Irrigation and Fertilization for Minimal Environmental Impact

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Abstract

Regulations regarding the use of water and concerns for ground and surface water pollution have resulted in Florida nursery and greenhouse plant producers seeking irrigation and nutrient delivery systems that minimize negative environmental impacts. In view of this, irrigation and nutrient management systems that result in minimal environmental impact were installed and evaluated in commercial greenhouses in central Florida. Systems evaluated included 1) capillary wick containers, 2) capillary mats and 3) water collection reservoirs beneath individual containers. These systems were compared to traditional overhead water delivery. Results indicated that less water was applied during plant production with capillary wicks than mats, although both systems require less water than overhead irrigation. For example, during a 2-month period in which *Calathea orbifolia* were grown in 20-cm diameter containers, plants irrigated with wicks and mats received approximately one-third and one-half, respectively, the water applied with overhead irrigation. Change in plant growth index during this time was largest for plants irrigated with capillary wicks. In another evaluation, shadehouse-grown *Spathiphyllum wallisii* 'Ty's Pride' growth indices were similar when plants received controlled-release fertilizer on substrate surface of each container or fertilizer applied through overhead irrigation water. The total daily load of nitrogen to the ground beneath plants was largest for fertilizer applied through overhead irrigation. Information from these irrigation and fertilization evaluations will be used to develop Best Management Practices for the nursery industry.

INTRODUCTION

The population of Florida increased by approximately one million persons between 1995 and 2000 and is predicated to be about 20.7 million persons by 2025 (Campbell, 1996). Rapid population increases result in about 66,800 hectares converted from natural areas to developed land each year (McCaffrey, 2002). Conversion of natural areas, agricultural lands and forest to urban centers can have an impact on recharge of groundwater aquifers by rainwater. Groundwater supplied 93 % of Florida's population in 1995 and accounted for 60% of freshwater withdrawals (Marella, 1999). Concern for nitrate nitrogen contamination of ground water increased in Florida during the early 1990's as population centers encroached on agricultural production areas. These concerns led to the passage of nitrate nitrogen legislation in 1994 (Chapter 576.045, Florida Statues). This legislation provided funds for research to develop Best Management Practices (BMPs) or practices verified by research to be effective at reducing or minimizing nitrate contamination of ground water.

Research has been ongoing with container-grown ornamental plants to develop BMPs. One aspect of this research involves reducing the opportunity for nitrate nitrogen to enter ground water. This has involved evaluation of irrigation systems that apply less water compared to the traditional overhead sprinkler irrigation systems and fertilizer applications targeted or directed to a specific location.

Foliage plants in central Florida are typically grown in plastic containers 20-cm or

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less in diameter filled with soilless substrates composed primarily of reed peat. Plants are typically grown in greenhouses or shadehouses (50 – 80% light exclusion) with containers placed on benches or other supporting structures that facilitate water loss to ground or native soil. Plant production time may range from a few weeks to 9 months, and sometimes longer depending on plant species and market demand. Plants are often irrigated frequently with water-soluble nitrogen in the water at concentrations of 150 – 300 mg L^{-1} applied by overhead irrigation. The percentage of nitrogen in the fertilizer injected into the overhead irrigation water may vary, but application of a fertilizer solution with 50% nitrate nitrogen is common. Additionally, ammoniacal nitrogen injected into irrigation water is likely converted to nitrate nitrogen after application. The number of fertilizer applications per unit of nitrogen applied to crop, timing of applications, and amount or volume of solution applied are usually decided or conducted based on the owner or grower's judgment. Judgment factors may include substrate testing and plant color or growth rate, but are not exclusive to other factors such as environmental conditions and days to market.

Overhead irrigation systems could be converted to microirrigation systems where small amounts of water are delivered to each container. However, in some locales, water quality is inadequate and emitters clog. Thus, benches designed for application and retention of bulk fertilizer solutions (Klock-Moore and Broschat, 2000) have been investigated, and these subirrigation systems could be used to prevent or minimize nitrate nitrogen loss to ground or native soil beneath greenhouse benches. Both microirrigation and flood or subirrigation systems are large capital investments and impart inflexibility to benches or irrigation delivery system conversions that might be needed later.

In our evaluations, we converted benches under overhead sprinkler irrigation to capillary mat irrigation or capillary wick irrigation systems. In addition, we converted benches with microirrigation to capillary mat irrigation or added water collection reservoirs under containers that received microirrigation. Where these systems were impracticable to implement, the fertilization regime was converted from nitrogen solution in overhead irrigation (fertigation) to controlled-release fertilizer applied to each container. Examples and impacts of implementing irrigation and fertilizer delivery system modifications will be discussed.

MATERIALS AND METHODS

Irrigation

A capillary mat (Bottom Up Irrigation Pty Ltd., Australia) irrigation system was installed in greenhouses at two locations near Apopka, Florida (28N41, 81W31) and water application amount recorded. Four benches ranging from 21.5 to 30.5 m long and 1.8 to 1.5 m wide, respectively, were retrofitted with capillary mats at each location (Fig. 1). An additional four benches (30.5 x 1.5 m) were retrofitted for capillary wick systems (Fig. 2). Four benches (30.5 x 1.5 m) were not retrofitted that received overhead irrigation (Fig. 3), microirrigation (21.5 x 1.8 m) or microirrigation with water collection reservoir (21.5 x 1.8 m) (Fig. 4). At both locations, the nursery owner or grower managed the irrigation systems, determining crops grown, plant spacing, irrigation regimes and other cultural factors. Therefore, plant measurements could be accomplished only when plants of the same age and size were located on all treatment benches. The irrigation studies were initiated in June 1999 and will continue until December 2002.

Fertilization

Spathiphyllum 'Ty's Pride' grown outdoors under ≈ 80% natural light exclusion in 15-cm diameter containers received nitrogen solution (≈ 300 mg N L^{-1}) in overhead spray irrigation water daily [15 min duration with Dramm Nifty Nozzles (Dramm Corp., Manitowoc, Wisconsin) ≈ 5.7 L $^{-min}$] during times of maximum water demand. Approximately 500 plants were grown on each of 24 wire benches (30.5 x 1.4 m). Half of the plants received fertilizer injected into irrigation water (fertigation) and the other half was fertilized with controlled-release fertilizer (1.9 g N per container applied to substrate surface) and irrigated with the same water without fertilizer. Controlled-release fertilizers were (Osmocote® Plus15N-4P-10K 12-14 month Scotts-Sierra Horticultural Products Co., Marysville, Ohio; Nutricote®19N-2P-5K T360 Florikan E. S. A. Corporation, Sarasota, Florida; Multicote® (12) 17N-2P-9K Haifa Chemical Co., Haifa Israel; Polyon® Plus 17N-2P-9K Pursell Technologies, Inc. Sylacauga, Alabama) applied randomly to each bench of plants in June 2000. A growth index (height + average width) was determined for 15 plants of each treatment (controlled-release fertilizers and fertilizer in irrigation water) 6 months after applications were initiated. Electrical conductivity (EC) was determined for three plants of each treatment using the pour-through extraction procedure (Yeager, et al., 1983). All fertigation applications were based on the nursery owner or grower's decision. Four cores of soil from fertigated and controlled-release fertilized areas (one core outside shadehouse) were obtained 1.2 meters below ground surface every 3 months and nitrate nitrogen extracted by standard procedures.

RESULTS AND DISCUSSION

Irrigation

Capillary mats resulted in less water being applied than overhead irrigation, microirrigation or microirrigation with water collection reservoir under containers (Tables 1 and 2). Water collection reservoirs under containers with microirrigation resulted in less water applied and similar plant growth to plants with micoirrigation but without reservoirs (Table 2).

Plants irrigated with capillary wicks received less water than plants irrigated with capillary mats and plant growth indices were similar (Table 1). The wick system does not have water loss to the ground as long as reservoir channels do not overflow, but the capillary mat system requires precise management of water application in order to minimize water and nutrient loss. In a separate evaluation conducted at University of Florida, Gainesville, Florida, (29N39, 82W20) *Spathiphyllum* 'Ty's Pride' was grown in a greenhouse with capillary mats, capillary wicks and overhead sprinkler irrigation (Bryant and Yeager, 2002). After 5 months, growth indices were similar. However, the capillary wick irrigation system resulted in 86% less water applied compared to overhead sprinkler irrigation and 81% less water applied compared to mat irrigation.

Fertilization

Plant growth indices were similar (Fig. 5) whether plants received nitrogen from controlled-release fertilizer or from fertilizer in overhead irrigation water (fertigation). Plants that received controlled-release fertilizer were visually lighter green than plants that received fertilizer in irrigation water, although plants fertilized with controlled-release fertilizer were not unacceptable for most markets. The substrate EC levels (Fig. 6) were indicative of the plant color. Based on the amount of water applied during the 6 months, controlled- release fertilizer would reduce loading of nitrogen to ground by 98 % assuming the plants direct 50% of nitrogen from overhead irrigation into containers and plants utilize 50% of nitrogen that gets into containers. Data in Fig. 7 indicates that average nitrate nitrogen levels in native soil 1.2 m below shadehouse floor were lower as a result of controlled-release fertilizer applications compared to fertigation with overhead applications.

Our evaluations indicate that foliage plants grown in containers and irrigated with capillary mat or wick irrigation delivery systems required less water than plants grown with overhead sprinkler irrigation. Thus, when fertilizer is applied in irrigation water to the capillary mat or wick system there is less potential for loading ground water with nitrogen. Additionally, reservoirs under containers that received microirrigation resulted in less water applied compared to containers with microirrigation but without water collection reservoirs under containers. Capillary wick irrigation systems do not have runoff and have the greatest potential for reducing nitrate nitrogen loss to ground water. In addition, directed or targeted nitrogen applications of controlled-release fertilizer are very effective for reducing nitrogen loading to the ground compared to fertilizer applied in overhead irrigation water.

Proactive nursery businesses of the future will spend more time than in the past accounting for production activity. Involvement in developing the accountability system or process is very important whether it is monitoring and recording nutrient application, irrigation amount, runoff discharge or a host of other activities. The proactive involvement of plant producers, universities, regulatory and non-regulatory agencies in development of BMPs is essential if these will be implemented and used effectively. Additionally, BMPs provide a means for communicating the nursery industry's environmentally conscious production practices used to grow the plants that enhance our environment and well being of Florida's increasing population.

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Tables

Table 1. Irrigation water applied by overhead, capillary wick or capillary mat irrigation and growth indices for *Calathea orbifolia* greenhouse-grown in 20-cm containers June 30 – September 28, 2000.[1]

	Water applied (L)	Final growth index (cm) [2]	Growth index change (cm) June – September
Overhead	14,411	74 ± 7	6
Capillary wick	4160	94 ± 11	25
Capillary mat	5928	80 ± 9	14

[1] Plants on 30.5 x 1.5 m bench with buffer plants
[2] Growth index = height + average width (n= 10 ± std.)

Table 2. Irrigation water applied by microirrigation, microirrigation with collection reservoir or capillary mat irrigation and growth indices for *Anthurium hybridum* 'Tropic Fire' greenhouse-grown in 20-cm containers August 20 – November 26, 2001.[1]

	Water applied (L) Aug. – Nov.	Final growth index (cm) [2]	Growth index change Aug. – Nov.
Microirrigation	3456	101 ± 7	23
Microirrigation with water collection reservoir	2241	99 ± 6	20
Capillary mat	1851	100 ± 9	17

[1] Plants on 21.5 x 1.8 m bench with buffer plants
[2] Growth index = height + average width (n=16 ± std.)

Figures

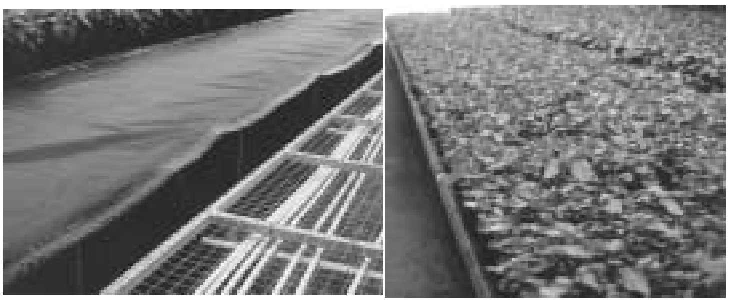

Fig. 1. Capillary Mat Irrigation – mat absorbs water that moves via capillarity through holes in containers and into substrate.

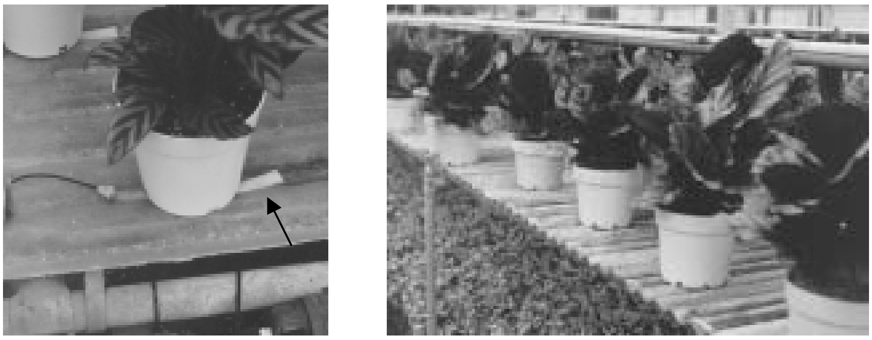

Fig. 2. Capillary Wick Irrigation – polyester water-absorbing wick protruding from substrate via hole in container, absorbs water in fiberglass channel blocked on each end.

Fig. 3. Overhead Irrigation – irrigation water was sprayed over plants.

Microirrigation

Microirrigation with water collection reservoir

Fig. 4. Irrigation water was delivered via flexible tube to substrate surface of each container that received microirrigation.

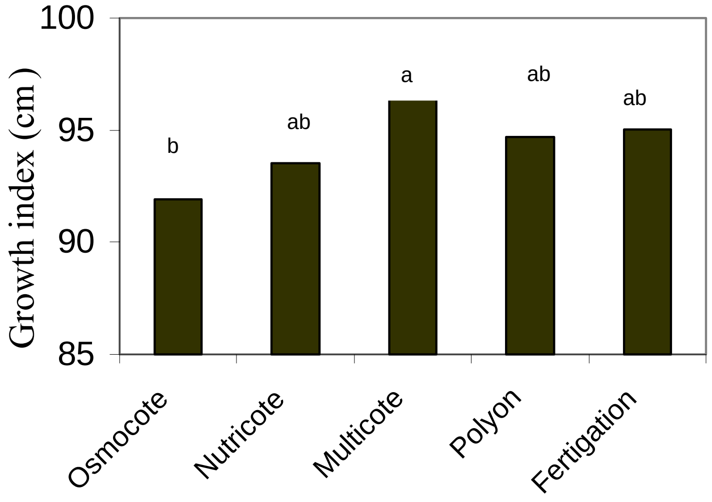

Fig. 5. Growth indices (height + average width) for *Spathiphyllum* 'Ty's Pride' grown in 15-cm diameter containers for 6 months under ≈ 80% light exclusion and fertilized with 1.9 g N per container from one of 4 controlled-release fertilizers or with fertilizer in irrigation water (fertigation ≈ 300 mg N L^{-1}). Means separated by Duncan's Multiple Range Test ($P \leq 0.05$).

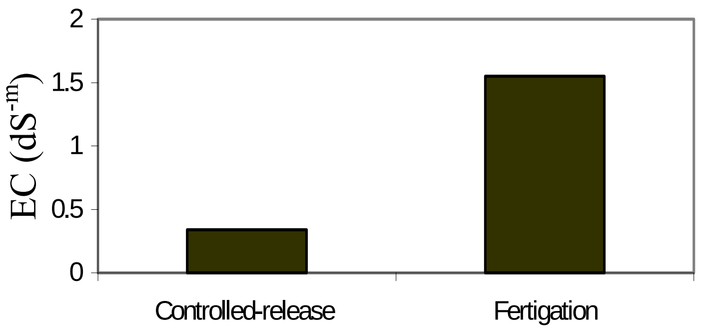

Fig. 6. Substrate electrical conductivity for *Spathiphyllum* 'Ty's Pride' grown in 15- cm diameter containers for 6 months under ≈ 80% light exclusion and fertilized with 1.9 g N per container from four controlled-release fertilizers or fertilizer in irrigation water (fertigation ≈ 300 mg N L^{-1}).

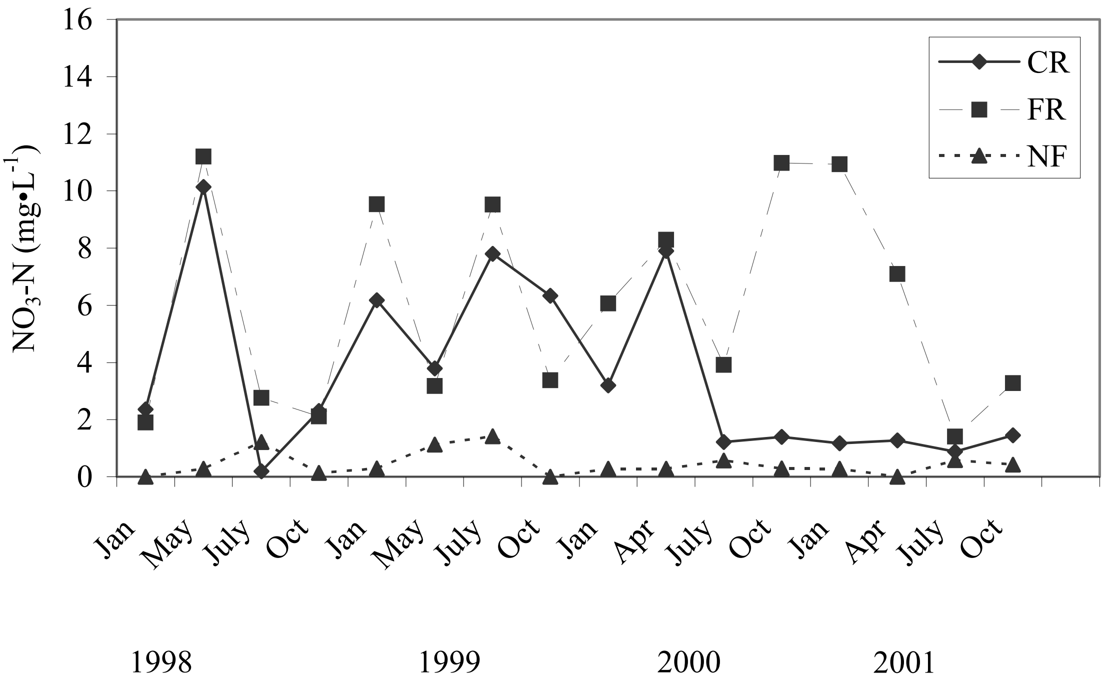

Fig. 7. Mean nitrate nitrogen levels (dry soil dilution basis) 1.2 m below ground surface in shadehouse (n=4). Controlled-release fertilizer was applied June 2000. CR= controlled-release (average 4 fertilizers), FR=fertigation, NF= no fertilizer (outside shadehouse n=1).