ing cultivars: Bluecrop, Blueray, Collins, Coville, Earliblue, and Herbert. The plants were mulched with sawdust to a depth of five inches. Standard fertilization practices were followed.

From each plant in each block, one fully developed, mature leaf was collected from the base of the first flush of the current season’s growth for measurement of respiration during the summer of 1967. In order to obtain a more representative daily rate of respiration, samples were collected at 6 a.m., 12 noon, and 6 p.m. Leaves were selected for freedom from injury, insects, and diseases. Two, 1.3 cm² discs were removed from the center of the leaf, one on each side of the midrib, to make a total of 12 discs for each cultivar per sampling time. Two, 15-ml respirometer flasks, each containing six discs selected at random, were used for each cultivar. Each disc was placed on a Gibson Respirometer and allowed to equilibrate for 20 minutes. Rate of respiration was determined in air at 28°C by the “Direct Method” of Warburg (2). Data were recorded for a period of two hours. The experiment was repeated on four different days over a period of two weeks.

Data presented in Table I show the respiration rates on an area basis obtained for leaves from six cultivars of highbush blueberry taken on four different days. Some variation in rates of respiration was noted between sampling dates, particularly for those cultivars which had higher rates of respiration. It was thought that this might be attributed to differences in weather preceding sampling, but no correlation between the two was apparent.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Aug. 21</th>
<th>Aug. 23</th>
<th>Aug. 29</th>
<th>Sept. 5</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coville</td>
<td>14.17</td>
<td>17.04</td>
<td>15.86</td>
<td>16.36</td>
<td>15.86</td>
</tr>
<tr>
<td>Earliblue</td>
<td>12.90</td>
<td>15.32</td>
<td>13.77</td>
<td>14.54</td>
<td>14.18</td>
</tr>
<tr>
<td>Collins</td>
<td>12.69</td>
<td>14.04</td>
<td>13.66</td>
<td>14.38</td>
<td>13.69</td>
</tr>
<tr>
<td>Herbert</td>
<td>12.40</td>
<td>14.40</td>
<td>14.11</td>
<td>14.41</td>
<td>13.71</td>
</tr>
<tr>
<td>Blueray</td>
<td>11.06</td>
<td>12.32</td>
<td>12.34</td>
<td>13.33</td>
<td>12.26</td>
</tr>
<tr>
<td>Bluecrop</td>
<td>11.89</td>
<td>12.02</td>
<td>11.50</td>
<td>12.21</td>
<td>11.91</td>
</tr>
</tbody>
</table>

1 Mean respiration of six leaf discs taken at each of three periods during the day.

2 Means followed by different letters are significantly different at the 1% level as determined by Duncan’s Multiple Range Test.

Table 1. Daily average rate of leaf respiration for six cultivars of highbush blueberry taken on four different days.

Mean rates of respiration for each cultivar were analyzed for statistical significance. Coville had a significantly higher rate of respiration than all of the other cultivars tested. Although not significantly different from each other, Earliblue and Collins had a significantly greater rate of respiration than the remaining three cultivars.

Further work is planned to correlate, if possible, various characteristics of these cultivars to their rate of respiration.

Literature Cited

Chemical Color Enhancement of Cranberry Fruit

Paul Eck, Rutgers University, New Brunswick, New Jersey

Abstract. Color enhancement in Howes and Early Black cranberry, as measured by pigment analysis and influenced by malathion, indole-3-acetic acid (IAA) and sucrose acid 2,2-dimethyl hydrazide (Alar) sprays prior to harvest, was investigated under New Jersey conditions. Malathion at the rate of 2.5 lbs. of active material/A. applied at 200 gal./A. significantly enhanced the extractable pigment content in both Howes and Early Black cranberry. The color enhancement was noted within four days of application, and the differential in pigment content between the malathion treated and control berries was maintained throughout the sampling period. Neither IAA at 50 ppm nor Alar at 2000 and 4000 ppm active material increased color in Early Black. There was an indication that Alar delayed red pigment formation in Early Black. Soluble solids and titratable acidity measurements of Howes and Early Black fruit indicated any significant difference between treated and control fruit at a given sampling date.

The importance of producing uniformly dark red cranberry fruit has been accentuated with the development of a cranberry juice product that has gained widespread public acceptance. Early color development has become desirable also because the increasing size of individual cranberry holdings has encouraged the early initiation of the cranberry harvest in order to complete the operation before the onset of excessively cold weather. The promotion of early and intense red pigment formation in the cranberry by a chemical means represents one approach to the solution of this problem.

Work in Washington by Shaw and the McFarlin cranberry variety has shown that the insecticide, malathion, is capable of enhancing red color development when applied 4 weeks before the desired harvest date. A 57% liquid malathion concentrate was effective in enhancing red coloration in the berries when applied as a drench at the rate of 2.5 lbs./A. active material, a rate that has been cleared for use on cranberries for insecticide purposes.

Devlin has used indole-3-acetic acid (IAA) at the rate of 50 ppm to enhance red color in Early Black cranberry in Massachusetts. The IAA was applied as a spray two weeks prior to harvest.

One of the more recent compounds that has been found to enhance red color in fruit is Alar. Shutak et al. (5) and Mattus (3) have reported that this material increases surface red color in apples and Ryugo (4) has reported that Alar will speed up anthocyanin metabolism in sweet cherry.

In this study the effects of malathion, IAA, and Alar on color enhancement of the Early Black cranberry under New Jersey growing conditions are reported. The effect of malathion on red color enhancement in the Howes variety was also investigated.

On September 30, 1966 malathion at the rate of 2.5 and 5 lbs./A. of active ingredient of a 57% liquid formulation was applied to predominantly green Howes cranberries in the field. Spray applications of malathion were made at the rate of 200 gal./A. Berries were sampled prior to treatment, four days after treatment, and at weekly intervals thereafter until the final harvest on October 25, 1966.

Duplicate samples of treated and control berries for each sampling date were analyzed for pigment content in the laboratory at the New Jersey Agricultural Experiment Station, Department of Horticulture and Forestry, New Brunswick, N.J. On May 29, 1967.

1 Received for publication December 26, 1967. Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Horticulture and Forestry, New Brunswick, N.J., 08903.
2 This research was sponsored in part by Ocean Spray Cranberries, Inc.
3 Stenographic report of the Ocean Spray Cranberry Research Seminar, Hanson, Massachusetts, December 14, 1966.
4 Personal communication.
5 Trade mark of the U. S. Rubber Company for succinic acid 2,2-dimethyl hydrazide.
were analyzed for red pigment content according to the method of Francis (2). Soluble solids, total solids, pH, and titratable acidity analyses of the fruit were made according to A.O.A.C. methods (1).

On August 27, 1967 treatments of malathion at 2.5 lbs./A. active ingredient of a 57% liquid concentrate, 2000 and 4000 ppm Alar, and 50 ppm IAA were applied as a leaf drench at the rate of 200 gal./A. to Early Black cranberries. Each treatment and a check plot were replicated five times in a Latin square design. Berry samples were taken before treatment, on September 1, 7, 19, and 26. Total red pigment was determined for each treatment at each sampling. The Duncan Multiple Range Test was used to test for significance between treatments.

**Malathion effect on Howes cranberry.** The application of malathion to Howes resulted in a significant increase in the amount of extractable pigment within four days of its application (Fig. 1). The 5 lb. rate of malathion produced slightly more pigment than the 2.5 lb. rate. The differential in pigment content between the treated and untreated berries remained throughout the harvest period despite the increase in pigment content of the control berries. These findings are in agreement with Shawa's observations on the McFarlin variety.

Analysis of the fruit for total solids, soluble solids, pH, and titratable acidity failed to indicate any significant difference between treatments and control (Table 1). This would suggest that whatever the mechanism for malathion enhancement of the pigment in the cranberry, it does not appear to influence the substrate. Inasmuch as these factors of maturity do not appear to be altered, it is questionable whether the malathion treatment, although affecting red coloration, has influenced the maturity of the fruit.

**Color enhancement in Early Black cranberry.** Of the three materials tested on Early Black, malathion produced the most dramatic and significant increase in pigment content (Fig. 2). Again the increase in pigment content was found to occur within four days, and the color differential between the malathion treated berries and the control berries was maintained throughout the sampling period.

Contrary to Devlin's findings, IAA did not significantly enhance pigment development in Early Black, although there was a trend toward higher pigment content in the last two sampling periods. Devlin had noticed an increase in pigment content of Early Black within two weeks of application of IAA. There was no color enhancement as a result of the Alar spray (Table 2). By the final sampling period, the

```
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total solids %</th>
<th>Soluble solids %</th>
<th>pH (0.1N NaOH/100 g. juice)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHECK</td>
<td>4.3</td>
<td>9.0</td>
<td>2.7</td>
</tr>
<tr>
<td>2-1/2 lbs. malathion</td>
<td>4.4</td>
<td>9.1</td>
<td>2.7</td>
</tr>
<tr>
<td>5 lbs. malathion</td>
<td>4.4</td>
<td>9.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*No significant differences.*
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**Fig. 1.** Malathion effect on red pigment content in Howes cranberry.

**Fig. 2.** Effect of malathion, IAA, and Alar on red pigment content in Early Black cranberry. Treatments enclosed by the same vertical bar at a given sampling date are not significantly different at the 5% level based on Duncan's Multiple Range Test.
check berries had significantly more pigment than the Alar treated fruit. The failure of Alar to enhance color development may have been due to the timing of the spray. An earlier spray of Alar may be necessary to promote early coloring. The significant reduction in red pigment as the result of Alar treatment at the final sampling would suggest that Alar may actually delay maturity in the cranberry. Analysis of this final sampling of fruit for soluble solids, pH, and titratable acidity, however, did not show any significant differences between the control and Alar treated plots.

Malathion is no longer recommended as an insecticide for use on cranberries in New Jersey because of observed phytotoxicity when applied to actively growing cranberry plants. It will be important to observe the effects of this late season application of malathion on subsequent growth and yield of the treated plants.

Table 2. Summary of cranberry pigment data in Early Black.

<table>
<thead>
<tr>
<th>Dates</th>
<th>Alar 2000 ppm</th>
<th>Alar 4000 ppm</th>
<th>Check 50 ppm</th>
<th>Malathion 2-1/2 lbs/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/1</td>
<td>0.17</td>
<td>0.19</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>9/7</td>
<td>0.30</td>
<td>0.27</td>
<td>0.31</td>
<td>0.28</td>
</tr>
<tr>
<td>9/19</td>
<td>0.37</td>
<td>0.41</td>
<td>0.41</td>
<td>0.42</td>
</tr>
<tr>
<td>9/26</td>
<td>0.55</td>
<td>0.55</td>
<td>0.63</td>
<td>0.67</td>
</tr>
<tr>
<td>Totals</td>
<td>1.39</td>
<td>1.42</td>
<td>1.53</td>
<td>1.55</td>
</tr>
</tbody>
</table>

*Any two values underlined by the same line are not significantly different based on the Duncan Multiple Range Test at the 5% probability level.

**Summary of cranberry pigment data in Early Black.**

**The Effect of Depth of Planting on the Survival, Yield, and Spread of the Common Lowbush Blueberry Vaccinium angustifolium Ait**

Lewis E. Aalders and Ivan V. Hall

Canada Department of Agriculture, Research Station, Kentville, Nova Scotia

Abstract. One-year old lowbush blueberry plants from 6 clonal lines were set in the field in May, 1964 at 3 planting depths: shallow (top of pot level with soil), medium (approximately 7 cm deeper than shallow), and deep (approximately 14 cm deeper than shallow). The shallow plants heaved an average of 2.19 cm the first winter, but there was no mortality due to desiccation injury as experienced in previous work. Plants at the medium and deep planting depths heaved very little. Forty-four of 72 plants at the deepest planting depth died as a result of burying. The shallow and medium plants had the greatest spread 2 years after planting, but suffered the most from burn pruning. The deep set plants had the greatest growth increase during the third and fourth years after planting, and as a result, the medium and deep planting depths had the greatest spread after 4 years. The shallow and medium plants had the greatest fruit yield in 1965, but in 1966, the medium and deep plants had the greatest fruit yield. It is concluded that the medium planting depth is the most satisfactory of the 3 depths at which to set lowbush blueberries.

In our program to domesticate the lowbush blueberry (1, 6) we have been setting plants in the field as early as one year following their propagation as rooted cuttings. Under these conditions, severe losses have sometimes been sustained through heaving of the plants in early spring followed by desiccation. It was observed that the depth at which the plants were set seemed to have some effect on the amount of heaving and hence on the amount of losses. This study was undertaken, therefore, to determine the effect of depth of planting on the heaving of plants in the first spring following planting and on their subsequent survival, spread and fruit yield.

Softwood cuttings of 6 clonal lines of the common lowbush blueberry, Vaccinium angustifolium Ait., were rooted under intermittent mist during the early summer of 1963. In mid-August, the rooted cuttings were potted into 3" peat pots in a 1:2:1 mixture of sand, peat and soil compost. The plants were grown under 16-hour days in the greenhouse for 6 weeks, and were then placed outdoors in a cold frame to harden off. In mid-May, 1964, the plants were set to the field at a spacing of 45 x 45 cm and at 1 of 3 planting depths: shallow (with the soil in the peat pot level with the soil in the field), medium (approximately 7 cm deeper than shallow), or deep (approximately 14 cm deeper than shallow). At the deepest planting depth, some plants were completely buried. A split plot design was used with 3 single-plant minor plots being randomized within the clone groupings, and the 6 clones being grouped systematically into major plots which were replicated 12 times. The plots were kept weed-free throughout the course of the experiment.

The heights to which the peat pots heaved during the first winter were recorded on April 12, 1965. The plots were irrigated once during the summer of 1965, and netting was placed over the plants to prevent damage to the ripening fruit by birds. The fruit was handpicked on August 16, 1965 and the weight of fruit from each plant was recorded.

The maximum aerial spread in cm of each plant was recorded on September 30, 1965. The plots were covered with straw in November, 1965 and were burn-pruned the following spring.

In July, 1967, the plants were again covered with netting to prevent bird damage to the ripening fruit. Ripe fruit was handpicked and yields recorded on August 21 and 22, 1967. Maximum spread of the plants was again recorded on September 14, 1967.

Literature Cited


*Any two values underlined by the same line are not significantly different based on the Duncan Multiple Range Test at the 5% probability level.