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Time of Transplanting Liners and Initial Growing Location Affects Growth of Woody Nursery Plants¹

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Abstract

Liners of four cultivars were planted in larger containers and subjected to selected production systems. Objectives were to compare planting liners in September or December and growing these plants can-to-can out-of-doors or in a polyhouse vs planting in April or May of the following year.

Substantially more shoot fresh weight was obtained with three of the four test species by planting liners in larger containers in September before cold weather occurred compared to planting in December, April or May of the following year. In general, planting liners in December compared to planting in April of the following year did not result in an increase in shoot fresh weight. Late planting in May, rather than in April, resulted in less shoot fresh weight and lower root ratings with three of the four species tested. Growing plants in a polyhouse compared to out of doors resulted in more shoot fresh weight only with *Ilex crenata* 'Compacta' and *Rhododendron* 'Formosa' planted in September and with *Ilex cornuta* 'Anicet Delcambre' planted in December.

Index words: growth, container, culture, transplanting

Species used in this study: Compacta holly, (*Ilex crenata* Thumb. 'Compacta'); Formosa azalea, (*Rhododendron indicum* L. 'Formosa'); Variegated Chinese Privet, (*Ligustrum sinense* Lour. 'Variegatum'); Anicet Delcambre Holly, (*Ilex cornuta* Lindl. and Paxt. 'Anicet Delcambre').

Significance to the Nursery Industry

Growth as indicated by shoot fresh weight of 'Compacta' holly, 'Formosa' azalea and 'Anicet Delcambre' holly but not 'Variegatum' privet was significantly greater for liners planted in September compared to planting in December, April or May. With 'Compacta' holly and 'Formosa' azalea, growing September planted liners in a polyhouse was slightly more advantageous in increasing growth compared to growing them out-of-doors. With the exception of 'Formosa' azalea grown in a polyhouse, planting in December was not advantageous in increasing plant growth compared to planting in April. Late planting in May resulted in lowest shoot fresh weight with 'Compacta' holly and 'Formosa' azalea by the end of the growing season.

Benefits of 1) increased growth by planting early and using polyhouses, 2) crop protection against low temperatures when using polyhouses and 3) a decrease in labor and equipment requirements in the spring by spreading planting time over a longer period were obtained by planting in September and December of the previous year. These benefits need to be evaluated against the risk of crop damage by cold injury. The increased costs incurred by the extension of time plants are in larger containers and the use of polyhouses also must be considered.

Introduction

Production methods and schedules used by nurserymen to grow woody landscape plants in containers are influenced by many factors, including low winter temperatures that cause injury and death, planting time to maximize growth, and harvest time most advantageous for sales. Production

practices that minimize risks from cold injury, take full advantage of the growing season, and result in marketable plants at the end of a growing season for fall and spring sales are most desirable.

Nurserymen grow or purchase small plants of a desired liner size for transplanting at a designated time into larger containers. Liners in 5 to 8 cm (2 to 3 in) containers are usually planted into larger containers in the spring (late March and April) in the mid-South (4). These plants are then grown out-of-doors, spaced during the growing season for optimum growth and unspaced, can-to-can, during the winter months for protection from cold temperatures in USDA Zones 8 and 9 (3 and 8).

Liners can also be planted into larger containers in the fall and winter months and grown unspaced out of doors or in polyethylene covered greenhouses until spring.

The objective of this study was to determine the effects of time of transplanting liners into larger containers, (planting early in September or December compared to planting in April or May of the following year) and initial growing location, (out-of-doors or in a polyhouse) on the growth, as measured by shoot fresh weight, and quality of shoots and roots of woody landscape plants.

Materials and Methods

This study was conducted in USDA Zone 8, which has a low temperature range of -12 to -7°C (10 to 20°F) (7). Liners of 'Compacta' holly, 'Formosa' azalea, 'Variegatum' privet and 'Anicet Delcambre' holly were obtained by planting rooted cuttings in 6.7×7.0 cm (2.6×2.8 in) containers in early winter, 1986 and growing them in a 9°C (48°F) minimum temperature greenhouse until spring and thereafter out of doors in a 55% shadehouse until transplanted into larger containers on the dates given in Table 1. When temperatures lower than -4°C (25°F) were pre-

¹Received for publication February 4, 1991; in revised form May 20, 1991. Published with the approval of the Director of the Mississippi Agricultural and Forestry Experiment Station as Scientific Contribution No. J 7677.

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Table 1. Effects of planting date and initial growing location, until April 1, 1987, on the growth of selected woody landscape plants in containers.

Planting date	Initial grow- ing location	April 1, 1987		October 12, 1987		
		Shoot fresh weight ^z (g)	Root growth index ^y (cm)	Shoot		Root quality ^y
				Fresh weight ^z (g)	Quality ^y	
<i>Ilex crenata</i> 'Compacta'						
Sept 9, 1986	Out-of-doors	25	23	511 b ^x	7.3 a	9.0 a
Sept 9, 1986	Polyhouse	42	26	610 a	8.1 a	9.2 a
Dec 19, 1986	Out-of-doors	17	9	367 c	5.9 b	7.7 b
Dec 19, 1986	Polyhouse	19	18	376 c	6.1 b	7.8 b
Apr 1, 1987 (check)	Out-of-doors	19	7	329 c	5.6 c	7.4 b
May 1, 1987	Out-of-doors			244 d	4.5 c	6.5 c
LSD ^x		—	—	49.9	.80	.58
<i>Rhododendron</i> 'Formosa'						
Sept 9, 1986	Out-of-doors	33	19	558 b	8.3 a	8.8 a
Sept 9, 1986	Polyhouse	92	22	787 a	8.6 a	8.6 a
Dec 19, 1986	Out-of-doors	9	8	490 cd	7.1 bc	8.2 a
Dec 19, 1986	Polyhouse	17	12	537 c	7.3 b	8.5 a
Apr 1, 1987 (check)	Out-of-doors	12	7	433 d	6.4 c	7.4 b
May 1, 1987	Out-of-doors			322 e	5.4 d	6.1 c
LSD ^x		—	—	66.4	.78	.77
<i>Ligustrum sinense</i> 'Variegata'						
Sept 9, 1986	Out-of-doors	18	34	461 a	8.4 a	9.6 a
Sept 9, 1986	Polyhouse	21	37	293 bc	5.9 cd	7.4 b
Dec 19, 1986	Out-of-doors	6	19	328 b	7.0 bc	9.6 a
Dec 19, 1986	Polyhouse	12	25	236 c	5.3 d	6.9 b
Apr 1, 1987 (check)	Out-of-doors	12	7	422 a	7.7 ab	9.2 a
May 1, 1987	Out-of-doors			276 bc	5.8 cd	7.3 b
LSD ^x		—	—	83.5	1.33	.97
<i>Ilex cornuta</i> 'Anicet Delcambre'						
Sept 9, 1986	Out-of-doors	23	21	205 a	6.2 a	7.2 a
Sept 9, 1986	Polyhouse	26	20	214 a	6.1 a	7.2 a
Dec 19, 1986	Out-of-doors	14	10	111 c	3.8 c	5.6 b
Dec 19, 1986	Polyhouse	17	18	155 b	5.5 ab	6.7 a
Apr 1, 1987 (check)	Out-of-doors	18	7	131 bc	4.6 bc	5.7 b
May 1, 1987	Out-of-doors			112 c	4.8 b	5.4 b
LSD ^x		—	—	23.4	.92	.87

^zValues are the mean of 10 plants from each initial growing location and planting date and 20 liners not planted in larger containers.

^yRoot growth index—(root length + width)/2; shoot and root quality—10 = excellent, 1 = very poor. Shoot ratings of 8, 9 or 10 indicate marketable quality.

^aMeans in a column followed by the same letter are not significantly different by the LSD test at the 0.05 level.

dicted the liners in the shadehouse were covered with 6 mil clear polyethylene.

Groups of 40 liners of each cultivar were transplanted into larger containers on September 9 and December 19, 1986. Liners of 'Anicet Delcambre' were transplanted into 3.8 L (1 gal) containers and liners of the remaining 3 test plants were transplanted into 10.4 L (2.8 gal) containers. The growth medium of 4 pine bark:1 sand (v/v) was amended with 2.4 kg/m³ (4 lb/yd³) of dolomitic limestone, 0.6 kg/m³ (1 lb/yd³) of 0N-7.7P-0K (0-18-0), 0.6 kg/m³ (1 lb/yd³) of 20.0N-2.2P-8.3K (20-5-10) Stagreen (Pursell Industries, Sylacauga, AL), and 0.9 kg/m³ (1.5 lb/yd³) of Micromax (Sierra Chemical Company, Milpitas, CA).

Half of the plants in each group were grown without replication out-of-doors, exposed to ambient temperatures and the other half were grown in a 2°C (36°F) minimum temperature polyhouse until April 1, 1987. September transplanted liners in the polyhouse were exposed to ambient temperatures until the polyhouse was covered with 6 mil clear polyethylene on November 10, 1986. The number of

hours of supplemental heat, supplied by a vented natural gas heater, to maintain a minimum temperature of 2°C (36°F) was recorded daily. Each cultivar at both locations was grown unspaced with a border of 2 rows of 6 L (1.6 gal) containers filled with milled pine bark. Maximum and minimum air temperature in the polyhouse were recorded daily. Growth medium temperatures of plants grown out-of-doors and in the polyhouse were taken daily at approximately 7:30 am and 3:30 pm (CST) and are an average of two thermometers inserted approximately 12.7 cm (5 inches) deep and 2.5 cm (1 inch) from the container wall.

Sta-green 20.0N-2.2P-8.3K (20-5-10) was surface applied on September 9 and December 8, 1986 to plants transplanted on September 9, 1986 and grown out-of-doors and also on September 9, 1986; October 22, 1986; December 2, 1986; January 14, 1987 and February 26, 1987 to those transplanted on September 9 and grown in the polyhouse. Plants planted in December and grown in a polyhouse also received a surface application of 20.0N-2.2P-8.3K (20-5-10) on February 26, 1987. Fertilizer rates were 1.8 g (0.06 oz) and

3.6 g (0.13 oz) per 3.8 and 10.4 L (1 and 2.8 gal) container plant, respectively.

Osmocote 17N-3P-10K (17-7-12) (Sierra Chemical Co., Milpitas, CA) was surface applied at the rate of 27 g/3.8 L (1 oz/1 gal) container and 74 g/10.4 L (2.6 oz/2.8 gal) container on April 8, 1987 and at the rate of 9 g/3.8 L (0.3 oz/1 gal and 25 g/10.4 L (0.9 oz/2.8 gal) on July 9, 1987.

Ten plants of each cultivar that were transplanted on September 9, and December 19, 1986 from both locations (out-of-doors and polyhouse) and 20 liners of each cultivar from the shadehouse were sacrificed for evaluation on April 1, 1987, (Table 1). Shoots were severed at the surface of the growth medium to obtain fresh weight. Root growth index was obtained by carefully removing the root ball from the container, shaking it lightly to remove excess media, laying it on a flat surface and measuring the length and width of the exposed roots. Also on April 1, 1987, ten liners of each cultivar were transplanted into larger containers. These plants and the remaining ten plants of September and December plantings from both growing locations were then spaced out of doors, arranged in a randomized complete block design, and replicated 10 times with a vacant plot area in each replication for liners to be transplanted into larger containers on May 1, 1987. Separate experiments were conducted with each cultivar and 1 container plant was an experimental unit. Plants in 3.8 and 10.4 L (1 and 2.8 gal) containers were spaced on 0.3 and 0.9 m (1 ft and 3 ft) centers, respectively and all plants were irrigated with an overhead system.

The study was terminated on October 12, 1987 and the following data were taken: visual quality, shoot fresh weight and root quality. Shoot fresh weight was taken as previously described. Visual shoot quality ratings were 10—excellent and 1—very poor with ratings of 8, 9 and 10 indicating marketable quality. Visual root quality ratings were 10—excellent and 1—very poor with a rating of 10 indicating that the entire surface of the root ball was covered with roots.

October data were analyzed using ANOVA for a randomized complete block design. If significant differences were found among the treatments, means were separated using the Least Significant Difference test $P = 0.05$.

Results and Discussion

Spring Evaluation of non-replicated plantings, April 1, 1987. Liners of all species transplanted into containers in September produced substantial shoot and root growth by the following spring. In general, more growth was obtained with liners grown in a polyhouse than with liners grown out-of-doors and earlier transplanted liners had more shoot and root growth than those transplanted later (Table 1).

The fresh shoot weight of December planted liners grown in a polyhouse, where average minimum air and growth medium temperatures were 7 and 9°C (44 and 49°F), and 11 and 13°C (52 and 56°F) in the months of January and February, respectively, was similar to the fresh weight of liners grown for planting in April. 'Formosa' azalea, however, was an exception where the fresh weight of those grown in a polyhouse and planted in December was greater compared to liners in the shadehouse until April.

The decrease in fresh weight of 'Formosa' azalea and 'Variegatum' privet planted in larger containers in December and grown out-of-doors appeared to be associated with

the considerable leaf drop observed with these two cultivars. Although very little shoot growth was obtained with December planted liners, considerable root growth activity was obtained with all December planted liners grown in a polyhouse and also with 'Variegatum' privet liners grown out-of-doors compared to liners grown in the shadehouse until April (Table 1).

Fall Evaluation, October 12, 1987. When measured after a full growing season, planting in September resulted in higher shoot fresh weight and shoot and root ratings with 'Compacta' holly and 'Formosa' azalea compared to planting in December, April or May with the exception of 'Formosa' azalea December root ratings compared to September root ratings (Table 1). Within September planting, significantly lower fresh weight, but not root ratings, were obtained with 'Compacta' holly and 'Formosa' azalea grown out-of-doors compared to those grown in a polyhouse (Table 1). 'Anicet Delcambre' holly produced more shoot growth with September plantings compared to other planting dates regardless of growing location (Figure 1). 'Anicet Del-

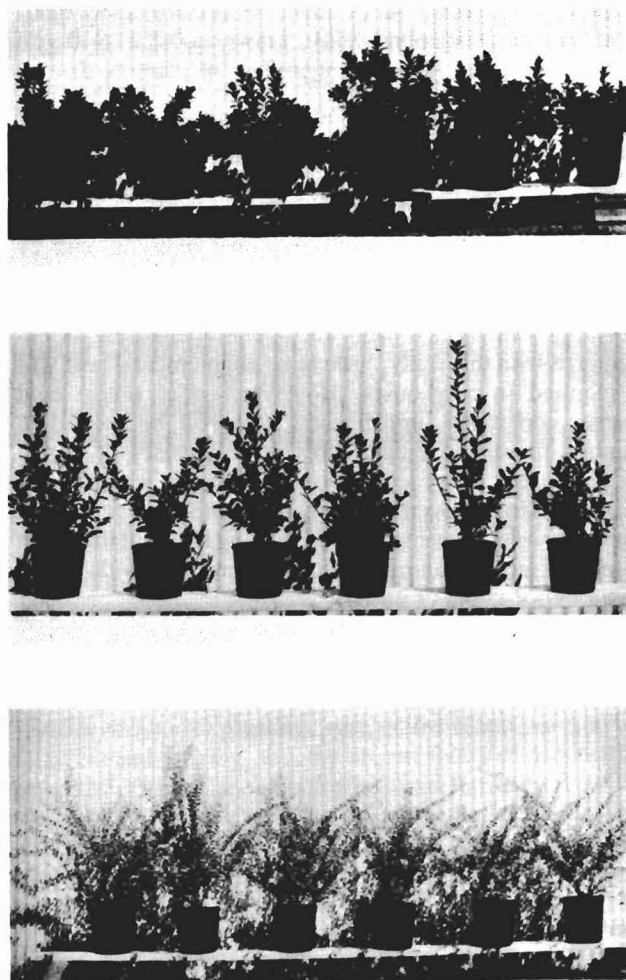


Fig. 1. Effects of initial growing location, until April 1, 1987, and planting date on the growth of *Rhododendron* 'Formosa' (top), *Ilex cornuta* 'Anicet Delcambre' (center) and *Ligustrum sinense* 'Variegata' (bottom). Treatments from left to right were: planted on September 9 and December 12, 1986 and grown out-of-doors; Planted April 1, 1987 (check); planted September 9 and December 12, 1986 and grown in a polyhouse; and planted May 1, 1987. Pictures taken October 8, 1987.

cambre' holly had more root growth with September plantings or with the polyhouse December planting compared to out-of-doors December planting and those planted in April and May. Root ratings of December planted liners were not significantly greater than April planting with 'Compacta' holly, but were greater with 'Formosa' azalea. Root ratings of April planted 'Anicet Delcambre' holly were not different from December planted liners grown out-of-doors or from liners planted in May.

Planting in September and growing plants out-of-doors or planting in April resulted in highest shoot fresh weight of 'Variegatum' privet. Regardless of planting dates, significantly less growth was obtained with this cultivar when grown in a polyhouse for part or the entire winter. Compared to planting in April, late planting in May resulted in less shoot growth and root quality ratings with three of the four cultivars tested.

Market quality of plants in 10.4 L (2.8 gal) containers was attained with September planted 'Compacta' holly grown in a polyhouse; September planted 'Formosa' azalea grown out-of-doors or in a polyhouse; and September planted 'Variegatum' privet grown out of doors. Marketable shoot quality of 'Anicet Delcambre' holly, grown in 3.8 L (1.0 gal) containers was not achieved regardless of planting date or growing location.

In the months of December, 1986 and January, 1987, out-of-door minimum temperatures were lower than the 30-year average (5). Nevertheless, supplemental heat to maintain a minimum temperature of 2°C (36°F) in the polyhouse for the entire winter was required only on January 23 and 27 for 1.2 and 1.8 hours, respectively, when out-of-door temperatures were -6°C (22°F) and -7°C (20°F). In areas with mild winters and with average temperatures, as encountered with this study, little or no supplemental heat will be required in polyhouses. However, under severe cold weather conditions supplemental heat will be needed to maintain minimum temperatures in polyhouses of -4°C (25°F) to avoid injury to the roots of container grown plants (2 and 8). Under severe cold weather conditions protective measures such as covering plants or using constant irrigation on plants grown can-to-can may be utilized with plants grown out-of-doors (1 and 6).

Planting liners in September, before the advent of cold weather, rather than in April, resulted in a substantially higher shoot fresh weight by fall of the following year with three of the four test species. The added expense of growing September plantings in a polyhouse was advantageous with 'Compacta' holly and 'Formosa' azalea, but not with 'Anicet Delcambre' holly and appeared detrimental to the growth of 'Variegatum' privet. Planting liners in December after the advent of cold weather and three months earlier than planting in April, did not result in significantly greater fresh weight at the end of the season. Planting liners in larger containers during the winter months and growing them out of doors is advantageous in that planting can be spread over a long period of time and demands on labor and equipment can be minimized in the spring. However, liners planted in the fall and winter months and grown out-of-doors are vulnerable to cold damage. The decrease in growth obtained by late planting in May emphasizes the benefits of early planting in the spring to maximize growth.

Literature Cited

1. Cobb, G.S. and G.J. Keever. 1989. Winter protection of container-grown woody ornamentals in zone 9a. *HortScience* 24:265-267.
2. Good, G.L., P.L. Steponkus and C. Wiest. 1976. Using polyhouses for protection. *American Nurseryman* 144(7):12, 120-124.
3. Hall, C.R., T.D. Phillips, A.J. Laiche, Jr. and S.E. Newman. 1987. Update of production systems and cost of production estimates for container-grown landscape plants, climatic zones 8 and 9. *Miss. Agri. and For. Expt. Sta., Agri. Econ. Res. Rept.* 176.
4. Laiche, A.J., Jr. 1976. Effect of time of transplanting on growth of greenhouse-produced woody ornamental liners. *Miss. Agri. and For. Expt. Sta. Res. Rept.* (2) No. 19.
5. Mississippi Agricultural and Forestry Experiment Station, South Mississippi Branch Experiment Station weather records, 1986 and 1987.
6. Smith, G.E. 1986. Cold protection update 1985-1986. *Proc. Southern Nurserymans Assoc. Res. Conf.* 31:179-181.
7. United States Department of Agriculture. Agricultural Research Service, 1989. *Misc. Pub. No. 1475.*
8. Whitcomb, Carl E. 1988. *Plant Production in Containers.* Lacebark Publications, Stillwater, OK.