Influence of Nutrition, Propagation Techniques, Light Intensity, and Insecticides on Episcia cupreata¹

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Abstract. Experiments were designed to develop information on commercial production systems for Episcia cupreata (Hook.) Hanst. (flame violet) encompassing nutrition, propagation, light intensity, and insect pest management. A 200–250 ppm N and 150 ppm K solution applied at a rate of 50 ml/10-cm pot per week provided adequate nutritional requirements for these major elements. Propagation techniques involving combinations of rooted or unrooted plantlets 5–13 cm in canopy diameter provided crop turnover rates from 4 to 12 weeks for production in 10-cm pots. Optimum light intensity was established at 17–22 klx. Acephate and oxamyl eliminated mealybugs (Ferrisia virgata) on Episcia plants and were not phytotoxic to the foliage.

Although Episcia cupreata, Gesneriaceae, does not share the popularity of the florist gloxinia or the African violet, it has many of the desirable traits of these close relatives. One of the most important attributes of Episcia is its ability to survive under low light conditions, making it suitable as a flowering house plant (3). Various reports (1, 2, 5, 6) describe production practices for the hobbyist, but limited information is available for commercial production systems. In this paper, data are presented on nutrition, propagation, light levels, and mealybug control for the commercial production of Episcia.

Materials and Methods

Experiment 1. Unrooted plantlets (7–9 cm diameter) of ‘Frosty’ and ‘Acajou’ Episcia were planted in 10-cm pots on July 29, 1977 and September 15, 1978, respectively. Potting medium was a volume mix of 5 Florida peat moss: 3 white builders’ sand: 3 horticultural-grade vermiculite: 1 coarse perlite, amended with 3 kg/m³ dolomite, 1.8 kg/m³ hydrated lime, 1.5 kg/m³ single superphosphate, and 1.2 kg/m³ Perk (a minor element mixture manufactured by Kerr-McGee Chemical Corporation). Plants were grown in a fiberglass greenhouse with interior polypropylene shade cloth providing a light intensity of 11–22 klx. Temperature ranged from 21°C night to 32° day. Three fertilizer solutions, (20.0 N–8.7 P–16.6 K from Nutrileaf fertilizer manufactured by Miller Chemical and Fertilizer Corporation at 200, 400, or 800 ppm N applied weekly, starting 1 week after potting, at a rate of 100 ml dilute solution per pot), were compared to determine their effects on flower and leaf numbers after 8 weeks. Plants were watered overhead when the soil surface was dry; about 100 ml was applied to yield 10 ml leachate per pot. Treatments were replicated 10 times in a completely randomized design and a single plant was the experimental unit.

Experiment 2. Three fertilizer regimes were tested. Regime 1 received a 50 ppm N solution 2 weeks after potting, 100 ppm N the 3rd week, and 200 ppm N for the next 5 weeks. Regime 2 received 100 ppm N two weeks after potting, 200 ppm N the 3rd week, and 400 ppm N for the next 5 weeks. Regime 3 received 200 ppm N, 400 ppm N, and 800 ppm N according to the above schedule. Fertilizer solutions were applied as 50-ml aliquots per pot, twice a week, from Nutrileaf. Cultivars, planting date, soil medium, environmental conditions, and experimental design were as in Experiment 1.

Experiment 3. Unrooted ‘Frosty’ plantlets were allowed to root in sand in 10-cm pots for 2 weeks. Fertilizer solutions varying in N from 0 ppm to 600 ppm in 50 ppm increments, with concentrations of P at 175 ppm and K at 400 ppm, were applied at the 3rd

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week as 50-ml aliquots per pot and continued for 8 weeks. In a similar test, K was applied with a range from 0 to 400 ppm in 50 ppm increments with concentrations of P at 175 ppm and N at 400 ppm. N was supplied from Ca(NO₃)₂ and KNO₃. K from KNO₃, KHCO₃ and K₂SO₄, and P from Ca₃(PO₄)₂. A microelement solution was applied at a rate of 30 ml/pot at week 4 and contained 54 ppm Mg, 1 ppm Fe, 0.5 ppm Mn, Zn, and B, 0.1 ppm Cu, and 0.01 ppm Mo. Fresh weight, leaf number, flower number, and leaf N and K (microKjeldahl and flame spectrophotometric determination, respectively) were determined 8 weeks after the first fertilizer application. Cutting size, environmental conditions, and experimental design were as in Experiment 1; cuttings were planted on October 12, 1979.

Experiment 4. ‘Frosty’ plantlets were divided into 5 size categories (5, 7, 9, 11, or 13 ± 0.5 cm canopy diameter), rooted in vermiculite for 2 weeks, and then transplanted to 10-cm pots. Osmocote (18.0 N-2.6 P-10.0 K) at 2.4 kg/m³ was incorporated into the media before planting and other factors were as in Experiment 1. Plant diameters were recorded 2, 4, 6, and 8 weeks after potting.

Experiment 5. Separate 2 x 3 factorial experiments, with either ‘Acajou’ or ‘Frosty,’ in a completely randomized design were initiated to determine the influence of rooted or unrooted plantlets and 3 plantlet sizes on the length of time to produce a marketable plant. A single plant constituted an experimental unit and treatments were replicated 10 times. Plantlets were either rooted for one week in vermiculite or potted directly in a 10-cm pot and divided into size categories of 5, 8.5, and 12 ± 0.5 cm diameter. Nutrileaf at 400 ppm N was applied twice each week at a rate of 50 ml per pot. The number of marketable plants was recorded 8 weeks after potting. Planting date was September 15, 1978; other environmental factors were as in Experiment 1.

Experiment 6. Polypropylene shade cloth was used to provide 80, 90, and 95% shade in a fiberglass greenhouse (17-22, 6-11, and 3-5 klx, respectively). Three enclosures at each light level contained 5 plants of ‘Frosty’ and ‘Acajou’ providing 3 replicates of 5-plant experimental units for each cultivar. Unrooted plantlets ca 8.5 cm diameter were used, and planting date, fertilizer, and environmental factors were as in Experiment 5. A rating scale of 1 to 5 was used, with 1 assigned to plants of highest quality and 5 to plants of poorest quality.

Experiment 7. The second light intensity experiment was conducted within a polypropylene shadehouse which provided 30% shade over the experimental area. Frames (46 × 92 × 92 cm) covered with polypropylene shade cloth provided 2 shade levels of 80% (17-22 klx light) and 55% (48-54 klx). Uncovered frames provided 30% shade (70-75 klx) to the plants. Single plants constituted the experimental unit and shade level treatments were replicated in 5 random blocks. Rooted cuttings of ‘Frosty’ and ‘Acajou’ were planted May 4, 1979 and evaluated at 7 weeks for number of leaves, plantlets, flowers, buds, and fresh weight, and were given a subjective rating on plant quality as in Experiment 6. Fertilizer rate was 50 ml/pot of a 400-ppm N solution as Nutrileaf applied twice each week.

Experiment 8. Eight insecticides were evaluated for control of the striped mealybug (Ferrisia virgata) infesting Episcia and for phytotoxicity to foliage and flowers (Table 4). The experimental design was a split-plot in 4 blocks with chemical treatments as whole plots and cultivars as subplots. Mealybug populations were established on 12-week-old ‘Acajou’ and ‘Frosty’ cultivars in a greenhouse by placing infested Caladium tubers into pots of test plants. Four weekly treatments of liquid preparations were applied, beginning June 15, 1978, with a sprayer equipped with an open cone nozzle and operated at 3 kg/cm². Plants were sprayed until all surfaces were wet. Temik, a granular insecticide, was applied as one of the treatments on the soil surface on June 15. Numbers of mealybugs and the phytotoxic responses of the foliage and flowers were determined 4 days after the last chemical application.

Results

Experiment 1. ‘Acajou’ was damaged by the high concentration of fertilizer (800 ppm N). The terminal shoot became water-soaked, necrotic, and then growth ceased. ‘Frosty’ was not as sensitive to the high fertilizer concentration, but similar symptoms were evident initially. Once the plants became established, those grown with 200 and 400 ppm solutions developed adequately (Table 1). Flowering was sporadic and did not appear to be influenced by fertilizer concentration.

Experiment 2. ‘Acajou’ responded most favorably to the fertilizer regime of treatment 1, with a fresh weight of 84 g/plant and no terminal necrosis, ‘Acajou’ grown at fertilizer regimes 2 and 3 had fresh weights of 49 and 44 g/plant, respectively. Nearly 50% of the ‘Acajou’ plants died or developed terminal necrosis at regimes 2 and 3. ‘Frosty’ was more salt-tolerant than ‘Acajou’ as similar fresh weights (86 and 92 g/plant) and no terminal necroses were found with regimes 1 and 2. The third regime was not satisfactory for ‘Frosty’; the terminal shoots of 20% of the plants developed necrotic areas and fresh weight was only 65 g/plant.

Experiment 3. Regression analyses indicated quadratic relationships for the effects of N and K on fresh weight, and shoot N and K treatments. Maximum growth, as measured by fresh weight, was estimated to be achieved at 338 ppm N and 261 ppm K. Plant width (max. 355 ppm N) and number of flowers and buds (max. 340 ppm) showed similar relationships with N treatments, while linear relationships were found for these parameters with K treatments.

Experiment 4. The mean diameter of ‘Frosty’ 8 weeks after potting 5-, 7-, 9-, 11-, or 13-cm plantlets was 14, 17, 23, 22.5 or 30 cm, respectively (Fig. 3). The mean number of plantlets per pot that had developed in 8 weeks was 0.8, 0.8, 1.8, 1.7, and 3.0, the mean number of flowers was 0.3, 0.8, 1.5, 1.0, and 1.2, and the mean number of leaves was 8, 9, 12.3, 10.6, and 9.8 for increasing initial plantlet sizes.

Experiment 5. The initial plantlet size affected the production time in a fashion similar to Experiment 4. After 5 weeks, 30, 100, and 100% of the plants were considered marketable from rooted

<table>
<thead>
<tr>
<th>Fertilizer rate ppm N</th>
<th>No. leaves</th>
<th>No. flower buds</th>
<th>Salt damaged shoots (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>8.0a</td>
<td>0.9</td>
<td>10%</td>
</tr>
<tr>
<td>400</td>
<td>6.1a</td>
<td>0.4</td>
<td>40%</td>
</tr>
<tr>
<td>800</td>
<td>0.4b</td>
<td>0.0 NS</td>
<td>90%</td>
</tr>
</tbody>
</table>

1. Plants were unrooted before treatment and evaluation was 8 weeks after transplanting.
2. 20 N-8.7 P-16.6 K from Nutrileaf.
3. Mean separation in columns within cultivar by Duncan’s multiple range test, 5% level.

Fig. 1. The effect of rates of N on fresh weight and shoot tissue N of *Episcia cupreata* 'Frosty'. The fit of the quadratic relationship was significant at the 1% level for both variables.

Fig. 2. The effect of rates of K on fresh weight and shoot tissue K of *Episcia cupreata* 'Frosty'. The fit of the quadratic relationship was significant at the 1% level for both variables.

Fig. 3. Influence of initial plantlet diameter on growth and marketability of *Episcia cupreata* 'Frosty' from 2 to 8 weeks after potting. Mean separation for each date after potting by Duncan's multiple range test, 5% level.

Table 2. Influence of light intensity on growth and flowering of *Episcia cupreata*, Expt. 6.

<table>
<thead>
<tr>
<th>Light intensity (klx)</th>
<th>Plant quality rating</th>
<th>No. leaves plant</th>
<th>Internode length (cm)</th>
<th>Fresh weight (g)</th>
<th>Flowering (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frosty</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-5</td>
<td>3.7a*</td>
<td>13.2</td>
<td>4.8a</td>
<td>-</td>
<td>53</td>
</tr>
<tr>
<td>6-11</td>
<td>2.8b</td>
<td>12.8</td>
<td>4.6a</td>
<td>-</td>
<td>73</td>
</tr>
<tr>
<td>17-22</td>
<td>1.8c</td>
<td>14.7ns</td>
<td>2.8b</td>
<td>-</td>
<td>73</td>
</tr>
<tr>
<td><strong>Acajou</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-5</td>
<td>2.6a</td>
<td>12.6</td>
<td></td>
<td>36c</td>
<td>20</td>
</tr>
<tr>
<td>6-11</td>
<td>2.0ab</td>
<td>13.0</td>
<td></td>
<td>55b</td>
<td>70</td>
</tr>
<tr>
<td>17-22</td>
<td>1.4b</td>
<td>11.2ns</td>
<td></td>
<td>71a</td>
<td>80</td>
</tr>
</tbody>
</table>

* Subjective rating from 1 (best) to 5.
* Mean separation in columns within cultivars by Duncan's multiple range test, 5% level.

differences among all treatments were observed in number of leaves (10-13) and stolons (2-3.5). However, the 12-cm cuttings averaged 6 flowers per plant which made them very desirable in both foliage and flower characteristics after 8 weeks, while the 8.5-cm plantlets averaged 4 and the 5-cm plants averaged only 1 flower per plant.

*Experiment 6.* The most satisfactory light level used in this test was 80% shade or 17-22 klx (Table 2). Flowering decreased in both cultivars at the 90 and 95% shade levels. 'Acajou' fresh weight and overall quality decreased and undesirable internode length increased at the higher shade levels; the general quality of those plants was diminished.

*Experiment 7.* Plants grown at the 17-22 klx light intensity had more leaves (with one exception) and stolons, a higher fresh
weight, and were of higher quality than those grown at the higher light intensities (Table 3). Generally, more flowers were observed as the light intensity dropped toward the 17–22 klx range.

Experiment 8. No mealybugs were observed following acep-tate (Orthene) and oxamyl (Vydate) programs (Table 4). Other treatments were effective in suppressing mealybug populations to very low levels. There was no significant effect on mealybug population density attributable to differences between Episcia cultivars or to cultivar x chemical treatment interaction.

No phytotoxicity developed on foliage treated by any of the chemicals. However, open flowers treated with Ethion, Metasystox-R, Resmethrin, Vydate, and Thiodan were spotted. Flower buds were unaffected by the chemical treatments, and a new complement of flowers developed quickly following insecticide application.

**Discussion**

Although the regression analysis estimated maximum fresh weight would result from a 338-ppm N rate, the flatness in the peak of the regression curve reveals relatively small differences in fresh weight from 200–250 through the 450-ppm N range. Similarly, the flat regression curve for K levels from 150–350 ppm indicated only slight differences in fresh weight, even though maximum response would be at a 261-ppm K rate. From a commercial standpoint, these differences would not be important, and producers should choose the lower rates. In addition, this test was run with ‘Frosty’ which is less sensitive to higher fertilizer rates than other cultivars. The 200-ppm N rates found satisfactory in nutrition tests 1 and 2 would tend to support this observation, with no significant benefit from increasing fertilizer rates as the plants grew. Since K is 83% of the K₂O labeled in commercial balanced fertilizers, most “balanced” fertilizers would provide an adequate N–K ratio.

Damage from excessive salts resulted from fertilizer concentrations that are commonly used for many flowering crops such as chrysanthemums and poinsettias. Episcia should be classed among the moderately salt-sensitive or low-fertilization plant groups, especially in the early propagation stage. In other tests (unpublished data), various microelement combinations and rates, media, and a pH range from 4 to 7 did not significantly influence growth, indicating most amended commercial media would be satisfactory.

Predicting crop turnover is especially critical with greenhouse crops because of costs associated with bench space-time relationships within the structure. ‘Frosty’ grown in 10-cm pots had sufficient number of leaves and flowers to be marketable when 15–20 cm in diameter or 1.5–2 times the pot diameter. When this guideline was followed, plantlet size at potting had a very significant effect on production time (potting to marketable stage). The 13-cm diameter plantlets were marketable in 10-cm pots 4–6 weeks after potting. The 9–11-cm plantlets required 6–7 weeks, while the 5–7-cm plantlets required 8–9 weeks from potting to a marketable stage (Fig. 3). Crop turnover was relatively constant with both cultivars during tests over the 3-year period when fertilizer rate was adequate. Scheduling should not be a problem with this crop.

**Episcia** are subject to chilling injury. A few hours at 10°C will kill many cultivars and little growth occurs with night temperatures below 15°C (2, 4, 5, 6, 7). In practice, growers should produce *Episcia* during summer months. The heavy shading that is required to achieve the low light levels (17–22 klx) determined optimum for production will also help keep greenhouse day tempera-

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Table 3. Influence of light intensity on growth and flowering of *Episcia cupreata*, Expt. 7.

<table>
<thead>
<tr>
<th>Light intensity (klx)</th>
<th>No. leaves/ plant</th>
<th>No. stolons</th>
<th>No. flowers and buds</th>
<th>Fresh wt (g)</th>
<th>Plant quality rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>70–75</td>
<td>4.5b</td>
<td>1.0</td>
<td>1.0b</td>
<td>9.1c</td>
<td>4.6a</td>
</tr>
<tr>
<td>48–54</td>
<td>9.8a</td>
<td>1.6</td>
<td>4.2a</td>
<td>16.2b</td>
<td>3.4b</td>
</tr>
<tr>
<td>17–22</td>
<td>11.8a</td>
<td>2.5x</td>
<td>6.0a</td>
<td>23.6a</td>
<td>1.8c</td>
</tr>
</tbody>
</table>

Table 4. Evaluation of insecticides for control of mealybugs and phytotoxicity to *Episcia cupreata*, Expt. 8.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Product/ 100 liters</th>
<th>Avg number mealybugs/plant</th>
<th>Phytotoxicity1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water check</td>
<td>—</td>
<td>36a</td>
<td>1.0</td>
</tr>
<tr>
<td>Ethion 4EC (ethion)</td>
<td>187 ml</td>
<td>3b</td>
<td>1.0</td>
</tr>
<tr>
<td>Metasystox-R 2EC (oxydemeton-methyl)</td>
<td>187 ml</td>
<td>6b</td>
<td>1.5</td>
</tr>
<tr>
<td>Orthene 75SP (acephate)</td>
<td>80 g</td>
<td>0b</td>
<td>1.0</td>
</tr>
<tr>
<td>SBP 1382 2EC (resmethrin)</td>
<td>125 ml</td>
<td>14b</td>
<td>2.0</td>
</tr>
<tr>
<td>Temik 10G (aldicarb)</td>
<td>1123 kg/ha</td>
<td>1b</td>
<td>1.0</td>
</tr>
<tr>
<td>Thiodan 3EC (endosulfan)</td>
<td>167 ml</td>
<td>19b</td>
<td>2.0</td>
</tr>
<tr>
<td>Vydate 2L (oxamyl)</td>
<td>500 ml</td>
<td>0b</td>
<td>1.0</td>
</tr>
</tbody>
</table>

1Subjective rating from 1 (best)—5.

2Mean separation within columns by Duncan’s multiple range test, 5% level. 

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tutes in the 21–32°C range. This should benefit employees working in the greenhouse, help reduce summer cooling costs, and provide a satisfactory temperature range. The low light requirements during summer months can be considered a positive factor in *Episcia* production.

Mites and aphids that are common pests of greenhouse floricultural crops were never observed on *Episcia* during the 4 years *Episcia* were grown at AREC-Bradenton. Southern armyworms, *Spodoptera eridania* (Cramer), were occasionally observed feeding on the foliage of *Episcia* but were controlled with methomyl (Lannate). Mealybugs appear to be the only major consistent insect problem. Several insecticides provided good control with only minor damage to open flowers. Greenhouse pests do not appear to be a major problem in *Episcia* production.

*Episcia* may well find a niche in the overall production of floricultural crops. It is a relatively fast crop, produced at a time when high temperature is a major problem for other commercial crops.

**Literature Cited**


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**Influence of Physical Stress on Photosynthesis and Transpiration of Apple Leaves**

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**Abstract.** Various treatments resulting in physical stress to leaves of apple (*Malus domestica* Borkh.) were tested for their influence on net photosynthesis (Pn) and transpiration (Tr). Brushing to simulate handling or wind rubbing reduced both Pn and Tr in one study and had little effect in another. Shaking 1 min/day had no influence on Pn or Tr. Six or more 1-cm cuts/leaf reduced Pn and had no effect on Tr. Removal of 20% of the leaf area and twenty-four 1-cm cuts/leaf reduced Pn in young expanding leaves; the amount of cut surface exposed by injury was more important than the amount of leaf area removed. Scoring and feeding of two-spotted spider mites (*Tetranychus urticae* (Koch)) reduced Pn.

Although environmental factors (2, 14, 19) and natural photosynthetic potential (3, 4) are the primary factors influencing photosynthesis (Pn) of apple leaves, various physical stresses due to cultural practices and pests may also influence Pn. The influence of pesticides (7) and various cultural factors (6) on Pn has recently been reviewed. Pn was not reduced until visible symptoms of apple scab, incited by *Venturia inaequalis*, or powdery mildew, incited by *Podosphaera leucotricha* (Ell. & Ev) Salm. (5, 22) appeared on the leaves; Pn reduction was related to the amount of leaf area infected. Several investigators have reported reduction in Pn due to mite feeding (1, 11). Hall and Ferree (12) simulated insect feeding using a cork borer to remove sections of leaves and found that a 10% or greater loss in leaf area caused a reduction in Pn. Poston et al. (17) found cork-borer damage was an adequate simulation of *Cynthia caldi* (L.) feeding on soybean and both resulted in reduction in net carbon exchange rate 12 hr after treatment. However, these studies did not investigate the influence of leaf injury resulting from cuts or breaks in the leaf blade without the loss of tissue.

Grace (10) in a review on wind damage to vegetation, suggested that the extent to which wind speed influences Tr and Pn depends on the magnitude of the boundary layer in relation to other resistances of the leaf. Wadsworth (23) investigated the effect of wind on *Brassica rapus* in a wind tunnel and indicated that net assimilation rate reached a maximum at low wind speeds and thereafter declined. Neel and Harris (16) found that gently shaking of liquidambar trees 30 sec/day resulted in significant reductions in growth and induced dormancy. Gently touching cocklebur leaves a few seconds/day to measure their length has been shown to result in a 30% reduction in their growth (20). Preston (18) found tree size was 12% greater and yield 67% greater on 13-yr-old permanent apple trees where the effect of wind was reduced 25% by interplanted trees. Under natural conditions, apple leaves are subjected to daily movement and rubbing and at times can be cut or torn by wind action or hail.

The series of studies reported here investigated the influence of various mechanical stresses on Pn and Tr of apple trees grown in containers.

**Methods and Materials**

'Golden Delicious' on Malling (M) 7 rootstocks were trained to a single shoot and grown in 20-cm diameter pots containing 2.9 liters of a medium composed of 3 parts loam soil: 1 part sphagnum peat: 1 part perlite (v/v/v). All trees received 15 g of slow release fertilizer (14N–6P–11K) placed on the soil surface with an additional 300 ml liquid fertilizer (20N–9P–16K) added monthly. The trees were grown in a greenhouse during late winter and spring of 1978.

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2Associate Professor of Horticulture and Professor of Entomology, respectively.

3We thank John H. Gregory and John C. Schmid for technical assistance.