

Germination of Different Wheat Cultivars under Salinity Conditions

Oproi E.^{1*}, Madosa E.¹

¹Banat's University of Agricultural Sciences Timișoara, Faculty of Horticulture and Forestry, Aradului Street 119, 300645 Timisoara, Romania
Corresponding author: E-mail: oproieugen@yahoo.com

Abstract Salinity effects were evaluated on seed germination of fourteen bread wheat cultivars (*Triticum aestivum* L.) Salinity treatments measuring (150mM, 200mM, 240mM) were achieved by adding NaCl in deionized water. A control (distilled water) was maintained for each cultivar for comparison. Data regarding germination attributes were recorded. Results revealed that increasing concentration of NaCl solution resulted in gradual reduction in seed germination in all wheat genotypes.

Key words

wheat, germination, salt tolerance

Salinity is one of the most important abiotic stresses limiting crop production in arid and semiarid regions, where soil salt content is naturally high and precipitation can be insufficient for leaching (17, 21). Salinity affects many morphological, physiological and biochemical processes, including seed germination, plant growth, and water and nutrient uptake (3). Wheat (*Triticum aestivum*L.) is the staple foods for more than 35% of world population (4).

New sources of salinity tolerance are needed for crops grown on salt-affected land (Rengasamy, 2002). More than 900 million hectares of land world-wide, approx. 20 % of the total agricultural land (FAO, 2007), are affected by salt, accounting for more than 6 % of the world's total land area. NaCl is the predominant salt causing salinization, and it is unsurprising that plants have evolved mechanisms to regulate its accumulation (16). Seed germination is an important and vulnerable stage in the life cycle of terrestrial angiosperms and determines seedling establishment and plant growth. Despite the importance of seed germination under salt stress (3), the mechanism(s) of salt tolerance in seeds is relatively poorly understood, especially when compared with the amount of information currently available about salt tolerance physiology and biochemistry in vegetative plants (10; 8; 12 20,14).

Salinity affects seed germination through osmotic effects (2), ion toxicity (9) or a combination of the two (11). In vegetative plants, salt stress causes reduced cell turgor and depressed rates of root and leaf elongation (22; 7), suggesting that environmental salinity acts primarily on water uptake. Furthermore, high intracellular concentrations of both Na⁺ and Cl⁻ can inhibit the metabolism of dividing and expanding cells (18), retarding germination and even leading to seed death. Ionic effects may be distinguished from osmotic effects by comparing the effect of salt solutions and iso-osmotic solutions of an inert osmoticum such as polyethylene-glycol (PEG;

technically primarily a matricum) that cannot penetrate the cell wall.

The objective of this research was to determine the effects of salinity on seed germination at various concentrations of NaCl, and selection of saline tolerant cultivars for breeding programs.

Material and Methods

Biological material was represented by a collection of Romanian and foreign varieties of wheat. Before cultivation, seeds were surface-sterilized for 5 min in sodium hypochlorite solution (10%) and then they were 3-5 times rinsed with distilled water. After sterilization, seeds were transferred into 9 cm sterile Petri dishes on filter paper and then were wetted with 7 ml distilled water (control) or saline water solution at 0, 150, 200 and 240mM NaCl. To prevent infection and evaporation of solution, all of the plates were closed with parafilm. All operations were performed under laminar flow. The Petri dishes were labeled and incubated in a germinator at 25°C and 18/6 h day/night illumination.

Preparation of NaCl solution

Saline condition were simulated by employing aqueous NaCl solution. For this purpose, different concentration (V1-150mM, V2-200mM, V3 -240mM) of NaCl solution were made by dissolving analytical grade NaCl (Merck USA) in distilled water. A distilled water control was run for comparison.

Germination of seeds was recorded on daily basis according to AOSA (1990) until a constant count was achieved. Seed was considered to be germinated when radicle length exceeded 2 mm.

Germination index (GI) was calculated as described by AOSA (1983):

GI= (No of emerged seeds/Days of first count)+---+(No of emerged seeds/Days of final count).

Final germination percentage (FGP) was taken as the ratio of number of seeds germinated to the total number of seeds sown and is expressed as percentage.

Data analysis

The data were analyzed using the Fisher's analysis of variance technique under randomized complete block design and the treatment means were compared by Least Significant difference (LSD) test at 0.05 probability level.

Results and Discussions

In table 1.1 is recorded the germination rate of each genotype normally hydrated, these results being considered the starting point of highlighting the influence of the germination medium on the germination of seed and germination rates of the three osmotic pressures. These results were recorded after three days.

Germination ranged from 50% to 100%. Compared with the control variety Alex, genotypes

with higher germination were: Soissons, (100%), Cubus, Calisol, Cerere, Apache (99%). With a lower germination compared to the control genotypes Alex were Exotic, the results recorded for this genotype being significantly negative in statistical terms. Increasing NaCl salinity level adversely affected germination attributes of the wheat cultivars (table1) . Wheat cultivars respond differentially to different salinity level.

When the salt concentration was 150mM NaCl the genotypes with a lower germination capacity compared to the control were Cerere (25%) and Exotic (25%) the results have statistical significance. In this conditions the cultivars with higher germination were Kappo (60%), Genesi (60), Solehlo and Soissons (75%), the results being significant positive.

In case of an increased salt concentration the germination percentage was between 15% and 70%. The genotypes that have registered significantly negative differences from control were Exotic, Esperia Iosef. Increasing NaCl salinity (240mM) determined decreased of germination from 65% to 10%.

Table 1

Effect of salinity on germination percentage of different wheat genotypes

Cultivars	Average V0	Relative value %	Difference/ Signif	Average V1	Relative value %	Difference/ Signif	Average V2	Relative value %	Difference/ Signif	Average V3	Relative value %	Difference/ Signif
Alex	96	100,000	0,000	40	100,000	0	35	100,000	0	30	100	0
Cerere	99	103,125	3,000	25	62,500	-15 ^o	25	71,429	-10	18	60	-12 ^{ooo}
Esperia	98	102,083	2,000	30	75,000	-10	20	57,143	-15 ^{oo}	16	53,33	-14 ^{ooo}
Apache	99	103,125	3,000	28	70,000	-12	22	62,857	-13 ^o	30	100	0
Glosa	98	102,083	2,000	50	125,000	10	35	100,000	0	25	83,33	-5
Kappo	95	98,958	-1,000	60	150,000	20 ^{**}	50	142,857	15 ^{**}	35	116,66	5
Exotic	50	52,083	-46,000 ^{ooo}	25	62,500	-15 ^o	15	42,857	-20 ^{ooo}	15	50	-15 ^{ooo}
Genesi	93	96,875	-3,000	60	150,000	20 ^{**}	40	114,286	5	25	83,33	-5
Iosef	96	100,000	0,000	30	75,000	-10	15	42,857	-20 ^{ooo}	10	33,33	-20 ^{ooo}
Zephyr	97	101,042	1,000	30	75,000	-10	25	71,429	-10	18	60	-12 ^{ooo}
Calisol	99	103,125	3,000	45	112,500	5	25	71,429	-10	15	50	-15 ^{ooo}
Cubus	99	103,125	3,000	50	125,000	10	42	120,000	7	10	33,3333	-20 ^{ooo}
Solehlo	96	100,000	0,000	75	187,500	35 ^{**}	65	185,714	30 ^{***}	45	150	15 ^{***}
Soissons	100	104,167	4,000	75	187,500	35 ^{**}	70	200,000	35 ^{***}	65	216,6667	35 ^{***}
		LSD5%	5,212		LSD5%	12,986		LSD5%	10,673		LSD5%	5,497
		LSD1%	7,034		LSD1%	17,525		LSD1%	14,403		LSD1%	7,418
		LSD0.1%	9,387		LSD0.1%	23,388		LSD0.1%	19,221		LSD0.1%	9,900

Increasing salinity concentrations often cause osmotic and/or specific toxicity which may reduce germination percentage (21). Similar declines in seed germination have been reported in the literatures (24;). 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 (26). 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⁻ (25).

Table 2

The final germination percentage

	Average V0	%	DIF.MT.	Average V1	%	DIF.MT.	Average V2	%	DIF.MT.	Average V3	%	DIF.MT.
	100	100	0	75	100	0	60	100	0	58	100	0
Cerere	100	100	0	90	120	15	73	121,6667	13**	68	117,2414	10
Esperia	100	100	0	35	46,66667	-40 ⁰⁰⁰	28	46,66667	-32 ⁰⁰⁰	30	51,72414	-28 ⁰⁰⁰
Apache	100	100	0	70	93,33333	-5	66	110	6	40	68,96552	-18 ⁰⁰
Glosa	100	100	0	65	86,66667	-10 ⁰	60	100	0	40	68,96552	-18 ⁰⁰
Kappo	99	99	-1	87	116	12**	67	111,6667	7	47	81,03448	-11
Exotic	88	88	-12 ⁰⁰⁰	70	93,33333	-5	50	83,33333	-10 ⁰	45	77,58621	-13 ⁰
Genesi	95	95	-5	90	120	15	80	133,3333	20***	75	129,3103	17**
Iosef	96	96	-4	90	120	15	85	141,6667	25***	80	137,931	22***
Zephyr	97	97	-3	90	120	15	75	125	15***	80	137,931	22***
Calisol	99	99	-1	95	126,6667	20***	95	158,3333	35***	80	137,931	22***
Cubus	99	99	-1	95	126,6667	20***	90	150	30***	85	146,5517	27***
Solehlo	96	96	-4	90	120	15	87	145	27***	85	146,5517	27***
Soissons	100	100	0	95	126,6667	20***	92	153,3333	32***	87	150	29***
		DL5%	5,343		DL5%	8,591		DL5%	7,853		DL5%	12,154
		DL1%	7,211		DL1%	11,594		DL1%	10,598		DL1%	16,402
		DL0.1%	9,623		DL0.1%	15,473		DL0.1%	14,144		DL0.1%	21,89

Final germination was inhibited with increase in NaCl concentration (table 2). Maximum germination was found in variety Soissons and maximum inhibition was found to be in case of Esperia (30%), Glosa(40%) and Exotic (45%) genotypes at 240mM

salinity level. These results were in good harmony with those obtained by(4; 1,15).

Significantly lower germination indices over control were recorded under the influence of different salinity level, yet Soissons scored higher GI value at all salinity level than rest of wheat genotypes.

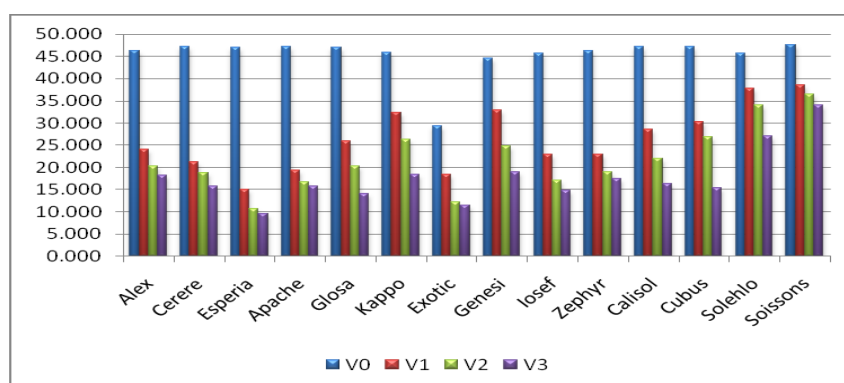


Fig1. Effects of NaCl salinity on germination index by seeds of wheat (*Triticum aestivum* L.) cultivars

Conclusions

In general, it can be concluded that under control condition (no salt stress) all genotypes of wheat had good

germination. But they showed different response to higher levels of salinity. However, salinity reduced all germination properties of wheat cultivars. These results

indicate that genetic variation exists among wheat cultivars under severe salt stress.

References

1. Bahrani, A. and M. Hagh Joo, 2012,. Response of some wheat (*Triticum aestivum* L.) genotypes to salinity at germination and early seedling growth stages. *World Appl. Sci. J.*, 16(4): 599-609.
2. Bliss RD, Plattaloia KA, Thomson WW. 1986;Osmotic sensitivity in relation to salt sensitivity in germinating barley seeds. *Plant Cell and Environment*. 9:721–725.
3. Chapman VJ. 1974, Salt marshes and salt deserts of the world. Stuttgart: J. Cramer Verlag;.
4. Datta, J.K., NAG, A.S. Banerjee, N.K. Mondal, 2009. Impact of salt stress on five varieties of wheat (*Triticum aestivum* L.) cultivars under laboratory condition. *J. Appl. Sci. Environ. Manage.* Sept., 13(3): 93-97.
5. Dodd GL, Donovan LA. 1999;Water potential and ionic effects on germination and seedling growth of two cold desert shrubs. *American Journal of Botany*. 86:1146–1153.
6. Flowers TJ ,2004, Improving crop salt tolerance. *J Exp Bot* 55:307-319.
7. Fricke W, Akhiyarova G, Wei WX, et al. 2006;The short-term growth response to salt of the developing barley leaf. *Journal of Experimental Botany*. 57:1079–1095.
8. Garthwaite AJ, von Bothmer R, Colmer TD. 2005;Salt tolerance in wild *Hordeum* species is associated with restricted entry of Na⁺ and Cl⁻ into the shoots. *Journal of Experimental Botany*. 56:2365–2378.
9. Hampson CR, Simpson GM. 1990;Effects of temperature, salt, and osmotic potential on early growth of wheat (*Triticum aestivum*). 1. Germination. *Canadian Journal of Botany-Revue Canadienne De Botanique*. 68:524–528.
10. Hester MW, Mendelssohn IA, McKee KL. 2001;Species and population variation to salinity stress in *Panicum hemitomon*, *Spartina patens*, and *Spartina alterniflora*: morphological and physiological constraints. *Environmental and Experimental Botany*. 46:277–297.
11. Huang J, Redmann RE. 1995;Salt tolerance of *Hordeum* and *Brassica* species during germination and early seedling growth. *Canadian Journal of Plant Science*. 75:815–819.
12. Hu L, Lu H, Liu QL, Chen XM, Jiang XN 2005; Overexpression of mtID gene in transgenic *Populus tomentosa* improves salt tolerance through accumulation of mannitol. *Tree Physiology*. 25:1273–1281.
13. Jing, R.L., and Chang, X.P., , 2003, Genetic diversity in wheat (*T. aestivum* L.) germplasm resources with drought resistance, *Acta Bot. Boreal-Occident Sin.* 23:410–416.
14. Kanai M, Higuchi K, Hagihara T, et al. 2007;Common reed produces starch granules at the shoot base in response to salt stress. *New Phytologist*. 176:572–580.
15. Kandil, A.A., A.E. Sharief and M.A. Elokda, 2012. Germination and Seedling Characters of Different Wheat Cultivars under Salinity Stress. *J. Basic & Appl. Sci.*, 8: 585-596.
16. Munns R, Tester M. 2008;Mechanisms of salinity tolerance. *Annual Review of Plant Biology*. 59:651–681.
17. Neumann, P.M., 1995, Inhabitation of root growth by salinity stress: Toxicity or an adaptive biophysical response. In: Structure and Function of Roots. Baluska, F., M. Ciamporova, O. Gasparikova and Barlow, P.W. (Eds.), the Netherlands: Kluwer Academic Publishers, pp: 299-304,.
18. Neumann P. 1997;Salinity resistance and plant growth revisited. *Plant Cell and Environment*. 20:1193–1198.
19. Rengasamy P., 2002, Transient salinity and subsoil constraints to dryland farming in Australian sodic soils: an overview. *Aust. J. Exp. Agric.* 42, 351–361.
20. Ren ZH, Gao JP, Li LG, et al. 2005;A rice quantitative trait locus for salt tolerance encodes a sodium transporter. *Nature Genetics*. 37:1141–1146.
21. Saboor, A., and Kiarostami, K., 2006. Salinity tolerance of wheat genotype at germination and early seedling growth. *Pakistan Journal of biological Sciences*, 9(11):2009-2021,
22. Werner JE, Finkelstein RR. 1995;Arabidopsis mutants with reduced response to NaCl and osmotic stress. *Physiologia Plantarum*. 93:659–666.
23. Willenborg, C.J., Gulden, R.H., Johnson, E.N. and Shirliffe, S.J., 2004 Germination characteristics of polymer-coated canola (*Brassica napus* L.) seeds subjected to moisture stress at different temperatures. *Agron. J.* 96:786–791,.
24. Sharma, A.D., Thakur, M., Rana M. And Singh, K., 2004. Effect of plant growth hormones and abiotic stresses on germination, growth and phosphatase activities in *Sorghum bicolor* (L.) Moench seeds. *Afr. J. Biotechnol.*, 3: 308-312,
25. 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.
26. Genc Y. 2007, Reassessment of tissue Na⁺ concentration as a criterion for salinity tolerance in bread wheat. *Plant Cell Environ* 30:1486-1498.