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Determination of salt tolerance level of Araz wheat (*Triticum aestivum* L.) cultivar concerning germination and growth parameters

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Abstract

As a result of climate change, an increased reliance on irrigation will be necessary for more arable lands. This will lead to elevated soil salinity levels, which will subsequently have a detrimental impact on both seed germination and plant growth. The primary aim of this research is to establish the threshold of salt tolerance in the Araz wheat cultivar (*Triticum aestivum* L.), using it as a representative example to delineate salt tolerance levels in other agricultural crop varieties. Araz is a widely cultivated wheat variety in Iraq and Kurdistan, and its salt tolerance was assessed by subjecting it to three different salt solutions: 0.01, 0.02, and 0.05 mol L^{-1}, which corresponded to 0.9, 1.82, and 4.6 EC (dS m^{-1}), respectively. The findings demonstrated notable impacts of the 0.01 mol L^{-1} salt concentration on germination and associated seedling parameters, with the exception of seed water uptake. The results indicated no discernible differences between the effects of 0.01 mol L^{-1} and 0.02 mol L^{-1} salt levels on the radicle's fresh weight. However, as salt levels increased to 0.05 mol L^{-1} , the adverse effects on growth became more pronounced. A salinity level of 4.6 EC (dS m^{-1}) was found to significantly inhibit both germination and seedling growth, indicating that the Araz variety is sensitive to this level of soil salt concentration. This suggests that the recommended soil condition for cultivating Araz should have an electrical conductivity (EC) of less than 4.6 dS m^{-1}.

Keywords: Wheat, Climate change, Salinity, germination, growth, EC (dS/m).

Introduction

Global wheat Production l in 2022 was 779.33 million tons [1], but it suffers significant grain yield losses due to soil salinity [2]. The impact of global climate change on increasing salinity has been confirmed by studies conducted by [3, 4], where they stated that increasing salinity level harms both human and plant life.

Soil salinity is one of the impacts of climate change on coastal agricultural land, as rises in sea levels have increased salinity from 1 to 33% over 25 consecutive years [5, 6].

Irrigation with saline water, low precipitation, and high evapotranspiration are vital factors that cause salinization at a rate of 10% annually to agricultural lands. At this rate, more than 50% of arable land will be salinized by 2050 [6, 7].

[8] constructed different simulation models to investigate the effect of increased temperature on the yield of four crops by analyzing yield data from 46 research articles and 48 sites on a global scale. He concluded that for each degree increase in global mean temperature (GMT), and stated that , wheat production has been predicted to reduce by 6.0%, rice by 3.2%, maize by 7.4%, and soybean by 3.1% worldwide.

Due to climate change, more arable lands will be dependent on irrigation which causes raising of salinity in the soil (www.agric.wa.gov.au) in many arid and semi-arid areas including Iraq and Kurdistan Salinity has become a primary abiotic stress due to high temperature that causes evaporation and leads to salt accumulation in soil and it is affecting plant growth . It was also confirmed that the concentrations of salts have detrimental effects on Germination of seeds and plant growth causes the delay of germination and growth of seedlings. [9]

The response of wheat to salt stress is genetically and physiologically controlled and may differ from one growth stage to another. Thus, a better understanding of these mechanisms and processes would help the breeding programmers to enhance wheat production under salt stress. Strategies to increase wheat production in salt-affected areas (such as leaching and drainage), and the cultivation of tolerant genotypes is recognized as the most effective way to overcome this limitation. The prerequisite is the identification of wheat genotypes with proven wide adaptation under saline conditions, therefore identification of salt tolerance level is essential for each crop in saline areas to determine its possibility for adaptation [2].

The EC is used as criteria for screening cultivars salinity tests ,and it is necessary to find reasonable soil for a required cultivar [10]. In this regard, objective of this study is to determine Araza wheat (*Triticum aestivum* L.) cultivars ,s salt tolerance degree by comparing its DTC levels to Ec classifications [4, 11].

The research aim is to study the salinity’s effect on germination and growth parameters of the Araz wheat (*Triticum aestivum* L.) cultivars cultivar and determine its salt tolerance level as an individual cultivar. Furthermore, to use the same methods and criteria to determine salt tolerance levels of other wheat cultivars and field crops, to determine their salt tolerance level in order to define the soil type that crops can tolerate salinity. Determination of wheat and other cultivars tolerance level of salinity defiantly contribute to select correct varieties that cope new environmental conditions created by climate change in order to keep productions of agricultural crops and ensure food security at national and international level.

Materials and Methods

The study was carried out in the Department of Bio-Technology and Crop Science laboratory in the College of Agricultural Sciences at University of Sulaimani in Marts 2017 on the seeds of wheat (*Triticum aestivum* L.) Araz cultivar which had been obtained from the laboratory of crop Science. The experiment was carried out by preparing three levels of salt solution 0.01, 0.02, and 0.05 mol L^{-1} and a control in sterilized water. The saline solutions were prepared by using four Erlenmeyer flasks with one-liter distillation water in each one. Three Erlenmeyer flasks were used for three of the given salt levels concentration and one for control CO ,which is equivalent to 0.9. 1.82, and 4.6 EC (dS m^{-1}) respectively.

The study was started by determination of water uptake in the three salt solutions and control ,where their seeds put in each Petri dish with three replications, and after twenty-four hours of germination , the weight of water uptake of seeds were measured by average , and b using electrical balance . The seeds were weighed after surface water was removed and compared to determine the water uptake at each concentration

$$Water\ uptake\% = (W_2 - W_1)/W_1 \times 100$$

W_1 = initial weight of seed

W_2 = weight of seed after absorbing water in a particular [12]

For studying germination and growth, the seeds (10 seeds per Petri dish) put in dishes, and were covered with filter papers to prevent pollution and evaporation until they germinate at 20-25°C, and humidity degrees 50-60% with approximately 12 hours dark and 12 hours light. Germination percentages were recorded every 24 hours for ten days.

$$Germination\ (\%) = \frac{Number\ of\ germinated\ seeds}{The\ total\ number\ of\ seeds\ tested} \times 100$$

And germination speed was measured for each treatment during the period of research till the end accordingly [12].

$$GS = n_1 \div d_1 + n_2 \div d_2 + n_3 \div d_3 \dots$$ [9].

Root and shoot length ,as well as their wet and dry weight was measured on the tenth day [13]. The dry matter was measured after drying samples at 70 °C for 48 h in an oven [14].

Statistical analysis

The experiment was carried out as a completely randomized design with three replications per treatment, and the results were analyzed statistically through one-way ANOVA using (thew XLSTAT) program, comparisons among the means were conducted following Duncan multiple range tests at significant levels of (0.05).

Results and Discussion

Water uptake and Germination

Obtained results in Table (1), show the effect of salinity on water uptake, and it was slightly decreased with increasing salinity levels, and the results detected the combination between water uptake, germination percentage, and speed ,where the less water uptake the less germination percentage and speed. Germination percentage and speed are affected by salt levels in relation to control significantly at salt level 4.46 dS m^{-1}.

Table (1): The effects of salt concentrations on germination percentage, germination speed, salt tolerance and seed water uptake (%)

dS m^{-1}	Germination Percentage (%)	Germination speed (Seed day^{-1})	Seed water uptake (%)
Control	96.667 a	1.867 a	40.270 a
0.90	81.667 b	1.667b	39.137 a
1.82	71.333 b	1.467c	37.150b
4.46	36.667 c	0.500 d	32.887c

Means followed by different letter within a column are different P≤0.05.

The results presented in Table 2 demonstrate substantial differences in seedling-related characteristics between the control group and varying levels of salt. Specifically, the concentration of 4.46 dS m^{-1} led to a significant fourfold decrease in radicle length compared to the control. Although the 4.46 dS m^{-1} concentration did not show significance, the salinity level of 1.82 dS m^{-1} still notably affected radicle length. In contrast, treatment with 0.9 dS m^{-1} had a minimal impact on radicle length compared to both salt concentrations used in this experiment.

Similar trends were observed for the effect of salinity on plumule length. The most pronounced reduction relative to the control, also at a fourfold decrease, was observed when using 4.46 dS m^{-1}, followed by 1.82 dS m^{-1}. The smallest effect was observed with 0.9 ds m^{-1}, all of which were statistically significant when compared to the control .

Regarding radicle fresh weight, only the 4.46 dS m^{-1} concentration showed a significant impact compared to the control. Among the different salt concentrations, including 4.46 dS m^{-1} , there was no significant difference.

Both radicle dry weight and plumule length were significantly affected by the 4.46 dS m^{-1} and 1.82 dS m^{-1} concentrations, as well as the 0.9 dS m^{-1} concentration, when compared to the control.

A similar pattern was observed for the effect of salinity on both fresh and dry plumule weight, with the most substantial decrease occurring at 0.016 and 0.003 g seedling^{-1}, respectively, compared to the control values of 0.059 and 0.007 g seedling^{-1}.

Table (2): The effect of salt on growth parameters, length of radicle and plumule, fresh weight of radicle and plumule, dry weight of radicle and plumule

dS m^{-1}	Length of Radicle (cm)	Length of Plumule (cm)	Fresh weight of Radicle (g)	Dry weight of Radicle (g)	Fresh weight of Plumule (g)	Dry weight of Plumule (g)
Control	8.067 a	6.900 a	0.068 a	0.006 a	0.059 a	0.007 a
0.90	5.267 b	4.600 b	0.041ab	0.005 b	0.044 a	0.005 b
1.82	3.133 c	2.767 c	0.037ab	0.003 c	0.025 b	0.004 b
4.46	1.900 c	1.767 c	0.026 b	0.002 c	0.016 b	0.003 c

Means followed by different letter within a column are significantly different P≤0.05.

There is rare research that have been done in both Iraq / and Kurdistan regarding the effects of salinity on cultivated crops and also scarce studies about individual crop varieties' salt tolerance degree /level. However, we realized in the study the slight effect of saline levels on water uptake .However other studies have proved significant decrease of water uptake under salt condition , such as studies on tomato [15], barley and a wheat variety [16]. The combination between water uptake and germination percentage as well as germination speed is seen in the results which indicate, the more water updates the more germination percentage and germination speed, therefor germination percentage and speed are considered as a criteria for salt tolerance and the same results have has been confirmed by [17].

The results confirm, that Salt levels along with treatment have significant effect on radical length in relation to control treatment , and it is shows that salinity deter root growth. And it is compatible to a report by [18] who confirmed ,that an inner layer of tissue in the branching roots that anchor the plant is sensitive to salt and activates a stress hormone, which stops radical growth. Salinity levels have significant effect on wet radical weight , as well as on dry wet weight except of salt level 0.9 dS m^{-1}, which does not, and it is matched to results found by [19] . Plumule length are significantly affected by salt levels , but more severe is at salt level 4.46 dS m^{-1}, and the same result was reported by [19]. Pumule wet and dry weight has not been affected significantly by salt level 0.9 dS m^{-1} but does with 1.82, and most by 4.46 dS m^{-1}. The obtained results showed that radicle is more tolerant to salt to in relation to plumule what is concerning fresh weight, but in contrast, Plumule are more sensitive what is concerning dry weight and it is confirmed also by [20], who reported that shoot growth is more sensitive than root growth.

it is realized , that the effect of salt levels on germination and growth parameters significantly with increasing salt level above 0.9 dS m^{-1}, and salt tolerance level for Araz (*Triticum aestivum* L.) cultivar is under 4.46 dS m^{-1}.

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