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Effect of different saline levels on germination and growth of some new promising wheat cultivars

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Abstract

Charmo, Maroof, and Alla are new promising rust-resistant wheat varieties were had been tested for their salinity tolerance through seed water uptake, germination percentage, and germination mean, as well as the growth of radical and plumule. The varieties were tested for their salt tolerance level by using salt solutions concentration levels with a control, 0.01, ,0.03.0,05, 0.07, and 0.09 mol, which are the answer to 0.0, 0.58,1.75,2.9,4.01 and 5.26 gL -1, that symbolized as C0, C1,C2, C3, C4and C5, which are equal to 0.9, 2.7, 4.6, 6.3, and 8.2 EC dS m−1 respectively.. The results showed significant effects of varsities on water uptake, germination percentage germination meantime, and wet and dry radicals, but no significant effect on radical number and length as well as plumule length and wet dry plumule. What is concerning the effects of salt levels on germination parameters and growth of seedlings, noted a significant effect of salt on germination meantime, germination percentage, growth radical and plumule length as well as on wet radical weight. And the interaction between varieties and salt levels, result has shown a significant effect of the interaction between varsities and salt levels on dry radical weight. Salt levels from C3 have indicted to have a significant effect on the germination of wet radicals but not a significant effect on water uptake, dry radicals, as well as on wet and dry plumule. The results of the effect of varieties on germination and growth parameters showed, that charmo and maroof are better than Alla, Charmo, and Maroof are tolerating C2 –C3/ 4,6 dS m−1 -6.3 dS m−1 but Alla does not, which is why it cannot be recommended to be used in soil with EC 4,6 dS m−1 which answers to C2.

Keywords: Salinity, water uptake Germination, growth, Tolerance level, EC dS m−1

Introduction

Arid and semiarid regions of the world are being faced by soil salinization which is hampering crop growth in these areas. As a result of this menace, a large area of arable land has become completely or partially nonproductive. Saline water and poor irrigation practices have converted good agricultural lands to barren lands [1].

In arid and semi-arid regions with low rainfall and high temperature, salinity is one of the major environmental stresses which reduce plant growth. In these regions, Groundwater continuously moves toward cultivation [2,3].

The beginning of the 21st century is marked by global scarcity of water resources, environmental pollution and increased salinization of soil and water. Increasing human population and reduction in land available for cultivation are two threats to agricultural sustainability [4,5].

The extent of salinity damage to plants depends on a number of different factors including species, genotype, plant growth phase, ionic strength, duration of salinity exposure, the composition of the salinizing solution, and which plant organ is exposed [6].

Regarding the effects of salinity on nutrients and water uptake by the plant,as well as physiological aspects [7] confirmed that the salinity affects the availability of nutrients and water as well as induces osmotic stress which reduces the growth and photosynthesis in plants. Salt stress also reduces the photosynthetic rate, biomass accumulation, and source-sink activity, which hastens the reproductive organ's senescence and negatively affects the yield response factors [8].

The stage of germination, root formation, and seedling growth are the primary stages for plant growth and its response to its biotic and abiotic environment and be used the measurement for plant tolerance in the given environment [9,10].

It was stated [11] stated in their study that, germination is a critical stage of the plant cycle and improved tolerance of high salinity could improve the stability of plant production.

Previously it was stated [12,13,14] that growth reduction due to salinity is attributed to ion toxicity and nutrient imbalance, which causes not only high sodium (Na^+) and chloride (Cl^-) accumulation in plants, but also antagonistically affects the uptake of essential nutrient elements such as potassium (K^+), calcium ($Ca2^+$) and magnesium ($Mg2^+$) in competition with Na^+ and also nitrate ($NO3^-$) in contrast with C^{-1}.

As a temporal difference in plant response to salinity [6,15] hypothesized that after exposure to salinity the first phase of growth reduction of plants occurs rapidly due to an ‘osmotic effect’ and the second phase of growth reduction, which is a much slower process, taking days to weeks, arises from a ‘salt-specific effect’ through the accumulation of salt ions, primarily in older leaves [6,15,16].

The objective of this research is to study the response of some wheat varsities which are rust resistant with respect to the effect of salt levels what is concerning seed water uptake germination parameters, growth parameters, and study the effect of varieties on the given water uptake, germination and growth parameters and then determinant the salt tolerance level of varieties and compare salinity tolerance between varieties to identify which varieties are most tolerance to salinity.

Material and Methods

The study was carried out in the laboratory of the Department of Biotechnology and Crop Science in the College of Agricultural Engineering Sciences at the University of Sulaimani, Seeds of three new promising rust-resistant wheat varieties (Charmo, Maroof and Alla), [17,18,19] was obtained from the laboratory of the Department of Biotechnology and Crop Science.The experiment was carried out by preparing a control and four solutions of salt concentration levels (0.01, 0.03, 0.05, 0.07, and 0.09 $molL^{-1}$). The saline solutions were prepared by using five Erlenmeyer flasks with one-liter distillation water in each one. Four Erlenmeyer flasks were used for four of the given salt levels concentration and one for control, and the salt solutions are equivalent to 0.58, 1.75, 2.92, 4.01, and 5.26 gL^{-1} of NaCl, which are symbolized as CO, C1, C2, C3, C4, and C5 as control, respectively.

After the obtained seeds were sterilized in 70% diluted Ethanol solution for 2 minutes then they were washed with sterilized water. Seeds were put in Petri dishes (10 seeds per Petri dish) containing filter paper and were added 10 ml of salt solutions concentrations (0.9, 2.7, 4.6, 6.3, and 8.2 EC $dS\ m^{-1}$). The seeds (10 seeds per Petri dish) in dishes were covered with filter papers to prevent pollution and evaporation till they began to germinate at 20-25°C, and humidity degrees 50-60% with 12 hours dark and 12 hours light. Germination percentages were recorded every 24 h for 10 days. The seeds were weighed after surface water was removed and compared to determine the water uptake at each concentration [20] , after 24 h of being in saline solutions and control. Mean germination time (MGT) was calculated to assess the rate of germination [21]. Root number, root length, and shoot length shoot wet and dry weight, root wet and dry weight were measured on the tenth day [22]. The dry matter was measured after drying samples at 70 °C for 48 h in an oven [23].

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

[24].

Mean germination time (MGT) = $\frac{\sum(n \times d)}{N}$, where n = the number of seeds germinated on each day, d = the number of days from the beginning of the test, and N = the total number of seeds germinated at the termination of the experiment [21].

$$\text{Water uptake\%} = \frac{(W2 - W1)}{W1} \text{ X } 100$$

W1 = Initial weight of seed
W2 = Weight of seed after absorbing water at a particular time [24].

Statistics: A factorial experiment in completely randomized design (CRD) was conducted to test the five concentrations of NaCl as well as control (Distilled water), each treatment combination was replicated 3 times. Two ways ANOVA was used as a general test, while the LSD test was used for comparing between means with 95% certainty.

Results and Discussion

Salinity has a dual effect on plant growth via an osmotic effect on plant water uptake and specific ion toxicities. By decreasing the osmotic potential of the soil solution, plant access to soil water is decreased, because of the decrease in total soil water potential. As the soil dries, the concentration of salt in the soil solution increases [25].

In this regard Table (1) shows the significant effect of varieties on germination percentage, germination meantime, water uptake, and weight of wet and dry radical, but have no significant effect on the radicle number and length, plumule length and weight of wet and dry plumule Charmo has the heights germination mean time value and germination percentage value in relation to Maroof and Alla. Maroof has the higher value of seed water uptake but however has a lower germination percentage and germination meantime in relation to Charmo, it does mean, that is not necessarily the higher water uptake also means the higher germination as other factors may play a role in higher germination value such as seed viability due to some physiological and biochemical character [26]. However, results confirm that Charmo and then Mahroof has better value in germination percentage, germination meant time as well as in the wet and dry weight of radical in relation to Alla. [27] Confirmed the same result in the effect of varieties on water uptake germination and seedling growth under saline conditions.

Table (1): Response of the varieties Charmo, Maroof, and Alla in terms of the studied characters.

Varieties	Germination Mean time	Root Number	Root Length (cm)	Shoot Length (cm)	Water uptake (%)	Germination percentage(%)	Radic wet weight (g)	Radical dry weight (g)	Shoot wet weight (g)	Shoot dry weight (g)
Charmo	5.632	4.444	6.131	6.594	0.054	54.44	0.026	0.009	0.063	0.039
Maroof	4.838	4.222	5.789	6.589	0.062	53.33	0.024	0.008	0.066	0.041
Alla	1.311	4.389	5.194	6.933	0.024	17.78	0.009	0.001	0.141	0.047
LSD ($p \leq 0.05$)	0.754	n.s	n.s	n.s	0.018	9.15	0.012	0.003	n.s	n.s

Table (2) shows the significant effect of salinity on germination, germination mean time, root and shoots length and the weight of wet radical but no significant effect on the seed water uptake, weight of dry radical, wet and dry plumule. The results indicate the direct relation between germination percentage and germination meantime with root and shoot length and wet weight of radical, and it does mean that the high salt level halter growth in both roots and shoots due to the subject of salt stress. The explanation of reducing germination and growth parameters is, firstly, due to salt concentrations decrease the osmotic potential of soil solution creating a water stress in plants. Secondly salt concentration causes severe ion toxicity, since Na^+ is not readily sequestered into vacuoles as in halophytes. Finally, the interactions of salts with mineral nutrition may result in nutrient imbalances and deficiencies [28]. The consequence of all these can ultimately lead to plant death as a result of growth arrest and molecular damage [28,29].

Table (2): Effect of different NaCl concentrations on the studied characters of varieties Charmo, Maroof and Alla.

NaCl Conc.	Germination Mean time	Root Number	Root Length (cm)	Shoot Length (cm)	Water uptake (%)	Germination percentage (%)	Radcal wet weight(g)	Radicadry weight (g)	Shoot Wet weight (g)	Shoot dry weight (g)
C0	4.80	4.556	7.872	7.611	0.046	54.444	0.042	0.007	0.064	0.044
C1	4.39	4.333	6.489	7.756	0.049	48.889	0.020	0.004	0.066	0.037
C2	4.27	4.556	5.767	7.433	0.060	44.444	0.017	0.008	0.069	0.042
C3	4.11	4.556	5.328	6.811	0.058	42.222	0.015	0.009	0.068	0.044
C4	3.32	3.667	4.056	5.133	0.034	36.667	0.009	0.005	0.149	0.051
C5	2.64	4.444	4.717	5.489	0.034	24.444	0.014	0.004	0.123	0.037
LSD ($p \le 0.05$)	1.05	n.s	1.345	1.114	n.s	12.938	0.016	n.s	n.s	n.s

The interaction in Table (3) between salt levels and varieties and their effect on germination and growth parameters shows that the interaction has no significant effect on any of parameters except of dry radical, because of accumulation of more salt in dry radical in relation to wet radical, plumule and dry plumule.

Regarding the consequence of the interaction of salt and plant [30] stated in their study, Salt stress influences cell ion homeostasis by altering ion balance, such as increased Na^+ and a simultaneous decreased $Ca2^+$ and K^+ content. And they stated A that the class I high-affinity K^+ transporter (HKT) family is involved in the exclusion of Na^+ from leaf blades at the reproductive stage, and this significantly influences sodium ion homeostasis under salinity stress. And [31] confirmed that besides ionic imbalance, salinity stress influences available soil water, tissue water content, water use efficiency, water potential, transpiration rate, rooting depth, root respiration, root biomass, root hydraulic conductance, cell turgidity, and osmolytes accumulations.

However the results of the interaction of germination parameters and growth show that Charmo and Maroof can tolerate salinity level C2-C3, but Alla does not, therefore Alla cannot be used even in very slightly saline (ECe = 2–4 dS m^{-1}), C1.

Table 3: The interactions effect of the varieties Charmo, Maroof and Alla , and different NaCl concentrations on the studied.

Varieties × NaCl Conc.	Germination Meantime time	Root Number	Root Length (cm)	Shoot Length (cm)	Water uptake (%)	Germination percentage (%)	Radcal wet weight(g)	Radical dry weight l (g)	Shoot Wet weight (g)	Shoot dry weight (g)
CharxC0	6.40	4.667	7.800	7.100	0.048	70.000	0.050	0.012	0.053	0.050
CharxC1	6.17	4.667	8.033	8.100	0.039	63.333	0.033	0.006	0.060	0.030
CharxC2	5.90	5.000	6.667	7.833	0.085	56.667	0.023	0.010	0.063	0.040
CharxC3	5.83	4.667	4.8837	6.100	0.075	56.667	0.013	0.009	0.063	0.040
CharxC4	5.00	3.333	4.333	5.033	0.037	50.000	0.010	0.010	0.067	0.047
CharxC5	4.50	4.333	5.067	5.400	0.040	30.000	0.027	0.008	0.073	0.030
MarxC0	6.00	4.000	9.283	7.733	0.053	66.667	0.050	0.006	0.070	0.040
MarxC1	5.17	4.333	5.917	7.867	0.076	60.000	0.017	0.006	0.077	0.050
MarxC2	5.17	4.333	5.550	7.100	0.071	56.667	0.023	0.012	0.063	0.033

MarxC3	**4.80**	**4.333**	**5.383**	**6.667**	**0.085**	**53.333**	**0.027**	**0.017**	**0.063**	**0.040**
MarxC4	**4.50**	**4.000**	**4.233**	**5.100**	**0.051**	**46.667**	**0.015**	**0.004**	**0.063**	**0.047**
MarxC5	**3.33**	**4.333**	**4.367**	**5.067**	**0.038**	**36.667**	**0.012**	**0.004**	**0.057**	**0.037**
AllaxC0	**2.00**	**5.000**	**6.533**	**8.000**	**0.037**	**26.667**	**0.027**	**0.002**	**0.070**	**0.043**
AllaxC1	**1.85**	**4.000**	**5.517**	**7.300**	**0.032**	**23.333**	**0.010**	**0.001**	**0.060**	**0.030**
AllaxC2	**1.74**	**4.333**	**5.083**	**7.367**	**0.026**	**20.000**	**0.004**	**0.002**	**0.080**	**0.053**
AllaxC3	**1.71**	**4.667**	**5.717**	**7.667**	**0.013**	**16.667**	**0.005**	**0.001**	**0.077**	**0.053**
AllaxC4	**0.47**	**3.667**	**3.600**	**5.267**	**0.014**	**13.333**	**0.003**	**0.001**	**0.317**	**0.060**
AllaxC5	**0.09**	**4.667**	**4.717**	**6.000**	**0.024**	**6.667**	**0.003**	**0.001**	**0.240**	**0.043**
LSD ($p\leq0.05$)	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**0.007**	**n.s**	**n.s**

In this study, it can be realized that Charmo and Maaroof are more tolerant varieties than Alla, which was sensitive to salinity. According to the results, charmo variety can be Recommended to plant for these salinity levels C2 and C3 , 0.01,0.03 0.09 molL-1 which are equivalent to 4,6 dS m−1 and 6.3 dS m^{-1}.

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