Managed Allowed Deficits in Container Moisture that Produce Commercially Acceptable Plants

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Florida

Nature of Work: In peninsula Florida, annual irrigation water allotments for container-grown ornamentals are subject to approval by Water Management Districts. Very little data exist on irrigation requirements needed to produce quality plants within an economical time frame. Harrison (2) monitored 3 nurseries in the Tampa, FL, area and reported annual irrigation rates of 56 to 111 acre-inches. As the first phase towards determining irrigation requirements for ornamentals in containers, we sought to determine the managed allowed deficit (MAD) in container moisture which produced commercially acceptable plants within a production time frame.

In February 1994, 390 Viburnum odoratissum (sweet viburnum), Ligustrum japonicum, and Raphiolepis indica (Indian hawthorn) (high, medium, and low irrigation demanding species, respectively) were upcanned from #1 into #3 containers using a 60 pine bark: 30 sledge peat: 10 sand substrate. Sixty-five plants of a species were placed in five independently overhead irrigated areas. Additional plants were micro-irrigated three times daily to promote maximum growth. Within each area, two plants were suspended in lysimeters. Available moisture was determined for each plant initially and reassessed in mid-May. Moisture deficit treatments (MAD) consisted of resaturating the substrate between 0200 h and 0600 hr when 20, 40, 60, or 80% of available water had been lost from both plants. Containers were considered resaturated when mean increases in plant/container weight were less than 20 g in 10 min. Control plants were irrigated at 0.75-inch daily, independent of rainfall. Plants were managed to promote commercial quality.

On 25 August, nurserymen examined plants within each unmarked treatment and judged whether an acceptable percentage were marketable. Afterwards, plants were graded according to the new Florida Grades and Standards for Nursery Crops (1). Growth measurements were recorded on 10 randomly-selected plants from each area and shoot dry weights were obtained. These measurements were compared to those of commercially produced plants.

Results and Discussion: During the 6 months of growth, rainfall exceeded the average by about 10 inches (33.9 inches total). Spring rainfall was below average, with most of the excess falling in late May, late June, and late July through August.

Based on grower evaluations, only the 20% MAD treatment produced acceptable plants for all species (Table 1). For hawthorne, a simple majority considered plants irrigated at 40% MAD to be commercially acceptable. Ligustrum irrigated at 0.75-inch were not acceptable, even though these plants were used to schedule time of evaluation.
Contrasting survey results, most treatments produced high percentages of marketable plants by the Grades and Standards (Table 2). Only plants graded No. 1 or Fancy were considered marketable. To be economically valid, only a 5% cull rate was allowed with about one-half the plants rated as Fancy. MAD treatments of 40%, 40%, and 20% for hawthorn, ligustrum, and viburnum, respectively, satisfied both requirements. Increasing the MAD affected quality by reducing the percentage of Fancy plants, more than reducing the number of marketable plants.

Table 1. Percentage of 30 nurserymen who judged that plants within each treatment met average marketable quality.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hawthorn</th>
<th>Ligustrum</th>
<th>Viburnum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75-inch</td>
<td>90</td>
<td>43</td>
<td>97</td>
</tr>
<tr>
<td>20%MAD</td>
<td>90</td>
<td>73</td>
<td>80</td>
</tr>
<tr>
<td>40%MAD</td>
<td>67</td>
<td>27</td>
<td>3</td>
</tr>
<tr>
<td>60%MAD</td>
<td>7</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>80%MAD</td>
<td>30</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 2. Effect of irrigation treatment on the percent marketability as graded by the new Florida Grades and Standards. Means represent 65 single plant replicates.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hawthorn Total</th>
<th>Hawthorn Fancy</th>
<th>Ligustrum Total</th>
<th>Ligustrum Fancy</th>
<th>Viburnum Total</th>
<th>Viburnum Fancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75-inch</td>
<td>100</td>
<td>58</td>
<td>98</td>
<td>74</td>
<td>100</td>
<td>85</td>
</tr>
<tr>
<td>20%</td>
<td>97</td>
<td>48</td>
<td>97</td>
<td>68</td>
<td>100</td>
<td>82</td>
</tr>
<tr>
<td>40%</td>
<td>97</td>
<td>60</td>
<td>97</td>
<td>48</td>
<td>89</td>
<td>60</td>
</tr>
<tr>
<td>60%</td>
<td>94</td>
<td>15</td>
<td>83</td>
<td>32</td>
<td>90</td>
<td>65</td>
</tr>
<tr>
<td>80%</td>
<td>95</td>
<td>28</td>
<td>55</td>
<td>23</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Micro-irrigated</td>
<td>100</td>
<td>66</td>
<td>98</td>
<td>74</td>
<td>98</td>
<td>92</td>
</tr>
</tbody>
</table>

*Percentage of 60 plants graded as Florida Fancy or No. 1.
Growth measurements of commercial plants were merged into a single group per species for analysis. Commercial hawthorn were similar in plant size (GI) and dry weight to those grown with 60% and 80% MAD (Table 3). However, commercial hawthorn plants were smaller than those usually sold due to excessive demand. Commercial ligustrum had the highest shoot dry weight with a GI comparable to micro-irrigated and 20% MAD plants (Table 3). Since micro-irrigated plants of all species were maintained at the highest water status, it is very unlikely larger commercial plants would be the same age, especially since older plants would have higher shoot dry weights due to more woody trunk mass. Commercial viburnum had shoot dry masses comparable to micro-irrigated plants, but with smaller canopies (Table 3), suggesting commercial viburnum were also older than the experimental plants. Growth indices of commercial viburnum were comparable to the control and 20 and 60% MAD treatments.

### Table 3. Comparison of growth indices between treatment and commercial plants.
Marketed plants from 3 to 6 nurseries were combined for the commercially-produced values.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Hawthorn GI(m³)</th>
<th>Hawthorn Dwt(g)</th>
<th>Ligustrum GI(m³)</th>
<th>Ligustrum Dwt(g)</th>
<th>Viburnum GI(m³)</th>
<th>Viburnum Dwt(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.75-inch</td>
<td>0.083 b</td>
<td>167 c</td>
<td>0.248 b</td>
<td>171 de</td>
<td>0.233 b</td>
<td>142 c</td>
</tr>
<tr>
<td>20%</td>
<td>0.088 b</td>
<td>196 b</td>
<td>0.330 a</td>
<td>210 c</td>
<td>0.264 b</td>
<td>187 b</td>
</tr>
<tr>
<td>40%</td>
<td>0.083 b</td>
<td>177 bc</td>
<td>0.235 b</td>
<td>188 cd</td>
<td>0.167 c</td>
<td>131 c</td>
</tr>
<tr>
<td>60%</td>
<td>0.054 c</td>
<td>117 d</td>
<td>0.179 c</td>
<td>164 d</td>
<td>0.224 b</td>
<td>162 bc</td>
</tr>
<tr>
<td>80%</td>
<td>0.061 c</td>
<td>132 d</td>
<td>0.143 c</td>
<td>135 e</td>
<td>0.102 d</td>
<td>88 d</td>
</tr>
<tr>
<td>Micro-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>irrigated</td>
<td>0.128 a</td>
<td>231 a</td>
<td>0.360 a</td>
<td>275 b</td>
<td>0.384 a</td>
<td>238 a</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.059 c</td>
<td>134 d</td>
<td>0.327 a</td>
<td>349 a</td>
<td>0.241 b</td>
<td>236 a</td>
</tr>
</tbody>
</table>

*Means with the same letter are not significantly different at _ = 0.05 using Fishers Protected LSD. Means are representative of 10 plant replicates.

For hawthorn, survey and grade data indicate plants irrigated at 40% MAD produced acceptable quality. Ligustrum grown at a 20% MAD were of grower-acceptable quality and similar size to commercial plants. The only MAD treatment that produced acceptable viburnum was the 20% moisture deficit. Similarly, photinia growth was maximized using a 25% MAD irrigation regime (3).
Significance to Industry: High, medium, and low water requirement landscape ornamentals can be grown to marketable size in 6 months after upcanning to #3 containers using daily irrigation rates of 0.75 inches, if 34 inches of rainfall occurs principally towards the end of the period. Equivalent plants were produced when irrigation was based on 20%, 20%, and 40% container moisture deficits for high, medium, and low irrigation demanding species, respectively, and the substrate was resaturated each time. Less frequent irrigation, smaller irrigation volumes or less rainfall would extend the time required for plants to reach marketable size by reducing growth rates.

Literature Cited


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Comparison of Morphological Features Affecting Water Loss in Norway Maple and Washington Hawthorn Stems

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Nature of Work: The composition and thickness of specialized protective layers that minimize water loss to the atmosphere vary by species. Crataegus phaenopyrum (Washington hawthorn) stems are known to become water stressed during cold storage at a faster rate than those of Acer platanoides (Norway maple) (1). However, there are no reports on the cuticular and peridermal characteristics of these species and on the possibility that these anatomical aspects are responsible for the species specific water loss traits. The objective of this study was to compare the degree of stem suberization and cuticular wax content and distribution of Norway maple (desiccation tolerant) and Washington hawthorn (desiccation sensitive) stems.

Cuticle studies. Five distal, middle and proximal stem segments of each species were removed from cold storage. A 0.75 cm cross-sectional portion of each stem segment was excised at a point near the middle of the stem segment. Tissue was fixed, sectioned and stained. Wax content was determined on five 27 cm (9 in) stem segments per species. Wax was removed by dipping stem sections for 30 seconds in 7 ml of chloroform contained in a preweighed glass test tube. The wax was filtered through Whatman No. 1 filter paper, evaporated to dryness under nitrogen and the test tube reweighed to determine net wax content (3). Each 27 cm stem segment was divided into nine 3 cm (1.2 in) long sections to calculate wax content as a function of distance from the stem apex.

Periderm suberization and analysis of hawthorn stem cracking. Sections were stained using Sudan IV in ethylene glycol (4) to detect relative amounts of suberin in periderm layers. Additional middle and proximal hawthorn stem segments containing longitudinal cracks were fixed, stained with Sudan IV and sectioned. Sections were examined with a light microscope to determine the depth and approximate dimensions of stem cracks. An environmental scanning electron microscope (ESEM) was used for examination of stem surface characteristics of both species. Use of this instrument eliminated the need for tissue fixation, dehydration and coating.

Results and Discussion: Cuticular wax. Examination of hawthorn stem cross-sections using light microscopy revealed that a relatively thick (10-20), uniform cuticle was present on the distal portion (0-10 cm). Maple cuticle at this stem location appeared as thick as hawthorn (photo not shown). Cuticle wax content decreased with increasing distance from the stem apex for hawthorn and maple (Fig. 1). However, hawthorn wax content at 27 cm from the apex was 0.10 mg/cm² whereas the corresponding value for maple was _ 0.2 mg/cm². Cuticle wax content can be an important factor affecting cuticular transpiration (2). Low wax content may contribute to the dieback of seedling tips which often occurs after transplanting. The species wax content differences do not appear to be large enough to account for the differing stem
water loss rates observed between hawthorn and maple in previous studies (1). Decreasing wax content with increasing distance from the stem apex may be due to decreasing production in the older portions of the stem as well as wax erosion by environmental factors.

**Tissue suberization:** Microscopic analysis of distal segment cross-sections showed a higher degree of suberization in maple periderm cells than in hawthorn periderm (photos not shown). The relatively high degree of maple periderm suberization found 10 cm from the stem apex continues into the middle (10-20 cm) and proximal (20-30 cm) stem locations. In contrast, the relatively low amount of hawthorn periderm suberization at the distal location is also evident at the middle stem location. Only at the proximal stem location (20-30 cm) is an increase in relative amounts of suberization apparent. Thus, as with the cuticular wax distribution (low wax content at proximal location), the low degree of suberization in the desiccation sensitive hawthorn may contribute to increased water loss and typically low post-transplant survival rates. The periderm of *Betula pendula* Roth. was shown to be very permeable to water transport as a result of little or no suberization of cell layers within the periderm (5).

**Stem cracking:** Examination of hawthorn stem surfaces using scanning electron and light microscopy revealed the presence of small longitudinal cracks or fissures (Fig. 2A). The cracks became noticeable between 10-20 cm from the stem apex and continued toward the proximal end of the stem. Few cracks were observed within 7 cm of the stem tip. Dimensions of the cracks were highly variable, depending upon distance from stem apex. Near the apex cracks generally were less than 75 microns wide and less than 400 microns long, while 20-30 cm from the stem apex cracks were usually 0.5-1.0 mm wide by 4-10 mm long. Cross sectioning stems through these cracked regions revealed that the depth of the openings usually extended at least through the cuticle and epidermis if present, and often extended through the periderm into cortical tissue. Cross sections made above or below the stem cracks disclosed the presence of open cavities enclosed by a layer of periderm several cells thick. This suggested that the amount of cortical tissue exposed by the crack exceeds the actual dimensions of the crack. Cracking in the middle (10-20 cm) section of the stem was estimated to account for 3 to 7% of the stem surface area and cracks in the proximal (20-30 cm) portion of the stem accounted for 5 to 12% of the stem surface area (data not shown). The location at which stem cracks usually appear on hawthorn stems corresponds with stem locations with low epicuticular wax content (Fig. 1). In contrast to hawthorn, examination of maple stems using scanning electron and light microscopy revealed a generally uniform stem surface with few disruptions in the cuticle or epidermis (Fig. 2B).

**Significance to Industry:** These findings, at least in part, explain the relative desiccation tolerance and high survival rates of Norway maple and the desiccation sensitivity and low survival rates of Washington hawthorn. Coating stems of the desiccation sensitive hawthorn trees with an antidesiccant compound before transplanting greatly reduced water stress and improved growth. While growers should take precautions to protect the roots of all bare-root stock from desiccating conditions during and after storage, sensitive species such as Washington hawthorn require both root and shoot protection to minimize water loss and increase survival.


Growth Responses to and Physical Properties of an Isolite-Amended Container Medium

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**Nature of Work:** Isolite (Isolite Insulating Product Co., LTD, Aich-Ken, Japan) is a porous ceramic medium amendment. Granules of Isolite acquire their characteristic microporosity during the process of rotary kiln firing diatomaceous earth and “natural” binding agents at temperatures of 1000°C. Isolite’s primary market is golf courses for use in tee boxes and greens, where soils consist principally of sand and require regular irrigation for proper maintenance. Anecdotal testimony from numerous golf course superintendents continues to support strong sales of Isolite (and similar American brands) to these target markets. More recently, distributors have attempted to increase sales of Isolite by expanding its use to include landscape horticulture and greenhouse production. Under these scenarios, Isolite may improve medium physical properties, including water-holding capacity and water release, maintain acceptable plant growth under reduced irrigation frequency, and prolong plant survival during drought. The objectives of this study were to determine how an Isolite-amended container medium influenced: (1) growth of *Impatiens* ‘Accent Red’ under different frequencies of irrigation, (2) water stress of *Impatiens* ‘Accent Red’ during drought, and (3) substrate physical properties and water release.

On 2 June 1993, 200 uniform 10-week old seedlings of *Impatiens* Hook.f. ‘Accent Red’ were transplanted into 10.5 liter black plastic pots containing a 4 composted pine bark : 1 coarse sand (by volume) media mix amended with Isolite CG-1 granules at rates of 0%, 10%, 15%, or 20% (by volume). These four media mixes were then amended with controlled-release fertilizer (Grace Sierra, Milpitas, CA) at a rate of 8.0 g L⁻¹ (17N-2.6P-8.4K plus minors) and dolomitic limestone at a rate of 3.6 g L⁻¹. **Experiment I.** Seedlings (5 reps) were irrigated (500 ml tap water) every 2 days for 2 weeks followed by a 4-week treatment period of irrigation every 1, 2, 3, 4, or 5 days. Upon inception of the treatment period, visual marketability rating and relative growth rate were determined weekly to examine the effects of irrigation frequency and Isolite amendment rate on plant growth. Plants were harvested from 15 to 23 July. Total leaf area was measured. Leaves, stems, and washed roots were dried separately in a forced air oven and then weighed. **Experiment II.** Seedlings (5 reps) were irrigated (500 ml tap water) every 2 days for 5 weeks followed by a 2-week drought. Upon inception of the drought, visual wilt rating, leaf expansion rate, and mid-day xylem pressure potential were measured at the same time each day to determine the effects of Isolite amendment rate on plant water stress. **Experiment III.** Following these greenhouse studies, physical properties and water release dynamics of Isolite-amended media mix treatments were analyzed in a laboratory setting. Mixes were evaluated for bulk density, total porosity, capillary porosity, air porosity, and water release between matric potentials of -1.0 and -73.4 kPa.
Results and Discussion. **Experiment I.** All plant growth variables significantly increased linearly with increasing irrigation frequency. However, as Isolite amendment rate increased, relative growth rate significantly decreased linearly. Marketability rating, plant dry weight variables, and leaf area were not significantly different among Isolite amendment rates. **Experiment II.** After drought initiation, as Isolite amendment rate increased, leaf expansion rate significantly decreased quadratically. Visual wilt rating and mid-day xylem pressure potential were not significantly different among Isolite amendment rates. **Experiment III.** As Isolite amendment rate increased, bulk density decreased linearly. Total porosity significantly increased linearly with increasing Isolite amendment rate due to associated linear increases in air porosity, but not capillary porosity. Water absorption significantly increased linearly with increasing Isolite amendment rate.

Significance to Industry. These data suggest that a 4 composted pine bark: 1 coarse sand container medium amended with Isolite had no beneficial qualitative or quantitative effects on growth under reduced frequency of irrigation or water stress during drought of *Impatiens 'Accent Red'* growing in a conventional bark-sand container media. Laboratory analysis of treatment media mixes established that Isolite amendments increased the porosity of the medium by creating large pores between particles of the media matrix. However, these macropores readily drained following saturation under normal gravimetric forces, resulting in no increase in capillary porosity and, therefore, water-holding capacity. Furthermore, the majority of water held within the pores of Isolite granules was unavailable for plant uptake within the range of matric potentials tested.