Growth and Landscape Performance of Three Landscape Plants Produced in Conventional and Pot-In-Pot Production Systems[1]

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Abstract

A study was conducted to evaluate the growth of *Ilex × attenuata* Ashe 'Savannah', *Lagerstroemia indica × fauriei* 'Natchez', and *Magnolia × Soulangiana* Soul.-Bod. grown in a conventional above-ground container production system in #7 containers compared to an in-ground "pot-in-pot" (PIP) production system. Container production system had little or no effect on the shoot growth of the species used in this study after seven months. For the container phase of the study, root dry weight and total root dry weight increased for *Lagerstroemia* and *Magnolia* grown in the PIP system and the root:shoot ratio of *Lagerstroemia* increased 87%. Between 4 to 5 PM EST (July 1, 1991), root-zone temperatures in the western quadrant of plants in the PIP system were 13°C (23°F) cooler than aboveground containers in the conventional production system. Root ratings were higher for all three species in the PIP system. After being transplanted in the field for several months, few differences in landscape establishment between production systems could be seen for *Ilex* and *Lagerstroemia*. Results of these studies indicate that for *Lagerstroemia*, production advantages seen during the container-phase of the PIP system may not be evident after one season in the field.

Index words: container production, holly, crape myrtle, magnolia

Species used in this study: *Ilex × attenuata* Ashe 'Savannah', *Lagerstroemia indica × fauriei* 'Natchez', *Magnolia × Soulangiana* Soul.-Bod..

Significance to the Nursery Industry

This study demonstrates that *Lagerstroemia indica × fauriei* 'Natchez' and *Magnolia × Soulangiana* benefit from being grown in a "pot-in-pot" (PIP) production system using #7 containers by producing more root dry weight and uniform root systems compared to a conventional production system after seven months. Improved root system development was related to lower container medium temperatures during the growing season. Growers should be aware of problems with certain species (*Lagerstroemia* and *Magnolia*) which have vigorous root systems that root-out through the planted container, through the holder pot and into the surrounding soil. Periodic rotation of planted containers within the holder pot or use of fabrics and root pruning compounds may also be useful. For *Lagerstroemia*, the benefits of being grown in the PIP system were not evident after one season in the landscape. With a slower growing plant such as *Ilex × attenuata* 'Savannah', production system had little or no effect on plant growth and landscape establishment. The added expense of producing plants in a PIP system needs to be weighed in relation to the limited benefits seen for landscape establishment for the species used in this study.

Introduction

Production of trees and shrubs in containers offers a number of production, marketing and establishment advantages compared to field-grown plants. Two problems associated with the production of container-grown plants are exposure of the root system to high and low temperature extremes during the growing season. Roots are not as hardy as foliage and stems, and extreme temperatures limit the production of container-grown plants (1, 2). Root systems of plants growing in the ground are insulated by the surrounding soil and, therefore, are not exposed to the large fluctuations in root-zone temperature which are seen in container-grown plants.

In an attempt to address some of the problems associated with container production, the idea for a "pot-in-pot" (PIP) production system was developed (7). With this production system, a holder pot is permanently placed in the ground with the upper rim remaining above grade. The container-grown plant is then placed inside the holder pot for the growing season. Using this production system, roots are protected from extreme temperatures and there are no problems with windthrow. The purpose of this study was to compare the growth and landscape establishment of three species grown in a PIP system compared to conventional above-ground container production system.

Materials and Methods

Experiment 1. Container production system. All experiments were conducted outdoors under full sun at the University of Georgia Coastal Plain Experiment Station, Tifton. Uniform liners of *Ilex × attenuata* Ashe 'Savannah', *Lagerstroemia indica × fauriei* 'Natchez', and *Magnolia × Soulangiana* Soul. -Bod. were transplanted from 2.8 l (#1) containers to 26 l (#7) containers (#070, The Lerio Corporation, Valdosta, Georgia) March 18, 1991. Potting medium consisted of milled pine bark and sand (4:1 by vol) amended

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with micronutrients at 0. 9 kg/m^3 (1. 5 lb/yd^3) and dolomitic limestone at 3.6 kg/m^3 (6.0 lb/yd^3). Plants were top-dressed with High-N 24N-1.7P-5.8K (24-4-7) at the rate of 0.9 kg N/m^3 (1.5 lb N/yd^3) on March 25 and June 3, 1991. Holder pots were placed in the ground with 2.5 cm (1 in) at the top of the container remaining above grade. Plants were irrigated daily with 160° low volume spot spitters at the rate of 3.8 l (1.0 gal) per container to maintain a favorable water status for plant growth in each production system. No drainage problems were encountered for the PIP production system with our soil type (Tifton loamy sand; fine-loamy, siliceous, thermic Plinthic Paleudult).

The experiment was a randomized complete block with three species, two container production systems (PIP and conventional above-ground) and ten replications. On July 1, 1991, container medium temperatures from 10 containers in each production system were measured using a hand-held thermocouple thermometer. Thermocouple probes were placed 2.5 cm (1 in) from the container wall on the north, south, east, and west quadrant and in the center of the container to a depth of 15 cm (6 in). Temperatures were recorded between 4 to 5 PM EST. Temperatures were also recorded on the western quadrant of the containers at 6 AM on January 17, 1992. At the termination of the container phase of the study in October 1991, measurements of shoot dry weight, root dry weight, and root dry weight between the holder pot and the planted container were taken for five replications. A root rating (1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80%, and 5 = 81-100% of the rootball covered with white roots) was taken for the north, south, east and west quadrants (n=5). For *Magnolia*, final height, caliper and branch number measurements were taken. With *Ilex* and *Lagerstroemia*, growth index ((height + width1 + width2)/3) measurements were taken.

Experiment 2. Landscape establishment. On February 12, 1992, four replications of both treatments from the container study for all three species were planted in the field as a randomized complete block. The container-grown plants were planted in augered holes measuring 61 cm (24 in) across and 30 cm (12 in) deep in a Tifton loamy sand. Plants were fertilized on February 12, April 1, and June 1 at the rate of 56 kg N/ha (50 lb N/A) over a 61 cm (24 in) circular area with Sta-Green 12N-2.6P-5.0K (12-6-6). Plants were watered at the rate of 2.5 cm (1 in) using drip irrigation when less than 2.5 cm of rainfall occurred during the previous week. All *Magnolia* plants in the field experiment died during midsummer due to undetermined causes. In October, 1992, final growth index and shoot dry weight measurements were made on *Ilex* and *Lagerstroemia*. The root system of each plant was manually excavated to the diameter of the original planting hole. Few roots were found beyond the 61 cm diameter planting hole. All roots extending past the original rootball were removed and were weighed separately to get a root regeneration dry weight beyond the original rootball as well as a rootball dry weight. Data analysis for all growth parameters were evaluated by analysis of variance using SAS. Mean separation where appropriate was conducted using a Waller-Duncan K-Ratio T-Test.

Results and Discussion

Production system had no effect on the height (133 cm) or caliper (4.1 cm) of *Magnolia* (data not shown). *Magnolia* plants grown in the PIP system had more branches (22.8±0.6) per plant compared to the conventional production system (20.0±0.8). Height (124 cm) and growth index (311) of *Ilex* were not affected by production system (data not shown). While the growth index (500) for *Lagerstroemia* was not affected by production system, height of plants grown in the conventional production system were taller (119±4 cm) than in the PIP system (104±3 cm).

Shoot dry weight and the root:shoot ratio of *Magnolia* were not affected by production system (Table 1). Root dry weight inside the planted container, total root dry weight and total plant biomass were all greater for plants grown in the PIP system (70%, 74%, and 65%, respectively) compared to the conventional production system. Production system had no effect on the growth of *Ilex* in the container phase of the experiment (Table 1)

Shoot dry weight and total biomass of *Lagerstroemia* were not affected by production system (Table 1). Root dry weight inside the planted container, total root dry weight and root:shoot ratio were all greater for the PIP system compared to the conventional production system. Root dry weight inside the planted container increased 47% while the root:shoot ratio increased 87% for plants grown in the PIP

Table 1. Influence of container production system (conventional vs. PIP) on the shoot and root growth of three ornamental landscape plants (n = 5).

	Shoot dry weight (g)	Root dry weight inside planted container (g)	Total root dry weight (g)[y]	Total biomass	Root:Shoot ratio
Magnolia					
Conventional production system	303	1300	1300	1603	4.7
PIP	390	2208	2256	2646	5.9
Pr>F[z]	NS	**	**	**	NS
Ilex					
Conventional production system	621	1004	1004	1626	1.6
PIP	652	1272	1278	1930	2.0
Pr>F	NS	NS	NS	NS	NS
Lagerstroemia					
Conventional production system	955	1384	1384	2339	1.5
PIP	749	2032	2108	2857	2.8
Pr>F	NS	**	*	NS	**

[z]Significance tests: ** ≤ 0.01, * ≤ 0.05, NS > 0.05

[y]Total root dry weight = root dry weight inside planted container + root dry weight between planted container and holder pot.

system. The percentage of roots on a dry weight basis found outside of the planted container but within the holder pot were 2.1%, 0.4% and 3.6% for *Magnolia, Ilex*, and *Lagerstroemia*, respectively.

Container medium temperatures at five positions were influenced by production system (Table 2). Between 4 and 5 PM in the afternoon, container medium temperatures in the conventional production system were warmer in all quadrants compared to the PIP system. The temperature in the western quadrant of containers in the conventional production system were approximately 13°C (23°F) warmer than containers in the PIP system. Mean container medium temperature across all quadrants was 39°C (102°F) for the conventional production system in contrast to 33°C (91°F) for the PIP system. Container medium temperatures in the western quadrant of the PIP system were 3.0°C warmer (2.9°C or 37.2°F) compared to the conventional production system (−0.1°C or 31.8°F) on the morning of 17 January, 1992 (data not shown). Air and soil temperatures (15 cm depth) at 6 AM were −3.7°C (25.3°F) and 4.2°C (39.6°F), respectively.

The root ratings for all three species were influenced by interactions between production system and quadrant of solar exposure (Table 3). For all three species in the conventional production system, the south, west and east quadrants had less root coverage compared to the north quadrant. There were no differences between quadrants for species grown in the PIP system. Root ratings for plants grown in the PIP system were increased for the south, west and east quadrants compared to the conventional production system.

After several months in the landscape, the only measurable difference in growth between production systems for *Ilex* was in root regeneration beyond the original rootball (Table 4). Plants grown in the conventional production system had 57% more root dry weight beyond the original rootball compared to plants grown in the PIP system. Production system had no effect on the root and shoot growth of *Lagerstroemia* after being placed in the landscape. Although

Table 2. Mean container medium temperatures by solar quadrant as influenced within production system. Temperature measurements (n = 10) were taken between 4 and 5 PM EST, July 1, 1991. Air temperature was ~ 33.5C (92F).

Production system	Quadrant	Container medium temperature (C)
Conventional production system	North	38.4 C[y]
	South	40.4 B
	East	37.0 D
	West	46.2 A
	Center	37.8 CD
PIP	North	32.6 BC
	South	34.0 A
	East	32.8 BC
	West	33.4 AB
	Center	32.1 C
Significance[z]		
Production system		**
Quadrant		**
Production system x Quadrant		**

[z]Significance tests: ** ≤ 0.01.

[y]Mean separation by Waller-Duncan K-Ratio T-Test. Means within each production system with different letters are significantly different at α = 0.05.

Table 3. Root ratings for three ornamental landscape plants as influenced by container production system and solar quadrant (n = 5).

	Quadrant	Production system[y] Conventional	PIP
Magnolia	North	5.0[x] A	5.0 A
	South	1.6 C	5.0 A
	East	3.6 B	5.0 A
	West	2.4 C	5.0 A
Ilex	North	5.0 A	5.0 A
	South	2.4 C	5.0 A
	East	4.0 B	5.0 A
	West	3.8 B	5.0 A
Lagerstroemia	North	4.6 A	5.0 A
	South	1.8 D	5.0 A
	East	3.8 B	5.0 A
	West	2.6 C	5.0 A
Significance[z]			
Production system		**	
Quadrant		**	
Production system × Quadrant		**	

[z]Significance tests: ** ≤ 0.01.

[y]Root rating: 1 = 0-20%, 2 = 21-40%, 3 = 41-60%, 4 = 61-80% and 5 = 81-100% of the rootball quadrant covered with white roots.

[x]Mean separation by Waller Duncan K-Ratio T-Test. Means with different letters are significantly different at α = 0.05.

not measured, root regeneration from plants grown in the conventional production system was less uniform around the circumference of the rootball compared to plants grown in the PIP system (personal observation). Lack of root regeneration in certain areas of the rootball was hypothesized to be due to high temperature damage to the rootball during the container-phase of the study (Table 3).

One problem encountered with the PIP production system was the difficulty of harvesting *Magnolia* and *Lagerstroemia* from the PIP system. Roots from these two species readily rooted-out from the planted container, through holes in the holder pot and into the surrounding soil which resulted in the plants having to be manually dug and root-pruned before the planted container could be removed from the holder pot. This problem has been noted (7) and some nursery operators rotate their planted containers within the holder pot to alleviate the rooting-out problem. Research has shown that certain fabric materials and root-pruning compounds can successfully reduce the degree of rooting-out in a PIP system (John Ruter, unpublished data).

Production system had little or no effect on the shoot growth of plants during the container phase of this study. Root dry weight inside the planted container and total root dry weight increased for *Magnolia* and *Lagerstroemia* grown in the PIP system compared to the conventional production system. This increase in root dry weight was associated with lower container medium temperatures in the afternoon and higher root ratings for *Lagerstroemia* and *Magnolia* in the PIP system. High root-zone temperatures have been shown to reduce the growth of several woody species (2, 3, 4, 6, 8, 9). When the walls of container-grown plants are exposed to solar radiation, root biomass is generally distributed in the shaded northern quadrant as well as the container medium core and bottom of the container where root-zone temperatures capable of causing direct membrane injury do not generally occur (2, 6). In *Magnolia gran-*

Table 4. Influence of production system on the landscape establishment of *Ilex* and *Lagerstroemia* in the field for one season (n = 4).

	Shoot dry weight (g)	Root dry weight inside original rootball (g)	Root regeneration beyond original rootball (g)	Total root dry weight (g)	Total biomass	Root:Shoot ratio
Ilex						
Conventional production system	870	1164	58	1222	2092	1.4
PIP	936	1640	37	1677	2613	1.8
Pr>F[z]	NS	NS	**	NS	NS	NS
Lagerstroemia						
Conventional produciton system	1503	1734	90	1824	3327	1.3
PIP	1479	1871	82	1953	3432	1.3
Pr>F	NS	NS	NS	NS	NS	NS

[z]Significance tests: ** ≤ 0.01, * ≤ 0.05, NS > 0.05.

diflora, differences in root growth patterns indicated that trees were able to overcome the detrimental effects of a 38°C rootzone treatment, whereas growth suppression was still evident after 16 weeks for a 42°C treatment (4). Prolonged exposure of woody plants to root-zone temperatures in excess of 38°C have been shown to be responsible for a number of physiological and biochemical alterations which were detrimental to plant growth (2, 3, 6, 8, 9). Root-zone temperatures as high as 50.2°C (122°F) in the western quadrant of some containers were measured in this study.

While production system influenced total root dry weight of two of the three species used in this study, this did not translate into a growth advantage after one season in the landscape. Future research on rooting-out and other production variables should provide essential information regarding the effects and possible benefits of the PIP system on a variety of species.

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