from bedded roots of ‘Georgia Jet’ and other sparse plant-producing sweet potato cultivars and to determine effects after longer storage durations before bedding.

**Literature Cited**


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**Polyethylene Glycol Incorporation in Table Beet Seed Pellets to Improve Emergence and Yield in Wet Soil**

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Additional index words. Osmoconditioning, priming, seed coating, embryo growth potential, Beta vulgaris

**Abstract.** Improved emergence rate and final stand occurred when ‘Ruby Queen’ beet seed pellets, amended with 1.10 to 3.95 mg polyethylene glycol 8000 (PEG) per seedball, were field planted. The number of seedlings per seedball 17 days after planting ranged from 1.39 to 1.60 for PEG-amended pellets, compared to 0.71 plants for non-PEG pellets or dry seeds. The PEG-amended seed pellets yielded 16 to 18 marketable roots per meter of row compared to 11 roots from non-PEG pellets.

Osmotic seed treatment or seed osmoconditioning with polyethylene glycol (PEG) has been reported to improve seedling emergence and yield in several vegetables in cold, wet soil (1, 4, 8, 9). Compared to the non-treated seeds, osmoconditioned seeds emerge more rapidly, produce more uniform and larger stands, show greater protection from damping-off by *Pythium* spp., and consistently give higher yields. Because it is difficult to treat large batches of seeds, the use of PEG is somewhat prohibitive for large-scale agricultural use. To circumvent this problem, seeds have been osmoconditioned in low-molecular-weight inorganic salts, such as MgSO4, with encouraging results (2, 4).

We previously observed that, unlike con-

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**Fig. 1.** Daily precipitation and maximum and minimum soil temperatures 2 weeks after sowing on 21 May 1984.
Fig. 2. Effect of PEG concentrations in beet seedball pellets on rate of emergence and stand size. Nonpelleted dry seeds were sown for comparison.

0.75 m apart at a depth of 2 cm, using a cone seeder. Five treatments were replicated 5 times in a randomized complete block design. Fertilizer (10N–20P–10K) was broadcast and mixed into the soil before planting at 400 kg ha−1. The maximum and minimum daily soil temperatures at a 5-cm depth and daily precipitation during 2 weeks after sowing are shown in Fig. 1. Emergence counts were taken at various intervals. Plants were harvested on 31 July 1984 and yield characteristics determined. Analyses of variance was used to determine the statistical significance of mean difference in emergence rate, stand size, and yield parameters.

Inclusion of PEG in the pellet improved the rate of emergence and the stand density relative to nonpelleted dry seeds or pelleted seeds with no PEG (Fig. 2). The number of seedlings per seedball 17 days after planting from PEG-treated pellets ranged from 1.39 to 1.60 and was nearly twice that from non-treated pellets or raw seeds (0.71 plants per seed). Improvement in plant stands have also been obtained from sowing PEG-treated pellets in field studies conducted in 1985 (data not shown). The concentration of PEG in the pellet had little effect on the number of seedlings that emerged. The average temperature during the first 2 weeks after planting was 17°C and ranged from 29° to 8° (Fig. 1). The precipitation during the first week was 2.6 cm, while a relatively wet condition (3.9 cm of precipitation) prevailed during the 2nd week after planting.

The stand count increased as a result of PEG addition to the pellet and this increase led to a larger number of marketable roots (after exclusion of culls) (Table 1). The inclusion of PEG tended to increase the top weight. No significant difference in total or individual root weight was observed as a result of PEG treatment. Large variations in yield components may have resulted from improper drainage conditions because of excessive rain during the growing season.

Seed pelleting for precision planting has several advantages: a) fewer seeds are needed to produce a stand, b) less labor is needed for thinning operation, and c) the stand from pelleted seeds tends to be generally more uniform than in conventional seedings. Studies indicate that physical and chemical properties of the pelleting material can be tailored to suit soil moisture conditions (7). Ideal hydrophobic and hydrophilic polymers are being investigated by the seed industry for pelleting purposes. The use of an osmoticum, such as PEG, in the pellet to improve seed performance, to our knowledge, has not yet been reported.

In this study, the presence of PEG in the seed pellet may have created a low-water-potential microenvironment (or "physiological drought") around the seeds, in effect simulating seed osmoconditioning as conducted in the laboratory. Several studies have shown that when seeds are transferred after osmoconditioning in PEG to water, they display greater germination or growth potential and respiratory capacity than nontreated seeds (4–6, 8). The improvement in emergence rate and final stand noted in this study are consistent with these observations. The cold and moderately wet soil during the first week after planting followed by a higher water potential during the 2nd week seemingly provided a condition suitable for rapid emergence. The increase in marketable root yield as a result of PEG amendments is similar to those observed previously in beet seeds planted after osmoconditioning in MgSO4 (4).

In crop seeds such as lettuce and celery, which require light for germination, a secondary dormancy is induced during low-water-potential PEG treatment in darkness (3, 6). Seeds of other crops, like carrots and beets, have no such light requirement and can be osmoconditioned in both light and darkness (8). These seeds evidently do not have a phytochrome block and hydration alone may trigger events that are responsible for improved germination and growth potential. This fact may be important in using PEG or another osmoticum for creating a microenvironment around crop seeds in the dark soil environment. The use of pelleting, gel, or other encapsulating material to deliver PEG and perhaps other osmotically active substances to the seed imbibition (or hydration) site in the soil may have great potential in invigorating the seed and thereby improving stand establishment and plant productivity of vegetables and other crops.

Table 1. Effect of PEG concentrations in beet seedball pellets on yield components.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (mg PEG/postball)</th>
<th>No. of roots/m row</th>
<th>Root fresh wt (g/root)</th>
<th>Root fresh wt (kg/m row)</th>
<th>Tops fresh wt (kg/m row)</th>
<th>Cull fresh wt (kg/m row)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-pelleted</td>
<td>0</td>
<td>11</td>
<td>0.46</td>
<td>43</td>
<td>0.35</td>
<td>0.06</td>
</tr>
<tr>
<td>Pelleted</td>
<td>0</td>
<td>11</td>
<td>0.71</td>
<td>56</td>
<td>0.50</td>
<td>0.04</td>
</tr>
<tr>
<td>Pelleted</td>
<td>0.10</td>
<td>18</td>
<td>0.75</td>
<td>41</td>
<td>0.61</td>
<td>0.11</td>
</tr>
<tr>
<td>Pelleted</td>
<td>0.85</td>
<td>17</td>
<td>0.72</td>
<td>39</td>
<td>0.69</td>
<td>0.11</td>
</tr>
<tr>
<td>Pelleted</td>
<td>3.95</td>
<td>16</td>
<td>0.61</td>
<td>38</td>
<td>0.54</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>Non-pelleted vs. all pelleted</strong></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Non-pelleted vs. 0 mg PEG pelleted</strong></td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Non-pelleted vs. &gt;0 mg PEG pelleted</strong></td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>**</td>
</tr>
<tr>
<td><strong>0 mg PEG pelleted vs. &gt;0 mg pelleted</strong></td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>*</td>
</tr>
</tbody>
</table>

Significance:
- **NS**: Significant at 0.05 and 0.01 levels, or not significant.
- NS: Roots <2.5 cm in diameter.
Flower and Pod Set of *Phaseolus vulgaris* Under Controlled Environment Conditions

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Additional index words: abortion, abscission, flowering light red kidney bean, pod set

**Abstract.** Plants of *Phaseolus vulgaris* L. ['Light Red Kidney'] grown under controlled conditions flowered over a 20-day period. The first flower to open was on the terminal (uppermost) raceme. Pods retained to maturity originated from flowers that opened within 5 days of anthesis and were located at the basal positions on a raceme. Flowers that opened 4 to 5 days after anthesis had a much higher proportion of aborted pods than those that opened at anthesis or one day thereafter.

A number of researchers have investigated the pattern of flower and pod (fruit) set in *Phaseolus vulgaris* (1, 3, 6, 8, 10). In comparing field and greenhouse experiments, Subhadra Bhandu et al. (11) found that in field-grown plants, flowering extended over a longer time period and plants had a higher rate of pod abscission. This advantage probably was associated with the increased number of flowers produced. Iwami (7) suggested that in *P. vulgaris* grown under field conditions, competition for nutrients affects flower formation, flowering, and flower drop. Smith and Pryor (9) showed that seed yield reduction under field conditions is related to flower abortion and to a reduction in the number of seeds per pod of flowers subjected to high temperatures.

These and other greenhouse and field studies have yielded important information on flowering and pod set of *P. vulgaris*, but the data are fragmented and difficult to compare. Such detailed investigations should have been preceded by observations under controlled environmental conditions; however, little information is available on bean plants grown under such conditions.

The purpose of this research was to determine quantitatively the pattern of flower and pod set of *P. vulgaris* 'Light Red Kidney' under controlled environmental conditions to provide a foundation for basic studies of early reproductive development. Bean plants of 'Light Red Kidney' were grown in a growth chamber in 12.7-cm pots in UC Davis soil mix [1 peat : 1 sand (by volume)]. Growth chamber conditions were as follows: day/night temperature, 25°C/19°C; light intensity, 400 μmol·s⁻¹·m⁻² (measured at pot level); light duration, 16 hr; and humidity, 50-60%. The 6 plants selected for this experiment were randomized on 2 sand-filled trays, 3 plants per tray. Commencing at anthesis (first flower to open on a plant) and continuing every day thereafter, counts were made of flower and pod set and flower and pod abortion on all racemes on each plant. Specific positions of flowers set and aborted and pods set and aborted on each raceme also were recorded. Plants were harvested 6 weeks after anthesis.

Racemes were numbered starting at the base of the main plant stem. Flowers and pods on a raceme were numbered starting at the most basal position and continuing acropetally. 'Flowering' refers to the opening of any flower regardless of position on a raceme or time of opening.

Each plant produced an average of 7 racemes. Anthesis occurred about 6 weeks after planting and on all plants the first flower to open was on the terminal (7th) raceme. Two days post-anthesis, flowers opened on racemes 2-6. No flowering occurred on the most basal (first) raceme. None of the secondary or tertiary racemes formed flowers. The pattern of flowering was acropetal on the 6 flower-bearing racemes. Flowers continued to open over a 20-day period. The lower-positioned racemes (2-5) continued to flower 8-10 days longer than the higher-positioned racemes (6 and terminal) (Fig. 1).

All flowers produced pods. Those retained to maturity originated from flowers that opened within 5 days of anthesis and most of these pods formed from flowers that opened within 3 days after anthesis (DAA) (Fig. 1, Table 1). Although terminal and 3rd racemes produced the most flowers, raceme 5 retained the most pods. Raceme 6 produced the fewest flowers and pods (Fig. 2). Only 18% of the total number of flowers was retained as mature pods.

<table>
<thead>
<tr>
<th>Days after anthesis</th>
<th>Percentage</th>
<th>SE</th>
</tr>
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<tbody>
<tr>
<td>0 to 1</td>
<td>61</td>
<td>11.5</td>
</tr>
<tr>
<td>2 to 3</td>
<td>34</td>
<td>8.4</td>
</tr>
<tr>
<td>4 to 5</td>
<td>21</td>
<td>6.2</td>
</tr>
<tr>
<td>6 to 19</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

Table 2. Percentage of flowers on individual racemes retained to pod maturity.

<table>
<thead>
<tr>
<th>Raceme</th>
<th>T</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage</td>
<td>20</td>
<td>29</td>
<td>31</td>
<td>17</td>
<td>14</td>
<td>10</td>
<td>---</td>
</tr>
<tr>
<td>SE</td>
<td>6.8</td>
<td>17.2</td>
<td>8.6</td>
<td>6.9</td>
<td>5.5</td>
<td>5.5</td>
<td>---</td>
</tr>
</tbody>
</table>

T = terminal raceme.

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