growth and senescence as described for CO₂ and ethylene emanation from senescent carnation flowers (12) or climacteric fruit (2). These results suggested that ethylene levels are associated with tissue transition and increases in callus growth.

**Literature Cited**


**Water Stress, Growth, and Critical Water Potentials of Rabbiteye Blueberry (Vaccinium ashei Reade)¹**

**Frederick S. Davies**

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

**Charles R. Johnson**

*Department of Ornamental Horticulture, University of Florida, Gainesville, FL 32611*

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**Abstract.** Moderate and severe water-stress, as determined by decreases in stomatal conductance, resulted in significant reduction of leaf area and plant weight in 1-year-old containerized 'Bluegem' rabbiteye blueberry. Drought-tolerance appeared to be intermediate to other plant species based on a number of physiological factors. Critical water potential for stomatal closure was −2.2 MPa, transpiration ratio averaged 222 g of water transpired per g dry matter produced and relative water content changed 6.4% per 1.0 MPa change in water potential.

Established rabbiteye blueberry bushes have been observed to be relatively drought-tolerant (1, 4). A waxy leaf cuticle which may partially occlude the stomatal antechamber (1), and moderately low stomatal conductances limit water losses during drought (6). Leaf transpiration ratio is low relative to other mesophytes (16) and rabbiteye blueberries remain productive even after exposure to severe spring drought periods (1, 4). Conversely, newly planted or container-grown bushes appear drought-sensitive. Spiers (15) found that 1- and 2-year-old 'Tiblue' bushes had a higher survival percentage and better growth under irrigated as compared with non-irrigated conditions.

Stomatal response to water deficits, and particularly, the critical water potential for stomatal closure are important factors associated with drought-tolerance (17, 18). Stomata tend to close at much lower water potentials in drought-tolerant than in drought-sensitive plants, which allows for photosynthesis over a wider range of water deficits. Differences in stomatal conductance and overall drought-tolerance have been observed among rabbiteye blueberry cultivars in the field (1, 6); however, critical water potential for stomatal closure has not been determined for rabbiteye blueberry. The relationship between relative water content (RWC) of the leaf and water potential also may be an indicator of plant drought-tolerance (11, 14). Bannister (2) found that Vaccinium myrtillus L. could withstand RWC as low as 68% without serious damage. This relationship has not been studied in cultivated Vaccinium species. The objectives of this study were to investigate the relationship of critical water potential and RWC to rabbiteye blueberry drought-tolerance as well as the effects of moderate and severe water-stress on growth of containerized rabbiteye blueberry plants.

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Materials and Methods

Water-stress studies. Forty-eight 'Bluegem' rooted cuttings were weighed and transferred to the greenhouse in 3.8 liter pots containing 1 sand : 1 pine bark : 1 sphagnum peat moss (v/v/v). One third of the group was watered every 2 days to maintain soil moisture content at container capacity (non-stressed). A second group was watered when the abaxial diffusion conductances \( g_s \) (8) of 3 indicator plants decreased to 80% of their initial values. This occurred at about 7 day intervals (moderate stress). A third group received water about every 10 days when the \( g_s \) of indicator leaves decreased by 50% from their initial values (severe stress). Stomatal conductances of 3 leaves per plant for each treatment were measured on 3 plants at 10 AM each day. Plants were watered when the average \( g_s \) reached the specified value. This system assured that the moderate and severe groups were actually under water-stress. Leaf water potentials as determined by the pressure chamber technique (13) were also more negative in moderate and severely-stressed bushes than non-stressed ones at the end of each drying period.

Critical water potential and relative water content. A second group of 'Bluegem' rooted cutting was grown outdoors for 3 months in a 1 peat: 1 pine bark mix (v/v). Ten healthy plants, 10 to 20 cm in height, were transferred to the greenhouse where the medium was allowed to dry over a 2-week period. Plants were then placed in a growth chamber at 25°C with 60–70% relative humidity and 650–700 \( \mu \text{Em}^{-2}\text{s}^{-1} \) photosynthetically active radiation (PAR). Two fully expanded, mature, unhardened leaves (blue-green in color) were selected from each bush. Leaf abaxial diffusion conductance was measured (8), after which leaf water potential was determined for the same leaf using the pressure chamber (13). Critical water potential for stomatal closure was then determined by linear regression analysis as described previously (5, 10). Leaves were detached and RWC determined following water potential measurements using a modified Barrs and Weatherley technique (3).

Transpiration ratio was determined for 3 non-stressed indicator plants by recording total water usage and dry weight increase over the 6-month-time duration of the experiment.

Results and Discussion

Growth, expressed as leaf area and root, stem and leaf dry weights, was decreased significantly by both moderate and severe water-stress (Table 1). The root : shoot ratio was not altered significantly by water-stress, indicating that growth of roots and shoots was balanced even during water deficits. Water-stress has been shown to decrease root : shoot ratios in cotton (7) but had no effect on the ratios in apples (5, 9). Reduction in growth at moderate stress levels indicated that even a 20% decrease in \( g_s \) may significantly alter young blueberry plant growth. Similarly, growth of young 'Tifblue' bushes in the field was decreased significantly by water deficits (15).

Table 1. Effect of water-stress upon growth of container-grown 'Bluegem' rabbiteye blueberry.

<table>
<thead>
<tr>
<th>Water-stress level</th>
<th>Leaf area (cm²)</th>
<th>Dry wt (g)</th>
<th>Root:Shoot ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-stressed</td>
<td>200 a⁴</td>
<td>30.0a</td>
<td>6.3a 9.0a 2.0a</td>
</tr>
<tr>
<td>Moderate</td>
<td>117 b</td>
<td>21.3ab</td>
<td>3.6b 5.3b 2.4a</td>
</tr>
<tr>
<td>Severe</td>
<td>102 b</td>
<td>16.0b</td>
<td>2.9b 4.5b 2.2a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water potential (MPa)</th>
<th>Relative water content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.5</td>
<td>95.1 ± 6.4x r=0.60</td>
</tr>
</tbody>
</table>

Fig. 1. Water potential and stomatal conductance of 'Bluegem' rabbiteye blueberry leaves. (The y intercept corresponds to the critical water potential for stomatal closure).

Critical water potential for stomatal closure was estimated at \(-2.2 \text{ MPa}\) for fully expanded rabbiteye blueberry leaves (Fig. 1). Critical water potentials generally range from \(-0.8 \text{ MPa}\) in field beans and sorghum to \(-2.8 \text{ MPa}\) in cotton (18) but can be as high as \(-3.5 \text{ MPa}\) in apple leaves (5). Although the critical potential for rabbiteye blueberries is relatively low, \( g_s \) is sensitive to slight changes in water potential as indicated by the rather steep slope of the line. This may explain the large differences observed in growth at even moderate reductions in soil moisture.

The relationship between leaf RWC and water potential implies an intermediate position in drought-tolerance for rabbiteye blueberry relative to other studied plant species (11) (Fig. 2). Rel-

ative water content decreased an average of 6.4% for every 1.0 MPa change in water potential. Bannister (2) observed a decrease in RWC of approximately 10.5% per 1.0 MPa change in water potential in Vaccinium myrtillus L. By comparison, RWC of drought-sensitive plants like tomato changes as much as 25% per 1.0 MPa change in water potential, while RWC of drought-resistant Acacia harpophylla changed only 2.7% over comparable water potential ranges (11).

Correlation coefficients of 0.65 and 0.60 for Fig. 1 and 2, respectively, indicate that other environmental or physiological factors besides those in this study influence drought-tolerance relationships. Nevertheless, the information in Fig. 1 and 2 can be used to compare drought-tolerance among plant species, and correlation coefficients are similar to those reported by others (5, 11).

Transpiration ratio (TR) of containerized bushes averaged 222 g of water transpired per g dry matter produced. This value is considerably higher than the leaf TR of 108 reported by Teramura et al. (16), but is still below values of 300 or more reported for other mesophytes (12). Teramura et al. did not correct for root respiration or carbohydrate translocation which may account for part of the discrepancy.

Relatively low critical water potentials, transpiration ratios and changes in RWC per unit change in water potential support field observations of an intermediate degree of drought-tolerance for rabbiteye blueberry as compared to other reported species of plants (11, 17, 18).

**Literature Cited**