Influence of salt-priming on mucilage yield of Isabgol (*Plantago ovata* Forsk) under salinity stress

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Seeds of Isabgol (*Plantago ovata* Forsk) were divided into three sub-samples, one of which was kept as control (unprimed), a sub-sample was soaked in 0.8% NaCl solution and another sub-sample was pretreated with 0.8% KNO₃ solution for 4 h in an incubator adjusted to 15°C. In laboratory, the highest germination rate and seedling dry weight were obtained by seeds primed with KNO₃. In the greenhouse, means of plant biomass, grain and mucilage yields per plant decreased with increasing salinity. The highest grain and mucilage yields were produced by the plants from seeds primed with KNO₃, which were not significantly different from those primed with NaCl. Neither salinity nor salt-priming had significant effect on turgidity coefficient and mucilage percentage. No significant interaction of salinity × salt-priming on Isabgol performance suggested that salt-priming can improve grain and mucilage yields of this medicinal plant under both saline and non-saline conditions. Therefore, salt-priming can be used to promote seed germination rate, seedling dry weight and grain yield of Isabgol which ultimately can enhance mucilage production.

**Key words:** Germination rate, Isabgol, mucilage yield, salt-priming, seedling dry weight.

INTRODUCTION

Salinity adversely reduces the overall productivity of plants by inducing numerous abnormal morphological, physiological and biochemical changes that cause delayed germination, poor stand establishment (Almansouri et al., 2001), high seedling mortality, stunted growth and lower yields (Allakhverdiev et al., 2000; Muhammad and Hussain, 2010). High salt (NaCl) uptake competes with the uptake of other nutrient ions, especially K⁺, leading to K⁺ deficiency. Increasing NaCl salinity induces Na⁺ and Cl⁻ enhancement and decreases Ca²⁺, K⁺, and Mg²⁺ levels in a number of plants (Khan et al., 1999, 2000; Khan, 2001). The adverse effects of salt stress may be alleviated by seed priming (Ashraf and Foolad, 2005). Seed priming is soaking of seeds in a solution of any priming agent followed by drying of seeds that initiates germination related processes without radicle emergence (McDonald, 1999). Common priming techniques include osmo-priming (soaking seeds in osmotic solutions), halo-priming (soaking seeds in salt solutions) and hydro-priming (soaking seeds in water) (Ghassemi-Golezani et al., 2008a). Seed priming has been reported to improve seed germination and seedling emergence (Abdulrahmani et al., 2007; Ghassemi-Golezani et al., 2008a, b; Ghassemi-Golezani et al., 2010a, b). Seeds with more rapid germination under salt stress may be expected to achieve a high final germination percentage and rapid seedling establishment (Rogers et al., 1995) and hence, ultimate yield.

For the first time, Strogonov (1964) proposed that salt tolerance of plants could be enhanced by treatment of seed with salt solution prior to sowing. Cayuela et al. (1996) have concluded that the higher salt tolerance of plants from primed seeds seems to be the result of a higher capacity for osmotic adjustment, since plants from primed seeds have more Na and Cl in roots and more sugars and organic acids in leaves than plants from unprimed seeds. Successful results of priming have been obtained for wheat (Mehta et al., 1979), tomato (Cano et al., 1991; Pill et al., 1991; Cayuela et al., 1996), rice (Chang-Zheng et al., 2002), melon (Sivritepe et al., 2003) and cucumber (Esmaielpour et al., 2006) under saline conditions.

However, we did not find any report about the effects of

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Table 1. Means of germination rate and seedling dry weight of Isabgol affected by salt-priming.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Germination rate (per day)</th>
<th>Seedling dry weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.3575ab</td>
<td>7.250b</td>
</tr>
<tr>
<td>NaCl</td>
<td>0.3475b</td>
<td>7.500b</td>
</tr>
<tr>
<td>KNO₃</td>
<td>0.4500a</td>
<td>9.250a</td>
</tr>
</tbody>
</table>

Different letters in each column indicate significant difference at p<0.05.

salt-priming on performance of Isabgol (*Plantago ovata* Forsk) under salinity stress. The husk derived from the seeds of Isabgol is used as emollient, demulcent and laxative and in the treatment of dysentery and diarrhea (Chopra et al., 1958).

Thus, this research was aimed to evaluate the influence of salt-priming on seed germination, seedling vigor and grain and mucilage yields of Isabgol under saline and non-saline conditions.

**MATERIALS AND METHODS**

Seeds of Isabgol (*P. ovata* Forsk) were divided into three sub-samples, one of which was kept as control (unprimed) and two other sub-samples were prepared for priming treatments. Seeds of a sub-sample were soaked in 0.8% NaCl solution with electrical conductivity of 15.3 dSm⁻¹ and seeds of another sub-sample were pretreated by 0.8% KNO₃ solution with electrical conductivity of 12.5 dSm⁻¹ (Ghassemi-Golezani et al., 2010b) for 4 h in an incubator adjusted to 15°C. After priming, seeds were washed with distilled water for 1 min and then dried back to primary moisture at 20 to 23°C in the laboratory. All the seeds were treated with Benomyl at a rate of 2g kg⁻¹. Laboratory tests were carried out with RCB design at the Seed Technology Laboratory of the University of Tabriz, Iran. Four replicates of 25 seeds were placed between moist filter papers and germinated in an incubator adjusted on 20°C for 21 days. Germination (protrusion time for radicle by 2 mm) was recorded in daily intervals. At the end, seedling dry weight was determined. Rate of seed germination (R) was calculated according to Ellis and Roberts (1980):

\[
R = \frac{\sum n}{\Sigma (D \times n)}
\]

Where n is the number of seeds germinated on day D and D is the number of days counted from the beginning of the test.

An experiment was conducted in the Greenhouse of the University of Tabriz in 2010. The experiment was arranged as factorial, based on RCB design with three replications. Ten seeds were sown 1 cm deep in each pot filled with 800 g perlite using 36 plastic pots. Salinity treatments (0, 4, 8, 12 dS.m⁻¹) were applied immediately after sowing. Tap water and saline solutions were added to the pots in accordance with the treatments to achieve 100% FC. After emergence, seedlings were thinned to keep four plants in each pot. During the growth period, the pots were weighed and the losses were made up with Hoagland solution (EC=2 dS/m).

Periltes within the pots were washed every 20 days and non-saline and salinity treatments were reapplied, in order to prevent further increase in electrical conductivity (EC), due to adding Hoagland solution. At maturity, plants from each pot were harvested and biomass and grain yield per plant was determined. Turgidity coefficient was measured according to Patel et al. (1996). Mucilage percentage of Isabgol was calculated according to Sharma and Koul (1986) and subsequently mucilage yield per plant for each treatment at each replicate was determined. Analysis of variance of the data was carried out using MSTATC software. Duncan test was applied to compare means of each trait at P<0.05.

Excel software was used to draw figures.

**RESULTS AND DISCUSSION**

Analysis of variance of the laboratory data indicated that, the rate of seed germination and seedling dry weight were significantly affected by salt-priming (P<0.05). The highest germination rate and seedling dry weight were recorded for seeds primed with KNO₃. However, germination rate and seedling dry weight of unprimed and primed seeds with NaCl were almost similar (Table 1). It might be due to early synthesis of nucleic acids e.g. DNA, RNA and proteins during salt hydration process, which ultimately resulted in improved energy of germination of seeds (Bray et al., 1989; Dell’Aquila and Bewley, 1989). Rapid germination of seeds ultimately could lead to the production of larger seedlings (Abdulrahmani et al., 2007; Ghassemi-Golezani et al., 2008b; Ghassemi-Golezani et al., 2010a, b).

The positive effects of osmo-priming on seed germination and seedling growth were also reported for barley (Abdulrahmani et al., 2007), cucumber (Ghassemi-Golezani and Esmaeilpour, 2008), fennel (Neamatollahi et al., 2009) and winter rapeseed (Ghassemi-Golezani et al., 2010b). The effect of salinity on plant biomass, grain yield per plant and mucilage yield was significant, but on turgidity coefficient and mucilage percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2). Mean plant biomass of Isabgol decreased, as salinity percentage was not. Salt-priming had only significant effect on grain yield per plant. Interaction of salinity × salt-priming for these traits was not significant (Table 2).
Table 2. Analysis of variance of the effects of salt-priming on grain yield per plant, turgidity coefficient, mucilage percentage and yield of Isabgol under salinity stress.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f</th>
<th>Plant biomass</th>
<th>Grain yield per plant</th>
<th>Turgidity coefficient</th>
<th>Mucilage percentage</th>
<th>Mucilage yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>0.100</td>
<td>0.006</td>
<td>0.174</td>
<td>8.275</td>
<td>0.002</td>
</tr>
<tr>
<td>Salinity (A)</td>
<td>3</td>
<td>2.988**</td>
<td>2.276**</td>
<td>0.137</td>
<td>3.491</td>
<td>0.067**</td>
</tr>
<tr>
<td>Priming (B)</td>
<td>2</td>
<td>0.722</td>
<td>0.536*</td>
<td>0.049</td>
<td>0.166</td>
<td>0.012</td>
</tr>
<tr>
<td>A*B</td>
<td>6</td>
<td>0.115</td>
<td>0.064</td>
<td>0.012</td>
<td>0.150</td>
<td>0.002</td>
</tr>
<tr>
<td>Error</td>
<td>22</td>
<td>0.349</td>
<td>0.148</td>
<td>0.166</td>
<td>4.159</td>
<td>0.005</td>
</tr>
<tr>
<td>%CV</td>
<td>-</td>
<td>8.63</td>
<td>18.48</td>
<td>19.69</td>
<td>13.71</td>
<td>23.56</td>
</tr>
</tbody>
</table>

*-, **: Statistically significant at \( p \leq 0.05 \) and \( p \leq 0.01 \), respectively.

Figure 1. Mean plant biomass of Isabgol affected by salinity stress.

stress was also reported for broad beans (Katerji et al., 1992), maize and sunflower (Katerji et al., 1996), cotton and wheat (Çullu, 2003), rice (Mahmood et al., 2009) and soybean (Ghassemi-Golezani et al., 2010c). Salinity may delay the onset, reduce the rate, and increase the dispersion of germination events, leading to reductions in plant growth and final crop yield (Ashraf and Foolad, 2005). Disturbed water and nutritional balance of plants may cause reduced crop yield in saline conditions (Muhammad and Hussain, 2010). Mean mucilage yield for 8 and 12 dS/m NaCl salinity was significantly lower than that for 0 and 4 dS/m NaCl salinity (Figure 3). This reduction in mucilage yield directly related with deductions in grain yield per plant under high salinity treatments (Figure 2), since mucilage percentage was not significantly affected by salinity stress (Table 2).

Salt-priming increased grain yield per plant of Isabgol. The highest grain yield was produced by the
Figure 2. Mean grain yield per plant of Isabgol affected by salinity stress.

Figure 3. Mean mucilage yield of Isabgol under saline and non-saline conditions.
plants from seeds primed with KNO₃, which was not significantly different from those primed with NaCl (Figure 4). Seed priming has been used to improve germination, seedling emergence and yield (Khan, 1992). No significant interaction of salinity × salt-priming on Isabgol performance (Table 2) suggest that, salt-priming can improve grain yield of this medicinal plant under both saline and non-saline conditions. Priming with KNO₃ and NaCl quantitatively (but not significantly) increased mucilage yield by 22% and 14%, respectively. Therefore, salt-priming can be used to promote seed germination rate, seedling dry weight and grain yield of Isabgol which ultimately can enhance mucilage production.

**REFERENCES**


