Poinsettia Irrigation Based on Evaporative Demand and Plant Growth Characteristics

C.D. Stanley and B.K. Harbaugh
Gulf Coast Research and Education Center, IFAS, University of Florida, 5007 60th Street East, Bradenton, FL 34203

Abstract. An easy method to estimate water requirements for poinsettia (Euphorbia pulcherrima Willd. ex Kl.) production with practical applications to commercial operations was developed to promote water conservation. A water-requirement prediction equation that used pan evaporation along with plant-canopy height and width as input variables was generated. Equation verification was carried out by comparing plant quality of crops irrigated according to the generated water-requirement prediction equation to crops irrigated "on-demand" or with capillary-mat irrigation. Plants irrigated with the prediction equation were smaller than plants grown with capillary mat, but plant quality ratings for 'Annette Hegg Diva' and 'Dark Red Annette Hegg' were not significantly different. 'Guthbier V-10 Amy' plants grown with irrigation on-demand were of higher quality than plants grown using either the capillary mat or the prediction equation. Applied water was significantly lower for plants irrigated with the prediction equation than would normally be applied in a commercial operation using a conservative fixed daily irrigation rate.

Conservation of water resources has become increasingly important to horticultural operations, due to associated costs for pumping or purchasing water, availability in quantities desired, and compliance with regulatory agency guidelines for water management to maintain acceptable runoff water quality. In recent years, the use of water-conserving irrigation systems has increased the producer’s ability to reduce the amount of water used to grow a crop. To properly conserve water while producing a high-quality commercial crop, regardless of irrigation system used, information on actual plant water requirements under specified conditions is necessary.

Any method used to accurately estimate plant water requirements must account for environmental and plant factors. Most models use many measurements of both environmental conditions (e.g., temperature, humidity, light energy, air speed) and plant characteristics (leaf area, fresh weight, leaf water potential, diffusion resistance, etc.) and include techniques that are destructive to the plants being measured to account for all the variables needed to estimate water requirements. Many commercial producers do not have instrumentation, technical expertise, or desire to use such models. A simplified method with practical application to commercial operations was developed in previous work. This method used plant canopy height and width, and pan evaporation to generate a water-use prediction model. Pan evaporation apparently was an adequate indicator of the integrated environmental effects influencing water requirements of several ornamental crops. The objectives of this study were to: 1) use the above method to develop a water-requirement prediction equation for poinsettia and 2) test the effectiveness of this equation for irrigation of poinsettia by evaluating growth and quality of plants grown with amounts of water estimated by the prediction equation.

Two studies were conducted in a fan- and pad-cooled glass greenhouse with temperatures ranging from 19°C (night) to 35°C (day). Shade was provided by the use of exterior paint, with the resulting photosynthetically

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Irrigation treatment</th>
<th>Final width (cm)</th>
<th>Final height (cm)</th>
<th>Plant quality (Rating)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guthbier V-10 Amy</td>
<td>II</td>
<td>38 b</td>
<td>19 b</td>
<td>3.7 b</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>45 a</td>
<td>19 b</td>
<td>4.7 a</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>47 a</td>
<td>24 a</td>
<td>2.8 c</td>
</tr>
<tr>
<td>Annette Hegg Diva</td>
<td>II</td>
<td>52 b</td>
<td>32</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>67 a</td>
<td>35 ns</td>
<td>2.3 ns</td>
</tr>
<tr>
<td>Dark Red Annette Hegg</td>
<td>I</td>
<td>54 a</td>
<td>36</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>64 b</td>
<td>36 ns</td>
<td>2.1 ns</td>
</tr>
</tbody>
</table>

*Values for each plant growth and quality characteristic listed represent the means of seven replications within each irrigation treatment.
*Means followed by a different letter within each column within cultivar are significantly different from each other by Duncan’s multiple range test (P < 0.05).
*Irrigation treatments were: I) using the prediction equation by entering plant data for individual pots; II) using the prediction equation by entering plant data averaged for a group of pots, and then irrigating the entire group based on the averages; III) subjective irrigation based on observed demand (determined by manually checking pot weight and plant condition daily); and IV) using a capillary-mat irrigation system to continually provide for water needs of the crop.
active radiation (PAR) at 1300 HR ranging for 500 to 800 μmol·s⁻¹·m⁻² on hazy to clear days, respectively. Relative humidity ranged from 60% (day) to 98% (night) as measured with a recording hair hygrometer. A Belfort Evaporation Recorder (Model 6075) located in the same growing area as the plants used for this study. This instrument has a 250-cm² evaporation pan with a 24-hr clock, and, thus, afforded a continuous record of pan evaporation amount and rate.

Data collected during this period were analyzed by a stepwise multiple-regression technique (SAS Institute, 1985). This method allowed addition or substitution of potential independent variables in the model to observe changes in statistical significance and improvement in the coefficient of determination ($R^2$) for each model. The postulated regression model was:

$$ET = f(HT, WT, EVAP) \quad [1]$$

where: $ET = $total water use (in milliliters), $HT = $plant canopy height (in centimeters), $WT = $plant canopy width (in centimeters), and $EVAP = $estimated pan evaporation (in millimeters).

Regression analyses were preformed for each variable as linear and quadratic components, as well as for combinations (such as WT-HT), and were entered into the model as individual variables. Both HT and WT were significant for linear and quadratic terms, but, since our objective was to develop a simplified and practical model, only linear terms of each were used in the final model, as addition of quadratic terms did not appreciably improve the $R^2$. The resulting equation, significant at $P \geq 0.01$ with an $R^2 = 0.78$, was:

$$ET = -118.00 + 2.3(HT) + 1.8(WT) + 58.2(EVAP) \quad [2]$$

and was chosen for estimating water requirements. Fig. 1 contains a plot of the estimated water requirements vs. measured water requirements using Eq. [2].

In the second series of experiments, rooted cuttings were planted 1 Sept. 1983 to verify the usefulness of the final water-use prediction equation developed earlier. Crops were irrigated using the following irrigation treatments: I) using the prediction equation by entering plant data for individual pots; II) using the prediction equation by entering plant data averaged for a group of pots, and then irrigating the entire group based on the averages; III) subjective irrigation based on observed demand (determined by manually checking pot weight and plant condition daily); and IV) using a capillary-mat irrigation system to continually provide for water needs of the crop. All treatments received fertilization in the same manner (controlled-release fertilizer), as was used in the plants used in the development of the prediction equation.

Three simultaneous experiments were conducted to compare combinations of the above irrigation treatments. Each experiment included a specific poinsettia cultivar with seven replications of irrigation methods, using single plants as the experimental unit. Specific model-verification studies included the

![Fig. 1. Measured poinsettia water requirements vs. predicted water requirements (from Eq. [2]) for data collected from 26 Aug. to 8 Dec. 1981.](image-url)
following: Expt. 1: ‘Gutbier V-10 Amy’ irrigated according to either treatment II, III, or IV; Expt. 2: ‘Annette Hegg Diva’ irrigated according to either treatment II or IV; Expt. 3: ‘Dark Red Annette Hegg’ irrigated according to either treatment I or IV.

Amounts of water applied were recorded in each experiment for treatments I, II, and III. On 23 Nov. 1983, data were recorded for plant height, plant width, diameter of the largest inflorescence (as an indication of color), and a subjective overall plant-quality rating ranging from 1 (poor) to 5 (excellent). Factors influencing the plant quality rating were pot: shoot ratio, inflorescence size, coloration and maturity, and leaf color.

Plant wetness generally was greatest for plants grown with capillary-mat irrigation (IV) (Table 1). This treatment also resulted in the greatest height of ‘Gutbier V-10 Amy’, which is a common characteristic of poinsettia grown on capillary mats (Freeman, 1974; Hannings, 1974; Wilfret and Harbaugh, 1977). There were no differences in inflorescence diameter (range 24 to 31 cm) due to irrigation method for any test. ‘Gutbier V-10 Amy’ plants grown with water-on-demand (III) were rated higher in quality than those irrigated using the prediction equation (II) or the capillary mat (IV). No differences in overall quality were observed in the other experiments. Quality ratings tended to be low, although similar, due to the fact that plant heights were one and one-half to two times greater than pot diameter, resulting in an undesirable pot: shoot ratio.

Plants irrigated with the prediction equation were slightly smaller and of lower quality than plants irrigated on-demand in Expt. 1. These plants wilted occasionally during periods of combined rapid plant growth and high evaporative demand, which indicated that the equation was not adequately predicting the necessary water requirement on such days. If underestimation and subsequent underapplication of water occurred, soil moisture in the pot would have been depleted, since irrigation based on the prediction equation only replaces estimated water used the previous day. It is apparent that additional information or some compensation coefficient is required to make the equation more responsive during high-demand periods.

In the only experiment where a valid comparison of seasonal water application quantities could be evaluated (Expt. 1), 11% less water was applied using the prediction equation (II) than with irrigating on-demand (III). A common irrigation practice in commercial operations consists of applying a constant amount of water daily (e.g., 200 to 300 ml/pot per day). If these amounts were used and compared to the seasonal amounts of water that were applied in any of the studies using treatments I or II, they would show substantial water savings (59% to 73% for Expt. 1, and 43% to 62% for Expts. 2 and 3) by use of the prediction equation. Since use of the prediction equation is based on applying the minimum amount of water needed to grow the plant, water for leaching is not included. However, with proper fertilization and adequate-quality irrigation water, leaching may not be required, as is the case with production using capillary-mat irrigation in humid regions.

The information obtained from this study indicates that a significant relationship exists between poinsettia water requirements and the plant and evaporative data that were used to estimate those requirements. We believe that the simplicity of this relationship is important, especially for its eventual use for commercial purposes. However, the specific equation developed in this study has not been evaluated for all growing conditions, and caution should be exercised with its use. Additional data are needed concerning the equation to be more responsive to high evaporative demand conditions need to be collected.

**Literature Cited**


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**Photoperiodic Induction of Flowering in Guayule**

R.A. Backhaus and R.R. Higgins

Botany Department, Arizona State University, Tempe, AZ 85281

D.A. Dierig

U.S. Department of Agriculture, Agricultural Research Service, U.S. Water Conservation Laboratory, Phoenix, AZ 85040

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**Abstract.** Flowering response in guayule (Parthenium argentatum Gray) was found to be photoperiodically induced by long days. The critical daylength for flowering was between 9.5 and 11 hours. The flowering response was the same when measured as days to first flower, node to first flower, or percentage of plants flowering. Plants flowered within 57 days of emergence under 16-hour long days or 8-hour short days, with a light interruption midway through the dark period, but did not flower under 8-hour short days. Flowering was most rapid under 20-hour days and slowed as daylengths approached 11 hours. Flower induction occurred with exposure to as few as three 20-hour photocycles.

Guayule is being considered as a domestic, natural rubber crop for the United States. Although much work was done during the 1940s regarding the response of guayule to numerous environmental conditions (Benedict, 1950; Bonner, 1943; Hammond and Polhamus, 1965), very little was done in characterizing its response to photoperiod. It was suggested that guayule was a long-day plant (Whitehead and Mitchell, 1943), yet the flowering response was never quantitatively characterized. The response may be of economic significance since active rubber accumulation occurs between fall and spring, the period when guayule is not flowering. Data from a study by Willard and Ray (1986) have shown that the removal of inflorescences at initiation caused a significant increase in plant dry weight. Removal also led to a significant increase in rubber yield of deflowered plants.

Our purpose was to determine whether flowering in guayule is photoperiodically controlled and to evaluate the most appropriate method for quantifying the flowering response, i.e., days to first flower, node to first flower, or percentage of plants flowering. Other goals were to determine the critical daylength for flowering and the minimum number of inductive photocycles necessary...