SECTION 3
FIELD PRODUCTION

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A Potential Method for Predicting Suckering Propensity of Apple Rootstocks

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Nature of the Work: Evaluation of suckering propensity can be time consuming and expensive requiring years of field testing under various cultural and environmental conditions. Chemicals and labor required to control suckering in the nursery, landscape, or orchard contribute to production costs. The succulent tissue of suckers and / or the wounds resulting from their removal can provide ports of entry for pathogens such as fireblight (3, 4). Currently no early screening method for detecting suckering propensity exists for use in rootstock breeding or selection programs (4).

In previous root regeneration studies (1) on Malus spp., a 68°F (20°C) root and 41°F (5°C) shoot forcing condition was found to greatly accentuate adventitious shoot formation on roots. The objective of this experiment was to determine if a 68°F root and 41°F shoot forcing condition could be used to identify, at an early age, rootstocks of Malus that exhibit excessive suckering.

Plants with known suckering propensities were selected to test the method. Rootstocks with high suckering potential include M.7 and EMLA7 (5, 6) and MAC24 (7). Although variable in response, Malus domestica seedlings have also been reported to sucker heavily (9). M.9, EMLA9, and MARK (MAC9) have been reported to have moderate suckering propensities (7, 8), while M.26, EMLA26, and Budagovski9 (Bud.9) have low suckering propensities under most conditions (2, 6, 9).

On 17 April 1990, 7 bare-root liners each rootstocks were planted in 0.7 gallon plastic containers filled with Turface medium after exposure to at least 2400 hours of chilling at 41°F. Plants were placed for 28 days in a randomized complete block design in specially designed temperature controlled root and shoot compartments (1) in a 41°F coldroom. Boxes were designed to maintain roots at 68°F and shoots at 41°F or 68°F. Fourteen hour photoperiods were used. After 28 days root, shoot, and sucker growth characteristics were measured. Data was analyzed using analysis of variance and Fisher's protected least significant difference test at $p \leq 0.05$.

Results and Discussion: Under 68°F forcing conditions for the entire plant none of the suckering parameters correctly grouped the selected rootstocks (data not shown) based on reported suckering in field trials (Table 1). Cummins and Aldwinckle (3) reported a similar lack of success in greenhouse studies with root cuttings and in field studies with layered plants. Using the total number or weight of suckers from all sources, including latent buds breaking from below the first root (Table 2), forcing conditions of 68°F roots and 41°F shoots identified very high suckering propensity clones, but did not differentiate between moderately and slightly suckering clones (Table 2). Seedling, MAC-24, and EMLA7 were generally ranked among the highest in suckering propensity of plants tested based on the weight of suckers from any source (Table 2). Seedlings were best identified as having a high suckering potential on the basis of number or weight of suckers originating from lateral roots. Breaking of latent buds was not useful for identifying suckering potential of seedlings (Table 2), as no latent buds were present on seedlings below the root collar. Additional testing is needed to determine if increasing the replication could enhance the sensitivity of this method for distinguishing among the suckering propensity groups.

Significance to Industry: The 41°F shoot and 68°F root forcing conditions in this study were effective in enhancing various sucker growth parameters that may be useful for identifying Malus clones which have high potentials to sucker in the nursery, landscape, or orchard. Those individuals which ranked consistently high on most sucker growth characteristics could be eliminated prior to expensive field testing. More testing is needed to determine the suitability of this screening procedure for other species of landscape and orchard plants.

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Table 1. Number of fifth year suckers per tree in NC-140 plantings (7, 8).[z]

Genotype	1980-81 Planting	1984 Planting
Seedling	- - - -	8.7 a
EMLA7	8.9 bc	4.7 b
MAC24	35.7 a	- - - -
EMLA9	0.5 c	- - - -
MARK	1.7 bc	- - - -
Bud.9	- - - -	0.4 c
EMLA26	2.1 bc	0.4 c

[z] Means in a column followed by the same letter are not significantly different at $p \leq 0.05$ by Duncan's Multiple Range Test.

Table 2. Sucker growth during forcing on Malus rootstocks.[z]

Genotype	Number of suckers Tap root or shank	Number of suckers Lateral roots	Total	No. latent buds breaking below the 1st root on the shank	Total of last two columns
Seedling	1.9 a	4.3 a	6.1 a	0.0 c	6.1 a
EMLA7	2.1 a	0.0 b	2.1 b	1.9 ab	4.0 ab
MAC24	1.7 a	0.0 b	1.7 b	1.6 ab	3.3 b
EMLA9	1.1 a	0.0 b	1.1 b	2.4 a	3.6 b
MARK	1.4 a	0.0 b	1.4 b	1.6 ab	3.0 b
Bud.9	0.7 a	0.0 b	0.7 b	2.0 ab	2.7 b
EMLA26	1.6 a	0.1 b	1.7 b	1.0 bc	2.7 b

Genotype	Fresh weight (g) of Suckers on Tap root or shank	Fresh weight (g) of Suckers on Lateral roots	Total	Buds breaking below 1st root on the shank	Total of last two columns
Seedling	0.24 ab	0.16 a	0.40 ab	0.00 b	0.40 b
EMLA7	0.50 a	0.00 b	0.50 a	0.34 a	0.84 a
MAC24	0.25 ab	0.00 b	0.25 ab	0.46 a	0.71 ab
EMLA9	0.14 ab	0.00 b	0.14 ab	0.40 a	0.54 ab
MARK	0.33 ab	0.00 b	0.33 ab	0.33 a	0.66 ab
Bud.9	0.08 b	0.00 b	0.08 b	0.30 a	0.38 b
EMLA26	0.19 ab	0.01 b	0.19 ab	0.23 ab	0.43 ab

[z] Means in a column followed by the same letter are not significantly different at $p \leq 0.05$ by Fisher's LSD.

The Affect of Nitrogen Application Techniques on the Growth of Drip Irrigated Flowering Dogwood, Oriental Dogwood, Red Maple and Mountain Laurel

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Nature of Work: Increased salable growth as well as a tree with more harvestable roots can be field grown when drip rather than overhead irrigation is used (1, 2). Since drip irrigation uses less water, further uses for this water conserving irrigation technique are being sought. Fertilizing through drip irrigation lines, fertigation, is a logical use of this system but research results suggesting appropriate rates of field fertigation for woody landscape plant production are lacking. The objective of this test was to compare plant growth under existing practice, granular fertilizer application, with growth under three nitrogen fertigation regimes.

Field plots were established in clay loam soils at the Mountain Horticultural Crops Research and Extension Center, Fletcher, NC. Soil was tested during the fall of 1987. Appropriate soil nutrient levels for each species were established as suggested by the Agronomic Division, N. C. Department of Agriculture, Soil Testing Laboratory for all nutrients except nitrogen in February 1988. Soils were then tilled to a depth of 8 inches to thoroughly mix these nutrients with the soil.

One year old seedling liners of Acer rubrum, *Cornus florida* and *Cornus kousa* were planted four feet apart while two year old container grown seedling *Kalmia latifolia* liners were planted two feet apart in rows twelve feet apart. Three plants of each species were planted per replicate with a total of 4 replicates. Replicates were randomized within treatments. A weed free row was maintained one foot on either side of the crop by mechanical means and with a directed spray of Gramoxone. The same pesticide application, Sevin for Japanese beetle control as needed was made to all treatments.

At the end of the second and third growing season the caliper of each of the tree species was measured at 6 inches above the soil surface. A Growth Index (GI) was determined for *Kalmia latifolia* by measuring the maximum height and width of plants when they were first planted in the field, adding these figures and dividing by two. A Growth Index was determined for each plant at the end of the second and third growing season by making the same measurements then subtracting the initial Growth Index.

Treatments were based on the application rates for actual nitrogen suggested by the North Carolina Cooperative Extension Service. These are 0.25 oz. the first year, 0.5 oz. the second year and 1.0 oz. the third year plants are in the field. Urea (45-0-0) was used as the source of nitrogen throughout the test. Granular urea was applied to bare soil in a circle around the plant, one foot away from the plant base, before bud break in the spring for the Control treatment. The total amount of nitrogen applied to the fertigation treatments was either 0.5, 1.0 or 2.0 times (X) the control rate. Fertigation treatments were applied six times at weekly intervals beginning at bud swelling in the spring. The amount to be applied was determined by adding the total number of plants per treatment. This was multiplied by the number of ounces of nitrogen to be applied. This figure was divided by 6, the total number of nitrogen applications, to determine how much fertilizer to inject per treatment each week. The corresponding quantity of urea was dissolved in a five gallon plastic bucket then injected via a Venturi injector into Roberts Row Drip 1 gph emitters with an emitter every two feet within the row.

The fertigation procedure was to turn on irrigation and time the duration required for water to flow to the end of the drip irrigation line. This is the length of time required to fill the irrigation lines, i.e., to charge the system. The fertilizer solution was then injected into the line until the bucket of stock solution was empty. Water was added to the bucket to dilute any remaining nutrients then this solution was injected. Finally, the irrigation was run for at least the length of time required to charge the system to be sure the lines were flushed. This process was repeated for each fertilizer treatment, always proceeding from the lowest to the highest application rate.

Results and Discussion: At the end of the second growing season, significant differences existed only in *Cornus florida* (Table 2) where plants grown under all fertigation treatments were larger than those grown with the application of granular fertilizer, our control. By the end of the third growing season, all plants grown under fertigation treatments were larger than the control for all species (Tables 1-4).

Significance to the Industry: Since one-half the standard amount of nitrogen fertilizer produced growth statistically as great as twice the standard rate of nitrogen fertilizer, it is suggested that any nurseryman choosing to fertigate use less nitrogen fertilizer than he would normally apply. How much less remains to be determined. However, since using half as much fertilizer produced significantly more plant growth, no more than one half suggested nitrogen rates for granular fertilizers seems appropriate.

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Table 1. Caliper (in.) of *Acer rubrum* following nitrogen fertilizer treatments.

Treatment	2 years	3 years
Control	0.49 b*	.87 b
0.5 X	0.68 ab	1.16 a
1.0 X	0.76 a	1.37 a
2.0 X	0.68 ab	1.13 a

*Rp05 Duncan's New Multiple Range Test

Table 2. Caliper (in.) of *Cornus florida* following nitrogen fertilizer treatments.

Treatment	2 years	3 years
Control	0.72 b*	.92 b
0.5 X	0.89 a	1.20 a
1.0 X	0.91 a	1.25 a
2.0 X	0.90 a	1.17 a

*Rp05 Duncan's New Multiple Range Test

Table 3. Caliper (in.) of *Cornus kousa* following nitrogen fertilizer treatments.

Treatment	2 years	3 years
Control	0.77 a*	1.05 b
0.5 X	0.86 a	1.28 a
1.0 X	0.84 a	1.20 a
2.0 X	0.88 a	1.23 a

*Rp05 Duncan's New Multiple Range Test

Table 4. Growth Index (in.) of *Kalmia latifolia* following nitrogen fertilizer treatments.

Treatment	2 years	3 years
Control	6.3 b*	11.1 b
0.5 X	9.4 a	17.5 a
1.0 X	8.2 ab	16.8 a
2.0 X	8.9 a	17.3 a

*Rp05 Duncan's New Multiple Range Test

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Effect of Aisle Cover Crops on Surface Runoff Quantity and Quality

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Nature of Work: Increasing consideration of the offsite effects of soil erosion might require nurserymen to increase the utilization of soil conservation practices. A study was conducted to determine the effect of various aisle cover crops on tree growth and soil erosion. In the spring of 1991 an experimental field plot was established at the Tennessee Tech University Farm on a Typic Paleudult with a silt loam surface texture and a 5% slope. A randomized complete block design was utilized including four aisle covers: clean tilled, two tall fescue plots, and 'Appalow' lespedeza. Appalow is a low growing lespedeza that produces decumbent stems that generally do not exceed 1 ft. in height. The plots were 10 ft. wide, 500 ft. long, ran east to west with crabapple tree liners planted in the center of the plots on the west half and silver maple tree liners on the east half. A 8 in. wide weed free strip centered on the tree rows was maintained using applications of glyphosphate and hoeing. The trees were grown using standard nursery tree production practices. In the summer and early fall of 1990, runoff monitoring plots were established in one replication. Metal strips were placed around the borders of each plot to maintain integrity of the runoff samples. A collection trough constructed out of PVC pipe was placed at the base of each plot which funneled the runoff through an H flume and across a chosocton wheel, which took a 0.5% subsample of the runoff and channeled it into a glass container. Attached to the H flume was a stilling well containing a float attached to a flow recorder. In the fall of 1990 the height and caliper of the crabapple and silver maple trees were measured, the tall fescue plots were lightly tilled and annual ryegrass and crimson clover was planted in their place. Runoff data was collected from October 17, 1990 through April 29, 1991. In March of 1991 the crabapple and silver maple trees were removed and new silver maple trees were planted in all plots.

Results and Discussion: Use of tall fescue as an aisle cover crop significantly reduced the height and caliper of the crabapple and silver maple trees (Table 1). Use of Appalow lespedeza reduced height and caliper of crabapple trees, but not the maple trees. As expected, runoff volume was increased by increased rainfall and was significantly affected by aisle cover (Table 2). Little difference in runoff between aisle covers was observed until the a rainfall event exceeded 0.39 in, then the greatest runoff was observed on the tilled aisles, followed by the appalow aisle; with the clover and ryegrass being about equal. Tilling the clover and ryegrass aisles prior to planting in the fall of 1990 probably reduced soil surface bulk density, increased infiltration rates, and reduced runoff compared to the appalow aisles which had been established two years earlier. Runoff sediment concentration was significantly greater for the tilled aisles than the aisles with cover crops during the smallest of rainfall events (Table 3). Because the appalow aisles were not disturbed they produced the lowest sediment concentration. The Ryegrass aisles produced a slightly lower sediment concentration than the clover aisles, probably because of mechanical difficulties at the time of planting did not allow the ryegrass aisles to be tilled as deeply as the clover aisles. Erosion rates were significantly greater for the tilled aisles once rainfall exceeded 0.39 in per event (Table 4). The erosion rate for the clover aisles was greater than the ryegrass aisles once rainfall exceeded 1.59 in per event, probably because of the differential tillage at the time of aisle cover establishment. The total amount of erosion that ocurred from the tilled aisles was 41.3 tons/acre compared to an average of 3.1 tons/acre if a aisle cover crop was used (Table 5). The greater erosion rate was due to an 84% increase in runoff from the tilled aisles and approximately a 630% increase in the sediment concentration of the runoff. The erosion rates compare favorably to erosion rates calculated using the universal soil loss equation, utilizing a continuous fallow C value for the tilled aisles and a alfalfa C value for the aisles with cover crops. The erosion data was obtained form Oct 17, 1990 through April 29, 1991 not including any difference that might occur between the perennial and annual aisle covers during summer months.

Significance to Industry: The data presented shows that soil erosion from tree nurseries can be greatly reduced by utilizing an aisle winter cover crop maintaining soil productivity and reducing offsite effects of tree nurseries. Also it was shown that appalow lespedeza might be suitable as a perennial aisle cover for some tree species.

Table 1. Effect of aisle treatment on height and basal diameter of two year old crabapple and silver maple tree liners.

Aisle Cover	Crabapple Tree Height	Crabapple Tree Basal Diameter	Silver Maple Tree Height	Silver Maple Tree Basal Diameter
	in	in	in	in
Tilled	50.3	0. 52	38 .1	0.39
Appalow	38.5	0.39	38.1	0.41
Tall Fescue	38.5	0.42	36.5	0.31
LSD (0.05)	7.7	0.07	8.7	0.09

Table 2. Effect of the amount of rainfall and aisle cover on sediment concentration in runoff.

Rainfall in	Appalow	Ryegrass	Crimson Clover	Tilled
	lb/lx10^6 gal			
0.0 - 0.19	0.75	1.08	1.17	2.16
0.2-0.39	0.75	1.58	1.91	6.74
0.4-0.79	0.50	1.25	1.50	7.49
0.8-1.59	0.75	1.67	1.50	12.07
> 1.6	3.16	4.00	4.50	39.55

Table 3. Effect of the amount of rainfall and aisle cover on runoff.

Rainfall in	Appalow	Ryegrass	Crimson Clover	Tilled
	1000 gal/acre			
0.0 - 0.19	26.5	40.7	69.7	66.8
0.2 - 0.39	191.7	62.5	96.0	120.6
0.4 - 0.79	341.1	170.1	258.0	571.7
0.8 - 1.59	817.8	593.6	575.6	916.1
> 1.6	1087.4	707.8	710.7	1850.7

Table 4. Effect of the amount of rainfall amount and aisle cover on erosion rate.

Rainfall in	Appalow	Ryegrass	Crimson Clover	Tilled
	tons/acre			
0.0 - 0.19	0.01	0.01	0.01	0.01
0.2 - 0.39	0.01	0.01	0.01	0.01
0.4 - 0.79	0.01	0.01	0.03	0.73
0.8 - 1.59	0.06	0.10	0.07	0.82
> 1.6	0.17	0.18	0.45	3.22

Table 5. Effect of the aisle cover on total runoff and erosion, and average sediment content of runoff.

Aisle Cover	Runoff	Sediment Conc.	Erosion
	1000 gal/a	lb/lx10^6 gal	tons/a
Appalow	22567	1.00	2.18
Ryegrass	12800	1.66	2.64
Crimson Clover	14916	1.91	4.34
Tilled	30808	11.10	43.30

Chemical Root Pruning of Field-Grown Crape Myrtle

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Nature of Work: The crape myrtle is often produced as a field-grown crop. An important consideration in field production of woody plants, such as crape myrtle, is the development of a fibrous, compact root system (2). Plants with properly developed root systems are easier to harvest, easier to transplant, and have a better chance for survival in the landscape (4). Mechanical root pruning during field production with a "U-blade" is often used to produce a more compact, fibrous root system (3). Fabric root-control bags are also used to restrict root growth in the field (6).

A relatively recent development in root pruning methods has been the use of chemical barriers (2). Copper compounds such as cupric carbonate and copper sulfate have been used successfully in stimulating fibrous root development in container-grown trees (1). Inner container walls are painted with a mixture of copper and some carrier, often acrylic latex paint.

Dinitroanaline herbicides, such as trifluralin also affect root growth (5). A root control system, BioBarrier™, that combines a timed-release formulation of trifluralin with a permeable geotextile fabric has been developed to protect streets and sidewalks from tree root damage. This technology could be useful in the production of field-grown woody plants. By lining the planting hole with this material, the grower may be able to promote fibrous root development in trees and shrubs without mechanical root pruning. The objective of this study was to evaluate chemical root pruning of BioBarrierTM and compare it with other chemical root pruning methods during field production of crape myrtle.

Rooted liners of two crape myrtle cultivars, *Lagerstroemia indica* x *L. fauriei* 'Miami' and 'Osage' were transplanted June 12, 1990 subjected to 7 root-zone treatments. There were 2 rows of each species with 28 plants per row on 3 ft centers. The seven root-zone treatments replicated 4 times in each row included, planting hole with BioBarrier™, planting hole treated with 0.016% or 0.032% trifluralin, 12.5% copper sulfate-treated planting hole, latex paint-treated planting hole, and two levels of control, augered and backfilled planting hole, and a tilled only, without an augered planting hole. Latex paint was added to equal parts of water to aid in consistent coverage. Planting holes for each treatment, excluding the tilled only treatment, were dug with a 12 inch auger 12 inches deep. Plant height was recorded after 1 growing season and 2 plants representing each cultivar and root-zone treatment were excavated for root and shoot dry weights.

Results and Discussion: There were no differences between height of 'Miami' and 'Osage'. Trees in the BioBarrierTM-lined holes were generally shorter and had less dry weight (Table 1). This response was probably the result of a restricted root system and increased nutrient depletion within the planting hole. Stem dry weight of 'Miami' was less than that of 'Osage'. 'Osage' is more vigorous than 'Miami' initially, but 'Miami' will generally grow taller than 'Osage' over time (personal communication. David Byers, Byer's Nursery Co., Inc., Huntsville, AL).

The Biobarrier™ treatment greatly enhanced fibrous root branching in 'Miami' and 'Osage'. A greater percentage of roots were found within a 12 inch diameter root-zone with the BioBarrier™ treatments. The remaining treatments appeared to have little effect on fibrous root production. Roots of plants in the unaugered controls were deflected horizontally due to a hardpan in the soil created by the rototiller, which compacted the soil.

Significance to the Industry: The Biobarrier™ fabric appears to show potential as a root control system for field production of woody plants. Additional studies are needed to determine the performance of trees after transplanting, to determine the proper bag size, fertilizer and irrigation requirements, and to compare various tree species.

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Table 1. First season height stem dry weight and root restriction of *Lagerstroemia indica x L. fauriei* 'Miami' and 'Osage' liners transplanted into modified root-zones.

Cultivar	Root-Zone Treatment	Height (in)	Stem Weight (oz)	Roots Inside 12" Zone (%)
'Miami'	BioBarrier™	20.4 bc[z]	0.88 b	88.4 a
	Trifluralin (lx)	25.5 a	1.60 ab	87.8 a
	Trifluralin (2x)	24 . 8 ab	1.22 b	82.2 b
	Copper Sulfate	22 .1 abc	1.71 ab	82.0 b
	Latex Control	25 . 5 a	3.17 a	80.1 b
	Augered Control	20.1 a	2.12 ab	80.0 b
	Tilled Control	25.0 c	1.15 b	82.3 b
'Osage'	BioBarrier™	18.0 c	0.88 c	96.7 a
	Trifluralin (lx)	28.4 a	3.32 ab	83.1 d
	Trifluralin (2x)	26.7 ab	3.68 a	80.2 b
	Copper Sulfate	22.8 b	1.71 bc	86.8 c
	Latex Control	22.2 bc	2.24 abc	82.4 cd
	Augered Control	22.9 b	2.54 abc	84.3 bc
	Tilled Control	23.4 a	3.06 ab	84.1 c

[z] Means within columns and cultivars followed by the same letter were not different at the 0. 05 level, according to the Least Significant Difference test.

Transplanting of Sycamore Trees Grown in Fabric Bags

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Mississippi

Nature of Work: The field-grow container or root bag has been the subject of much attention and many testimonials over the past several years (1,2,3,4). The attractiveness of a convenient root harvesting system for field-grown nursery trees, such as the field-grow bag, is obvious when considering increasing labor costs, inclimate weather conditions and the decreasing availability of skilled balled in burlap (B&B) digging personnel (2,4).

A concern to a grower considering field-grow bags is timing of harvest (1). Manufacturers recommend that 14 inch bags be used for 1 1/2 inch caliper trees, 18 inch bags be used for 2-2 1/2 inch caliper trees and 22 inch bags be used for 3-4 inch caliper trees. The question arises as to what does a grower do with trees in bags ready to harvest with no market? A container grower may simply shift to the next larger container, but this is not feasible for a field grower. The objective of this study was to compare root growth and transplanting success of field-grown sycamore trees, with and without 18 inch fabric bags that had a caliper 40% in excess of manufacturer's recommendations and 133% larger in caliper than AAN specifications for the root ball diameter harvested.

One-year seedling sycamore trees *(Platanus occidentalis)* were planted with or without 18 inch fabric bags in May 1987. The soil was a Leeper silty clay loam and irrigation was provided as needed. After three years in the field, during March 1990, tree height (measured from the ground to the tallest branch) and caliper (measured 6 in. from the ground) was recorded. The trees were categorized into caliper groups (≤3.5 in. and >3.5 in.) dug and transplanted. Five bag-grown trees of each caliper group were dug and transplanted by hand and 5 trees without bags of each caliper group were dug and transplanted using a tree spade with a 36-38 inch diameter root ball. No supplemental irrigation was provided to the transplanted trees. Bag-grown trees required staking and guying. Five bag-grown trees and 5 trees without bags of each caliper group were dug with the tree spade and washed for root analysis. Survival and plant quality, 0 representing dead and 5 best quality, were measured May 1991.

Results and Discussion: Height of the trees was not different between bag-grown trees and trees without bags at harvest (Table 1). Bag-grown trees had 113% more root mass than trees without bags, in spite of differences in the volume of soil excavated (Table 1 and 2). Bag-grown trees less than 3.5 inch caliper had a larger caliper compared to those grown without a bag with no difference in height; whereas, bag-grown trees greater than 3.5 inch caliper were slightly taller than those grown without a bag with no difference in caliper (Table 2). Bag-grown trees were considerably easier to handle than the spade-dug plants simply due to the difference in soil mass. A few root escapes were noted and they occurred in regions of seams along the bottom of the container, which the manufacturers have corrected in later generations of the bag.

Bud break after transplanting was delayed nearly 4 days for the bag-grown trees compared to trees without bags (Table 3). The spring and early summer of 1990 had adequate rainfall; therefore, supplemental irrigation was not considered. However, the remainder of the summer of 1990 was dry and the transplanted trees were subjected to considerable stress. After 14 months, more spade transplanted trees had survived than bag-grown tree (Table 3). No differences in survival due to caliper size was noted (data not shown). The quality of the spade transplanted trees that survived was higher than the bag-grown trees (Table 3). This difference in survival and plant quality most likely could have been negated by supplemental irrigation. The larger soil volume explored by the roots of the spade transplanted trees provided more soil moisture to the tree; whereas, the bag-grown root system was confined to a smaller volume, thus less available soil water.

Significance to the Industry: This study illustrates that fabric bags are a viable alternative to spade harvesting techniques, yielding a larger volume of roots in the soil ball during harvest for similar sized trees. However, due to the difference in soil volume occupied by roots, bag-grown trees may require irrigation after transplanting.

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Table 1. Caliper, height and root dry weight of field-grown sycamore trees with and without 18 inch fabric bags.

Bag	Caliper (in)	Height (ft)	Roots (lb)
-	3.40 ± 0.20[z]	14.8 ± 0.4	5.33 ± 0.66
+	3.35 ± 0.16	15.5 ± 0.4	9.55 ± 2.76

[z] Mean ± standard error of the mean.

Table 2. Caliper, height and root dry weight of field-grown sycamore trees less than or equal to 3.5 inches and greater than 3.5 inches, with and without 18 inch fabric bags.

Size	Bag	Caliper (in)	Height (ft)	Root (lb)
≤3.5 in	-	2.56 ± 0.13[z]	13.8 ± 0.6	4.88 ± 0.77
	+	2.83 ± 0.11	14.5 ± 0.5	6.95 ± 0.58
>3.5 in	-	4.35 ± 0.20	16.0 ± 0.4	5.71 ± 1.05
	+	4.14 ± 0.15	16.9 ± 0.4	12.15 ± 1.60

[z] Mean ± standard error of the mean.

Table 3. Days after transplanting to bud break plus percent survival and tree quality 14 months after transplanting.

Bag	Bud Break (days)	Survival (%)	Quality[z]
-	7.5 ± 1.3[y]	70	2.7 ± 0.2
+	11.3 ± 0.8	60	1.7 ± 0.5

[z] Quality ranking was 0 to 5 with 0 representing dead and 5 representing active growth with no die back.

[y] Mean ± standard error of the mean.

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