Seed germination and yield of marigold (*Calendula officinalis* L.) as affected by biophysical priming techniques

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**Abstract**

Seed priming has been reported to enhance growth of plants. To evaluate the effect of some physical seed priming materials (ultrasonic, gamma, beta and laser irradiation, magnetic field and hydro-priming) on seed germination and growth of marigold a laboratory experiment was conducted at Islamic Azad University of Tabriz branch, using completely randomized design, with three replicates. The results revealed that the highest seed germination percent took place in seeds treated with “magnetic field” for 5 min. and lowest in those treated by beta irradiation and “magnetic field” for 15 min. Mean comparisons indicated that the highest root length belonged to seeds treated by ultrasonic and laser irradiation for 10 min. and lowest from seeds primed by beta irradiation, magnetic field for 15 min., laser irradiation for 5 min. and control. Higest seedling vigor index was obtained when seeds primed by laser irradiation for 10 min. It was also observed that the lowest fruit yield produced by seeds treated with beta irradiation. It may be concluded that tomato producers could improve seed germination percent by priming the seed with magnetic field for 15 minutes.

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Introduction

Marigold (Calendula officinalis) as an important medicinal plant has been cultivated and adopted in certain areas in Iran. Its seed quality is one of the factors to the yield of this plant and its productivity in agricultural ecosystems. Thus, characterization of factors to optimize seed quality would improve productivity of marigold. Gamma rays belong to ionizing radiation and are the most energetic form of such electromagnetic radiation. It has an energy level of around 10 kilo electron volts (keV) to several hundred keV. Therefore, they are more penetrating than other types of radiation such as alpha and beta rays (Kova’cs and Keresztes, 2002). Germination and seedling establishment are critical stages in the plant life cycle (Ganjari Arjenaki et al., 2011). Pre-sowing hydration treatments (priming) include non-controlled water uptake systems (methods in which water is freely available and not restricted by the environment) and controlled systems (methods that regulate seed moisture content preventing the completion of germination). There are several indications that many physiological mechanisms are involved in seed priming such as the repair of the age related cellular and subcellular damage that can accumulate during seed development (Bray, 1995) (Burgass and Powell, 1984) and an advancement of metabolic events of imbibition that prepare the radicle protrusion (Dell’aquilla and Beweley, 1989).

Gamma irradiation was found to increase plant productivity. In this connection, Jawardena and Peiris (1988) stated that gamma rays represent one of the important physical agents used to improve the characters and productivity of many plants (e.g. rice, maize, bean, cowpea and potato). Also Gamma irradiation has been found to be very useful for both sterilization and for preservation of food and cereal grain in nutrition and agriculture (Mokobia and Anomohanran, 2005). Results of experiments conducted in New Delhi, India by Sharma and Rana (2007) revealed that the productivity and economic returns from castor cultivation could be enhanced through adoption of suitable cultivar and level of gamma radiation. On the other hand, high dose of gamma ray, applied to the seeds before sowing, had adverse effect on traits of plants under investigation. This depended on plant species or varieties and the dose of irradiation. In faba bean, Artk and Peksen (2006) found a reduction in seed yield and harvest index in some varieties and also stated that, 25 and 50 Gy gamma radiation varied from the control treatment in many of the studied variables. In another study Rashid et al., (2006) found that soaking of barley seeds in water results in better performance of straw and seed. It is thus decided to evaluate the effects of physical seed treatments of tomato seeds on their germinations, growth marigold in the following study.

Materials and methods

The experiment was conducted at Islamic Azad University, Tabriz branch, using a completely randomized design with three replications during 2010 growing season. marigold seeds, with 45% viability, were differently treated by ultrasonication for 10 minutes (Yaldagard and Mortazavi, 2008), laser irradiation (Mohammadi et al., 2012) for 5, 10 and 15 minutes, magnetic field for 5, 10 and 15 minutes (Iqbal et al., 2012), gamma irradiation for 10 minutes (Farahvash et al., 2007), beta irradiation for 10 minutes (Bradford, 2000) and hydro-priming for 24 hours (Artola et al., 2003). Prior to planting, the seeds were surface sterilized with NaOCL 5% for 5 minutes to avoid fungal invasion and then washed immediately with distilled water. Petri dishes and filter papers were also disinfected by NaOCL and UV radiation for 24 hours in a sterile hood before their incubations. For each of 11 physical treatment techniques twenty five treated seeds were placed in 9-cm Petri dishes and then incubated in a germinator with 20 °C temperature for 14 days. Two days after incubation, seeds germinated (having radicle length of at least 5 mm.) were counted daily for 14 days. Traits measured in the laboratory were root length, shoot length, seedling length, germination percentage and seedling vigor index. Analysis of variance of data collected was made by the software MSTAT-C, graphs were drawn with excel software, and means of traits were compared by using LSD test at 5% probability level.
Results and discussion

Root length
Analysis of variance of the traits studied is depicted in Table 1. It shows that seed primings affected root length at 1% level of probability. Comparison of means indicated that highest root length belonged seed treatments by ultrasonic (6.33 cm) and laser irradiation 10 min. (6 cm) respectively. Lowest root length was obtained when seed primed by beta irradiation (1.6 cm).

Table 1. Variance analysis of traits under study as affected by physical seed priming techniques.

<table>
<thead>
<tr>
<th>s.o.v</th>
<th>df</th>
<th>Root length</th>
<th>Shoot length</th>
<th>Seedling length</th>
<th>Germination (%)</th>
<th>Vigor index (SVI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>10</td>
<td>6.39 **</td>
<td>4.75 **</td>
<td>15.13 **</td>
<td>1929.28 **</td>
<td>188784.88 **</td>
</tr>
<tr>
<td>Error</td>
<td>22</td>
<td>0.30</td>
<td>0.38</td>
<td>0.76</td>
<td>19.21</td>
<td>3322.02</td>
</tr>
<tr>
<td>C.V (%)</td>
<td></td>
<td>13.31</td>
<td>18.17</td>
<td>11.55</td>
<td>8.45</td>
<td>13.81</td>
</tr>
</tbody>
</table>

**, means significant at 1% levels of probability.

Intermediate treated by root length stood when seed magnetic field for 15 min. (2.6 cm), laser 5 min (2.66 cm) and control (3.66) (Table 2). However, root length of the seeds treated by gamma irradiation was 5.5 cm, by magnetic field for 10 min. was 4.8 cm, by laser for 15 min. was 4.16 cm, hydropriming and magnetic field for 5 min. was 4 cm (Fig 1). Root length was highly correlated, seedling length and vigor index (Table 3). Chaudhuri (2002) reported that gamma radiation of seed by higher doses induced, germination percentage, shoot length, while, by lower doses, (0.1 kGy) did not affect germination percentage.

Table 2. Comparison of means effects of physical seed priming on some traits in (Calendula officinalis L.) in laboratory.

<table>
<thead>
<tr>
<th>Priming Agents and Duration of Exposure</th>
<th>Root length (cm)</th>
<th>Shoot length (cm)</th>
<th>Seedling length (cm)</th>
<th>Germination (%)</th>
<th>Vigor index (SVI) (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic field 5 minutes</td>
<td>4</td>
<td>3.16</td>
<td>7.16</td>
<td>86.33</td>
<td>618.3</td>
</tr>
<tr>
<td>Magnetic field 10 minutes</td>
<td>4.83</td>
<td>4.59</td>
<td>9.33</td>
<td>61.67</td>
<td>575.8</td>
</tr>
<tr>
<td>Magnetic field 15 minutes</td>
<td>2.66</td>
<td>3.66</td>
<td>6.33</td>
<td>20</td>
<td>287.5</td>
</tr>
<tr>
<td>Laser 5 minutes</td>
<td>2.66</td>
<td>2.50</td>
<td>5.16</td>
<td>71.67</td>
<td>370</td>
</tr>
<tr>
<td>Laser 10 minutes</td>
<td>6</td>
<td>4.16</td>
<td>10.17</td>
<td>81.67</td>
<td>827.5</td>
</tr>
<tr>
<td>Laser 15 minutes</td>
<td>4.16</td>
<td>5.26</td>
<td>9.43</td>
<td>71</td>
<td>669.7</td>
</tr>
<tr>
<td>Ultrasonic 10 minutes</td>
<td>6.33</td>
<td>1.66</td>
<td>8</td>
<td>35</td>
<td>160</td>
</tr>
<tr>
<td>Gamma ray minutes</td>
<td>5.50</td>
<td>4.33</td>
<td>10.17</td>
<td>57.33</td>
<td>580</td>
</tr>
<tr>
<td>Beta ray minutes</td>
<td>1.66</td>
<td>1.46</td>
<td>3.13</td>
<td>11.67</td>
<td>36.33</td>
</tr>
<tr>
<td>Hydro-priming 24 hours</td>
<td>4</td>
<td>4.33</td>
<td>8.33</td>
<td>29.33</td>
<td>173.3</td>
</tr>
<tr>
<td>Control</td>
<td>3.66</td>
<td>2.33</td>
<td>6</td>
<td>45</td>
<td>293.3</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>0.93</td>
<td>1.04</td>
<td>1.48</td>
<td>7.42</td>
<td>97.60</td>
</tr>
</tbody>
</table>

Shoot length
Physical seed treatments also affected shoot length significantly at 1% level of probability (Table 1). Mean comparisons indicated that highest shoot length (5.26 cm) was due to seed treatment by laser for 15 min. (Fig 2). Lowest shoot length belonged to beta irradiation treatments (1.46 cm.) and ultrasonic irradiation (1.66 cm). Shoot length as to the other treatments 4.50 cm. for magnetic field 10 min., 4.33 cm. for gamma irradiation and hydropriming, 3.16 cm. for magnetic field 5 min. and 3.66 cm. for magnetic field 15 min. (Table 2). Correlations of shoot length with seedling length, germination percentage, seedling length vigor index were positive and significant at 1% levels of probability (Table 3). It has reported that the effect of the laser light on plant productivity is far more than other waves, such that crop yields can be increased from 10 to 50 percent (Vasilevski, 2003). Farahvash et al. (2007) reported that gamma radiation of wheat seeds positively
affected its productivity. Effect of gamma radiation on some physiological traits of wheat were studied and showed that the plant at doses of 900 (Rad) for 8-day period, highly increased crop yields.

Table 3. correlation between traits of study in laboratory in (*Calendula officinalis* L.).

<table>
<thead>
<tr>
<th>Trait</th>
<th>Root length</th>
<th>Shoot length</th>
<th>Seedling length</th>
<th>Germination (%)</th>
<th>Vigor index (SVI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root length</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoot length</td>
<td>0.27 **</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seedling length</td>
<td>0.82 **</td>
<td>0.77 **</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germination (%)</td>
<td>0.23</td>
<td>0.52 **</td>
<td>0.45 **</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Vigor index (SVI)</td>
<td>0.50 **</td>
<td>0.72 **</td>
<td>0.75 **</td>
<td>0.89 **</td>
<td>1</td>
</tr>
</tbody>
</table>

**, means significant at 1% and 5% probability levels.

**Seedling length**

The effect of seed priming methods on the seedling length was significant at 1% level of probability (Table 3). Mean comparisons for seedling length revealed that seeds treated with gamma irradiation and laser irradiation for 10 min. (10.17 cm), increased seedling length as compared to control (6 cm) by 41% (Table 2). Highest seedling length (10.17 cm) was obtained when seeds primed with gamma and laser for 10 min. irradiation. Also, seedling length by laser for 15 min., magnetic field for 10 min., hydroprriming were 9.43, 9.33 and 8.83 respectively (Fig 3). Correlation of seedling length with germination percentage and vigor index is significant at 1% level of probability (Table 3). Soliani *et al.* (2006 a, b) reported a positive effect of magnetic field on *Asparagus officinalis* and *Ocimum basilicum* seed germination and seedling growth. Podleoeny *et al.* (2004) stated that effect of magnetic treatment on the germination and emergence of two broad bean cultivars was positive and significant. Similar effects were also observed on cucumber seedlings by Yinan *et al.* (2005).

**Fig. 1.** Root lengths as affected by different priming techniques.

**Fig. 2.** Shoot lengths as affected by different priming techniques.

**Seed germination percentage**

Analysis of variance of the data on seed germination is depicted in Table 1. It shows that seed primings affected this trait at 1% level of probability. Mean comparisons for germination percentage also revealed that seeds treated with magnetic field for 5 min. resulted in higher germination percentage of (86.33). Lowest germination percentages (11.67% and 20%) were observed for exposure of seeds to beta irradiation and magnetic field 15 min respectively (Fig 4). Treating seeds with magnetic field for 5 minutes increased germination percentage by over 47% (Table 2). Correlation of germination percentage with shoot length and seedling length was significantly positive at 1% level of probability (Table 3). This is in conformity with Moon and Sook (2000) where they concluded that seed priming of tomato seed by electrical and magnetic field increased seed germination percentage. Moon and Chung (2000) also reported similar results from seeds treated with AC electric and magnetic field on germination percentage and better seedling establishment seedling.
as compared with untreated tomato seeds Yinan et al., (2005). Also reported increased plant growth under magnetic field seed treatment.

**Fig. 3.** Seedling lengths as affected by different priming techniques.

![Seedling lengths graph]

**Fig. 4.** Germination percentage in calendula as affected by different priming techniques.

![Germination percentage graph]

**Fig. 5.** Germination percentage in calendula as affected by different priming techniques.

**Seedling vigor index (SVI)**

Analysis of variance showed that the effects of seed priming agents on vigor index of calendula was significant that at 1% level of probability (Table 1). Comparison of means (Table 2) indicated that priming of calendula seed with laser irradiation for 10 min. increased seedling vigor index by 64% against control. Higest seedling vigor index was obtained when seeds primed with laser irradiation for 10 min. (827), and lowest from beta irradiation seed treatment (36.33) (Figure 5). Seedling vigor indices of seed priming with laser irradiation 15 min., magnetic field for 5 min., magnetic field for 10 min. and gamma irradiation were 669.7, 618.3, 575.8 and 580 respectively.

**Conclusion**

Based on the results obtained from this study it can be concluded that treating marigold seeds with laser and magnetic field treatments increase germination of marigold.

**References**


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