WATER MANAGEMENT

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Section Editor and Moderator

Twenty-eight students competed In the Bryson L. James Student Research Competition and twenty-nine research projects were presented in poster form, which were displayed for review during the SNA Research Conference and Trade Show, this year. Their research is presented in the topical sections which follow and are designated as Student or Poster papers.

Effect of Cyclic Overhead Irrigation on the Growth of Ten Species of Woody Ornamentals Grown in #1 Containers

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Nature of Work: Cyclic irrigation refers the practice of applying a day's normal irrigation volume in two or more subvolumes, rather than in a single irrigation event. In 1991, Beeson reported landscape plants grown in #3 containers which were cyclic irrigated (termed "pulsed irrigation") using Dram rings grew significantly larger over a season than those irrigated daily in a single event with overhead sprinklers. Concurrent data suggested that cyclic irrigation limited growth-inhibiting water stress which usually develops in the full-sun grown plants by early afternoon (Beeson, 1991). Growth increase and water conservation benefits of applying cyclic microirrigation using individual spray stakes for trees have also been reported (Beeson and Haydu, 1995). At the substrate level, Karam and Niemiera (1994) showed that cyclic irrigation resulted in more water being retained by a substrate, suggesting it allowed the micropores to be filled rather than the water draining by mass flow through the macropores. It was further shown that the slower the application rate, the greater the percentage of water which was retained by the substrate in the container.

Some nurserymen in central Florida interpreted these studies to indicate that by cyclic irrigating, they could reduce their daily irrigation applications by up toe 25% and still produce the same quality plant in the same time period. Almost invariability though, these nurseries were irrigating with overhead sprinklers. Penetration of overhead sprinkler water through a canopy to the substrate is rarely 100% due to shielding and retention by a canopy (Beeson and Knox, 1991). The following study was implemented to compare shoot growth of 9 species of landscape ornamentals grown outdoors in #1 containers irrigated with either cyclic or single event overhead impact sprinklers.

On 15 March 1995, 60 uniform liners of 9 species of landscape shrubs were transplanted into #1 containers using a 3 pine bark fine: 1 Fla. Sledge peat: 1 course sand substrate amended with 1.5 lb of micronutrients and 4 lb of dolomite per cubic yard. Species used were wax myrtle, Japanese boxwood, sweet viburnum, gardenia, green pittosporum, variegated pittosporum, 'Blue Pacific' juniper, dwarf Burfordii holly, and confederate jasmine. Twenty plants of each species were randomly placed on polyethylene ground cover in full sun in each of 3 independently irrigated production areas where irrigation uniformity was >0.87

(CU), with application rates averaging 2.25-inches (5.7) cm) per hr. Plants were given 0.4 oz (12 g) of Osmocote 18-6-12 a week after potting and again in mid-July.

The irrigation application rate of each production area was calibrated. Treatments consisted of the same volume of water per 24 hr period applied in a single irrigation event (Single), or split into two cyclic irrigation events. Cyclic irrigation events were either applied during early morning with a 45 min pause between applications (Cyclic-night) or with one-half applied in the early morning and the other half applied at 1:00 P.M. (Cyclic-day). From 15 March to early May, 0.52-inch (1.3 cm) were applied daily, thereafter until harvest, daily irrigation rates were 0.82 inch (2.1) cm per day.

When most of the plants within a species obtained marketable size in the Single irrigation treatment, all plants of that species were harvested and removed from the experiment. Thus, harvest began in July with wax myrtle and concluded in October with Japanese boxwood. At harvest, a canopy's widest width and width perpendicular to this were recorded along with average shoot height. Growth indices estimating canopy volumes were calculated as width 1 * width 2 * height. Shoots were removed at the substrate level and dried at 150° F until a constant dry weight was obtained. Data were analyzed separately by species using a random design with 20 replications.

Results and Discussion: With a few exceptions, differences in growth indices (GI) or shoot dry mass (Dwt) among irrigation treatments were not significantly different ($P>0.05$) within a species (data not shown). Of the exceptions, wax myrtle (GI) and juniper (Dwt) Cyclic-night irrigated were larger than those Cyclic-day irrigated (Table 1). Sweet viburnum Single irrigated were larger than those irrigated Cyclic-day (Table 1).

Cycling overhead irrigation generally failed to increase plant growth. Thus, it is very unlikely that nurseries could reduce their irrigation rates by 25% and maintain previous growth rates. At 0.82 inch per day, about 12.8 oz (380 mL) of water would have fallen above a container surface, likely less than that would have reached the substrate surface due to canopy shedding. Assuming all the water reached the substrate, the application rate would have been about 0.57 oz (17 mL) per min. This is about 4 times higher than the quoted average nursery rate of 0.5 inch per hr. If single event applications led to mass flow drainage, differences between single and cyclic irrigation treatments, especially Cycling-night, should have been evidenced by differences in canopy growth. Canopy growth is tightly linked to water availability. The 12.8 oz per day is about the average growing season daily water use of marketable common ligustrum in #1 containers in central Florida and only about 75% of the average water use in July (Beeson, unpublished data). Thus, if a portion of the water immediately drained out the bottom of the pot, plants in the single irrigation treatment would have had insufficient water to meet average demands and would have grown slower than Cyclic-night plants. The rate of 0.57 oz per min is about 8-fold higher than the rate used by Karam and Niemiera (1994) when they reported increased water retention by cyclic irrigation compared to single event irrigation. However, in absolute terms, their difference was 4% to 0.4 oz (13 mL). This is about 3% of the average daily water use of market size ligustrum in #1 containers. Thus, relative to daily growing season plant water use, gains in water retention by cyclic overhead irrigation demonstrated by Karam and Niemiera (1994) are minor and are reflected in the generally indistinguishable differences in plant growth reported here.

Significance to Industry: Cycling overhead irrigation during the night did not improve plant growth compared to a single event at equivalent daily irrigation volumes. Thus, it is very doubtful that traditional growth rates would be maintained if irrigation volumes were reduced with the implementation of cyclic overhead irrigation. While in laboratory experiments, cyclic overhead irrigation improves water retention in container substrates, under nursery conditions, application rates are low enough, and cannot economically be lowered further, so that benefits of cyclic overhead irrigation in terms of water availability are very small and likely not justified by the expense.

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Table 1. Mean growth parameters for select species where significant differences (P>0.05) among irrigation treatments were calculated. Each mean is representative of 20 individual plant replications.

		Irrigation Treatments		
Species	Parameter[z]	Single	Cyclic-night	Cyclic-day
Wax myrtle	Growth index	0.0704 ab[y]	0.0788 a	0.052 b
Sweet viburnum	Growth index	0.0804 a	0.0690 ab	0.0586 b
Juniper	Shoot dry mass	30.4 ab[x]	37.1 a	29.58 b

[z] Type of plant growth measurement. Growth index is a measure of canopy cubic volume (m3).

[y] Means with the same letters are not significantly different (P=0.05) based on Fisher's Protected LSD within rows.

[X] Grams

The Deep-Channel Wick-in-Pot Subirrigation System for Greenhouse-Grown Potted Plants

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Nature of Work: Capillary wicks have been used for several years in some decorative containers as a water transfer linkage from a built-in reservoir to the root zone of interior and exterior ornamental plants. Capillary wicks have thus far not been used commercially for irrigation of container-grown greenhouse crops. The “deep-channel/wick-in-pot subirrigation system” (DCWIPSS) is an irrigation concept for commercial greenhouse production of potted plants developed at the University of Florida’s Central Florida Research and Education Center during the past decade. Work on the system was initiated out of need for an affordable irrigation technology that would reduce the risk of point source pollution from fertilizers used in commercial greenhouses.

Design criteria for the DCWIPSS were as follows:

- The system should be easy to install, operate and maintain.
- It should be composed primarily of relatively inexpensive, off-the-shelf materials and components available from a variety of suppliers.
- The system should have a very low energy requirement for operation.
- It should be a closed irrigation system that will prevent spillage of water and nutrients on the floor or ground.
- Nutrient solution in the system should move along a one way path from the nutrient solution tank to the containerized root zone to minimize movement of water borne pathogens and pests from pot to pot.
- The system should distribute fertilizer to plants with a high degree of control over the intensity and balance of nutrients throughout the crop cycle.
- It should provide moisture from below the container in a manner which avoids wetting the foliage or blemishing the container surface with unsightly residues.

- The system should be adaptable to small or large irrigation zones which can be managed independently to accommodate the water and nutrient needs of different crops, stages of crop growth, pot sizes and pot spacing.

- It should be capable of irrigating most potted plant sizes up to 3-gallon capacity.

- The system should be adaptable to fixed or mobile bench designs and accept bottom heating technology.

Results and Discussion: A description of the DCWIPSS and some of the management techniques recommended to operate it successfully are provided below. The DCWIPSS is a closed, non-recirculating design which places nutrient solution or water in a supply channel under containerized plants which are equipped with capillary wicks extending from inside the pots to the bottom of the supply channel (Figure 1). Research on wick materials to date indicates that several capillary irrigation mat materials may be cut into strips 0.25- to 0.5-inch wide and used for wicks in the DCWIPSS (1).

Fresh water first enters an elevated reservoir tank with the bottom positioned one or more feet above the bench top. Water is delivered to the fresh water reservoir under pressure and the reservoir water level is controlled with a simple float valve. From this tank, water flows to one or more nutrient solution tanks by gravity.

Predetermined fertilizer amounts are periodically added to the nutrient solution tank to satisfy crop needs. The nutrient solution tank dispenses liquid fertilizer to a specialized bench top equipped with parallel channels that carry the solution under each plant on the bench. Since fresh water flow into the nutrient solution tank is controlled by a float valve inside the nutrient solution tank and the fresh water reservoir tank bottom is more than one foot above the solution level in the nutrient solution tank, back flow of fertilizer solution should not occur. Each nutrient solution tank holds at least enough diluted fertilizer or water to thoroughly irrigate one zone one time. Using a pulsed mode of irrigation, the nutrient solution tank would not be refilled until the plants need irrigation again. The frequency of irrigation could be managed similarly to other irrigation systems. A solenoid valve actuated by a moisture sensor or a manual control is positioned in the fresh water line just ahead of the float valve in the nutrient solution tank to provide the mechanism for providing irrigation cycles. The frequency of irrigation, amount and type of fertilizer added to the nutrient solution tank for each zone will depend upon the crop, stage of growth and its nutritional status.

Unlike most other subirrigation systems, using the wick-in-pot with a channel below the pot, the air-moisture balance of the containerized potting medium immediately after irrigation can be partially managed. By lowering the channel solution level, less water is absorbed by the pot-plant-system due to the increased length of capillary wick exposed between the solution in the supply channel and the potting medium. This management procedure is especially important for shallow containers. Deeper containers can be more thoroughly irrigated by increasing the channel solution level. In all cases the DCWIPPS avoids wetting the plant canopy and minimizes surface blemishes on the container.

The DCWIPSS can also be operated in a constant solution level mode which maintains a uniform moisture supply in the root zone from a continual level of nutrient solution in the supply channel. Although the constant level mode is easiest to accomplish, it is regarded as the least desirable option from a plant growth perspective.

For greatest control over the rate of plant growth, the pulsed mode of irrigation management described above is recommended. In the pulsed mode, nutrient solution or water is delivered to the channel as the potting medium dries to a selected level. At that time, enough solution is administered to the channels to restore the desired moisture level in the container until the next irrigation is needed.

The bench top or bed channels mentioned in this paper can be made from several different materials and configured for specific container sizes and spacings. The primarily constraints placed on the channel system are that it be durable, structurally matched to meet the anticipated crop load, impervious to water and cost effective. The irrigation supply channels should be approximately 2 to 3 inches deep and 0.5 to 1.0 inch wide. Since there is no industry design standards for the DCWIPSS, channel spacing will depend upon the anticipated container spacing patterns. Channels approximately 6 inches apart will accommodate 4- to 8-inch pots on several different container spacing patterns. The bench top is the most crucial component of the system because it currently is not commercially available. It could be fabricated from extruded polystyrene foam, vacuum-formed rigid plastic or fiber reinforced rigid plastic.

Several small prototype modules of the DCWIPSS have been fabricated from 2-inch thick extruded polystyrene foam with 1.5-inch-deep routed channels and others have been made from corrugated fiberglass panels using selected troughs for the supply channels and drip tubes to supply them with nutrient solution. The ultimate DCWIPSS bench top should accomplish all or most of the following functions: plant support, irrigation (closed system), bottom heating, mobility (rolling benches) and material handling (mobile bench modules).

Significance to Industry: The DCWIPSS has been used experimentally by the author to successfully grow over 15 genera of greenhouse potted plants during the past 10 years. Several of the genera grown on the DC/WIPPSS include: Aglaonema, Anthurium, Aphelandra, Chamaedorea, Dieffenbachia, Dracaena, Epipremnum, Ficus, Hedera, Kalanchoe, Nephrolepis, Peperomia, Philodendron, Schefflera, Spathiphyllum and Syngonium. It is a cost effective, easy to manage and maintain, closed subirrigation system and is a viable alternative to many other irrigation systems currently in use for greenhouse production of potted plants.. It can be fabricated from a number of off-the-shelf building materials and will accommodate most bench configurations, container types and spacings. It is also anticipated that, with proper anchorage to deal with wind, the DCWIPSS can be used outdoors for production of containerized landscape plants up to 3-gallon capacity.

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Runoff Nitrogen Levels from Two Alabama Nurseries

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Nature of Work: The nursery industry has often been targeted as a source for nonpoint source pollution. In 1987 the EPA mandated states to address agricultural (nursery industry included) nonpoint source pollution problems and to implement management plans (1). Two wholesale container nurseries, one located in north Alabama and one in south Alabama were monitored during 1997 for nitrate-nitrogen (NO_3-N) levels. Sample locations at the north Alabama nursery were: irrigation water pumped from a retention basin, bed runoff prior to entering a grass filter strip, bed runoff exiting grass filter strip, and a collection pond. Sample locations at the south Alabama nursery were: irrigation water pumped from a deep well, bed runoff, collection pond, and leaving the property. Samples at both nursery locations were collected after designated irrigation events (1, 4, 8, 24, and 48) following fertilizer application. Irrigation at both nurseries was applied using overhead impact heads; application amount for each event was from 0.7 to 0.8 inches. Nutricote 20-7-10 fertilizer was applied at the north Alabama nursery on June 19, and Sierra 17-7-10 fertilizer was applied at the south Alabama nursery applied on July 9. Fertilizer was applied as a top-dress according to manufacture's recommendations at both locations. Triplicate water samples were collected at each event. After collection, all samples were placed in a cooler, iced, transported to the laboratory, and frozen for later nitrogen analysis. Nitrogen analysis was conducted with a WesCan Model 360 Ammonia Analyzer (2).

Results and Discussion: All samples at both nursery locations had NO_3-N levels below the 10 mg ($liter^{-1}$ maximum contaminate level as mandated by the 1974 Safe Drinking Water Act, for public water systems. At the south Alabama nursery, runoff water NO_3-N levels were reduced an average of 84 percent in the collection pond and 99 percent as the water overflowed the pond and left the property compared to bed runoff (figure 1). At the north Alabama nursery, runoff water NO_3-N levels were reduced from an average of 7.0 mg • $liter^{-1}$ prior to entering grass filter strip, to 4.7 mg •$liter^{-1}$ upon exiting the grass filter strip. This amounts to a 33 percent reduction (figure 2). No NO3-N levels were detected in the collection pond at the north Alabama nursery. These data support previous research showing runoff water levels below 10 mg ($liter^{-1}$ in critical locations: wells, collection ponds and leaving the property (3).

Significance to Industry: This study demonstrates the positive impact selected best management practices have in reducing NO_3-N levels in runoff water. Use of controlled release fertilizers resulted in runoff water at both nurseries with NO_3-N levels less than 10 mg • liter^{-1} at all sample dates. These data tend to disconfirm the perception that nursery runoff water contains high NO_3-N levels. Collection ponds and grass filter strips can be important best management practices to further reduce NO_3-N levels in nursery runoff water.

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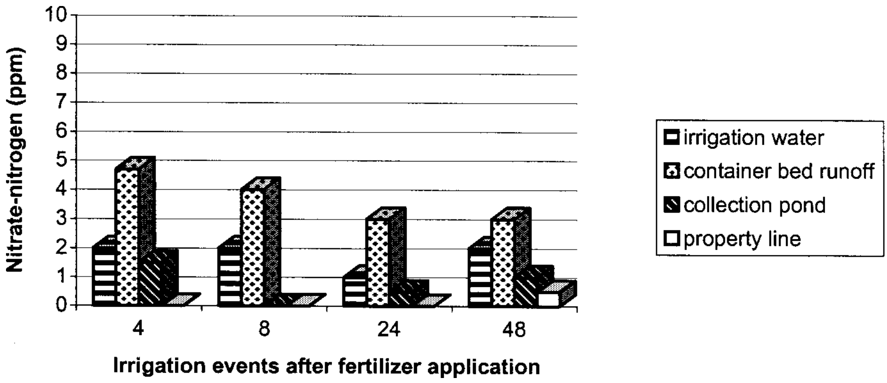

Figure 1. Runoff water Nitrate-nitrogen levels at a south Alabama container nursery.

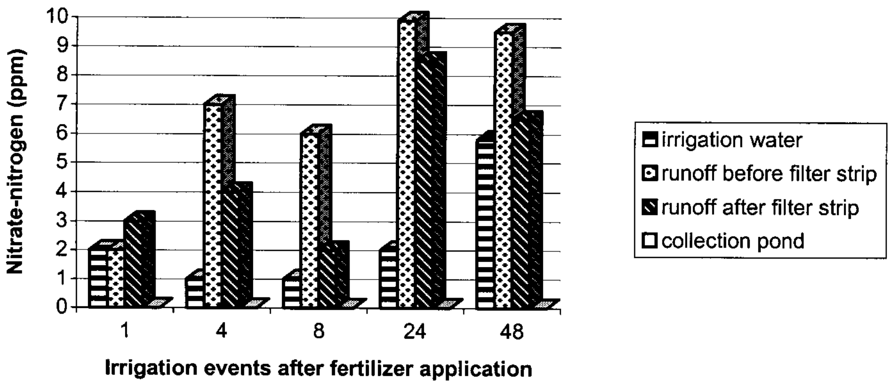

Figure 2. Runoff water Nitrate-nitrogen levels at a north Alabama container nursery.

Square Funnel Containers for Nursery Production
(Student)

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Nature of Work: Container-grown woody ornamentals are commonly placed under overhead irrigation with space between containers to accommodate plant canopy growth. Spacing one-gallon containers without plants on 1-ft centers arranged in a square pattern results in only 9% of the ground surface area being covered (3); however, due to plant canopy effects overhead irrigation application efficiency ranges from 13 to 63% (1, 5).

A method for increasing irrigation application efficiency would be to extend the container lip so water is funneled into the container. This would enable containers to cover 100% of the ground surface area, if containers were spaced so that funnel edges touched.

The purpose of the following research was to investigate the water capture of square funnel containers compared to conventional round containers.

Results and Discussion:
Uniformity of Irrigated Area
To evaluate the irrigation water capture by different designs of containers a uniform irrigation system was needed. A 20-ft by 20-ft irrigation area was set up with a Rain Bird® SideWinder SW2000NHF head (Rain Bird, Glendora, Cal.) and number 15 nozzle on 4-ft risers at each corner. The area was delineated into 100 2-ft by 2-ft squares. The outer row on each side was removed and measurements were taken on the inner 64 squares. The irrigation system was run four times at two rates, 13.6 and 68 minutes, when there was no wind. Water was collected in cups placed in the center of each square. After each irrigation, water volume from each cup was measured using a graduated cylinder and recorded according to location of each cup.

The Christensen equation was used to determine irrigation application uniformity [$C_u = 100\,(1 - B/A)$], where A is the sum of individual observations and B is the sum of the absolute value of differences between the average and each individual observation. Uniformity achieved with each run time surpassed the 87% needed for container crops (4). The mean uniformity was 88.8%. The mean application rate was 0.029 cm/min or 0.6 inches per hour, a common application rate in nurseries (2). This irrigated area was used for subsequent experiments.

Water Captured Without Plants

The lips of square funnels on the square funnel containers measured 1-ft by 1-ft. The surface of the square funnel container is about 5 times larger than the surface of a round container while having the same volume of growing media. Square funnel and round containers were placed in a completely randomized design in groups of nine, in a three container by three container square pattern on 1-ft centers in areas of greatest irrigation uniformity. Measurements were taken on the center container, which had the drainage holes covered with duct tape and filled with silicon glue. Irrigation was applied for 22 minutes. The containers were weighed before and after irrigation. A capture factor of the square funnel container to round container was calculated from the volume of water (weight) the square funnel containers captured divided by the volume of water (weight) the round containers captured. The experiment was conducted without wind and repeated four times. The capture factor mean was 4.3 ± 0.1.

Water Captured With Plants

This experiment was conducted to determine if *Viburnum odoratissimum* (Ker-Gawl.) size influenced the effectiveness of the square funnel containers. Four treatments were used, 1) large plant in round container, 2) large plant in square funnel container, 3) small plant in round container, and 4) small plant in square funnel container. Each experimental unit was the center plant from a group of nine plants arranged three containers by three containers on 1-ft centers. During the experiment each container plant was placed inside another 1-gallon container. The additional container had its drainage holes secured shut by placing duct tape on the outside of the container and silicon cement filled the drainage holes. Treatments were randomly arranged in irrigated areas of greatest uniformity. The experiment was conducted under windless conditions and the irrigation system ran for 22 minutes. Volume of water collected by plants was determined for each experimental unit by weighing the plant and additional container before and after irrigation and the difference in weight was the volume of water collected. By dividing the mean volume collected for square funnel containers by the volume collected for round containers, a capture factor was determined for each size of plants. There were eight replications over time. Leaf area was determined using a Li-Cor leaf area meter LI-3000A (Li-Cor, Lincoln, Neb.). The leaf areas were 803 in^2 for large plants and 597 in^2 for small plants. Volume of water captured by round or square funnel containers was not different due to plant size. However, the amount of water captured by square funnel containers (570-ml) was greater ($P \leq .05$) than round containers (423-ml) resulting in a capture factor of 1.3. The fact that the capture factor with plants was less than the capture factor without plants could have been due to plant foliage funneling water onto the media surface. Funneling of water by foliage decreased the effect of the square funnel container, because most of the funnel was covered by foliage leaving little of the funnel exposed to collect water.

Significance to Industry: Square funnel containers spaced on 1-ft centers captured more water than conventional round one-gallon containers. The effectiveness of the funnel was masked when foliage extended beyond media; however, the extent of the masking may differ depending on plant size and species. Further research needs to be conducted to determine the effects of the water capture on nutrient leaching and possible methods of fertilizing square funnel containers.

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Frequent Irrigation Increases the Growth of Pot-in-Pot Sugar and Red Maple
(Student)

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Nature of Work: Recent investigations have shown that cyclic micro-irrigation can be used in pot-in-pot production systems to increase tree growth, improve irrigation efficiency and reduce fertilizer leaching losses (1,7). Pot-in-pot production utilizes a permanent, in-ground 'socket pot,' in which containerized trees are grown (6). The system is commonly used with micro-irrigation systems (spray stakes) which can be used frequently during the day to maintain near ideal water status in containers without the water losses associated with overhead irrigation. Cyclic micro-irrigation has been shown to reduce nutrient leaching from containers (5,2). For these reasons, as well as the improved cost effectiveness, use of the pot-in-pot system with micro-irrigation is increasing rapidly in the southern US (3,4,7). There remains a need to investigate the use of these technologies under a wide variety of production conditions and situations. Therefore, the goal of the current research is to investigate the benefits of cyclic micro-irrigation on a fast-growing species (red maple) and a moderate species (sugar maple) during the two years of production they are typically kept in a pot-in-pot production area.

The experiment was conducted at the Virginia Tech Urban Horticulture Center, Blacksburg, VA. Liners (four feet tall) were planted in 56-liter (15-gallon) containers, in pine bark substrate amended with 3.6 kg/m^3 (6.0 lb/yd^3) dolomitic limestone and 0.9 kg/m^3 (1.5 lb/yd^3) Micromax® micronutrients. Trees of each species, *Acer rubrum* 'Franksred' (red maple) and Acer saccharum 'Green Mountain' (sugar maple), were planted in the spring of 1996 and 1997 so that trees of two ages and two species were available for the experiment during the summer of 1997. All plants were topdressed with 113 g (3.99 oz.) of 18N-2.4P-9.6K (18-6-12) slow release fertilizer (Osmocote®, Sierra Chemical Co., Milpitas, CA) each spring. Initial measures of height and caliper were taken on May 15, 1997, with final measurements taken November 6, 1997. Irrigation was either a single application (1X) at 6:00am, or the same total amount applied at three times (3X), 3/5 at 6:00am, 1/5 at 10:00am and 1/5 at 2:00pm. Irrigation volume was determined to always bring plants to container capacity at the 6:00am irrigation for 1x and 3X. The actual volume of water applied was increased throughout the summer as evapotranspiration increased (as assessed by periodic leachate collection). The experimental design was a split-plot.

Results and Discussion: There were important differences in the growth of trees of different production cycles between years and between species (Table 1.) The most striking differences are between species, so they will be discussed independently. In short, the fast-growing red maple showed improved caliper development during both years of production with 3X irrigation. Red maple showed no difference between the irrigation treatments for height growth, but did show an overall decrease in height growth in the second production cycle. The slower growing sugar maple showed no significant response to irrigation treatment in the first production cycle, but in the second production cycle they showed a dramatic increase in both height and caliper growth with frequent irrigation.

Red maple showed significantly greater caliper growth under 3X irrigation, in both years, averaging 1.20 cm as opposed to 0.98 cm for 1X. This increased growth can be explained as decreased moderate water stress during hot dry afternoons. Red maple did not show similar results for height growth, showing significant differences between production cycles only. The decreased height growth in the second production cycle, 34.2 cm as opposed to 70.0 cm in the first production cycle, may have resulted from their large size. Visual assessment of the root systems showed that these trees were beginning to become potbound by the end of their first production cycle. This condition may have altered the root to shoot ratio, accounting for the observed effects.

Sugar maple trees did not show any significant response to irrigation frequency during the first production cycle in terms of height or caliper growth. This may also be due to tree size. The relatively small trees were furnished with sufficient water, in the large containers, to support near optimal growth with or without frequent re-supply. The situation changed in the second production cycle. As the sugar maples began to fill the containers with roots, the container water capacity became limiting for the 1X trees, and they began to show differences in height and caliper growth between the irrigation treatments. During the second production cycle height growth was 53.1 cm for the 3X irrigation treatment, but only 31.5 cm for the 1X treatment. Caliper growth showed a similar reaction with average growth of 1.14 cm for the 3X treatment and 0.81 cm for the 1X treatment.

Significance to Industry: Fast growing trees like red maple may suffer compromised growth if kept in a pot-in-pot production system for more than a single production cycle, though cyclic micro-irrigation may alleviate some water stress, and enable improved caliper development. Trees which grow at a moderate rate, like sugar maple may not benefit from cyclic irrigation in their first production cycle, but show improved response when large enough to impose a significant drain on a container's water holding capacity.

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Table 1. Effects of irrigation frequency on height and caliper growth of red and sugar maples in two production cycles.

Species/ Production Cycle[1]	Irrigation Treatment[2]	Height Growth (cm)	Caliper Growth (cm)
Red Maple			
First Production Cycle	3X	67.1a	1.19a
	1X	72.6a	1.01b
Second Production Cycle	3X	38.1b	1.22a
	1X	30.4b	0.95b
Sugar Maple			
First Production Cycle	3X	14.4b	0.82b
	1X	22.5b	0.84b
Second Production Cycle	3X	53.1a	1.14a
	1X	31.5b	0.81b

[1] Means in the same column for the same species followed by the same letter(s) are not significantly different at the p=0.05 level (LSD).

[2] Irrigation treatments were all water applied in morning (1X) or the same amount of water split into three unequal applications per day.

Cyclic Irrigation Affects on Container-Grown 'Little Gem' Magnolia Growth and Fertilizer Leaching

(Student)

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Nature of Work: Landscape tree production in large containers (>25 gallons) is becoming more popular. Large containers includes wooden boxes and plastic pots up to 700 gallons. However, the most efficient method of watering large containers has not been established. Cyclic irrigation, dividing daily irrigation into several applications, has been shown to reduce effluent and leaching of nutrients (1,2,3,4,5,6). The objective of this study was to determine the most efficient irrigation frequency for 32-gallon 'Little Gem' Southern magnolias while minimizing nutrient leaching.

This experiment was performed on the Louisiana State University Hill Farm, Baton Rouge, LA. Three gallon 'Little Gem' Southern magnolias were transplanted on April 18, 1997 into 32 gallon wooden boxes filled with a pinebark: peat: sand (3:1:1 v/v/v) medium with incorporated amendments of 12 lbs/yd^3 Nutricote Total® 17-7-8 (Type 270) with micronutrients and 12 lbs/yd^3 dolomitic lime (Gordonsville, TN).

The wooden tree boxes were placed onto square angle iron frames raised 10 inches from the ground. Between the frame and box was a 24 inch square piece of neoprene rubber with a drain positioned in the center. Effluent was collected in closed 5 gallon Igloo® containers. Irrigation was supplied with 48" drip tubing fashioned into rings (Drip-In Irrigation Co., Fresno, CA) placed on the medium surface. In-line emitters spaced 6 inches apart were pressure regulated to allow 0.5 gallons per hour/emitter. Trees were irrigated appoximately 2.1 gallons per day in June, 3.0 gallons per day in August and 2.5 gallons 3 times per week in November. Trees were arranged in a RCBD with 4 irrigation treatments; (1, 2, 4, and 8 times a day) and 5 replications. One time per day 1(X) trees were watered at 6:00 AM; two times per day 2(X) 6:00 AM and 3:00 PM; four times per day 4(X) 6:00 AM, 9:00 AM, 12:00 AM, and 3:00 PM; 8 times per day 8(X) 4:30 AM, 6:00 AM, 7:30 AM, 9:00 AM, 10:30 AM, 12:00 AM, 1:30 PM, and 3:00 PM.. Effluent was collected June 30, August 15, and November 21 and measured. Leachates were taken from the effluent and analyzed for pH, E.C. and N, P, and K. Effluent volume was collected once per week during the months of June and August and twice per month in November. Shoot height measurements were taken from the medium surface to the apical meristem to the nearest 0.25 inches utilizing a calibrated measuring pole. Stem caliper measurements were taken one inch from the soil line using a Mitutoyo® digimatic caliper to the nearest 1/100 of an inch.

Results and Discussion: Results indicated that the 1(X) treatment had significantly more effluent than 2(X), 4(X), and 8(X) per day, and 2(X) treatment was significantly greater than the 8(X) per day treatment for June, August and November (Table 1). In June 4(X) and 8(X) reduced effluent by 50% and 2(X) by 43%. Effluent collected in the month of August was reduced 16% by irrigating 2 and 4 times per day and by 26% watering 8 times per day. In November watering 2(X) and 4(X) reduced leaching by 11% and to 44% with 8(X).

Significant differences in height were found in June with 1(X) being the tallest (Table 2). No significant differences were found in caliper measured in June. In August, 8(X) had a larger caliper when compared to the 1(X) treatment. Significant height differences were not found. There were no significant height and caliper differences to report for November.

The 1(X) total N, P, and K leached was significantly greater than the 2(X), 4(X), and 8(X) treatments in June (Table 3). Total nitrogen and phosphorus leached averaged a 85% reduction for June. There was an average of 96% reduction in total potassium leached in the 1(X) treatment compared to the 2(X), 4(X), and 8(X) treatments. In August, total phosphorus for the 4(X) was significantly greater than 1(X) and 8(X). There were no significant differences in total N and K leached in August. For the month of November total N and K leached followed similar patterns with 1(X) per day leaching the greatest amount of nutrients. The 2(X) and 8(X) per day treatments leached 77% less N and K than the 1(X) treatment. Also, 4(X) reduced N and K leaching by 60%. There were no significant P differences between the 1(X), 2(X), or 4(X) treatments. However, the 8(X) treatment leached 40% less than 1(X) treatment.

Significance to Industry: This research indicates that irrigating more than once per day decreases leaching of nutrients therefore utilizing fertilizer more efficiently and conserving water. Therefore, a grower can maximize tree growth and reduce the cost of production by using cyclic irrigation.

Table 1. Mean daily effluent collected from container-grown ‘Little Gem’ Southern magnolias during June, August, and November 1997 influenced by irrigation frequency.

Irrigation Frequency	June (gallons)	August (gallons)	November (gallons)
1	1.4 a	1.9 a	1.8 a
2	0.8 b	1.6 b	1.6 b
4	0.7 c	1.6 b	1.6 b
8	0.7 c	1.4 c	1.0 c

[z]Means within columns followed by the same letter are not significantly different according to Duncan’s Multiple Range Test ($P \leq 0.05$).

Table 2. Shoot height and stem caliper of container-grown 'Little Gem' Southern magnolias during June, August, and November 1997 as influenced by irrigation frequency.

	June 4, 1997		August 14, 1997		November 15, 1997	
	Height	Caliper	Height	Caliper	Height	Caliper
Irrigation Frequency	··········Inches··········					
1	73 a	0.77 a	79 a	0.80 b	90 a	1.2 a
2	68 b	0.76 a	80 a	0.83 ab	86 a	1.3 a
4	69 ab	0.78 a	77 a	0.81 ab	90 a	1.2 a
8	72 ab	0.78 a	83 a	0.85 a	94 a	1.2 a

[z]Means within columns followed by the same letter are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Table 3. Total N, P, and K collected from container-grown 'Little Gem' Southern magnolias on selected dates in June, August, and November as influenced by irrigation frequency.

Irrigation Frequency	June 30, 1997			August 15, 1997			November 21, 1997		
	mg								
	TNL	TPL	TKL	TNL	TPL	TKL	TNL	TPL	TKL
1	152 a	28839 a	734 a	83 a	30113 b	604 a	63 a	22878 a	467 a
2	19 b	4450 b	25 b	85 a	36748 ab	545 a	15 b	20729 a	106 b
4	12 b	2818 b	8 b	95 a	50568 a	615 a	25 ab	19391 a	189 ab
8	33 b	5577 b	49 b	75a	34007 b	396 a	14 b	13651 b	106 b

[z]Means within columns followed by the same letter are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).
TNL=Total Nitrogen Leached; TPL=Total Phosphorus Leached; TKL=Total Potassium Leached.

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Water Sample Collection Procedures for Container Nurseries

(Poster)

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Nature of Work: Many nurseries in the southeast are confronted with water management regulations. These regulations often focus on ground water, and regulate the quantity used for irrigation and the time of day irrigation can be applied. Consequently, some nurseries are collecting and recycling production bed runoff water, utilizing water reclaimed by municipalities, or collecting and storing rain water for irrigation because these sources of water are usually less regulated than ground water. Other nurseries are utilizing these alternative sources of irrigation water because of poor quality ground water.

When utilizing these alternative water sources, it is very important to monitor water quality; however, prudent management strategies should include water quality monitoring regardless of source. Monitoring the water quality will reveal changes in inorganic ion composition of the water. Common ionic analyses include pH, electrical conductivity (EC), NO_3-N, Ca, Mg, Cl, and Fe. Water analyses can be performed by university or private laboratories. Water quality guidelines and laboratories are listed in the *Best Management Practices Guide for Producing Container-grown Plants* (3). Water quality standards for potable water are given in *Ground Water and Wells* (2).

A very important part of monitoring water quality is taking the samples. It is important that samples represent the water source and that sampling procedures are reproducible and consistent. Water samples are usually taken from the source, such as a well or surface water, water discharged from production areas, collection basins or reservoirs, and water leaving the property. An important consideration when taking samples is whether or not the desired sampling location is safe (1). This is particularly important when sampling runoff collection basins, small bodies of water, or streams where water exits the property. Dense vegetation around water can harbor dangerous animals. Also, if sampling is done from piers or planks that extend over water, check their structural integrity. A second consideration is whether sampling can be repeated (1) at the specific location and depth. A third consideration is appropriate documentation (1) of the sampling location. There should be sufficient landmarks noted on a map that will enable others to sample at the same location.

Frequency of sampling may vary. Collection of samples every two to four months is usually sufficient for routine monitoring; whereas, weekly sampling may be needed for trouble shooting a specific problem. At each sampling location, collect three replicate samples.

Results and Discussion: The following is a list of procedures for sampling well water, runoff water, reservoirs or collection basins, or water from irrigation risers. Sample collection from streams would be similar to reservoirs except sample depth is usually less for streams.
This information was compiled after several years of sampling at container nurseries in Florida. Perhaps you can add additional procedures.

General Sample Collection Procedures

- Collect a full new plastic bottle (100 ml or one-half cup) for each replicate sample
- Cool samples, place on ice or refrigerate
- Filter to remove sand and particulates
- Analyze immediately

Well Water

- Collect from well water supplying production beds
- Run water 5 minutes prior to sampling
- Avoid sampling during air blast from spigot
- Avoid sampling during times of extreme pressure fluctuation
- Rinse bottle and cap
- Collect full bottle

Production Bed Runoff Water

- Find depression or water deep enough to submerge bottle and collect full bottle
- Avoid old water already in depression or in place to be sampled
- Avoid areas where soil movement was caused by equipment
- Be careful not to bump pipes or disturb soil next to sample location
- Avoid sampling runoff from just one side of production bed
- Sample from lower end of one production bed where sample represents total bed area
- Sample runoff from several production beds after runoff has flowed together
- Avoid getting overhead irrigation water in sample
- Collect sample near end of irrigation cycle
- Avoid excess debris in sample
- Injected fertilizer concentration could vary with sampling location

Basin or Reservoir Water

- Gently move to one side the scum on water surface
- Remove debris from water several minutes before sampling
- Submerge bottle opening down
- Collect full bottle 1-2 feet below surface

Water from Irrigation Riser

- Avoid areas of poor irrigation uniformity
- Run water 5 minutes prior to sampling
- Rinse bottle and cap
- Collect full bottle
- Use pan to collect irrigation water if fertilizer is pulse injected

Significance to Industry: Documenting the nutrient composition of water used and discharged is an important management practice. For example, the electrical conductivity or soluble salts of the irrigation water may become elevated during times of inadequate rain. This can only be detected by periodic monitoring. Water samples should be obtained from the irrigation water source, reservoirs or basins containing irrigation water, runoff from production beds, and water discharged from the property.

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