Economic Feasibility of Micro-Irrigating Container-Grown Landscape Plants[1]

J.J. Haydu[2] and R.C. Beeson, Jr.[3]
University of Florida, Institute of Food and Agricultural Sciences
Central Florida Research & Education Center, 2807 Binion Road, Apopka, FL. 32703

Abstract

While past research has examined certain technical efficiencies, little effort has been directed at the economic feasibility of various irrigation systems for container-grown landscape plants. Two irrigation systems, cyclic micro-irrigation and overhead impact sprinkler, were examined to determine economic advantages of one system over the other for container-grown landscape plants. Seedlings of *Acer rubrum* L. and *Quercus virginiana* Mill. produced in #3, #7, #10 and #15 (10.2, 26.5, 37.8, and 56.8 liter) polyethylene containers were considered. A two-step methodology was used to establish the biological and economic parameters of the study. Three major conclusions were arrived at in this paper. First, with the exception of the smallest container size, there was little difference in initial investment costs and variable costs of production between the two systems. Second, water costs were shown to be prohibitive for larger container sizes when reclaimed water is used in conjunction with overhead systems. Third, the potential impact of cyclic micro-irrigation on a firm's economic returns were shown to be positive. Cyclic micro-irrigation markedly speeds up the production process, utilizes less material inputs and a fraction of the water of an overhead system.

Index words: micro-irrigation, overhead irrigation, tree production, installation costs, direct costs, gross returns, net returns, container production.

Significance to the Nursery Industry

Water use and business profitability are two important factors influencing nursery production. This concern is heightened where large agricultural interests are in close proximity with fast growing urban populations. Many current water use practices are coming under close scrutiny in these areas as competition for increasingly scarce water escalates. Cyclic micro-irrigation for container production offers a viable alternative to overhead irrigation systems, despite the higher costs associated with installation and maintenance. In this study, water consumption was between 1/4 and 1/16 the levels of overhead systems, depending on container size. Profitability was also considerably more favorable for cyclic micro-irrigation in every container size category due to the shorter times required to obtain a saleable crop.

Introduction

Few subjects are more important to agricultural producers today than business profitability and water use. As the doors to global markets open wider (7), competitive pressures to improve economic efficiency have grown markedly in recent years. Similarly, mounting urban populations place unprecedented pressures on water quality and availability and many agricultural users are increasingly forced to justify their consumption patterns (2). These issues are particularly salient in some southern states where traditional agricultural interests are feeling the pressure of high-growth urban centers. Florida may be at the apex of this urban-agricultural dilemma. With a net population growth of nearly 1,000 people per day (3) and an agricultural sector representing 40,000 farms on 10.57 million acres yielding $6.14 billion in 1992 cash receipts (10), concerns on both sides are deep-rooted and pervasive.

Florida's nursery and greenhouse industry is also feeling the pressure for more responsible use of water resources and maintaining business profitability (6). Regarding the latter, the number of firms have declined by one-fourth in the past five years, per firm production areas have increased 19 percent, and unit sales have grown by 25 percent (5). Prudent use of Florida's water has become a major issue for state and local decision makers, particularly the regulatory agencies responsible for allocating these resources among frequently competing user groups. Many nurseries are located close to (or within) large urban centers and potential conflicts over water appear certain. For example, the Southwest Florida Water Management District (SWFWMD) estimates that within ten years most nurseries in the area will be using reclaimed water (12).

Since reclaimed water is considerably more expensive than groundwater, such a mandate would have important implications for producers using high-volume overhead systems. Irrigation efficiencies become an important factor under such high-cost scenarios. These efficiencies provide a basis for comparing irrigation systems from the standpoint of water beneficially used and from yields per unit of water used (4). Although no irrigation system is waste free since the cost of preventing all loss is prohibitive, some systems are capable of minimizing this waste. In contrast to overhead sprinklers, micro-irrigation uses water more efficiently, yet currently less than 5 percent of ornamental crop acreage is estimated to be utilizing this form of irrigation (6, 11). Thus, the question is no longer whether water restrictions will occur, but rather when, how many, in what form, and at what cost to producers. Consequently, the purpose of this paper is to explore the potential economic benefits to nurserymen of using micro-irrigation technology in contrast to traditional overhead irrigation systems.

[1]Received for publication March 11, 1996; in revised form September 9, 1996. University of Florida Agricultural Experiment Station Journal Series No. R-05052.

[2]Associate Professor, Central Florida Research and Education Center, Apopka, IFAS, University of Florida, 2807 Binion Rd., Apopka, FL 32703.

[3]Associate Professor, Central Florida Research and Education Center, Sanford, IFAS, University of Florida, 2700 E. Celery Ave., Sanford, FL 32771.

Materials and Methods

In this study we examined the specific costs associated with establishing and operating micro-irrigation and overhead systems for a one-year period. Secondly, we explored the differences plant growth rates and container size had on net returns to the firm. Finally, we addressed differences in water use for the two systems and the potential impacts to producers from alternative water sources. The research involved a two-step process of collecting and tabulating biological and economic data. In the first step, seedlings of *Acer rubrum* (red maple) grown in #1 (3.8 liter) containers and *Quercus virginiana* Mill. (live oak) grown in 4 in (1 liter) pots were transplanted into #3 (10.2 liter) polyethylene containers in mid-March and mid-April, respectively. Trees of each species were randomly distributed among six micro-irrigated treatments and an overhead control (1). Overhead irrigation was applied at 0500h daily using impact sprinklers. Micro-irrigation was applied with an individual spray stake (Terracotta Spot Spray, Roberts Irrigation Products, San Marcos, CA) in each container in three different subvolume frequencies daily at the same and twice the volume of water per pot applied to the overhead control trees. All trees were given a controlled-release fertilizer twice during production and pruned to promote commercially acceptable quality. Tree height and trunk diameter at 6 in (15 cm) from the tree base were recorded during production with final measurements made in mid-December shortly after quiescence. Growth rates were analyzed by calculating linear regression equations of increases in tree height and trunk diameter with time. Slopes of resulting equations were compared using single-degree-of-contrast (8) to distinguish differences among treatments. The cyclic micro-irrigation treatments used in the second step were those which produced the greatest growth (Fig. 1). For live oak, growth rates were based on the same volume per pot as the overhead 0.29 gallon (1.1 liter) applied in 2 cycles (1). For red maple, growth rates from the double overhead volume applied as 3 cycles was used (1). Slopes from these equations were used to estimate growth schedules for larger container material.

The second step involved identifying and tracking all the costs associated with the two irrigation methods during the #3 (10.2 liter) container production phase (Step 1) and extrapolated for #7, #10 and #15 (26.5, 37.8 and 56.8 liter) container sizes to a convenient-sized production area. To accomplish this, 10,560 ft^2 (1,000 m^2) production systems were designed and installation costs estimated for both overhead and cyclic micro-irrigation using #3 (10.2 liter) containers. Costs were organized under two categories, installation costs and variable costs of production. Installation costs for the overhead system included materials such as impact sprinklers, ball valves, and several sizes of PVC pipe. A labor expense was also included in the installation. For micro-irrigation, materials consisted of emitters, 0.125 in (3.2 mm) (spaghetti) tubing, polyethylene tubing, PVC pipe, electric valves, clocks, and labor. The primary difference between the two systems was that, for a given area, installation costs were independent of container size in an overhead system but were directly related to the number of containers for micro-irrigation. More containers required additional materials and labor to install a micro-irrigated system. Variable costs associated with production for materials and labor were tracked for each activity on a small scale (overhead—56 trees; micro-irrigation—56 trees) during the entire production pe-

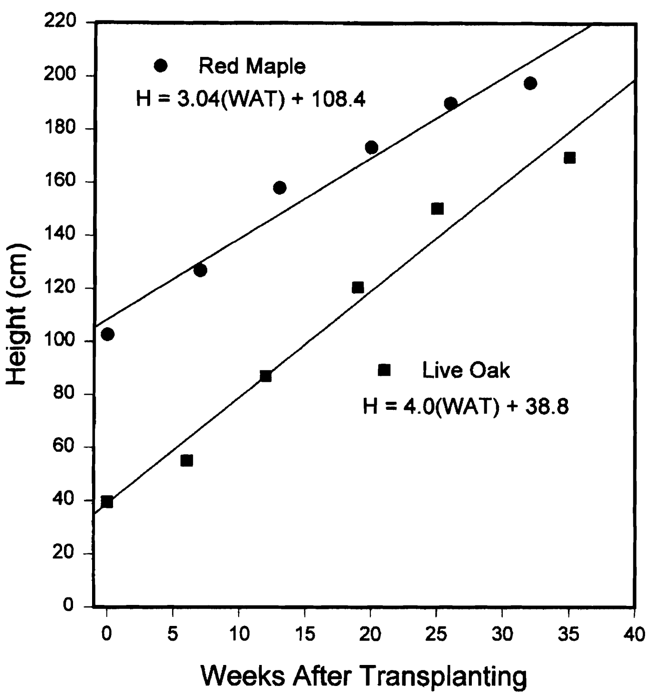

Fig. 1. Linear regressions of height growth rates for the fastest growing treatments for live oak (■) and red maple (●) cycle irrigated. Live oak were irrigated in two cycles with the single volume, while red maple were irrigated in three cycles with the double volume. Each point is the mean of 13 single plant replications.

Table 1. Production times used in the economic analysis for tree liners to reach market specifications in each container size.

	Irrigation method			
	Cyclic micro-irrigation[z]		Overhead sprinklers[y]	
	Oak	Maple	Oak	Maple
Container size	Weeks to reach saleable specifications			
#3	28[x]	24[w]	82[v]	62
#7	74[u]	60	104[t]	78
#10	87[u]	69	122[s]	91
#15	108[u]	82	135[r]	117

[z]Production times based on growth rates of #3 (10.2 liter) container trees measured in Step 1 and extrapolated to larger container sizes, assuming 3 month dormancy period.

[y]Production times for each container size were the cumulative time from liners to market specifications of a large local tree farm for live oak and red maple, respectively.

[x]Based on measured tree growth.

[w]Based on tree growth plus 12 weeks to account for liner to #1 container stage.

[v]Based on transplanting liners to #1 then #3 containers.

[u]Based on growth rates of #3 container trees, assuming 9 months of growth and 3 months of dormancy for both species.

[t]Based on transplanting liners to #1 then #7 containers for both species.

[s]Based on transplanting liners to #1 then #3 then #10 containers for both species.

[r]Based on transplanting liners to #1 then #3 then #15 containers for both species.

riod of Step 1. These costs were then extrapolated for the 0.25 A (0.1 ha) area and for trees produced to marketable size in #7, #10 and #15 gallon (26.5, 37.8, and 56.8 liter, respectively) containers. Production times for larger container sizes were based on growth rates of #3 (10.2 liter) grown trees from Step 1 and adjusted for seasonal dormancy (3 months) for the cyclic micro-irrigated treatments. Data for the overhead control was obtained from the production schedule of a 450-acre local tree farm (Table 1). This nursery has been producing containerized trees for 15 years and is recognized for its efficient production methods and high quality material. Growth periods to attain trees of marketable size are considered comparable to those attained under optimal conditions. Economic returns were determined for each tree species, irrigation method and container size, the variables most significantly impacting growth rates. Representative wholesale prices were obtained for live oak and red maple from the April 15, 1994, *PlantFinder*, a nursery trade magazine in Florida that inventories nurseries selling specific types of plants. Prices used in this study were the average of all nurseries listed for the respective size. These prices were used to calculate gross and net returns in the economic assessment. For simplicity of comparison, both variable costs and gross returns were calculated for a production period of one year. Finally, it was assumed that under either irrigation method trees would be sold immediately upon their reaching marketable size.

Results and Discussion

Generally, trees grown under a cyclic micro-irrigation system reached a marketable size substantially faster than those under an overhead system. For example, whereas a #3 (10.2 liter) live oak required 82 weeks to mature with overhead irrigation, it needed only 28 weeks under a cyclic system. With a faster growth rate, a grower could potentially produce 1.86 crops in one year (52 weeks/28 weeks) using micro-irrigatation and increase sales markedly. At the same time, variable costs would also increase, since more materials and labor would be required for the additional production.

As noted earlier, the production area in this study was 1,000 m^2 and it held 3,888 #3, 1,540 #7, 644 #10 and 374 #15 containers (10.2, 26.5, 37.8 and 56.8 liter, respectively). Installation costs for overhead systems were independent of container size, remaining constant at $717 for 10,560 ft^2 (1,000 m^2) of production area (Table 2). In contrast, these same costs varied considerably for micro-irrigation. Costs ranged from a high of $1,605 for 1,000 m^2 #3 (10.2 liter) material to a low of $289 for #15 (56.8 liter) containers. Since each container/plant had its own emitter, most variability (52 percent) was due to the cost of these emitters and the 0.125 in (3.2 mm) polyethylene 'spaghetti' tubing leading to them. Time clocks were also significant accounting for roughly 25 percent of installation costs for each container size. Labor used in installing the equipment for micro-irrigation was large

Table 2. Installation costs for overhead (OH) and micro-irrigation (MI) systems, for # 3, # 7, # 10 and #15 (10.2, 26.5, 37.8 and 56.8 liter, respectively) material on 0.25 A (0.1 ha) production area.

Materials	#3 Container		#7 Container		#10 Container		#15 Container	
	Units	Dollars[z]	Units	Dollars[z]	Units	Dollars[z]	Units	Dollars[z]
Micro-irrigation								
Emitters[y]	3,888	544	1,540	216	644	90	374	52
Spaghetti tubing[x]	4,755 m	296	1,878 m	117	785 m	49	456 m	28
25mm PVP tubing[w]	330 m	87	330 m	87	330 m	87	330 m	87
Time clock[v]	9	405	4	180	2	90	1	45
Labor[u]	42 mh	273	20.2 mh	132	6 mh	78	3.5 mh	62
Total MI		**1,605**		**732**		**394**		**289**
Overhead[t]								
Impact sprinklers	13	432	13	432	13	432	13	432
Ball valves	13	155	13	155	13	155	13	155
25 mm PVC pipe	110 m	58	110	58	110	58	110	58
12 mm PVC pipe	24.3 m	13	24.3 m	13	24.3 m	13	24.3 m	1
Labor[s]	9 mh	59	9 mh	59	9 mh	59	9 mh	59
Total OH		**717**		**717**		**717**		**717**

[z]Costs are rounded to the nearest dollar.

[y]Emitters $0.14 each.

[x]Spaghetti tubing $62.30 for 1,000 meters (m).

[w]25mm PVP tubing $262.50 for 1,000 meters (m).

[v]Time clock $45.00 each.

[u]Labor at $6.50 per man hour (mh). Installation costs comprise two activities: Activity 1, laying trunk lines (3 mh) and laterals (3 mh) requires a total of 6 mh and is independent of container size. Activity 2, assembly and installation is a function of the number of containers. Man hours were based on the time required for 1 person to cut, assemble and install into a 50 ft. polyethylene lateral with 100 emitters. Installing 1,000 m^2 of #3 containers requires 36 mh. Installing 1,000 m^2 of #7 containers takes roughly 40% less time (1,540/3,888 = 0.396, or 14.2 mh). Therefore, total labor costs (TLC) for #7 containers are: (TLC = [Activity 1: {6 mh × $6.50 = $39.00}] + [Activity 2: {36 mh × 0.396 × $6.50 = $93}] = $132.00). Labor for MI diminished with larger pot sizes because there are fewer emitters per unit area to assemble and install.

[t]Installation costs of overhead irrigation is independent of container size.

[s]Labor at $6.50 per man hour. Man hour based on estimated time for 2 person crew with appropriate equipment.

Table 3. **Annual labor costs associated with producing #3, #7, #10 and #15 (10.2, 26.5, 37.8 and 56.8 liter, respectively) material on 0.25 acre (0.1 ha) production area, using micro-irrigation or overhead.**

	System type[z]			
	Micro-irrigation		Overhead	
Type of labor activity	Man hours[y]	Costs ($)	Man hours[y]	Costs ($)
Potting liners	179	1,164	179	1,164
Inspect irrigation	195	1,267	6	39
Pruning	241	1,566	241	1,566
Weeding	—[x]	—[x]	118	767
Fertilizing	37	240	37	240
Spraying	10	65	10	65
Total	**662**	**4,312**	**591**	**3,841**

[z]Labor activities are assumed to be the same for all pot sizes. Differences are negligible because although the area per pot increases, the number of pots per unit area decreases.

[y]All man hours based on time recorded for each activity for #3 container over the 35 week production period constituting Step 1 and extrapolated to a 0.25 acre area based on container number.

[x]Due to the weekly frequency, weeding was included with irrigation inspections.

when compared to the overhead system. However, since the expense of installing micro-irrigation increases proportionately to the number of containers in a given area, it is financially limiting only for #3 containers and less. On a unit area basis, an overhead system is actually more expensive than micro-irrigation for material in #10 (37.8 liter) and #15 (56.8 liter) containers.

Variable costs also differed between the two systems. Variable costs were divided into labor (Table 3), materials (Table 4) and water (Table 5). Labor activities were assumed to be independent of container size. Although a larger tree and container may require more labor than a smaller one (e.g., weeding, pruning, fertilizing), at the same time there are fewer containers and trees per given area. The most notable labor requirement under either irrigation system was pruning. Pruning is essential for obtaining commercially saleable products and is, therefore, regarded equally important for both systems. A major difference in labor use that surfaced was the frequent inspections required for micro-irrigation. Whereas problems with an overhead system can be determined rapidly, micro-irrigation has as many emitters as containers, and each emitter must be checked regularly. Emitters can be clogged or spaghetti tubing can be cut by rodents or acciden-

Table 4. **Annual cost of materials for producing #3, #7, #10 and #15 (10.2, 26.5, 37.8 and 56.8 liter, respectively) material on 0.25 acre (0.1 ha) production area, using overhead and micro-irrigation systems.**

	Type of material						
Container size	Number of pots	Substrate (yd^3)	Number of liners	Fertilizer[z] (lb)	Insecticide[y] (qt)	Herbicide[x] (lb)	Total cost
# 3							
Units	3,888	47	3,888	1,791	2.5	78	
$ Cost[w]	933	1,034	1,750[v]	1,613	216	107	5,653
# 7							
Units	1,540	56	1,540	2,128	3.0	54	
$ Cost	2,202	1,232	693	1,918	258	42	6,345
# 10							
Units	644	35	644	842	1.9	7.8	
$ Cost	1,591	770	290	758	161	10	3,580
# 15							
Units	374	31	374	582	1.6	5.1	
$ Cost	1,036	682	168	524	140	7	2,557

[z]Fertilizer was Osmocote (Scotts Co., Marysville, OH) with rate of 70 g/#3 container and adjusted for larger pot sizes.

[y]Insecticide was Talstar (FMC Corp. Agr.Chem. Co., Philadelphia, PA) applied at 4 ml/liter @ 10 applications for #3 containers and adusted for larger pot sizes.

[x]Pre-emergence herbicide Ronstar 2-G (Rhone-Poulenc Agr. Co., Research Triangle Park, NC) applied twice a year at 4.72 oz per 100 ft^2.

[w]Cost based on local wholesale prices in the spring of 1994.

[v]Based on initial liner cost of $0.45/liner. Difference between liner and use of #3 (for #7 and #10) and #7 (for #15) for transplant stock is factored in as differences in production time as crop turnover rate (Table 7).

Table 5. **Annual water use and costs for cyclic micro-irrigation and overhead systems for producing #3, # 7, # 10 and #15 (10.2, 26.5, 37.8 and 56.8 liter, respectively) material in 0.25 A (0.1 ha) area.**

	Overhead			Micro-irrigation		
Container size	10^3 Gallon	WCost1[z]	WCost2[y]	10^3 Gallon	WCost1	WCost2
#3	1,845	129	1,291	448	31	313
#7	3,379	236	2,365	534	37	374
#10	10,788	755	7,552	890	62	623
#15	12,998	910	9,099	775	54	542

[z]WCost1 is the cost of extracting groundwater, estimated at roughly $0.07/1,000 gallons. The energy used to calculate this estimate was 3.13/(0.885 hp-hr/kwh) = 3.54 kwh to pump 3,360 gallons in one hour.

[y]WCost2 is the low-end estimate ($0.70/1,000 gal.) for reclaimed water by the SWFWMD in 1992.

tally pulled from the lines by employees. Inspecting emitters amounted to 24 percent of labor costs during the 9 month production period. In contrast, labor costs for monitoring overhead irrigation were negligible.

Material expenses were nearly identical for the two irrigation methods but differed substantially across container size (Table 4). The most expensive items were pots, soil, rooted liners and fertilizer. Pots, soil and fertilizer costs increased when changing from #3 (10.2 liter) to #7 (26.5 liter) material, then diminished with the two largest containers. The cost of liners, which was the same for any container size ($0.45/each), fell proportionately with the number of pots. Production disparities that arose from using the same sized liners for larger containers (e.g., liners in #3 containers were used as transplant stock for #7 and #10 containers) were accounted for as differences in production times (Table 4, footnote x).

Although water use is becoming a prominent natural resource issue in Florida, water costs are still small when compared to other production inputs. This is evident when examining the data from Tables 5 and 6. Table 5 shows the estimated number of gallons used under overhead and micro-irrigation, as well as two levels of costs. The column identified as "WCost1" reflects the cost of groundwater in the Central Florida area, where water is essentially free with the exception of extraction costs. Pump costs averaged about $0.07 for 1,000 gallons of water (for cost calculation, refer to Table 5, footnote z), or about 1 percent of total variable costs (TVC) for #3 (10.2 liter) material under an overhead system. However, these costs rose to 12 percent of TVC for #15 (56.8 liter) material (Table 6). In contrast, water use under micro-irrigation was very small. Compared to an overhead system, consumption levels varied from 1/4 as much for #3 (10.2 liter) containers to 1/16 less for #15 container material (Table 5). 'WCost2' represents the low-end cost ($0.70–$0.90/1,000 gal) of reclaimed water in 1992 (10). Reclaimed water was used because it is the most likely alternative to groundwater in Florida. The SWFWMD estimates that most nurseries will be compelled to use this water source within ten years. Under this scenario, water as a production input could become a serious constraint with costs increasing ten-fold from the current $0.07/1,000 gallons for groundwater. Water consumption is heavily affected by container size. By dividing the cost of reclaimed water (Water2) by total variable cost (Total2) in Table 6 we determined the proportion these costs represent for each container size. With an overhead system, distributing reclaimed water represented 12 percent of TVC for #3 (10.2 liter) material, 19 percent for #7 (26.5 liter), 50 percent for #10 (37.8 liter), and 58 percent for #15 (56.8 liter) containers. On the other hand, water costs under micro-irrigation were small for every container size, accounting for only 7 percent of TVC in the worst cases (#10 and #15).

However, costs by themselves do not accurately reflect the potential benefits and costs of a technology. Economic returns to production are a more useful indicator. To establish the economic returns to each system, it was important to account for the differences in production periods required to obtain a saleable crop. Table 7 documents these growth rates for live oak and red maple. The first row under each treatment shows the estimated number of weeks it would take trees to reach a commercially saleable size under the two types of irrigation. In all circumstances both live oaks and maples would grow much faster under cyclic micro-irrigation than under the overhead sprinkler system. This same result is presented differently in the second row (crop turnover rate or CTR) in each treatment. The CTR represents the number of tree crops capable of being grown in one year (52 weeks) based on the rate it took the plant to reach a market-

Table 6. Summary of annual variable costs for producing live oak and red maple in #3, #7, #10 and #15 (10.2, 26.5, 37.8 and 56.8 liter, respectively) material in 0.25 A (0.1 ha).[z]

Variable costs	Container size # 3	# 7	# 10	# 15
Costs - Overhead	Dollars			
Labor[Y]	3,841	3,841	3,841	3,841
Materials	5,653	6,345	3,580	2,557
Water1[X]	129	236	755	910
Water2[W]	1,291	2,365	7,552	9,099
Total1[V]	**9,623**	**10,422**	**8,176**	**7,308**
Total2[U]	**10,785**	**12,551**	**14,993**	**15,497**
Costs - Cyclic Micro-irrigation				
Labor	4,312	4,312	4,312	4,312
Materials	5,653	6,345	3,580	2,557
Water1	31	37	62	54
Water2	313	374	623	542
Total1	**9,996**	**10,694**	**7,954**	**6,923**
Total2	**10,278**	**11,031**	**8,515**	**7,411**

[z]Variable costs were tracked for #3 (10.2 liter) material for 8.75 months. Material and labor costs for larger container sizes were estimated from these numbers.

[y]Labor requirements were assumed to be independent of container size. Larger containers hold more material and have larger areas to weed or fertilize, but there are also fewer containers per given area.

[x]Water1 refers to extraction costs of ground water, roughly $0.07/1,000 gallons as of March 1994.

[w]Water2 refers to the cost of reclaimed water at $0.70/1,000 gallons.

[v]Total1 includes water1 costs.

[u]Total2 includes water2 costs.

Table 7. Number weeks to reach saleable size, growth ratios, and conversion factors for live oak and red maple.

Container size and growth factors	Live oak OH[z]	Live oak MI[y]	Red maple OH	Red maple MI
# 3				
Weeks[x]	82	28	62	24
Crop turnover rate[w]	0.63	1.86	.84	2.17
# 7				
Weeks	104	74	78	48
Crop turnover rate	0.50	0.70	0.67	1.08
# 10				
Weeks	122	87	91	69
Crop turnover rate	0.43	0.60	0.57	0.75
# 15				
Weeks	135	108	117	82
Crop turnover rate	0.39	0.48	0.44	0.63

[z]Overhead irrigation.

[y]Cyclic micro-irrigation.

[x]Weeks refers to the length of time required for plants to reach commercially saleable size. This includes dormancy periods of 3 months for both species in #7 and larger containers and in #3 containers overhead irrigated.

[w]Crop turnover rate is the number of crops capable of being grown in one year (52 weeks) based on the plant's growth rate.

Table 8. **Estimated annual gross returns, direct costs and net returns for overhead (OH) and cyclic micro-irrigation (MI) systems for producing live oaks and red maple on 0.25 A (0.1 ha) nursery area.**

	Container size			
Costs and returns	**3 gallon**	**7 gallon**	**10 gallon**	**15 gallon**
A1. Overhead—Oak	$ 000			
Gross return[z]	11.40	9.14	7.52	4.63
Direct cost 1[y]	6.78	5.92	4.23	3.57
Direct cost 2[x]	7.51	6.99	7.16	6.76
Net return 1[w]	**4.62**	**3.22**	**3.29**	**1.06**
Net return 2[v]	**3.89**	**2.15**	**0.36**	**(2.13)**
A2. Micro—Oak				
Gross return	33.66	12.80	10.50	5.70
Direct cost 1	20.20	8.22	5.20	3.61
Direct cost 2	20.72	8.45	5.50	3.85
Net return 1	**13.46**	**4.58**	**5.30**	**2.09**
Net return 2	**12.94**	**4.35**	**5.00**	**1.85**
B1. Overhead—Maple				
Gross return	13.34	13.13	8.37	4.53
Direct cost 1	8.80	7.70	5.38	3.93
Direct cost 2	9.78	9.13	9.25	7.54
Net return 1	**4.54**	**5.43**	**2.99**	**0.60**
Net return 2	**3.56**	**4.00**	**(0.88)**	**(3.01)**
B2. Micro—Maple				
Gross return	34.47	21.17	11.02	6.49
Direct cost 1	23.30	12.28	6.36	4.65
Direct cost 2	23.91	12.65	6.78	4.96
Net return 1	**11.17**	**8.89**	**4.66**	**1.84**
Net return 2	**10.56**	**8.52**	**4.24**	**1.53**

[z]Gross returns for 1 year = (number usable plants) × (price) × (crop turnover rate) from Table 6. 'Number usable plants' assumed 5% plant loss.

[y]Direct cost 1 (DC1) = {(installation cost) + (variable cost × crop turnover rate)}. DC1 includes water cost WCost1 from Table 5.

[x]Direct cost 2 (DC2) calculated the same way, but includes WCost2 from Table 5.

[w]Net return 1 = Gross return – Direct cost 1.

[v]Net return 2 = Gross return – Direct cost 2.

able size. For example, under the category #3 (10.2 liter) micro-irrigation, 1.86 live oak crops could theoretically be produced in one year, compared to only 0.63 of a crop under the overhead system. Similarly, #3 (10.2 liter) maples using cyclic micro-irrigation reached a saleable size in roughly forty-percent of the time that maples took using overhead irrigation, suggesting that over two crops could be grown annually. This result has particular relevance when one recalls the substantial water savings that are accrued under micro-irrigation. The CTR figures were used to calculate costs and returns of the two irrigation methods (Table 8).

The calculations in Table 8 indicate the direct costs and returns associated with producing tree crops under the alternative irrigation methods. These represent only those costs that can be directly attributed to the specific product being grown. Indirect costs considered in a comprehensive analysis of a business operation, such as taxes, administrative overhead, and depreciation of buildings and equipment were considered beyond the scope of this exercise. Gross returns were calculated for 1 year using the following formula:

Gross Returns = {Number Usable Plants × Price × CTR}

where 'Number usable plants' assumes a 5 percent loss rate and CTR is the crop turnover rate taken from Table 7.

Direct costs (DC) were calculated with the following formula:

Direct Costs = {(IC) + (Var Cost × CTR)}

where IC = installation cost, Var cost = variable cost, and CTR = crop turnover rate. For simplicity, installation costs were included directly in the calculation of both systems. For a longer-term analysis (several years) one would depreciate equipment or factor in an 'opportunity cost' of the investments. However, this was considered beyond the scope of this paper since the time period was limited to one year. Variable costs 'varied' in direct proportion to the number of crops produced since additional units of material and labor would be required for each new crop. However, two types of costs are included. 'Direct cost 1' includes water costs using groundwater charges ($0.07/ 1,000 gal) and 'Direct cost 2' includes the cost of reclaimed water ($0.70/ 1,000 gal). The same calculation process was used for both net returns (1 & 2) categories (see footnotes w and z in Table 8).

Net returns, which are the difference between gross return and direct costs, varied substantially depending on container size and type of irrigation method. In contrast to micro-irrigation, net returns under either water scenario (ground or reclaimed water) were less for live oak production using an overhead system. With regard to container size, returns varied from roughly 50 percent more for #7 (37.8 liter) and #10 (37.8 liter) cyclic micro-irrigation to nearly three times more for 3 gallon material. Roughly the same differences in magnitude were found between the two systems for the production of red maple. When reclaimed water costs were used (Net return 2), net returns for #10 and #15 (37.8 and 56.8 liter) containers for maple and #15 containers for oak were negative with overhead systems. Recall that reclaimed water represented 58 percent of total variable cost in this container category.

There has been considerable resistance in the nursery industry to convert watering systems to micro-irrigation. There are two good reasons for this hesitation. First, water in most areas of Florida is inexpensive and readily accessible. Overhead systems may be wasteful but water prices are so low that there is no incentive to change. Secondly, installing and maintaining micro-irrigation is considered to be more costly than an overhead system for nursery crops, initially and over an extended time period (11). A low cost input combined with a high cost alternative are two convincing reasons to maintain the status quo.

This research was comprehensive in that it examined both installation and maintenance costs and included an analysis on four different container sizes. The results of this study lead us to some interesting conclusions. First, there was little difference in the costs of installation (Table 2), labor (Table 3), and variable costs of production (Table 6) between the two systems. The only exception was in the case of #3 (10.2 liter) material. In fact, overhead systems were actually more expensive for #10 (37.8 liter) and #15 (56.8 liter) container sizes. Second, this study has established that the cost of water will be prohibitive for many producers if reclaimed water is used in conjunction with overhead irrigation (Table 5). Large containers, in particular, use tremendous amounts of water—over 20,000 gallons for one #15 (56.8 liter) live oak. If water policies become more restrictive in the future, water as a production input will become more expensive. When producers are charged for the water they use rather than merely the energy to extract it, the impact of this new cost on profitability will be much greater than today. Higher water prices will change what nurserymen grow and how they grow it. Third, under the assumptions made in this paper, the potential impact of cyclic micro-irrigation on a firm's economic returns were shown to be positive. Cyclic micro-irrigation markedly speeds up the production process and uses a fraction of the water of an overhead system. Faster production for the same marketable commodity means fewer inputs and therefore lower unit costs. It also suggests greater efficiencies as more product can be grown in the same area for a given period of time. These factors have been calculated into the net returns in Table 8 and results indicate the economic benefits of using cyclic micro-irrigation. A fourth consideration is the 'market window' advantage a shorter production period gives a grower using cyclic micro-irrigation. Under highly competitive conditions, which are pervasive in the nursery and greenhouse industry, having a marketable crop several weeks prior to competitors places that producer in a unique strategic advantage, both in terms of potential market share and in price. Although financial gains may decline as more producers adopt similar systems, the overall benefits from using more efficient irrigation should remain positive. Finally, despite the thorough approach adopted, the study does have limitations. The most significant lies with the fact that costs and returns were measured and extrapolated under controlled research conditions. In this sense, results tend to be biased optimally. A next step should be to examine a sample of actual nurseries in the industry utilizing each system and then compare economic efficiencies. If designed properly and an adequate number of similar businesses could be identified, the information could provide a truer reading of potential benefits and costs of cyclic micro-irrigation.

Literature Cited

1. Beeson, R.C. and J.J. Haydu. 1995. Cyclic micro-irrigation in container-grown landscape plants improves plant growth and water conservation. J. Environ. Hort. 13:6–11.

2. Carriker, R.L. 1993. Agriculture, water quality, and public policy. Univ. Florida, IFAS, Food Res. Econ. Dept., SP93-15, pp. 25.

3. Clouser, R.L., L.W. Libby, S.A. Ford, M. Rahmani, and D. Mulkey. 1990. Agriculture and economic change in Florida: facts, issues, and options. Univ. Florida, IFAS, Florida Coop. Ext. Serv. Cir. 888, pp. 28.

4. Haman, D.Z., A.G. Smajstrla, and D.J. Pitts. 1996. Efficiencies of irrigation systems used in Florida nurseries. Univ. Florida, IFAS, Florida Coop. Ext. Serv. Bulletin 312, pp.7.

5. Haydu, J.J. 1994. Florida's ornamental nursery industry. Univ. Florida, IFAS, Food and Res. Econ., Florida Coop. Ext. Serv., # 116, pp. 4.

6. Hodges, A.W, G.D. Lynne, M. Rahmani, and C.F. Casey. 1994. Adoption of energy and water-conserving irrigation technologies in Florida. Univ. Florida, IFAS, Florida Coop. Ext. Serv. Fact Sheet EES 103, pp. 6.

7. Polopolus, Leo C. 1992. North American Free Trade Agreement, Caribbean Basin Initiative, and Florida agriculture. Univ. Florida, IFAS, Food Res. Econ., Florida Coop. Ext. Serv., # 108, pp. 4.

8. Snedecor, G.W. and W.G. Cochran. 1980. Statistical Methods. 7th Ed. Iowa State University Press. Ames, IA.

9. Southwest Florida Water Management District. 1994. Economic impact statement. Project No. P261. Tampa, FL.

10. United States Department of Agriculture. State Financial Summary, 1992. Economic indicators of the farm sector. Economic Research Service. Washington: U.S. Government Printing Office, 1993.

11. IFAS Task Force on Micro-irrigation in Florida. 1993. Micro-irrigation in Florida: systems, acreage and costs. Univ. Florida., IFAS, Florida Coop. Ext. Serv. Bull. 276, pp.12.

12. Yingling, J.W. 1995. Senior Economist, Planning Department, Southwest Florida Water Management District, personal communication.