

The Effect of Hydropriming and Halopriming on Germination and Early Growth Stage of Wheat (*Triticum aestivum* L.)

Hamid Abbasdokht, Mohammad Reza Edalatpishe, Ahmad Gholami

Abstract—In order to study of hydropriming and halopriming on germination and early growth stage of wheat (*Triticum aestivum*) an experiment was carried out in laboratory of the Department of Agronomy and Plant breeding, Shahrood University of Technology. Seed treatments consisted of T1: control (untreated seeds), T2: soaking in distilled water for 18 h (hydropriming). T3: soaking in -1.2 MPa solution of CaSO₄ for 36 h (halopriming). Germination and early seedling growth were studied using distilled water (control) and under osmotic potentials of -0.4, -0.8 and -1.2 MPa for NaCl and polyethylene glycol (PEG 6000), respectively. Results showed that Hydroprimed seeds achieved maximum germination seedling dry weight, especially during the higher osmotic potentials. Minimum germination was recorded at untreated seeds (control) followed by osmopriming. Under high osmotic potentials, hydroprimed seeds had higher GI (germination index) as compared to haloprimed or untreated seeds. Interaction effect of seed treatment and osmotic potential significantly affected the seedling vigour index (SVI).

Keywords—Wheat, hydropriming, halopriming, germination

I. INTRODUCTION

SALINITY is one of the major and increasing problems in irrigated agriculture in Iran, particularly in wheat grown areas. The areas affected by varying degrees of salinity are reported at around 6.3 M ha within Canal Command areas, of which half is cultivable or cultivated to some extent [15]. Ghassemi *et al.* [10] estimated about 14% of irrigated land to be badly affected by salinity in Pakistan.

The adverse effects of high concentration of salts for plants are due to the osmotic retention of water and to specific ionic effects on the protoplasm. Water is osmotically held in salt solutions, so as the concentration of salt increased water becomes less and less accessible to the plant. Poor germination and seedling establishment are the results of soil salinity. It is an enormous problem adversely affecting growth and development of crop plants and results in to low agricultural production [9].

Wheat is grown on all type of soils and is classified as a moderate, salt tolerant crop [14]. Yield losses on salt affected soils of Iran average about 64%. Seed priming was defined as pre-sowing treatments in water or in an osmotic solution that allows seed to imbibe water to proceed to the first stage of germination, but prevents radicle protrusion through the seed

coat. The most important priming treatments are Halopriming and hydropriming. Halopriming is a pre-sowing soaking of seeds in salt solutions, which enhances germination and seedling emergence uniformly under adverse environmental conditions. Hydropriming involved soaking of seed in water before sowing. Previous work [2,4,6,16] suggested that the adverse and depressive effects of salinity and water stress on germination can be alleviated by various seed priming treatments. Although the effects of priming treatments on germination of some seed crops has been studied, but relatively little information is available on the invigorating of wheat seed under salt stress.

The aim of the study was to evaluate whether priming with water and salt solution (CaSO₄) results in enhancement of seed vigour in wheat (cv. Darab) under a range of osmotic potentials due to NaCl and PEG, respectively. Further to realize whether responsible factors for failure of wheat seed germination under saline condition is an osmotic blockade or is due to toxic effects of NaCl.

II. MATERIAL AND METHODS

In order to study of the effect of hydropriming and halopriming on germination and early growth stage of wheat (*Triticum aestivum*) an experiment was carried out an experimental design as factorial with three factors based on completely randomized design (CRD) with three replications. First factor was solution (NaCl and PEG), the second factor was seed treatments (control, hydropriming and halopriming) and third factor was osmotic potential levels (0, -0.4, -0.8, -1.2 MPa). Seeds of wheat (*Triticum aestivum* L.) cv. Darab were used for this study.

The study was conducted in laboratory of the Department of Agronomy and Plant breeding, Shahrood University of Technology. Seed treatments consisted of T1: control (untreated seeds), T2: soaking in distilled water for 18 h (hydropriming). T3: soaking in -1.2 MPa solution of CaSO₄ for 36 h (halopriming).

Both priming treatments were conducted at 20°C in the dark separately and redried up to original weight with forced air under shade following Basra *et al.* (2005a). Germination and early seedling growth were studied using distilled water (control) and under osmotic potentials of -0.4, -0.8 and -1.2 MPa for NaCl and polyethylene glycol (PEG 6000), respectively. NaCl concentrations had the electrical conductivity (EC) values of 3.7, 12.3, 17.4 and 21.8 dsm⁻¹, respectively. Referred osmotic potential of NaCl solution (-

0.4, -0.8 and -1.2 MPa) were prepared by using of 5.25, 10.5 and 15.75 grams of NaCl per liter. Osmotic solution of PEG was prepared by using of 161, 241 and 302 gram of PEG per liter, respectively for -0.4, -0.8 and -1.2 MPa. Three replications of 50 seeds were germinated in 12 cm diameter glass Petri dishes at 25±1 °C in a dark growth chamber with 45 % relative humidity. 10 ml osmotic solution was added to each Petri dish and a seed scored germinated when root length reached 2 mm. Germinating seed were counted daily, and terminated when no further germination occurred.

Seedling vigour index (SVI) was calculated following modified formula of Abdul-Baki and Anderson [1]:

$$SVI = [\text{seedling length (cm)} \times \text{germination percentage}]$$

The germination index (GI) which expressed as speed of germination was calculated as described in the Association of Official Seed Analysts [3]. Mean shoot and root lengths at the end of germination were measured per replication. Dry weights of seedlings were taken with the help of an electric balance after drying each replication at 70 °C in the oven to get the constant weight [2].

For comparison of control (untreated seeds) in stress and normal conditions the reduction percentage of germination (RPG) was calculated according to the formula of Madidi *et al.*, [13]. For statistical analysis, the data of germinating percentage were transformed to arcsin X /100. Data were subjected to analysis of variance (ANOVA) procedures SAS program [18] and LSD test was applied at 5 % probability level to compare the differences among treatment means.

III. RESULTS AND DISCUSSION

Results showed that there is a significant three way interaction (seed treatment × solution × osmotic potential) for germination percentage. Germination percentage showed the significant reduction with decrease in osmotic potential. Hydroprimed seeds achieved maximum germination especially during the higher osmotic potentials (i.e. 0 and -0.4 MPa). Minimum germination was recorded at untreated seeds (control) followed by osmopriming. At both seed treatments greater reduction in germination percentage due to PEG compared to NaCl was recorded (Figure 1).

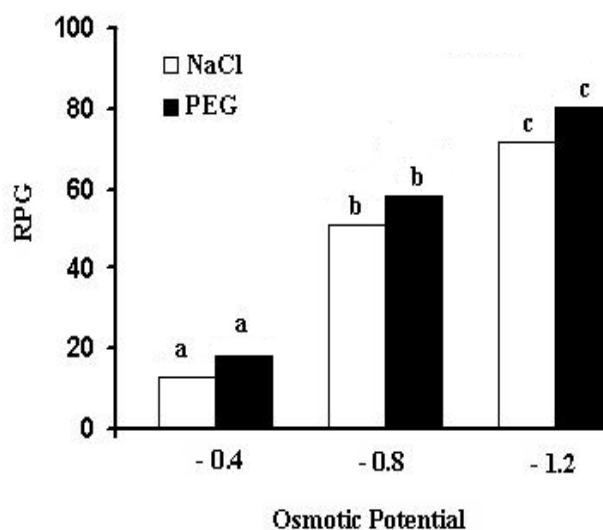


Fig. 1. Interaction effect of solution (NaCl or PEG) and osmotic potential on reduction percentage of germination (RPG) of wheat (cv. Darab). Figures not sharing same letters differ significantly at P=0.05, (RPG at each osmotic potential is average of all seed treatments).

A significant interaction of seed treatment × solution was found for seedling dry weight. Maximum seedling dry weight was attained from hydroprimed seeds under saline condition, while halopriming could not improve this character under all condition as compared to control (Figure 2).

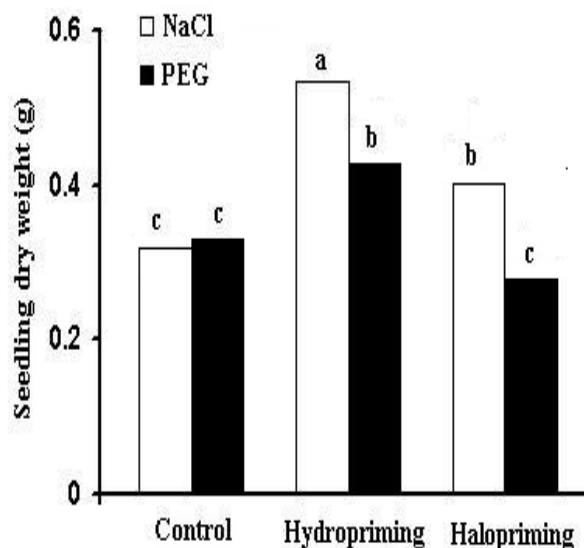


Fig. 2. Influence of different seed priming treatments on seedling dry weight of wheat (cv. Darab) under drought (PEG solution) or salt stress (NaCl solution).

There was a significant interaction of seed treatment × osmotic potential on both root length and shoot length (Figure 3A, B).

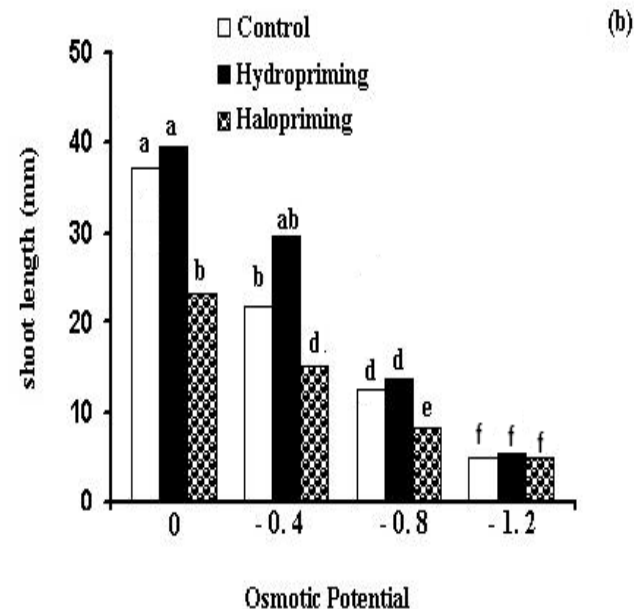
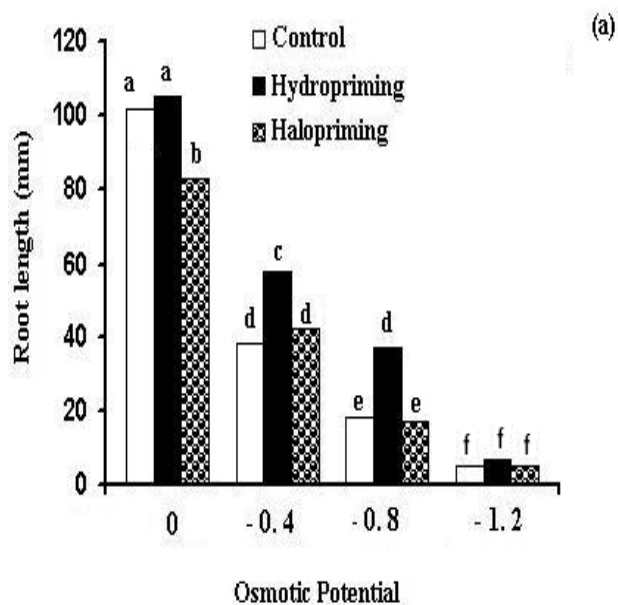


Fig.3. Effect of different seed priming treatments (control, hydropriming and halopriming) on (a) root length, (b) shoot length averaged from wheat (cv. Darab) under different levels of osmotic potential during germination test. The vertical bars with different alphabets are statistically different (at $p=0.05$) indicating interactive effect of seed priming treatments and osmotic potential.

The root and shoot length of seeds that were subjected to hydropriming significantly differed from those subjected to halopriming and control, especially in high osmotic potentials (i.e. 0 and -0.4 MPa). Interaction of seed treatment and osmotic potential for germination index (GI) showed that under high osmotic potentials (i.e. 0 and -0.4 MPa), hydroprimed seeds had higher GI as compared to haloprimed or untreated seeds (Figure 4).

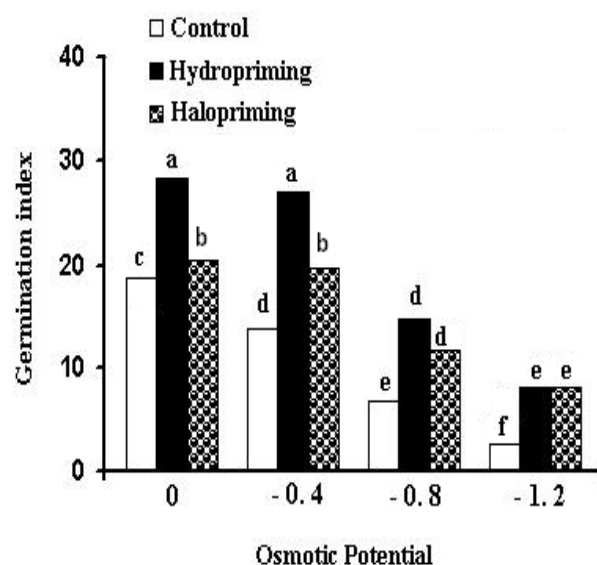
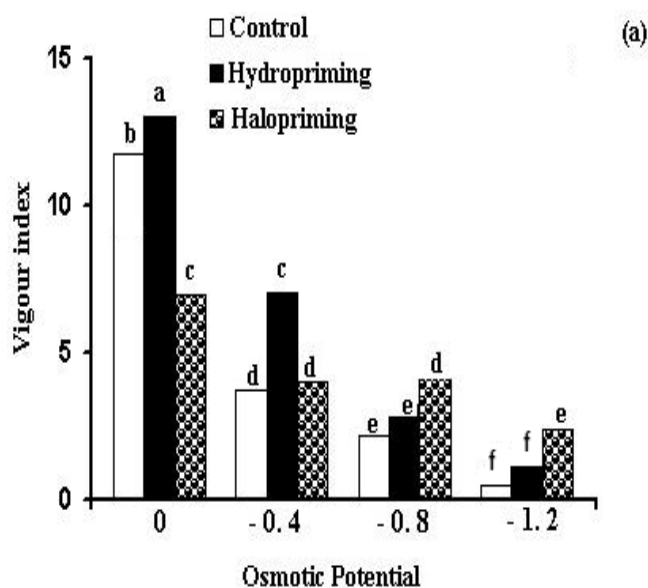


Fig. 4. Influence of different seed priming treatments on germination index of wheat (cv. Darab) under different osmotic potential levels. The bars with different alphabets are statistically different at $P=0.05$. Germination index of each osmotic potential is averaged from NaCl and PEG solution).

Interaction effect of seed treatment and osmotic potential significantly affected the seedling vigour index (SVI). Hydropriming significantly increased SVI, mainly at high osmotic potentials. Averagely SVI of hydroprimed seeds was higher than untreated seeds (Figure 5a). Interaction of solution (NaCl or PEG) and seed treatment was significant for SVI. In the similar way hydropriming could improve this parameter while maximum value was recorded from the saline conditions (Figure 5b).



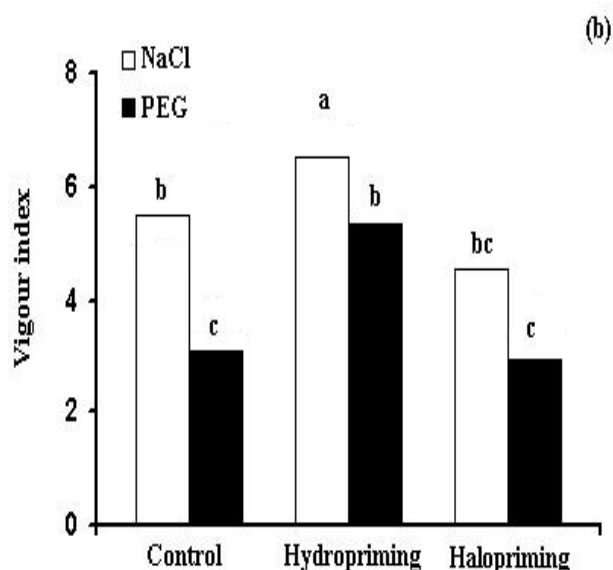


Fig. 5. Effect of different seed priming treatments on seedling vigour index of wheat (cv. Darab), (a) during different osmotic potentials (b) under drought (PEG solution) or salt stress (NaCl solution). The bars with different alphabets are statistically different at $p=0.05$.

Present study showed that both salinity and drought stress affected germination adversely while the effects of drought stress were more severe than salinity stress. Compared to the control both seed treatments showed enhanced performance under stress conditions. Hydropriming technique compared with halopriming clearly improved seed germination and seedling early growth under both stress and non-stress conditions. Hydroprimed seeds could achieve earlier and more uniform germination, or by higher GI and longer and heavier seedlings.

The findings of present study are in agreement with the results of Kaya *et al.* [11] and Basra *et al.* [6] who reported the hydroprimed seeds of sunflower and wheat could germinate faster and produced longer seedling under salinity stress, compared with untreated seeds. Although some earlier studies referred that osmopriming can contribute to improve germination rate and seedling emergence in different plant species by increasing the expression of aquaporins [8], enhancement of ATPase activity, RNA and acid phosphatase synthesis [7], also by increase of amylases, protease or lipases activity [5].

Results of the present study showed that halopriming with CaSO_4 compared to hydropriming can not be recommended as suitable invigoration treatment under both stress and non-stress conditions. It may be due to toxic effect of CaSO_4 or might be because of long period of priming or low osmotic potential (lower than critical potential). However, the superiority of hydropriming on germination could be due to soaking time effects rather than CaSO_4 treatment. Hydroprimed seeds imbibed water for a longer time, compared to haloprimed seeds, and went through the first stage of germination without protrusion of radicle. Seeds

germinated better in NaCl than PEG at the equivalent water potential, possibly due to the uptake of Na^+ and Cl^- ions by the seed, maintaining a water potential gradient allowing water uptake during seed germination. With no toxicity effect of PEG reported [12], the lower germination percentage obtained from PEG compared with NaCl suggests that adverse effects of PEG on germination were due to osmotic effect rather than specific ion accumulation.

Results showed significant improvement in germination and early growth of wheat (cv. Darab) due to hydropriming treatment. Soaking seeds for 36 h resulted in invigorate of germination under salinity and drought stress as well as normal conditions. This study also revealed that at equivalent osmotic potentials drought stress induced by PEG had more drastic inhibitory effects on germination. Thus, it is concluded that under salinity stress the osmotic effect is rather important than toxic effect in loss of seed germination. Generally our results suggested that hydropriming could be as suitable, cheap and easy seed invigoration treatment when for wheat.

REFERENCES

- [1] Abdul-baki, A.A., J.D. Anderson, 1973. Relationship between decarboxylation of glutamic acid and vigour in soybean seed, *Crop Sci.*, 13, 222-226.
- [2] Afzal, I., S.M.A. Basra, A. Iqbal, 2005. The effects of seed soaking with plant growth regulators on seedling vigour of wheat under salinity stress, *J. Stress Physiol and Biochem.* 1, 6-14.
- [3] Association of Official Seed Analysis (AOSA). 1983. Seed Vigour Testing Handbook. Contribution No. 32 to the handbook on Seed Testing, Spring field, IL.
- [4] Ashraf, M., H. Rauf, 2001. Inducing salt tolerance in maize *Zea mays* (L.) through seed priming with chloride salts: growth and ion transport at early growth stages, *Acta Physiol.Plant.*, 23, 407-414.
- [5] Ashraf, M., M.R. Foolad, 2005. Pre-sowing seed treatment-a shotgun approach to improve germination growth and crop yield under saline and none-saline conditions, *Advan. Agron.*, 88, 223-271.
- [6] Basra, S.M.A., I. Afzal, S. Anwar, M. Anwar-ul-haq, M. Shafiq, K. Majeed, 2006. Alleviation of salinity stress by seed invigoration techniques in wheat (*Triticum aestivum* L.), *Seed Technol.*, 28, 36-46.
- [7] Fu, J.R., X.H. Lu, R.Z. Chen, B.Z. Zhang, Z.S. Liu, Z.S. Li, D.Y. Cai, 1988. Osmoconditioning of peanut *Arachis hypogaea* (L.) seeds with PEG to improve vigour and some biochemical activities, *Seed Sci. Technol.*, 16, 197-212.
- [8] Gao, Y.P., L. Young, P. Bonham-smith, L.V. Gusta, 1999. Characterization and expression of plasma and tonoplast membrane aquaporins in primed seed of *Brassica napus* during germination under stress conditions, *Plant Mol. Biol.*, 40, 635-444.
- [9] Garg, B.K. and I.C. Gupta, 1997. Plant Relations to salinity. In: *Saline wastelands environment and plant growth*. Pp: 79-121. Scientific Publishers, Jodhpur.
- [10] Ghassemi, F., A.J. Jakeman, H.A. Nik, 1995. Salinisation of land and water resources. Human causes, extent, management and case studies, University of New South Wales Press, Sydney, pp 526-225 Seed invigoration techniques to improve germination.
- [11] Kaya, M.D., G. Okcu, M. Atak, Y. Cikili, O. Kolsaric, 2006. Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.), *Europ. J. Agronomy.*, 24, 291-295.
- [12] Khaje-hosseini, M., A.A. Powell, I.J. Bingham, 2003. The interaction between salinity stress and seed vigour during germination of soybean seeds, *Seed Sci. Technol.*, 31, 715-725.
- [13] Madidi, S., B. Barudi, F.B. Ameer, 2004. Effects of salinity on germination and early growth of barley (*Hordeum vulgare* L.) cultivars, *Int. J. Agri. Biol.*, 6, 767-770.
- [14] Mass, E.V. and G.J. Hoffman, 1977. Crop salt tolerance current assessment. *J. Irrig. Drain.*, 103: 115-134.

- [15] Rafique, M., 1990. Soil resources and soil related problems in Pakistan. In Ahmad, M. (ed.), Soil Physics Application under Stress Environments. BARD, PARC, Islamabad.
- [16] Roy, N.K., A.K. Srivastava, 2000. Adverse effect of salt stress conditions on chlorophyll content in wheat (*Triticum aestivum* L.) leaves and its amelioration through pre-soaking treatments, Indian J. Agric. Sci., 70, 777-778.
- [17] Scott S. J., Jones R. A. and W. A. Willams. 1984. Review of data analysis methods for seed germination. Crop Science. 24: 1192-1199.
- [18] SAS Institute Inc., 1988. SAS/STAT User's Guide, Release 6.03. SAS Institute Inc., Cary, NC.