in the future and meetings established for discussion and comment. The interim measures of today could be BMPs communicated to the public in the future, so it is vital to develop interim measures that are beneficial and useful for the nursery industry.

**USE OF SUBIRRIGATION TO REDUCE FERTILIZER RUNOFF**

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**Abstract.** The growth of areca palm (*Dypsis lutescens* (H.Wendl.)) Beentje & J. Dransf.) and philodendron (*Philodendron* Schott. ‘Hope’) plants was compared between subirrigation and overhead irrigation systems. Plants were fertilized with top-dress application of Osmocote 15N-4.1P-9.96K at 7, 10, or 14 g per pot. The amount of water used by both irrigation systems as well as the amount of nitrate-nitrogen (NO$_3$-N) lost to the environment from each system also was recorded. Ten times less water was used per square meter of bench space with the subirrigation system than with the overhead system. No NO$_3$-N was lost to the environment from the subirrigation benches because the irrigation solution was captured and reused after each watering while the cumulative amount of NO$_3$-N lost per square meter of bench space from the overhead watered plants by the end of the experiment was 1149 mg. For both irrigation systems, plant growth increased as the fertilizer application rate increased. Shoot dry mass of philodendron plants fertilized with 7 or 14 g was greater in subirrigated pots than in overhead watered pots. However, the shoot dry mass of philodendron plants fertilized with 14 g were greater in overhead watered pots. At all fertilization rates, areca palm shoot dry mass was greater in overhead watered pots.

Conservation of water and reducing runoff of fertilizer salts from greenhouse irrigation systems is concerns for many growers (Elliott, 1990; Evans et al., 1992). The use of a subirrigation system that captures and re-uses the irrigation solution is one method for eliminating greenhouse runoff. Other methods include reducing leaching fractions, changing to substrates with higher water-holding capacities, or changing the type and amount of fertilizer used (Biernbaum, 1992). For example, Broschat (1995) reported that nutrient leaching for spathiphyllum and areca palm plants was highest with the soluble type of fertilizers and lowest for the controlled-release type of fertilizers. The objectives of this project were to grow selected tropical ornamental plants using a controlled-release fertilizer product and to compare the growth of plants grown in a subirrigation system to plants grown using overhead irrigation. A second objective was to compare the amount of water used and NO$_3$-N leached/captured by each irrigation system.

**Materials and Methods**

In April 1999, liners of areca palm and philodendron ‘Hope’ were transplanted into 800 ml round pots filled with 50% composted pine bark, 40% Florida sedge peat, and 20% sand (by volume) substrate. At transplanting all pots were top-dressed with Osmocote 15N-4.1P-9.96K (8 to 9 month release) (The Scotts Co., Marysville, OH) at 7, 10, or 14 g per pot. Plants were exposed to air temperatures of 30/21°C ± 3°C day/night.

The three fertilization rates were replicated four times over a total of twelve Ebb-Flow Benches (Midwest GroMaster, Inc., St. Charles, IL). All experiments were arranged as a split-plot with irrigation as the main plot and fertilization rate as the sub-plot. Five pots per species were placed on each of the twelve Ebb-Flow benches. Plants were watered daily by flooding each bench with water to a depth of 2.5 to 3 cm and draining after 10 min. The water in the subirrigation tanks was not changed throughout either experiment. Weekly samples were collected from each subirrigation tank to determine NO$_3$-N concentrations and then the volume of water used to bring tanks back to initial volume was measured.

Five additional pots per species were placed on one of twelve bench sections with the same pattern as the Ebb-Flow benches. Overhead watered pots were placed in a flat supported 2-cm above the bottom of another flat without holes to collect the leachate. Pots were watered daily using Robert’s sprinkler heads set 60 cm above the benches. Each overhead watered plant was watered to establish a 0.2 leaching fraction. Daily leachate samples were collected and poured into a covered 38-L container. Once a week, leachate volume was recorded and samples were collected to determine NO$_3$-N concentrations.

**Literature Cited**

Sixteen weeks after transplanting, plants were harvested when 75% of the plants had reached a marketable size according to industry standards. Shoots dry mass was determined for each plant. Substrate samples also were collected. The surface 1 to 2 cm of the 9 cm substrate column from each pot was removed to ensure that substrate samples were collected from the active root-zone. Nutrients were extracted with distilled water using the saturated media extraction method (SME) (Warncke, 1986). Substrate EC was determined from the extracted solution using a platinum electrode at 25°C (Acumet model 20 pH/conductivity meter, Fisher Scientific, Pittsburgh). Solution NO₃-N was determined using an NO₃-N specific ion electrode (Accumet model 1003 meter, Fisher Scientific, Pittsburgh). All data were analyzed using ANOVA as well as linear and quadratic regression models to examine trends in fertilizer application rate (SAS Systems, SAS Institute, Cary, NC).

**Results and Discussion**

**Solution Analysis.** Approximately ten times more water was used per square meter of bench space for overhead watered benches than for the subirrigation benches (Fig. 1). Previous research also reported that the use of subirrigation reduces total water use compared with overhead irrigation (Klock-Moore and Broschat, 1999; Dole et al., 1994; Holcomb et al., 1992; Elliott, 1990).

No NO₃-N was lost to the environment from the subirrigation benches because the irrigation water was captured and re-used. However, the concentration of NO₃-N in the solution captured from the subirrigation benches and the concentration of NO₃-N in the solution leached from the overhead watered benches increased over time (Fig. 2). The final NO₃-N concentration in the solution in the subirrigation tanks was seven times less than the total amount of NO₃-N leached from the overhead watered benches (Fig. 2). Because the majority of irrigation solution in subirrigation systems is taken up via capillary action, little solution flows out of the substrate on subirrigation benches (Barrett, 1991; Biernbaum, 1993; Weiler, 1996). We would not expect high concentrations of NO₃-N in the solution captured in the subirrigation tanks. However, water leached from overhead watered pots probably would contain fertilizer salts (Barrett, 1991; Biernbaum, 1993; Weiler, 1996).

**Plant Growth.** For both irrigation systems, philodendron and areca palm shoot dry mass increased as the fertilizer application rate increased (Fig. 3). Final substrate EC also increased as fertilization rate increased (Table 1).

Philodendron shoot dry mass was greater in subirrigated pots than in overhead watered pots when plants were fertilized with 7 or 10 g, but philodendron shoot dry mass was greater in overhead watered pots when plants were fertilized with 14 g per pot (Fig. 3). At all fertilization rates, areca palm shoot dry mass was greater in overhead watered pots than in subirrigated pots (Fig. 3).

Substrate EC concentrations in the subirrigated substrates were significantly higher than the concentrations in overhead watered substrates (Table 1). One of the drawbacks of using subirrigation is the accumulation of salts in the upper half of the substrate and the potential for the accumulation of salts to increase with time (Lieth, 1996; Guttormsen,
1969). Areca palm plants are sensitive to soluble salt concentrations in the substrate while philodendron plants are heavy feeders requiring generous amounts of fertilizer (Griffith, 1998). According to Warncke and Krauskopf (1983), soluble salt concentrations of 3.5 to 5 dS·m⁻¹ are slightly higher than desirable but are suitable for high-nutrient requiring plants. However, concentrations greater than 6 dS·m⁻¹ are often associated with severe salt injury. It appears that philodendron plants were not as sensitive to salts in the subirrigation substrates at the lower fertilization rates but were sensitive to salts at the highest fertilization rate while areca palms were sensitive to the high soluble salts in the subirrigated substrates at all three fertilization rates.

Subirrigation systems like the one used in this experiment that capture and re-use the irrigation solution are a good method for eliminating runoff of NO₃-N from the greenhouse. Overhead irrigation, on the other hand, is a high water use method for reducing water use. Average water use was found to be only about 50 cm·yr⁻¹ due to re-use of the irrigation system solution. However, concentrations greater than 6 dS·m⁻¹ are often associated with severe salt injury. It appears that philodendron plants were not as sensitive to salts in the subirrigation substrates at the lower fertilization rates but were sensitive to salts at the highest fertilization rate while areca palms were sensitive to the high soluble salts in the subirrigated substrates at all three fertilization rates.

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### Literature Cited


### Table 1. Final substrate electrical conductivity concentrations for philodendron and areca palm substrates fertilized with Osmocote 15N-4.1P-9.96K top-dressed at 7, 10, or 14 g per pot and watered using subirrigation or overhead irrigation.

<table>
<thead>
<tr>
<th>Fertilization rate (g/pot)</th>
<th>Subirrigation EC (dS·m⁻¹)</th>
<th>Overhead irrigation EC (dS·m⁻¹)</th>
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</thead>
<tbody>
<tr>
<td>7</td>
<td>5.34</td>
<td>1.48</td>
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<td>10</td>
<td>6.89</td>
<td>2.77</td>
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<td>14</td>
<td>10.20</td>
<td>3.14</td>
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<td>2.46</td>
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<td>Philodendron</td>
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<td>7.65</td>
<td>1.72</td>
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<tr>
<td>10</td>
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</table>

Abstract. Irrigation and nutrient management practices research was conducted to develop recommendations for nitrogen best management practices (BMPs) for leatherleaf fern [Rumohra adiantiformis (Forst.) Ching] production. Primary research components consisted of a literature review, an on-farm grower survey, creation of a geographical information system soils database, experiments using gravimetric lysimeters, larger scale experiments in research shadehouses, and field studies at commercial ferneries with surficial aquifer monitoring. None of the previous research on leatherleaf fern had a leachate water quality component. Using lysimeters, crop water use was found to be only about 50 cm·yr⁻¹ due to reduced radiation and other factors inside the shadehouse. For established fern, commercially acceptable frond yields and quality, as well as leachate nitrate-nitrogen concentrations below the maximum EPA limit of 10 mg·L⁻¹ were obtained with nitrogen application rates from 114 to about 335 kg·ha⁻¹·yr⁻¹.