Comparative Photosynthesis and Transpiration in Excised Shoots of Rabbiteye Blueberry

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Abstract. Photosynthesis in rabbiteye blueberry (Vaccinium ashei Reade) was found to saturate at low irradiances and had a low light compensation level. In contrast to many other plants, both stomatal and residual diffusion resistance contributed equally to the total leaf diffusion to CO2. Relatively higher stomatal resistances in rabbiteye blueberry result in an efficient water-use, enabling it to withstand drought. No cultivar differences were found in photosynthesis, transpiration, or dark respiration to account for differences in yield.

Rabbiteye blueberry is shallow-rooted yet is highly productive in habitats too dry for high-bush blueberry. It is tolerant to high summer temperatures and has only a moderate chilling requirement, making it ideally suited to many areas throughout the southeastern United States and particularly adaptable to Florida. Interest in rabbiteye blueberry has increased recently due to its increased potential for production and water-use efficiency. The present experiment was designed to study the photosynthetic and transpirational characteristics of 3 rabbiteye blueberry cultivars and the relationships of these processes to differences in yield and irrigation responses.

Uniform, well-exposed shoots at least 30 cm long were collected from 5-year-old rabbiteye blueberries from May until September. Shoots were re-cut under water prior to each set of measurements to assure a continuous water column and placed under a light bank providing an irradiance of 1000µmolm⁻²sec⁻¹ photosynthetically active radiation (PAR) at mid-shoot. Previous experiments indicated stomatal diffusion resistance and xylem pressure potential were unaffected by this procedure and leaves remained turgid for several days after excision.

Photosynthesis, transpiration, and dark respiration were measured on single, attached leaves using a pincher-type cuvette. All measurements were done on the second or third fully expanded leaf from the shoot apex. CO2 was measured in an open system using a Beckman 215B infrared gas analyzer operating differentially. Water vapor fluxes were continually monitored with an EG and G Model 880 dew point hygrometer. Gas exchange measurements were done at a leaf temperature of 30° ± 1°C, ambient CO2 concentration (320 µl/liter), and a vapor pressure deficit of 20 mb. Irradiance at the leaf surface was supplied by a tungsten halogen lamp filtered through 30 cm of water. Light saturation levels were determined by measuring photosynthetic responses over a PAR range of 2000 to 1000µmolm⁻²sec⁻¹ in increments of 100µmolm⁻²sec⁻¹PAR. All reported photosynthetic rates were made at saturating irradiances, after which leaves were covered and measurements were made for dark respiration. Leaf diffusion resistance to water vapor was calculated following conventional resistance analyses (6). Resistances to CO2 were related to the analogous resistance to water vapor as described previously (7, 14). Reported values are means of at least 10 determinations for 'Bluegem' and 'Woodard' but only 2 replicates for 'Tifblue'. The photosynthetic response to irradiance was similar in the 3 cultivars (Fig. 1). Photosynthesis in rabbiteye blueberry became light-saturated at intermediate irradiances, 700 to 800µmolm⁻²sec⁻¹PAR, compared with peach, 450 to 500µmolm⁻²sec⁻¹ (5), orange and lemon, 500µmolm⁻²sec⁻¹ (11), or pecan, 600 to 700µmolm⁻²sec⁻¹ (4). Much higher saturating irradiances, 900 to 1000µmolm⁻²sec⁻¹PAR, were reported for apples (12) and apricots (16). A moderate light-saturation level indicates that photosynthesis is not light-limited in most of the blueberry canopy. Measurements made over several days showed that the mean irradiance for leaves in the innermost canopy was between 250 and 300µmolm⁻²sec⁻¹PAR, which is sufficient for 50 to 60% of maximum photosynthesis. The low compensation irradiance, 50 to 75
\[ \mu \text{mol m}^{-2} \text{sec}^{-1} \text{PAR} \]

Further aids in the maintenance of a positive carbon balance even with heavy shading or extended periods of overcast skies.

The light-saturated rate of photosynthesis, 8 to 11 mg CO$_2$ dm$^{-2}$ hr$^{-1}$, was comparable to those reported for peach (5), orange and lemon (11), apricot (16), grapefruit (9), and pecans (4). However, apples have nearly twice the photosynthetic rate (2, 12) found in rabbiteye blueberries. Dark respiration rates were about 10 to 15% of the photosynthetic rate (Table 1).

The diffusive pathway of CO$_2$ from the ambient air to the site of carboxylation meets 2 major resistances, a stomatic and a residual diffusion resistance. The stomatal component includes the unstirred boundary layer and is a function of stomatal pore width and frequency; whereas the residual component includes transfer resistances across membranes, excitation and carboxylation resistances, etc. (8, 15). Both resistances are sensitive to environmental factors and either can be limiting to photosynthesis. No significant differences were found in this study among cultivars in either stomatal or residual diffusion resistance (Table 1). The relative magnitudes of the 2 diffusion resistances were comparable, indicating both contributed significantly to the total leaf resistance to CO$_2$. Watson et al. (17) reported similar relationships in 'Golden Delicious' apples. In contrast, the residual diffusion resistances are usually greater than the stomatal components in many other crop plants (15) and citrus leaves (9, 11). The comparatively higher stomatal diffusion resistances reported in this study for rabbiteye blueberry were associated with the presence of epicuticular waxes on the leaf surfaces reported by Anderson et al. (1).

Stomatal diffusion resistances have a large effect on reducing rabbiteye blueberry transpiration ratios (Table 1). The ratio between the amount of water lost per unit of CO$_2$ fixed is useful in evaluating the efficiency of water use. Many deciduous trees and conifers have ratios ranging between 170 and 300, while agricultural C$_3$ plants commonly have ratios ranging between 500 and 800 (13). In contrast, drought-resistant CAM plants such as pineapple have a transpiration ratio as low as 50 (10). Rabbiteye blueberry also has a relatively low transpiration ratio which in part accounts for its adaptability to drought conditions.

Buchanan et al. (3) indicated there were cultivar differences in response to supplemental water. Berry yield increased in 'Bluegem' and 'Tifbluey' in proportion to the amount of additional water supplied but 'Woodard' was unaffected. We cannot account for cultivar yield differences on the basis of our photosynthesis, dark respiration, transpiration, or transpiration ratio data.

### Literature Cited


**Table 1. Photosynthesis, dark respiration, diffusion resistances, transpiration, and transpiration ratio (TR) in 3 rabbiteye blueberry cultivars.**

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Photosynthesis (mgCO$_2$dm$^{-2}$hr$^{-1}$)</th>
<th>Dark respiration (mgCO$_2$dm$^{-2}$hr$^{-1}$)</th>
<th>Diffusion resistances (sec cm$^{-1}$)</th>
<th>Transpiration (gH$_2$Odm$^{-2}$hr$^{-1}$)</th>
<th>TR (gH$_2$O/gCO$_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bluegem</td>
<td>8.3</td>
<td>-1.5</td>
<td>12.7</td>
<td>10.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Tifbluey</td>
<td>9.4</td>
<td>-1.2</td>
<td>10.0</td>
<td>12.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Woodard</td>
<td>11.1</td>
<td>-1.7</td>
<td>8.0</td>
<td>14.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

*There were no significant differences among cultivars using Duncan’s multiple range test at the 5% level.

*Mean of 2 leaf measurements.