sphagnum and after-ripened, 3) covered with black polyethylene and after-ripened, and 4) exposed on surface of sphagnum and not after-ripened. Seed was after-ripened at 35° to 40°F in moist condition for three months.

Plots to be maintained in the dark were immediately enclosed in black polyethylene bags to exclude light. Paper was laid over the polyethylene bags to prevent sunlight from striking the polyethylene and creating a high temperature within the bags. The surface of all plots was kept moist by use of intermittent mist.

First blueberry germination counts were made six weeks after planting, when the polyethylene bags were removed. First germination counts with strawberries were made at two weeks or four weeks after placing the seed trays in the greenhouse, when the polyethylene bags were removed. Rubus germination counts were made at the end of three months.

Greenhouse temperatures from January through March fluctuated between 70° and 80°F during the day and held fairly constant at nights at 65°. Greenhouse temperatures in July fluctuated between 80° and 105° in the day, and at night 65° to 75°F. Temperatures on the surface of the sphagnum, inside and outside of the black polyethylene bags, were indicated to be the same by thermocouple temperature points.

**Blueberry**: Seed sown in light had an average germination of 39% at the end of six weeks with no additional germination up to 16 weeks. Seed that received no light during the six weeks after planting germinated about 2%, but by the end of 13 weeks (six weeks in dark and seven in light) germination was equal to that of seed held for 13 weeks in light (Table 1). Seeds held for six weeks in the dark, and then exposed to light, required still another six to seven weeks for germination.

Blueberry seeds do not germinate in the dark. Exposure to light causes germination of most seeds, but does not completely overcome a delay in germination.

**Strawberry**: Seed without after-ripening maintained in light germinated 46.3% after four weeks, whereas those held in dark germinated 2.4% (Table 2). The oldest seed lots had the highest germination. At six weeks after planting, seed in the light had germinated 66.1%, and that held four weeks in the dark plus two weeks in light germinated 37.3%. By the end of eight weeks total germination was the same for both treatments.

Strawberry seed after-ripened for three months at 40 to 45° germinated rapidly in both light and dark in the greenhouse (Table 4). Seed in light germinated 88.4%, compared with 52.5% for dark-held seed. The lowest germination (28.4%) occurred with dark-held seed of the youngest lot.

**Rubus**: Blackberry seed exposed to light and after-ripened had a mean germination of 31.6%, whereas seed covered with sphagnum and black polyethylene to exclude light germinated only 1.8% and 1.6% respectively (Table 5). Raspberry seed exposed to light and after-ripened germinated 31.2%, but seeds covered with black polyethylene to exclude light gave no germination. When seeds were covered with sphagnum 9.8% germinated compared with 31.2% for fully exposed seed. Non-after-ripened seeds of blackberries and raspberries gave low germination, which agrees with previous reports.

**Literature Cited**

---

**Growth Response of Several Rootstocks to Soil Water**

R. F. Carlson

*Department of Horticulture*

*Michigan State University*

*East Lansing, Michigan*

Eleven apple clones and a seedling source of Red Delicious (*Malus sylvestris*) were grown in one-gallon containers in the greenhouse to evaluate growth responses to soil water. All clones and seedlings were non-grafted and these are listed in Table 1. Uniform one-year-old plants of these clones and seedlings were planted in non-porous one-gallon metal containers in a uniform soil mixture of one-half silt loam and one-half peat moss. The containers with the plant and moist soil were weighed to a uniform seven pounds per unit. Then water was added to bring the low water level to seven and one-half pounds and the high water level to eight and one-half pounds. The high water level was estimated to be equal to field capacity of soil water. Each clone and each treatment was replicated ten times.

Subsequently, water was added when the plants under low water level showed signs of wilting at which time

---

1Published with the approval of the director of the Michigan Agricultural Experiment Station as Journal Article number 4030.
all containers were brought up to the weights previously mentioned and the amount of water added was recorded. Water was added nine times during the 135 day growing period. Uniform nutrients in the form of 10-52-17 were added to all plants twice during the experiment.

At the termination of the experiment, the total shoot extension growth was recorded, and leaf area of the clones and the seedlings was measured by the Sorensen's Photometer, and fresh weight determined.

Growth of the clones and the seedlings differed, but not according to the degree of dwarfing they produce on the scion variety. For example, EM VII, a semi-dwarfing clone produced the most shoot growth and EM II, a semi-standard clone, and Red Delicious seedlings standard sort, produced less growth. The other clones produced growth which varied in the range between the EM VII and EM IX clones (Figure 1).

The high soil water produced greater shoot growth than the low soil water level. The poor growth of EM IX under both water levels cannot be explained. According to shoot growth and fresh weight measurements, growth was approximately doubled under the high water level for many of the clones and the seedlings (Figures 1 and 2). Although growth was less under low moisture conditions, the plants appeared normal except for some leaf drop of EM 26 and slight marginal leaf scorch of EM VII and Robusta 5.

Photometric determinations of leaf areas clearly showed that the different clones and seedlings did not have equal leaf areas. Robusta 5 had the largest leaf area and MM 109 the smallest. In addition, the high soil water level significantly increased the leaf area by as much as forty-three percent in the case of EM VII and to

Figure 1. Shoot growth of 11 clones and Red Delicious seedlings when grown for 135 days at two soil water levels.

Figure 2. Typical growth pattern of apple clones grown under low and high soil water levels. 3 = Alnarp 2, 4 = EM 26, 5 = MM 111 and 6 = MM 106. The plant on the left in each case grew under low soil water.
a lesser degree among the other clones (Figure 3).

The inherent size of the leaf area of the different clones may play a role in the performance of grafted cultivars. For example, a small-leaved cultivar grafted on a large-leaved rootstock may perform differently than a combination with equal sized leaf areas. Similarly, increased leaf area due to more adequate soil water supply of the cultivar may alter the performance of the rootstock whether or not it has a small or large inherent leaf area. This needs further investigations for confirmation.

The amount of water utilized by the various clones indicated that certain ones are more efficient in water use than others. For example, MM 104, and 111, respectively, consumed 18 and 22 percent less water than Red Delicious seedlings and yet produced more terminal growth. (The seedlings were used as a standard measure.) Robusta 5 used 24 percent more water than Red Delicious seedlings and made good terminal growth, whereas Alnarp 2 and EM II, respectively, used 18 and 27 percent more water but produced less terminal growth (Table 1). Preston and Rogers (1) has reported that cultivars on MM 111 have survived summer drought conditions better than cultivars on EM II. The data here reported show that certain non-grafted clones perform well with less soil water than others.

Figure 3. Leaf area in square centimeter of the clones grown at high and low soil water levels for 135 days.

Table 1. Average amount of water consumed and growth produced by each clone during 135 days under greenhouse conditions.

<table>
<thead>
<tr>
<th>Clones</th>
<th>Average Water Consumed (ml)</th>
<th>Water Increase or Decrease (Percent)</th>
<th>Growth Rank*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
<td>Difference</td>
</tr>
<tr>
<td>Robusta 5</td>
<td>2277</td>
<td>4947</td>
<td>2670</td>
</tr>
<tr>
<td>East Malling VII</td>
<td>2770</td>
<td>4936</td>
<td>2166</td>
</tr>
<tr>
<td>Red Delicious S.</td>
<td>2164</td>
<td>4227</td>
<td>2063</td>
</tr>
<tr>
<td>East Malling 26</td>
<td>2886</td>
<td>4975</td>
<td>2089</td>
</tr>
<tr>
<td>Malling Herton 106</td>
<td>2710</td>
<td>4937</td>
<td>2227</td>
</tr>
<tr>
<td>Malling Herton 104</td>
<td>2373</td>
<td>3967</td>
<td>1594</td>
</tr>
<tr>
<td>Malling Herton 111</td>
<td>2811</td>
<td>4618</td>
<td>1807</td>
</tr>
<tr>
<td>East Malling IX</td>
<td>2934</td>
<td>4434</td>
<td>1500</td>
</tr>
<tr>
<td>East Malling XII</td>
<td>2580</td>
<td>3307</td>
<td>727</td>
</tr>
<tr>
<td>Alnarp 2</td>
<td>2643</td>
<td>5122</td>
<td>2479</td>
</tr>
<tr>
<td>East Malling II</td>
<td>2478</td>
<td>5298</td>
<td>2820</td>
</tr>
<tr>
<td>Malling Herton 109</td>
<td>2633</td>
<td>4683</td>
<td>2050</td>
</tr>
</tbody>
</table>

*12=Greatest terminal growth; 1=Least growth

Literature Cited


PETERS SPECIAL

THE "STANDARD" OF SOLUBLE FERTILIZERS

Peters fertilizers are among the most widely used by commercial growers of horticultural crops. We concentrate exclusively on the manufacture of highest quality horticultural specialty soluble fertilizers. Write us for your free information brochure.

ROBERT B. PETERS CO., INC.
2833 Pennsylvania Street Allentown, Penna.