Germination of Papaya Seed in Response to Desiccation, Exposure to Subzero Temperatures, and Gibberellic Acid

Antonieta N. Salomão¹ and Rosângela C. Mundim²
Embrapa–Recursos Genéticos e Biotecnologia P.O. Box 02372-70849-970 Brasília–DF Brazil

Abstract. The effects on germination of two lots of Carica papaya seed of dehydration at 25 °C, followed by exposure to –20 °C or –196 °C, were evaluated with and without gibberellic acid (GA₃) treatment. In the absence of GA₃ treatment, dehydration increased subsequent germination only in seed lot 1 when moisture content (m.c.) was reduced from 59% to 6.0% and 5.3%. In seed lot 2, dehydration followed by exposure to –196 °C increased germination compared with dehydration alone. Treatment with GA₃ enhanced germination rate in all treatments. Dehydration to 5.3% (lot 1) or 6.9% and 6.8% m.c. (lot 2), followed by exposure to subzero temperatures and treatment with GA₃, were the most favorable combined treatments to enhance papaya seed germination. The results suggest that papaya seed presents an orthodox behavior, permitting germplasm conservation in conventional and cryogenic genebanks.

Materials and Methods

The slow and asynchronous germination of papaya seeds is attributed to the presence of inhibitors (mainly phenolic compounds) in the sarcotesta and seed coat (Chow and Lin, 1991; Reyes et al., 1980). In addition, some seeds lack embryos (Nagao and Furutani, 1986). Seed treatments to promote germination and to reduce germination time have been widely investigated. Satisfactory results were obtained by removing the sarcotesta (Gherardi and Valio, 1976; Lange, 1961; Pérez et al., 1980), sowing seeds at warm temperatures (30°C or 20 to 30°C) (Yahiro, 1979), exposing dry seeds to 10°C prior to sowing (Hore and Sen, 1993), drying seeds (Sippel and Claassens, 1993), and soaking seeds in distilled water, potassium nitrate, thiourea, sodium thiosulfate, tannic acid or ferulic acid (Furutani and Nagao, 1987; Hore and Sen, 1993; Nagao and Furutani, 1986; Olalde and Oryoji, 1980), sowing seeds at 25 °C under a 12 h photoperiod. Radicle protrusion (length ≥ 1.0 cm) after at least 1 week was the criterion for successful seed germination. The results were expressed as final germination percentage. The average germination time (T (day)) was calculated according to Labouriau and Pacheco (1979): 

\[ T = \frac{\sum \text{germination percentage}}{\sum \text{days}} \]

Statistical analysis. Germination percentages were subjected to two-way analysis of variance (ANOVA) followed by Bonferroni post-tests, for each temperature.

Results

Initial seed moisture content (m.c.) values were 59% (lot 1) and 67% (lot 2) (Table 1). Drying was rapid and equilibrium was reached after 2 d over silica gel at room temperature. Seeds from both lots germinated poorly if not dried or treated with GA₃ (Table 1). Drying alone markedly improved germination of lot 1, but had no effect on that of lot 2. Treatment with GA₃ did not improve germination of dried seeds of lot 1, but was effective in lot 2. The interaction between GA₃ and seed moisture content was significant for both seed lots.

Lot 1 seeds, dehydrated and exposed to –20 °C for 3 d, germinated in either water or GA₃ (Table 2). The germination rate was enhanced by GA₃, irrespective of moisture content. In the presence of water, the highest germination percentages occurred with seeds submitted to 2 and 3 d of dehydration. The interaction between GA₃ and seed moisture content was nonsignificant after seed exposure to –20 °C (Table 2).

The effect of GA₃ on dehydrated seeds was similar to that of exposure to –196 °C for 3 d (compare Tables 1 and 2). In seeds exposed to –196 °C, germination rate was enhanced by GA₃, but the final germination percentages were similar for water and GA₃ (Table 2). The interaction between GA₃ and seed moisture content was nonsignificant after seed exposure to –196 °C.
Table 1. The effects of dehydration of papaya seeds at 25 °C and subsequent treatment with GA3 on germination (G) and average germination time (T).

<table>
<thead>
<tr>
<th>Dehydration period (d)</th>
<th>Seed lot 1</th>
<th>Seed lot 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m.c. (%)</td>
<td>GA3 (%)</td>
</tr>
<tr>
<td>0</td>
<td>59.0</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>+ 86</td>
<td>+ 71</td>
</tr>
<tr>
<td>1</td>
<td>6.0</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>+ 80</td>
<td>+ 74</td>
</tr>
<tr>
<td>2</td>
<td>5.3</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>+ 90</td>
<td>+ 77</td>
</tr>
<tr>
<td>3</td>
<td>5.3</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>+ 65</td>
<td>+ 75</td>
</tr>
</tbody>
</table>

**Significance**

- **NS, ***P ≤ 0.01 or 0.001.
- **+ P ≤ 0.05 or 0.1.

Table 2. The effects on papaya seeds germination (G) and average germination time (T) of dehydration at 25 °C and exposure for 3 d to −20 °C (lot 1) or −196 °C (lot 2).

<table>
<thead>
<tr>
<th>Dehydration period (d)</th>
<th>−20 °C (lot 1)</th>
<th>−196 °C (lot 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m.c. (%)</td>
<td>GA3 (%)</td>
</tr>
<tr>
<td>1</td>
<td>6.0</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>+ 90</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>5.3</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>+ 90</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>5.3</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>+ 100</td>
<td>9</td>
</tr>
</tbody>
</table>

**Significance**

- **NS**
- **+ P ≤ 0.05 or 0.1.

Discussion

According to the literature, the removal of sarcotesta, with or without desiccation, reduces the level of dormancy in papaya seeds. The combined treatments (removal of sarcotesta and seed desiccation) promoted germination of seed lot 1, but did not of lot 2, in water. Thus the seed lots responded differently to desiccation. The effectiveness of GA3 in breaking dormancy and accelerating germination indicates that a chemical inhibitor may have been present (Chow and Lin, 1991; Reye et al., 1980) and that GA3 was effective, regardless of seed moisture content. Seeds of both lots tolerated desiccation without injury.

Exposure to −20 °C did not reduce seed germinability, and the seeds maintained their ability to germinate with or without GA3. Germination after −20 °C treatment appeared to be influenced by seed m.c. Seeds dehydrated for 3 d (5.3% m.c.) germinated better irrespective of the germination medium (water or GA3). The positive effect of exposure to −20 °C strengthens the conclusion that papaya seed shows an orthodox behavior. However, this result is in disagreement with the related observation that papaya germinability was affected negatively by storage at −20 °C (Ellis et al., 1991). These contrasting findings may explain the variation in the degree of dormancy and the requirements for breaking it exhibited by different seed populations of papaya (Baskin and Baskin, 1998).

Exposure to liquid nitrogen (−196 °C) enhanced seed germination without GA3 treatment, and GA3 treatment did not affect response; however, seeds took longer to germinate. One possible explanation for this is that ultra-low temperature may induce cracks in the seed coat (Busse, 1930; Jordan et al., 1991). These treatments to enhance germination in water or had no effect on seed germination. Exposure to subzero temperatures promoted seed germination. In addition, dehydration improved germination in both water and GA3. The best combined treatments to enhance germination were dehydration to 5.3% m.c. and exposure to −20 °C (lot 1), and dehydration to 6.9% or 6.8% followed by exposure to −196 °C (lot 2). Papaya seeds showed a positive response to desiccation and exposure to subzero temperatures. This suggests that they may be conserved in both conventional and cryogenic genebanks.

Literature Cited


