Influence of Pruning at Transplant Time on Growth and Establishment of *Liquidambar styraciflua* L., Sweet Gum[1]

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Abstract

Pruning of container-grown sweet gum trees by heading 20, 30, and 50% of the top at transplant time produced no significant positive influence on growth and establishment when compared to nonpruned trees. Total growth of plants pruned 30 and 50% was restricted. Heading impaired the natural excurrent (conical) form of sweet gum. However the lost leader of some trees was replaced by a clearly dominant, upright lateral branch. Results of fall and spring transplanting were similar. Supplemental irrigation during prolonged dry periods produced significantly larger, more desirable landscape trees.

Index words: planting time, irrigation, water status, pressure chamber, landscape installation

Introduction

Removal of various portions of the shoot at transplanting to compensate for roots lost in digging balled and burlapped or bare root nursery stock or to balance the root-to-shoot ratio of container plants is a longstanding horticultural practice (3, 5, 10). The practice arises from what seems to be a logical assumption: the smaller root system of the newly planted tree or shrub can no longer take-up adequate water to supply the top thus shoot pruning becomes necessary.

The efficacy of pruning at transplanting in improving growth and establishment of landscape plants has become a source of controversy (2, 3, 10). Richardson (8) found that initiation of spring root growth in silver maple required the presence of a physiologically active bud, the removal of which delayed root growth. Disbudding or treating with bud-inhibiting chemicals inhibited the ability of pistacia seedlings to form lateral roots (7). Struve and Mosher (11) compared the importance of buds and shoots in root regeneration of two oaks and obtained contrasting results: buds and shoots promoted root regeneration by pin oak, a readily transplantable species, but in scarlet oak, a difficult to transplant species, no promotive effect on the early stages of root regeneration was detected. Shoot pruning of Japanese holly when plants were moved from the 5 cm (2 in) liner pots to containers 15 cm in diameter by 30 cm deep (6 in × 12 in) increased the number of new shoots and suppressed root growth over a two month period when compared to nonpruned plants (4).

In field transplant studies with 12 bare root tree species, Shoup et al. (10) removed 0, 15, 30, or 45 percent of the plant height before the spring growth flush and found pruning treatments had no effect on survival of any species. Based on their results, the authors recommended that only corrective pruning be done at transplant because excessive pruning reduced visual quality, increased suckers on some species and did not aid in establishment or survival (10, 13, 14).

Pruning at transplant can have a profound effect on tree form. In some species, severe pruning tends to promote basal suckering thus destroying the natural form of the species (10). When evaluating the potential effect of pruning, the tree's natural branching habit must be considered. According to Harris (5) the extremes of tree form are the excurrent form where a single leader outgrows the lateral branches beneath producing a cone-shaped crown, and the decurrent where the lateral branches grow nearly as fast or faster than the terminal producing a spreading, rounded crown.

The type of pruning cut also has considerable influence on the growth response of the plant. When trees are headed, the response is the production of one or a number of shoots from buds just below the cut (5). These shoots usually grow in an upright and vigorous fashion and compete to replace the leader which has been lost. In trees with a decurrent growth habit, a number of branches arising at or near the same point is aesthetically undesirable and structurally unsound. If one shoot does not assume dominance and replace the leader, the tree's usefulness from a landscape and safety standpoint may be impaired. In contrast to heading, thinning cuts produce a more evenly distributed growth response in the plant (5). Thinned plants become more open but retain their natural form.

The objective of this research was to study the effect of transplant time, supplemental irrigation and heading at transplant on growth and establishment of a normally excurrent tree species, *Liquidambar styraciflua* L., sweet gum.

Materials and Methods

Sweet gum seedlings were obtained from the Florida Dept. of Forestry March 1983 and were potted in Metro-Mix 500 (W.R. Grace & Co., Cambridge, MA, USA) in 3.8 l (#1) containers. Plants were placed in a nonheated saran shade structure (47% light attenuation), fertilized with surface applied Osmocote 18.0N-2.4P-10.0K (18-6-12) at a rate of 12 gm (0.42 oz) per container every 3 months and watered as needed.

On October 10, 1983, 48 uniform plants averaging 138 cm (4.5 ft) in height with an average stem caliper of 1.2 cm

[1]Received for publication January 27, 1986; in revised form May 12, 1986. University of Florida Journal Series No. 7197. This research was supported in part by a Richard P. White Research Grant from the Horticultural Research Institute.

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(0.5 in) 15 cm (6 in) above the soil-line were selected for transplanting into the field. Eight rows of trees were planted 1.5 meters (5 ft) on center in a well-drained Arredondo fine sand soil that had been roto-tilled prior to planting. According to standard recommendation (5), holes were hand dug 2 times the diameter of the container or 30 cm (1 ft) in diameter and, because the soil was sandy, 5 cm (2 in) deeper than the root ball or 20 cm (8 in) deep. Holes were backfilled with excavated soil containing no amendment and trees were thoroughly watered.

Four pruning treatments, 0, 20%, 30% and 50% top removal were randomly applied at transplanting time. Because of sweet gum's excurrent growth habit and small lateral branches in these young trees, pruning treatments consisted of heading the leader to the specified height. Tree height and caliper 15 cm (6 in) above ground were measured immediately after pruning. Half of the trees in each pruning treatment were randomly selected for attachment to a drip irrigation system. To simulate conditions that might be expected on a medium to large scale landscape project, trees in the irrigated treatment were watered only during periods of low rainfall (less than 2.5 cm, 1.0 in, of rainfall in the previous two week period) while trees in the nonirrigated treatment were to receive only ambient rainfall. However, prolonged dry periods in May–June and again in August, 1984, necessitated hand watering nonirrigated trees four times.

On March 28, 1984, 48 trees with an average height of 148 cm (4.85 ft) and stem caliper of 1.4 cm (0.55 in) 15 cm (6 in) above the soil line were transplanted from the shade structure to the field location. Planting procedures, experimental treatments and measurements were the same as described for fall planted trees. All trees were fertilized with surface applied Osmocote 18.0N-2.4P-10.0K (18-6-12) at a rate of 12 gm (0.42 oz) per plant on June 25, 1984.

Leaf xylem pressure potential (^{P}leaf) measurements of water status were made with a Scholander pressure chamber (9) on the first 3 mature leaves at the apex of 3 trees randomly selected from each treatment (16 treatments) on May 16, 1984. All plants had been watered 48 hours earlier because of low rainfall in the previous 2 weeks.

Plant caliper 15 cm (6 in) above soil-line and total plant height from soil-line to the terminal bud of the leader or the tallest upright branch were measured the second week of October 1984. Because plants in this experiment were headed, an effort was made to determine the degree of competition between new shoots produced by the trees in our study. This was done by recording the total number of shoots originating up to 10 cm (4 in) below the pruning cut and producing vigorous, upright branches competing to replace the leader. Shoot lengths from point of origin to terminal bud and calipers measured 8 cm (3 in) above their point of origin were then summed for all shoots. Caliper of the leader 8 cm (3 in) above the terminal bud scale scars and height of new growth was recorded for the nonpruned, control plants.

April 5, 1985, 18 months after the fall planting and a year after the spring planting, plant form and desirability as a landscape tree was visually rated according to the following scale: 1 = excellent form, clearly dominant leader, exhibits classic excurrent form; 2 = acceptable form, single leader, may be slight competition but lateral branches have wide angle of attachment to trunk; 3 = unacceptable form, at least two codominant branches with narrow angles of attachment competing for role as leader, needs additional pruning to correct defects. Treatments were arranged in a 2 × 2 × 4 factorial with a completely random design and 6 replications per treatment. Plants and leaves in the ^{P}leaf analysis were treated as nested variables.

Results and Discussion

Analysis of variance indicated there were no significant interactions between the main effects of planting time, irrigation and pruning treatment in this experiment. Growth measurements taken one year after transplanting for the fall and 6.5 months after transplanting for the spring planted trees indicated plant caliper increase was significantly greater for fall planted trees while plant height increase was not significantly affected by planting time (Table 1). Spring planted trees overwintered in the shade structure under more favorable environmental conditions retained their leaves and continued to grow nearly 4 weeks longer than trees in the field. As a consequence the spring trees were significantly taller and with greater stem diameter at planting time than were the fall planted trees. In October 1984, calipers were not significantly different for the two planting times but spring planted trees retained a significant height advantage (Table 1).

Number of new shoots and shoot caliper totals were significantly greater for fall planted trees. Total new shoot length and visual ratings were not significantly different for the two planting seasons. ^{P}leaf measurements while indicating spring trees were an average of −0.11 MPa more stressed than the fall were not significant.

Swanson (12) compared fall and spring transplanting of 30 woody ornamental species in Colorado and concluded that spring planting was superior to fall in areas of cold, open winters with low relative humidities. The exception was his observation that fall planted potentillas were superior to those planted in the spring. Studies with tulip tree seedlings showed root regeneration capacity was greater when seedlings were transplanted in spring than in the fall (6). The sweet gums in this experiment were planted in Florida where winters are mild and the ground does not freeze. Under these conditions our results indicated there was no practical difference between spring and fall planting of container-grown sweet gum trees.

Although the same size at planting, irrigated plants made significantly greater height and caliper increases than nonirrigated plants and by October 1984 were significantly larger (Table 2). Total new shoot caliper and length were increased by irrigation but number of shoots was not affected. Visual ratings indicated irrigated trees where more desirable than nonirrigated. ^{P}leaf differences while indicating nonirrigated plants were under −0.1 MPa more stress than irrigated plants were not significant. Improvement of growth by irrigation during periodic water stress is not surprising but the pronounced benefit gained from a few additional irrigations (in this experiment, 8 to 10 thorough waterings) at times of critical water shortage is noteworthy. Irrigated plants in this study were not watered frequently but only on an as needed basis when rainfall was low. Landscape contractors during a guarantee period and owners responsible for newly transplanted plants can, with a few additional irrigations during times of drought, significantly influence the growth of plants in their care.

Table 1. **Influence of planting time on growth and water status of sweet gum trees.**

	Caliper at planting (mm)	Caliper Oct. 1984 (mm)	Plant caliper increase (mm)	Height at planting (cm)	Height Oct. 1984 (cm)	Plant height increase (cm)	Total new shoot caliper (mm)	Total new shoot length (cm)	Number of new shoots	Visual rating[y]	Pleaf (MPa)
Fall Planting	12.2 a[z]	22.5 a	10.3 a	103.6 a	133.1 a	29.5 a	17.9 a	80.9 a	2.7 a	2.5 a	−0.38 a
Spring Planting	13.8 b	21.0 a	7.1 b	112.4 b	147.5 b	35.2 a	13.5 b	73.1 a	2.0 b	2.2 a	−0.49 a

[y]Plant form was rated according to the following scale: 1 = excellent form, 2 = acceptable form, 3 = unacceptable form.
[z]Means within columns followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 2. **Influence of irrigation during periods of drought stress on growth and water status of sweet gum trees.**

	Caliper at planting (mm)	Caliper Oct. 1984 (mm)	Plant caliper increase (mm)	Height at planting (cm)	Height Oct. 1984 (cm)	Plant height increase (cm)	Total new shoot caliper (mm)	Total new shoot length (cm)	Number of new shoots	Visual rating[y]	Pleaf (MPa)
Irrigated	12.8 a[z]	24.0 a	11.1 a	107.9 a	151.5 a	43.7 a	20.1 a	103.4 a	2.5 a	2.1 a	−0.39 a
Nonirrigated	13.2 a	19.5 b	6.3 b	108.0 a	129.5 b	22.1 b	11.3 b	50.5 b	2.2 a	2.5 b	−0.49 a

[y]Plant form was rated according to the following scale: 1 = excellent form, 2 = acceptable form, 3 = unacceptable form.
[z]Means within columns followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Table 3. **Influence of pruning at transplant time on growth and water status of sweet gum trees.**

	Caliper at planting (mm)	Caliper Oct. 1984 (mm)	Plant caliper increase (mm)	Height at planting (cm)	Height Oct. 1984 (cm)	Plant height increase (cm)	Total new shoot caliper (mm)	Total new shoot length (cm)	Number of new shoots	Visual rating[y]	Pleaf (MPa)
No pruning	13.5 a[z]	22.1 a	8.5 ab	143.4 a	157.8 a	14.5 a	5.9 a	19.2 a	1.1 a	1.9 a	−0.48 a
20% Top removal	13.0 a	23.3 a	10.4 a	115.5 b	151.1 a	35.5 b	16.9 b	88.5 b	2.6 b	2.5 b	−0.41 a
30% Top removal	12.8 a	21.7 ab	8.9 ab	99.1 c	136.2 b	37.1 b	18.3 b	91.5 b	2.6 b	2.5 b	−0.43 a
50% Top removal	12.8 a	19.7 b	7.0 b	73.0 d	117.5 c	44.5 b	21.8 b	109.0 b	3.2 b	2.3 ab	−0.43 a

[y]Plant form was rated according to the following scale: 1 = excellent form, 2 = acceptable form, 3 = unacceptable form.
[z]Means within columns followed by the same letter are not significantly different at the 5% level using Duncan's multiple range test.

Plant calipers 15 cm (6 in) above ground were not statistically different at planting however trees in the 50% top removal treatment made less caliper growth and by October 1984 were significantly smaller than the nonpruned controls or plants in the 20% pruning treatments (Table 3). While overall plant height increase was less for the nonpruned plants, these plants were 20, 30 and 50% taller because of the pruning treatments than the other plants at the beginning of the experiment and, in spite of the greater height increase of pruned plants, the nonpruned plants were as tall as or significantly taller than the pruned plants in October 1984. All plants were uniform in size before pruning treatments were administered. Pruned plants produced vigorous upright shoots that grew very rapidly, replacing much of the height lost to pruning. Plants that were 80, 70, and 50% the height of the controls after pruning were 96, 86, and 75% respectively the height of the controls by October 1984. Although new shoots made considerable growth, removal of as much as 30 to 50% of the stem at transplant time appears to have stunted the overall growth of trees in this experiment.

Number of shoots, length, and caliper totals were significantly greater for the pruned plants than the nonpruned controls (Table 3). Shoot measurements for the controls represent the increase in size of the central leader with the exception of several nonpruned trees where die back of the terminal bud or the first few cm of the leader resulted in competition betweeen new shoots to replace the leader. After heading the terminal, a flush of growth in the form of a number of upright shoots was formed on most pruned plants. The response of sweet gum to heading was similar to that predicted by Harris (5) and observed in Japanese holly (4).

Evans and Klett (2) showed that 50% removal of branches by thinning reduced leaf dry weight 31% on two-year-old bare-root Sargent crabapple. Heading the branches remaining after thinning by an additional 50% did not change leaf production. Both headed and thinned trees compensated for lost branch length by an increase in length of shoots formed. The authors concluded the only qualitative difference between the heading and thinning response was a greater percentage of buds elongating on headed trees.

Pruning treatment did not significantly influence the water status of sweet gum trees in this study (Table 3). Castle (1) found only small differences in ^{P}leaf values when comparing 8-year-old citrus trees with either 30 or 50% of the canopy removed. Based on pruning treatments of 30, 50, and 80% canopy removal, he suggested that tree survival as related to short-term water stress did not warrant major concern at transplanting.

During the April 1985 visual evaluation of plant form, a tendency for one upright shoot to become dominant and replace the lost leader was observed. Visual evaluation results indicated the nonpruned trees were of significantly better form than trees pruned back 20 and 30%, but the difference between the 50% pruning treatment and the controls was not significant. Formation of a new leader by the most vigorous, upright branch was occurring rapidly in many of the pruned plants. This may be due to the fact that sweet gum, when young, has a naturally excurrent form with strong apical control (5). A tree genetically programmed to the excurrent form may be much more likely to develop a central leader after heading whereas a decurrent tree if headed when young, may be more likely to produce several competing, codominant leaders.

Significance to the Nursery Industry

Removal of 20, 30, and 50% of the top by heading at transplant time did not improve growth and establishment of sweet gum trees grown in 3.8 l (#1) containers, when compared to nonpruned plants. Severe pruning, 30 and 50% top removal, stunted plant growth. Top removal in the manner practiced in this study produced a less desirable landscape tree, however, sweet gum with its strong naturally occurring central leader growth system was rapidly replacing its lost leader and may not have been as permanently damaged as a tree with a naturally spreading growth habit. Under the mild winter conditions of Gainesville, Florida, there was no practical difference in the performance of fall and spring transplanted trees. Significant plant growth improvement occurred in response to a few supplemental irrigations during prolonged dry periods and points to the importance of watering newly transplanted trees during times of drought.

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