12. Stanley, J. and I. Baldwin. 1980. Standing grounds — A key to successful container growing. Amer. Nurs. 152(1):24-25,64

DWIGHT HUGHES: You mentioned that there might be a problem with containers larger than 2 gal. Would you address that issue?

ELTON SMITH: The system has worked well up to 3 gal containers. Larger than that you get into plants that require a lot of water and there is just not enough draw.

JIM CROSS: Have you tried perforated black poly on top of the sand.

ELTON SMITH: No, however, that system is also available from Evert Green.

PROPAGATING SHADE TREES BY CUTTINGS AND GRAFTS

WILLIAM FLEMER, III

Princeton Nurseries
Princeton, New Jersey 08540

Growing shade and ornamental trees from cuttings is no startling new development on the horticultural scene. For many centuries trees like willows and poplars have been grown from hardwood cuttings. With the development of mist propagation and rooting hormones it was discovered that many more genera could be successfully grown from softwood cuttings. Tree hybridization and the selection of superior clones of natural species has given much impetus to research in rooting tree cuttings and expanding the list of cultivars which can be propagated in this manner.

There are many advantages to cutting propagation over grafting, budding, and other methods of vegetative propagation. One very important factor is cost. In general it is much cheaper to make up and root a cutting than to buy or grow an understock, then pot it or plant it out in the open ground, and finally graft or bud it. After that there are the inevitable losses and the subsequent expenses of cutting out suckers and staking the shoots or scions. In general, a skilled propagator can make several cuttings in the same time that would be required to make a graft or clean, bud, and tie an understock tree in the field.

Rooting cuttings also avoids the problem of scion-understock incompatibility. This problem varies widely depending on the genus or even species of the plant to be grown. In grafting ginkgos and *Tilia cordata* clones on *T. cordata* understock for example, incompatibility is negligible but in budding or grafting clones of *Acer rubrum*, *A. saccharinum*, *Quercus rubra*, and *Q. palustris* on their own species, incompatibility is very serious and heavy losses can be sustained as the trees mature. To date, little has been discovered as to why this phenomenon occurs with some genera or species and not with others. Why should graft incompatibility be so common with *A. rubrum* and *A. saccharinum* and yet so rare with *A. platanoides* and *A. saccharum?*

Another advantage to cutting propagation is that relatively unskilled help can be trained to make cuttings much more easily and quickly than to graft or to bud. In this era, craftsmanship is at a discount and hand work is unpopular. A workable cutting crew can be trained in only a few days, because making acceptable cuttings is so simple whereas it takes weeks or even months to train a worker to make good grafts fast enough to make the operation economical. There is no problem in finding willing candidates to drive a truck or tractor, but few indeed want to learn to graft or bud.

While cutting propagation of shade trees has many obvious advantages, there are some serious drawbacks too. To begin with, there are a number of genera and species, sometimes quite closely related, which are difficult or impossible to root. *Quercus palustris* and *Q. rubra* are commercially impossible, for example. The hybrid *Magnolia* × *soulangiana* is easy to root but one of its parents, *M. denudata*, is almost impossible. *Prunus serrulata* 'Kwanzan' is relatively easy but *P. serrulata* 'Shirotae' is extremely reluctant, and *P. sargentii* is even worse.

A problem with some species is that, although they can be rooted successfully, the root system or structure is so poor that the resultant trees are unsaleable at digging time. It is possible to root *Sophora japonica* from hardwood cuttings in the greenhouse or from softwood cuttings under mist. When planted out in the field, the young trees grow on well enough, but the root system is too sparse for successful transplanting at a larger size. If the young trees are dug, root pruned, and replanted a couple of times in the production cycle good roots can be produced, but the cost of such operations far exceeds the cost of budding or grafting on seedling understocks to begin with, and also avoids the extra handling. It is possible to root *Pyrus calleryana* 'Bradford' from softwood cuttings, but the young trees develop poor, irregular root systems and are very susceptible to wind-throw when larger, either in the nursery or on city streets. *Tilia cordata*, which is subject to some wind-throw when grown on seedling understocks, is much worse on its own roots.

Over-wintering tree cuttings is particularly difficult during the first winter after rooting for some species. Cutleaf weeping birch *Betula pendula* 'Dalecarlica (Syn.: B. *alba* var. 'Laciniata') can be quite successfully rooted from softwood cuttings. However, getting the young plants through the first winter is another matter and losses can be so severe that the leading Dutch proponants of this method of propagation have given it up. *Stewartia* species are especially difficult and *Hamamelis mollis* is even more so. *Cornus florida* 'Rubra' and *C. kousa* are practical, but the over-wintering temperature requirements are very strict and narrow. The cuttings must have enough winter cold to satisfy their dormancy requirements, yet if they freeze the bark splits and all is lost. In effect, this means that the winter temperature surrounding the cuttings must range between 33° and 40°F. The length of cold required has not been worked out for each species, but the average requirement is 90 to 100 days.

It is relatively easy to subject a few flats of cuttings or potted cuttings to these exacting requirements and many arboreta and botanical gardens have the equipment to do so. However it is another matter to over-winter hundreds of thousands of cuttings in such a narrow temperature range, and expensive facilities or very watchful care in less elaborate structures are required for success.

Another problem with some cutting-grown trees is lack of vigor in the young tree for many years after it is lined out in the nursery field. Cutting-grown young *A. rubrum* trees are almost as vigorous as buds. Cutting grown *T. cordata* clones are very slow indeed. A budded *T. cordata* can produce a whip 7 or 8 ft tall in the first summer after the understock is cut back, while a cutting-grown tree of the same clone may take 3 growing seasons to reach the same height. A seedling of *A. griseum* may put on 18 in. of growth in the second year while a cutting will only grow 3 or 4 in. Slow growth is not invariably the case, however, for a seedling poplar or willow may grow only 18 in. tall in one growing season, whereas a yearling tree of the same species grown from a spring-planted hardwood cutting may reach 9 or 10 ft in height.

For some as yet unexplained reason, young plants from cuttings of certain tree species are much less cold-hardy even when several years old than grafted trees of the identical species and clone. *Cornus florida* and its various clones are notorious in this respect, as are the various forms of *A. palmatum*. I can recall an especially cold winter in which we had a polyethylene covered house full of 2 year *A. palmatum* 'Bloodgood' trees in 1 gal. cans, half of them grafts and half own-root plants. Without exception every cutting-grown plant died and every graft lived. Evidently the bark of cutting-grown plants is somehow different from that of seedlings, as it splits readily at ground level when frozen. It would be a neat morphological problem to find out why this occurs. In any case, plants which exhibit this problem for many subsequent years always seem to be the same ones which are especially difficult to get through the first winter after rooting.

Having summarized the distinct advantages and problems encountered in growing trees from cuttings, it is worthwhile to review the various forms of cutting propagation and the trees which are readily reproduced by each method.

HARDWOOD CUTTINGS

This was historically the first method which was used to propagate trees from cuttings (See Table 1 for a list of shade trees that can be grown from hardwood cuttings). It is still by far the best method for trees like willows and most poplars. Where cuttings can be stuck directly in the open field where the trees are to be grown on, it is the cheapest of all forms of cutting propagation. It has the added advantage of being an operation in which making up the cuttings is done in the winter when the work load is lightest. Hardwood cuttings are collected after the leaves have fallen, preferably not until December or later when the wood is hardest and the food stored in the stems is at its highest point. As is true with many kinds of softwood and conifer cuttings, tree hardwood cuttings made with a "heel" often root more easily than straight cuttings. Such extra care is not necessary with species like willows and poplars which have pre-formed root primordia beneath the bark of young stems.

Table 1. Trees that can be propagated by hardwood cuttings

Elaeagnus angustifolia
Franklinia alatamaha[1]
Maclura pomifera
Metasequoia glyptostroboides
Morus *alba*, (*M. platanifolia*, possibly lobed, sterile forms of *M. alba*)
Malus, fruiting understock clones[2]
Platanus, all species
Populus, most species (see root cutting list for exceptions)
Prunus cistena, *P. cerasifera* purple cultivars, fruiting understock clones[2]
Salix, all species
Sophora japonica[1]
Syringa *reticulata* (Syn.: S. *Amurensis* var. *japonica*)

[1] Stick in a greenhouse with bottom heat
[2] Stick in "Garner Bin"

Rooting hardwood cuttings of fruit understocks such as plums, apples, and pears by the "Garner Bin" method has been successfully used in England. The cuttings, up to 18 in. or more in length, are made up, bundled, treated with a hormone soak and then heeled-in in special bins in which the tops are exposed to the open air but the bottoms are heated up to 70°F to encourage callusing and root initiation. When the latter occurs the cuttings, which still have dormant tops, are lined out in the open field as understock for summer budding. This intriguing method has not been so successful in the U.S.A. In part it depends upon establishing blocks or hedges of special understock clones in which juvenility is maintained by hard cutting back each winter. If the plants lose their juvenility, they will no longer root satisfactorily. Furthermore, the much colder and drier "continental" climate of central and eastern Canada and the U.S.A. is apparently detrimental although experiments in rooting 'Bartlett' and 'Old Home' pear by hardwood cuttings in California were successful. The "Garner Bin" should not be dismissed arbitrarily. It is possible that extended research, in techniques, different rooting structures and in various strengths and formulations of rooting hormones could be very fruitful. Isolated reports in rooting hardwood cuttings of *M.* × *soulangiana* hybrids and *A. palmatum* 'Atropurpureum' indicate what is possible, although there are big unsolved problems because extensive propagation by this method has not taken hold. Serious research in this neglected corner of plant propagation is well worthwhile. In addition to cheapness, hardwood cutting propagation is valuable because such large liners are produced, a marked contrast to the feeble little plantlets which come out of the tissue culture labs.

SOFTWOOD CUTTINGS

Propagating shade and ornamental trees from softwood cuttings is not a new method (see Table 2 for a list of shade trees that can be propagated by softwood cuttings). Dr. L.C. Chadwick published a paper on rooting ginkgos in the 1920's. Japanese cherries, oriental magnolias, *M. grandiflora*, and some purple-leafed plums have been grown by this method of many years. Recently, Dr. Elwin Orton's work in rooting cuttings of *A. rubrum* clones has led to renewed interest in shade tree propagation by this method and much new work has been done. It is safe to generalize that almost all of the major shade trees are difficult to propagate from softwood cuttings. Whenever the propagator has to deal with a "difficult" species of woody plant, clonal differences in rooting ability are especially pronounced. Thus *A. rubrum* 'Red Sunset' roots easily while *A. rubrum* 'Bowhall' is difficult, *P. serrulata* 'Kwanzan' is fairly easy but P. serrulata 'Shirotae' is very difficult and P. serrulata 'Tai Haku' is worse. A few clones of *A. saccharum* will root but most will not.

Table 2. Trees that can be propagated by softwood cuttings

Acer griseum, A. palmatum, A. rubrum, A. saccharinum*
Amelanchier spp.
Betula pendula 'Dalecarlica' (Syn: *B. alba* 'Laciniata'), *B. nigra* 'Heritage'
Cercidiphyllum japonicum
Cornus *florida* clones[1], C. kousa[1] and cv. 'Summer Stars', C. mas
Davidia involucrata[1]
Franklinia alatamaha
Ginkgo biloba
Ilex aquifolium, I. opaca, I pedunculosa
Lagerstroemia indica
Liquidambar styraciflua
Magnolia × 'Galaxy', M. grandiflora, M. Kobus var. loebneri, M. × *soulangiana* clones, *M. kobus* var. *stellata*, *M. virginiana*
Malus, oriental species and hybrids, dwarfing understocks
Metasequoia glyptostroboides
Platanus, all species
Prunus maackii, P. serrulata (some clones), *P. subhirtella*[1], *P. yedoensis*
Pyrus calleryana clones[1]
Quercus robur 'Fastigeata'
Sophora japonica
Stewartia koreana, S. pseudocamellia*[1]
Styrax japonica
Syringa reticulata
Taxodium distichum
Tilia cordata clones
Ulmus americana, U. carpinifolia, × *U. hollandica*
Zelkova serrata

[1] Cuttings difficult to bring through their first winter after rooting.

The development of mist propagation has been especially important for successful rooting of tree cuttings. Many which were considered impossible in earlier times are commercially practical today. With the perfection of mist propagation systems the addition of bottom heat for softwood propagation has become practical as well. Bottom heat is especially important in the cool summer climate of the Pacific Northwest, but even in the heat and humidity of the Middle South and the East, bottom heat makes it possible to root some species which are very difficult without it. Mist is important also because of the critical timing necessary in taking softwood cuttings of many trees. Many species and hybrids of elms, for example, will root from extremely soft cuttings taken very early in the summer but not from cuttings of more mature wood. Properly regulated applications of mist can keep these fragile cuttings turgid long enough for rooting to occur, almost an impossibility under older methods of propagation.

Supplemental lighting to extend day length to 18 hours after midsummer and on into the fall proved to be the solution to successful cutting propagation of many deciduous azaleas which were formerly considered difficult or impossible by this method. Extra light greatly increases the summer growth and winter survival of cuttings of *A. palmatum* clones, *C. florida* 'Rubra, and *C. kousa* 'Summer Stars', as well as *A. rubrum* clones. It may well be that the answer to overwintering rooted cuttings of *Betula pendula* 'Dalecarlica' (*B. alba* 'Laciniata'), *A. saccharum*, and *Stewartia* species lies in getting them to make a flush of growth, no matter how small, in the same summer in which they were rooted, the same technique which is so successful with *A. palmatum* clones and *C. florida* 'Rubra.'

With the perfection of mist propagation and the accompanying option of being able to use bottom heat safely in the summer months, the only other problem is to find new kinds of concentrations and new combinations of rooting hormones in order to expand the list of trees which can be propagated from softwood cuttings on a commercial scale. The same kind of intensive and persistant research which has made it practical to root the vast array of rhododendrons now grown from cuttings can produce equal results with shade and ornamental trees. Like so many hybrid rhododendrons a generation ago, there are quantities of tree species which will callus well under mist but never go on to root. The impetus to root rhododendrons was strong because so many are sold each year. Dozens of shrubs are sold for every shade tree and at higher prices for young plants. With the escalating costs of budding and grafting, however, the trees merit their turn for expanded research.

ROOT CUTTINGS

The third form of cutting propagation for trees is little used but is of great value for a limited list of subjects (see Table 3 for a list of shade trees that can be propagated by root cuttings). This is propagation from sections of roots stuck in rooting medium so that they form aerial shoots as well as a new root system. Root cuttings are much more difficult to gather than aerial cuttings, and this factor has limited their use. In effect, the most economical way to gather them is during the spring digging season. Large numbers of trees are then available bare-root, from which occasional roots can be cut off and placed in boxes or baskets for temporary storage until they are cut up into suitable lengths, usually 2 to 3 in. long. Root cuttings stuck or planted in the early spring begin to grow promptly without a long period of dormancy in which they can decay, as is the risk in making fall cuttings. It is just as important to pot or stick root cuttings with the apical end up as it is to stick softwood or hardwood cuttings with the apical tip up. However, workers who would never think of sticking a leafy cutting upside down will do so with root cuttings because the difference between top and bottom is so much less obvious. With appropriate species, root propagation is so reliable that the cuttings can be potted up or set in containers when they are made with good stands resulting and effecting a considerable saving in costs.

Table 3. Trees that can be propagated by root cuttings

Ailanthus altissima (Syn.: *A. glandulosa*)	*Kalopanax septem lobus* (Syn.: *K. pictus*)
Albizia julibrissin	*Malus*, dwarfing understock
Aralia elata, *A. spinosa*	*Populus alba*, *P. grandidentata*, *P. tremula* clones, *P. tremuloides*
Asimina triloba	*Pyrus calleryana*
Diospyros virginiana	*Robinia*, all species
Gleditsia triacanthos clones	*Sassafras albidum*
Gymnocladus dioica	*Ulmus* × *hollandica*

As in other forms of cutting propagation, there are striking differences in response, even in the same genus. For example, most of the *Ulmus* × *hollandica* clones sprout well from root cuttings, whereas *U. americana* does not. In other genera like *Robinia*, all species are readily grown from root cuttings. One particularly valuable aspect of root cutting propagation is that it is a method for restoring juvenility to a plant. Thus root cuttings can be used to reestablish a stock block of juvenile plants which can then be easily grown from soft- or hardwood cuttings. For example, *Ulmus* 'Christine Buiseman' roots with great difficulty if the cuttings are taken from mature trees. However, cuttings made from the sprouts from root cuttings root rapidly and give a good stand. In the case of apple clonal rootstocks, if the juvenility of a hedge of mother plants is lost because of neglected trimming, it is possible to restore the desired juvenility to the clone by growing new stock plants from root cuttings. In the case of trees which are difficult to bud or graft and will not root from stem cuttings (male *Gymnocladus* trees are a good example), root cuttings are the most practical method of vegetative propagation. The technique will always remain a rare but useful addition to the propagator's list of methods for special purposes.

Cutting propagation of trees is no universal panacea. It has distinct advantages and some definite disadvantages as well, depending on the tree to be grown. After some years of relative neglect it is now receiving greatly increased attention and is being used on a much expanded scale. From a research point of view, the surface has only been scratched. There are dozens of important tree species which could be grown from cuttings if only the proper chemical and environmental requisites can be worked out.

PRODUCING SHADE TREES BY GRAFTING

A great many shade and ornamental trees cannot be rooted using stem cuttings and they will not sprout from root cuttings. Similarly, many of the same species, at least at present, cannot be reproduced by tissue culture. If selected clones of such trees are to be reproduced, it must be done by grafting or budding.

Wherever budding will give acceptable stands it is to be preferred over grafting because in the hands of a skilled operator it is so much faster and cheaper. Furthermore, a budded tree, in which all the energy of the large and established root system of the field grown seedling understock is concentrated behind the growth of a single bud, will be many times the height of a grafted tree at the end of the first growing season. For example, 8 to 9 ft tall whips of *A. platanoides* 'Crimson King' can be obtained at the end of one season's growth in Oregon, but the same trees grown from dormant "bench grafts" will scarcely become 18 in. tall in the same period of time. Budding or grafting can be used as a fascinating measure of the photosynthetic effeciency of different tree clones. For example, *Acer platanoides* 'Emerald Queen' or 'Summershade' can make 10 foot tall whips in one summer's growth but the variegated *A. platanoides* 'Drummondii', grown on the same understock, will scarcely reach 5 ft in height, even in the splendid growing conditions of the Pacific Northwest.

There is much to be gained by budding trees whenever they can be propagated by that method. However, not all trees can be budded and these must be reproduced by grafting, despite its disadvantages. A typical example is the European beech, *Fagus sylvatica*. It has produced a number of beautiful variants such as the several purple-leafed forms, a splendid weeping clone, a fastigiate one, and a lacy cutleafed clone. All of these must be propagated by grafting them on seedling understocks. The normal process is to pot up beech seedlings in the winter or early spring, grow them over the summer in a cold frame or plunged in outside beds, then bring them in for grafting the following February or March. If the grafted plants are set up in a sufficiently humid greenhouse, it is not necessary to protect the newly grafted plants under double sash as used to be done in an earlier era. In parts of Holland and in Holstein, Germany, where the early spring weather is mild and very humid, beeches can be cleft-grafted on seedlings of considerable size already established in open nursery beds, using short scions of 2-year-old wood of a suitable diameter. The first year's growth of such open ground grafts is phenominal in comparison to the normal pot-grafted beeches. Unfortunately in most of the U.S.A. and Canada the climate is too dry and the temperatures rise too rapidly in the spring for field grafting to succeed, so more cumbersome and expensive greenhouse methods must be used.

For trees such as cherries, pears, and crabapples, which are much easier to transplant than oaks or beeches, grafting scions on dormant bareroot understocks (bench grafting) is the preferred method. Bench grafts are much cheaper and quicker to make than grafts on potted understocks. In addition to speed, the great saving is in the costs of the understocks. A potted seedling is already an expensive article. First, the seedling must be grown for a season in a bed. Then come the costs of potting it up and carrying it on long enough to build a good root system. Finally comes the grafting process itself, at least as much slower than bench grafting, as the latter is in comparison to budding.

Bench grafting is useful for reproducing trees which are not easy to bud. *Prunus subhirtella* 'Pendula,' for example, with its normally thin twigs and tiny, thin-barked buds is a difficult tree to bud in the open field, but it is not difficult to bench graft. *Prunus subhirtella* seedlings, when available, are much to be preferred over *P. avium* seedlings because of their much more fibrous roots and superior graft stands. Another advantage is that bench grafting is done in January and February, when the average nursery is looking for indoor work. Many nurseries which have field budding programs up to the limit of their capacity, resort to bench grafting to supplement production capability. A third advantage of bench grafting is that there is much less suckering necessary in the growing season in comparison with budding because the graft union is planted well below the soil surface, whereas a bud union is at or above the surface. In orchard apple production, bench grafting can save a year's field production time. Where inter-stem trees are desired, the stem portion of the tree can be bench grafted on suitable understocks. These are planted out and budded to the desired fruiting cultivar that same summer. Thus the three-part tree can be produced in 2 years rather than 3 years, with substantial savings in costs.

Bench grafting has some advantages in producing small trees for special purposes. For example, small branched crabapple trees are desirable for mail order sales. The shipping costs for normal big 2-year budded trees are exorbitant. A 2-year graft will make a nice, well branched little 3 to 4 ft tree which is substantial yet small enough for a reasonable shipping cost.

Most bench grafts are made either as splice grafts or whip and tongue grafts. The latter are slower and more difficult to make, but they hold the graft together as it is passed to the wrapper which speeds up that process. Also the greater cambial contact of the whip and tongue graft seems to result in better stands. For the normally hard-wooded trees, there does not appear to be any substitute for a sharp knife in the hands of a skilled grafter. The Omega grafting machine, though clever and speedy to operate in the hands of even a rank beginner, simply does not give acceptable stands with trees. It was originally designed for the soft, porous wood of grapevines, and there it works well indeed. Similarly, the various other European grafting machines were designed for grape grafting, which is a very large scale enterprise indeed, but they are useless for tree grafting. The pressing motion on which they operate bruises the tree wood so severely that decay instead of healthy callusing results. Also, of course, the cutting blades are extremely difficult if not impossible to sharpen. A really effective grafting machine would be a boon to the nursery industry but, given the infinite variability of scion and understock sizes, shapes, and angles, making grafts, like making babies, seems destined to be done in perpetuity in the good old-fashioned way!

There are parts of the nursery industry, especially container production of the easily rooted common broadleaf and coniferous everygreens, in which the big new corporate entrants seem poised to exterminate the small family nursery. In the production of specialty shade and flowering trees, especially those which must be budded or grafted, the conglomerate is at a serious disadvantage. In this area, propagation is as much an art as a science and it is certainly not an industrial process, and here the skillful plantsman will always reign unchallenged.

Thursday Afternoon, December 16, 1982

The Thursday afternoon session convened at 1:30 p.m. with Steven Still serving as Moderator.