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Advantages of Using Selected Seed Sources of Sycamore and Sweetgum for Field Nursery Production and Transplant Establishment[1]

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Abstract

Adaptability of forest tree improvement program seed sources to landscape nursery production and subsequent bare-root transplanting were investigated. Growth during two years of field production of seedlings from two elite half-sib families of sycamore (*Platanus occidentalis* L.) and a bulk open pollinated seed orchard mix of sweetgum (*Liquidambar styraciflua* L.) were compared with a commercially available seed source of sweetgum and a locally collected half-sib family of sycamore. Utilization of select half-sib families of sycamore resulted in 11% to 19% increases in height and an 11% increase in caliper during field production compared to the local seed source. Seedlings from elite half-sib families of sycamore resumed limited height and caliper growth during the year following transplanting while seedlings from the local seed source did not. Less pruning cuts were required to remove multiple leaders and large basal suckers on elite sycamore and sweetgum seedlings during production.

Index words: field production, transplant establishment, provenance, seed source, bare-root, genetic improvement, technology transfer.

Species used in this study: American sweetgum (*Liquidambar styraciflua* L.); sycamore (*Platanus occidentalis* L.).

Significance to the Nursery Industry

Simply changing the genetic source of seeds used to produce sycamore and sweetgum seedlings can significantly improve seedling growth and/or may reduce pruning requirements under field nursery conditions. Larger plants should command premium prices. Reduced pruning could mean fewer person-hours resulting in potential labor cost savings. In addition to increased growth during production, this study demonstrates that improvement in initial post-transplant establishment of large bare-root trees may be possible with appropriate seed source selection. Post-transplant performance is the ultimate measure of the post-harvest quality of nursery stock. While these early results are promising, many questions remain unanswered. For example, provenances, seed sources, and selected half-sib families need to be tested in each geographical area and production regime in which they are used as their relative performance may vary depending on environmental conditions (10, 11). Additionally, this paper deals only with the production and initial transplant establishment phases and should not be used as an indication of long term landscape performance of the seed sources.

Introduction

Use of genetically improved seed sources is common practice in the production of agronomic and floricultural crops (4), while such resources are not generally utilized in sexually reproduced nursery crops. Superior clonal selections of many nursery crops are widely use in the nursery trade, but many desirable landscape trees cannot be easily vegetatively propagated (3). Nurserymen typically collect seed of these

[1]Received for publication April 1, 1994; in revised form June 20, 1994. Tennessee Technological University College of Agriculture and Home Economics manuscript number F94-1. The authors wish to thank Drs. R. Rousseau, J. Hendrickson, and S. Schlarbaum for providing seed from their programs for this study.

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species from local trees (planted exotic provenances or native stands) or obtain seed from a commercial seed supplier (typically of unknown provenance). In many cases genetically improved seed sources of tree and shrub species are not available. However, an increasing diversity of both coniferous and deciduous tree species are being included in tree improvement programs throughout the world (10, 11). As various tree improvement programs' seed orchards mature, excess seed may become more readily available to nurserymen for ornamental plantings. Since many mother trees from superior provenances in forest tree improvement programs were selected for improved disease resistance and long-term growth it is likely that some of these characteristics will be passed to the seedlings (10, 11).

The benefits of genetically improved sources of seeds are well documented for forestry conditions and timber rotations of up to 40+ years (10, 11), but little information is available concerning the adaptability of these selections for use in nursery production of landscape trees. Growth differences during container production of seedlings from 23 northern red oak (*Quercus rubra* L.) mother trees has been reported (8). Seedlings used in most operational reforestation programs are typically dug as 0.5 to 1 m (1.5 to 3 ft) tall bare-root trees (10), so information on the performance of larger trees either as bare-root or container-grown transplants is unavailable.

The objectives of this study were to compare the field nursery performance of sycamore and sweetgum seedlings from selected forest tree improvement program seed versus the performance of seedlings from conventional seed sources. Additionally, we sought to determine the effect of these genotypes on initial transplant establishment.

Materials and Methods

In December 1990, seed from selected mother trees from first generation seed orchards were obtained for sycamore (R. Rousseau, Westvaco Central Woodland Seed Orchard, Wickliffe, KY, mother trees WV-14 and WV-2) and sweetgum (J. Hendrickson, Scott Paper Co., Saraland, AL, bulk open pollinated seed orchard mix), and placed in moist sand in polyethylene bags in a 4°C (39°F) cooler for two months. The mother trees of improved seed sources were typically selected for improved height, caliper or volume, straight boles, and disease (example—anthracnose on sycamore) and/or environmental stress resistance. Non-improved seed sources, typical of those currently used by nurserymen, of sycamore (from a typical tree in a native stand in Cookeville, TN) and sweetgum (K & S Jeane Seed, Quitman, LA) were included for comparison.

In mid-February 1991, seeds of each source were germinated in flats in a greenhouse set at 24/18°C (75/65°F) day/night under natural photoperiods. When one to two true leaves were present, seedlings were gently up-rooted from the medium and planted in 1.1 liter (1 qt) open-bottom, square, black plastic containers (Anderson Die & Mgt. Co., Portland, OR) filled with milled pine bark:sand (3:1, by vol) media amended with 3.5 kg dolomite/m^3 (6 lb/yd^3), 1.7 kg 0N-20P-0K/m^3 (3 lb/yd^3), and 0.68 kg micronutrients (Micromax, Sierra Chemical Co., Milpitas, CA)/m^3 (1.5 lb/yd^3). The experiment was a randomized complete block design with 6 blocks with 5 plant replications per block for each species and seed source. One week after planting 16 g (0.6 oz) 18N-3.1P-8.3K-1Fe (18-7-10) Sierrablen Nursery Mix 3–4 month formulation (Sierra Chemical Co., Milpitas, CA) was surface applied to each container. A 20N-8.7P-16.7K (20-20-20) water-soluble fertilizer (Peters, W.R. Grace Co., Fogelsville, PA) was applied weekly at the rate of 200 mg N/liter (200 ppm) of water while seedlings remained in the greenhouse.

On May 5, 1991, the seedlings were moved outdoors under 55% light exclusion and 16 g (0.6 oz) 18N-3.1P-8.3K-1Fe (18-7-10) 8–9 month slow release fertilizer was surface applied to each container. On May 16, 1991, the seedlings were transplanted, at 0.6 m (2 ft) within row and 2.1 m (7 ft) between row spacings, to a clean cultivated field plot (silt loam, Cookeville, TN) maintaining the greenhouse blocking design. Plants were watered at transplant only. A banded application of 56 kg/ha (50 lb/A) of granular 15N-6.5P-12.5K (15-15-15) was applied after transplanting and in the spring of 1992. In the fall of 1991 and 1992 multiple leaders and basal suckers ≥ 15 cm (6 in) long were removed.

In November 1992, limbs on the basal 1 m (3 ft) of the trunk of the seedlings were removed. The seedlings were under cut with a U-blade at a depth of 20 cm (8 in), lifted from the soil bare-root, and transplanted, at 1.2 m (4 ft) within row spacings, to a second site approximately 100 m (109 yd) to the southwest. The same blocking design was retained. The following spring (1993) a banded application of 56 kg/ha (50 lb/A) of 15N-6.5P-12.5K was applied.

Data was collected on the following traits on all trees: height at transplanting; height, caliper at 15 cm (6 in) above the soil surface, and number of suckers and multiple leaders removed at the end of the first and second growing seasons; number of primary lateral roots ≥ 1 cm (0.4 in) in diameter at lifting; and height and caliper at the end of the first season following bare-root transplanting. Data for each species were analyzed separately using the general linear models procedure in PC-SAS (7). Where significant ($P \leq 0.05$) main effects of the treatments were found, differences among means were compared using Fisher's LSD test.

Results and Discussion

Survival during production was between 93 and 100% for sweetgum, 90 and 93% for sycamore, and was not affected ($P \leq 0.05$) by the treatments. No significant disease problems were noted on any seed source. Control of Japanese beetle (*Popillia japonica*) was necessary on all sycamore seedlings during the second year in production and during the year following transplanting.

Sycamore seedlings from select half-sib families (WV-2 and WV-14) were only slightly taller than the local source (Cookeville) at planting, but they had greater height growth during the first growing season resulting in the elite families exhibiting a 22 to 25 cm (8–10 in) height advantage and 25% greater caliper by the end of the first year (Table 1). The selected half-sib sycamore families retained much of their growth advantages through the second season, with WV-2 seedlings averaging 52 cm (20 in) greater height than seedlings derived from the local mother tree (Table 1). Growth differences in height and volume among forest plantings of sycamore provenances and/or families have been reported (1, 2, 9). While sweetgum seedlings from the bulk seed orchard mix tended to have numerically greater height and caliper than seedlings from the commercial seed source, differences were not statistically significant (Table 1). Differences in height and caliper growth between the bulk seed

Table 1. Growth of selected seed sources of sycamore and sweetgum during two years of field production and the initial year following bare-root transplanting. Values are means of 6 blocks.

Species	Genotypes	Growth during field production: Height (cm) Planting	Height (cm) year 1	Height (cm) year 2	Caliper (mm) year 1	Caliper (mm) year 2	Growth after transplanting Height (cm)	Growth after transplanting Caliper (mm)	Number of pruning cuts: Multi-leaders year 1	Multi-leaders year 2	Multi-leaders Total	Limbing up 1 m year 2
Sweetgum	Commercial	17 a[z]	71 a	192 a	11 a	30 a	193 a	32 a	0.8 a	0.7 a	1.5 a	20 a
	Bulk mix	16 a	79 a	219 a	13 a	33 a	216 a	36 a	0.6 a	0.4 a	1.0 b	17 b
Sycamore	Cookeville	5 c	107 b	274 b	16 b	43 a	276 b	44 b	1.3 a	0.4 ab	1.7 a	13 a
	WV-14	7 a	129 a	305 ab	20 a	48 a	310 a	50 ab	0.8 b	0.2 b	1.0 b	14 a
	WV-2	6 b	132 a	326 a	20 a	48 a	335 a	52 a	0.9 b	0.6 a	1.5 ab	13 a

[z]Means within a species and criteria followed by different letters were significantly different (Fishers LSD at $P \leq 0.05$).

orchard mix and commercial sweetgum seed sources were less dramatic than those of the half-sib sycamore families. This was not unexpected as genetic gains from bulk seed lots, even from elite seed orchard trees, would not be as great as that of seedlings from the best half-sib families (10, 11).

The number of suckers and multiple leaders removed were less for the genetically improved sweetgum and sycamore genotypes than for the conventional seedlings during production (Table 1). Also fewer limbs needed to be removed from the genetically improved sweetgum seedlings when raising the height (1 m (3 ft)) of the lowest limbs of the trees for harvest than on the conventional seedlings (Table 1). One of the criteria frequently used during phenotypic selection of native trees for inclusion in breeding programs is a long straight single bole and a clear trunk, suggesting an inherent natural tendency for a single leader and self-pruning of lower limbs (2). While reductions in pruning cuts required per tree were small (Table 1), if hundreds or thousands of trees were produced then eliminating one pruning cut every two or three trees could result in considerable time and labor cost savings.

Greater numbers of primary lateral roots have been shown to be associated with increased survival and growth following transplanting of bare-root northern red oak and sweetgum seedlings in forest plantations (5, 6). Genetically improved seedlings of sycamore and sweetgum averaged one to three more large primary lateral roots than non-improved seedlings, but differences were not significant ($P \leq 0.05$, data not presented).

Cumulative survival following production and transplanting was between 70 and 80% for sycamore and 87 and 93% for sweetgum with no significant ($P = 0.05$) differences among seed sources. During the initial year following transplanting, sweetgum seedlings grew little (Table 1). Similar results were recorded for the Cookeville sycamore seedlings. However, WV-14 and WV-2 sycamore seedlings continued to grow but at a reduced rate (Table 1). The net result for WV-14 and WV-2 seedlings after two years of production and one season's establishment following transplanting was a 34 cm (1.1 ft) and 59 cm (1.9 ft) height advantage, respectively, over the Cookeville seedlings. Elite half-sib sycamore families also had an increase in caliper of 14% to 18% (Table 1).

Growth differences among half-sib families following transplanting of larger bare-root sycamore seedlings (2.8 to 3.3 m (9 to 10.5 ft)) suggests that in addition to genetic gains in size achieved during field production, post-transplant establishment and subsequent growth of bare-root landscape trees could perhaps be improved via utilization of forest tree improvement programs' seed sources.

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