Fertilizer Levels and Medium Affect Foliage Plant Growth in an Ebb and Flow Irrigation System[1]

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Abstract

Three species of foliage plants were produced with three media, in an ebb and flow irrigation system (experiments 1 and 3) or with overhead manual irrigation (experiments 2 and 4). Expt. 1 used a constant feed program of 24N-3.5P-13K (24-8-16) soluble fertilizer added to the water supply at rates of 0.21, 0.42, 0.63 or 0.84 g/L. In experiments 2, 3 and 4, plants were fertilized with a constant feed program using the soluble fertilizer at 0.63 g/L or with a 19N-2.6P-10K (19-6-12) slow release fertilizer at rates of 2.5, 5.0 or 7.5 g/15 cm (6 in) pot. Plants produced in a Canadian sphagnum peat:pine bark mix were shorter and received lower plant grades compared to Fafard #4 and Vergro Container Mix. Height increase and plant grade for all plants was greater when fertilizer rate was increased from 0.21 to 0.42 g/L (0.79 to 1.58 g/gal), but height increase and plant grade did not improve much as fertilizer rates rose beyond 0.42 g/L (1.58 g/gal). In expt. 3, increase in height and plant grade for plants treated with 0.63 g/L (2.36 g/gal) soluble fertilizer was similar to height increase and plant grade for plants receiving the 5.0 and 7.5 g/15 cm pot slow release fertilizer.

Index words: Irrigation, medium, fertilization

Species used in this study: Petra croton (*Codiaeum variegatum* (Lodd.), Camille dieffenbachia (*Dieffenbachia maculata* [Lodd.] G. Don), Petite spathiphyllum (*Spathiphyllum* × Petite)

Significance to the Nursery Industry

During the next decade, federal, state and local regulating agencies will likely begin to regulate limits on nitrate runoff from agricultural enterprises, including greenhouses and nurseries. Environmental plant producers need to implement more efficient watering systems in order to meet new standards which will be set to conserve water, control greenhouse runoff and limit ground water contamination. Producers will require information demonstrating how these new water management technologies will affect other components of the total production regime, such as fertilization and medium selection, in order to implement systems that best meet their individual requirements. Results from these tests clearly indicate that salable quality *Codiaeum variegatum* 'Petra', *Dieffenbachia maculata* 'Camille' and *Spathiphyllum* 'Petite' can be grown in an ebb and flow system using either liquid or slow release fertilizer, if the proper growing medium is selected. *Dieffenbachia maculata* 'Camille' produced from this system continue to be attractive when moved to an interior environment.

Introduction

Ground water contamination as well as pollution of lakes and rivers caused by nitrates from site runoff has become a major global environmental concern. These issues and the related problem of shrinking water reserves due to pollution and depletion of water resources are of growing interest to the environmental plant industry (11). Constant feed liquid fertilizer production regimes relying on loose porous growing media and excessive amounts of irrigation water to provide leaching can produce unacceptable levels of nitrates in runoff water (2, 13). Conservation measures researched and successfully adopted by the industry in recent years in order to conserve water and limit runoff include drip irrigation, capillary mat irrigation, slow release fertilizers and various closed hydroponic systems (3, 4, 5, 7, 8, 12, 13, 14). New production methods requiring even less water and fertilizer in order to create little or no runoff, such as pulse irrigation and other sophisticated automated computer controlled irrigation systems, recycling irrigation runoff, the use of absorbent gels and higher quality growing media, are being examined by producers of landscape, nursery and floral plants (1, 3, 9, 10, 15). Some conservation techniques, like ebb and flow irrigation systems, have been around for decades, but until recently, were perceived as too complicated or expensive by the majority of U.S. foliage and nursery crop producers.

Previous research on fertilization levels for foliage plants produced in closed irrigation systems or in sub-irrigation systems mainly focused on slow release fertilizers or hydroponic culture (4, 5, 7, 12). The recommended application rates for liquid fertilizer on foliage plants have been established based on overhead irrigation (6). The following research was initiated to examine how medium composition, fertilizer source and fertilizer application rate affect plants produced in an ebb and flow system.

Materials and Methods

Experiment 1, a 3 × 4 factorial experiment with 8 replications was initiated on April 4, 1990, when liners of *Codiaeum variegatum* 'Petra', *Dieffenbachia maculata* 'Camille' and *Spathiphyllum* 'Petite' were potted into 15 cm (6 in) containers using one of the three growing mixes tested. Growing media tested in all four experiments were:

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1) Fafard Container Mix #4[3] composed of Canadian sphagnum peat moss, pine bark, vermiculite, a wetting agent and a starter nutrient charge; 2) Vergro Container Mix A[4] composed of Canadian sphagnum peat moss, coarse grade vermiculite, perlite (2:1:1 by volume), a wetting agent and a starter nutrient charge and 3) a non-commercially manufactured medium composed of Canadian sphagnum peat moss and pine bark (1:1 by vol), a commonly used peat to bark ratio, amended with a 3.2 kg/m^3 (7 lb/yd^3) dolomite, 0.68 kg/m^3 (1.5 lb/yd^3) Micromax[5] and Aqua-Gro,[6] a wetting agent.

Plants were grown on light weight 1.486 m^2 (16 ft^2) plastic bench sections.[7] Four replications of each medium per species tested were included per tray, so that each tray initially held 36 plants arranged in random order. Trays were set on benches in a greenhouse receiving 300 μmol $\cdot$ s^{-1} $\cdot$ m^{-2} (2000 ft-c) maximum light and minimum and maximum temperatures of 18° and 32°C, respectively (64° and 90°F). A 24N-3.5P-13.3K (24-8-16) soluble fertilizer specially formulated for use on tropical foliage[8] was added to the irrigation water at rates of 0.21, 0.42, 0.63 or 0.84 g/L (0.79, 1.58, 2.36 or 3.14 g/gal) so that nitrogen rates tested in experiment 1 were 50, 100, 150 and 200 ppm.

Irrigation water for each bench was stored in a heavy duty closed Rubbermaid[9] 121 liter (32 gal) container and volume was maintained at 93 L (25 gal) by weekly monitoring. Tap water used to fill containers had a pH of 7.3, 330 μmhos/cm, 27 ppm Ca, 7 ppm Mg, 4 ppm Na, 13 ppm Cl, 21 ppm SO_4, 0.21 ppm F and 0.03 ppm Fe. Water in containers was analyzed periodically[10] for NO_3-N, NH_4-N, P, K, Ca, Mg, Fe, Mn, B, Cu, Zn, Mo, Na, Al, pH and electrical conductivity. The water added to containers each week contained 0.21, 0.42, 0.63 or 0.84 g/L fertilizer, the four levels being tested. No attempt was made to adjust g/L of fertilizer in the water already in the containers.

Each container was equipped with a 115 v, 60 hz, 1.7 amps 1 ph submersible pump.[11] The pumps were connected to a computerized automatic timer set to allow them to operate for 10 minutes per day. Plants were watered daily between 8:00 and 10:00 am when the stored water and fertilizer solution was pumped to bench level for 10 minutes, flooding benches to a depth of 2.5 cm (1 in), then drained into the storage containers. Water depth in trays was adequate for media to absorb water by means of capillary action for approximately 15 minutes per day.

Experiment 2, a 3 × 3 factorial experiment with 4 replications, was also initiated on April 4, 1990. *Dieffenbachia maculata* 'Camille' and *Spathiphyllum* 'Petite' were potted into 15 cm containers using the 3 mixes previously described, then placed in the same greenhouse as plants tested in experiment 1, but on conventional benches, and watered by overhead irrigation applied manually 2, 3 or 4 times/wk. Plants were top dressed with 5 g/15 cm pot 19N-2.6P-10K (19-6-12) Osmocote[5] 3 month release rate fertilizer, on April 4, 1990.

Experiment 3 was a 3 × 4 factorial experiment with 6 replications initiated on September 7, 1990, again using liners of *Codiaeum variegatum* 'Petra', *Dieffenbachia maculata* 'Camille' and *Spathiphyllum* 'Petite'. The liners were potted into 15 cm pots using the same three growing mixes as in experiment 1 and 2, then grown in a greenhouse on ebb and flow benches under 300 μmol $\cdot$ s^{-1} $\cdot$ m^{-2} (2000 ft-c) maximum light and a temperature range of 21° to 32°C (70° to 90°F). Plants were watered daily using the same equipment and method described in experiment 1.

Liquid and slow release fertilizers were compared. Fertilizer treatment 1 was 24N-3.5P-13.3K (24-8-16), as used in experiment 1, added to the irrigation water to make a solution of 0.63 g/L (2.36 g/gal), so that nitrogen rate tested was 150 ppm. Treatments 2, 3 and 4 were 2.5, 5.0 and 7.5 g/15 cm (6 in) pot 19N-2.6P-10K (19-6-12) Osmocote, 3 month slow release fertilizer, incorporated September 7, and surface applied December 27, 1990.

Experiment 4, also initiated on September 7, 1990, measured the growth of the same plants used in experiment 3 growing in the three media described above, when watered by manual overhead irrigation 3 times a week. Plants were placed in the same greenhouse as plants in experiment 3, but placed on conventional benches adjacent to the ebb and flow benches. Plants were fertilized with 5.0 g/15 cm pot 19N-2.6P-10K (19-6-12) Osmocote, 3 month slow release fertilizer, applied September 7 and December 27, 1990.

Heights of plants in experiments 1 and 2 was determined monthly. Height of plants produced in experiments 3 and 4 was recorded initially and then at three month intervals. Electrical conductivity and pH of the leachate from the growing media of *Dieffenbachia maculata* 'Camille' from experiments 1 through 4 was recorded every 4 weeks using the pour through nutrient extraction method (16). Samples of the irrigation water stored in containers in experiment 1 were analyzed every two weeks to determine mg/L macro- and micro-nutrients, pH and electrical conductivity. Plants were graded when research was terminated, based on a scale of 1 = poor quality, unsalable plant material, 3 = fair quality, salable, 5 = excellent quality plant material.

On July 18, 1990, greenhouse production of plants grown in experiments 1 and 2 ended. Dieffenbachias grown in both experiments were moved to rooms simulating interior environments, where they were maintained for 65 days, after which a final plant grade was determined. While in the rooms, plants received 12 hours of 20 μmol $\cdot$ s^{-1} $\cdot$ m^{-2} (150 ft-c) daily from cool white fluorescent bulbs and air temperatures ranging from 21 to 27°C (70 to 80°F). Experiments 1 and 2 ended on September 21, 1990. Experiments 3 and 4 were terminated on April 11, 1991.

Results and Discussion

Data collected from plants in experiment 1 showed no significant statistical difference in height increase and plant grade of crotons and spathiphyllums grown in either Fafard Container Mix #4 or Vergro Container Mix A (Table 1). Dieffenbachias grown in the Fafard Container Mix #4 received a slightly higher plant grade than plants grown in Vergro Container Mix A. All plants produced in the Canadian sphagnum peat:pine bark mix were shorter and received lower plant grades compared to the two commercially

[3]Fafard Inc., Apopka, FL 32704.

[4]Verlite Co., Tampa, FL 33680.

[5]Grace/Sierra Co., Milpitas, CA 95035.

[6]Aquatrols Corp., Pennsauken, NJ 08110.

[7]Rough Brothers, Inc., Cincinnati, OH 45216.

[8]Peters Fertilizer Products, Fogelville, PA 18051.

[9]Rubbermaid Commercial Products Inc., Winchester, VA 22601.

[10]Fafard Analytical Services Inc., Apopka, FL 32704.

[11]Little Giant No Korode pump, model number NK-2, Little Giant Pump Co., Oklahoma City, OK 73112.

manufactured mixes. Height increase and plant grade for all plants were greater when fertilizer rate was increased from 0.21 to 0.42 g/L (0.79 to 1.58 g/gal), but height increase and plant grade did not improve much as fertilizer rates rose beyond 42 g/L (1.58 g/gal). These results agree with earlier published fertilizer rate recommendations (4) for these foliage plant species based on open watering systems. Plants grown with the highest fertilizer level tested had higher leachate soluble salts than plants produced with the 0.42 g/L (1.58 g/gal) rate (Table 2). Electrical conductivity (micromhos/cm) and pH of media from pots containing *Dieffenbachia* 'Camille', obtained using the pour-through nutrient extraction method (16), generally showed pH decreasing over time and also as fertilizer levels increased (Table 2).

Spathiphyllum 'Petite' grown in experiment 2 on conventional benches testing the three media and overhead irrigation rates of 2, 3 or 4 times per week showed no statistical differences for height increase and plant grade for all factors tested. *Dieffenbachia* 'Camille' were taller with higher plant grades when grown in Fafard Container Mix #4 and Vergro Container Mix A compared to the Canadian sphagnum peat:pine bark medium. No statistical difference was found in plant grade or height increase for irrigation rate (data not included in tables).

Plant grades of *Dieffenbachia* 'Camille' grown in experiment 1, in the ebb and flow system, were still greater than plant grades of *Dieffenbachia* 'Camille' grown in experiment 2 with overhead watering after both were maintained under indoor conditions for 65 days (data not shown). All

Table 1. Plant grade and height increase of three foliage plant species produced in an ebb and flow irrigation system using three growing media and four fertilization levels. Experiment 1, initiated April 7, 1990, terminated September 21, 1990.

	Codiaeum 'Petra'		*Dieffenbachia* 'Camille'		*Spathiphyllum* 'Petite'	
	Plant grade[z]	Height increase cm	Plant grade	Height increase cm	Plant grade	Height increase cm
Growing media	June 15	June 11	July 5	July 10	July 31	August 1
Fafard	3.6 a[y]	11.4 a	4.1 a	21.7 a	3.7 a	23.0 a
Vergro	3.9 a	11.8 a	3.7 b	19.9 a	3.5 a	22.6 a
CP:PB	3.1 b	8.8 b	3.1 c	14.8 b	2.9 b	16.4 b
Fertilizer rate[x]						
0.21 g/L	2.6	7.8	2.1	10.9	2.4	16.2
0.42 g/L	3.7	11.0	4.0	19.9	3.4	19.4
0.63 g/L	3.8	11.8	4.0	21.5	3.8	23.8
0.84 g/L	4.0	12.2	4.4	22.8	4.0	23.1
Significance[w]						
linear	**	**	**	**	**	**
quadratic	**	*	**	**	**	*

[z]Plant grade was based on a scale of 1 = poor quality, unsalable, 3 = fair quality, salable, 5 = excellent quality plant material.

[y]Mean separation in columns by Duncan's multiple range test, 5% level. Numbers in column with same letters are not statistically different.

[x]Plants fertilized with 24N-3.5P-13.3K (24-8-16) soluble fertilizer added to the irrigation system so that nitrogen rates tested were 50, 100, 150 and 200 mg N/L.

[w]ns, *, **Results nonsignificant, significant at P = 0.05 and P = 0.01, respectively.

Table 2. Electrical conductivity (µmhos/cm) and pH of *Dieffenbachia* 'Camille' grown with three growing media and four fertilizer rates in an ebb and flow irrigation system. Experiment 1, initiated April 4, 1990, terminated September 21, 1990.

	April 12, 1990		May 10, 1990		June 6, 1990		July 10, 1990	
Growing media	pH	µmhos/cm	pH	µmhos/cm	pH	µmhos/cm	pH	µmhos/cm
Fafard	7.6 a[z]	926 a	6.7 a	1104 a	6.0 a	844 ab	5.6 a	588 ab
Vergro	7.7 a	1090 a	6.9 a	1156 a	6.2 a	990 a	5.9 a	836 a
CP:PB	7.6 a	601 b	6.6 a	851 a	6.1 a	516 b	6.0 a	405 b
Fertilizer rate[y]								
0.21 g/L	7.8	547	7.8	415	7.6	282	7.2	169
0.42 g/L	7.6	782	6.9	797	6.5	457	6.3	236
0.63 g/L	7.6	981	6.2	1285	5.3	990	5.2	628
0.84 g/L	7.6	1180	6.1	1652	5.0	1406	4.5	1406
Significance[x]								
linear	ns	**	**	**	**	**	**	**
quadratic	ns	ns	ns	ns	ns	ns	**	**

[z]Mean separation in columns by Duncan's multiple range test, 5% level. Numbers in column with same letters are not statistically different.

[y]Plants fertilized with a 24N-3.5P-13.3K (24-8-16) soluble fertilizer added to the irrigation system so that nitrogen rates tested were 50, 100, 150 and 200 mg N/L.

[x]ns, **Results nonsignificant, significant at P = 0.05 and P = 0.01, respectively.

Dieffenbachia 'Camille' placed in the simulated interior environment for 65 days maintained their original quality (data not shown).

When electrical conductivity of the media leachate was measured for *Dieffenbachia* 'Camille' grown in experiment 2, the Canadian sphagnum peat:pine bark potting mix usually had a lower pH and lower micromhos/cm than the two manufactured mixes tested (Table 3). As irrigation rate increased from 2 to 4 times per week, pH increased, and soluble salts of the leachate decreased.

No statistical difference was found in height increase or plant grade for plants grown in the three mixes in experiment 3, conducted during the cooler fall and winter months, September 7, 1990 until April 11, 1991. When soluble and slow release fertilizers were compared in experiment 3, increase in height and plant grade for plants treated with 0.63 g/L (2.36 g/gal) soluble fertilizer was similar to height increase and plant grade for plants receiving the 5.0 and 7.5 g/15 cm pot slow release fertilizer (Table 4). No difference was found in electrical conductivity of the leachate from media of *Dieffenbachia* 'Camille' treated with the 0.63 g/L (2.36 g/gal) soluble fertilizer and the 5.0 g/pot slow release rate fertilizer, but pH of the leachate from mixes receiving the soluble fertilizer gradually decreased over time and was very low when the experiment was terminated (Table 5).

Experiment 4 showed plant grade and height increases were similar for the two commercially manufactured mixes and slightly lower for the Canadian sphagnum peat:pine bark medium (Table 6). The Fafard Container Mix #4 had lower pH than the other two mixes tested.

The amount of water lost from each of the 93 L storage containers was determined weekly, then totaled, to determine the total water used per tray for the plants growing in the ebb and flow systems in experiments 1 and 3. Water utilization increased slightly with an increase in fertilization level (Table 7). The storage containers holding the soluble

Table 3. Electrical conductivity (μmhos/cm) and pH of *Dieffenbachia* 'Camille' produced on conventional benches with overhead irrigation using three media and three watering frequencies, and fertilized with 5 g/pot 19-6-12 on April 4, 1990. Experiment 2, initiated April 4, 1990, terminated September 21, 1990.

	April 12, 1990		May 10, 1990		June 6, 1990		July 10, 1990	
Growing media	pH	μmhos/cm	pH	μmhos/cm	pH	μmhos/cm	pH	μmhos/cm
Fafard	6.2 b[z]	2557 a	7.1 a	1758 a	6.9 a	411 a	6.6 a	94 a
Vergro	7.5 a	2031 b	7.9 a	1605 a	7.5 a	457 a	7.3 a	106 a
CP:PB	6.1 c	1151 c	6.4 b	1344 a	6.4 b	431 a	6.3 b	140 a
Irrigation rate								
2/wk	6.5	2068	6.6	2177	6.6	672	6.5	207
3/wk	6.5	1877	7.3	1418	7.1	384	6.8	60
4/wk	6.8	1794	7.6	1112	7.2	242	7.0	74
Significance[y]								
linear	ns	ns	**	**	*	**	*	**
quadratic	ns	ns	ns	ns	ns	ns	ns	**

[z]Mean separation in columns by Duncan's multiple range test, 5% level. Numbers in column with same letters are not statistically different.

[y]ns, *, **Results nonsignificant or significant at P = 0.05 or 0.01, respectively.

Table 4. Plant grade and height increase of three foliage plant species produced in an ebb and flow system using three growing mixes and liquid and slow release fertilizer. Experiment 3, initiated September 7, 1990, terminated April 11, 1991.

	Codiaeum 'Petra'		*Dieffenbachia* 'Camille'		*Spathiphyllum* 'Petite'	
	Plant grade[z]	Height increase cm	Plant grade	Height increase cm	Plant grade	Height increase cm
Growing media	January 15	January 15	April 11	April 11	April 11	April 11
Fafard	3.7 a[y]	12.2 a	3.5 a	16.8 a	4.1 a	15.4 a
Vergro	3.6 a	12.5 a	3.5 a	16.5 a	4.1 a	15.4 a
CP:PB	3.5 a	13.0 a	3.4 a	15.5 a	4.1 a	14.4 a
Fertilizer rate[x]						
0.63 g/L	3.5 ab	13.3 a	3.7 a	16.6 a	4.8 a	14.8 ab
2.5 g/pot	3.2 b	11.4 a	3.5 ab	15.7 a	3.0 c	14.0 b
5.0 g/pot	3.8 ab	12.4 a	3.3 b	16.1 a	3.9 b	15.9 a
7.5 g/pot	3.9 a	13.2 a	3.4 b	16.8 a	4.7 a	15.7 a

[z]Plants graded on a scale of 1 = poor quality, unsalable, 3 = fair quality, salable and 5 = excellent quality plant material.

[y]Mean separation in columns by Duncan's multiple range test, 5% level. Numbers in columns with same letters are not statistically different.

[x]Fertilizer treatment 1 was a 24N-3.5P-13.3K (24-8-16) soluble concentrate added to the irrigation water to make a solution of 0.63 g/L (2.36 g/gal), so that nitrogen rate was 150 mg N/L. Treatments 2, 3 and 4 were 2.5, 5.0 and 7.5 g/15 cm (6 in) pot 19N-2.6P-10K (19-6-12) Osmocote 3 month slow release fertilizer applied September 7, and December 27, 1990.

Table 5. Electrical conductivity (µmhos/cm) and pH of *Dieffenbachia* 'Camille' grown in an ebb and flow irrigation system with three growing mixes and liquid and slow release fertilizer. Experiment 3, initiated September 7, 1990, terminated April 11, 1991.

	Dieffenbachia maculata 'Camille'							
	Sep 11, 1990		Nov 6, 1990		Jan 15, 1991		Mar 22, 1991	
Growing media	pH	µmhos/cm	pH	µmhos/cm	pH	µmhos/cm	pH	µmhos/cm
Fafard	6.2 a[z]	3754 a	5.9 a	2404 a	6.5 a	1680 a	5.8 a	1965 a
Vergro	6.9 b	3353 a	6.1 a	2242 a	6.8 a	1770 a	6.4 a	2066 a
CP:PB	6.1 a	1723 b	6.5 a	1668 a	7.0 a	846 b	6.4 a	1365 a
Fertilizer rate[y]								
0.63 g/L	6.5 b	2314 b	4.5 a	1771 bc	5.1 a	1518 b	4.4 a	1511 b
2.5 g/pot	6.4 b	2927 ab	7.7 c	1152 c	7.9 b	649 c	7.6 c	624 c
5.0 g/pot	6.4 b	3187 ab	6.9 c	2092 b	7.6 b	1270 b	7.2 c	1907 b
7.5 g/pot	6.1 a	3346 a	5.6 b	3402 a	6.7 b	2292 a	5.6 b	3153 a

[z]Mean separation in columns by Duncan's multiple range test, 5% level. Numbers in columns with same letters are not statistically different.

[y]Fertilizer treatment 1 was a 24N-3.5P-13.3K (24-8-16) soluble concentrate added to the irrigation water to make a solution of 0.63 g/L (2.36 g/gal), so that nitrogen rate was 150 mg N/L. Treatments 2, 3 and 4 were 2.5, 5.0 and 7.5 g/15 cm (6 in) pot 19N-2.6P-10K (19-6-12) Osmocote 3 month slow release fertilizer applied September 7, and December 27, 1990.

Table 6. Height increase, final plant grade and electrical conductivity of *Dieffenbachia maculata* 'Camille' produced with three growing media on conventional benches with overhead irrigation and fertilized 5.0 g/15 cm (6 in) pot Osmocote 3 month release rate fertilizer applied on September 7, and December 27, 1990. Experiment 4, initiated September 7, 1990, terminated April 11, 1991.

	Dieffenbachia maculata 'Camille'							
			Sep 11, 1990		Dec 7, 1990		Mar 22, 1991	
Growing media	Plant grade[z]	Height increase (cm)	pH	µmhos/cm	pH	µmhos/cm	pH	µmhos/cm
Fafard	4.2 a[y]	20.7 a	5.6 a	4970 a	6.2 a	388 a	5.6 a	326 c
Vergro	4.1 ab	18.7 ab	6.5 b	4695 a	7.5 b	375 a	7.0 b	604 a
CP:PB	3.8 b	15.8 b	6.0 b	1857 b	7.6 b	361 a	6.6 b	463 b

[z]Plants graded on a scale of 1 = poor quality, unsalable, 3 = fair quality, salable and 5 = excellent quality plant material.

[y]Mean separation in columns by Duncan's multiple range test, 5% level. Numbers in columns with same letters are not statistically different.

Table 7. Total water consumption per 1.5 m^2 ebb and flow tray in experiment 1, April 4, until August 1, 1990 and experiment 3, September 7, 1990 until April 11, 1991. Trays initially held 36 plants, 12 of each species tested.[z]

Experiment 1		Experiment 3	
Fertilization rate[y]	Water consumed	Fertilization rate[x]	Water consumed
50 N mg/L	244.8 L (64.6 gal)	150 N mg/L	401.3 L (106.0 gal)
100 N mg/L	285.8 L (75.5 gal)	2.5 g/6 in pot	505.4 L (133.5 gal)
150 N mg/L	285.8 L (75.5 gal)	5.0 g/6 in pot	543.2 L (143.5 gal)
200 N mg/L	280.1 L (74.0 gal)	7.5 g/6 in pot	501.6 L (132.5 gal)

[z]Plants were removed from trays when ready for sale and remaining plants were re-spaced. Experiment 1: Crotons were removed June 19, dieffenbachias were removed July 18, and spathiphyllums were removed August 1, 1990. Experiment 3: Crotons were removed January 16, dieffenbachias and spathiphyllums were removed April 11, 1991.

[y]Plants were fertilized with a 24N-3.5P-13K (24-8-16) soluble fertilizer added to the irrigation system so that nitrogen rates tested were 50, 100, 150 and 200 mg N/L.

[x]Fertilizer treatment 1 was a 24N-3.5P-13.3K (24-8-16) soluble concentrate added to the irrigation water to make a solution of 0.63 g/L (2.36 g/gal) so that nitrogen rate was 150 mg N/L. Treatments 2, 3 and 4 were 2.5, 5.0 and 7.5 g/15 cm (6 in) pot 19N-2.6P-10K (19-6-12) Osmocote 3 month slow release fertilizer applied September 7, and December 27, 1990.

Table 8. **Fertilizer analysis (mg/L) of irrigation water stored in containers in experiment 1. Experiment 1, initiated April 7, 1990, terminated September 21, 1990.[z]**

Fertilizer rate[y]	B	Ca	Cu	Fe	Mg	Mn	Mo	Na	Zn	P	K	NH_4-N	NO_3-N
0.21 g/L	0.06	44	0.02	0.11	21	0.03	0.01	24	0.18	8	40	4	47
0.42 g/L	0.07	49	0.05	0.24	24	0.11	0.01	22	0.27	18	71	23	76
0.63 g/L	0.07	50	0.09	0.33	26	0.17	0.01	24	0.32	28	117	45	120
0.84 g/L	0.08	48	0.13	0.42	24	0.23	0.01	22	0.37	38	145	70	150

[z]Tap water, which had a pH of 7.3, 330 μmhos/cm, 27 ppm Ca, 7 ppm Mg, 4 ppm Na, 13 ppm Cl, 21 ppm SO_4, 0.21 ppm F and 0.03 ppm Fe, was used in this test. Irrigation water in containers was analyzed periodically (Fafard Analytical Services Inc., Apopka, FL 32704) for mg/L B, Ca, Cu, Fe, Mg, Mn, Mo, Na, Zn, P, K, NH_4-N and NO_3-H and numerical values were averaged.

[y]Plants fertilized with 24N-3.5P-13.3K (24-8-16) soluble fertilizer added to the irrigation system so that nitrogen rates tested were 50, 100, 150 and 200 mg N/L.

fertilizer treatment in experiment 3 lost much less water compared to storage containers supplying plants fertilized with the 3 rates of slow release fertilizer.

Results of the fertilizer analysis tests of the irrigation water held in the storage containers (experiment 1) showed levels of N, P, Cu, Fe, Mn and Zn in the solutions increased as fertilizer rate increased (Table 8).

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