Seed Priming and Field Performance of Soybean (*Glycine max* L.) in Response to Water Limitation

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**Abstract**

Laboratory tests and a field experiment were carried out to evaluate the effects of priming methods on seed invigoration and field performance of soybean (cv. ‘Zan’). The field experiment was arranged as split plot based on RCB design with three replications. Irrigation treatments (I\(_1\), I\(_2\) and I\(_3\): irrigation after 70, 110 and 150 mm evaporation from class A pan) and priming methods (water, 3% KH\(_2\)PO\(_4\) and 3% KNO\(_3\) for 8 h at 15±1°C) were allocated to main and sub-plots, respectively. Germination percentage, seedling dry weight and field emergence percentage decreased, but mean emergence time increased, due to seed priming. Grain yield under severe water deficit was 29.32% less than that under normal irrigation. Pods per plant, grains per plant and grain yield per plant were significantly enhanced as a result of low stand establishment caused by seed priming. Consequently, biological and grain yields per unit area and also harvest index were statistically similar for plants from primed and unprimed seeds. In general, priming methods had no any beneficial effect on laboratory and field performance of soybean seeds.

**Keywords:** grain yield, seed priming, seedling emergence, soybean

**Introduction**

Soybean (*Glycine max* L.) is one of the most important contributors to protein and worlds edible vegetable oils. Water deficit during vegetative and reproductive stages can limit soybean growth and yield (Brown *et al.*, 1985; Daneshian and Jonobi, 2001; Daneshian and Zare, 2005). However, it is not clear whether cultivation of high quality seeds or seed priming can reduce the deleterious effects of water limitation on soybean performance.

The use of high quality seeds with appropriate seed rate are essential to establish a suitable plant population in a soybean field for better returns (Ajouri *et al.*, 2004; Marwat and Nafziger, 1990). Seed quality may be improved by production techniques or by seed pretreatments with water (hydro-priming), osmotic solutions (osmo-priming) and matric materials (matri-priming) (Hur, 1991; Harris *et al.*, 1999; Kaya *et al.*, 2008; Pill *et al.*, 1991). Seed priming is a pre-germination treatment in which seeds are held at a water potential that allows imbibition, but prevents radicle extension (Bradford, 1986). Seed priming is a suitable method to enhance seed and seedling vigor, leading to better stand establishment and yield (Bruggink *et al.*, 1999; Khalil *et al.*, 2010).

The beneficial effects of seed priming have been demonstrated for many field crops such as wheat (Parera and Cantilffe, 1994), sweet corn (Chiu *et al.*, 2002), mungbean (Khan *et al.*, 2005), barley (Abdulrahmani *et al.*, 2007), lentil (Ghassemi-Golezani *et al.*, 2008), cucumber (Ghassemi-Golezani and Esmaeilpour, 2008) and winter rapeseed (Ghassemi-Golezani *et al.*, 2010). However, seed priming decreased germination percentage in barley and corn (Sharif *et al.*, 2006) and reduced rate of seedling emergence and plants per unit area in sunflower (Hussain *et al.*, 2006). This research was carried out to investigate the effects of hydro and osmotic priming on seed invigoration in the laboratory and seedling emergence and grain yield of soybean under different irrigation treatments in the field.

**Materials and methods**

Seeds of soybean (cv. ‘Zan’) were obtained from Agricultural Research Institute, Khoy, Iran. These seeds were divided into four sub-samples. A sub-sample was kept as control (unprimed) and the three other sub-samples were prepared for priming treatments. Water and 3% KH\(_2\)PO\(_4\) and 3% KNO\(_3\) solutions were used to pre treat each of the sub-samples with each of these solutions for 8 h. Priming treatments were performed in an incubator adjusted on 15±1°C under dark conditions. After priming, seeds were washed with tap water and then dried back to 30-40% moisture content at room temperature of 20-25°C.

Laboratory tests were carried out as RCB design at 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 at 15°C for 14 days. Germination (protrusion of radicle by 2 mm) was re-
corded in daily intervals. Mean germination time for each treatment was calculated according to Ellis and Roberts (1981). At the end of germination test (14 days), radicles and shoots were cut from the cotyledons and then dried in an oven at 75±2°C for 48 hours. The dried radicles and shoots were weighed and the mean seedling dry weight for each treatment at each replicate was determined.

The field experiment was conducted at the Research Farm of Tabriz university (Latitude 38°5’ N, Longitude 46°17’ E, Altitude 1360 m above sea level) in 2009. The experiment was arranged as split plot using RCB design with three replications. Irrigation treatments (I₁, I₂ and I₃; irrigation after 70, 110 and 150 mm evaporation from class A pan) and priming methods were assigned to main and sub-plots, respectively. All plots were irrigated immediately after sowing. Irrigation treatments were applied after seedling establishment. Weeds were controlled by hand weeding during crop growth and development. The number of emerged seedlings in an area of 1 m² within each plot was counted in daily intervals until seedling establishment stabilized. Mean emergence time was calculated similar to mean germination time.

At maturity, plants of 1 m² in the middle part of each plot were harvested and the number of pods per plant, grains per plant, 1000 grain weight and grain yield per unit area were recorded. The data were analyzed by MSTATC software and the means were compared using Duncan multiple range test at P≤0.05.

Results and discussions

Effects of seed priming on germination percentage and seedling dry weight were significant (P≤0.01), but on mean germination time was insignificant. The results indicated that germination percentage and seedling dry weight of unprimed seeds were higher than those of primed seeds (Tab. 1). Seedling emergence percentage and time were also significantly (P≤0.01) affected by seed priming. Seedlings from unprimed seeds emerged earlier than those from primed seeds (Tab. 1).

Reduction in germination percentage and seedling dry weight in the laboratory and seedling emergence percentage and rate in the field (Tab. 1) due to seed priming clearly indicate that all priming treatments have deleterious effects on soybean seed germination and seedling growth. Similar results were reported for barley, maize and oat (Sharif et al., 2006) and sunflower (Hussain et al., 2006). Pill and Kilian (2000) found that soaking parsley seeds in water or GA, decreased the germination percentage. Pill and Necker (2001) found that hydro-priming failed to improve emergence in common Kentucky bluegrass seeds. Also, soaking wheat seeds in 5% NaHCO₃ or NaCl for 30 min or 24 h decreased emergence percentage, tillers and yield (Singh and Gill, 1988).

Irrigation treatments had no significant effect on pods per plant, grains per plant, 1000 grain weight, grain yield per plant, biological yield, grain yield per unit area and harvest index of soybean in the field (Tab. 2). Although the effect of irrigation on grain yield was insignificant, but mean yield under severe water stress was 29.32% less than that under well watering. Water deficit through the reduction in the leaf area index and photosynthetic capacity reduces grain yield, because the earliest response to the leaf water deficit is stomata closure, which limits CO₂ diffusion to chloroplasts (Berkowitz et al., 1983; Cornic and Masacci, 1996; Muller and Whitsets, 1996). Reduction of

<table>
<thead>
<tr>
<th>Pre-treatments</th>
<th>Germination (%)</th>
<th>Germination time (day)</th>
<th>Seedling dry weight (mg)</th>
<th>Seedling emergence (%)</th>
<th>Emergence time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-primed</td>
<td>97 a</td>
<td>3.75 b</td>
<td>687.5 c</td>
<td>84.7 c</td>
<td>16 c</td>
</tr>
<tr>
<td>Water</td>
<td>77 b</td>
<td>3.75 b</td>
<td>457.5 b</td>
<td>41.4 b</td>
<td>17 b</td>
</tr>
<tr>
<td>KH₂PO₄</td>
<td>67 c</td>
<td>3.25 a</td>
<td>337.5 c</td>
<td>24.6 a</td>
<td>18 a</td>
</tr>
<tr>
<td>KNO₃</td>
<td>31 d</td>
<td>3 a</td>
<td>142.5 d</td>
<td>23.2 c</td>
<td>18 c</td>
</tr>
</tbody>
</table>

Different letters in each column indicate significant difference at P≤0.05.

Tab. 2. Analysis of variance of the effects of irrigation and seed priming on field performance of soybean

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Pods per plant</th>
<th>Grains per plant</th>
<th>1000 grain weight</th>
<th>Grain yield per plant</th>
<th>Biological yield</th>
<th>Grain yield per unit</th>
<th>Harvest index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>188.1 a</td>
<td>620.4 a</td>
<td>1450.8 a</td>
<td>52.6 a</td>
<td>1936.5 a</td>
<td>1694.9 a</td>
<td>78.3 a</td>
</tr>
<tr>
<td>Irrigation(I)</td>
<td>2</td>
<td>1445.7 a</td>
<td>7324.1 a</td>
<td>583.1 a</td>
<td>77.2 a</td>
<td>66473.3 a</td>
<td>9075.9 a</td>
<td>53.8 a</td>
</tr>
<tr>
<td>Error</td>
<td>4</td>
<td>1015.7 a</td>
<td>644.2 a</td>
<td>426.8</td>
<td>119.3</td>
<td>12386.1</td>
<td>5103.4 a</td>
<td>31.2</td>
</tr>
<tr>
<td>Priming (p)</td>
<td>3</td>
<td>4516.8 a</td>
<td>28812 a</td>
<td>59.9 a</td>
<td>625.8 a</td>
<td>1541 a</td>
<td>171 a</td>
<td>13.2 a</td>
</tr>
<tr>
<td>I×P</td>
<td>6</td>
<td>313.3 a</td>
<td>1674.7 a</td>
<td>58.1 a</td>
<td>35.1 a</td>
<td>11570.6 a</td>
<td>3529.4 a</td>
<td>13.6 a</td>
</tr>
<tr>
<td>Error</td>
<td>18</td>
<td>297.9 a</td>
<td>1662.1 a</td>
<td>137.3</td>
<td>47.5</td>
<td>10142.8</td>
<td>2638.9 a</td>
<td>19.7</td>
</tr>
<tr>
<td>CV (%)</td>
<td>36.38</td>
<td>36.80</td>
<td>8.38</td>
<td>44.17</td>
<td>33.55</td>
<td>34.61</td>
<td>8.83</td>
<td></td>
</tr>
</tbody>
</table>

ns, * and **: No significant and significant at P≤0.05 and P≤0.01, respectively.
the plant growth and grain yield due to water deficit has also been reported for millet (Kumari, 1988; Mahalakshmi and Bidingger, 1985), rice (Yao et al., 1990), chickpea (Probhakar and Safar, 1990; Singh, 1991), sorghum (Berenguuer and Faci, 2001), common bean (Adiku et al., 2001; Ghassemi-Golezani and Mardfar, 2008), soybean (Mirakhor et al., 2009; Paknejad et al., 2009) and faba bean (Ghassemi-Golezani et al., 2009).

Pods per plant, grains per plant and grain yield per plant of soybean were significantly affected by priming (P≤0.01), but it had no significant effect on 1000 grain weight, biological yield, grain yield and harvest index (Tab. 2). Pods per plant, grains per plant and grain yield per plant were significantly enhanced by seed priming, particularly by priming with KNO$_3$ (Tab. 3). However, the interaction of irrigation × priming was insignificant for yield and yield components of soybean (Tab. 2).

Seed priming resulted in lower plant population density, compared with that of control (Tab. 1). These plants were able to use available resources more efficiently, because of low rivalry among plants (Dahmardeh et al., 2010; Taheri-Aghhari et al., 2009). This was resulted in production of more pods per plant, grains per plant and grain yield per plant, compared with those from unprimed seeds (Tab. 3). In other words, reduction in plant density due to seed priming was largely compensated by improvements in individual plant performance. Consequently, biological and grain yields per unit area and also harvest index did not differ significantly between plants from primed and unprimed seeds (Tabs. 2 and 3).

Conclusions

Germination percentage, seedling dry weight and field emergence percentage and rate of soybean decreased as a result of seed priming. Pods per plant, grains per plant and grain yield per plant were significantly improved by low stand establishment caused by seed priming. This was resulted in statistically similar biological and grain yields per unit area and also harvest index for plants from primed and unprimed seeds. Therefore, priming treatments has no any beneficial effect on laboratory and field performance of soybean seeds.

References


