Effect of seed priming on germination and yield of corn

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ABSTRACT: This study was carried out in order to evaluate effect of seed priming on seed germination and yield of corn (Zea mays var S.C704) in Islamic Azad University, Pars Abad Moghan Branch, Iran, in 2011. The experimental design was a two factors factorial on basis of randomized complete block design with four replications. The first factor was priming methods (control, ZnSO₄, KH₂PO₄, KNO₃ and H₂O) and the second factor was priming duration (control, 6, 12, 18 and 24 hours). Results showed that priming methods and duration increased germination percentage, germination rate, numbers of seed row, seed numbers in row, ear length, ear diameter, 1000-seed weight, biological yield, seed yield and harvest index. According to the results of this experiment, seed priming by H₂O with 18 hours had an appropriate performance and could increase seed germination, seed yield and yield components to an acceptable level. Therefore, hydro-priming is a simple, low cost and environmentally friendly technique for improving seed yield in corn.

Keywords: Corn, Priming, Seed yield.

INTRODUCTION

One potential way of improving establishment is to develop seed treatments that can increase seed vigor or germination rates. A common method employed is seed priming. Seed priming is a controlled hydration process followed by re-drying that allows seed to imbibe water and begin internal biological processes necessary for germination, but which does not allow the seed to actually germinate. Seed priming can be accomplished through different methods such as hydro-priming (soaking in DW), osmo-priming (soaking in osmotic solutions such as PEG, potassium salts, e.g., KCl, K₂SO₄) and plant growth inducers (CCC, Ethephon, IAA) (Capron et al., 2000; Chiu et al., 2002; Harris et al., 1999; Chivasa et al., 1998).

Several investigations confirmed that seed priming has many benefits including early and rapid emergence, stand establishment, higher water use efficiency, deeper roots, increasing in root growth, uniformity in emergence, germination in wide range of temperature, break of seed dormancy, initiation of reproductive organs, better competition with weed, early flowering and maturity, resistance to environmental stresses (such as drought and salinity) and diseases (Sclerotium rolfsii L.): Higher grain yield in wheat (Triticum aestivum L.) (Ghana and Schillinger, 2003), corn (Zea mays L.) (Subedi and Ma, 2005) canola (Brassica napus L.) (Farhoudi and Sharifzadeh, 2006), pearl millet (Pennisetum glaucum L.), chickpea (Cicer arietinum L.), rice (Oriza sativa L.) (Harris et al., 1999 and 2005) lettuce (Lactuca sativa L.) (Cantliffe et al., 1984) is reported from field and laboratory studies. Inversely, longevity of primed seed can be decreased (Bruggink et al., 1999). Singh and Agrawal (1977) found that wheat seeds which were treated with DW for 12h increased nitrogen uptake for 11 kg/ha. Misra and Dwivedi (1980) reported that seed soaking in 2.5% KCl for 12 h before sowing increased wheat grain yield for 15%. Paul and Choudhury (1991) observed that seed soaking with 0.5 to 1% solutions with KCl or K₂SO₄ significantly increased plant height, grain yield and its components in wheat genotypes. Kulkarni and Eshanna (1988) stated that pre-sowing seed treatment with IAA at 10 ppm improved root length, rate of germination, and seedling vigor.

The objective of this research was to test whether seed priming methods would affect seed emergence and yield of corn in field

MATERIALS AND METHODS

Experimental Treatments and Field Design

This study was carried out at the Experimental Farm of Islamic Azad University, Pars Abad Moghan Branch, Iran (latitude 39°40’ N, longitude 47° 31’ E, elevation 50m above mean sea level) in 2011. The soil has
sand loam texture with low organic matter and some physical and chemical properties are shown in the Table 1.

**Table 1. Soil physical and chemical properties of experimental area.**

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Soil texture</th>
<th>PH</th>
<th>E.C (ds/m)</th>
<th>Organic Carbon (%)</th>
<th>Total N (%)</th>
<th>Available P (ppm)</th>
<th>Available K (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 30</td>
<td>15</td>
<td>60</td>
<td>25</td>
<td>Sand loam</td>
<td>7.8</td>
<td>2.91</td>
<td>0.51</td>
<td>0.06</td>
<td>8.1</td>
<td>252</td>
</tr>
<tr>
<td>Optimum</td>
<td></td>
<td></td>
<td></td>
<td>Optim loam</td>
<td>6.5 - 7.5</td>
<td>2.0&lt;</td>
<td>&gt;1.0</td>
<td>1.0&gt;</td>
<td>10 - 15</td>
<td>200 - 300</td>
</tr>
</tbody>
</table>

The experimental design was factorial on basis of randomized complete block design (RCBD) with four replications. The seed (10% seed moisture) of corn cultivar S.C. 704 was primed using hydro-priming, halo-priming (solutions of 1% KNO₃) and osmo-priming (solutions of ZnSO₄ with 10 mM Zn and KH₂PO₄ with 50 mM P). Dry seed was used as control.

**Growth Experiment**

Individual plot consist of 5 rows, 6 m long and spaced 75 cm apart. The experimental fields were mould-board ploughed and seedbed preparation consisted of two passes with a tandem disk. Seeds were planted 3 to 3.5 cm deep at a rate of 7 seeds m⁻² on 10th May 2011. For all treatments, N:P:K fertilizers applied at a rates of 200:100:50 kg, respectively. P, K and one-third of N were applied per plant and incorporated. Other two-third of N was split equally at the 8 leafed and tasseling. Weeds were also hand weeded during the season. Final harvests were carried out at the 30th October 2011.

**Estimation of Traits**

Data on days to 50% emergence were calculated from the date of sowing and date of 50% emergence by counting seedling emergence in each plot daily. Emergence m⁻² data was recorded by counting number of plants emerged in one meter row length at three randomly selected rows in each plot. The data were then converted to emergence m⁻².

Data collected included seed yield determined after drying at 70°C for at least 48 h (obtained by combining the three center rows at each experimental unit), dry matter was in an air oven. The following measurements were carried out: seedling emergence percentage, seedling emergence rate, number of seed row, seed number in row, ear length, ear diameter, 1000-seed weight, biological yield, seed yield and harvest index.

**Statistical analysis**

The data were statistically analyzed using analysis (ANOVA) procedure. Means were separated using duncan test at 0.05 level of probability.

**RESULTS**

**Number of seed rows**

Priming method and priming duration significantly increased the number of seed rows in corn. Data regarding the effect of priming method and priming duration on number of seed rows are given in Table 3. In general, the maximum number of seed rows (16.1) was obtained to priming with KNO₃, while the least value (13.5) was recorded at control treatment.

**Ear length**

The effect of priming method and duration on ear length was significant (Table 2). The maximum ear length (18.1 cm) was obtained using H₂O and the minimum ear length (13.1 cm) was gained in control plots (Table 3). Means comparisons indicated that maximum ear length (18.4 cm) was observed for 18 h duration and minimum value (12.8 cm) was observed control treatment.

**Ear diameter**

Ear diameter was significantly affected by priming method and duration (Table 2). The maximum ear diameter (4.5 mm) was obtained by KH₂PO₄ and H₂O priming and minimum ear diameter (3.8 mm) was gained in control plots (no priming) (Table 3). Mean comparison also indicated that priming duration of 18 hours had more ear diameter compared with other times.

**Harvest Index**

The harvest index was significantly affected by priming method and duration. The maximum harvest index (49.1%) was observed in H₂O priming treatment and the minimum harvest index in control treatments. There was a significant difference between priming duration regarding this trait (Table 2). Maximum and minimum harvest index was observed in 18 hours and control, respectively.
One thousand seed weight (1000-seed weight)

The effect of priming method and duration on 1000-seed weight was significant (Table 2). The maximum 1000-seed weight (305.8 gr) was observed in seed priming of H2O which was not significantly different from seed priming of KH2PO4 treatment and the minimum 1000-seed weight (250.2 gr) in control treatment. Maximum 1000-seed weight (310.1 gr) was produced by 18 hours priming duration while minimum (261.7 gr) by control.

Seed yield

Seed yield is the main target of crop production. The seed yield was significantly affected by priming method and duration. Seed priming with H2O significantly increased the seed yield in comparison with other treatments. The seed yield varied between 4.175 ton. ha⁻¹ in without priming till 5.702 ton. ha⁻¹ in seed priming with H2O (Table 3). Maximum seed yield was produced by 18 hours duration (5.413 ton.ha⁻¹) while minimum by control (4.291 ton.ha⁻¹).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>df</th>
<th>MS Germination percentage</th>
<th>Germination rate (day)</th>
<th>Seed row number</th>
<th>Seed number in row</th>
<th>Ear length (cm)</th>
<th>Ear diameter (cm)</th>
<th>1000-seed weight (gr)</th>
<th>Biological Yield (ton/ha)</th>
<th>Seed Yield (ton/ha)</th>
<th>Harvest Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>3</td>
<td>90.4*</td>
<td>0.2</td>
<td>8.2</td>
<td>110.7*</td>
<td>5.4*</td>
<td>11.2*</td>
<td>1154.2*</td>
<td>2.2*</td>
<td>1.7*</td>
<td>8.4*</td>
</tr>
<tr>
<td>Priming method (P)</td>
<td>4</td>
<td>522.1*</td>
<td>0.8*</td>
<td>23.1*</td>
<td>342.3*</td>
<td>19.2*</td>
<td>57.6*</td>
<td>4247.5*</td>
<td>5.4*</td>
<td>3.2*</td>
<td>45.9*</td>
</tr>
<tr>
<td>Priming duration (D)</td>
<td>16</td>
<td>612.3*</td>
<td>0.7*</td>
<td>31.7*</td>
<td>372.1*</td>
<td>18.8</td>
<td>51.2*</td>
<td>4711.3*</td>
<td>4.3*</td>
<td>2.5*</td>
<td>39.3*</td>
</tr>
<tr>
<td>P*D</td>
<td>16</td>
<td>82.5*</td>
<td>0.3*</td>
<td>6.2*</td>
<td>78.1*</td>
<td>4.2*</td>
<td>12.7*</td>
<td>1012.4*</td>
<td>1.7*</td>
<td>1.4*</td>
<td>10.2*</td>
</tr>
<tr>
<td>Error</td>
<td>72</td>
<td>61.4*</td>
<td>1.4</td>
<td>15.1</td>
<td>25.2*</td>
<td>7.6</td>
<td>9.4</td>
<td>926.8</td>
<td>1.8</td>
<td>0.8</td>
<td>9.1</td>
</tr>
<tr>
<td>C.V</td>
<td>18</td>
<td>18.3*</td>
<td>1.4</td>
<td>15.1</td>
<td>25.2*</td>
<td>7.6</td>
<td>9.4</td>
<td>926.8</td>
<td>1.8</td>
<td>0.8</td>
<td>9.1</td>
</tr>
</tbody>
</table>

For a given means within each column of each section followed by the same letter are not significantly different (p<0.05)

Table 2. Analysis of variance for experimental traits

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Germination percentage (%)</th>
<th>Germination rate (day)</th>
<th>Seed row number</th>
<th>Seed number in row</th>
<th>Ear length (cm)</th>
<th>Ear diameter (cm)</th>
<th>1000-seed weight (gr)</th>
<th>Biological Yield (ton/ha)</th>
<th>Seed Yield (ton/ha)</th>
<th>Harvest Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>71.2*</td>
<td>0.052*</td>
<td>13.5*</td>
<td>20.7*</td>
<td>13.1*</td>
<td>3.8*</td>
<td>250.2*</td>
<td>8.952*</td>
<td>4.175*</td>
<td>44.3*</td>
</tr>
<tr>
<td>ZnSO4</td>
<td>82.4*</td>
<td>0.069*</td>
<td>14.5*</td>
<td>26.5*</td>
<td>14.8*</td>
<td>4.2*</td>
<td>294.2*</td>
<td>9.720*</td>
<td>4.912*</td>
<td>48.7*</td>
</tr>
<tr>
<td>KH2PO4</td>
<td>84.1*</td>
<td>0.074*</td>
<td>14.6*</td>
<td>32*</td>
<td>17.9*</td>
<td>4.5*</td>
<td>301.7*</td>
<td>10.741*</td>
<td>5.302*</td>
<td>47.3*</td>
</tr>
<tr>
<td>KNO3</td>
<td>80.3*</td>
<td>0.056*</td>
<td>15.4*</td>
<td>25.9*</td>
<td>15*</td>
<td>4.3*</td>
<td>277.4*</td>
<td>9.930*</td>
<td>4.668*</td>
<td>46.4*</td>
</tr>
<tr>
<td>H2O</td>
<td>91.4*</td>
<td>0.087*</td>
<td>16.1*</td>
<td>30*</td>
<td>18.1*</td>
<td>4.3*</td>
<td>305.8*</td>
<td>11.471*</td>
<td>5.702*</td>
<td>49.1*</td>
</tr>
<tr>
<td>Control</td>
<td>69.1*</td>
<td>0.059*</td>
<td>13.1*</td>
<td>20.1*</td>
<td>12.8*</td>
<td>3.7*</td>
<td>261.7*</td>
<td>8.670*</td>
<td>4.291*</td>
<td>43.4*</td>
</tr>
<tr>
<td>6 hour</td>
<td>76.2*</td>
<td>0.062*</td>
<td>14.2*</td>
<td>26.2*</td>
<td>14.7*</td>
<td>4.5*</td>
<td>289.8*</td>
<td>10.342*</td>
<td>4.601*</td>
<td>45.1*</td>
</tr>
<tr>
<td>12 hour</td>
<td>79.8*</td>
<td>0.079*</td>
<td>15.2*</td>
<td>29.1*</td>
<td>15.1*</td>
<td>4.6*</td>
<td>299.8*</td>
<td>9.780*</td>
<td>4.907*</td>
<td>47.5*</td>
</tr>
<tr>
<td>18 hour</td>
<td>88.4*</td>
<td>0.092*</td>
<td>15.8*</td>
<td>33.1*</td>
<td>18.4*</td>
<td>4.9*</td>
<td>310.1*</td>
<td>10.927*</td>
<td>5.413*</td>
<td>49.2*</td>
</tr>
<tr>
<td>24 hour</td>
<td>82.7*</td>
<td>0.085*</td>
<td>14.7*</td>
<td>30.7*</td>
<td>15.8*</td>
<td>4.5*</td>
<td>285.4*</td>
<td>10.126*</td>
<td>4.712*</td>
<td>46.2*</td>
</tr>
</tbody>
</table>
DISCUSSION

Priming seeds with water, KH$_2$PO$_4$, ZnSO$_4$, and KNO$_3$ resulted in advanced metabolic processes and higher germination percentage and germination rate, compared with unprimed seeds (Table 3). This suggests that there is no toxic effect of KNO$_3$, ZnSO$_4$ nor KH$_2$PO$_4$, due to ion accumulation in the embryo (Demir and Venter, 1999). Pre-sowing treatment with inorganic salts not only promotes seed germination of most crops, but also stimulates faster growth, metabolic processes and hence, ultimate crop yield (Sallam, 1999).

Hydro-primed seeds had the rapid and high seedling emergence in the field, compared with the other seed treatments (Table 3). Kibite and Harker (1991) reported seed hydration of wheat, barley and oats seeds improved the uniformity of seedling emergence. Harris et al (1999) found that hydro-priming enhanced seedling establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields. The resulting improved stand establishment can reportedly increase drought tolerance, reduce pest damage and increase crop yield (Harris et al, 1999). These results suggest that hydro-priming is a useful method for improving seedling vigor, establishment and yield of corn in the field.

REFERENCES