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Container Size and Initial Trunk Diameter Effects Growth of *Acer rubrum* L. During Production[1]

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Abstract

Two studies were conducted to determine container size and liner (young bare root trees) trunk diameter effects on growth of *Acer rubrum* L. 'Franksred', Red Sunset™ red maple. In experiment 1, maples liners with initial mean trunk diameters of 12.2 mm (0.5 in), 15.9 mm (0.6 in), and 22.3 mm (0.9 in) were potted in 26.5 liter (#7), 37.8 liter (#10), and 56.8 liter (#15) containers and grown for 18 months (2 growing seasons). Height and trunk diameter growth at the end of each growing season were affected by both the initial liner trunk diameter and container size. During year 1, liners with an initial trunk diameter of 12.2 mm (0.5 in) increased 28 and 70% more in height growth compared to liners initially 15.9 mm (0.6 in) and 22.3 mm (0.9) in trunk diameter, respectively. Twenty three percent more height growth occurred with maples in 37.8 liter (#10) and 56.8 liter (#15) containers compared to those in 26.5 liter (#7) containers. Trunk diameter growth increased 50% more with 12.2 mm (0.5 in) liners compared to 22.3 mm (0.9 in) liners. A 25% increase in trunk diameter growth occurred with liners potted in 56.8 liter (#15) compared to 26.5 liter (#7) containers. At the end of the second growing season, final tree size was similar with liners that were initially 12.2 mm (0.5 in) and 15.9 mm (0.6 in) liners in trunk diameter to those initially 22.3 mm (0.9 in) when potted into 37.8 liter (#10) and 56.8 liter (#15) containers. In experiment 2, maple liners with trunk diameters 17.5 mm (0.7 in), 20.5 mm (0.8 in), and 29.0 mm (1.1 in) were potted in container sizes 26.5 liter (#7), 37.8 liter (#10), and 56.8 liter (#15) and grown for 18 months (2 growing seasons). Liners grown in 56.8 liter (#15) containers had 92% more height growth and 48% more trunk diameter growth than with liners in 26.5 liter (#7) containers. At termination, the shoot dry weight was 41% larger with maples in 56.8 liter (#15) containers compared to those grown in 26.5 liter (#7) containers.

Index words: container production, nursery production, pot bound, root ball, root restriction.

Species used in this study: *Acer rubrum* 'Franksred' L. (Red Sunset™) red maple.

Significance to the Nursery Industry

Container grown trees are an important product for the nursery and landscape industry. Red maple is ranked in the top five trees grown and marketed in the United States. Determining optimal container size for specific liner (young bare root tree) caliper is essential for producing quality trees in a 1- or 2-year production cycle. Data from this project showed that more growth occurred with smaller tree liners in a one year production system and were similar in size after two growing seasons to liners that were initially larger at potting. For a 1- or 2-year production system, results indicated greater plant growth and performance occurred with plants grown in 56.8 liter (#15) containers compared to 26.5 liter (#7) or 37.8 liter (#10) containers.

Introduction

The U.S. Census of Horticulture (9) reported maples as one of the top five trees grown for the landscape market. Landscaping trends have dictated a change in the availability of nursery stock from a traditional spring/fall balled and burlap market to a market offering year-round availability. Summer digging requires special care and increases liability to the producer. The demand for 26.4 liter (#7) to 56.8 liter (#15) container grown trees has therefore increased in recent years (personal observation).

The American Standards for Nursery Stock (1) recommends a maximum of 3.2, 3.8, and 5.1 cm (1.25, 1.5, and 2.0 in) trunk diameter shade tree in a 26.4 liter (#7), 37.5 liter (#10) and 56.8 liter (#15) container, respectively. However, the relationship of container size and liner (young bare root trees) size effects on growth of maple trees has not been quantified.

Container size is often overlooked as an important factor in tree production. Smaller containers restrict root and subsequent shoot growth (2, 3, 5 and 8). Bilderback stated in an interview by Rodda, that after 12 to 18 months, plants need to be repotted or sold in order to avoid iron or calcium deficiencies (6).

Tilt et al. (8) reported a 2-fold increase in dry shoot weight of three ornamental species (*Ilex cornuta* x *aquifolium* 'Nellie R. Stevens', x *Cupressocyparis leylandii* Jacks and Dall. 'Haggerston Grey', and *Rhododendron* sp. 'Sunglow') occurred as container volume increased from 3.8 liter (#1) to 11.4 liter (#3) with a coarse bark substrate. Weeping fig (*Ficus benjamina* L.) and loquat (*Eriobotrya japonica* (Thunb.) Lindl.) both grew faster in larger 11.3 liter (#3) containers than smaller 3.8 liter (#1) containers with a commercial peat based substrate (3).

The effects of container size on growth of ornamentals have been studied in conjunction with fertilizer rates and substrate components. Green ash (*Fraxinus pennsylvanica* Marsh), birch (*Betula pendula* Roth.), and honey locust (*Gleditisia triacanthos* L.) produced greater shoot dry weight, root dry weight and stem diameter with controlled release fertilizer compared to controlled release plus liquid feed when grown in a pot-in-pot system in 76 liter (#20) containers compared to 38 liter (#10) containers (4). Poole and Conover (5) reported schefflera (*Brassaia* spp.) plants increased growth and quality as container size increased, but fertilizers rates had no effect on plant growth. In contrast, optimal growth of *Rhododendron indicum* L. 'Formosa' and *Ilex cornuta* x *aquifolium* 'Nellie R. Stevens' was obtained in 45.4 liter (#15) containers compared to 11.4 liter (#3) or 22.7 liter (#7), but only when sufficient quantities of nutrients were applied (2).

[1]Received for publication December 7, 2004; in revised form November 29, 2005. The technical support of Sue Scholl is gratefully acknowledged.

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Larger containers may provide more growing room, but the initial investment of substrate, fertilizer, and space is more expensive; and handling may be more difficult. Production costs may be recovered, though, with increased growth rates and better quality plants (7).

Using the guidelines in the American Standards for Nursery Stock (1), some producers have been observed potting liners that are of adequate trunk diameter or larger for the container size they are potting in, with the anticipation of marketing the trees after one growing season. In this system, trunk diameter is not expected to increase, but roots are expected to establish in the container during one growing season. A potential problem with this practice is lack of growth on branches that would develop into a uniform plant canopy with maples.

Previous studies were conducted with plants that were initially the same size at potting and growth increase was related to container size or fertility rates. There are no reports comparing tree liner sizes to various container sizes in a 1- or 2-year container production regime. Therefore, the objective of this project was to determine the influence of three bare root liner sizes and three container sizes on growth of red maple during a 1- and 2-year production cycle.

Material and Methods

Experiment 1. *Acer rubrum* L. 'Franksred', Red Sunset™ red maple liners were potted March 24, 1999, in pine bark substrate amended with 6.5 kg (11.0 lb) of 19–5–9 (19N–2.2P–7.5K) Osmocote Pro controlled-release fertilizer (O.M. Scotts Co., Maryville, OH), 3.0 kg (5.0 lb) of dolomitic lime, and 0.6 kg (1.0 lb) of Micromax (O.M. Scotts Co., Maryville, OH) per m^3 (per yd^3). Maple liners selected for the project had initial average trunk diameters of 12.2 (± 0.9) mm (0.5 in), 15.9 (± 1.3) mm (0.6 in), and 22.3 (± 1.9) mm (0.9 in) trunk diameter 15 cm (6 in) above the root collar. Nine plants of each trunk diameter size were potted into 26.5 liter (#7), 37.8 liter (#10), or 56.8 liter (#15) containers (Lerio Corp., Mobile, AL) and placed in three replications with three trees in each experimental unit.

Trees were grown outside on a gravel container bed in McMinnville, TN, and cyclic irrigated daily at 5, 6, and 7 AM during the growing season unless rainfall exceeded 1.3 cm (0.5 in) within 12 hours of the next irrigation event. Micro-spray stakes (Netafilm USA, Fresno, CA) applied sufficient water or moisture to maintain a 20% leaching fraction daily in each container size. On May 3, 1999, and May 25, 2000, trees were lightly pruned to promote canopy development. In May 2000, plants were topdressed with 19–5–9 (19N–2.2P–7.5K) Osmocote Pro at 166, 249, or 333 g per 26.5 liter (#7), 37.8 liter (#10), or 56.8 liter (#15) container size, respectively, as recommended by the manufacturer. Height and trunk diameter [measured at 15 cm (6.0 in) above the root collar] were measured at potting and at the end of each growing season. In August 2000, 5 industry representatives evaluated the maples for plant quality (rating scale: 1 = superior, full uniform canopy, straight trunk; 2 = excellent, partially full canopy, straight trunk; 3 = good, partially full canopy, slightly crooked trunk; 4 = marginal, underdeveloped canopy, crooked trunk; and 5 = not saleable (data not shown). In October 1999 and September 2000, one tree per replication per treatment was harvested to obtain leaf number, root and shoot dry weight. Pine bark substrate was completely washed or removed from the roots prior to drying. Both roots and shoots were dried in a forced-air oven at 75C for 7 days.

In order for the irrigation application to maintain a 20% leaching fraction with each container size, a randomized block design was utilized. All data were subjected to analysis of variance with the GLM procedure of SAS (SAS for Windows Version 9.1, SAS Institute, Cary, NC) and means were separated by using Tukey's Studentized Range test $p < 0.05$.

Experiment 2. Methodology was similar to experiment 1 with the following exceptions. *Acer rubrum* L. 'Franksred', Red Sunset™ red maple liners were potted April 2, 2003, in pine bark substrate described above with an addition of 0.6 kg (1.0 lb) magnesium sulfate per m^3 (lbs per yd^3). Initial average trunk diameters were 17.5 (± 0.6) mm (0.7 in), 20.5 (± 1.2) mm (0.8 in), and 29.0 mm (± 1.8) (1.1 in) at 15 cm (6 in) above the root collar. Plants of each trunk diameter size were potted into 26.5 liter (#7), 37.8 liter (#10), or 56.8 liter (#15) containers (Nursery Supplies, Chambersburg, PA) for a total of nine plants in seven single plant replications. On June 17, 2003, and May 21, 2004, trees were lightly pruned to promote proper canopy development. In August 2004, five trees representing five replications of each treatment were harvested to obtain shoot dry weight.

Results and Discussion

Experiment 1. Container size and trunk diameter affected Red Sunset™ red maple growth, but there were no interactive effects (Table 1). Increases in height were affected more in year 1 (1999) by liner size than container size. Liners with initial trunk diameter of 12.2 mm (0.5 in) increased 28% in height compared to liners 15.9 cm (97 vs 70 cm) and 70% compared to liners that were initially 22.3 cm in trunk diameter (97 vs 27 cm) (Table 1). Maples averaged 23% more height growth in 37.8 liter (#10) and 56.8 liter (#15) containers compared to those in 26.5 liter (#7) containers (71 and 70 vs 54 cm).

Trunk diameter growth was affected more in year 1 by liner size than container size (Table 1). Trunk diameter growth increased 12% (11 mm vs 9.0 mm) and 50% (11 mm vs 5.4 mm) with 12.2 mm (0.5 in) liners compared to 15.9 mm (0.6 in) and 22.3 mm (0.9 in) liners, respectively. Increasing container size influenced trunk diameter growth. A 12% increase in trunk diameter growth occurred with liners potted in 37.8 liter (#10) compared to 26.5 liter (#7) containers, and a 25% increase in 56.8 liter (#15) compared to 26.5 liter (#7) containers.

Container size and liner size affected maple growth in year 2. Increases in height and trunk diameter growth were more affected by the container size than liner size. Plants grown in 56.8 liter (#15) containers had more height growth than plants in 26.5 liter (#7) or 37.8 liter (#10) containers (Table 1). It appeared that by August 2000, the plants in 26.5 liter (#7) and 37.8 liter (#10) containers were affected by the volume of the container, which suppressed plant growth.

Trunk diameter growth was influenced by liner size and container size in year 2. Liners with the initial trunk diameter of 12.2 mm (0.5 in) and 15.9 mm (0.6 in) increased 37 and 42%, respectively, more than 22.3 mm (0.9 in) liners. Trunk diameter of liners in 56.8 liter (#15) containers was more than double that of liners in 26.5 liter (#7) containers and 16% greater than those in 37.8 liter (#10) containers.

At the end of August 2000, final tree size demonstrates the effect from container size and liner size on growth. Height

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Table 1. Effect of container size and initial liner size on height growth, trunk diameter growth and shoot dry weight of Red Sunset™ red maple, 1999-2000, experiment 1.

Container size	Trunk diameter[z] (mm)	Growth increase Year 1, 1999[y] Height (cm)	Growth increase Year 1, 1999[y] Caliper (mm)	Tree size at end of Year 1, 1999 Height (cm)	Tree size at end of Year 1, 1999 Caliper (mm)	Growth increase Year 2, 2000[x] Height (cm)	Growth increase Year 2, 2000[x] Caliper (mm)	Tree size at end of Year 2, 2000 Height (cm)	Tree size at end of Year 2, 2000 Caliper (mm)	Leaf #, Year 2, 2000[w]	Dry weight (g) Year 2, 2000 Shoot	Dry weight (g) Year 2, 2000 Root
26.5 liter (#7)	12.2	84.8ab[v]	9.7ab	234.1e	20.9e	5.8ab	1.8cd	227.6d	25.8f	666c	560.7e	682.3c
37.8 liter (#10)	12.2	92.2ab	9.6ab	258.4cde	23.4cd	9.9ab	4.2abc	260.2bcd	31.1d	869abc	795.0de	875.0bc
56.8 liter (#15)	12.2	114.7a	12.8a	264.2cde	25.8bc	21.4a	5.9a	269.4bc	35.0bc	1027abc	996.7cd	1010.0ab
26.5 liter (#7)	15.9	58.1bcd	7.7bc	242.3de	23.0de	2.3b	2.9bcd	243.5cd	27.8ef	887abc	702.7de	827.3bc
37.8 liter (#10)	15.9	85.6ab	9.6ab	280.2bc	25.1cd	18.7ab	4.7ab	274.3abc	32.9cd	1065abc	961.7cd	1034.7ab
56.8 liter (#15)	15.9	67.7bc	10.9ab	271.8bcd	27.8b	23.9a	5.3ab	286.0ab	36.0ab	1335ab	1355.0ab	1119.3ab
26.5 liter (#7)	22.3	22.0d	4.8c	299.0ab	25.1cd	4.7b	1.0d	280.6abc	28.3e	825bc	739.0de	683.7c
37.8 liter (#10)	22.3	33.2cd	5.9c	301.5ab	27.9b	13.4ab	3.4a–d	285.7ab	34.0bc	1019abc	1136.7bc	1081.0ab
56.8 liter (#15)	22.3	24.5d	5.6c	327.6a	31.0a	16.0ab	3.2a-d	314.9a	38.0a	1435a	1494.7a	1259.0a
Significance												
Container		0.0344	0.0014	0.0921	<0.0001	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Liner		<0.0001	<0.0001	<0.0001	<0.0001	0.2305	0.0024	<0.0001	<0.0001	00.0133	<0.0001	0.0162
Container × Liner		0.1280	0.2087	0.0941	0.8283	0.1442	0.4430	0.5387	0.7529	0.2317	0.0225	0.1199

[z]Initial trunk diameter was measured 15 cm (6 in) above the trunk flare, subsequent measurements were made 15 cm (6 in) above the substrate.

[y]Growth increase was the difference in growth from the initial measurement at potting to October 1999.

[x]Growth increase was the difference in growth from October 1999 to August 2000.

[w]Leaf number was counted prior to harvest for shoot dry weight, August 2000.

[v]Means within columns followed by the same letter are not different according to Tukey's Studentized Range Test ($P < 0.05$).

was greatest with plants that were initially 22.3 mm (0.9 in) in trunk diameter, but were similar in size to plants that were 12.2 and 15.9 mm (0.6 in) when potted into 37.8 liter (#10) and 56.8 liter (#15) containers.

Container size and liner size affected final trunk diameter measurement at the end of year 2 experiment 1. Liners that were initially 22.3 mm (0.9 in) and grown in a 56.8 liter (#15) had the largest trunk diameter and were similar to 15.9 mm (0.6 in) liners grown in 56.8 liter (#15) containers.

At harvest in August 2000, container size and liner size affected the number of leaves in the canopy. Plants grown in 37.8 liter (#10) and 56.8 liter (#15) had similar leaf counts (1095 and 1093) and more leaves than plants grown in 26.5 liter (#7) containers (853). Maples that were initially 12.2 mm (0.5 in) in trunk diameter and planted in 56.8 liter (#15) containers produced similar leaf numbers compared to plants that were initially 15.9 or 22.3 mm (0.9 in).

Shoot and root dry weight reflected a trend similar to the effects of container size and liner size on height and trunk diameter growth. At termination in August 2000, shoot dry weight was similar with liners in 37.8 liter (#10) and 56.8 liter (#15) containers, 1006 and 1123 g as well as root dry weights 993 and 1007 g, respectively. Liners grown in 26.5 liter (#7) containers had 30% less shoot dry weight and 15% less root dry weight than plants grown in 56.8 liter (#15) containers.

Initial liner size also affected the plant dry weight. The 22.3 mm (0.9 in) liner produced 48 and 28% more shoot dry weight than a 12.2 mm (0.5 in) and 15.9 mm (0.6 in) liner, respectively. Root dry weight was 35% greater with a 22.3 mm (0.9 in) liner than 12.2 mm (0.5 in) liner and 12% greater than a 15.9 mm (0.6 in) liner.

In August 2000, 5 industry representatives evaluated the maples for plant quality. About 80% of the maples grown in 37.8 liter (#10) and 56.8 liter (#15) containers were rated with superior quality, which includes full canopy and straight trunks. However, only 10% of trees grown in 26.5 liter (#7) containers were rated as saleable, irrespective of liner size. This research agrees with Bilderback's (Rodda 2004) observations that plants held for an extended time or grown in too small containers can effect plant growth and quality.

Experiment 2. Container size and liner size affected Red Sunset™ red maple height growth (Table 2). There were no interactions between container and liner size. Liners with initial trunk diameter of 17.5 mm (0.7 in) and 20.5 mm (0.8 in) had 80% more height growth than 29.0 mm (1.1 in) liners in the first year. More height growth occurred with liners in 37.8 liter (#10) (93 cm) containers than 26.5 liter (#7) (77 cm) or 56.8 liter (#15) (56 cm) containers.

Trunk diameter growth was not significantly affected by container size in year 1. However, initial liner trunk diameter had an effect on trunk diameter growth. The two smaller liner groups with trunk diameters of 17.5 mm (0.7 in) and 20.5 mm (0.8 in) had about 50% more trunk diameter growth than the 29.0 mm (1.1 in) liners.

At the end of year 1, the height of the liners was not correlated with the initial liner size. Liners that were grown in 26.5 liter (#7) (296 cm) and 37.8 liter (#10) (322 cm) containers were taller than liners in the 56.8 liter (#15) (280 cm) containers.

Trunk diameter growth was not affected by container size at the end of the first growing season. Each respective container size had an average trunk diameter 30.0 mm. However, initial trunk diameter did influence final trunk diameter (Table 2). Liners that were initially 29.0 mm (1.1 in) still had the largest trunk diameter, 36.4 mm, compared to 32.6 mm and 35.4 mm for liners with initial trunk diameters of 17.5 mm (0.7 in) and 20.5 mm (0.8 in) liners, respectively. Interestingly, more trunk diameter growth occurred with the two smaller liner groups, but the final trunk diameters were still smaller than that of the largest trunk diameter liner.

Height growth increase in year 2 was affected more by the container size than the liner size. Liners grown in 56.8 liter (#15) containers had 92 and 89% more growth than liners in

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Table 2. Effect of container size and initial liner size on height growth, trunk diameter growth and shoot dry weight of Red Sunset™ red maple, experiment 2.

Container size	Trunk diameter[z] (mm)	Growth increase Year 1, 2003[y] Height (cm)	Growth increase Year 1, 2003[y] Caliper (mm)	Tree size at end of Year 1, 2003 Height (cm)	Tree size at end of Year 1, 2003 Caliper (mm)	Growth increase Year 2, 2004[x] Height (cm)	Growth increase Year 2, 2004[x] Caliper (mm)	Tree size at end of Year 2, 2004 Height (cm)	Tree size at end of Year 2, 2004 Caliper (mm)	Shoot dry weight (g) Year 2, 2004
26.5 liter (#7)	17.5	101.9abc[w]	8.2ab	291.7ab	25.8c	14.3c	4.0a–d	313.4b	30.0e	770.0c
37.8 liter (#10)	17.5	133.6a	10.1a	327.2a	27.3bc	6.7c	5.5ab	342.7b	33.3cde	1021.4bc
56.8 liter (#15)	17.5	79.6bc	8.5a	268.7b	26.1bc	126.0a	6.9a	405.6a	33.3cde	1428.4b
26.5 liter (#7)	20.5	111.0abc	8.0abc	297.3ab	27.7bc	16.3c	3.3bcd	319.7b	30.9de	805.4c
37.8 liter (#10)	20.5	118.4ab	9.1a	320.9ab	29.8b	8.1c	4.2a–d	335.4b	34.3bcd	1161.6bc
56.8 liter (#15)	20.5	71.1cd	7.6a-d	267.3b	29.0bc	117.6a	5.8ab	401.4a	35.0bcd	1355.4b
26.5 liter (#7)	29.0	17.1e	4.3cd	297.0ab	34.2a	4.3c	1.9d	307.6b	37.0abc	1281.2b
37.8 liter (#10)	29.0	28.0de	4.0d	313.4ab	34.2a	9.0c	1.9cd	332.4b	38.3ab	1376.0b
56.8 liter (#15)	29.0	17.3e	4.7bcd	308.5ab	35.6a	70.6b	4.7abc	398.8a	41.0a	2083.8a
Significance										
Container		0.0001	0.3415	0.0006	0.1362	<0.0001	<0.0001	<0.0001	<0.0001	0.0007
Liner		<0.0001	<0.0001	0.4216	<0.0001	0.0262	<0.0001	0.6613	<0.0001	<0.0001
Container × Liner		0.1252	0.5540	0.2074	0.5928	0.0542	0.7547	0.9627	0.6455	0.5572

[z]Initial trunk diameter was measured 15 cm (6 in) above the trunk flare, subsequent measurements were made 15 cm (6 in) above the substrate.

[y]Growth increase was the difference in growth from the initial measurement at potting to October 2003.

[x]Growth increase was the difference in growth from October 2003 to October 2004.

[w]Means within columns followed by the same letter are not different according to Tukey's Studentized Range Test ($P < 0.05$).

26.5 liter (#7) and 37.8 liter (#10) containers, respectively. A similar response was observed during the first experiment, but the growth differences were not as dramatic. A 45 and 42% increase in height growth occurred with liners that were initially 17.5 mm (0.7 in) and 20.5 mm (0.8 in), respectively, compared to liners that were initially 29.0 mm (1.1 in) in trunk diameter.

More trunk diameter growth occurred in year 2 with plants in 56.8 liter (#15) containers than plants in 26.5 liter (#7) or 37.8 liter (#10) containers, 48 and 34%, respectively. Trunk diameter increase with the 17.5 mm (0.7 in) liners was almost doubled (5.5 mm) compared to the increase in the 29.0 mm (1.1 in) liners (2.8 mm) and 36% greater than the 20.5 mm (0.8 in) liners.

At termination in August 2004, average tree height was similar regardless of the initial liner size. The largest trees were those grown in 56.8 liter (#15) containers (401 cm in height) compared to 313 cm and 336 cm in 26.5 liter (#7) and 37.8 liter (#10) containers. Trees grown in 26.5 liter (#7) and 37.8 liter (#10) containers were similar in height.

The final trunk diameter was largest for liners with an initial 29.0 mm (1.1 in) diameter grown in a 56.8 liter (#15) container, although 29.0 mm (1.1 in) diameter liners grown in 26.5 liter (#7) or 37.8 liter (#10) containers had similar caliper as liners with initial trunk diameter of 20.5 mm (0.8 in) grown in 37.8 liter (#10) or 56.8 liter (#15) containers. The smallest container, 26.5 liter (#7), restricted trunk diameter development by 11% compared to liner trunk diameter in 56.8 liter (#15) containers.

Shoot dry weights were affected by container size and liner size. Shoot dry weight with plants grown in 56.8 liter (#15) was 41 and 27% higher compared to plants grown in 26.5 liter (#7) and 37.8 liter (#10) containers, respectively. Liners that were initially 29.0 mm (1.1 in) in trunk diameter had about 30% more shoot dry weight than the liners that were initially 17.5 mm (0.7 in) or 20.5 mm (0.8 in). There was no difference in shoot dry weight between the 17.5 mm (0.7 in) liner and 20.5 mm (0.8 in) liner.

These experiments show that initial trunk diameter was an important criterion in container production of Red Sunset™ red maple. The availability of liners of a particular trunk diameter may be unpredictable from year to year, thus container size must be selected based on the liner trunk diameter in order to provide the best growing conditions and a higher quality plant. A recent national survey of quality bare root liner producers that grows a popular cultivar such as Red Sunset™ showed that a 13.0 mm (~0.5 in) trunk diameter tree liner ranged from $12.50–$17.85 per plant, a 19.0 mm (~0.75 in) trunk diameter liner ranged from $14.80–$23.05, and a 25.0 mm (1.0 in) trunk diameter liner ranged from $16.15–$29.10 depending on the height and branching structure. Based on this research, smaller trunk diameter tree liners grow faster and can be a similar size within 17 months to liners that were initially larger at potting.

In these experiments, container size strongly influenced growth and performance during the second growing season. Red maples that were about 2.5 cm (1.0 in) trunk diameter when potted and other liners that grew to about 2.5 cm (1 in) trunk diameter in these 17-month experiments were too large for a 26.5 liter (#7) container. The plants were smaller and quality was poorer when compared to plants grown in larger containers. One of the reasons for the poor performance was the root volume. A 26.5 liter (#7) container has about 60% less root volume than a 56.8 liter (#15) container, which is 30% larger than a 37.8 liter (#10) container. The recommendation by the American Standards for Nursery Stock (1) is problematic if one is expecting a quality tree with about a 2.5 cm trunk diameter in a 26.5 liter (#7) container.

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