Effects of different levels of osmotic potential on germination percentage and germination rate of barley, corn and canola

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Abstract

Iran is located in a hot and dry region. As a result of low precipitation and a vast area of salty and alkali soil, osmotic pressure is very high in most parts of the country (i.e., osmotic potential is more negative). In the present study four levels of osmotic pressure (-0.25, -0.35, -0.45, -0.50 MPa) were created artificially, by polyethylene glycol (PEG) and treatment of three seed types, namely, barley, corn and canola. The study aimed at finding the seeds with better germination potential under high osmotic pressure. The seeds' germination potential under different levels of osmotic pressure was also investigated. The experiment was conducted with four replications at the Laboratory of Faculty of Agriculture, Islamic Azad University, Saveh Branch, in a completely randomized design. Parameters under study were germination rate and germination percentage. Results showed that germination rate was not affected by osmotic potential. Considering germination percentage, only osmotic potential of -0.50 reduced germination percentages of corn seeds. Levels of osmotic potential did not affect seed germination in barley and canola.

Keywords: peg; drought stress; soil; plant

Gharoobi, B., M. Ghorbani, and **M. Ghasemi Nezhad.** 2012. 'Effects of different levels of osmotic potential on germination percentage and germination rate of barley, corn and canola' *Iranian Journal of Plant Physiology* 2 (2), 413-417.

Introduction

Two factors play an important role in increasing the osmotic potential of soil. Temperature can decrease water content of the soil in hot seasons resulting in an increase in soil osmotic pressure. The second factor is the high levels of salts in the soil, particularly where soils are saline and alkaline causing increased osmotic pressure in the soil. As a result of increase in the osmotic pressure, water absorption by seed and also plant through the soil will be decreased and the plant shows symptoms like dryness stress. Under this circumstance, the seed will not be able to germinate. The symptoms of dryness, saline and osmotic stresses are almost like each other, because they cause lack of water absorption by the plant.

Seed germination has a very important role in determining final plant density per area and sufficient plant density per area can be calculated when the seeds germinate fully and with an appropriate rate (Baalbaki et al., 1990).

Germination begins with water uptake by dry seeds and ends with development of radicle

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Received: December, 2011
Accepted: January, 2012

(Bewley and Black, 1994). Dryness is one of the important tensions in reducing the growth and production of plants. It can affect many aspects of plant metabolism and growth, because this tension reduces germination rate and percentage and finally delays establishment of plantlets (Prisco et al., 1992).

Water absorption under optimal conditions, after breaking the seed dormancy (if any) leads to the activation of metabolic processes which result in germination. The presence of compounds with osmotic properties which results in decreasing osmotic potential often leads to disturbance in germination of seeds (Ungar, 1996) and limits the water source. Water tension can decrease germination rate and percentage.

Day and Carr (1995) through an experiment on vetch concluded that as an effect of dryness stress, all germination features decrease. Daveman (2006) reported that dryness stress decreases seed germination percentage and the length of radicle and plumule.

Overall, it is important to determine the potential for seed germination in osmotic or saline stress conditions. Because, in this phase resistance against osmotic stress is a genetic quality and it is a good criterion for selection of salt resistant populations (Ashraf et al., 1987). Therefore, it is important to identify figures or genotypes which show tolerance against salinity in this phase of growth.

The creation and maintenance of a pure water potential in the environment of soil is almost a difficult job. So in this regard, establishing conditions of dryness stress using different osmotic materials to create the osmotic potential is considered as one of the best methods to study the effects of dryness stress on germination. Among these substances, due to the simulation of natural environmental conditions, polyethylene glycol has many applications and is widely used *in vitro* (Ibrahim et al., 2001; Rade Et al., 1995). Because this compound has a high molecular weight, it cannot pass through the cell wall and therefore it is used to regulate water potential in germination tests. Polyethylene glycol with large molecular weight (PEG 6000) is more appropriate than smaller molecules such as those with PEG 4000 to create dryness stress, because germination percentage of seed in polyethylene glycol 6000 and in soil with the same water potential is approximately equal (Emmerich et al., 1990).

Obviously, seeds that can show high tolerance under tension will have a significant role in establishment of plants in farm and increasing their efficiency. So this study was conducted in order to analyze the effects of dryness stress on germination of three seed types and identify the most tolerant one under drought stress.

Materials and Methods

This experiment was conducted in a completely randomized design with four replications aimed at evaluating the effects of different levels of osmotic potential on germination of three crops. Factors included 3 kinds of crop, namely, barley (*Hordeum vulgare*), corn (*Zea mays*) and canola (*Brassica napus*) and different levels of polyethylene glycol solution that artificially created 4 levels of osmotic potential (-0.25, -0.35, -0.45, -0.50 MPa). The types of crops in the study were corn (Iranian 704), barley (kavir) and canola (401 Hybrid Hyola). Required amounts of polyethylene glycol (PEG 6000) were calculated to create each osmotic potential, using the formula suggested by Kaufman Eckard (1971). Distilled water was used for the zero treatment or control.

Forty seeds from each crop were selected and after disinfection with bleach water solution (3%) they were completely dried and then put in Petri dishes. Filter paper was placed at the bottom of each Petri dish. Then Polyethylene glycol solution was added with a specific osmotic potential. The dishes were then put in a germinator with temperature set at 20 °C. Germinated seeds were counted every 24 hours. The seeds with minimum root length 2 mm were considered germinated. Counting was continued until the number of seeds germinated in each sample for two days remained constant.

Table1
Germination percentage of barley, corn and canola

Var. / Osmotic Potential (MPa)	corn	barley	canola
-0.25	72.5 ± 4.78	80 ± 10.8	90 ± 4.1
-0.35	77.5 ± 4.78	70 ± 4.1	85 ± 8.66
-0.45	82.5 ± 6.29	82.5 ± 2.5	92.5 ± 2.5
-0.50	22.5 ± 6.29	65 ± 5	62.5 ± 17

Table 2
Germination rate of barley, corn and canola

Var. / Osmotic Potential (MPa)	corn	barley	canola
-0.25	1.81 ± 0.11	2.00 ± 0. 27	2.25 ± 0.1
-0.35	1.93 ± 0.11	1.75 ± 0 .1	2.12 ± 0.21
-0.45	2.06 ± 0.15	2.06 ± 0.06	2.31 ± 0.00
-0.50	0.56 ± 0.15	0. 25 ± 0. 12	1.56 ± 0.44

In order to keep the minimum moisture, some PEG solution was added to Petri dishes every 8 hours daily. At the end of germination, two factors of germination percentage and germination rate were calculated using the following formulae:

Germination rate= $\sum n/t$

n= The number of germinated seeds at (t) time
t= Days or hours of experiment

Germination Percentage: $\sum ng/nt$

ng= The number of germinated seeds
nt= Total number of seeds.

Statistical analysis

Duncan test was used for analysis of data calculated using SPSS software ($p< 0.05$) .

Results

Germination percentage

AS for the germination percentage of barley and canola, there was no significant difference between 4 levels of PEG. In fact, osmotic potentials developed with 4 concentrations of polyethylene glycol did not have any effect on plant germination of these two crops.

In corn however, there was a significant difference between germination percentage of seeds placed in the fourth level of osmotic potential and all but the last level of osmotic potential of PEG. This means that only osmotic potential developed in the fourth level of PEG was effective in germination of the corn seeds. This effect was negative and reductive. -0.50 osmotic potential was found to be a limitation for germination percentage of corn seeds (Table 1).

Discussion

Only osmotic potential of -0.50 in the study reduced germination percentages of corn seeds. This could be explained by the idea that osmotic potential of -0.40 is a border line for starting the reduction of germination features. Ghomri zare et al (2008) suggest that considering seed characteristics, plant populations do not follow a regular pattern. This involves the germination percentage. This means that in some species, the effect of drought created by PEG on germination is not significant, and germination is not affected by drought stress.

Khazayi et al (2008) in their study concluded that negative potentials between -0.4 and -0.8 MPa are the best condition for studying germination features of different genotypes of plants under drought stress. These same researchers also maintained that sometimes in potentials more than -0.4, there will be some contradictions in results about germination features and negative potentials up to -0.4 MPa did not have any effects on rate and percentage of germination. Similarly, Hasani (2005) studying germination of basil seed, found that considering final germination percentage, there was no significant difference between osmotic potentials of 0 to -0.41 MPa.

As the corn seed is bigger than the other two seeds in this study and its water demand is much more the other seeds, this can affect the reduction of its germination percentage in the present study. It seems that if osmotic potential levels were more negative, perhaps we would see more interesting results.

Acknowledgements

The authors are thankful to Dr Farzami Sepehr for her help in managing the research project.

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