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The effect of salinity stress on germination and seedling growth of native and breeded varieties of wheat

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ABSTRACT: Salinity is one of the major abiotic stresses which adversely affect the seed germination. Germination of seeds, one of the most critical phases of plant life. This study was done as factorial experiment based on completely randomized design with three replications. Experimental factors are the wheat varieties (native: Sholeh and Arvand; Breeded: Chamran and Dez) and NaCal concentrations (0, 3, 6, 9, 12 and 15 ds.m-1 salt). Based on orthogonal analysis of Variety effect, there was a significant differences between native (Arvand and Sholeh) and breeded (Chamran and Dez) varieties in germination percent (G), mean germination time (MGT), vigour index (VI), stem length (SL), stem dry matter (STDM) and seedling dry matter (SEDM) at all salinity levels. Native varieties have a higher germination percent (96.33%, 98.33%) than the breeded varieties (92.55%, 91.44%). Regression analysis of salinity effects on traits showed that, there was a negative linear relation between NaCl concentrations with traits. Germination percentage was significantly reduced with salinity. Decreasing in stem length in breeded varieties has more than the others (R^2=0.45 and 0.93). Generally, Salinity had a negative effect on studied traits, and this adverse effect was more severe than in breeded varities than the native ones.

Keywords: salinity stress, Vigour index, mean germination time, stem dry matter, stem length, Wheat.

INTRODUCTION

Drought and salinity are widespread problems around the world. Nearly half of the irrigated land and 20% of the world's cultivated land are currently affected by salinity (Zhu, 2001). Salinity is one of the major abiotic stresses which adversely affect the crop growth and yield. High concentrations of salt resulting from natural processes or disarrangement in irrigated agriculture result in inhibition of plant growth and yield (Demiral and Turkan, 2006). Salinity also induces water deficit even in well watered soils by decreasing the osmotic potential of soil solutes, thus making it difficult for roots to extract water from their surrounding media (Sairam and Srivastava, 2002).

Germination of seeds, one of the most critical phases of plant life, is greatly influenced by salinity (Misra and Dwivedi, 2004). Salinity either completely inhibits germination at higher levels or induces a state of dormancy at low levels (Iqbal et al., 2006). Salinity greatly affects seed germination (Misra and Dwivedi, 2004), and consequently induces a reduction in germination rate and a delay in the initiation of the germination and seedling establishment (Almansouri et al., 2001). Seed germination is a major factor limiting the establishment of plants under saline conditions (Al-Karaki, 2001). The response to salinity during germination has been reported to be more complex than during plant growth because it depends on the availability of stored compounds (González et al., 1985). However, salt stress affects germination percentage, germination rate and seedling growth in different ways depending on plant species. NaCl decreased germination percentage, speed of germination and seedling dry matter in different types of rice (Khan et al., 1995), reduced final germination percentage in wheat (Almansouri et al., 2001) and lowered both germination rate and germination percentage in cowpea (Murillo-Amador et al., 2000) and tomato (Cuartero and Fernandez-Munoz, 1999) . However, in pepper, NaCl delayed germination but did not reduce the final germination percentage (Chartzoulakis and Klapaki, 2000).

Poor germination and decreased seedling growth result in poor establishment and occasionally crop failure. Poor establishing in turn causes (Soltani and Galeshi, 2002; Soltani et al, 2006): (1) decreased crop's competitiveness with weeds (Lemerle et al., 1996 cited in Rebetzke and Richards, 1999); (2) lower shading of the soil surface and subsequently higher loss of soil water through evaporation and hence, lower availability of water for crop; (3) lower light interception and yield potential; (4) lower growth in early season when vapor pressure deficit is low and as a result diminished CO2 fixation per unit transpirational water loss (Condon et al., 1993; Tanner and Sinclair, 1983).

Some plants can germinate under high concentrations of NaCl. However, other species are more sensitive during germination. Consequently, the study of salt tolerance during germination, early and late growth of plants is important for determining saline limits at each developmental phase (Zapata et al., 2004). Seed germination and seedling growth of wheat (Triticum aestivum L.), like other crops, were negatively affected by salinity stress (Ashraf and McNeily, 1988; El-Sharkawi and Salml, 1977; Francois et al., 1986; Hampson and Simpson, 1990). "Sholeh" and "Arvand" are the old and native cultivated varieties, while "Chamran" and "Dez" are the modern and breeded varieties in Khozestan province, Iran. The objectives of this study were 1) investigation of seed germination and seedling growth of wheat varieties under salt stress, and 2) compression of differences between native and breeded varieties under this situation.

MATERIALS AND METHODS

This study was done as factorial experiment based on completely randomized design with three replications at agronomy laboratory of Agriculture and natural Resources of Ramin University, Ahvaz, Iran, in 2013. Experimental factors are the wheat varieties (native: Sholeh and Arvand; Breeded: Chamran and Dez) and NaCal concentrations (0, 3, 6, 9, 12 and 15 ds.m-1 salt). After the sterilization of seeds with sodium Hypochlorite (10%), 50 seeds of each variety in individual petri dishes were subjected with salt solution at 24 ºC in germinator. Seeds for 7 days were monitored daily; and each seeds were recorded as a germinated seed, if it had a radicle more than 2 mm. after 7 days, all germinated seeds were dried at 65 ºC in order to dry matter measuring. Germination percent (G), mean germination time (MGT), stem length (SL), root length (RL), seedling dry matter (SEDM) and stem dry matter (STDM) were measured. Vigour index was calculated as below:

$$VI = G_{max} \times SL \quad (3)$$

Where Gmax and SL are maximum of germination and seedling length as Cm (stem length+root length), Respectively (Vashisth and Nagarajan, 2010).

The data were analyzed with "glm" procedure and "contrast" in SAS, in order to finding a probable difference between native and breeded wheat varieties (Orthogonal analaysis). For salinity effect the data were subjected to "reg" procedure in SAS (Regression analysis) (SAS Institute 1992). All Figures were drawn with excel.

RESULTS AND DISCUSSION

Based on orthogonal analysis of Variety effect, there was a significant differences between native (Arvand and Sholeh) and breeded (Chamran and Dez) varieties in germination percent, mean germination time (MGT), vigour index (VI), stem length (SL), stem dry matter (STDM) and seedling dry matter (SEDM) at all salinity levels (Table 1).

Table 1. Orthogonal analysis of variety effect on traits germination percent (G), mean germination time (MGT), vigour index (VI), stem length (SL), root length (RL), stem dry matter (STDM) and seedling dry matter (SEDM) at all (in total), low (0-3 $ds.m^{-1}$), medium (6-9 $ds.m^{-1}$) an high (12-15 $ds.m^{-1}$) salinity levels

Salinity levels	G (%)	MGT (day)	VI	SL (Cm)	RL (Cm)	STDM (gr)	SEDM (gr)
Mean of Squares of Errors (MSE)							
In Total	501.39**	20.70**	936624.22*	56.44**	0.31ns	68.05**	88.89**
0-3	8.16ns	2.99**	122522.46*	19.80**	2.04ns	5.04ns	15.04*
6-9	66.66*	5.92**	55931.41ns	4.55ns	1.42ns	8.16*	1.50ns
12-15	770.66**	13.83**	1187527.08**	41.34**	2.73ns	84.38**	126.04**

* and ** are the significant difference at $\rho \leq 0.05$ and $\rho \leq 0.01$, respectively. ^{ns} is the non-significant at $\rho \leq 0.05$

Wheat varieties have a significant difference in germination percent, native varieties has a higher germination percent (96.33%, 98.33%) than the breeded varieties (92.55%, 91.44%) (Table 1 and Figure 1). Arvand and Sholeh varieties as wheat native varieties in Khozestan province have a lesser mean time germination than the others that have known as breeded varieties. That is means that at salinity stress these varieties germinate with more rate than breeded varieties and starts their life cycle. Also, in VI, SL, STDM and SEDM, native varieties have a more considerable operation than the Chamran and Dez varieties as breeded varieties (Table 1 and Figure 1). It seems that with breeding of varieties for a restricted series of goals, for instance for higher yields, the varieties have been were sensitized to stresses. The sensitivity to salinity of a given species or cultivar may change during ontogeny. It may decrease or increase, depending on the plant species, cultivar or environmental factor (Marschner, 1995).

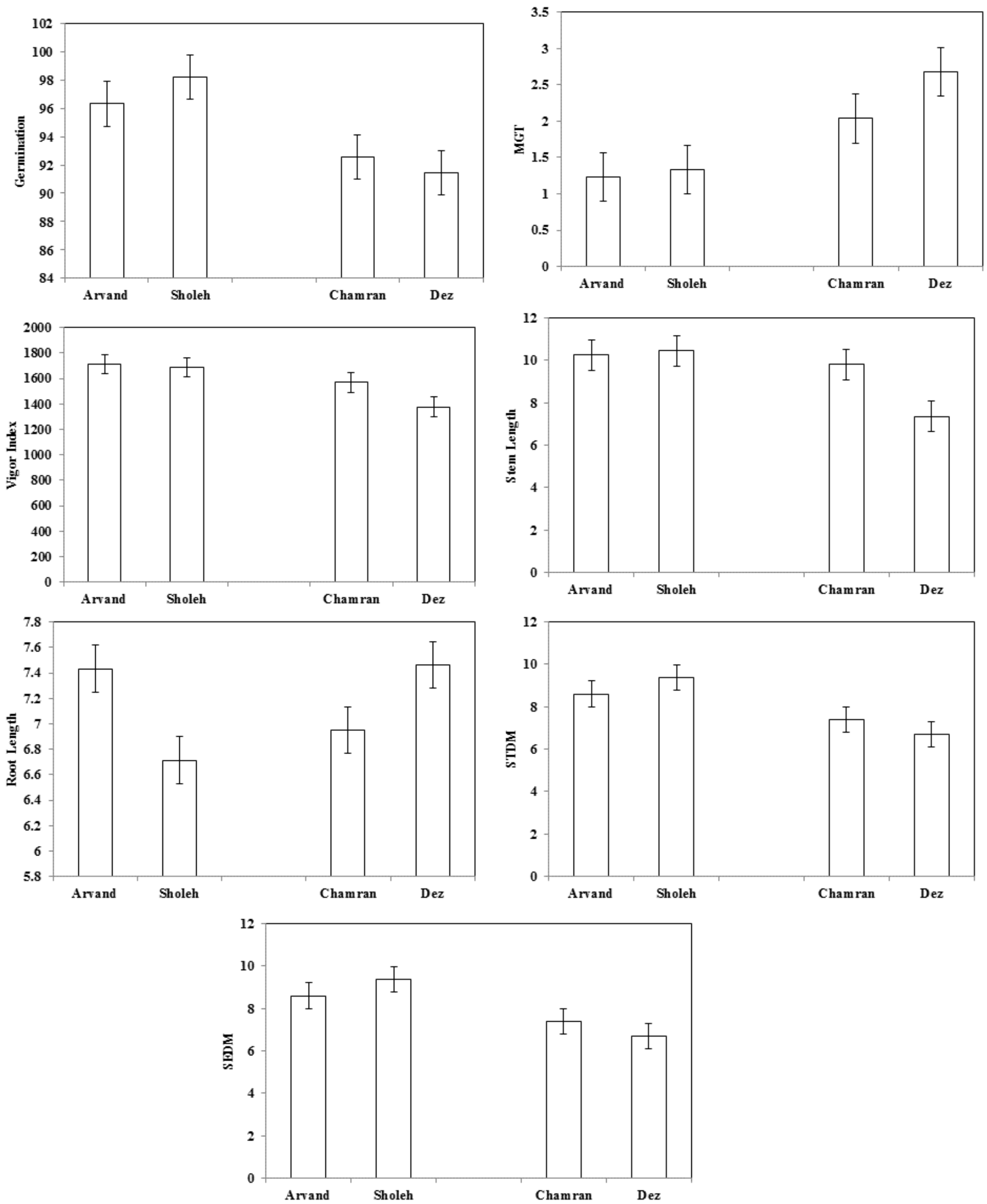

Fig 1. Mean of germination percent (G), mean germination time (MGT), vigour index (VI), stem length (SL), root length (RL), stem dry matter (STDM) and seedling dry matter (SEDM) of native (Arvan and Sholeh) and breeded (Chamran and Dez) varieties at under stress.

Regression analysis of salinity effects on traits showed that, there was a negative linear relation between NaCl concentrations with traits. With increasing of salinity, germination percent (G) decreased linearly. This decreasing in breeded varieties was higher than the native varieties. Slope of these decreasing was very low especially in Sholeh (-0.16) as a native varities (R2= 56%). With increasing salinity in unit scale, G decreased as -0.16 unit (table 2, Figs 2).

Table 2. Regression analysis of variety effect on traits germination percent (G), mean germination time (MGT), vigour index (VI), stem length (SL), root length (RL), stem dry matter (STDM) and seedling dry matter (SEDM) under salinity stress

cultivar	traits	A (intercept)	B (slope)	R^2	RMSE	C.V
	G	100.095±0.78	-0.501±0.085	0.8961^{**}	1.072	1.11
	MGT	1.066±0.109	0.022±0.012	0.4578^{ns}	0.15	12.226
	VI	2245±121.87	-70.99±13.42	0.875^{**}	168.395	9.829
Arvand	SL	13.077±0.603	-0.375±0.066	0.8882^{**}	0.834	8.121
	RL	9.505±0.76	-0.276±0.084	0.73^{*}	1.05	14.122
	STDM	10.21±0.356	-0.212±0.04	0.88^{**}	0.49	5.71
	SEDM	13.94±1.01	-0.228±0.121	0.47^{ns}	1.52	12.44
	G	99.46±0.67	-0.17±0.07	0.56^{ns}	0.92	0.94
	MGT	1.12±0.09	0.029±0.01	0.67^{*}	0.13	9.6
	VI	1933.41±41.79	-32.72±4.6	0.93^{**}	57.74	3.2
Sholeh	SL	11.52±0.4	-0.14±0.044	0.72^{*}	0.55	5.3
	RL	7.95±0.48	-0.16±0.05	0.71^{*}	0.66	9.92
	STDM	9.7±0.62	-0.04±0.07	0.08^{ns}	0.85	9.12
	SEDM	13.57±1.06	-0.03±0.12	0.02^{ns}	1.48	11.08
	G	98.22±2.05	-0.75±0.22	0.74^{*}	2.838	3.067
	MGT	1.73±0.18	-0.04±0.02	0.51^{ns}	0.25	12.21
	VI	2099±274.69	-70.85±30.24	0.58^{ns}	379.54	24.2
Chamran	SL	12.42±1.74	-0.35±0.121	0.45^{ns}	2.4	24.47
	RL	9.16±1.24	-0.29±0.14	0.54^{ns}	1.71	24.6
	STDM	10.84±1.31	-0.46±0.14	0.72^{*}	1.81	24.55
	SEDM	14.26±2.3	-0.50±0.25	0.49^{ns}	3.17	30.02
	G	100.92±3.52	-1.26±0.39	0.73^{*}	4.87	5.32
	MGT	1.63±0.13	-0.14±0.015	0.95^{**}	0.19	7.15
	VI	1920.31±120.43	-72.5±13.26	0.88^{**}	166.4	12.09
Dez	SL	9.65±0.37	-0.31±0.041	0.93^{**}	0.52	7.04
	RL	9.68±0.84	-0.295±0.091	0.72^{*}	1.16	15.5
	STDM	8.37±0.52	-0.22±0.05	0.78^{*}	0.72	10.76
	SEDM	11.93±0.79	-0.18±0.09	0.53^{ns}	1.09	10.39

R^2, RMSE and C.V are the regression coefficient, root mean of square errors and coefficient of variance, respectively. * and ** are the significant difference at $\rho \le 0.05$ and $\rho \le 0.01$, respectively. ^{ns} is the non-significant at $\rho \le 0.05$

Inhibition of germination due to salinity has been reported earlier in greegram cultivars (Abdul Jaleel et al. 2007; Misra and Dwivedi, 2004). The decreasing germination due to increasing salinity can be correlated to the nature of salinity to reduce imbibition of water due to lowered osmotic potentials of the medium and causes changes in metabolic activity (Yupsanis et al., 1994). Moreover, salinity perturbs plant hormone balance (Khan and Rizvi, 1994) and reduces the utilization of seed reserves (Ahmad and Bano,1992). High levels of NaCl decreased final germination percentages in wheat (Almansouri et al., 2001) and other species such as cowpea (Murillo-Amador et all, 2000), tomato (Cuartero et al., 1999) and sugar beet (Ghoulam and Fares, 2001).

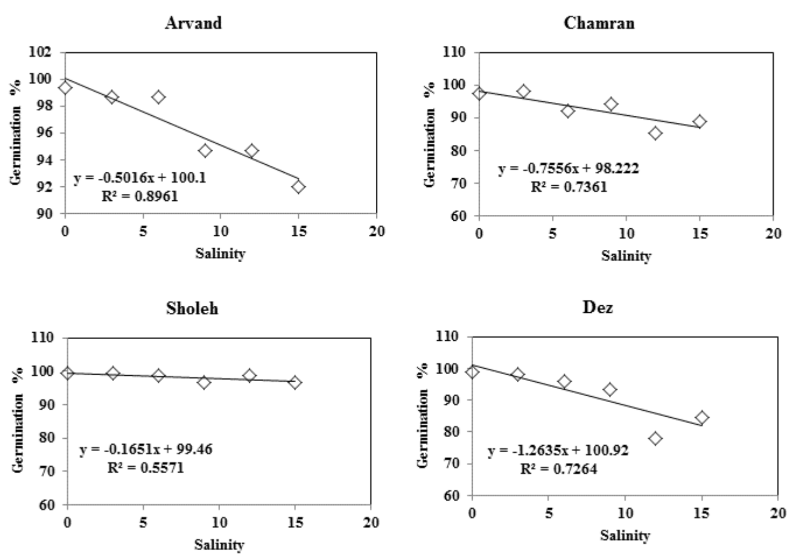

Figure 2. Regression analysis of the salinity effect on germination of native (right) and breeded (left) varieties

Mean germination time in Arvand and Sholeh were lesser than the others at salinity stress. Breeded varieties have more MGT, that is that its germination were delayed (0.13 for Dez) as increasing NaCl concentration in unit (R2=95) (Table 2). Zapata et al., 2003. Reported that Salinity caused a delay in germination .

Sholeh, as a native variety, losses its VI lesser than the Dez as a breeded variety under salinity stress (slope of VI losses -32.72 in compare -72.5 , respectively, with increasing of salinity per unit) (Table 2 and Figure 3).

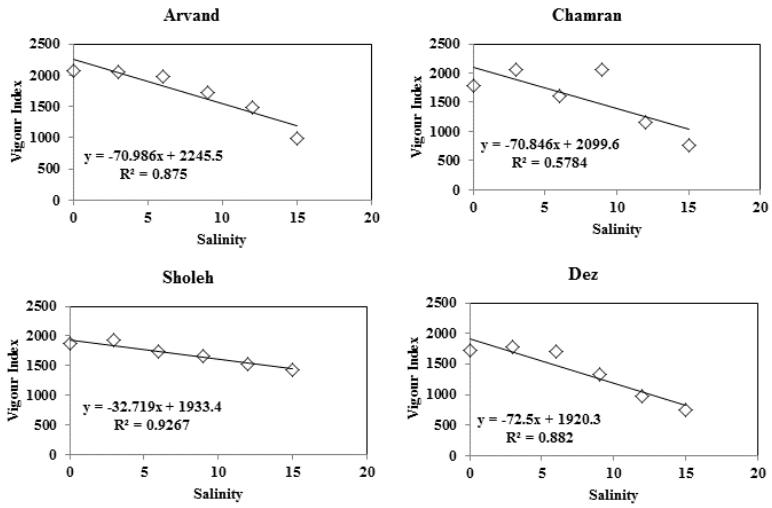

Figure 3. Regression analysis of the salinity effect on vigour index of native (right) and breeded (left) varieties

Decreasing in stem length in breeded varieties has more than the others (R2=0.45 and 0.93) (table 2 and Figure 4). This trend has been observed in relation to root length. Abdul Jaleel et al. (2007) find a trend of decreasing root length of seedlings with increasing NaCl concentrations. Salt stress inhibits the efficiency of the translocation and assimilation of photosynthetic products (Xiong and Zhu, 2002) and might have caused reduction in shoot growth.

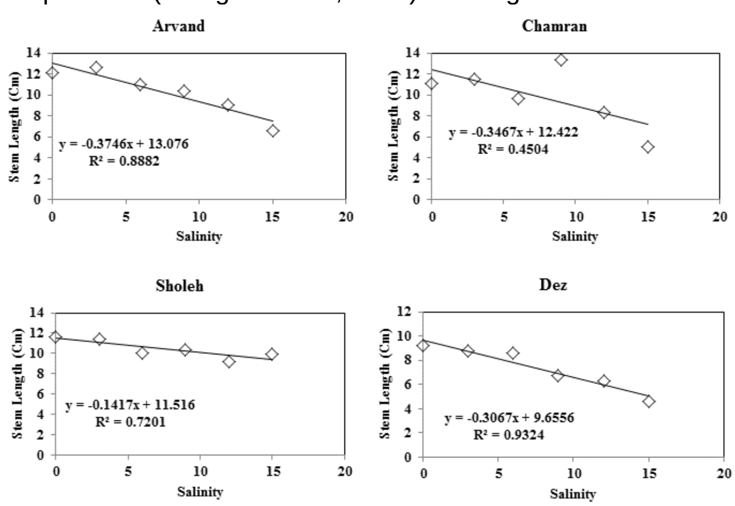

Figure 4. Regression analysis of the salinity effect on stem length of native (right) and breeded (left) varieties

Sholeh has a relatively constant trend in its seedling dry matter and stem dry matter under salt stress (table 2 and Figure 5). These native variety with Arvand, showed that the better characteristics under salinity effect. Similar finding have been reported by Soltani et al (2006; 2002) They found that seedling dry weight reduction in response to salinity was a result of reduction in seed reserve mobilization, not con version efficiency of mobilized reserve to seedling tissue. A growth inhibition by salinity was observed in all the cultivars. This is in agreement with other reports about different species such as sunflower (Benavides et al., 1997), wheat (Reggiani et al., 1994) and rice (Kakkar et al., 2000). The mechanism of growth inhibition produced by salt is still not clear. According to AlKaraki (2001), the adverse effect of salt stress on seed germination in barley might result from internal osmotic stress or restricted imbibition rather than from ion toxicity effects. The inhibitory influence of NaCl on sugar beet seed germination was principally a specific ionic effect and only a small portion of the inhibition could be attributed to an osmotic effect (Ghoulam and Fares, 2001). Moreover, other authors (Ashraf, and Wahid, 2000) indicate that the adverse effect of salt on seed germination in maize seedlings is partly due to impairment in breakdown of seed lipids so as to supply soluble sugars to the respiratory metabolism of the growing embryo.

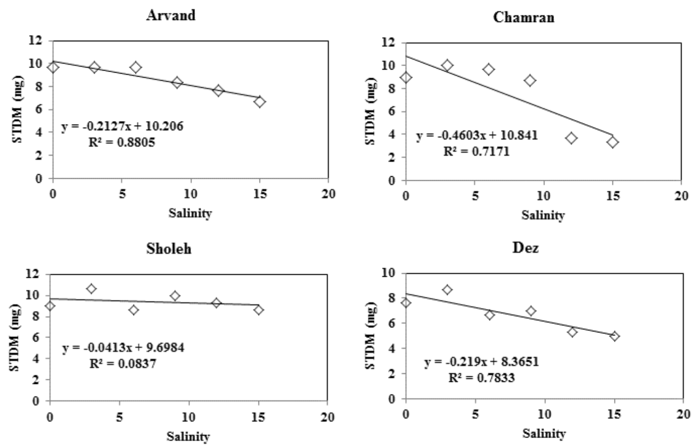

Figure 5. Regression analysis of the salinity effect on stem dry matter of native (right) and breeded (left) varieties

Khozestan province has a saline soils in almost agricultural lands, hence were suggested that these native varieties are the better than the breeded varieties for this situation. If breeded varieties have more grain yield and performance, suggested that Characteristics of salt tolerant of Sholeh and Arvand to be added to these breeded varieties.

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