CLONAL PROPAGATION OF SUGAR MAPLE BY ROOTING CUTTINGS

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ABSTRACT.--Sugar maple cuttings from mature trees are difficult to root. The major problem of developing a successful propagation program is not only rooting, but also the overwintering survival of newly rooted cuttings. Sugar maple cuttings that did root failed to break bud and resume growth the next spring. This paper reviews the research conducted at the USDA Forest Service's Burlington Sugar Maple Laboratory and reports successful techniques for rooting and overwintering sugar maple cuttings. Overwintering survival was significantly increased when the cuttings were forced to break bud and produce a flush of new growth immediately after being rooted.

SCIENTISTS at the Northeastern Forest Experiment Station's Sugar Maple Laboratory in Burlington, Vermont, have been studying methods to vegetatively propagate sugar maple (*Acer saccharum* Marsh.) (Atkinson 1964; Donnelly 1971, 1974, 1977; Donnelly and Yawney 1972; Gabriel et al. 1961; Greenwood et al. 1976; Koelling 1968; Yawney et al. 1978). The objective of these studies that involved the rooting of cuttings was to develop a workable procedure that would allow propagators to reproduce and multiply sugar maple trees, particularly those selected for high sap-sugar content. After the genetic evaluation phase of our superior-tree selection program is completed, clonal stock propagated from the "sweet trees" may be used to establish high-yielding sugarbushes.

The problems with vegetative propagation of sugar maple were last discussed by Atkinson in 1964 at the Northeastern Forest Tree Improvement Conference. Since then we have continued our rooting work with sugar maple, and while the cause and effect relationships of root development in stem cuttings are far from understood, we have achieved some success in rooting cuttings. This paper reviews the research conducted at the Burlington Sugar Maple Laboratory and reports the successful methods for rooting.

The propagation of sugar maple by rooting cuttings includes two distinct phases: (1) root initiation and development and (2) overwintering of rooted cuttings.

FACTORS AFFECTING ROOT INITIATION AND DEVELOPMENT

It is well known that the age of the parent tree can significantly affect rooting response; that is, cuttings taken from juvenile trees will root easier and faster and overwinter more successfully than cuttings from mature trees of the same species. We found this to be the case with sugar maple. The mature age of our experimental trees, quite probably, was a major factor contributing to the difficulty we experienced with sugar maple. But, we continue to use cuttings from mature trees in developing our rooting techniques, because trees that were selected for high sap-sugar content in our improvement program were at least 50 years old.

Rooting response of individual trees can range from zero to 100 percent. How well cuttings taken from a sugar maple tree for the first time will root cannot be predicted. Rooting trials are necessary to establish the rooting potential of a given genotype. The potential for rooting in sugar maple appears to be subject to strong genetic control (Gabriel et al. 1961; Donnelly and Yawney 1972). From year to year, parent trees tend to be consistent in rooting ability. If cuttings root well one year, they will tend to root well in other years. Conversely, trees that are poor rooters in one year will be poor rooters in other years. It is not known why cuttings from some sugar maple trees root better than cuttings from other trees. We were unable to detect any correlations between endogenous auxin content of cuttings and rooting ability (Greenwood et al. 1976).

The frequency and rate of root development varies considerably among genotypes. For example, we observed that cuttings from one tree were 80 percent rooted with roots measuring up to 10 cm in length after only 4 weeks, while cuttings from other "good rooters" did not begin to exhibit roots until after 6 weeks. Some variation in rooting from one year to the next may be noted in cuttings taken from the same tree. Although environmental effects may be a factor, this variation may also be attributed to our inability to take cuttings at the precise optimum time of maximum rooting potential. However, with experience, and particularly after working with cuttings from the same parent tree for several years, the chances for obtaining maximum rooting are greatly increased.

Maximum rooting is achieved with greenwood cuttings taken during the month of June (Koelling 1968). Apparently, that is when the current-year shoots are at the physiological and anatomical stage of development most conducive to root formation. Figure 1 shows the rooting percentage of cuttings collected twice weekly from four trees during the month of June. Some variation is noted in peak response (70, 90, 90, and 100 percent) among the four trees. But, considerably greater variation is evident in the length of time that cuttings are at their maximum potential for rooting. One tree rooted well over a period of nearly 3 weeks, whereas the other three trees rooted well

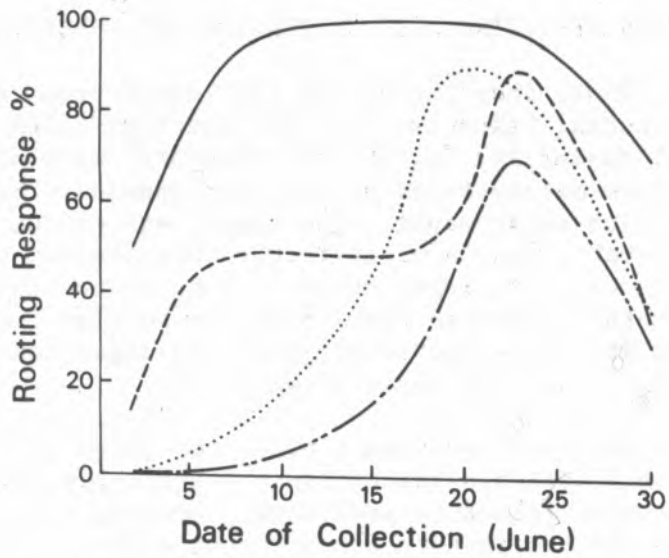

Figure 1. Individual tree differences in the relationship between date of collection and rooting response of sugar maple cuttings. Each line represents cuttings from a different tree (from Donnelly, 1977).

at only one collection period. This emphasizes the importance of proper timing in making cutting collections. These differences in the length of time that plants retain their potential for developing adventitious roots may explain some of the clonal variability frequently observed by propagators when attempting to root cuttings from selected plants.

Because seasonal weather conditions influence the rate and pattern of tree growth, the optimum date for taking stem cuttings will vary from year to year. As a general guide, the characteristics of the developing shoot that coincide with maximum rooting are: leaves just reach full size and are bright green; the base of the petioles shows signs of reddish-purple coloration; shoots begin to stiffen slightly, and lenticels are pronounced; and terminal buds are barely visible as two dark brown scales measuring about 2.5 mm in height (Donnelly 1977).

We examined the relationship between shoot size and rooting response (Donnelly 1974). In general, our data support the assumption that large cuttings root better than small ones, but we observed large tree-to-tree variation related to the effect of cutting size. Cuttings from some trees rooted relatively well, regardless of size. For other trees, rooting response and cutting size was closely correlated, and for some trees, rooting response was poor, regardless of cutting size. Because of tree-to-tree variation, rooting response on the basis of cutting size cannot be predicted. But, this should not obscure the fact that there tends to be a positive correlation between cutting size and rooting response, and propagators may in crease their chance of success if they take advantage of this relationship.

Rooting hormones are commonly used to stimulate adventitious root formation in cuttings of a wide variety of plant species. We therefore tested the effects of several types and concentrations of rooting hormones on sugar maple (Donnelly 1971; Donnelly and Yawney 1972). These included: (1) Hormodin No. 3 [1,2] (0.8% IBA powder), (2) Jiffy Grow [3] (0.5% IBA + 0.5% NAA liquid), (3) Jiffy Grow diluted 1:1 with distilled water, (4) diluted Jiffy Grow plus Hormodin No. 3, (5) talc containing 0.5 percent IBA (indolebutric acid), (6) talc containing 1.0 percent IBA, (7) talc containing 2.0 percent IBA, (8) talc containing 4.0 percent IBA, and (9) distilled water (control).

Results of this study indicated no significant differences between type of hormone used. But, differences between trees in re sponse to hormone concentration were observed. Figure 2 shows the variation in rooting of cuttings from three different trees. Cuttings

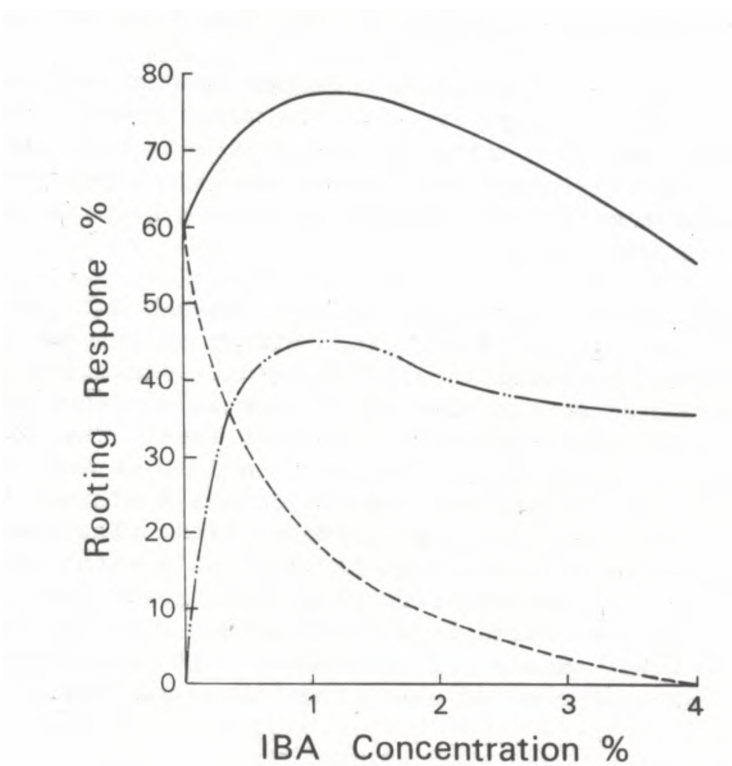

Figure 2. Individual tree differences in the response of cuttings to various concentrations of IBA. Each line represents cuttings from a different tree (from Donnelly, 1971).

from one tree rooted well (60 percent) without hormone treatment, and decreased in rooting percentage as the concentration of the applied hormones was increased. Cuttings from another tree also rooted well (60 percent) without hormones, but in this case, treatment with exogenous hormones resulted in increased rooting. Cuttings from a third tree rooted poorly (5 percent) without applied hormones, but rooting in this tree was increased to approximately 45 percent with hormone applications. Where the use of hormones showed a positive effect, maximum rooting was achieved at concentrations approaching 1 percent. Concentrations higher than 1 percent appeared to have an inhibiting effect on rooting.

The reason for different rooting responses to hormone treatment is not known. However, we hypothesize that the different responses may be due to inherent differences in the endogenous auxin concentrations within the three trees studied. If auxin concentrations are low, applied hormones would have a stimulating effect, but if the cuttings contain high levels of endogenous auxin, additional amounts might be toxic and inhibit rooting. Thus, we suggest that, when taking cuttings from a tree for the first time, treat half of the cuttings with rooting hormones and do not treat the other half so that the procedure most appropriate for that tree can be identified.

It is important that cuttings do not become desiccated during collection. Take cuttings early in the morning while the shoots are turgid and the day is still cool. After taking the cuttings, place them immediately in chest-type coolers in layers between cool, moist sphagnum moss for transportation to the rooting chamber, and stick them the same day.

Our rooting facility is a 6 x 18-m quonset hut greenhouse covered with corrugated fiberglass. Either 50 percent saran shade cloth or shading compound is used to reduce insolation to help reduce daytime temperatures, the greenhouse is equipped with thermostatically controlled coolers and exhaust fans. The 120-cm wide rooting beds are built at ground level on a 30-cm bed of gravel. They are 15 to 20 cm deep and consist of a 1:1 mixture of shredded sphagnum moss and horticultural-grade perlite. The temperature of the rooting medium is maintained at about 25°C with underlying heating cables. An intermittent mist is operated from 4 a.m. to midnight and is controlled by a time clock. The mist is 1 to 2 seconds once every minute. Supplemental lighting (150-watt incandescent lamps, one meter above the beds) provides a 20-hour day length.

Prior to sticking, the greenwood cuttings are wounded at the basal end by making light scrapes about 1 inch long on opposite sides of the stem through the bark to expose the cambium, and dipped into talc containing 0.8 percent IBA. The cuttings are then stuck to a depth of about 5 cm.

Given the right set of circumstances, such as properly timed collections from trees of known rooting potential, the expeditious handling with the appropriate hormone treatment, and adequate rooting facilities, the adventitious roots on sugar maple stem cuttings can be expected to appear in 1 to 3 months after sticking.

OVERWINTERING ROOTED CUTTINGS

Atkinson (1964) pointed out that the major obstacle to developing a successful program was not only rooting, but also the overwintering survival of newly rooted cuttings. The problem, simply stated, was that sugar maple cuttings that did root would, more often than not, fail to break bud and resume growth the next spring.

Overwintering survival, after summer rooting of cuttings, is a problem common to other species. Waxman (1961 and 1965), at the University of Connecticut, suggested that survival in dogwood and azalea would be increased when cuttings were made to flush and produce new growth of stem and leaves in the same year that they were rooted. With sugar maple, we found that bud break followed by an active growth period significantly increased overwintering.

In developing our procedures, we discovered that overwintering survival was greatly enhanced by keeping the cuttings in the rooting bed for as short a time as possible. The technique to accomplish this is: Examine cuttings for visible signs of roots 4 weeks after sticking, and then every week thereafter. When roots are 1 to 2 cm in length (Fig. 3), remove the cuttings from the rooting bed and pot. By potting at this time the risk of root damage is minimized, the actual potting procedure is greatly facilitated, and the roots are established in the pots and are able to absorb moisture and nutrients as they develop.

Pot in 15- to 20-cm diameter pots with a 1:1:1 mixture of loam, peat, and perlite supplemented with lime and fertilizer according to the recommendations of Boodley and Sheldrake (1972). Water the cuttings after potting. Because the root systems are so small, and to keep the plants from becoming desiccated, place the potted cuttings under the mist system. However, to prevent the mist from overwatering the cuttings, cover the pots with plastic cards that have been cut with a slot and fitted around the cuttings. The root systems at this stage tend to develop very rapidly in the pots. Generally, the roots will grow through the soil and appear at the side of the pots in 1 to 2 weeks. When this occurs, remove the cuttings from the mist system and transfer to greenhouse benches where they are maintained under a 20-hour day length. In our greenhouse, cool-white fluorescent and incandescent lamps provide about 400 ftc of supplemental light.

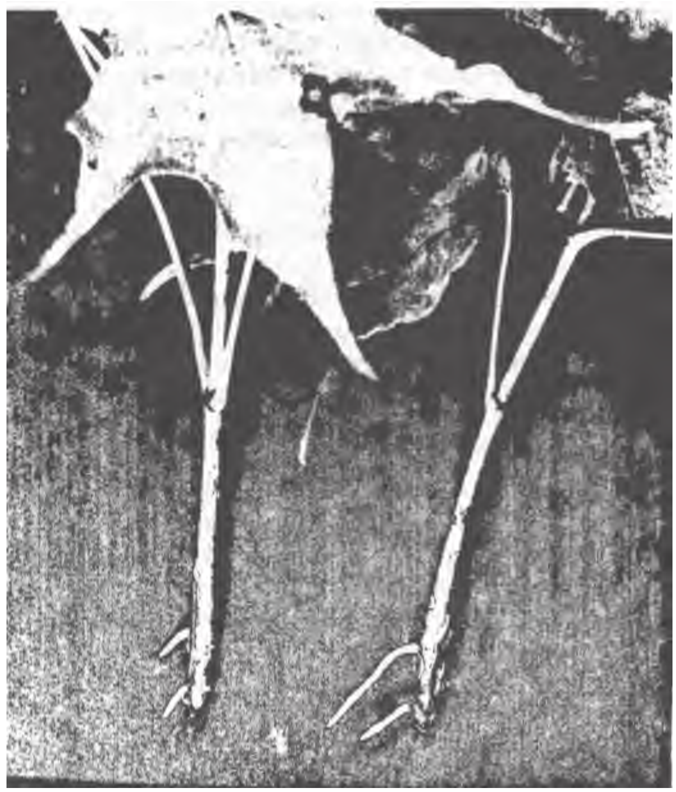

Figure 3. Newly-developed adventitious roots on sugar maple cuttings approximately 1 to 2 cm long.

This operational procedure, by keeping the time that cuttings are under mist to a minimum, appears to have a positive effect on those factors that contribute to the cuttings' ability to overwinter successfully. Cuttings treated in this manner appear to be in much better condition physiologically. Because of their apparent improved condition, a certain number of cuttings will flush and grow shortly after rooting without forcing budbreak.

Cuttings that do not flush are forced by applying gibberellic acid (GA) (75% K salt) to the buds (Yawney et al. 1978). In experiments to force budbreak, gibberellic acid, used as a foliage spray, was applied with an atomizer to some rooted cuttings daily and to other rooted cuttings every 4 days over a 16-day period. Concentrations tested were 0, 100, 1,000 and 7,500 ppm (Fig. 4). The 7,500-ppm concentration applied daily was the best treatment, and over 70 percent of the cuttings flushed. Spray applications of GA were compared with application of GA with an eyedropper to buds. There was no significant difference between these two methods of application.

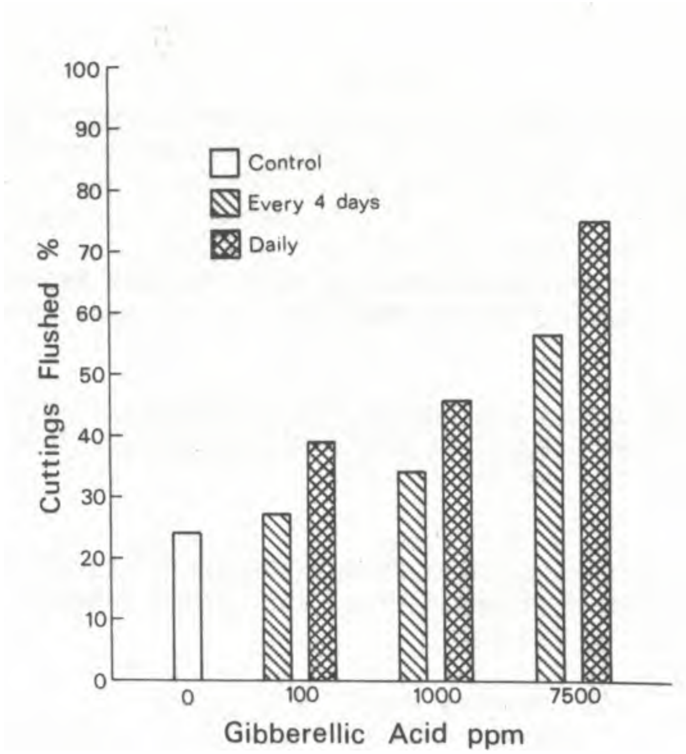

Figure 4. The effect of several concentrations of gibberellic acid applied daily and every 4 days in forcing bud break in rooted cuttings of sugar maple.

The cuttings were maintained in a growing condition until mid or late December. At that time, with shorter days and lower temperatures, they are hardened off over a 3- to 4-week period in preparation for overwintering. The overwintering period is 6 to 8 weeks at 2°C and is sufficient to satisfy the dormancy requirements of the rooted cuttings. We used a walk-in cooler to overwinter the cuttings, but cuttings may be placed outdoors if they are completely and thoroughly hardened off. After the overwintering period, the cuttings were brought into the greenhouse to resume growth.

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FOOTNOTES

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