VEGETATIVE PROPAGATION OF SOME SELECTED HARDWOOD FOREST SPECIES IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

Physiologically juvenile softwood cuttings have been successfully used to vegetatively propagate individual trees from ten genera of commercially important hardwoods from the southeastern United States. They arise from epicormic buds, and the lower on the bole that the suppressed buds are released, the greater is the chance of favorable rooting response. Stump or root collar sprouts are preferable but forced epicormic branches from the lower 4 to 6 m of the bole also give good results. The diurnal temperature fluctuation and the difficulty of maintaining rooting media temperatures between 20°C and 28°C are two problems encountered in propagation of rejuvenated material from mature forest trees. With our present biological information and rooting technology the vegetative propagation of softwood cuttings from the crown of mature forest trees remains extremely difficult for most species.

INTRODUCTION

There has been an increasing awareness over the last two decades of the need to develop clonal lines of selected hardwoods for seed orchards, research purposes, or even for general outplanting. Many foresters cognizant of developments in rooting woody ornamental species found similar techniques to be generally unsuitable for forest trees, and resorted to grafting to preserve specific genotypes. Foresters were at a disadvantage in that they were forced by their selection procedures to attempt rooting of cuttings from older trees (often 50 to 100 years old), whereas horticulturists are able to propagate many woody perennials in the juvenile stage of development.

During the late 1950s and early 1960s, many attempts were made at the Forestry Sciences Laboratory in Athens to propagate specifically selected trees but most trials were unsuccessful. Finally, one group of yellow-poplar (*Liriodendron tulipifera* L.) stump sprouts from a mature tree was rooted and the important difference between "mature softwood cuttings" and "physiologically juvenile softwood cuttings" was forever impressed upon us (McAlpine 1965). Since this initial success with yellow-poplar, 10 forest tree genera have been successfully propagated using juvenile cuttings obtained from mature trees.

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Our interest in vegetative propagation stems from the need to establish specific clonal lines for investigations in mineral nutrition, water utilization, and the morphological basis of site adaptability. Thus, like most horticulturists, our attempts at propagation have been as practitioners of the art using first one species then another as the need arose. The one integrating feature, however, has been the use of "physiologically juvenile material" and ascertaining the most efficient way of obtaining it from mature forest trees.

The methods used for routine propagation are simple and do not require sophisticated equipment or chemicals. They are similar to widely used horticultural techniques except that the need for semi-aseptic conditions as reported by others (Hartmann and Kester, 1968) has been found to be unnecessary and has been discontinued. Some of our studies have been directed towards morphogenetic aspects of root initiation in order to determine in more detail the reasons for our successes or failures.

PROPAGATION PROCEDURES

The following recommendations are based upon the use of raised outdoor mist beds using juvenile softwood cuttings from mature trees except where specifically stated otherwise. Based upon our experience, better results can be expected if the mist beds are constructed in greenhouses or if the juvenile material is obtained from younger parent trees.

Bed Considerations

Because of the hot and humid summers prevalent in the Piedmont region of the southeastern United States, raised outdoor mist beds (approximately 1 m above ground) normally used in commercial horticultural enterprises with easy-to-root vegetative material have been adequate but less than optimum. The beds are filled to a depth of 15 cm. with a 1 : 1 mixture of peat moss and washed medium sand. The misting schedule of 5 seconds per minute is controlled by a series of timers and solenoid valves which operate from sunrise to sunset. The beds are put into operation in the early part of May when new growth is available and can be used until early September. Cuttings of most species removed late in September have too little time to become established in the transplant beds for over-wintering, and mortality usually increases significantly in such cuttings.

The greatest problem with this system for propagating difficult-to-root forest trees is diurnal temperature fluctuation. For most species, rooting media temperatures from 20°C to 28°C are most favourable, but in outdoor mist beds this regime is obtained for only four to six hours during each day. Characteristically, in early summer or fall the rooting media temperature may drop to between 6°C and 12°C at night, and during cool, cloudy days or periods of inclement weather may not reach 20°C for several consecutive days. This temperature fluctuation is characteristic of all outdoor misting systems in temperate zones, and to a large degree it may be responsible for the extreme variation in rootability trials that are part of many vegetative propagation programmes (Hartmann and Kester, 1968; Doran, 1957).

Cutting Considerations

If a species can be vegetatively propagated the use of stump sprouts commonly offers the greatest possibility of success. The two major drawbacks of this procedure for obtaining juvenile cuttings are (1) that the selected trees must be destroyed and (2) the

fact that it is not unusual to find stumps from mature trees which fail to sprout. To circumvent these problems, a method of partially girdling selected trees to stimulate the development of epicormic branches from suppressed buds was found to be a good alternative to felling selected trees (Kormanik and Porterfield, 1966). The forced epicormic branches that develop along the lower 4 to 6 m of the tree's bole seem to possess the same desirable juvenile rooting characteristics as do stump sprouts. On older trees with thick bark it may take two years for the epicormic branches to develop after the partial girdles are applied and it is necessary to renew the girdles periodically during the season. If a girdle is bridged by even a single callus, the suppressed buds may be reinhibited by polarly transported growth substances and no epicormic branches will develop under that specific girdle.

Although partial girdles may be unsightly, they usually callus over within two years; and no mortality has occurred among the large numbers of trees that we have treated in this manner. Perhaps the greatest drawback of this procedure is that surrounding trees must be cut so that sunlight strikes the bole to hasten epicormic branch eruption.

Treatment of Cuttings

Practically all the major growth substances which have been shown to be useful in rooting trees elsewhere have been tried at one time or another at our laboratory. Twelve years of work has convinced us that there is no chemical panacea for propagation. A complete and thorough literature review is presented elsewhere in these proceedings (Farmer, 1974) and need not be duplicated here. However, for all our routine propagation work we use indole-3-butyric acid (IBA) in talcum in concentrations of 0.3 to 0.8%. We tend to use the higher concentrations most frequently because it has given us the most consistent (though not necessarily the best) results. The greatest limitation of propagation in outdoor mist beds is that it is difficult to appraise accurately the rootability of a given tree or a chemical treatment because of temperature fluctuations. It is possible that we have had relatively consistent results with IBA because we repeatedly obtain our cuttings during the same period of the year. The internal physiological balance of the plant material during this period may favour response to this chemical. Others also report that IBA is probably the best overall material for general use since it is non-toxic over a wide range of concentrations and seems to be helpful with a great number of species (Hartmann and Kester, 1968).

Of the three common methods of applying root promoting chemicals, viz., powder dips, dilute solution soaking method, and concentrated solution dip method, powder dips have been most satisfactory for us. With difficult-to-root species, treatment of the cutting with fungicides, *i.e.,* Ferbam, Captan or Folpet (Doran, 1957; Duncan and Matthews, 1969), may be quite beneficial following the chemical dip, although we seldom use it. Because of inherent differences in growth response it is difficult to make recomendations for the best time to collect cuttings of forest trees. However, for most of our work, cuttings reach propagation size by June and July and are collected at that time. With species like yellow-poplar that exhibit long periods of growth, sprout material can be cut back and re-harvested from mid-May until late August with considerable success in rooting. With species like the oaks that normally flush only once during the growing season, cuttings collected in June or early July seem to root best.

With all species it is best to leave two or three full-sized leaves on cuttings and allow enough stem beneath to insert the cutting 8 to 10 cm into the media, leaving the leaves 2 to 5 cm above the media. Leaves in contact with the rooting media usually rot.

Transplanting Rooted Cuttings

Cuttings usually root after 21 to 60 days and can be transplanted when the roots are about 1 to 3-cm long. The cuttings are kept covered with 60% shade for at least two weeks to permit sufficient root development and to prevent desiccation. The transplanted cuttings are lightly fertilized at weekly intervals and may be ready for outplanting to the field the following spring. If they are held in the transplant bed for an additional year, they may also be used as a source of additional cuttings the second year without interfering with root establishment.

RESULTS OBTAINED WITH INDIVIDUAL SPECIES

The results obtained for individual tree species can not be interpreted to mean that all individuals of that species are easy or difficult to root. Some species can generally be rooted easily while others prove to be consistently difficult to propagate. Our work has convinced us, however, that it is possible to propagate vegetatively all commercially important hardwood species. Practitioners of the art need only patience and time.

Liriodendron tulipifera L.

Most stump sprouts or forced epicormic branches from the lower 6 m of the bole of this species can be propagated in outdoor mist beds. The essential criteria for obtaining uniform rooting responses during June and July with this species are: 0.8% IBA powder dip, and rooting bed media heated from 20°C to 24°C. Juvenile material seems essential and the lower on the bole that the sprouts are obtained the greater is the chance of successful propagation.

For 10 years this species has been propagated with sufficient regularity that the question is not "can it be propagated?", but rather "how best to propagate it?".

Liquidambar styraciflua L.

This species has been difficult to propagate from both stump sprouts and forced epicormic branches from mature trees. The cuttings remain in the mist beds from 12 to 16 weeks before a small percentage may initiate exceedingly small, hair-like roots. These fine opaque roots die off rapidly upon transplanting, a condition common to other species. Recently we have been conducting propagation studies with this species in a Percival growth chamber equipped with a intermittent mist system. An 18-hour photoperiod with temperature regimes of 23°C dark and 26°C light appears to enhance rootability of this species greatly. The study is still in progress, but we have already obtained 80% rooting with some trials combining various chemical treatments. Our present results indicate the importance of optimum temperature of the rooting beds.

It is possible, however, to propagate sweetgum by root cuttings (McAlpine and Brown, 1964; Farmer, 1965). Lateral roots 1 to 3 cm in diameter and 15 to 20-cm long are placed in planting beds with overhead shade and kept well watered. If preformed root buds are present, propagation can be accomplished in about six weeks. If such buds are lacking, it may take up to 4 to 6 months before adventitious buds differentiate and propagation is accomplished.

Platanus occidentalis L.

This species roots readily from hardwood cuttings taken from stump sprouts up to 4 or 5 years of age. The cutting can be planted either vertically or horizontally in lengths from about 20 cm to 4 or 5 m (McAlpine *et al.,* 1972). No special chemical aids are needed. Current year's softwood cuttings root well in mist beds with little need for chemical treatment although 0.3% IBA powder dips shorten the rooting period somewhat. These softwood cuttings tend to die back because the axillary buds are inhibited and will not initiate growth in most cases. If the cuttings survive, they make respectable growth the following year. We feel it is better to let cutting material harden off the first year and to propagate them the second year.

We think this species (like many *Populus spp.)* needs no further research into methods of vegetative propagation; it is now a matter of which technique bests suits the specific need.

Acer rubrum L.

This species roots readily from either stump sprouts or forced epicormic branches, with rooting percentages varying from about 75 to 99% during the months of June and July. Little clonal variation has been encountered in rootability and the lower (0.3%) or the higher (0.8%) IBA powder dips have both been equally effective. Even cuttings accidentally left unattended in a storage container filled with water rooted after several weeks. Transplanted propagules are easily established and grow well. There seems to be little technical difficulty in the vegetative propagation of red maple.

Acer leucoderme Small

These are small, rare trees perhaps of greater horticultural than any other value. In our limited experience with this species we have rooted only forced epicormic branches from five trees estimated to be about 20 to 30 years of age. Only the lower 0.3% IBA powder dip was used and it gave favourable results of 30 to 40% rooting. The cuttings were collected during the middle of June.

Acer saccharum Marsh.

Sugar maple has been successfully rooted for a number of years in the northeastern United States, but very little or no progress has been possible with survival of the cutting after rooting (Snow, 1941). We were able to propagate vigorous one- and two-year-old stump sprouts collected from a commercial clear-cutting on the Allegheny National Forest near Warren, Pennsylvania, and sent to Athens, Georgia, for trial propagation. Both the one- and two-year-old cuttings collected in July had an overall root strike of about 40% with 0.8% IBA powder dip. Of the 16 that were transplanted, 12 over-wintered with no apparent difficulty. Two of these died during the following summer. The 10 surviving propagules became well established by the end of the second growing season.

The over-wintering losses may be overcome by rooting the material in a warmer climate and transporting the propagules to their native habitat after at least one or two additional growing seasons in the transplant beds.

Fraxinus pennsylvanica Marsh.

This species roots readily from stump sprouts and forced epicormic branches with the 0.8% IBA powder dip. Root strikes of from 20 to 75% are normal and complete failure rarely occurs. We have suspected that the sex of the trees plays a major role in

this variation, but this aspect has not been specifically investigated. Epicormic branches have been harvested from individual trees from early June until late July without noticeable reductions in rooting percentages.

Our experience indicates that just two or three partial girdles on the lower 2 m of the bole may produce enough sprouts to practically guarantee its establishment without excessive damage to the selected tree.

Juglans nigra L.

This species has been very difficult to propagate from cuttings obtained from mature trees. It is possible to obtain callus on cuttings collected in early June, but its development takes 4 weeks, and by that time the compound leaves have abscised and roots fail to develop. Furthermore, this species is quite susceptible to rot and the cuttings often develop serious decay problems within 10 to 15 days after being placed in the mist beds.

Nyssa aquatica L.

Four individuals of this species were propagated from forced epicormic branches using both 0.3 and 0.8% IBA powder dip. Too few cuttings were available to ascertain any difference from treatment but about 15% of the cuttings rooted. The cuttings were put in the mist beds towards the latter part of June.

Quercus spp.

This genus has many species and much work remains to be done towards its propagation. The wide range in species-site requirements and growth patterns makes one suspect that many species will have specific propagation problems. With the oaks, some temperature control of the rooting media will probably be required for obtaining uniformity in rooting, and the timing of cutting collections may become quite critical.

We have propagated the following oak species at our laboratory using 0.3 or 0.8% IBA powder dips with forced epicormic branches collected in June or July: *Q. alba* L., *Q. nigra* L., *Q. falcata* var. *pagodaefolia* Ell. and *Q. palustris* Muenchh. Some tests included only five trees; but results indicate that, if the need arises, these species can be propagated in sufficient numbers to satisfy our research needs. Our greatest difficulty has been year-to-year variability in root strike.

Cornus florida L.

On several different occasions this species was rooted from stump sprouts, forced epicormic branches, and even the current year's branch growth with either the 0.3 or 0.8% IBA powder dip. The age of the parent trees was not determined because of the species minor importance to our programme.

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