Comparative Study of Pre-Sowing Seed Enhancement Treatments in Fine Rice (Oryza sativa L.)
Shahzad Maqsood Ahmed Basra, Muhammad Farooq and Abdul Khaliq
Department of Crop Physiology, University of Agriculture, Faisalabad-Pakistan
1Department of Agronomy, University of Agriculture, Faisalabad-Pakistan

Abstract
Changes in germination and seedling vigour after priming of fine rice seeds were studied. For priming, rice seeds were soaked in tap water by traditional method, hardened for 18 and 24 h at 25°C (two cycles), and osmoconditioned (with –1.1 MPa KNO₃) for 24 and 48 h at 25°C. All the treatments significantly effected the time to start the germinations, T₅₀, MGT, fresh and dry weight of root and shoot, root and shoot length, root/shoot ratio and EC of seed leachates. Seed hardening for 24 h resulted in higher germination percentage, root and shoot length, root/shoot ratio and lower MGT, T₅₀, and EC.

Keywords: Seed enhancement, Rice, MGT, T₅₀ Hardening, Osmoconditioning

Introduction
Traditionally, rice seedlings have always been transplanted in Pakistan, but in recent years, direct seeding has been extensively studied to reduce the production costs, i.e. removing the expenses for raising and transplanting rice seedlings. In the traditional method, rice seeds are presoaked in water and then germinated at the optimum germination temperature. The well-germinated seeds are sown in a protected nursery bed of soil. However, when dry seeds are planted directly in field, poor emergence rate and delayed germination are often serious problems, especially at early planting. The seeds germinate slowly and display significant individual variation. However, uniform and rapid germination are necessary to obtain the optimum plant population in the direct seeding of rice.

Priming enhances seed performance by increasing germination rate and uniformity. Furthermore, these enhancements persist under less than optimum field conditions, such as salinity (Wiebe and Muhlyaddin, 1987), excessively high or low temperatures (Bradford, 1986; Pill and Finch-Savage, 1988; Valdes et al., 1985), and reduced water availability (Fertt and Pill, 1989).

Materials and Methods
Seeds of fine rice cultivar BASMATI-385 were obtained from the Rice Research Institute, Kala Shah Kakoo. The initial seed moisture was 8.33%.

Seed Treatment
Following seed treatments were employed:
Traditional seed soaking
Two hundred fifty gram seeds were soaked in 500 mL water for 24 h at room temperature. These seeds were then placed between two layers of saturated gunny bags up to chitting.

Seed hardening
A weighed quantity (250 g) of seeds was soaked in 500 mL distilled water at 25°C for 18 or 24 h followed by drying under shade. This soaking and drying of seeds was repeated twice (Lee et al., 1999).

Osmoconditioning
The seeds were soaked in aerated –1.1 MPa KNO₃ solution (Mauromicale et al., 1994) for 24 or 48 h.

Post priming operations
After treatments, seeds were given three surface washings with distilled water (Khan et al., 1992) and redried to original weight with forced air under shade. These seeds were sealed in polythene bags and stored in refrigerator for further use.
Vigour evaluation

Seed germination

Germination was observed daily at 27°C according to the AOSA method (AOSA, 1990).

Time to start 50% germination ($T_{50}$)

$T_{50}$ was calculated according to Coolbear et al. (1984) using the following formula:

$$T_{50} = t_i + \left(\frac{N + 1}{2} + n_i\right) \left(\frac{t_j - t_i}{n_j - n_i}\right)$$

Where $N$ is the final number of germination and $n_i, n_j$ cumulative number of seeds germinated by adjacent counts at times “$t_i$” and “$t_j$” when $n_i < (N+1)/2 < n_j$.

Mean germination time (MGT)

MGT was calculated according to the equation of Ellis and Roberts (1981).

$$MGT = \frac{\sum Dn}{\sum n}$$

Where “$n$” is a number of seeds which were germinated in day “$D$” and “$D$” is the number of days counted from the beginning of germination.

Seedling vigour

Control and treated seeds were sown in plastic trays having moist sand and were placed in a net house. Weather data recorded during the course of studies is given in Table I. The seedlings were evaluated 10 days after sowing as described in the seedling evaluation Handbook of AOSA (1990).

Electrical conductivity of seed leachates

After washing with distilled water, 5 g seeds were soaked in 50 mL distilled water at 25°C. Electrical conductivity of seed leachates was measured 0.5, 1.0, 1.5, and 2, 6, 12 and 24 h after the soaking using the conductivity meter (Model Twin cod B-173) and expressed as $\mu$S/cm/g.

Results

Germination

All the seed treatments significantly affected the time to start the germination, $T_{50}$, MGT and final germination percentage (Table 2). Statistically similar and earlier germination was observed in seeds traditionally soaked, hardened for 18 or 24 h and osmoconditioned for 24 h than control and osmoconditioned for 48 h in which seeds germinated one day later.

Seed hardening for 24 h resulted in lower $T_{50}$ and MGT, and higher germination percentage than all other treatments including control. Osmoconditioning for 48 h resulted in delayed germination and ultimately higher $T_{50}$ and MGT, and lower germination percentage even than that of untreated seeds.

Seedling vigour

All the seed treatments significantly affected the seedling vigour of fine rice (Table 2, 3). Statistically longest roots and shoots were observed in seeds hardened for 24 h. All the seed treatments significantly improved the seedling length except osmoconditioning for 48 h that resulted in shorter seedlings even than that of untreated seeds. Similar trend was noted in root/shoot ratio and root fresh and dry weight where seed hardening for 24 h invigorated the fine rice seedlings, while osmoconditioning for 48 h resulted in performance even less than untreated seeds. All the seed treatments resulted in higher root fresh weight but contrary response was noted in root dry weight where all the treatments resulted in lower root dry weight (Table 3).

Electrical Conductivity (EC)

The lowest EC of solute leakage was observed in the seeds osmoconditioned for 24 h (Figure 1). Maximum rate was recorded in untreated seeds. The trend shows that all the seed treatments resulted in lowering the rate of seed leachates.

Discussion

Pre-sowing seed treatments shortened the MGT and $T_{50}$ and the treated seeds germinated earlier. It is possible that coleoptile from the treated seeds elongated faster and longer than ones from non-treated and over primed seeds (Rennick and Tiernan, 2002). The earlier and faster germination in the treated seeds might be due to increased metabolic activities in the primed seeds than non-primed (Lee and Kim, 2000). Primed seeds usually exhibit increased germination rate, greater germination uniformity, and sometimes greater total germination percentage of a large number of species (Heydecker and Coolbear, 1977; Brocklehurst et al., 1984; Zheng et al., 1994; Taylor et al., 1998; Welbaum and Bradford, 1991; Jett et al., 1996; Özbingöl et al., 1998; Hardegree Van Vactor, 2000).

Priming treatments either were ineffective or significantly reduced the seed vigour. It is evident from reduction in germination percentage and slower germination that resulted in week seedlings (Table 2, 3). Over-priming might be due to KNO$_3$ toxicity during prolonged soaking in KNO$_3$ solution that might have injured the cellular organelles (Singh and Gill, 1988). The results presented here confirm earlier data (Haigh and Barlow, 1987), which indicated that priming with alone or combinations of KNO$_3$, K$_2$HPO$_4$, and K$_3$PO$_4$ proved toxic to sorghum seeds. They also reported that germination was more closely related to ionic strength of the potassium solutions than to the osmotic potential of the imbibitional solution. The deleterious effects of KNO$_3$ treatment may be due to penetration of ions in to the seeds (Brocklehurst and Dearman, 1984).

The earlier and faster germination by hardening for 24 h resulted in increased dry matter accumulation as shown by fresh and dry weight of the shoots and the roots. Increased root length and weight might be due to the induced replication of DNA/RNA in the root tips (Bose and Mishra, 1992). Hardening also improved the repair mechanism both structural and genetic. Improved membrane integrity in the treated seeds resulted in lower seed leachates (Rudrapal and Nakammra, 1988).

Conclusion

Performance of fine rice can be enhanced by different invigoration treatments; however, seed-hardening treatment for 24 hours was found significantly better in the vigour enhancement and can be an alternative of traditional seed soaking method being used for decades.
Table 1: Weather data during the course of study

<table>
<thead>
<tr>
<th>Date</th>
<th>Temperature (ºC)</th>
<th>R.H. (%)</th>
<th>Rainfall (mm)</th>
<th>Sunshine hours</th>
</tr>
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<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td></td>
<td></td>
</tr>
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<td>25-7-02</td>
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<td>38</td>
<td>60</td>
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<tr>
<td>26-7-02</td>
<td>30</td>
<td>36</td>
<td>62</td>
<td>00</td>
</tr>
<tr>
<td>27-7-02</td>
<td>28</td>
<td>40</td>
<td>61</td>
<td>00</td>
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<td>28-7-02</td>
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<td>00</td>
</tr>
<tr>
<td>30-7-02</td>
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<td>41</td>
<td>53</td>
<td>00</td>
</tr>
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<td>31-7-02</td>
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<td>01-8-02</td>
<td>28</td>
<td>39.5</td>
<td>64</td>
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<tr>
<td>02-8-02</td>
<td>29</td>
<td>39.5</td>
<td>57</td>
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<tr>
<td>03-8-02</td>
<td>31.5</td>
<td>42</td>
<td>48</td>
<td>0.4</td>
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</tbody>
</table>

Source: Agr-Meteorological Cell, Department of Crop Physiology, University of Agriculture, Faisalabad

Table 2: Effect of seed treatments on germination and seedling vigour in fine rice seed

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Time to start germination (days)</th>
<th>T50 (days)</th>
<th>MGT (days)</th>
<th>Final Germination (%)</th>
<th>Shoot Length (cm)</th>
<th>Root Length (cm)</th>
<th>Root/ Shoot Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2.000 A</td>
<td>1.500 B</td>
<td>2.000 C</td>
<td>86.67 B</td>
<td>9.433 C</td>
<td>2.800 C</td>
<td>1.007 CD</td>
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<tr>
<td>Traditional soaking</td>
<td>1.00 B</td>
<td>0.976 D</td>
<td>2.233 D</td>
<td>100.00 A</td>
<td>11.33 B</td>
<td>4.967 A</td>
<td>0.7133 A</td>
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<tr>
<td>Seed Hardening 18 h</td>
<td>1.00 B</td>
<td>1.277 C</td>
<td>2.867 B</td>
<td>83.33 B</td>
<td>8.667 C</td>
<td>3.100 C</td>
<td>0.3700 BC</td>
</tr>
<tr>
<td>Seed hardening 24 h</td>
<td>1.00 B</td>
<td>0.907 E</td>
<td>2.133 D</td>
<td>100.00 A</td>
<td>14.07 A</td>
<td>5.33 A</td>
<td>0.3733 AB</td>
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<tr>
<td>Osmoconditioning 24 h</td>
<td>1.00 B</td>
<td>1.470 B</td>
<td>2.900 B</td>
<td>86.67 B</td>
<td>11.90 B</td>
<td>3.967 B</td>
<td>0.3733 AB</td>
</tr>
<tr>
<td>Osmoconditioning 48 h</td>
<td>2.00 A</td>
<td>2.033 A</td>
<td>3.133 A</td>
<td>63.33 C</td>
<td>8.667 D</td>
<td>2.033 D</td>
<td>0.3533 D</td>
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<tr>
<td>LSD</td>
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<td>0.168</td>
<td>8.386</td>
<td>1.321</td>
<td>0.450</td>
<td>0.050</td>
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</table>

The letters with different alphabets are statistically different at p 0.05; MGT = Mean germination time

Table 3: Effect of seed treatments on seedling vigour of fine rice seeds

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shoot fresh weight (mg)</th>
<th>Root fresh weight (mg)</th>
<th>Shoot dry weight (mg)</th>
<th>Root dry weight (mg)</th>
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</thead>
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<tr>
<td>Control</td>
<td>22.50 B</td>
<td>8.733 D</td>
<td>4.76 C</td>
<td>4.83 A</td>
</tr>
<tr>
<td>Traditional soaking</td>
<td>26.07 A</td>
<td>26.67 A</td>
<td>7.33 AB</td>
<td>5.26 A</td>
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<tr>
<td>Seed Hardening 18 h</td>
<td>18.73 BC</td>
<td>14.00 C</td>
<td>6.50 B</td>
<td>2.36 C</td>
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<tr>
<td>Seed hardening 24 h</td>
<td>26.47 A</td>
<td>11.70 C</td>
<td>9.70 A</td>
<td>3.80 B</td>
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<tr>
<td>Osmoconditioning 24 h</td>
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<td>23.70 B</td>
<td>6.63 B</td>
<td>3.63 B</td>
</tr>
<tr>
<td>Osmoconditioning 48 h</td>
<td>16.50 C</td>
<td>27.07 A</td>
<td>4.90 C</td>
<td>1.733 D</td>
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<tr>
<td>LSD</td>
<td>2.871</td>
<td>1.821</td>
<td>1.872</td>
<td>1.53</td>
</tr>
</tbody>
</table>

The letters with different alphabets are statistically different at p 0.05

Figure 1: Effect of soaking period on electrical conductivity in rice variety Basmati-385
References
Basra et al.