Estimating Leaf Area for ‘Kakea’ and ‘Keaau’ Macadamia

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Abstract. Leaf areas of Macadamia integrifolia Maiden & Betche cvs. Kakea and Keaau were estimated by equations involving linear dimensions length and width in second degree polynomials. The equations accurately estimated leaf area at 2 locations for each cultivar.

The most common methods for estimating leaf area, the planimeter (1, 2, 5) and grid squares (4), are either destructive or time consuming (7). Estimating area by leaf length and width has been developed for pecan (Carya illinoinensis Koch) (9) and grape (Vitis vinifera L.) (5). Other researchers have used equations of the product of length and width for maize (Zea mays L.) (10). Cormack and Bate (1, 2) in Rhodesia developed equations for estimating the leaf area of several cultivars of macadamia, including ‘Kakea’ and ‘Keaau’, from measurements of leaf dimensions. However, our preliminary analysis of these models showed large discrepancies between measured and estimated leaf areas (Table 1). The objective of this study was to develop a rapid method for estimating leaf area in the field.

Twenty leaves, ranging in age from juvenile to mature leaves, were selected randomly from interior and peripheral branches 1.2 to 1.8 m above the ground on each of six 10-year-old macadamia ‘Kakea’ and ‘Keaau’ trees. A total of 100, undamaged leaves of each cultivar from each tree were selected. Leaf length and width at the broadest part of the leaf were measured, and leaf area was determined by a LI-COR Inc. LI-3100 Area Meter (Lincoln, Neb.). Models relating leaf length and width to leaf area for both cultivars were developed by forward selection stepwise multiple regression using the Statistical Analysis System (SAS) (6) on an IBM 370 computer.

Testing of these models required different sets of leaf data than used in developing the models. Three ‘Kakea’ and ‘Keaau’ trees were selected from a 10-year-old orchard at Mauna Loa and from a 15-year-old orchard at the Univ. of Hawaii Waiakea Experiment Station near Hilo, Hawaii. Twenty leaves from each tree were selected. Lengths, widths, and areas of 50, undamaged leaves of each cultivar from each location were determined as described previously and compared with estimated leaf areas predicted by the models.

Leaf length and width and leaf area were correlated highly for both cultivars (Fig. 1). Soule and Malcolm (8) found no significant correlation between either leaf length or width and leaf area for mature and juvenile (combined) leaves of mango (Mangifera indica L.). However, log length and log area were correlated highly.

There is a curvilinear relationship between

Figure 1. Relationship between length (C) and width (●) and area of 100 leaves of ‘Kakea’ (A) and ‘Keaau’ (B) macadamia at Mauna Loa Macadamia Nut Corporation.
Table 1. Accuracy of Cormack and Bate's models (1, 2) in estimating leaf area of 100 leaves of 'Kakea' and 'Keaau' macadamia at Mauna Loa Macadamia Nut Corporation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Cultivar</th>
<th>Total area measured (cm²)</th>
<th>Total area predicted (cm²)</th>
<th>Dev. (%)</th>
<th>Mean dev. (cm²)</th>
<th>Mean dev. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = 0.74LW + 0.55</td>
<td>Kakea</td>
<td>2629</td>
<td>2866</td>
<td>9.0</td>
<td>2.4</td>
<td>10.3</td>
</tr>
<tr>
<td>A = 0.79LW - 1.39</td>
<td>Keaau</td>
<td>3411</td>
<td>3783</td>
<td>10.9</td>
<td>3.8</td>
<td>10.8</td>
</tr>
</tbody>
</table>

aPercentage of deviation = (total measured area - total predicted area) x 100 / total measured area. Vertical bars represent absolute value.

bMean deviation = (Σ [measured area, predicted area]) / n.

bMean percentage of deviation = (Σ [measured area, predicted area]) x 100 / measured area, / n.

Table 2. R², MSE, and C values (6) for terms used in equations, derived by stepwise multiple regression, defining the relationship between length (L) and width (W) and area (A) of 100 leaves of 'Kakea' and 'Keaau' macadamia at Mauna Loa Macadamia Nut Corporation.

<table>
<thead>
<tr>
<th>Term entered</th>
<th>Coefficient of multiple determination (R²)</th>
<th>Unexplained variation (%)</th>
<th>Mean square error (MSE)</th>
<th>Total squared error (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW</td>
<td>0.974</td>
<td>2.6</td>
<td>2.52</td>
<td>9.30</td>
</tr>
<tr>
<td>L</td>
<td>0.976</td>
<td>2.4</td>
<td>2.33</td>
<td>2.63</td>
</tr>
<tr>
<td>W</td>
<td>0.976</td>
<td>2.4</td>
<td>2.35</td>
<td>4.27</td>
</tr>
<tr>
<td>W²</td>
<td>0.977</td>
<td>2.3</td>
<td>2.34</td>
<td>4.91</td>
</tr>
<tr>
<td>L²</td>
<td>0.977</td>
<td>2.3</td>
<td>2.34</td>
<td>6.00</td>
</tr>
</tbody>
</table>

'Kakea' model was A = 0.67L + 0.60LW - 3.25

LW² | 0.976 | 2.4 | 3.99 | 25.59 |
W² | 0.980 | 2.0 | 3.27 | 4.74 |
L² | 0.981 | 1.9 | 3.18 | 3.11 |
W | 0.981 | 1.9 | 3.19 | 4.15 |
L | 0.981 | 1.9 | 3.21 | 6.00 |

'Keau' model was A = 0.90L² - 1.24W² + 1.34LW + 0.91

aTerms entered sequentially by forward selection stepwise multiple regression. Equation is A = 0.67 L + 0.60LW - 3.25 for 'Kakea' and A = 0.90L² - 1.24W² + 1.34LW + 0.91 for 'Keaau'.

bPercentage unexplained variation is (1 - R²) x 100.

Table 3. Comparison of accuracy of forward selection stepwise multiple regression models and Cormack and Bate's models (1, 2) in estimating leaf area of 50 leaves of 'Kakea' and 'Keaau' macadamia at 2 locations.

<table>
<thead>
<tr>
<th>Model</th>
<th>Cultivar</th>
<th>Location</th>
<th>Total area measured (cm²)</th>
<th>Total area predicted (cm²)</th>
<th>Dev. (%)</th>
<th>Mean dev. (cm²)</th>
<th>Mean dev. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = 0.67 L + 0.60LW - 3.25</td>
<td>Kakea</td>
<td>Mauna Loa</td>
<td>1211</td>
<td>1106</td>
<td>1.3</td>
<td>1.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Cormack and Bate (1)</td>
<td>Mauna Loa</td>
<td>1310</td>
<td>1300</td>
<td>0.8</td>
<td>1.1</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>A = -0.09L² - 1.24W² + 1.34LW + 0.91</td>
<td>Keaau</td>
<td>Mauna Loa</td>
<td>1333</td>
<td>1310</td>
<td>1.7</td>
<td>1.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Cormack and Bate (2)</td>
<td>Waiakea</td>
<td>1531</td>
<td>1505</td>
<td>1.6</td>
<td>1.4</td>
<td>4.9</td>
<td></td>
</tr>
</tbody>
</table>

aDefinitions given in Table 1.
Fertilized portions of 1-year-old plants of 'Berkeley' blueberry (Vaccinium corymbosum L.) displayed significantly greater shoot dry weight, shoot thickness, leaf dry weight, and mean number of shoots than unfertilized portions. Fertilized portions blossomed and produced fruit while flower buds on the unfertilized portions died. Blossomed and produced fruit while flower buds on the unfertilized portions died. Fertilizing fruit plantings costs the grower in both labor and materials. This is doubly true for fertilizing blueberry plantings where costs of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

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Abstract

Fertilized portions of 1-year-old plants of 'Berkeley' blueberry (Vaccinium corymbosum L.) displayed significantly greater shoot dry weight, shoot thickness, leaf dry weight, and mean number of shoots than unfertilized portions. Fertilized portions blossomed and produced fruit while flower buds on the unfertilized portions died.

Fertilizing fruit plantings costs the grower in both labor and materials. This is doubly true for fertilizing blueberry plantings where 2 or 3 applications per year are recommended (4). Traditional recommendations have the fertilizer spread in a broad band completely around the plant beneath the dripline (2) or along each side of the row (3). This requires the grower to make at least 2 passes per row. Time would be saved if the grower were to fertilize only 1 side of the row, moving along alternate rows. Chandler (1) advised against fertilizing only 1 side of a fruit tree. He stated that applying fertilizer to 1 side only would improve growth only on that side.

This study was undertaken to determine if 1-sided fertilization of highbush blueberry plants could be done successfully.

Ten 1-year-old 'Berkeley' plants were selected for uniformity of vigor and size in Sept. 1982. The root ball and the basal 5 cm of the main stem of each plant were slit lengthwise in equal portions with a grafting knife and seated in specially constructed containers (Fig. 1). Each container consisted of an 8.8 liter plastic pot with a 2-mm-thick, white, plastic partition centered in the pot and extending its complete length. The junction of the partition and the pot walls was sealed with butyl caulk to prevent flow of water and nutrients from one side of the pot to the other. Each pot then was filled with 1 liter of a 1:l sand : peat mixture and the plants placed 1 to a pot so that about half of the root ball was positioned on each side of the partition.

The split-stem of the plant was seated firmly on the partition. Tree wound dressing sprayed over the outside cut surface on the stem made a tight seal. Plants were placed in the greenhouse under a 16-hr day/8-hr night regime. One half of each container received a weekly fertilizer solution treatment of 500 ppm 20N-8.6P-16.6K, while the other half received only water. Growth and development were monitored by weekly inspection for 6 months. Within a few days after the start of the experiment, the fertilized segment of each


Split-root Fertilizer Application to Highbush Blueberry Plants

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Additional index words. Vaccinium corymbosum, cultural practices, fertilizer, soil management

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Literature Cited