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 width 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 concerned with modifying the equation to be more responsive to high evaporative demand conditions need to be collected.

Literature Cited


**Photoperiodic Induction of Flowering in Guayule**

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Additional index words. Parthenium argentatum, daylength, flowering, long-day plant

**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
to induce flowering. This information will be useful if guayule is to be developed further as a commercial crop and will make it possible to establish experimental conditions to examine the effect of flowering on growth and rubber accumulation in future studies.

Guayule plants (line 593) were grown from seeds in a 1 peat : 1 sand (v/v) U.C. mix in 3.8-liter pots and irrigated daily with tap water and bi-weekly with half-strength Hoagland’s solution. Nine plants were used per treatment and were arranged in a completely randomized design in growth chambers (Model E 3486 HL, Environator Corp., West Des Moines, Iowa) maintained at light/dark temperature regimes of 29/13 ± 0.5°C. The chamber light was a mixture of cool-white fluorescent and incandescent lamps with a photosynthetic photon flux of 500 μmol·s⁻¹·m⁻² of 400 to 700 nm at plant level. The experiment compared flowering of germinated seedlings grown under: a) 16-hr long day (LD), b) 8-hr short day with a 1-hr light interruption, c) 8-hr short day (SD) to determine whether flowering was photoperiodically controlled. Flowering was measured as: a) days to first flower, b) node to first flower, and c) the percentage of plants flowering after 100 days. The transition from the vegetative to the floral stage was accompanied by a conspicuous change in the apex, which formed small flower primordia that were visible without magnification.

Critical daylength for flowering was determined on 35-day-old seedlings initially grown in a greenhouse under natural, non-inductive daylengths (between November and February in Tempe, Ariz.); they were then transferred to separate growth chambers with daylengths of 8, 9.5, 11, 12, 16, and 20 hr. Plants were maintained for 100 days and flowering observed. The days to flowering and change in node to first flower reflect the initial age of the plants at the start of the experiment. The minimum number of photocycles necessary for induction was determined by transferring 35-day-old plants to 8-hr days after exposure to 0, 1, 2, 3, 4, 6, 10, 14, 16, or 32 photocycles of 20 hr. Plants were grown in 8-hr days for up to 100 days and observed for flowering.

The flowering response, measured as days to first flower or node to first flower, was essentially the same for LD and SDI treatments (Table 1), but did not flower after 100 days in SD. The percentage of plants flowering also revealed that photoperiodic induction occurred in LD and SDI, but not in SD. Flowering could be detected after 16 days in 20-hr daylengths vs. 35 days in 11-hr daylengths when plants were only 35 days old at the start of the experiment (Fig. 1). Similar results occurred when flowering was measured as the change in node to first flower, where plants flowered between node 6 and 7 under 20-hr daylengths and on node 10 under 11-hr daylengths. The critical daylength for flowering was between 11 and 9.5 hr. Onset of flowering was more rapid under 20-hr than 11-hr daylengths. Percentage of plants flowering (Fig. 2) revealed no plants flowering in daylengths 9.5 hr.

The response of guayule to daylength was the same for all flowering indices. The more convenient measures of flowering were days to first flower and percentage of plants flowering. The measurement of node to first flower may be useful but was more difficult to evaluate because lateral branches developed when flowers were initiated. The large number of lateral branches that developed made counting tedious. In this study, the number of flowers per plant was not used as an index of flowering, but it may be a useful measure under other circumstances.

Since 20-hr daylengths appeared optimum for flowering, the number of 20-hr photocycles necessary for induction was determined. Full flowering (100% of plants flowering) was achieved after exposure to ten 20-hr photocycles (Fig. 3). We observed throughout the experiment that partial induction occurred with as few as three 20-hr photocycles. When fewer than three photocycles...
TABLE 1. The effect of daylength on flowering in guayule.2

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Time to first flower (days)</th>
<th>Flowering node (no.)</th>
<th>Plants flowering (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD</td>
<td>57 ± 3</td>
<td>12.5 ± 0.2</td>
<td>100</td>
</tr>
<tr>
<td>SDI</td>
<td>57 ± 2</td>
<td>13.0 ± 0.3</td>
<td>90</td>
</tr>
<tr>
<td>SD</td>
<td>NF</td>
<td>NF</td>
<td>0</td>
</tr>
</tbody>
</table>

2Newly emerged seedlings were placed in growth chambers under 16-hr long days (LD), 8-hr short days with a 1-hr light interruption midway through the dark period (SDI), or 8-hr short days (SD) and measured for flowering response within 100 days. Values for days to first flower and flowering node are the average of at least nine plants ± 3SE. NF = plants did not flower in this treatment.

were used, plants did not flower. Previous reports (Hammond and Palhamus, 1965; McGinnies, 1979) state that guayule is a day-neutral plant that flowers only when temperature and moisture conditions are favorable. This work clearly shows, however, that guayule is a long-day plant that has a critical daylength for flowering between 9.5 and 11 hr (Fig. 2). This result corroborates observations of field plantings in Arizona that begin flowering in mid-February when natural daylengths approach 11 hr and agrees with the suggestions made by Whitehead and Mitchell (1943). Guayule was sensitive to daylength and exhibited a classic LD response similar to other plants (Bernier, 1969).

Guayule appears to go through a juvenile phase, during which it was incapable of flowering, ever under LD. This period lasted ~35 days and extended from seed germination to the first seven nodes, after which induction was possible. This transition coincides with a change in leaf morphology, in which older leaves became lobed. Lobed leaves may be photo-inducible and nonlobed leaves may not. A previous report stated that flowering in guayule was not possible in plants younger than 6 months (Hammond and Palhamus, 1965).

Knowledge of the photoperiodic response of guayule may be useful to plant breeders and growers for several reasons. Seed production for transplants, direct seeding, and early seed for breeding programs could be better controlled. Also, if the plant conserved energy by not flowering, the energy could be directed toward increasing rubber content. However, to accomplish this, research is needed on chemicals capable of controlling flowering and on how to direct photosynthetic rubber into rubber or biomass production. If it is decided that guayule is most economically grown from seed, this information will help determine where to grow plants and when to begin watering for optimal flowering and seed production. Also, generation times possibly may be reduced to ~35 days and extended from seed germination to the first seven nodes, after which induction was possible. This transition coincides with a change in leaf morphology, in which older leaves became lobed. Lobed leaves may be photo-inducible and nonlobed leaves may not. A previous report stated that flowering in guayule was not possible in plants younger than 6 months (Hammond and Palhamus, 1965).

Most ornamental plants produced in containers are grown in media with at least 95 days from seed-to-seed by growing plants under artificial LD conditions. However, other considerations, such as cost and viability of seed produced under such a light regime, would have to be determined before this procedure can be applied in plant breeding.

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Medium and Hydrogel Affect Production and Wilting of Tropical Ornamental Plants

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Additional index words. Codiaeum variegatum, Dieffenbachia, Hibiscus rosa-sinensis, pH, electrical conductance, evapotranspiration

Abstract. Vetivera hydrogel at rates of 0, 1.75, or 2.50 kg m⁻³ was tested for the production of three tropical ornamental plant species in two or all of the three media. These were a commercial peat-lite medium (SUN), a medium consisting of equal volumes of peat moss, bark, and sand (PBS), and a mix containing equal volumes of peat moss and bark (PB). Codiaeum was grown in SUN and PBS, Dieffenbachia was produced in all three media, and Hibiscus was planted in SUN and PB. Codiaeum variegatum (L.) Blume ‘Norma’ and Dieffenbachia ‘Camille’ grew more and required a longer time to reach initial wilting when grown in SUN than PBS. Hibiscus rosa-sinensis L. ‘Brilliant Red’ had similar growth in SUN and PB. In general, hydrogel had no beneficial effect on plant growth in a greenhouse. Hydrogel extended the time required to reach initial wilting of C. variegatum by 3 days (from 24 to 27 days), but had no effect on D. variegata. Leachate from PBS had higher pH and lower electrical conductance (EC) than that from SUN. Hydrogel had no effect on leachate pH, but decreased EC of the leachate for C. variegatum used at the 2.5 kg m⁻³ rate and for H. rosa-sinensis at both rates.

Most ornamental plants produced in containers are grown in media without any mineral soil. Media composition may affect plant growth by altering the physical and chemical properties of the media. Philodendron oxycardium grew poorly in a medium containing bark and no peat (Poole and Waters, 1972). Beaucamea recurvata had greater growth in media containing bark and sand than a peat-lite medium (Wang and Sauls, 1988). Dieffenbachia maculata and Brassia actinophylla grown in a peat, bark, and sand medium were superior to plants produced in a peat, bark, and shavings medium (Poole and Conover, 1982). Lantana pictavi ‘Cream Carpet’ in a half peat and half sand medium grew twice as tall as plants in a medium containing half bark and half sand (Joiner and Conover, 1965). Growth of Pittosporum tobira, however, was unaffected by media containing various proportions of peat and sand or bark and sand (Joiner and Conover, 1965). Bark was shown to maintain plant turgidity for a longer time than peat moss (Beardsell et al., 1979).

Johnson (1984) reported that hydrogels improved the water holding capacity of porous soils and delayed the onset of permanent wilting where evaporation was intense.

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