between berry size and seed number was $r = 0.72$, indicating that seed number accounts for 51% of the observed variation in berry size; whereas in crosses with high pollen stainability (81 ± 15%), the correlation was $r = 0.48$, accounting for 12% of the observed variation. The relationship between pollen viability and seed production suggests that plants with low pollen viability tend to have commensurately low ovule and low zygotic viability. Thus each seed has a relatively larger impact on berry size when pollen viability is low than when viability is high.

**Literature Cited**


**Inbreeding Depression in Rabbiteye Blueberries**

Paul Lyrene  
*Fruit Crops Department, University of Florida, Gainesville, FL 32611*

**Abstract.** Three populations of 2-year-old seedlings of rabbiteye blueberry (*Vaccinium ashei* Reade) produced by one generation of selfing were compared for seedling survival and vegetative vigor with comparable hybrid populations. Over the 3 populations, the inbred seedlings as compared to hybrids averaged lower in survivorship (30% vs. 48%), length of 3-tallest shoots (46 vs. 72 cm), and largest-shoot diameter (4.2 vs. 7.2 mm).

Blueberries (*Vaccinium* sp.) are a group of insect-pollinated, largely out-crossing species of which several are cultivated. Cultivars of 3 taxa are being grown in the United States: lowbush (based on *V. angustifolium* Ait.), highbush (based on *V. corymbosum* L.), and rabbiteye (*V. ashei*) (4). These classes are not entirely distinct, because some cultivars have been developed from crosses between cultivated types, and various noncultivated *Vaccinium* species have been used in breeding.

The effects of self-pollination vs. cross-pollination on fruit set and seed production have been studied in cultivated highbush and rabbiteye blueberries (3, 7, 8). In general, cross-pollination produces more fruit, larger fruit, and more seeds per fruit. This effect is more pronounced with rabbiteye blueberries than with highbush. Some highbush cultivars are fully self-fruitful and produce normal seed numbers when self-pollinated, but fruit set is severely reduced in self-pollinated rabbit eyes.

The effect of self-pollination on seedling vigor has not been reported in blueberries. This effect is of interest because it provides information on the severity of inbreeding depression. Some inbreeding has probably occurred in all blueberry breeding programs as a result of recurrent selection in which only a few genotypes were used in the initial population and relatively few clones were used as parents in each cycle of selection. Hancock and Stiefker (5) reported that coefficients of inbreeding (F) ranged from 0.00 to 0.25 for 63 highbush blueberry cultivars released by public agencies in the United States. Inbreeding levels in rabbiteye breeding programs are also substantial, since the cultivated germplasm traces back almost entirely through 2 to 4 cycles of recurrent selection to the 4 landrace *V. ashei* cultivars ‘Ethel’, ‘Myers’, ‘Clara’, and ‘Black Giant’ (6).

It is apparent from visual examination of numerous seedling populations in the University of Florida blueberry breeding nurseries that seedlings from cultivar crosses have lower average vigor than seedlings from open-pollinated wild rabbiteye selections from western Florida and southeastern Georgia. Differences in growth rate and survival of cultivar-derived and wild rabbiteye seedlings become apparent when seedlings are only a few months old and these differences persist through maturity. Low vigor is undesirable in blueberry cultivars; it decreases plant survival, increases plantation establishment costs, and increases the time required for a new plantation to reach full production. The purpose of this study was to determine the effects on vigor of one generation of selfing in rabbiteye blueberries.

Seed for this study was obtained by hand-crossing and selfing flowers on potted greenhouse plants following emasculation. The plants used included 2 cultivars (‘Premier’ and ‘Bluebelle’), one advanced selection soon to be released as a cultivar (Fla. 80–178), one wild *V. ashei* selection from Alachua County, Florida (Fla. W78–122), and 3 *V. ashei* composites. Composite 1 included 6 late ripening wild plants from Alachua County. Composites 2 and 3 were each composed of 10 advanced selections from the Florida breeding program. In producing $S_i$ seeds from Composite 3, each plant in the composite was individually selfed and the resulting seeds were bulked.

Seeds were planted on the surface of sphagnum peat in one-liter pots in the greenhouse in Oct. 1980. When seedlings were about 2 cm tall they were transplanted to trays of peatmoss and grown in a greenhouse until April 23, 1981 when they were transplanted to a high-density field nursery. PH of the nursery soil had been adjusted to 4.5 by addition of sulfur the previous summer, and the soil was fumigated with methyl bromide for weed control. Seedlings were spaced 8 cm apart in rows 30 cm apart. Plants were fertilized and irrigated to maximize growth.

Three selfed populations and 5 outcrossed populations were evaluated. Each selfed population was grown in the row or rows immediately adjacent to the outcrossed populations with which it was being compared. Individual plants of the populations being compared were not randomly interplanted in the same row, but because the rows were only 30 cm apart and the plots had been selected and managed to keep growth con-
ditions uniform, it is unlikely that row effects were significant.

On Sept. 10, 1982, the lengths of the 3 longest shoots were determined for each plant. Rabbiteye seedlings tiller freely, and almost every plant had at least 3 separate shoots rising from the plant base. The diameter of the thickest shoot was measured 5 cm above ground level with a caliper.

Each Si population was compared with the outcrossed population in the adjacent rows. Means for each population and variances within each population were calculated. Variances were pooled for the inbred and comparable outcrossed populations, and the t-test was used to determine whether means differed significantly (9). Plant survival was compared for inbred and outcrossed populations with the Chi-square test for independence (9).

In each comparison, S1 seedlings averaged lower in shoot length, shoot diameter, and plant survival than corresponding hybrid seedlings (Table 1). Few if any S1 seedlings were vigorous enough to be used as cultivars. Mean shoot lengths over all comparisons were 45.7 cm for S1 seedlings and 72.4 cm for hybrids. Shoot diameters averaged 4.2 mm for S1 and 7.2 mm for hybrids, and overall survival was 29.9% for S1 and 47.8% for hybrids.

All populations, whether S1 or hybrid, appeared quite variable for each vigor parameter measured, but the amount of this variation that was genetic could not be estimated because individual genotypes were not replicated.

These data indicate that inbreeding greatly reduces plant vigor in rabbiteye blueberries. Because the species is all hexaploid (2), a single generation of selfing should still leave much potential for heterosis among contrasting alleles on homoeologous chromosomes, and the pronounced inbreeding depression observed was unexpected.

Most plants of V. ashei are highly self-incompatible (3, 7). To produce the S1 plants used in this study, large numbers of flowers had to be pollinated. The strong tendency for outcrossing under natural conditions, enforced by flower morphology, insect pollination, and self-incompatibility genes, probably explains why V. ashei is so intolerant of selfing. Because natural selfing is rare, natural selection has not been very effective against alleles that have deleterious effects only when homozygous, and such alleles tend to accumulate in the species gene pool. Highbush blueberries, which are far more self-fertile than rabbiteyes, would probably show less inbreeding depression than rabbiteyes.

In view of the extreme inbreeding depression observed in this study, the narrow gene base upon which rabbiteye cultivar breeding is being conducted is alarming. Because most cultivars and advanced breeding lines trace back to the same 4 to 6 original plants (1, 6), virtually every cross made in modern rabbiteye breeding programs is between parents that are consanguineous to some extent. The reduced vigor of seedlings from such crosses compared to seedlings from open-pollinated wild rabbiteyes is already apparent in the Florida breeding program. It is imperative that additional wild V. ashei plants be introduced into breeding programs. Although this may temporarily slow breeding advance because of the marked horticultural inferiority of wild plants compared to improved germplasm, there seems to be no alternative solution to the serious problem of inbreeding depression.

### Table 1. Percentage of survival, plant height, and shoot diameter for S1 and F1 rabbiteye blueberry seedlings.

<table>
<thead>
<tr>
<th>Population</th>
<th>Survival (%)</th>
<th>n</th>
<th>Height (cm)a</th>
<th>Largest shoot diam (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean Range</td>
<td>Mean Range</td>
</tr>
<tr>
<td>Premier selfed</td>
<td>34.8</td>
<td>114</td>
<td>48 4–104</td>
<td>4.3 0.9–8.4</td>
</tr>
<tr>
<td>Premier x Comp. 1  1a</td>
<td>44.9*</td>
<td>82</td>
<td>26 12–133</td>
<td>7.5** 1.5–12.9</td>
</tr>
<tr>
<td>Bluebelle selfed</td>
<td>17.4</td>
<td>5</td>
<td>56 12–78</td>
<td>3.7 1.1–6.0</td>
</tr>
<tr>
<td>Bluebelle x Comp. 2</td>
<td>30.8 NS</td>
<td>15</td>
<td>79** 24–117</td>
<td>8.1** 4.2–12.0</td>
</tr>
<tr>
<td>Bluebelle x Fla. W78-122</td>
<td>51.9**</td>
<td>26</td>
<td>92** 25–134</td>
<td>10.2** 4.0–13.5</td>
</tr>
<tr>
<td>Comp. 3 selfed</td>
<td>16.2</td>
<td>15</td>
<td>31 14–54</td>
<td>4.0 2.2–5.7</td>
</tr>
<tr>
<td>Beckyblue x Fla. 80-178</td>
<td>62.0**</td>
<td>31</td>
<td>52** 19–92</td>
<td>5.3** 2.5–7.8</td>
</tr>
<tr>
<td>Powderblue x Fla. 80-178</td>
<td>55.9**</td>
<td>30</td>
<td>54** 23–95</td>
<td>5.8** 3.4–8.8</td>
</tr>
</tbody>
</table>

aBased on means of 3 tallest shoots per plant.

1No plants sampled.

1Composite 1: 6 wild V. ashei plants. Composites 2 and 3: each 10 selected V. ashei seedlings from the breeding program. Fla. W 78-122: a wild V. ashei selection. Fla. 80-178: an advanced selection from the breeding program.

1Nonsignificant (ns) from the comparable selfed population or different at the 5% (*) and 1% (**) levels. Comparisons were by adjusted Chi-square (Ref. 9 p. 371) for survival and by t-test for height and diameter.

### Literature Cited