Vegetative Propagation Methods for Hardwoods

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Man has been propagating plants by vegetative means for many centuries. Grafting, for instance, was a well-known art among the ancient Greeks and Romans, and the Chinese have been successfully air-layering plants for well over 2000 years. More recently, horticulturists and. pomologists have been propagating fruit, nut, and shade trees on a production scale. Some of these species are of primary interest to foresters.

Beginning about 30 years ago, foresters began selecting, breeding, and propagating trees that evidenced superior traits in an effort to increase volume and quality production. These first efforts were confined largely to conifers. Only recently have hardwoods been given serious consideration. Today, hundreds of acres of seed orchards attest to the success of the attempts to upgrade quality of conifers. Many organizations are now beginning

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tree improvement programs aimed exclusively at the selection and breeding of hardwoods.

Methods of vegetative propagation fall into three general categories: grafting, layering, and rooting of cuttings. The use of any, or all, of these may well depend upon the objectives of propagation, the particular species involved, and the age of the trees to be propagated. The objective may be to create genetically identical lines or clones for use in environmental studies where control of genetic variation is desirable, or to preserve a particular clone, or to bring trees into a central breeding area for ease and convenience of working. It may be to bring together a number of superior clones in order that natural pollination can take place among these individuals. Sometimes overlooked in tree improvement programs is the use of vegetative propagation as a simple means of providing planting stock for artificial regeneration.

Hardwoods vary in their ability to root, graft, or layer. This variation exists among trees of the same species as well as among the various species. For instance, Populus species, in general, root very easily from stem cuttings, but aspen is rooted with difficulty except from root cuttings or suckers. Oaks have been considered difficult to root or graft, yet one or two species have rooted fairly well from young stem cuttings.

The problem of aging is an ever-present factor in asexual reproduction. Sax (1902), in his review of some aspects of aging, states that probably one of the most universal and consistent characteristics of juvenile trees is the relative ease in rooting cuttings. Older trees root with difficulty, if at all. Many studies have shown that with most species of forest trees rooting drops off sharply at ages much exceeding 2 to 5 years. The success of grafting, on the other hand, is more closely associated with vigor of the ortet than with its age. It is quite possible to graft relatively old trees with some facility. This is important, for a tree must attain some degree of maturity before it exhibits those characteristics which are important in a selection program. One other important trait associated, with grafting is the shortening of the period necessary for flowering and fruiting. Horticulturists have recognized this characteristic for some time, and they often resort to grafting scions on dwarfing root stocks not only to decrease the age required for fruiting but to keep the trees small and workable.

Tree improvement work now underway at a number of locations in the south includes several vegetative propagation trials. The Tennessee Valley Authority, with a long history of propagating both forest and nut trees, is presently engaged in a seed orchard program which includes several species of the more important hardwoods. Their program depends mainly on grafting and budding, although they are doing some experimental rooting. Species receiving primary attention at this time are yellow-poplar, black walnut, black cherry, and white, chestnut, and northern red oaks.

GRAFTING

Several grafting and budding techniques are used by the T.V.A. at the Clinton Nursery. Some species are best propagated. by using a particular technique, others may be grafted or budded in a number of ways and at different times of the year. Bench grafts are preferable, not because of better success, but because grafting can be done during the dormant season when the work load is relatively light. If a species lends itself well to this method, dormant scions are grafted to dormant rootstocks using whip, whip-tongue, or various other grafts and stored, bound, and waxed, in moist spaghum moss in a cool place for callusing. After about 30 days the grafts are outplanted.

Yellow-poplar may be field grafted or budded on lined-out stock but usually bench grafting is preferred. Field grafting is usually done in late winter or early spring, and budding is done in late summer. Grafts are made as low as possible on the stock using a modified cleft graft with complete waxing of the union and scion. Chip budding is used primarily for simplicity, although other budding methods work very well.

Churchwell (1965), at the Pinson Nursery, Tennessee Division of Forestry, grafted dormant yellow-poplar scions to both dormant and growing rootstocks. A side graft was used to join the scion to the rather large 3- and 4-year-old stock trees. The scion and union were covered with a polyethylene bag and shaded, by a kraft bag. Only 5 percent of the grafts on dormant rootstocks lived, whereas 85 percent of the grafts were successful on stocks which had begun to grow prior to grafting.

Churchwell pruned the stock trees rather heavily after it was apparent that grafts had taken. This stimulated the scions to grow so rapidly that many were damaged by high winds. His recommendations are: (1) Prune gradually in order to prevent excessive growth of the scion, and (2) Keep grafts as low as possible on the stock.

David Funk (1962), near Athens, Ohio, tried bud grafting young stock at different times of the year, in the open and in the lathe house, and with and without cutting back the tops. He found a general trend for "takes" to be rather low in June, to increase toward fall, and by September to be 100 percent successful. His recommendations are:

(1) Schedule budding between 3 and 6 weeks after height growth ends in the woods.
(2) If stock plants happen to have basal sprouts (either because of damage or deliberate cutting back), graft buds at the base of these new sprouts.
(3) Cut the tops off stock trees just above the bud. about 10 days after budding.

He found little difference between trees budded in the open and in the lathe house.

The University of Tennessee has 5 yellow-poplar seed orchards, the oldest of which is 5 years. According to Dr. Eyvind Thor, some of the clones began flowering within 3 years after grafting. Side grafts on lateral branches were used to establish these orchards. Dr. Thor says that he usually makes 2 grafts on each 2- or 3-year-old root-stock. All grafting is done outdoors and the union and scion covered with a liquid plastic wound dressing. Plastic and kraft bags used earlier were discarded as being unnecessary.

Budding by the T method in August and September has given fair results, but vigorous shoot growth presumably due to nursery fertility often leads to damage from early fall frosts.

Weyerhaeuser, in eastern North Carolina, has begun a clonal seed orchard program using dormant scion material grafted by the cleft or side method to potted wildings of yellow-poplar. All work is performed in a polyethylene-covered hot house where tempera-tures are kept above freezing. Mr. Peevy [1/] obtains wildings, approximately 2 years of age, and pots them in 14-inch fruit baskets. Scions are taken from selected trees and grafted the next day to stock which is just breaking dormancy. Grafts are outplanted in the seed orchard after danger of frost is over. Mr. Peevy tells me that he locates grafts for good diameter match of scion and stock rather than specifically high or low on the root stock.

The Southeastern Forest Experiment Station, at Bent Creek near Asheville, North Carolina, has begun an improvement program for mountain hardwoods. Yellow-poplar selections are being grafted or budded to potted nursery stock in the greenhouse. Dormant scions are shot from the crowns of trees selected for their apparent ability to sprout heavily or remain relatively free of epicormics. Grafting is done on forced rootstock and successful grafts will be outplanted in spring along with single parent progeny from the same parents.

Black cherry, like yellow-poplar, can be easily propagated by grafting or budding. Horticulturists have been propagating species of Prunus for years, and techniques are well established Hatmaker [3/] at Clinton Nursery, T.V.A., prefers to bench graft cherry during the winter slack period, but he has also field grafted it during early spring, handling it very much like yellow-poplar. Slunder [3/] at Bent Creek, is doing similar propagation work with some success.

Black Walnut is field grafted at the Clinton Nursery using a modified cleft graft on decapitated stock. This species does not lend itself well to bench grafting. One of the problems recognized by people who graft black walnut is lengthy bleeding of the decapitated stock once dormancy is broken. Hatmaker recommends waiting until bleeding stops before attempting to graft. Budding done in late July or August is not affected by bleeding if pruning is delayed until the following spring. It is preferable to delay pruning so buds remain dormant over winter to prevent injury from early frosts.

Weber (1961), speaking at the annual meeting of the Northern Nut Growers Association, gave 28 specific recommendations for the vegetative propagation of several nut trees in-eluding black walnut. Among these, he recommended grafting black walnut on black walnut

2/ Personal communication.

3/ Personal communication.

understock, not grafting on bleeding stock, use of understock less than 2 inches in diameter use of splice graft where stock and, scion are same diameter, use of modified cleft graft where scion is smaller than stock and stock is not over 1 inch in diameter, and the use of either the cleft graft or the bark graft when the stock is more than 1 inch in diameter.

Oaks as a group are hard to handle. Wright (1953), at the Second Southern Conference on Forest Tree Improvement, was prompted to say that oaks are nearly impossible to root and are difficult to graft. Today, some oaks are being grafted and budded. Hatmaker, of T.V.A. using a modified cleft graft, has field grafted white, chestnut, and northern red, oaks. White oak has been grafted on sawtooth oak with fair success. Northern red oak has been budded in the field using both chip and patch budding. Patch budding appears to be more likely to succeed, at this time. Bleeding is a problem in oaks as in walnut and grafting should be delayed in decapitated stocks until bleeding ceases.

Weyerhaeuser presently has about 8 acres of seed orchards in eastern North Carolina. About 800 ramets from 25 selections of sweetgum have been outplanted thus far. Of particular interest is the fact that Mr. Peevy was not able to graft sweetgum during the dormant season, but was successful in field grafting in late June and throughout the month of July. All were side grafts without pruning of the stock. Pruning was begun after the scion began to grow. Sweetgum proved to be a persistent sprouter and pruning became a continuous job throughout the first season. Takes for both sweetgum and yellow-poplar ranged from 65 to 70 percent at the Weyerhaeuser Orchard.

At Stoneville, Mississippi, the Southern Forest Experiment Station is conducting research in vegetative propagation of sweetgum and other hardwoods. Bottle grafting of scions having flower buds is being used as a technique in controlled pollination. More about this technique is given in Dr. Webb's article on improvement of sweetgum.

Red maple grafting at Weyerhaeuser has been disappointing. So far, all grafting has been done on 1-year-old wildings which have been dug and lined out in the orchard. Successful grafts, thus far, have numbered less than 10 percent. Mr. Peevy is planning to change from dormant season grafting to summer grafting in an attempt to increase the number of successful grafts.

Most, if not all, of the important hardwoods have been propagated vegetatively by one or more methods of grafting or budding. Included are the maples, oaks, ash, elms, persimmon holly, honey locust, cherry, dogwood, chestnut, walnut, hickory, pecan, yellow-poplar, sweetgum, and even poplar and willow, normally considered so easy to root that grafting is unnecessary.

There are some problems and inadequacies in the grafting method which limit its use or make it less desirable than other methods. For instance, own-rooted trees are not obtained by either grafting or budding. In propagation for disease resistance, in many cases, the clonal root system is desired. This is true also of remets propagated primarily for studies of environmental effects. The problem of incompatability of scion and rootstock is often evident only after 5 or 6 years of apparently good growth.

LAYERING

Layering involves the rooting of plant parts while they are still attached to the ortet Often this can be accomplished by simply bending down the main stem or branch, wounding by girdling, scraping or strangling, and covering the wounded part with soil or organic matter. After rooting, the terminal part is removed from the parent and outplanted. Foresters are generally working with trees much too large to bend over and they find it convenient to take the rooting media into the crown of the tree. This is commonly called air-layering. The part to be rooted is wounded in some manner, a rooting hormone is brushed on the wound surface or dusted on a handful of moist spaghnum moss which is then pressed around the wound, and the whole covered with plastic film. Often, aluminum foil is wrapped around the layer to help prevent build-up of heat, and some splinting arrangement is made to keep the wind from breaking the layer.

Bonner (1963) has done some of the most recent work in air-layering. He treated green ash, sweetgum, cherrybark oak, nuttall oak, and yellow-poplar during April, June, and August Yellow-poplars were 4 years old and the others ranged from 5 to 20 years of age. Air-layering succeeded in April and June on green ash, sweetgum, and cherrybark oak. Green ash also

rooted in August. Two out of 50 layers on nuttall oak rooted in late summer. Yellow-poplar did not root.

Air-layering is very limited, in its use. Layering in the crowns of large hardwoods, most with very brittle branches, is very hazardous. On younger trees or grafts, however, the method may provide a convenient way of producing own-rooted stock of species which are difficult to root by cuttage.

ROOTING OF CUTTINGS

Rooting or cuttage, as it is often called, is the simplest and least expensive method. of vegetative propagation. It is probably the only method. by which clones of forest trees may be mass produced economically. The technique involves planting a short stem or root section in a suitable medium, such as sand, vermiculite, perlite, or soil and waiting for a few weeks for roots to form.

The natural rooting ability depends primarily on species and age. As mentioned earlier, species such as Populus root fairly easily, whereas species such as the oaks root with difficulty. The age of the tree from which the cuttings are taken has a very definite effect on rooting. As a rule seedling or sprout material roots much easier than branch or stem material from trees more than 2 or 3 years old.

Rooting may also depend on factors which can be controlled. The part of the tree made into cuttings, for instance, may be very important, as is the time of year cuttings are taken. Of equal importance is the rooting media, rooting hormones used, the rooting environment, and techniques used in handling the cuttings.

Cottonwood and sycamore are species which root so easily that unrooted cuttings may be planted directly in the field. Rather large acreages in the Mississippi Delta are devoted to the propagation of cottonwood cuttings for planting, and each year several thousand acres in the South are planted to cottonwood. Sycamore cuttings have been planted experimentally, and, early growth compares favorably with that of medium grades of seedlings. Survival of cuttings, usually around 60 percent in field plantings, is less than seedlings which with reasonable care should exceed 90 percent.

Other species are not rooted as easily. The use of mist systems, however, allows rooting of greenwood cuttings during the growing season and has materially increased rooting in some cases. Yellow-poplar, previously considered very difficult to root, was rooted easily by Enright (1957) in a greenhouse mist bed. Cuttings from the lower crowns of trees 30 years old and older were treated by dipping in aqueous solutions of indolebutyric acid (IBA) at 3 concentrations and were planted in a sand media under intermittent mist. Cuttings taken during August and dipped in a 2 percent solution of IBA rooted best (78 percent). Enright does not mention survival or growth after transplanting.

We attempted for several years at Athens to determine the relation of age to rooting by taking cuttings from trees of 5 age classes and using a modification of Enright's method_ Our beds were constructed outdoors and the media used was fine sand mixed half-and-half with peat moss. Cuttings were collected in April, May, June, and July of 1959 from yellow-poplar trees ranging in age from 1 to over 60 years. The best rooting obtained was 36 percent for the 1- to 5-year class in April. In May, 13 percent of the cuttings, from the 5- to 20-year class, and 5 percent, from the 20- to 40-year class, rooted. One cutting taken in May from 40- to 60-year-old trees rooted, and. none rooted from trees older than 60 years.

In 1960 the rooting bed. was elevated. above ground. for better drainage; three kinds of media were used. Cuttings were collected in late May from the same age classes, and in most cases the same trees, as in 1959. These were treated as before by dipping in IBA and planted. in fine, medium, or coarse sand. Cuttings were examined periodically, and those that rooted were lifted and potted for use in another study. The type of media used had a very definite effect on rooting percent. In fine sand, 36 percent rooted; in coarse sand, 17 percent; and in medium textured sand, only 8.0 percent rooted. In this trial 19 cuttings from trees over 60 years of age rooted.

Tt became apparent from this study that age influences not only rooting ability but also the subsequent survival of transplanted cuttings. After one year, 19 transplants of the 1- to 5-year class were living and in good condition, whereas only one survived from

the 5- to 10-year class and only a single propagule from the 20-year-old trees was living but in poor condition. All others died.

More recently, using soft tissue cuttings from stump sprouts, we have been able to root from 60 to 100 percent of almost all clones tested, McAlpine (1964). The yellow-poplar ramets propagated from this lush juvenile material have survived. and have grown exceedingly well, although taken from stumps as old as 165 years and transplanted in mid-summer. The media used was composed of one-half fine sand and one-half well decomposed sawdust. All cuttings were dipped in a powder containing 0.8 percent indolebutyric acid and mist was applied intermittently during daylight hours. The ramets were planted during the winter following rooting in a clonal orchard where in the succeeding 2 years they have grown sufficiently large to be cut back and allowed to sprout. Cuttings obtained from these stumps will be used to multiply selected clones to furnish material for use in environmental studies.

We anticipate some reluctance in cutting selected yellow-poplar trees in order to obtain sprouts for rooting. To eliminate this problem, we suggest either partial girdling to stimulate sprouting, or the grafting of branch material, and then cutting back the scion to obtain sprouts that will root. We have used the latter method at Athens and have obtained 20 percent rooting. Once we have rooted cuttings the problem of future multiplications of clonal material is solved.

Sweetgum behaves very much like aspen. It sprouts and suckers prolifically but can be rooted only sparingly from cuttings. Usually, any species which suckers can be propagated. vegetatively from root cuttings (Adriance and Brison, 1955). At Athens we were successful in rooting only a few sprout cuttings, so we tried root cuttings. Roots from several 3-year-old and three 20-year-old trees were dug in mid-July, cut into 4-inch sections, and planted, in serial order in a medium of fine sand and peat moss (Brown and McAlpine, 1964). By October from 20 to 94 percent of the root sections had budded and produced new roots. Cuttings from younger trees budded earlier and shoots grew faster than cuttings from the 20-year-old trees. Kinetin applied as an aid to budding was ineffective.

Other tree species which may be propagated from root cuttings include mimosa, black locust (Swingle, 1937) honey locust (Stoutemeyer, et al, 1944), and elm (Doran, 1949; Schreiber, 1963).

Oaks still remain difficult to propagate. Thimann and Delisle (1939) rooted 82 percent of the cuttings taken from basal parts of 4-year-old northern red oaks after treatment with ind.oleacetic acid. Recently Farmer (1965) reported rooting of as high as 78 percent of cuttings taken from 1- to 4-month-old cherrybark oak and treated with indolebutyric acid. Our trials at Athens to root soft tissue sprout material from white oak stumps failed. The prospect of rooting cuttings taken from the crowns of mature trees is not promising at this time.

Red maple is a species which has received, considerable attention from propagators. Snow (1941), rooted stump sprouts of red maple in an outside rooting bed after treatment with indolebutyric acid. Best results were obtained by soaking cuttings for 6 hours in an aqueous solution of IBA at a concentration of 200 mg. per 1. Among the 24 clones tested, rooting varied from 17.5 to 97.5 percent, indicating the possibility of clonal differences in rooting ability. In later work, Snow (1942) found that the rooting ability of different clones of red maple was apparently correlated in some way with the sex of the tree. Average rooting for male trees was 52 percent and for female trees 33 percent. In a later study, Edgerton (1944) used the same clones and the same treatments used by Snow and found that the rooting of cuttings was more closely associated with seeding habits of red maples than with sex. He also found that cuttings from the lower portion of the crowns rooted on average of 49 percent, whereas cuttings taken from upper-crown positions rooted only 27 percent.

At Athens we have found that 1-year-old greenwood cuttings from stump sprouts will root at better than 90 percent within 2 or 3 weeks. All rooting is done in an outdoor mist bed in a media of sand and sawdust at a 1 to 1 ratio. The basal portion of each cutting is dipped in Hormodin No. 3 (0.8 percent indolebutyric acid in talc). The very small sprout tips and the large basal portions are discarded.

In summation it is well to repeat that the method of propagation which is chosen depends (1) upon the objectives of propagation, (2) the species we wish to propagate and

(3) the age of the trees to be propagated.

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