TWIG GROWTH OF EIGHT SPECIES OF SHADE TREES FOLLOWING TRANSPLANTING

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Abstract. Deciduous trees of eight species commonly used in the landscape (Norway maple, green ash, red maple, redbud, sugar maple, pin oak, ginkgo, and little leaf linden), 5-10 cm in diameter, were transplanted on four different dates during the 1979 growing season. The survival rate was excellent for each date. Significant variations in twig growth noted prior to transplanting had no relationship to growth rates after transplanting. For all species, twig growth was significantly reduced during the first 3 years after transplanting. Annual twig growth of all species except Norway maple equaled or exceeded pretransplanting rates by the fifth season after transplanting. Transplanting dates had no consistent effect on total twig growth after 5 years. Many species performed better when transplanted in late spring or summer rather than when transplanted in early spring or fall.

When landscape plants are transplanted, the severe reduction of their root system imposes a period of stress, which reduces vigor. Spring and fall are often considered best for transplanting (1), especially when maintenance after planting is expected to be minimal, because soil moisture is usually more available than in the summer. Summer is often avoided, even though many other conditions for growth are optimum. The objective of this study was to investigate the effect of transplanting on tree vigor, specifically the duration of the period of reduced growth and influence of transplanting date.

Materials and Methods

Deciduous trees of eight species—Norway maple (*Acer platanoides*), green ash (*Fraxinus pennsylvanica*), red maple (*Acer rubrum*), redbud (*Cercis canadensis*), sugar maple (*Acer saccharum*), pin oak (*Quercus palustris*), ginkgo (*Ginkgo biloba*), and little leaf linden (*Tilia cordata*) were transplanted on four different dates during the 1979 growing season (Table 1). Trees of each species, 5-10 cm in diameter (approximately 12 years old) were moved in groups of four with a 1.12 m (44-inch) tree spade from the Illinois Natural History Survey arboretum (Urbana, IL) to a site of similar soil type within the arboretum. Maintenance after transplanting involved limited pruning, wrapping the trunk with standard tree wrap, and applying a 7-8 cm layer of wood chip mulching to the area within the dripline of each tree and regular watering for one growing season. Average annual twig growth had been obtained for the year before the trees were transplanted and was obtained for 5 years following transplanting. Each September, the growth of approximately 30 terminals located in the middle third of the crown was visually estimated. These growth estimates were confirmed with a metric ruler. The majority of 1979 growth for trees transplanted in March and May occurred after the date of transplanting, and 1979 was considered to be the first year's growth after transplanting. Terminal twig growth for 1979 had already been completed for trees transplanted in July and October and for these trees 1980 was considered to be the first year's growth after transplanting. Thus, annual growth measurements began in either 1979 or 1980 depending on time of transplanting.

Statistical procedures were performed using the Statistical Package for the Social Sciences version 8.3 (2). Paired T-Tests were used to compare yearly differences in growth. Growth of individual trees therefore was compared before transplanting and at yearly intervals after transplanting. Results were judged significant when probability levels were equal to or less than five percent (0.05). One-way analysis of variance was used to study the effect of planting date on growth. Separation of means was by the Student-Newman-Keuls procedure with significance at one percent (0.01).

Results

Twig growth for each of the eight species

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decreased significantly during the first year after transplanting and continued to decrease during the second and sometimes during the third year (Fig. 1). Minimum growth ranged from 22 to 38 percent of the average growth before transplanting. Twig growth was significantly greater during the fourth year than during the third year for all species except sugar maple and pin oak. For green ash, redbud, and ginkgo, growth during the fourth year equaled the pretransplanting growth. During the fifth year, twig growth increased significantly over the fourth year rates for all species except green ash: for green ash, red maple, sugar maple, and pin oak, mean twig growth in the fifth year equaled the growth before transplanting; for redbud and ginkgo, mean twig growth in the fifth year exceeded the pretransplanting growth. Only the twig growth of Norway maple remained significantly lower through year 5 than the growth before transplanting. The number of lindens transplanted was insufficient for statistical analysis.

For species that had been transplanted on at least three different dates, with the exception of sugar maple, significant differences in 5-year cumulative growth were observed (Fig. 2). The transplanting date for maximum growth, however, was not the same for all species. Redbuds moved in May and Norway maples moved in July produced greater total growth than those transplanted in other months. Green ashes and Norway maples moved in October produced less growth than those moved in other months.

For two species, ginkgo and Norway maples, the date of transplanting affected annual growth during the first two years after transplanting. Ginkgos moved in May, during leaf and shoot expansion, showed moderate growth the first year, much of which probably had occurred prior to transplanting (Fig. 3). Almost no growth occurred the second year and moderate increases were observed in years 3, 4, and 5. Growth of ginkgos moved in July was negligible during the first year after transplanting (i.e., the following spring) but tremendous growth took place in each of the next

Table 1. 1979 dates for planting 8 species of deciduous trees. An X denotes a group of 4 trees transplanted.

Tree species	Date transplanted March 26	May 14	July 26	October 10
Norway maple	X	X	X	X
Green ash	X		X	X
Red maple	X	X	X	X
Sugar maple		X	X	X
Redbud	X	X	X	X
Pin oak		X	X	
Ginkgo		X	X	
Linden			X	

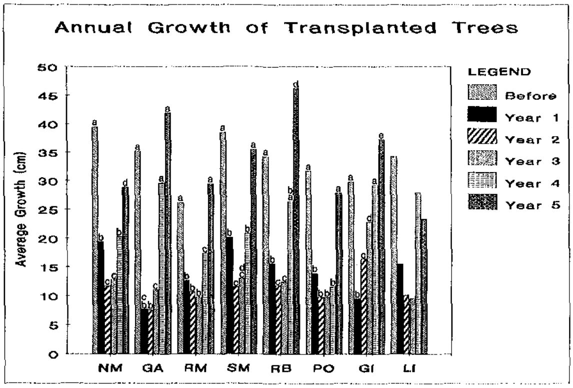

Fig. 1. Average annual twig growth of trees for 5 years following transplanting. Mean separation between groups by the Student-Newman-Keuls procedure with significance at 1 percent. Insufficient data for analysis of linden data. NM = Norway maple, GA = green ash, RM = red maple, SM = sugar maple, RB = redbud, PO = pin oak, GI = ginkgo, LI = little leaf linden.

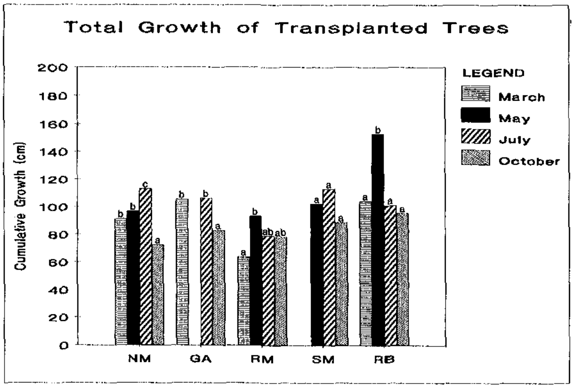

Fig. 2. Cumulative twig growth of trees for 5 years following transplanting. Mean separation within groups by the Student-Newman-Keuls procedure with significance at 1 percent. NM = Norway maple, GA = green ash, RM = red maple, SM = sugar maple, RB = redbud.

four years. The 5-year growth total was greatest for the July transplants. The Norway maples transplanted in July produced unusually large growth in the second and third years after transplanting, equaling the pretransplanting growth by the third year (Fig. 4). Growth rates declined in the fourth and fifth years, but no other visual symptoms of decline were observed.

Survival rates of all species were excellent for each transplanting date except July. One Norway maple and one green ash moved in July died. Both trees showed signs of severe water stress immediately following transplanting, and both failed to leaf out the following spring. Four redbuds declined severely over the 5-year period, but redbuds in the arboretum that had not been transplanted also showed similar symptoms, and the decline was not attributed to the transplanting process.

Since a mechanical tree spade was used, trees from the perimeter of the plot had to be transplanted first. In several species, this sequence resulted in significant differences in growth rates prior to transplanting (Table 2, 'before' columns). These differences, however, seemed to have no influence on the cumulative growth for 5 seasons after transplanting (Table 2, 'after' columns).

Discussion

The data indicate that a period of 4 or more years of stress and reduced vigor follows transplanting, even for relatively small (5-10 cm dbh) landscape trees. Over 95 percent of a tree's root system can be lost during transplanting (4), and the years of slow growth following transplanting are related to the time required for replacement of the root system. Balance between the roots and crown must be restored before vigorous top growth can occur. The data from this study closely correlate with the predictions made earlier by Watson (3) that a 10-cm (4-inch) dbh tree would replace its original root system and regain vigorous growth in 5 years.

Transplanting dates did not have a major effect on the vigor of transplanted trees. The minor differences between spring, summer, and fall transplanting showed no pattern that could be used to develop general recommendations for all ornamental species and cultivars. The data does, however, suggest optimum dates for transplanting the species used in this study. The results lend support to judicious transplanting during the summer months. Several environmental factors favor summer transplants. Soil and air temperatures are warm, day length is long, and the tree has a fully developed crown for the production of car-

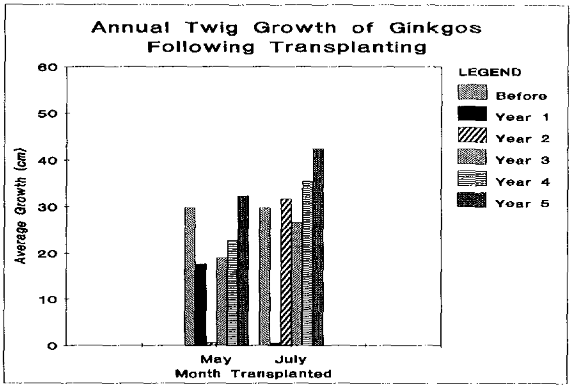

Fig. 3. The effect of May and July transplanting dates on annual twig growth of ginkgos. Date of transplanting affected growth of ginkgos in the first two years. The high value for year 1 of May transplants is deceiving because much of this growth had been completed before transplanting. Twig growth of July transplants was greater over the 5-year period.

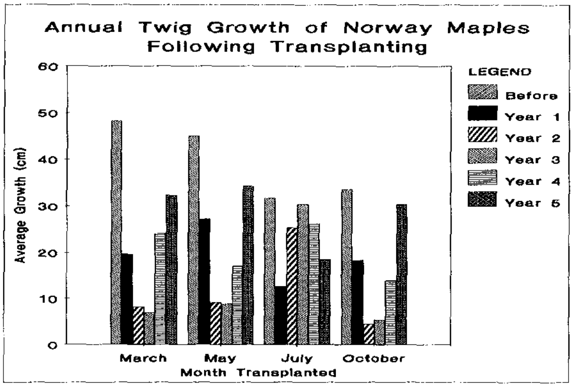

Fig. 4. Annual twig growth of Norway maples following transplanting. Trees transplanted in July showed unusually high growth in the second and third years after transplanting, followed by a decrease in growth in years 4 and 5.

bohydrates needed in root regeneration. Regular watering, however, must be used throughout the summer to minimize drought stress. July transplanting allowed several months for root regeneration before the next shoot growth period. The larger absorbing root system available to support spring shoot growth the first year after transplanting, and each year thereafter, may have been a significant factor in the good performance of trees transplanted in July.

Since variation in time of transplanting was part of the experimental design, the weather conditions for each group of trees also varied. For example, the trees transplanted in July were subject to the hottest weeks of the year immediately following transplanting (in fact, the temperature was in the 90s on the day when the trees were moved), while the first period of hot weather stress did not occur for the trees transplanted in October until the following summer. If the summer in which the trees were transplanted had been extremely hot and dry, the trees transplanted in July may not have survived as well. No physiological studies were done to determine the degree of stress of the transplanted trees, or how much more stress the trees might have tolerated. While it is acknowledged that the severity of annual weather extremes could have a profound effect on survival and growth of transplanted trees, it is difficult to determine how these annual variations affected transplanting success in this experiment.

Earlier data on initial root regeneration of several of these same species indicates that season has little influence on transplanting success, if adequate soil moisture is maintained (5). No major difference in root regeneration was reported, regardless of transplanting season, with one exception. Root regeneration was slower when Norway maples were transplanted in March, during the early stages of shoot elongation. Data in this report indicate that date of transplanting had no effect on cumulative twig growth over the 5-year period; but the initial reduction of root regeneration noted earlier may be an important factor in survival under severe drought conditions.

Two groups of transplanted ginkgos varied widely in cumulative growth (Fig. 3). Total growth of the May transplants was much lower than the total growth of the group moved in July. Transplanting ginkgos during shoot expansion may have inhibited root regeneration as previously reported for Norway maples (5). Since ginkgo roots have a much more sparsely branched growth habit than the roots of Norway maple (i.e., a smaller ratio of surface area to tissue mass), reduced root regeneration may have had a greater impact on shoot elongation in this species. Information on transplanting this species in early spring and fall would probably aid in understanding this difference in growth, but such information is not available in this study. The data indicate that transplanting ginkgos during leaf expansion reduced vigor and should be avoided. Transplanting in midsummer, however, produced excellent results. Norway maples transplanted in July exhibited a decline in growth rates after the third year (Fig. 4). Even with this reduction, the early growth of these trees was so great that they pro-

Table 2. Relation of twig growth before transplanting in cm and total growth four years after transplanting.

Time of	*Norway maple*		*Green ash*		*Red maple*		*Sugar maple*		*Redbud*	
Transplanting	*Before*	*Total*	*Before*	*Total*	*Before*	*Total*	*Before*	*Total*	*Before*	*Total*
March	48.7b	91.6b	48.3b	105.4b	30.6b	63.7a	—	—	32.2a	104.7a
May	44.9b	96.8b	—	—	30.6b	91.9b	49.5a	102.1a	43.2a	149.0b
July	31.2a	113.5c	27.2a	106.2a	25.4b	79.2ab	32.3a	113.3a	30.5a	108.5a
October	33.5a	72.6a	—	82.8a	18.3a	77.9ab	33.5a	88.9a	34.3a	95.5a

Growth data in the same column bearing the same letter were not significantly different (1% level) using one-way analysis of variance with separation of means using the Student-Newman-Keuls procedure.

duced the highest cumulative total growth of all Norway maples transplanted. Data for individual trees in this group were consistent, and all trees exhibited a decline in growth during the fourth and fifth years. This decline suggests potential problems for Norway maples transplanted in summer months.

Growth before transplanting was compared with growth after transplanting. Our study indicated that growth before transplanting had no influence on the growth after transplanting. Since all trees in this study were reasonably vigorous, it should not be assumed that trees with low vigor would perform as well as vigorous trees.

Survival was only slightly affected by date of transplanting. Loss of one Norway maple and one green ash moved in July could be attributed to transplanting. Both trees were at the upper limit of the recommended size for the tree spade used. If slightly smaller trees had been available, such losses might have been avoided.

Conclusion

The eight species of shade trees used in this study represent only a few of the many tree species and cultivars used in the landscape. The response of individual species to date of transplanting varied, but no general trend emerged to support the commonly held belief that spring and fall are best for transplanting. To the contrary, several species performed better when transplanted in late spring and summer. Adequate maintenance, however, must be considered essential.

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Abstract

KEITH, S. L. 1985. **Chainsaw safety: what you don't know can hurt you.** Am. Forests 91(9):22-27, 62-63.

Gone are the days when the only ones operating chainsaws were those burly loggers of the north woods, professional Paul Bunyans who cut their teeth on wood chips and slash piles. Today a host of ranchers, farmers, and suburbanites have swollen the ranks of chainsaw users, and the tool has become a common sight in many a garage and tool shed. According to the Consumer Product Safety Commission's (CPSC) most recent report, about 35,000 injuries involving chainsaws were treated in emergency rooms in 1976. The number fluctuated somewhere around 63,000 between 1978 and 1982, and was projected to be 69,000 for 1983. Dealing with kickback is the name of the game. And while the potentially deadly phenomenon goes with the territory, each individual manufacturer has worked long and diligently in addressing the problem. Chain brakes seem the common answer, along with asymmetrical guide bars and low-kick chains. Although kickback causes the most serious injuries, other hazards are faced by those who take a chainsaw into their hands. Front handguards protect against accidental encounters with a moving saw chain. Rear handguards keep knuckles from being slapped by loose or broken chains, and chain catchers serve to restrain a flailing chain. The throttle lockout is a sort of chainsaw "parking brake" designed to prevent accidental ignition. Bumper spikes on the front of the engine or motor housing are meant to grip the wood and help hold the saw in place during cutting. Antivibration systems absorb engine and cutting vibrations, lessening operator fatigue.