AcademicPres

Available online at www.notulaebiologicae.ro

Print ISSN 2067-3205; Electronic 2067-3264

Not Sci Biol, 2011, 3(3):130-134

Notulae Scientia Biologicae

Germination and Seedling Properties of Different Wheat Cultivars under Salinity Conditions

Hamdollah ESKANDARI*, Kamyar KAZEMI

*Payame Noor University, Agriculture department, 19395-4697, Tehran, Iran; ehamdollah@gmail.com (*corresponding author)*

Abstract

Salinity effects were evaluated on seed germination and seedling growth of four bread wheat cultivars (*Triticum aestivum* L.) including 'Taro', 'Shoa', 'Chamran' and 'S-78-11'. The seeds were subjected to four levels of electrical conductivity (EC) 0.0, 4.0, 8.0 and 12.0 ds m^{-2}. The measured factors consisted of germination percentage, speed of germination, shoot and root dry weight and shoot and root lengths. The experiment was arranged as split plot based on randomized complete block design (RCBD) with three replications (NaCl levels as main plot and cultivars as sub-plots). By increasing NaCl concentration, seed germination delayed and decreased in all cultivars. The lowest germination percentage took place in 'Shoa' cultivar and the highest germination in 'S-78-11' cultivar. The largest shoot length was observed in the control (no salt) condition. Increasing NaCl concentrations adversely affected plumule and radicle dry weight in each cultivar; shoot dry weight fluctuated by varying NaCl concentrations. The lowest value found in 'Shoa' cultivar. Regarding the relationship between speed of germination and seed vigour, salt stress decreased seed vigour of wheat cultivars. 'S-78-11' was a superior cultivar under all salinity levels.

Keywords: salinity, salt stress, seed germination, seedling property, seed vigour

Introduction

During their growth, crop plants usually exposed to multitude of natural biotic and abiotic stresses which limit their growth and productivity. Salinity is major abiotic constraints on crop production and food security and adversely impact the social-economic fabric of many developing countries. It is estimated that 20% of all cultivated land and nearly half of irrigated land is affected by salt, greatly reducing the yield of crops to well below their genetic potential (Flowers, 2004; Jones, 2007; Munns *et al.,* 2006). Achieving genetic increases in yield under these stresses had always been a difficult challenge for plant breeders (Blum, 2005).

Seed germination is a critical point in seedling establishment and subsequent plant health and vigour. Seeds may be more sensitive to stresses than mature plants, because of exposure the dynamic environment close to the soil surface (Dodd and Donovan, 1999). Seed response to salinity can be estimated by NaCl induced ionic stress in the germination experiments. Ionic stress is caused by toxic accumulation of NaCl in plant tissues. Germination rates decrease with an increase in NaCl concentration (Akbarimoghaddam *et al.,* 2011; Murillo-Amador *et al.,* 2002). Salinity can affect germination and seedling growth either by creating an osmotic pressure (OP) that prevents water uptake or by toxic effects of sodium and chloride ions on germinating seed (Atak *et al.,* 2006; Akbarimoghaddam *et al.,* 2011). However, screening for seeds with a greater tolerance to salt stress aids in the development of salt tolerant cultivars.

For winter crops such as wheat, soil may contain even more salts at sowing because of high rate of evaporation in the previous summer fallow during which salts migrate to the soil surface (Maghsoudi Moudi and Maghsoudi, 2008). For satisfactory producing under saline conditions, seeds must germinate and seedlings must vigorously pass through the salty layer of the soil and survive (Huang *et al.,* 2003). Under such conditions vigorous seedling growth is very important for crop establishment.

Wheat is the major crop in Iran (Keshavars *et al.,* 2006). It is cultivated over a wide range of environments, because of wide adaptation to diverse environmental conditions. It is a moderately salt-tolerant crop (Maghsoudi-Moudi and Maghsoudi, 2008; Saboora *et al.,* 2006). In Iran, 6.2 million hectares are under wheat cultivation, of which 33% is irrigated and 67% is rain fed, the irrigated wheat growing areas (2 million hectares) are located mostly in southern, central and eastern of Iran (Keshavars *et al.,* 2006). Rapid and uniform seed germination under saline condition not only increases early seedling establishment but also has the advantage of higher drought tolerance (Bradford, 1995). Thus, this research was aimed to screen wheat cultivars for salt stress by assessing germination and seedling properties.

Materials and methods

Seed materials

Seeds of four bread wheat cultivars (*Triticum aestivum* L.) including 'Taro', 'Chamran', 'Shoa' and 'S-78-11' were used as material for the study. The seeds were obtained

Received 21 May 2010; accepted 13 July 2011

from the Agricultural Research Center of Ahwaz. Before cultivation, seeds were sterilized in 1% sodium hypochlorite solution for three minutes, and then were rinsed with sterilized water and were air-dried.

Preparation of NaCl solutions

The solutions were prepared based on methods by (Rhoades *et al.,* 1992) with electrical conductivity (EC) of 0 (as control), 4.0, 8.0 and 12.0 ds m^{-2}.

Experimental details

To observe the influence of different NaCl concentration on seed germination and seedling growth of wheat cultivars, a split plot experiment based on randomized complete block design (RCBD) with three replications was employed. The main plots were allocated to salinity levels, while the sub-plots were assigned for wheat cultivars.

Percentage of germination

25 seeds of each variety were placed in Petri dishes. In each Petri dish, 2 layers of filter paper were moistened with 10 ml of salinity treatments. The plates were placed into an incubator at 25±2°C in darkness for 7 days. The papers were altered once after every 2 days to prevent salt accumulation (Rehman *et al*., 1996). The germinability was recorded on the seventh day after placing. The number of seeds germinated was expressed as percentage under each treatment.

Speed of germination

25 seeds each in four replications were planted in substratum for germination. The substratum was kept in a germinator maintained at 25±2°C temperature for 7 days. Numbers of seedlings emerging daily were counted from day of planting the seeds in the medium till the time germination was completed. Thereafter a germination index (G.I.) was computed by using the following formula (ISTA, 2005):

G.I=n/d

Where:

n=number of seedlings emerging on day 'd'

d=day after planting

Tab. 1. Effect of salinity (ds m^{-2}) on germination percentage of different wheat cultivars

Cultivar	0.0	4.0	8.0	12.0	Mean
'Taro'	98.0 a	79.0 b	50.0 a	0.0 a	56.75
'Shoa'	98.0 a	56.0 c	8.0 b	0.0 a	40.5
'Chamran'	97.0 a	58.0 c	19.0 b	0.0 a	43.5
'S-78-11'	99.0 a	97.0 a	63.0 a	1.0 a	65.0
Mean	98.0	72.5	35	0.25	
LSD (0.01)	2.5	2.0	14.3	1.8	
CV (%)	2.79				

Different letters in each column indicates significance at P ≤0.01

Seedling properties

The data for the shoot and root length (mm), fresh weigh (mg) of plumule and radicle and dry weight (mg) of plumule and radicle were measured eighth days after germination (ISTA, 2005). Dry weights were measured after drying at 70°C for 48 h into an oven (ISTA, 2005).

Data analysis

The analysis of variance of the data and the comparison of the means on the base of the least significant difference (LSD) were carried out, using MSTATC software.

Results and discussion

Percentage of germination

Percentage of germination was significantly affected by salt stress and cultivars (P≤0.01), where increasing in severity of salinity stress reduced percentage of germination (Tab. 1). While no significant difference was observed under control condition (salinity level of 0.0 ds m^{-2}), increasing in salinity from 0.0 to 8.0 ds m^{-2} had different effect on germination percentage of wheat cultivars, where 'Shoa' and 'S-78-11' were the most susceptible and tolerant cultivars to salt stress, respectively. No germination occurred under the highest level of salt stress (12.0 ds m^{-2}) (Tab. 1).

Speed of germination

A direct relationship was observed between speed of germination and increase of NaCl concentration up to 12.0 ds m^{-2} (P≤0.01) (Tab. 2). When NaCl concentration increased to 12.0 ds m^{-2}, speed of germination decreased in comparison to control condition. It decreased to 51.56%, 85.0%, 80.0 and 44% (from 0.0 to 8.0 ds m^{-2} of salinity level) in 'Taro', 'Shoa', 'Chamran' and 'S-78-11' cultivars, respectively (Tab. 2). Maximum germination speed was recorded in 'S-78-11' cultivar. Based on speed of germination the cultivars can be arranged in the following order: 'S-78-11' > 'Taro' > 'Chamran' > 'Shoa'.

Seedling properties

Fresh weight of plumule and radicle

Salinity had significant effect on plumule and radicle fresh weight (P ≤0.01), where increasing in salt concen-

Tab. 2. Effect of salinity (ds m^{-2}) on germination speed of different wheat cultivars

Cultivar	0.0	4.0	8.0	12.0	Mean
'Taro'	9.7 a	7.1 a	4.4 b	0.0 a	5.3
'Shoa'	8.3 b	5.5 b	1.2 c	0.0 a	3.75
'Chamran'	8.8 ab	5.8 b	1.7 c	0.0 a	4.08
'S-78-11'	10.0 a	8.1 a	5.6 a	0.11 a	5.95
Mean	9.05	6.38	3.23	0.03	
LSD (0.01)	1.0	1.1	1.1	1.0	
CV (%)	8.3				

Different letters in each column indicates significance at P ≤0.01

tration reduced these traits (Tab. 3). Differences in fresh weight of plumule and radicle were significant in different cultivars under different salinity level (P ≤0.01). 'Taro' and 'S-78-11' cultivars had the highest value of fresh weight of plumule and radicle under control (0.0 ds m^{-2}) treatment. However, 'S-78-11' was superior cultivar under sever salinity stress in terms of these traits (Tab. 3).

Dry weight of plumule and radicle

These traits decreased with increasing in salinity level (Tab. 4). There were significant differences among wheat cultivars (P≤0.01) at NaCl levels for dry weight of plumule and radicle. The highest dry weight of plumule and radicle was observed for 'S-78-11' cultivar. While 'Shoa' cultivar showed highest reduction (99.9%) of plumule dry weight (from 0.0 to 8.0 ds m^{-2} of salinity level), 'Chamran' cultivar had highest reduction (94%) of radicle dry weight (Tab. 4).

Length of plumule and radicle

Increasing in NaCl concentration resulted in reduction of plumule and radicle length (Tab. 5). By increasing in salt stress (from 0.0 to 8.0 ds m^{-2}) plumule length (mm) of 'Taro', 'Shoa', 'Chamran' and 'S-78-11' decreased 86.6, 90.9, 82.2 and 66.6%, respectively (Tab. 5). Results showed that the plumule growth of 'Shoa' cultivar was more affected by salt stress. Regarding radicle growth, decreasing of this trait was observed under salt stress (Tab. 5). As was expected, the control and the highest concentration of NaCl had the longest and shortest radicle length, respectively. 'Shoa' was the most susceptible cultivar to salt stress in terms of radicle length (Tab. 5).

Little researches have been performed regarding seed germination responses of Iranian bread wheat cultivars to salinity stress (Akbarimoghaddam *et al.,* 2011; Saboora *et al.,* 2006). This research was carried out to observe the effects of salinity on germination and seedling growth of four bread wheat cultivars. The maximum germination

Tab. 3. Effect of salinity (ds.m^{-2}) on fresh weight (mg) of plumule and radicle of different wheat cultivars

	Plumule fresh weight					Radicle fresh weight				
Cultivar	0.0	4.0	8.0	12.0	Mean	0.0	4.0	8.0	12.0	Mean
'Taro'	710.0 a	90.0 b	13.0 b	0.0 a	203.25	1100 a	150 b	50 b	0.0 a	325.0
'Shoa'	220.0 b	70.0 b	3.0 c	0.0 a	73.25	200 b	80 d	22 c	0.0 a	75.50
'Chamran'	330.0 b	80.0 b	10.0 b	0.0 a	105.0	420 b	90 c	12 c	0.0 a	130.50
'S-78-11'	650.0 a	610.0 a	33.0 a	0.9 a	323.27	1400 a	650 a	90 a	3.0 a	535.75
Mean	477.50	212.50	14.80	0.23		780.0	242.5	43.5	0.75	
LSD (0.01)	150.0	88.0	5.0	1.5		350.0	5.50	18.0	3.5	
CV (%)	10.77					3.65				

Different letters in each column indicates significance at P ≤0.01

Tab. 4. Effect of salinity (ds.m^{-2}) on dry weight (mg) of plumule and radicle of different wheat cultivars

	Plumule dry weight					Radicle dry weight				
Cultivar	0.0	4.0	8.0	12.0	Mean	0.0	4.0	8.0	12.0	Mean
'Taro'	85.0 a	12.0 b	4.0 b	0.0 a	25.25	88.0 a	15.0 b	9.0 b	0.0 a	28.0
'Shoa'	20.0 c	10.0 b	0.02 d	0.0 a	7.50	20.0 c	15.0 b	6.0 bc	0.0 a	10.25
'Chamran'	49.0 b	10.0 b	1.1 c	0.0 a	15.03	50.0 b	12.0 b	3.0 c	0.0 a	16.25
'S-78-11'	88.0 a	79.0 a	6.3 a	0.1 a	43.35	110.0 a	72.0 a	15.0 a	1.0 a	49.5
Mean	60.50	27.75	2.86	0.025		67.0	28.5	7.5	0.25	
LSD (0.01)	9.2	11.2	0.9	1.01		12.5	8.4	3.0	1.55	
CV (%)	1.98					4.1				

Different letters in each column indicates significance at P ≤0.01

Tab. 5. Effect of salinity (ds.m^{-2}) on length (mm) of plumule and radicle of different wheat cultivars

	Plumule length (mm)					Radicle length (mm)				
Cultivar	0.0	4.0	8.0	12.0	Mean	0.0	4.0	8.0	12.0	Mean
'Taro'	15.0 b	12.0 a	2.0 b	0.0 a	7.25	22.0 b	15.0 b	4.0 b	0.0 a	10.25
'Shoa'	22.0 a	14.0 a	2.0 b	0.0 a	9.50	60.0 a	20.0 ab	5.0 b	0.0 a	21.25
'Chamran'	17.0 b	5.0 b	3.0 b	0.0 a	6.25	31.0 b	17.0 b	3.0 b	0.0 a	12.75
'S-78-11'	24.0 a	17.0 a	8.0 a	1.3 a	12.58	68.0 a	30.0 a	17.0 a	2.0 a	29.25
Mean	19.5	12.0	3.75	0.33		45.25	20.5	7.25	0.5	
LSD (0.01)	4.0	6.0	4.0	1.8		15.1	10.2	6.6	2.8	
CV (%)	4.65					8.8				

Different letters in each column indicates significance at P ≤0.01

percentage under all salinity levels took place in 'S-78-11' cultivar and minimum in 'Shoa' and 'Chamran' cultivars. The results showed that by increasing NaCl concentrations, germination in the cultivars delayed and decreased .Increasing salinity concentrations often cause osmotic and/or specific toxicity which may reduce germination percentage (Saboora *et al.,* 2006). Similar declines in seed germination have been reported in the literatures (Sharma *et al.,* 2004; Sayar *et al.,* 2010). Results showed that, although planted under the same conditions, the two genotypes displayed distinct responses to salinity. In this sense, genetic variability within a species offers a valuable tool for studying mechanisms of salt tolerance (Gregorio *et al.,* 2002). Na^+ and Cl^- penetrate into plant cells and can accumulate in the vacuole of tolerant plants or in the cytoplasm of sensitive cultivars (Genc, 2007). One of the salt tolerance mechanisms depends on the capacity for osmotic adjustment which allows plant growth to continue under saline conditions. Under salt stress, osmotic adjustment is accomplished by uptake and accumulation of inorganic ions, mainly Na^+ and Cl^- (Sayar *et al.,* 2010).

Significant differences were observed between the examined cultivars, with regard to germination rate. According to Abogadallah and Quick (2009), salinity may affect seed germination by decreasing the ease with which the seeds take up water because the activity and events normally associated with germination get either delayed and/ or proceed at a reduced rate. Salinity (NaCl) may also affect germination by facilitating the intake of toxic ions which may change certain enzymatic or hormonal activities of the seed (Smith and Comb, 1991). These physicochemical effects upon the seed seem to result in a slower and/or lower speed of germination. According to ISTA (2005) speed of germination is one of the most important factors for evaluating seed vigour. Since germination speed of wheat cultivars was decreased under salt stress condition, it can be concluded that salinity may be resulted in reduced seed vigour which may delay the emergence of seedlings.

The plumule and radicle growth are the most important parameters for salt stress because roots are in direct contact with soil and absorb water from soil and shoot supply it to the rest of the plant. For this reason, plumule and radicle length provides an important clue to the response plants to salt stress (Jamil *et al.,* 2006). The plumule and radicle length of seedlings grown in salt solutions also showed decline, indicating that the salt stress not only affected germination but also the growth of seedlings, which indicates that synthetic ability of seed, and thus, dry matter production of the seedlings, was affected. This is in conformity with the findings of Djanaguiraman *et al.* (2003) and Hakim *et al.* (2010) who reported that plumule and radicle length was conspicuously affected by salt. The reduction in plumule and radicle development (their length and weight) may be due to toxic effects of the NaCl used as well as unbalanced nutrient uptake by the seedling. Reduced seedling growth has also been reported by Huang and Reddman (1995) on barley, Foolad and Jones (1993) on tomato, Maghsoudi Moudi and Maghsoudi (2008) on wheat and Jeannette *et al.* (2002) on phaseolus under salt stress condition.

Conclusions

In general, it can be concluded that under control condition (no salt stress) all four cultivars of wheat had good growth. But they showed different response to higher levels of salinity. However, salinity reduced all germination properties of wheat cultivars, especially seed vigour. These results indicate that genetic variation exists among wheat cultivars in terms of early seedling growth rate under salt stress condition, where under sever salt stress, 'S-78-11' cultivar was the most tolerant cultivar which can be suggested for cultivation under salt stress condition.

References

Abogadallah GM, Quick WP (2009). Vegetative salt tolerance of barnyard grass mutants selected for salt tolerant germination. Acta Physiol Planta 31:815-824.

Akbarimoghaddam H, Galavi HM, Ghanbari A, Panjehkeh N (2011). Salinity effects on seed germination and seedling growth of bread wheat cultivars. Trakia J Sci 9(1):43-50.

Atak M, Kaya MD, Kaya G, Cikili Y, Ciftci CY (2006). Effects of NaCl on the Germination, Seedling Growth and Water Uptake of Triticale. Turk J Agric 30:39-47.

Blum A (2005). Drought resistance, water-use efficiency and yield potential are they compatible, dissonant or mutually exclusive? Aust J Agric Res 56:1159-1168.

Bradford KJ (1995). Water relations in seed germination, p. 351-396. In: Kigel J and Galili G (Eds.). Seed development and germination. Marcel Dekker, New York.

Djanaguiraman M, Ramadass R, Durga-Devi D (2003). Effect of salt stress on germination and seedling growth in rice genotypes. Madras Agric J 90(1-3):50-53.

Dodd GL, Donovan LA (1999). Water potential and ionic effects on germination and seedling growth of two cold desert shrubs. Am J Bot 86:1146-1153.

Flowers TJ (2004). Improving crop salt tolerance. J Exp Bot 55:307-319.

Foolad MR, Jones RA (1993). Mapping salt-tolerance genes in tomato using trait-based marker analysis. Theor Appl Genet 87:184-192.

Genc Y (2007). Reassessment of tissue Na+ concentration as a criterion for salinity tolerance in bread wheat. Plant Cell Environ 30:1486-1498.

Gregorio GB, Senadhira D, Mendoza RD, Manigbas NL, Roxas JP, Guerta CQ (2002). Progress in breeding for salinity tolerance and associated abiotic stresses in rice. Field Crops Res 76:91-101.

Hakim MA, Juraimi JS, Begum M, Hanafi M, Ismail MR, Selamat A (2010). Effect of salt stress on germination and early seedling growth of rice. Afric J Biotech 9(13):1911-1918.

Huang J, Reddman RE (1995). Salt tolerance of Hordeum and Brassica species during germination and early seedling growth. Can J Plant Sci 75:85-819.

Huang ZY, Zhang XS, Zheng GH, Gutterman Y (2003). Influence of light, temperature, salinity and storage on seed germination of *Haloxylon ammodendron*. J Arid Environ 55:453-464.

ISTA (2005). International rules for seed testing. International Seed Testing Association. Zurich, Switzerland.

Jamil M, Lee D, Jung KY, Ashraf M, Lee SC, Rha ES (2006). Effect of salt stress on germination and early seedling growth of four vegetables species. J Cent Euro Agric 7:273-282.

Jeannette S, Jimenez B, Craig R, Lynch JP (2002). Salinity tolerance of phaseolus species during germination and early seedling growth. Crop Sci 42:1584-1594.

Jones HG (2007). Monitoring plant and soil water status: established and novel methods revisited and their relevance to studies of drought tolerance. J Exp Bot 58:119-131.

Keshavars A, Jalalkamali MR, Hidari A (2006). Programming of increase of wheat production in Iran. Seed and Plant Improvement Institute.

Maghsoudi-Moudi A, Maghsoudi K (2008). Salt stress effects on respiration and growth of germinated seeds of different wheat cultivars. W J Agric Sci 4(3):351-358.

Munns R, James RA, Läuchli A (2006). Approaches to increasing salt tolerance of wheat and other cereals. J Exp Bot 57:1025-1043.

Murillo-Amador B, Lopez-Aguilar RL, Kaya C, Larrinaga-Mayoral J, Flores-Hernandez A (2002). Comparative effects of NaCl and polyethylene glycol on germination, emergence and seedling growth of cowpea. J Agric Crop Sci 188:235-247.

Rehman S, Harris PJC, Bourne WF, Wilkin J (1996). The effect of sodium chloride on germination and the potassium and calcium content of Acacies seeds. Seed Sci Technol 25:45-57.

Rhoades JD, Kandiah A, Mashali AM (1992). The Use of saline waters for Crop production. FAO Irr. And Drain. Rome.

Saboora A, Kiarostami K, Behroozbayati F, Hajihashemi S (2006). Salinity tolerance of wheat genotype at germination and early seedling growth. Pak J Bio Sci 9(11):2009-2021.

Sayar R, Bchini H, Mosbahi M, Khemira H (2010). Response of durum wheat growth to salt and drought stresses. Czech J Plant Breed 46(2):54-63.

Sharma AD, Thakur M, Rana M, Singh K (2004). Effect of plant growth hormones and abiotic stresses on germination, growth and phosphoaphatse activities in *Sorghum bicolour* (L.) moench seeds. Afric J Biotechnol 3:308-312.

Smith PT, Comb BG (1991). Physiological and enzymatic activity of pepper seeds (*Capsicum annuum*) during priming. Physiol Plant 82:71-78.