SECTION 3
FIELD PRODUCTION

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Effects of Planting Depth on Three Ornamental Trees

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Nature of Work: A major problem in the production of field grown ornamental crops as well as in landscape plantings is the practice of planting trees too deep.(1) This is a problem that occurs at planting or during the cultural practice of cultivating. Cultivation heaps soil in the row and produces the same effect.

Horticultural recommendations are to plant liners no deeper than the root collar, or the depth they were growing at the nursery.(2) Forestry planting guidelines for pine trees recommends planting 2 to 4 inches deeper than the root collar.

Some ornamental plants are more intolerant of the practice of planting too deep than others. Death of Dogwoods, Hemlocks and Boxwoods are often attributed to this planting practice, either directly or indirectly. Stress resulting from this planting practice makes the plants more susceptible to attack by disease and insect pathogens. This project was designed to evaluate effects of planting depth on three trees, Dogwood (Cornus florida), Red Maple (Acer rubrum) and Virginia pine (Pinus virginiana).

Trees were planted at the Piedmont Substation in Camp Hill, Alabama. The field, which consists of a Cecil, Clay-Loam soil was plowed and cultivated. Lime and fertilizer were applied according to Auburn University Soil Test recommendations. Trees were planted six feet within the row and eight feet between each row on April 4, 1991. The experiment employs a random complete block design using treatment combinations of three species, (Dogwood, Red Maple and Virginia pine), irrigated and non-irrigated and four different planting depths (0, 2, 4 and 6 inches above the root collar). There were four replications with five samples per treatment within each replication. Trees were marked at 2, 4 and 6 inches above root collar prior to planting. Rows were kept weed free the first year by spraying a postemergence, contact herbicide as needed. Areas between the rows were kept mowed.

Trees were irrigated May through October using a 1 gallon per hour drip emitter at each tree. Irrigation needs were determined by replacing the daily evaporation totals from a class A Evaporation Pan, 3 times per week. Height, Caliper and survivability were evaluated on January 15, 1992.

Results and Discussion: First year data showed no differences in irrigation treatments for survivability, height increase or caliper increase on any of the tree species. However, heavy rainfall during the months of May, June and July totalled 25.68 inches at the Piedmont Substation. By the end of 1991, the trees had received 10.35 inches above the normal amount of rainfall resulting in similar results for irrigated and non-irrigated treatments.

Red Maples and Virginia Pines showed the greatest difference in survival response to varying root depths. Red Maples, had 65% mortality (13 out of 20) at the zero planting depth, where they were originally growing at the nursery. The six inch planting depth had 35% (7 out of 20). Both two and four inch planting depths for Red Maples resulted in 100% survival.

Virginia Pines had a 80% mortality (16 out of 20) at the six inch depth. The zero planting depth resulted in a 62% mortality rate. Two and four inch planting depths, both had the highest survival rates at 47% and 50% respectively. Dogwoods, both irrigated and non-irrigated, resulted in almost 100% survivability across all treatments.

There was a significant relationship between planting depth and height for Red Maple. Zero planting depth resulted in a mean height of 4.9 feet. Two and four inch depths both had mean heights of 6.1 feet. The six inch depth dropped back to 4.9 feet.

There was also a significant relationship between planting depth and caliper for Red Maple, but the difference was negligible. Calipers ranged from 0.9 inches to 0.8 inches for all planting depths.

There was a significant relationship between planting depth and height for dogwood. The greatest height occurred at zero planting depth (3.4 feet) and decreased to 3.2 feet, 3.0 feet and 3.0 feet at the 2, 4 and 6 inch depths respectively. Dogwoods at the zero and two inch planting depth both had the greatest caliper (0.5 inches). Four and six inch depths both resulted in 0.4 inch caliper.

There was no significant relationship between depth and height or depth and caliper for Virginia Pines.

Initial results of this two year study indicate no one depth is best for all three species. Dogwoods perform best at zero planting depth but no deeper than 2 inches. Maples perform best at the two and four inch depth for survivability, height and caliper. Virginia Pines survive best at two and four inch depths but show no significant relationship for height and caliper increase at any depth.

Significance to Industry: Data presented here is the first year results of a two year study. At the end of the 1992 growing season, second year data will be collected, analyzed and reported. Determining an optimum planting depth for planting certain species of liners (irrigated and non-irrigated) will result in growers achieving a higher percentage of initial survivability as well as increased height and caliper.

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Effects of Liner Size on Growth and Establishment of Dogwoods

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Nature of Work: Production articles often instruct producers to cull smaller, weaker liners in favor of larger more vigorous liners. The same amount of money is invested in a smaller tree that occupies the same space, takes the same amount of water, fertilizer, and labor. If liners cost 10 to 50 cents or even a dollar, culling may be an alternative. Grafted or budded liners range in cost from $5.00 to $9.00. It would be very hard to cull $5.00 trees. Liners are priced based on height. Is height the best parameter to make a decision on growth and establishment of a tree? This study evaluated liner size of budded Cornus florida var. rubra on growth and survivability of trees in 5 gallon containers.

One hundred bare root trees were ordered of two grade sizes of budded pink dogwoods, (24-30" and 30-36"). Prices for the liners (average of prices from several nurseries) were $5.50 each for the smaller liners and $6.50 each for the large liners. Graded trees ranged in height from 30" to 48" instead of 24" to 36". When nursery producers are out of a particular size tree, they traditionally upgrade to the next larger size at no additional cost. We arbitrarily divided the liners into three sizes (30-36", small, 36-42", medium, and 42-48" large).

Trees were also graded for root volume using a water displacement tube. All soil adhering to the root was removed by rinsing with water. Roots were submerged to the soil line or base of tree in the displacement tube. Excess water displaced by the roots was captured and measured. Caliper measurements were taken at 6" height.

All three sizes of the dogwood liners were potted in five gallon containers. Trees were potted on April 15, 1991 in a pine bark medium amended with

5 pounds of dolomitic lime, 11 pounds of Osmocote 17-7-12 slow release fertilizer and 1.5 pounds of Micromax (Grace/Sierra) per cubic yard. The trees were spaced on 2 1/2 foot centers in a completely random design and watered twice daily throughout the growing season. A fungicide drench (Subdue 2E, 2 fl oz/100 gal) was applied at potting and again in July. Preemergent herbicide (Snapshot 2.5 TG at labeled rate) was applied at planting and again in July. Caliper and height of each tree were recorded in November.

Results and Discussion: Root displacement measurements showed no differences in initial size of roots. Regardless of the size of the tree liner, the same U-blade was used to harvest the trees resulting in similar sized roots. There were no initial differences in caliper and no correlation was found among any of the initial size parameters. Mean height differences of 0.6 and 0.5 ft. existed between liner grade sizes, small and medium and medium and large, respectively. There were 37 (38%), 44 (45%) and 16 (17%) samples within the small, medium and large size grades, respectively.

At the end of the growing season, there were no differences in caliper, or increase in caliper (difference between initial and final caliper measurements) for the three grades of plants (Table 2). Mean final height of the small grade liner was 0.7 ft. and 0.5 ft. shorter than the larger and medium liner, respectively. No difference were found between the large and medium liners. Large liners only increased height by 1.3 ft, a 0.3 ft. smaller increase than the smaller liner sizes. This could be due to the relatively smaller root sizes of the larger (by height) liners.

Only 2 liners died during the season, both from the small liner grade. This is only a 5% loss, which is within normal, acceptable losses for a nursery.

Future research should compare some of the smaller liner grades to get the economic break point for selecting liner sizes for container production.

Significance to the Industry: Price differences among the three liner grades increased an average of one dollar, from $5.50 and $6.50 for small and medium liners to $7.50 for large liners. From the small to the large liner, there was only a 0.7 ft. increase in height with no increase in caliper. Container trees are sold by container size with an “appropriate sized” tree for the given container size. Roots must fully exploit the container. When size is considered, height is the proper measurement for trees less than 6 feet. Since tree sizes were all within an acceptable size, planting of smaller liners could save $1.00 to $2.00 per tree and subsequently increase profits.

Table 1. Evaluation of growth parameters of three liner grades of Cornus florida var. rubra

	Root Displacement (ml)	Height (ft)	Caliper (in)
Small[y]	177	3.2 c[z]	0.21
Medium	144	3.8 b	0.21
Large	156	4.3 a	0.20

[z]Means within columns for each species separated by Duncan's multiple range test, P=5%. Means not followed by common letter differ significantly from one another. All other comparisons not significant.

[y] Small, Medium and Large designations represent liner heights of 30-36, 36-42, and 42-48 inches, respectively.

Table 2. Effects of initial liner size on growth of Cornus florida var. rubra

	Final Height (ft)	Final Caliper (in)	Increase Height (ft)	Increase Caliper (in)
Small [y]	4.9 b[z]	0.36	1.6 a	0.16
Medium	5.4 a	0.36	1.6 a	0.16
Large	5.6 a	0.39	1.3 b	0.18

[z]Means within columns for each species separated by Duncan's multiple range test, P=5%. Means not followed by common letter differ significantly from one another. All other comparisons not significant.

[y]Small, Medium and Large designations represent liner heights of 30-36, 36-42, and 42-48 inches, respectively.

N Fertilization of Field Grown Woody Ornamentals

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Nature of Work: Limited definitive work in determining the N fertilizer requirements of woody ornamental trees has been accomplished due to the large number of variables and the time commitment before growth differences are manifested (Dirr, 1975). The information used to make N fertilization recommendations for field grown nursery stock has been obtained from studies with nursery stock that is either ready to be transferred to landscapes or has already been transferred to landscapes. Very little information is available on appropriate N fertilizer rates for newly established nursery stock (Tilt). Van de Werken (1970) reported that no response of field grown nursery stock to N fertilization was observed until the third year following planting of Acer saccharum (sugar maple), Ouercus palustris (pin oak), and Liriodendron tulipifera (Tulip poplar). Hensley and Aldridge (1990) reported that when ammonium nitrate was band applied to newly planted Pinus sylvestris (Scotch pine), application of 50 lb N/a increased survival and growth compared to 0, 100, and 200 lb N/a. Ammonium nitrate applied at 200 lb N/a did not significantly increase the caliper of Acer rubrum (red maple) compared to 50 lb N/a (Ponder et al., 1988). Determining N needs of woody ornamental plants are further complicated because N taken up during the year can be stored in the woody tissues of trees during dormancy and then used for growth during part of the following growing season (Kozlowski, 1971). Current recommendations for N fertilization of field grown nursery stock in Tennessee is a split application of actual N in mid February and late June for a total of 150-180 lb N/a/yr (Tilt).

Nitrogen fertility requirements of ornamental trees and shrubs were evaluated in 1990 through 1992 on a 2-5% slope Ochreptic Fragiudults soil. Boxwood (Buxus sempervirens), burning bush (Euonymus alatus), and weeping crabapple (Malus ‘Red Jade’), nitrogen rate experiments utilized randomized complete block designs. The boxwood and crabapple experiments had six N treatments replicated three times. The treatments were: 0, 25, 50, 75, 100, and 125 lb N/a. Burning bush N rate experiments had five treatments replicated three times. The treatments were 0, 25, 50, 75, and 100 lb N/a. Standard nursery cultural practices were followed. Each plot was 20 ft long and 5 ft wide with variable plant numbers. Fertilizer was spread in early to mid May of each year. The fertilizer treatments in each study were band applied in tree rows. Prior to fertilization each year, canopy height and width measurements were taken from boxwood and burning bush plots and graft caliper measurements were taken from the crabapple plot. Also prior to fertilization in 1991 and 1992 leaf samples were collected for N determination.

and canopy width growth decreased in 1990 as a result of N fertilization (Table 2). This resulted in slightly smaller boxwood plants in the plots fertilized with N in 1991. However, though not statistically significant, growth in 1991 was least for the unfertilized check plots. There was little difference in growth between any of the plots receiving N fertilizer. Weeping crabapple growth was not significantly effected by N fertilization in 1990 (Table 3). However, due to 1991 growth, trees receiving N fertilizer had a significantly greater graft calipers in 1992. There was no statistical difference in the calipers of plants receiving N fertilizer. Leaf N content data generally agrees with the growth data (Table 4). Leaf N sufficiency data for many ornamentals has been published by Jones et al. (1991) (Table 5).

Significance to Industry: This data along with the cited literature and data previously reported by the author (Cripps and Davis, 1990) indicate that current recommended N fertilization rates are high. If a producer with a 500 acre farm uses the current recommended N fertilization rate of 180 lb N/acre/yr his/her fertilizer bill would run about $24,500/yr. If a the producer used the rate suggested by the data presented here (25 lb N/acre) the cost would be $3,400/yr, even at twice this N fertilization rate the producer would save $17,700/yr.

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Table 1. Effect of N fertilization rates on burning bush height and width growth.

lb N/acre	1990	90 Growth	1991	91 Growth	1992
			height, cm		
O	10.0	1.5	11.4	33.5	45.0
25	10.3	2.2	12.5	32.1	44.7
50	8.9	3.3	12.2	33.2	45.0
75	10.2	2.2	12.4	29.6	42.0
100	10.2	3.0	13.2	28.4	41.6
LSD 0.05	NS	NS	NS	NS	NS
lb N/acre			width, cm		
0	7.6	1.9	9.6	24.7	34.3
25	8.0	1.5	9.5	24.4	33.8
50	7.3	2.7	9.9	24.9	34.7
75	7.3	1.5	8.8	24.2	33.1
100	7.2	1.7	8.8	22.4	31.3
LSD 0.05	NS	NS	NS	NS	NS

Table 2. Effect of N fertilization rates on boxwood height and width growth.

	1990	90 Growth	1991	91Growth	1992
lb N/acre	height, cm				
0	17.6	15.5	33.1	5.4	38.5
25	15.8	14.4	30.2	8.5	38.6
50	16.5	13.5	20.0	10.1	40.1
75	18.2	11.5	29.7	9.1	38.8
100	17.6	11.0	28.7	9.4	38.1
125	18.7	7.4	26.1	10.4	35.6
LSD O . 05	NS	2 . 8	3 . 7	NS	NS
lb N/acre	width, cm				
0	9.5	4.9	14.3	9.4	23.8
25	9.9	4.1	14.0	12.7	26.7
50	9.7	4.4	14.1	13.3	27.5
75	10.6	3.5	14.2	13.0	27.2
100	10.3	3.8	14.1	12.2	26.3
125	10.3	2.7	13.0	10.4	23.6
LSD 0.05	0.7	0.8	0.5	NS	NS

Table 3. Effect of N fertilization rates on crabapple graft caliper growth.

N Rate	1990	90 Growth	1991	91 Growth	1992
lb N/acre	mm				
0	7.3	0.5	7.7	8.7	16.4
25	7.0	0.6	7.5	11.8	19.3
50	7.3	0.5	7.8	10.0	17.8
75	7.6	0.1	7.5	10.2	17.7
100	7.7	0.9	8.6	10.1	18.7
125	7.7	0.5	8.3	11.5	19.8
LSD 0.05	NS	NS	NS	2.4	2.0

Table 4. Effect of N fertilization rates on leaf N content.

	Crabapples		Boxwood		Burning Bush	
N Rate	1991	1992	1991	1992	1991	1992
lb N/acre	%N					
0	2.22	1.85	3.49	3.29	2.49	2.40
25	2.33	2.25	3.43	3.31	2.50	2.53
50	2.46	2.50	3.51	3.45	2.35	2.45
75	2.38	2.45	3.47	3.33	2.68	2.60
100	2.46	2.65	3.49	3.43	2.91	2.71
125	2.81	2.75	3.57	3.77	-	-
LSD 0.05	0.41	0.31	NS	NS	NS	NS

Table 5. Reported N content ranges for selected ornamentals.

Ornamental	Low	Sufficient	High	Nursery Average
	%N			
crabapple	1.07-1.89	1.90-2.60	2.70-3.00	-
boxwood	<3.0	3.00-3.60	>3.6	-
burning bush	-	-	-	2.4

Influence of Slow-Release Fertilizer Placement on Growth of Field Grown Acer rubrum

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Nature of Work: The use of slow-release (SLR) fertilizers in field conditions for production of shade trees is relatively new. To maintain these fertilizers at the point of application, they generally must be incorporated. Rainfall and/or irrigation will move the granules around on the soil surface since they do not readily dissolve. This research was directed toward determining if placing the fertilizer on one side of the row was adequate.

Sierrablen 17-7-10 (Sierra Chemical Co., Milpitas, CA) was applied at the total rate of 1.5 pounds per tree. The variables were (1) placing all of the fertilizer in a shallow trench on one side of the tree row or (2) equally dividing the material in trenches on each side of the tree row. The trenches were 10-12 inches from the tree row, 1-2 inches deep and covered after the fertilizer application.

Each plot consisted of 3 - 2 yr old Acer rubrum cv 'October Glory' trees. A randomized complete block statistical design with 6 replications was used. Treatments were applied on 4-18-91 and leaf tissue sampled on 9-16-91. Leaf samples were oven dried and analyzed by standard laboratory procedures at the Clemson University Agricultural Services Laboratory.

Results and Discussion: Placement of the slow release fertilizer had no significant effect on trunk caliper increase or tree height increase (Table 1). Leaf tissue analysis found that placement of the fertilizer had no significant effect on leaf nutrients except for N and Zn (Table 2).

Significance to Industry: The results of this research suggest that it would be more economical to place the slow release fertilizer in a single trench compared to both sides of the tree row. This allows the grower to treat two rows from the same middle, reducing time and trips through the nursery. A side effect of the fewer trips is the reduction in soil compaction from equipment.

Table 1. Effect of placement of slow release fertilizer on trunk caliper and tree height of field grown 'October Glory' red maple.

	Row placement[z,y]	
	One-side	Two-side
Trunk caliper increase, mm(in)	12.02(0.47)	l0.80(0.42)
Tree height increase, m(ft)	0.56(1.84)	0.48(1.57)

[z] Each tree received the same actual amount of fertilizer, placement was the only variable.
[y] Means within a row are not significantly different using the LSD test.

Table 2. Influence of slow release fertilizer placement on leaf nutrient levels of field grown 'October Glory' red maples.

Nutrient Element	Row placement[z,y]	
	One-side	Two-side
N	1.90 a	1.84 b
P	0.14 a	0.15 a
K	0.82 a	0.81 a
Ca	0.81 a	0.86 a
Mg	0.33 a	0.36 a
Zn	239.0 a	265.5 b
Cu	10.5 a	8.5 a
Mn	121. 5 a	143.7 a
Fe	199 . 7 a	175. 5 a

[z] Each tree received the same actual amount of fertilizer, placement was the only variable.
[y]Means within a row followed by a common letter are not different statistically at the P= 0.10 level using the LSD test.

Effect of Fertigation and Fabric Bag on Root Development of Ilex X 'Nellie R. Stevens' Holly

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Nature of Work: In recent years the improvement of drip irrigation techniques and the introduction of the fabric bag have created some interesting production questions. Several workers have studied the effects of irrigation and fabric bags on the production of field grown ornamentals (1, 2, 3). The injection of nutrients into the irrigation water and its effect on root development Ilex x 'Nelle R. Stevens' holly grown with and without fabric bags is the subject of this study.

Fertigation treatments were the whole plots (12 plants) and bag treatments served as subplots (6 plants). Twelve inch fabric bags were installed by normal procedures. Holly liners in 4 inch pots were used in this study. Fertigation treatments consisted of a IX dry standard 12-6-6 and drip applied 12-6-6 at 0.5X, I.OX, and 1.5X rates. The IX level increased each year as the plants grew. The drip plots were applied in 8 equal amounts from May 1 to September 15 each year. The dry standard treatment was applied 3 times during the season. Adequate soil moisture levels were maintained throughout the study. A randomized complete block statistical design with 6 replications was used for the whole plot treatments.

After 3 years of treatment, the root systems were dug using a 30 inch tree spade in order to obtain a uniform soil volume from which to measure root growth. The soil was allowed to dry and the root systems removed. A 12 inch cylinder was used to mark the roots in an area similar to the 12 inch fabric bag. Dry root weights inside and outside the 12 inch cylinder were measured and recorded.

Results and Discussion: Fertigation treatments had a significant effect on the total root weight as shown in Table 1. The dry standard IX was heavier than the drip IX. The weight of the roots inside the 12 inch cylinder (fabric bag or simulated zone for no bag) were in the same relationship as total weight. No significant difference were found for the root weight outside the 12 inch cylinder area.

The effect of the fabric bag on root partitioning was very dramatic as shown in Table 1. Roots within the 12 inch cylinder area with bag treatments were significantly heavier than with root systems from no-bag plots. Conversely, no-bag treatments had more roots outside the 12 inch cylinder area than bag treatments.

The application of 12-6-6 as a dry material gave a better root system than applying equal amounts of 12-6-6 through the drip irrigation system. The use of fabric bags gave a heavier more compact root ball in this study.

Significance to Industry: The fertigation portion of this study indicates that existing fertilization methods still produce good quality root systems. The use of drip irrigation to apply nutrients can be used if proper rates are used. The drip method could be more economical from a labor standpoint.

Table 1. Effect of fertilizer rate and application method and fabric bag on root weight of Ilex x 'Nelle R. Stevens' holly.

Treatment	Root weight, g		
	Total	Inside[z]	Outside
Fertilizer			
Dry standard,			
I.0X	1458.67 a[y]	1197.58 a	261.08 a
Drip applied,			
0.5X	1198.08 b	972.83 b	225.25 a
1.0X	1209.33 b	984.00 b	225.33 a
1.5X	1348.92 ab	1120.33 ab	228.58 a
P level	0.05	0.01	0.05
	Fabric Bag		
Without bag	1156.29 a[y]	786.12 a	370.17 a
With bag	1451.21 b	1351.25 b	99.96 b
P level	0.01	0.01	0.01

[z] Inside and outside weights represent measurements relative to a 12 inch fabric bag or equivalent.

[y] Means within a column and subsection followed by a common letter are not significantly different statistically at the P levels indicated at the bottom of each respective column using the LSD test.

The use of the fabric bag is still questionable. They produce more compact root systems but tend to be rather labor intensive on both ends of the production cycle.

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Provenance Selection Improves the Nursery Performance of Sycamore and Sweet Gum Seedlings in the Field

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Nature of Work: Use of genetically improved seed sources is common practice in the production of agronomic and floricultural crops, while such resources are not generally utilized in sexually reproduced nursery crops. Nurserymen typically collect seed from local trees (planted exotic provenances or native stands) or order seeds from a commercial seed supplier. In many cases genetically improved seed sources of tree and shrub species are not available. However, increasing numbers of both coniferous and deciduous tree species are being included in tree improvement programs throughout the world (2,3). The benefits of genetically improved seed sources are well documented for forestry conditions and timber rotations of up to 40+ years (2,3), but little information is available concerning the effect of these seed sources on ornamental nursery production. Considerable growth differences during container production of seedlings from 23 northern red oak mother trees has been reported (1). As various tree improvement programs' seed orchards mature, excess seed may become more readily available to nurserymen. The purpose of this study was to determine if selected genetically improved seed sources from forestry tree improvement programs could improve the nursery performance of sycamore, sweet gum, and eastern white pine seedlings under ornamental nursery conditions.

In the winter of 1991, genetically improved seed of provenances from first generation seed orchards were obtained for sycamore (Platanus occidentalis L., R. Rousseau, WestVaco Central Woodland Seed Orchard mother trees WV-14 and WV-2), sweet gum (Liquidambar styraciflua L., J. Hendrickson, Scott Paper Co., Bulk seed orchard mix), and eastern white pine (Pinus strobus L., S. Schlarbaum, Univ. Tenn. Knoxville, Seed orchard mother trees UT79, UT62, and PSG303) and placed in cold stratification. The mother trees of improved seed sources were typically selected for improved height, caliper or volume, straight boles, and disease (ex. anthracnose on sycamore) and/or environmental stress resistance (ex. sulfur dioxide on eastern white pine). Non-improved seed sources of sycamore (bulk seed mix from native stand in Cookeville, TN), sweet gum (K & S Jeane Seed, Quitman, LA), and eastern white pine (Sheffield's Seed Co., Locke, NY) were included for comparison. In mid-February, 1991, seeds were germinated in flats, potted in 1 qt containers (Anderson Die & Mgt. Co., Portland, OR) containing 3:1 by volume milled pine bark:sand amended with 6 lb dolomite and 3 lb treble superphosphate per yd^3, and micronutrients, and topdressed with 1 teaspoon/pot of 3-4 month 18N-6P-12K slow release fertilizer and grown in a greenhouse set at 75/65°F day/night under natural photoperiods. Plants were arranged in a randomized complete block design with 6 blocks containing 5 plant replications per block for each species and seed source. On May 5, 1991, the plants were moved outdoors under 55% shade and fertilized with 1 teaspoon of 18N-7P-10K-lFe 8-9 month slow release fertilizer/pot. On May 16, 1991, the plants were transplanted to a clean cultivated field plot (silt loam) maintaining the greenhouse blocking design. Plants were watered at transplant only. A banded application of 50 lb of granular 15N-15P-15K per acre was applied after transplant and in the spring of 1992. Height at transplant, height, caliper at 6" above the soil surface, and number of suckers and multiple leaders removed (pruning cuts/plant) at the end of the first growing season, and height and caliper at mid-June of the second year were measured. Data were analyzed using ANOVA and Fisher's least significant difference test at the 5% level.

Results and Discussion: Survival of all eastern white pines seed sources was $\leq$ 50%, thus only data for sycamore and sweet gum are presented. Survival was between 94 and 100 % for all sycamore and sweet gum seed sources. Genetically improved sycamore seedlings (WV-2 and WV-14) were only slightly taller than the non-improved source at transplanting (Table 1), but they had greater height growth during the first growing season (Table 1) resulting in improved genetic sources exhibiting a 8 - 12" height advantage and 20% greater caliper by the end of the first year (Table 1). Genetically improved sycamores retained their growth advantages through mid-June of the 2nd season (Table 1). Non-improved sweet gum seedlings were actually slightly taller at transplanting than the genetically improved source (Table 1), but greater growth during the 1st growing season and early part of the 2nd season allowed the genetically improved seedlings to attain similar 1st year and greater mid-June 2nd year heights and 15 - 20% larger calipers (Table 1). The number of suckers and multiple leaders removed on both species were less for genetically improved sources than for non-improved sources (Table 1), perhaps due to selection for straight boles on mother trees. No significant disease problems were noted on any seed source.

Significance to the Industry: Simply changing the genetic source of seeds used to produce sycamore and sweet gum seedlings can significantly improve seedling growth and require less pruning under ornamental field nursery conditions. Larger plants should command premium prices. Reduced pruning means less man-hours resulting in labor savings. Since the mother trees of improved provenances were selected for improved disease resistance and long-term growth it is likely that some of these characteristics will be passed to the seedlings (2,3). If similar results could be achieved with progeny from forestry tree improvement programs containing other sexually reproduced ornamental nursery species, significant improvements in nursery profits and the postharvest quality of nursery stock could be attained. Remember, provenances need to tested in each geographical area in which they are used as their relative performance may vary depending on environmental conditions (2,3).

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Table 1. Field nursery performance of selected provenances of sycamore and sweet gum seedlings in a non-irrigated silty loam soil in Cookeville. Tennessee. Entries are means of 30 observations.

Species & Provenance	Transplant height (cm)	First year height growth in field (cm)	Total height (cm)	Caliper (mm)	No. of pruning cuts / plant	Mid-June of second year Height (cm)	Mid-June of second year Caliper (mm)
Sycamore							
Cookeville	5.1 c[z]	103 b	108 b	16.0 b	1.3 a	139 b	20.2 b
WV-14	7.4 a	121 a	129 a	20.2 a	0.8 b	164 a	24.8 a
WV-2	6.1 b	126 a	132 a	19.9 a	0.8 b	169 a	24.4 a
Sweet Gum							
Non-improved	17.4 a	54 b	71 a	11.4 b	0.8 a	97 b	14.6 b
Scott's	15.5 b	63 a	79 a	13.3 a	0.6 b	114 a	16.3 a

[z] Means within a column and species followed by the same letter are not significantly different ($\underline{P} \leq 0.05$, Fisher's LSD).

Root Development of Field Grown Sawtooth Oak After Chemical Root Pruning of Seedlings

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Nature of Work: Slow growth and shoot die back of transplanted tree seedlings has been correlated to variability in seedling root development (5). A possible solution to this problem is selection of seedlings with well developed lateral root systems. Recent studies by Kormanik et al. and Ruehle (2,3,4) successfully used lateral root morphology as an indicator of seedling quality in oak, sweetgum and loblolly pine. Seedlings graded for more first-order lateral roots (FOLR) increased planting success and reduced variation in field performance.

Our previous studies using copper compounds to chemically root prune container grown woody ornamentals were successful (1). Problems of root kinking and root coiling within the container were reduced. An increase in development of secondary and lateral root growth was observed. There were no signs of copper toxicity. The objective of this study was to monitor and evaluate root development of field grown Quercus acutissima, sawtooth oak, seedlings after they had been chemically root pruned in seedling containers.

This experiment was a randomized complete block design with 9 treatments and 6 replications with 5 seedlings per experimental unit. Sawtooth oak acorns were collected in September 1989 and placed in flats filled with pine bark medium. Acorns were covered with black fabric weed barrier to retain moisture and maintain even temperature, placed on raised benches in a double-layer, poly-covered greenhouse and watered as needed. On February 1, 1990, tribasic copper sulfate (TCS) was incorporated with either exterior acrylic latex paint or interior latex paint at rates of 0, 47, 90 and 228 g/l (1). Each TCS mixture was painted onto the interior walls of #38 Tree Trays, and allowed to air dry.

Two hundred seventy seedlings were selected for uniformity with shoot length 4 to 5 inches and root length 3 to 4 inches. On February 2, 1990, seedlings were planted in ground pine bark amended with 7 lb. dolomitic limestone, 2 lb. treble superphosphate, 2 lb. 10-10-10 granular fertilizer, 2 1/4 lb. gypsum ($CaS0_4$), 1 1/2 lb. Micromax and 2 lb. epsom salts ($MgSO_4$) per cubic yard. Seedlings were grown in a heated fiberglass greenhouse for 15 weeks under long days (18 hours) provided by 400 watt high pressure sodium lamps placed 42 inches above tray tops.

Chemical Root Pruning Phase: On May 17, 1990 height and caliper of each seedling was recorded. Each root plug was removed from the tray and the number of roots deflected and continuing to grow after contacting tube walls was recorded. Fibrous root development on the surface of each plug was assigned a rating of 1 for minimal, 2 for moderate and 3 for heavy fibrous root development.

Four seedlings from each experimental unit were transplanted into untreated, 1 gallon black plastic containers and placed outdoors in the container research nursery. Seedlings were fertilized at 5 day intervals with Peter's 20-20-20 at the rate of 200 ppm N. Supplemental watering was done by hand. At weekly intervals, one seedling from each experimental unit was removed and media washed from the root system. Data were recorded for height, caliper, fresh weight (FW) and dry weight (DW) of stems and of roots. The number of roots regenerated from the first 1 1/2 inch of the tap root was also recorded.

Field Regeneration Phase: A single seedling was randomly selected from each experimental unit and transplanted into the field research nursery on May 18, 1990. Seedlings were fertilized with Nursery Special 12-6-6 at 8 to 10 week intervals during both growing seasons. Supplemental watering was by overhead irrigation. At the end of the 1991 growing season, height, caliper, tap root diameter and number of first order lateral roots were recorded.

Results and Discussion: *Chemical Root Pruning Phase:* There were no differences in height, caliper, FW or DW of roots due to any treatment level at termination of chemical root pruning. The type of latex paint had no effect in this portion of the experiment. All levels of TCS controlled root deflection. Surface fibrous root development on the plug was reduced by contact with copper treated container walls. There was no difference in seedling caliper at any treatment level 3 weeks after transplanting from plug trays.

The lowest level of TCS showed more lateral root regeneration in the first 1 1/2 inch of tap root than the highest level. After cleaning media from the root system, visual inspection showed increased lateral and secondary root growth on roots inhibited by contact with treated tube walls. Configuration of the root system was improved in seedlings treated with TCS. Increased lateral and secondary root growth should reduce stress when plug seedlings are planted in the field by providing more root tips for absorption of water and minerals.

Field Regeneration Phase: All levels of copper increased tap root diameter, number of FOLR and average diameter of FOLR compared with the control treatment of no paint and no copper. Average tap root diameter 4 inches below soil level was greater when acrylic exterior latex paint was used as a carrier for the copper compared with interior latex paint. However, there were no differences in average number of FOLR or average diameter of FOLR resulting from either exterior or interior paint carriers.

Significance to Industry: In Kormanik's studies (2,3) up to 50% of the nursery bed grown seedlings were culled out as unacceptable for field planting due to lack of FOLR. Chemical root pruning in the seedling production phase can increase lateral and secondary root growth, providing a greater number of acceptable seedlings with well developed FOLR.

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