MODIFIED GROWTH CHAMBER ENHANCES VEGETATIVE PROPAGATION OF SELECTED SWEETGUM AND YELLOW-POPLAR

Paul P. Kormanik and Claud L. Brown

Abstract. --A growth chamber was modified with an intermittent spray mist for vegetative propagation of sweetgum and yellow-poplar with both etiolated and nonetiolated current-year shoots. Most of the etiolated cuttings of both species rotted after several weeks regardless of treatment, and the use of such cuttings is questionable. The rooting of nonetiolated cuttings was better than anticipated: over 90 percent success with yellow-poplar and better than 50 percent with sweetgum. Clonal variation in treatment response was apparent and warrants reevaluation of the possibilitiesfor propagation of difficult-to-root species for inclusion in seed orchards.

Additional keywords: Propagation, growth chamber, *Liquidambar styraciflua L., Liriodendron tulipifera* L.

Sweetgum *(Liquidambar styraciflua* L.) and yellow-poplar *(Liriodendron tulipifera* L.) represent opposite extremes in response to propagation of cuttings from selected mature trees. Sweetgum is difficult to root even with physiologically rejuvenated cuttings taken from the main bole, although it can be propagated with segments of lateral roots (Brown and McAlpine, 1964; Farmer, 1966). The use of root cuttings is the only proven method of propagating this species, but the technique is laborious and is dependent upon the presence of preformed buds on the roots for reasonable success.

Succulent stem cuttings of sweetgum have been maintained in outdoor mist beds for periods of 4 months without rooting or undergoing appreciable decline and decay. In rare instances when roots are initiated, they are few in number, very fine in texture and opaque in color, and the cuttings seldom survive transplanting.

Stump sprouts or succulent cuttings from forced epicormic branches of yellow-poplar can be propagated readily, but considerable tree-to-tree variation is often encountered. It is not uncommon for cuttings from one clonal line to strike root 75 percent of the time, while those from another may root only 5 percent of the time. Tree-to-tree variability in vegetative propagation is well-known, and horticulturists have bypassed this problem by concentrating on individual lines that propagate readily (Hartmann and Hester, 1968; Adriance and Brison, 1955). Foresters frequently lack this option, and rooting variability frequently limits the propagation of selected clones needed for seed orchards or for specific experimental studies.

Although tree-to-tree variability in root strike with yellow-poplar causes many difficulties, a more serious problem is the variability in root strike encountered in successive trials with selected clones during the same year or

---

Research Forester, Southeastern Forest Experiment Station, USDA Forest Service, Athens, Ga., and Professor, School of Forest Resources, University of Georgia, Athens.

between years. Usually, an easily rooted clonal line, i.e., one that has a demonstrated rooting percentage of 75 or over, will root throughout the summer even under adverse conditions, although the rooting percentage may drop to 10 or 20 on some trials. Likewise, under similar conditions a clonal line with an average rooting percentage of 25 to 30 may not strike root at all. This type of variability is repeatedly encountered even with vigorous, thrifty stump sprouts purposely produced for vegetative propagation. When succulent plant material is obtained for the first time from selected mature trees (McAlpine and Kormanik, 1972), the quality may be less than desirable or below optimum, and rooting success may be quite low. In fact, under these conditions, many selected trees are discarded which may be badly needed for seed orchards or specific studies.

Over the past 5 years, many new rooting techniques have been tried at the Forestry Sciences Laboratory, USDA Forest Service, and the School of Forest Resources, University of Georgia, Athens, Georgia, in an attempt to reduce tree-to-tree and trial-to-trial variability in root strike. Until recently, almost all of our propagation work was done in raised outdoor mist beds of conventional design, with little progress in reducing variability. Whenever daily weather conditions are favorable (i.e., 24 to 35°C.), good rooting results are obtained, but when night temperature drops below 18°C. and daily temperatures are lower than normal, treatment differences are erased and rooting variability becomes a serious problem. Under the conditions of propagation being investigated at this location, environmental factors (especially temperature fluctuation) seem to be affecting root strike and to be an important factor in rooting variability.

A large growth chamber became available during the past summer (1972) at the School of Forest Resources, and it was adapted as a propagation mist chamber. By keeping temperature fluctuation at a minimum, we believed much of the rooting variability could be eliminated. Three different pilot studies were run with the chamber before a long-term study was installed. The results of these studies were quite encouraging and are reported here.

GENERAL METHODS

All propagation in the modified growth chamber was conducted under an 18-hour photoperiod with 26°C. day temperatures and 23°C. night temperatures. The outdoor mist schedule of 5 seconds per minute during the light period was started in the chamber. When it proved to be too high, it was adjusted downward until a time schedule of 5 seconds every 3 minutes proved satisfactory. The rooting medium was the standard mixture of 1:1 silcia sand and peat moss used at this location for many years. The medium was steam-sterilized for 24 hours before being placed in the chamber.

SPECIFIC METHODS AND RESULTS

Study No. 1: Comparison of outdoor and chamber mist beds for rooting response of two yellow-poplar clones of proven rootability from etiolated and nonetiolated cuttings.

Twenty-four, 4-year-old stems of clone 2 (good rootability) and the same number of clone 3 (fair to poor rootability) were cut 3 feet high during early March in a clonal outplant plantation. Twelve stems from each clone had metal frames built over them and covered with 50-mil black vinyl plastic to exclude light. The twelve adjacent stumps of each clone were left undisturbed to permit sprouts to develop normally. By mid-July, sprouts had developed sufficiently well to provide adequate numbers of suitable cuttings, and they were harvested and placed in the appropriate mist beds. The cuttings were removed at the end of August.

Because earlier tests with these two specific clones gave the best results with 0.8 percent indol butyric acid (IBA) in talcum, this concentration was used in the present study. The purpose of this test was to compare the results of the standard treatment with those obtained in a growth chamber with normal and etiolated cuttings.

Discussion of Results

The stumps covered with black plastic produced an abundant supply of etiolated cuttings, which varied from 12 to 36 inches in length. These were, of course, much longer than those cuttings from the uncovered stumps; the latter ranged from 6 to 18 inches in length.

Space limitations in the growth chamber permitted the use of only 4 trays for this study. The trays were about 2 feet square and 6 inches deep. In each tray, we planted either 30 of the etiolated or normal cuttings, In our outdoor beds, we planted three rows of 12 cuttings each, or 36 cuttings per treatment per clone. The excessive rise in temperature under the black plastic in the open field precluded the replication of the study later in the summer. The study was closed on August 22, 1972. The rooting percentages from this study are summarized in table 1.

Table 1.--Rooting percentages for etiolated and normal stump sprouts from two clonal lines of yellow-poplar

Clone number	Outdoor bed		Growth chamber	
	Normal	Etiolated	Normal	Etiolated
	Percent			
2	72	5	90	3
3	39	0	93	3

Within 10 days after being put into the mist beds, most of the etiolated cuttings underwent rapid senescence and died. Some of the cuttings did strike root, but with their small, nongreen leaves, they were unable to sustain growth and eventually succumbed, All of the surplus etiolated cuttings were placed in the outdoor beds (perhaps a hundred more than used in the experimental study itself), and all of these became necrotic within 2 weeks. Obviously, the use of etiolated cuttings of yellow-poplar under similar propagation procedures should be discouraged.

The rapid root development of the yellow-poplar clones in the controlled growth chamber was extremely encouraging, as shown by the rooting percentage in table 1. After 20 days, the rooted cuttings in the outdoor mist beds had two to four roots about 1 to 1-1/2 inches long, whereas the chamber cuttings possessed three to five times this number of roots, which were growing out the bottom of the trays when the study was closed on August 22 (fig. 1).

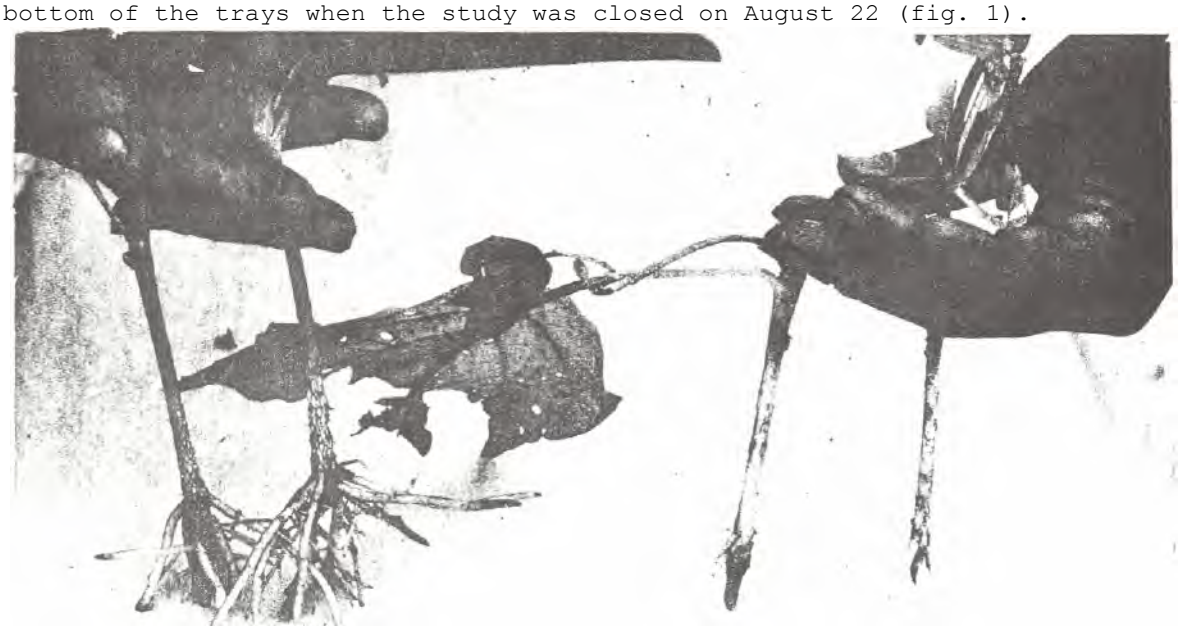

Figure I.—Root development on yellow-poplar propagules in modified growth chamber (left) was four to five times greater than that on propagules from outdoor mist beds (right) after 20 days.

With clone 2, rooting percentage in outdoor beds often ran as high as 70 to 75 whereas clone 3 in our previous tests seldom ran as high as 40 percent, with 25 to 30 percent being the norm. If the few unrooted cuttings had remained longer in the chamber, it may have been possible to obtain 100 percent root strike for both clonal lines.

Study Number 2: Vegetative propagation of difficult-to-root clones with different combinations of growth hormones

By the end of July, the superiority of rooting yellow-poplar inside the chamber wits evident, and a second study with different growth hormones on four of our newly established yellow-poplar clones was initiated. These clones had been initially selected and established in 1970 from older parents, and some difficulty was being encountered in getting them to root in sufficient numbers for our purposes in the outdoor misting beds. The clones used in this study were YP 70-6, YP 70-12, YP 70-14, and YP 70-31; these were placed in the chamber on August 7. The six treatments used and the methods of application were as follows:

1. Treatment 1--Commercial 0.8 percent IBA in talcum--basal dip application

2. Treatment 2-500 p.p.m. IBA paste in lanolin--basal application

3. Treatment 3--500 p.p.m. each of 2-4D and indoleacetic acid (IAA) in lanolin--spread around the stem at the first exposed node above the rooting medium

4. Treatment 4--Same as treatment 2 except that gibberellic acid (GA3) at 10 p.p.m. and kinetin (K) at 100 p.p.m. in lanolin paste were smeared around the stem at the second internode below terminal bud

5. Treatment 5--Same as treatment 3 except that GA_3 at 10 p.p.m. and kinetin at 100 p.p.m. in lanolin paste were smeared around the stem at the second internode below terminal bud

6. Control --Without hormones.

Discussion of Results

An abundant supply of cuttings for all clones was aot available, and all clones could not be represented in each treatment. However, the studies were preliminary and the emphasis here was on the trial itself. The clones that were selected were not necessarily the most difficult ones to propagate; however, they are not classified as easy to root. *We* were fortunate enough to have these clones under intensive care in outdoor transplant beds.

The two most important observations from this study were: (1) the tremendous variation among clones in response to treatment, and (2) the enhanced rootability of the controls YP 70-12 and 14 under controlled conditions (table 2). These two clones had previously rooted with such difficulty for *2 y*ears in outdoor beds that two cells in the study were left open because of the scarcity of cuttings.

Table 2.--Rooting percentages in four yellow-poplar clones at the end of 21 days in the growth chamber

Number	Control	0.8% IBA	IBA paste	2-4D IAA aste	IBA paste GA_3 + K	IAA + 2-4D paste GA_3 + K
			Percent			
YP 70-6	20	60	0	30	0	60
YP 70-12	80	80	0	0	a/	a/
YP 70-14	40	40	10	10	a/	a/
YP 70-31	10	30	0	60	0	a/

a/ Cuttings available of specific clones were insufficient to be included in experiment.

With a single nonreplicated trial, nothing can be said about the response to specific treatments, but the fact that the controls in all clones rooted to varying degrees is evidence that temperature fluctuation in outdoor beds may be one of the main causes of rooting variability. It also appears that 0.8 percent IBA in talcum still provides a reasonable chemical aid to propagation of this species. The 500 p.p.m. IBA applied in lanolin paste over the entire buried portion of the cutting was apparently toxic and resulted in excessive rotting.

With all clones, the proliferation of lenticels and phloem was greatly stimulated with the IAA-2-4D treatment, and additional studies with different concentrations of these chemicals are planned. Although attempts to find a single best treatment for each clone may not be feasible or warranted at this time (table 2), the development of a method of propagating difficult material is encouraging.

Study No. 3: Comparing rootability of etiolated and nonetiolated epicormic branches from sweetgum in a modified growth chamber.

In February 1972, 12 sweetgum trees averaging 10 to 12 inches d.b.h. were partially girdled to stimulate the development of epicormic branches, as previously reported for other species as a means of obtaining physiologically rejuvenated cuttings (Kormanik and Porterfield, 1966; McAlpine and Kormanik, 1972). Circular styrofoam collars were fitted around seven of the trees, and black plastic polyethylene was placed around the boles to produce etiolated epicormic branches. The other five trees were left uncovered to permit normal epicormic branches to develop.

By July 11, five of the covered trees and two of the uncovered trees had developed enough epicormic branches so that a minimum of 50 cuttings could be collected for use. In order to assess any possible clonal variation in root-ability, the cuttings from each tree were kept separate by treatment. We were unable to include a separate control because insufficient cuttings were available from some of the clones. To overcome this deficiency, a total of 48 normal cuttings were randomized and used as controls. A like number of etiolated shoots from clones 72-1, 2, and 3 were randomized and used as controls.

The treatments used were the same as in study 2 with yellow-poplar.

Discussion of Results

This study was the last and most informative one of our trials during 1972. The percentages in table 3 depict the conditions of the cuttings as of September 11. At that time, a noticeable buildup of hydrogen sulfide was detected when the specimens were examined on the biweekly schedule. Except for noting this buildup, no attempt was made at that time to provide more aerobic conditions for the media. Within 10 days, all newly formed roots had died and the cuttings were rapidly deteriorating. The study was abandoned, and the growth chamber was thoroughly cleaned before new studies were initiated.

Table 3--Rooting percentages for etiolated and nonetiolated epicormic branches from five parent sweetgum trees at the end of 60 days

Clonal Number-a/	Treatments				
	0.8% IBA	IBA paste	IAA + 2-4D paste	IAA + 2-4D GA3 + K paste	IBA GA3 + K paste
	Percent				
SG 72-2E	50	40	40	10	70
SG 72-3E	15	0	0	0	0
SG 72-4E	30	10	0	0	20
SG 72-5N	20	10	20	20	0
SG 72-6N	60	30	40	30	60

a/ after number identifies etiolated cuttings; N identifies nonetiolated ones.

The problem arose because the previously sterilized trays of media were stored in the chamber for several weeks before use. In the high temperature and humidity regime, aeration was impeded and anaerobic respiration gradually built up over 3 to 4 months. Because of this problem, we eliminated peat moss from the media, and after 6 months we have encountered no difficulty from using a medium-sized sterilized sand.

The variation in root initiation and root growth among the different clonal lines in response to specific treatments was striking, but overall propagation was so successful that these results overshadowed the variability in this trial (table 3). In our opinion, any technique that results in 70 percent root strike within 60 days from 30-year-old sweetgum should be given a second look.

during the summer, a great many surplus cuttings from all five etiolated sources were available, and these were placed in outdoor mist beds. All of the cuttings died in about 3 to 4 weeks except those from the SG 72-2E clone; however, the cuttings from this tree did riot root in the outdoor mist beds,

Although the variation to treatment from the nonetiolated cuttings was extremely wide, those that died did not succumb nearly as rapidly as the etiolated ones. The range in response is, however, thought-provoking. In a given treatment of similar and very uniform material, some cuttings rooted, the bases of others turned light in color (a change which usually indicates impending root strike), while other cuttings remained the same as when they were collected 2 months previously.

CONCLUSIONS

The exploratory studies reported here indicate that better approaches are possible for prescribing methods of vegetative propagation of difficult-to-root hardwood species. While initially we may be forced to obtain juvenile material to propagate selected trees, a better understanding of the species response to rooting hormones under specific conditions may alter this requirement. Although the cost of propagating trees in growth chambers for general outplanting would be prohibitive, the same costs may be justified for seed orchards. Furthermore, one may improvise ways to control temperature, light, and humidity, within desirable limits for large-scale propagation without costs becoming prohibitive.

LITERATURE CITED

Adriance, Guy W., and Brison, Fred R. 1955. Propagation of horticultural plants. 2nd Ed. 298 p. N. Y.: McGraw-Hill Book Co., Inc.

Brown, Claud L., and McAlpine, R. G. 1964. Propagation of sweetgum from root cuttings. Ga. Forest Res. Pap. 24, 5 p. Ga. Forest Res. Counc., Macon, Ga,

Farmer, R. E. 1966. Vegetative propagation of sweetgum by softwood cuttings. Eighth South. Conf. Forest Tree Improv. Proc. 1965: 123-124.

Hartmann, Hudson T., and Kester, Dale E. 1968. Plant propagation - principles and practices. 2nd Ed. 702 p. N. J.: Prentice-Hall, Inc.

Kormanik, Paul P., and Porterfield, Edward J. 1966. Rooting yellow-poplar cuttings. Forest Farmer 26(2): 24, 41-42.

McAlpine, Robert G., and Kormanik, Paul P. 1972. Rooting yellow-poplar cuttings from girdled trees. USDA Forest Serv. Res. Note SE-180, 4 p. Southeast. Forest Exp. Stn., Asheville, N. C.