (gm plant-1): The grain yield of the harvested plant was estimated after conducting manual threshing, then after the straw was isolated from the grain, it was weighed to calculate the grain yield (gm plant-1).
- Stomata density.
- Stoma length.
- Stoma width.

Anatomical analysis samples were also collected from the third leaf of the plant [14], and then the samples were examined by an Olympus compound light microscope, using a lens with a magnification of x40 and a graduated lens with a magnification of x7. The graduated lens was calibrated by 0.1 mm micrometer slides, measurements were taken using an ocular micrometer, and samples were photographed under the microscope camera.

The data were analyzed statistically using the Genstat statistical program by the method of analysis of variance, and the means were compared using the least significant difference (L.S.D) at the level of 0.05 [15].

Results

Plant Height (cm)

The results of Table No.(2) showed that there were significant differences in the plant height trait, as the third salinity level gave the lowest average for this trait amounted to (46.11) cm, compared to the first salt concentration, which gave the highest average of (53.55) cm.

As for the varieties, the Babylon variety gave the highest average of (54.33), while the lowest average was (45.67) for the Rasheed variety.

The reason for the decrease in plant height may be due to the exposure of the plant to water stress as a result of the high concentrations of sulfate, magnesium and sodium, which impeded the process of photosynthesis and caused nutrients not to reach the cells, and as a result, they did not elongate and the plant dwarfed [16], and the varieties differ genetically in most of the growth traits, especially the length of the internodes and the length of the spike holder, which represents about half the height of the plant in some genotypes. This is consistent with what he found [17], while the effect of overlap was not significant

Table 2. Effect of varieties and salinity on plant height.

SV	S1	S2	S3	Mean
V1	61.33	51.33	50.33	54.33
V2	52.33	47.33	44.67	48.11
V3	47.00	46.67	43.33	45.67
mean	53.55	48.44	46.11	
L.S.D(0.05)	S	V	S*V	
	5.067	5.067	N.S	

Tillers number of Plant^{-1}

The results of table No. (3) showed that there were significant differences in the trait of the tillers number, as the third salinity level gave the lowest average for this trait, which amounted to (1.45) tillers plants^{-1}, compared to the first salt concentration, which gave the highest average of (2.44) plant^{-1} tillers.

The reason for the low number of tillers was attributed to the osmotic pressure caused by salinity and its effect on the vegetative system by reducing the number of leaves and their surface area, which leads to a decrease in photosynthesis products and the amount of nutrients available during the emergence of the tillers from the main stems [18], while the effect of varieties and interaction was not significant.

Table 3. Effect of varieties and salinity on the tillers number				
SV	**S1**	**S2**	**S3**	**Mean**
V1	3.00	2.00	1.67	2.22
V2	2.33	2.00	1.00	1.78
V3	2.00	1.67	1.67	1.78
mean	2.44	1.89	1.45	
L.S.D(0.05)	S	V	S*V	
	0.652	N.S	N.S	

The Leaf Area (cm^2)

From the results of Table (4), it was found that the effect of salinity was significant on the trait of the area of the flag leaf, as the third salinity level gave the lowest average for this trait, reaching (30.75) cm^2 compared to the first salt concentration (42.42) cm^2, which gave the highest average. The reason for this discrepancy may be attributed to the fact that the flag leaf growth rate is one of the important adaptive activities associated with avoiding salinity [18], while the effect of varieties and overlap was not significant.

Table 4. Effect of varieties and salinity on leaf area.				
SV	**S1**	**S2**	**S3**	**Mean**
V1	34.92	30.59	29.76	31.76
V2	37.24	34.96	26.60	32.93
V3	55.10	37.14	35.91	42.71
mean	42.42	34.23	30.75	
L.S.D(0.05)		S	V	S*V
		7.01	N.S	N.S

Spike Length (cm)

The trait of the spike length was affected significantly under salinity levels, as the third salinity level gave the lowest average for this trait, which amounted to (7.72) cm, compared to the first salt concentration, which gave the highest average of (12.17) cm.

The varieties also differed significantly, as the variety Rashid gave the highest mean (10.78) while the lowest average was (9.00) for the research class, and the overlap was significant, as the combination S1V3 gave the highest mean (13.83) while the lowest mean was for the treatment S3V1 (7.00).

The salt stress may cause the plant to reduce the orientation of the processed dry matter from the source towards the spikes, which causes a reduction in the length of the spike [19]. The difference in the length of the spikes between the varieties may be due to their genetic nature.

Table 5. Effect of varieties and salinity on Spike length.

VS	S1	S2	S3	Mean
V1	12.50	9.50	7.00	9.67
V2	10.17	9.33	7.50	9.00
V3	13.83	9.83	8.67	10.78
mean	12.17	9.56	7.72	
L.S.D(0.05)	S	V	S*V	
	0.853	0.853	1.477	

The Number of Grains Per Ear (Spike grain^{-1})

The results showed significant differences in the number of grains per ear, as S1 gave the highest average for this trait, reaching (51.2) grains spike^{-1}, compared to S3, which gave the lowest average of (24.2) grains spike^{-1}.

The varieties also differed significantly, as the Rasheed variety gave the highest average of (41.2), while the lowest average was (33.4) for the Babylon variety.

Salt stress may lead to a shortening of the differentiation period of spikelets, which leads to a reduction in the number of fertile florets and the number of grains per spike [20], and varieties differ in this capacity due to their genetic nature. While the effect of interference was not significant.

Table 6. Effect of varieties and salinity on the number of grains per spike.

VS	S1	S2	S3	Mean
V1	40.3	37.3	22.7	33.4
V2	53.3	37.0	22.3	37.6
V3	60.0	36.0	27.7	41.2
Mean	51.2	36.8	24.2	
L.S.D(0.05)	S	V	S*V	
	5.93	5.93	N.S	

Weight of 1000 Grains (g)

The trait of the weight of 1000 grains showed significant differences, as the (control) gave the highest average for this trait amounted to (49.4) gm, compared to the third saline concentration, which gave the lowest average amounted to (32.2) gm.

The varieties also differed significantly, as the Babylon class gave the highest mean of (45.2), while the class Research gave the lowest mean of (33.4).

There are many factors that affect the final grain weight, including factors before fertilization that lead to determining the size of the flower and then determine the size of the resulting grain [21], as well as genetic structure differences. While the effect of interference was not significant

Table 7. Effect of varieties and salinity on the weight of 1000 grains.

VS	S1	S2	S3	Mean
V1	56.2	45.5	33.8	45.2
V2	44.0	29.8	29.8	34.6
V3	48.0	33.8	33.0	38.3
Mean	49.4	36.4	32.2	
L.S.D(0.05)	S	V	S*V	
	7.97	7.97	N.S	

Grain Yield (g plant^{-1})

The effect of varieties and salinity and the interaction between them on grain yield was not significant.

Table 8. Effect of varieties and salinity on grain yield.

VS	S1	S2	S3	Mean
V1	5.25	5.28	3.89	4.81
V2	6.22	3.80	4.23	4.75
V3	6.45	3.18	5.23	4.95
Mean	5.97	4.09	4.45	
L.S.D(0.05)	S	V	S*V	
	N.S	N.S	N.S	

Stomata number

The results indicated that salinity had a significant effect, as the lowest average was (5.11) in the third saline level and the highest average was (6.00) for the first saline level (the control).The varieties had no significant effect, while the overlap had a significant effect, as treatment S1V2 gave the highest average of (7.00), while the lowest average was for treatment S3V2 and S2V3, which amounted to (4.33).

Salt-tolerant species conserve water in cells under conditions of high osmotic stress through low stomata number [22].

Table 9. Effect of varieties and salinity on stomata number.				
VS	**S1**	**S2**	**S3**	**Mean**
V1	5.33	6.33	5.00	5.55
V2	7.00	5.67	4.33	5.67
V3	5.67	4.33	6.00	5.33
Mean	6.00	5.44	5.11	
L.S.D(0.05)	S	V	S*V	
	0.608	N.S	1.053	

Stomata length

The results of table (10) showed that salinity had a significant effect on the trait of the length of the stoma, as the highest average was (1.61) µm in the first and third salinity levels, while the lowest average was (1.42) µm in the second salinity level. The effect of varieties and the interaction between varieties and salinity was not significant.

Table 10. Effect of varieties and salinity on stoma length.				
VS	**S1**	**S2**	**S3**	**Mean**
V1	1.76	1.36	1.63	1.58
V2	1.43	1.33	1.63	1.46
V3	1.63	1.56	1.56	1.58
Mean	1.61	1.42	1.61	
L.S.D(0.05)	S	V	S*V	
	0.1304	N.S	N.S	

The Width of Stoma

The trait of the width of the stoma was significantly affected by salinity, as the lowest average was (0.73) µm in the first saline level (control) and the highest average was (0.81) µm for the second and third saline levels. The varieties had no significant effect, while the overlap had a significant effect, as the S2V1 treatment gave the highest average of (1.03), while the lowest average was for the S2V2 treatment of (0.63).

Table 11. Effect of varieties and salinity on stoma width.				
VS	**S1**	**S2**	**S3**	**Mean**

V1	0.67	1.03	0.76	0.82
V2	0.86	0.63	0.76	0.75
V3	0.67	0.76	0.90	0.78
mean	0.73	0.81	0.81	
L.S.D(0.05)	S	V	S*V	
	0.0673	N.S	0.1166	

Conclusions

The statistical research showed that salinity affected height, number of tillers, leaf area, spike length, and yield variables including number of grains per spike and weight of 1000 grains. Babel was the tallest and heaviest 1000-grain variety. Rashid's spike length and grain count were superior. Morphologically, saline stress reduced the number and length of stomas, but increased their breadth at the second and third levels.

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