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Effect of salt stress (sodium chloride) on germination and seedling growth of durum wheat (*Triticum durum* Desf.) genotypes

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The impact of salt stress under different salinity level (0, 50, 100, 150, 200 mMol of NaCl) on ten genotypes of durum wheat namely: Werd Bled, Hmira, Bidi, Arbi, INRAT 69, Agili, Derbassi and Bayatha, Karim and Maali was conducted. Germination rate were recorded daily using radicle extrusion as a criterion. Morphological studies root length, shoot length, fresh weight and dry weight of root and shoot were also measured. Analysis of variance (ANOVA) showed that germination rate of durum wheat genotypes was significantly affected by the salt stress. Results show a reduction of germination rate in response to the highest dose of NaCl for almost all the varieties except for Maali and Derbassi durum wheat cultivar in case150 and 200 mMol concentrations. After 6 days of germination, these lines showed germination percentage respectively of 70 and 60% against a rate of 0% for Bidi AP4 and Bayatha. For morphological traits, the effect of varieties was highly significant (P<0.01) on almost traits measured expect shoot dry weight, root fresh weight and root dry weight. Results show that all studied traits were significantly (P<0.001) reduced due to salt stress. The data showed that different level of salinity significantly affected the growth attributes by reducing root and shoot length for salinity below 50 mMol NaCl. Fresh weight and dry weight of root and shoot were reduced significantly with subsequent treatment.

Key words: Durum wheat, germination, landraces, salt stress.

INTRODUCTION

Salinity, whether natural or induced, is a serious environmental stress limiting the growth and development of salt sensitive plants. Plants vary greatly in their tolerance to salts. However, the performance of crops under saline conditions depends on seed germination, plantlet appearance, establishment and also tolerance at later stages of growth. Germination is a complicated phenomenon comprising physiological and biochemical variation due to embryo activation. Salinity as a non live stress makes many hardships for seed in germination period either by limiting water absorption by the seeds (Dodd and Donovan, 1999), by affecting the mobilization of stored reserves

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(Bouaziz and Hicks, 1990; Lin and Kao, 1995) or by directly affecting the structural organization or synthesis of proteins in germinating embryos (Ramagopal, 1990). These parameters could be affected by both the ionic and the osmotic components of salt stress although the relative importance of each component differs among species and even among cultivars (Dodd and Donovan, 1999; Davenport et al., 2005). When plant is exposure to salinity by NaCl, water and ion transport processes may be affected and disturb plant nutrient situation and ionic balance or disordered physiological process. Salinity decrease water availability for the seed by taking down osmotic potential and in second stage cause to toxicity and change in enzyme activity. Salt stress affects germination percentage, germination rate and seedling growth in different ways depending on plant species (Ungar, 2005; Gul and Weber, 1999). Therefore, Boubaker (1996) showed that germination and seedling characteristics are also viable criteria for selecting salt tolerance in durum wheat in a screening experiment with eight durum wheat cultivars. Increased salt tolerance requires new genetic sources of this tolerance. Landraces are important genetic resources for improvement of crops in saline areas, since they have accumulated adaptation to harsh environment over long time. The aim of the present study were i) to assess the impact of salt stress on different landraces and varieties of durum wheat at germination and seedling stage ii) to screen out best salinity tolerant durum wheat variety and iii) to assess the various morphological changes associated with the plants under different salinity gradient.

MATERIALS AND METHODS

Plant material

Ten genotypes of durum wheat included Karim, Maali, Werd Bled, Hmira, Bidi, Arbi, INRAT 69, Agili, Derbassi and Bayatha. Seeds were sterilized by 12% bleach for 10 min and then washed 3 times with sterilized water. Germination trials were carried out in sterilized petri dishes containing a sheet of blotting paper, and moistened with distilled water or saline solution (0, 50, 100, 150, 200 mMol of NaCl). Each of the three replicates contained 10 seeds. Each treatment was carried out for 12 days. Germinated seeds were counted, and then these seeds were removed from petri dishes. Seeds were considered germinating with the emergence of the radicle.

Observations and measurements

The percentage of germination of treated genotypes and compared to the control (parent) were determined. Germination percentages were recorded daily up to 6 days using radicle extrusion (≥ 2 mm long) as a criterion. At the end of the germination period, the germination percentage was calculated using the equation:

Germination rate (%) = Number of daily germinated seeds/ total number of seeds planted

Morphological studies root length, shoot length, root and shoot fresh weight, root and shoot dry weights were measured.

Analysis statistic

Statistical analysis including analysis of variance (ANOVA), Duncan's test was performed to study the significance of different salinity gradient on different parameters studied.

RESULTS AND DISCUSSION

For all genotype studied, germination rate were recorded daily up to 6 days. The Figure 1 showed that germination process can be considered in terms of three sequential steps: inhibition corresponding to the time necessary for the apparition of the first germs, metabolism leading to initiation of radicle growth representing a fast increase in the rate of germination, and radical growth leading to radicle emergence corresponding a final rate of germination. After 96 h, all varieties reached 100% of germination rate in distilled water. The varieties Hmira, Maali, INRAT 69 and Ward bled reached 100% of germination rate after 48 h in control conditions. The effect of salt treatment was highly significant on rate germination (Table 1). Germination rate was reduced from 50 mMol NaCl salt concentration onwards for almost all the varieties. There is considerable reduction of germination rate in response to the highest dose of NaCl for almost all the varieties except the results were reciprocal for Maali and Derbassi durum wheat cultivar in case 150 and 200 mMol concentration. After 6 days of germination, these lines showed germination percentage respectively of 70 and 60% against a rate of 0% for Bidi AP4 and Bayatha. Results show that exposure of seeds to stress condition had an effect on germination of seeds. Similar effect was observed in *Limonium stocksii* seeds (Zia and Khan, 2004) and *Salsola imbricata* Forssk (Zaman et al., 2010) where only 5% of seeds germinated at stress conditions but 100% germination was achieved when transferred to distilled water. The reduced level of seed germination may be due to (i) loss of viability at higher salinity level (ii) delaying germination of seeds at salinities that cause some stress to but not percent germination as reported by some workers. The results of salt stress were almost prominent from 100 mMol salt concentration onwards for all the ten durum wheat varieties resulting into germination rate. From the results of this present investigation it can be concluded that seeds of 10 different durum wheat cultivars were susceptible to higher concentrations of salt solutions in germination stage which was supported by the works of Gul and Weber (1999) and Datta et al. (2009). Some authors assessed that germination percentage in salt stress conditions may be used as a valuable criterion for the screening of salinity resistance in plant populations (Ashraf et al., 1987).

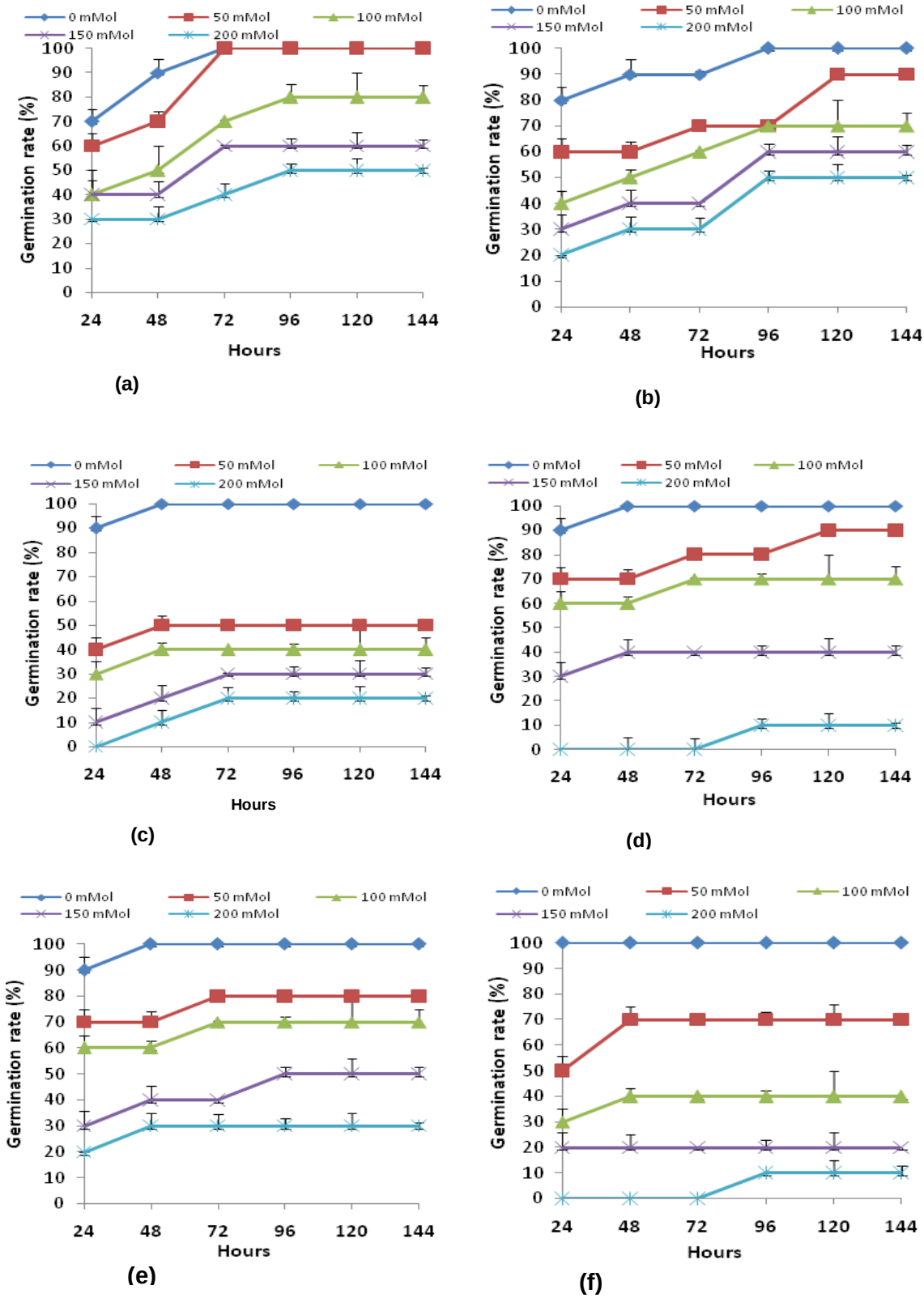

Figure 1. Germination rate in normal (0 mMol NaCl) and in salt stress conditions (50, 100, 150, 200 mMol NaCl) for different durum wheat genotypes studied (a: Agili; b: Arbi; c: Karim; d: INRAT 69; e: Werd Bled Karim; f: Hmira; g: Bidi AP4; h: Bayatha; i: Derbassi; j: Maali).

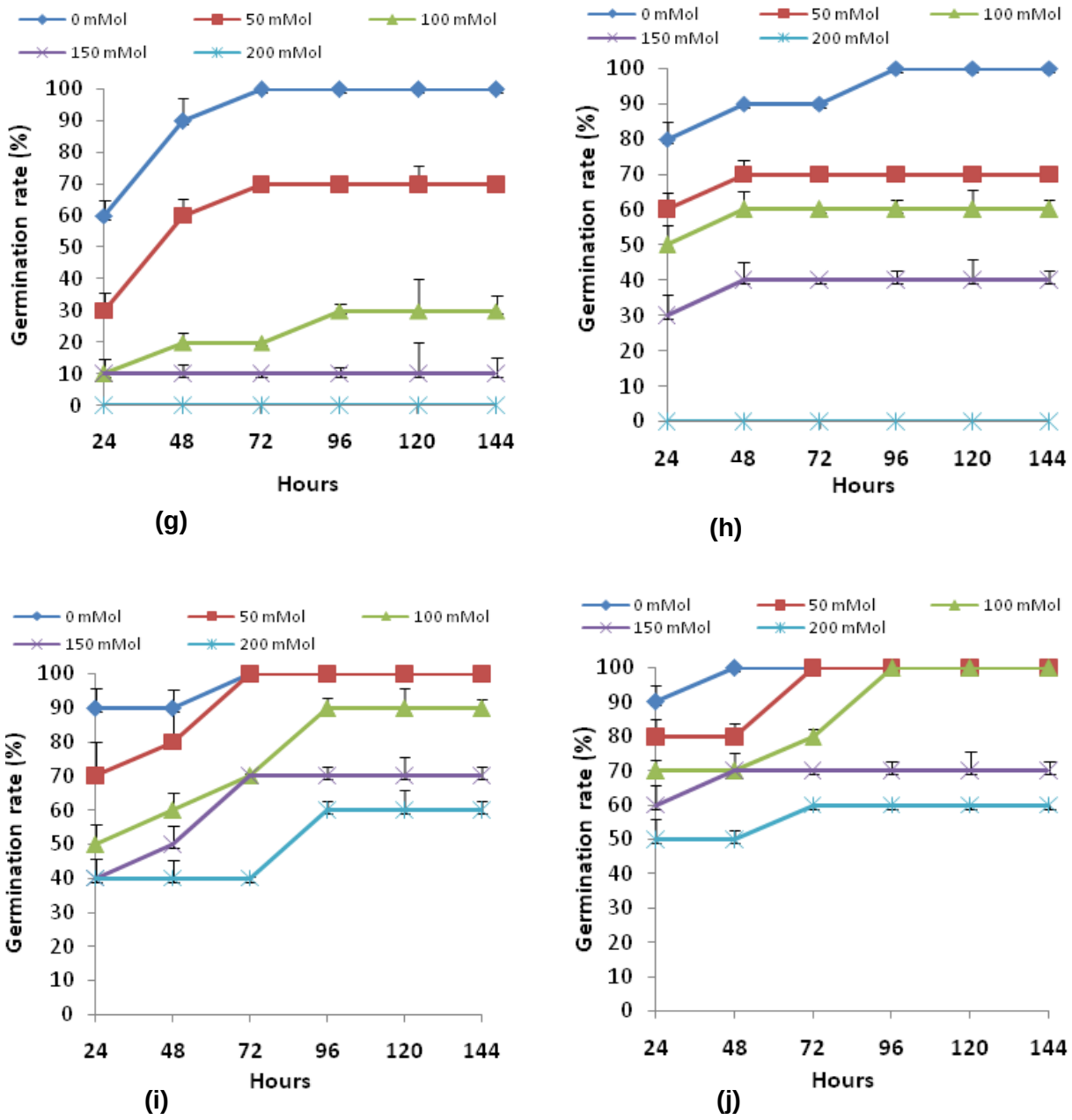

Figure 1. Contd.

Table 1. Variance analysis (mean square and F value) of germination rate in different level of salt stress.

Variation source	df	Mean square	F
Genotype	9	1710.00	9.79**
Treatment	4	2488.33	14.24**
Genotype* Treatment	36	174.25	0.99ns
Error	100	174.66	

**: highly significant at P<0.001. ns: non significant. df: degree freedom.

The study of morphological traits showed that the effect of varieties was highly significant (P<0.01) on almost traits measured expect shoot dry weight, root fresh weight and root dry weight (Table 2). Salinity caused a significant (P<0.01) reduction on all parameter measured at the higher NaCl concentration. Increase in the salinity had an effect on shoot and root length, shoot and root fresh weight, shoot and root dry weight (Table 1). In the current investigation the higher level of salinity had a pronounced effect on root length and shoot length. Datta

Table 2. Variance analysis of shoot length, root length, shoot and root fresh weight, shoot and root dry weight in normal conditions (0 mMol NaCl) and in different salt stress level (50, 100, 150, 200 mMol NaCl) for different durum wheat genotypes studied. Each value represents the mean of 3 replicates.

Parameter	Shoot length	Root length	Shoot fresh weight	Shoot dry weight	Root fresh weight	Root dry weight
Treatment						
T1	3.2^{d}	4.1^{c}	0.19^{c}	0.02^{b}	0.10^{c}	0.01^{c}
T2	2.6^{c}	2.8^{b}	0.14^{b}	0.01^{b}	0.09^{c}	0.01^{b}
T3	2.0^{b}	2.3^{b}	0.11^{bc}	0.01^{b}	0.06^{b}	0.01^{bc}
T4	1.0^{a}	1.3^{a}	0.07^{a}	0.01^{a}	0.03^{a}	0.00^{ab}
T5	0.5^{a}	1.4^{a}	0.09^{ab}	0.00^{a}	0.02^{a}	0.00^{a}
Genotypes						
Agili	1.71^{bc}	2.30^{b}	0.11^{ab}	0.010^{ab}	0.064^{ab}	0.004^{a}
Arbi	2.25^{bc}	2.87^{b}	0.13^{ab}	0.012^{b}	0.072^{ab}	0.005^{a}
Bayatha	1.45^{b}	1.96^{b}	0.10^{ab}	0.010^{ab}	0.060^{ab}	0.005^{a}
Bidi AP4	2.06^{bc}	2.58^{b}	0.12^{b}	0.012^{b}	0.058^{ab}	0.004^{a}
Derbassi	2.00^{bc}	2.74^{b}	0.08^{ab}	0.010^{ab}	0.059^{ab}	0.004^{a}
Hmira	2.07^{bc}	2.58^{b}	0.11^{ab}	0.010^{ab}	0.045^{a}	0.004^{a}
INRAT 69	0.67^{a}	0.92^{a}	0.06^{a}	0.005^{a}	0.057^{ab}	0.003^{a}
Karim	2.05^{bc}	3.12^{b}	0.18^{c}	0.010^{ab}	0.044^{a}	0.007^{a}
Maali	2.65^{c}	2.74^{b}	0.11^{b}	0.013^{b}	0.079^{b}	0.006^{a}
W.Bled	1.99^{bc}	2.52^{b}	0.12^{ab}	0.012^{b}	0.061^{ab}	0.005^{a}
ANOVA						
Genotypes	3.26*	3.04*	3.24*	1.70ns	1.03ns	0.76ns
Treatement	30.38**	20.72**	15.04**	14.26**	20.23**	7.42**
Genotype*Treatment	1.65*	2.30**	5.54**	1.17ns	1.40ns	0.50ns

Values with different superscripted letters are significantly different according to the Duncan's multiple range test ($P < 0.05$).

et al. (2009) showed that different level of salinity significantly affected the growth attributes by reducing root and shoot length for salinity below 125 mMol. The same authors found that the reduction in root and shoot development may be due to toxic effects of the higher level of NaCl concentration as well as unbalanced nutrient uptake by the seedlings. High level of salinity may have also inhibit the root and shoot elongation due to slowing down the water uptake for overall osmotic adjustments of the plant body under high salt stress condition.

The increase of salt stress from 50 mMol onwards significantly reduced the root length and shoot length. The effect of salt stress was completely inhibitory at 200 mMol NaCl concentrations for almost all the varieties. Growth processes are especially sensitive to the effects of salt. Thus, these traits provide reliable criteria for assessing the degree of salt stress and the ability of a plant to withstand it as reported by (Amor et al., 2005).

According Garciarrubio et al. (2003), shoot and root length decrease in salt conditions.

Regarding fresh weight and dry weight the effect of salt stress was pronounced from 50 mMol Nacl concentration onwards. It was completely inhibitory from 150 mMol onwards. The proportion of fresh weight and dry weight allocated to root and shoot decreased with increased NaCl levels. Parida and Das (2005) have shown that salinity can be reduce fresh weight and dry weight.

In conclusion, we revealed in the present work that salt stress delayed and inhibited germination processes and seedling stage in durum wheat by acting on different parameters especially germination percentage, shoot length, root length and shoot fresh weight. These traits may be used as a valuable criterion for the screening of salinity tolerance in durum wheat.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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